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National Institute of Publications of the
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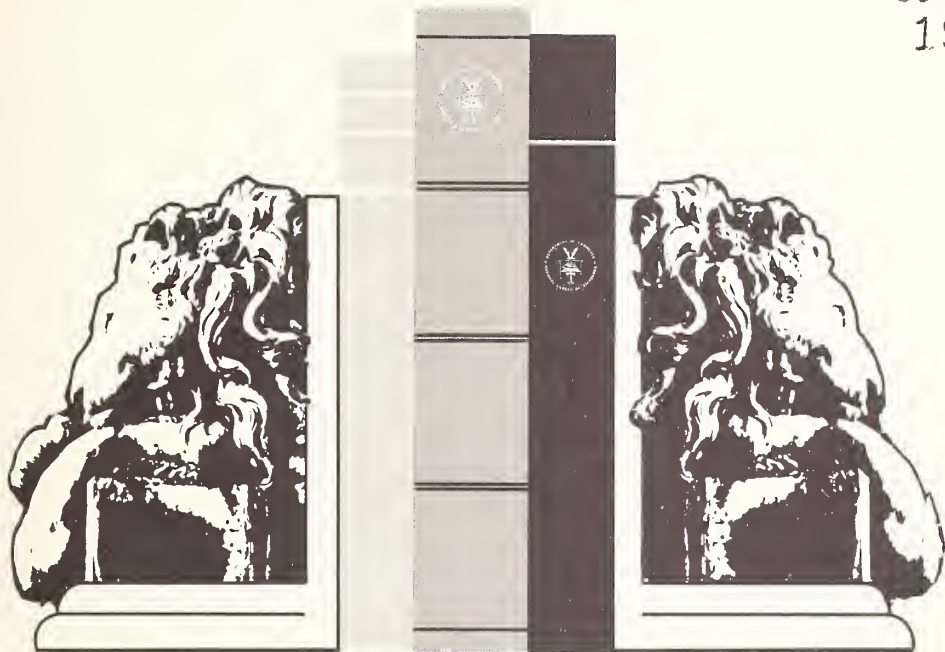
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PUBLICATIONS OF THE NATIONAL BUREAU OF STANDARDS

1978 CATALOG/SUPPLEMENT TO

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards¹ was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

THE NATIONAL MEASUREMENT LABORATORY provides the national system of physical and chemical and materials measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; conducts materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government Agencies; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

Absolute Physical Quantities² — Radiation Research — Thermodynamics and Molecular Science — Analytical Chemistry — Materials Science.

THE NATIONAL ENGINEERING LABORATORY provides technology and technical services to users in the public and private sectors to address national needs and to solve national problems in the public interest; conducts research in engineering and applied science in support of objectives in these efforts; builds and maintains competence in the necessary disciplines required to carry out this research and technical service; develops engineering data and measurement capabilities; provides engineering measurement traceability services; develops test methods and proposes engineering standards and code changes; develops and proposes new engineering practices; and develops and improves mechanisms to transfer results of its research to the ultimate user. The Laboratory consists of the following centers:

Applied Mathematics — Electronics and Electrical Engineering² — Mechanical Engineering and Process Technology² — Building Technology — Fire Research — Consumer Product Technology — Field Methods.

THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides scientific and technical services to aid Federal Agencies in the selection, acquisition, application, and use of computer technology to improve effectiveness and economy in Government operations in accordance with Public Law 89-306 (40 U.S.C. 759), relevant Executive Orders, and other directives; carries out this mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards guidelines, and managing Federal participation in ADP voluntary standardization activities; provides scientific and technological advisory services and assistance to Federal Agencies; and provides the technical foundation for computer-related policies of the Federal Government. The Institute consists of the following divisions:

Systems and Software — Computer Systems Engineering — Information Technology.

¹Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

²Some divisions within the center are located at Boulder, Colorado, 80303.

National Bureau of Standards
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Publications of the National Bureau of Standards 1978 Catalog

A Compilation of Abstracts and Key Word and Author Indexes

Betty L. Burris and Rebecca J. Morehouse, Editors

Technical Information and Publications Division
National Bureau of Standards
Washington, D.C. 20234



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Special order 205 copies

U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, Secretary

Jordan J. Baruch, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

Issued June 1979

Library of Congress Catalog Number: 48-47112

National Bureau of Standards Special Publication 305 Supplement 10
To Accompany National Bureau of Standards Special Publication 305; and its Supplements 1 through 9
Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 10, 679 pages (June 1979)

CODEN: XNBSAV

Issued June 1979

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1979

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(Order by SD Stock No. 003-003-020699). Price \$11.00 (Add 25 percent additional for other than U.S. mailing).

PREFACE

Publications constitute an important means of transmitting the results of NBS and NBS-sponsored research to the diverse audiences served by the National Bureau of Standards. NBS research covers the wide range of physics, chemistry, engineering, mathematics, and computer sciences, all related to the specific program areas listed on the inside cover. Over 59,000 pages were published by NBS in 1978, in over 1900 papers issued in the Bureau's own publication series and in non-NBS journals, books, and proceedings.

The present catalog again includes citations for patents issued to NBS inventors and for reports prepared under NBS contracts. Also included, as in past years, are citations for papers published in the Journal of Physical and Chemical Reference Data, which is published for NBS by the American Institute of Physics and the American Chemical Society.

All papers are cited by full title, author(s), place of publication, abstract, and key words. Permuted author and key word indexes facilitate use of the listings, as does the edge index on the back cover. Citations for papers published in the Bureau's formal program are organized by NBS publications series. NBS-authored papers in non-NBS media are cited separately in numerical sequence. In addition, for the convenience of specialists, the titles of all NBS publications for 1978, categorized by major primary subject area, are listed in a special section of this catalog.

NBS papers published by the Government Printing Office are sold by the Superintendent of Documents and also, in microcopy form, by the National Technical Information Service (NTIS). The NBS Federal Information Processing Standards Publications (FIPS PUBS) and National Bureau of Standards Interagency Reports (NBSIR's) are sold only by NTIS, both in paper and microcopy form.

For the convenience of researchers, this issue contains information on previous NBS catalogs and on the availability of NBS papers published in past years. Also included, for completeness, are those NBS papers published prior to 1978 but not reported in previous issues of this annual catalog. This 1978 catalog, Supplement 10 to NBS Special Publication 305, was produced by means of computer-assisted photocomposition.

Since the issue of the 1977 annual catalog, NBS has published SP 535 which represents a consolidation of Supplements 1 through 8 of NBS SP 305 covering the period 1966-1976. This 11-year record of NBS publications is available in two volumes as cited on page 9. The 1977 annual catalog (Supplement 9 of SP 305) and the present catalog (Supplement 10) update NBS publications through 1978.

W. R. Tilley
Chief, Technical Information and Publications Division

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A GUIDE TO USERS OF THIS PUBLICATION

In addition to the usual author index, a subject index is provided in the form of a permuted key word index. In this type of index the key words in each publication or paper are arranged by shifting each group of key words along the horizontal printing line so that each key word in turn has an opportunity to appear alphabetically. The user is thus able to locate

papers of interest to him through the subject-related words he finds in the key word index.

The index symbols used in the author and key word indexes are explained in the following three tables. These tables also give the pages on which the abstracts of the various publication series begin.

SYMBOLS FOR NBS PUBLICATIONS

A. Symbols for the Periodicals

	Index Symbol		Issue Date	Page Number
	Vol.	No.	1978—Bi-monthly	
NBS Journal of Research	J. Res. 83	1	January–February	47
	J. Res. 83	2	March–April	47
	J. Res. 83	3	May–June	48
	J. Res. 83	4	July–August	49
	J. Res. 83	5	September–October	50
	J. Res. 83	6	November–December	52

	Index Symbol		Issue Date	Page Number
	Vol.	No.		
Journal of Physical and Chemical Reference Data	JPCRD 7	1	1978	54
	JPCRD 7	2	1978	54
	JPCRD 7	3	1978	55
	JPCRD 7	4	1978	56

	Index Symbol		Issue Date	Page Number
	Vol.	No.	1978—11 issues per year	
DIMENSIONS/NBS	DIM/NBS 62	1	January	58
	DIM/NBS 62	2	February	58
	DIM/NBS 62	3	March	58
	DIM/NBS 62	4	April	58
	DIM/NBS 62	5	May	58
	DIM/NBS 62	6	June	59
	DIM/NBS 62	7/8	July/August	59
	DIM/NBS 62	9	September	59
	DIM/NBS 62	10	October	59
	DIM/NBS 62	11	November	59
	DIM/NBS 62	12	December	59

B. Symbols for the Nonperiodicals

NBS Nonperiodical Series	Index Symbol	Page Number
Monographs	Monogr.	61
Handbooks	H	62
Special Publications	SP	64
Applied Mathematics Series	AMS	139
National Standard Reference Data Series	NSRDS	140
Building Science Series	BSS	141
Federal Information Processing Standards	FIPS PUBS	144
Product Standards	PS	145
Technical Notes	TN	146
Consumer Information Series	CIS	152
NBS Interagency Reports	NBSIR	153
Grantee/Contractor Reports and Patents	GCR and/or NBS Patent	179

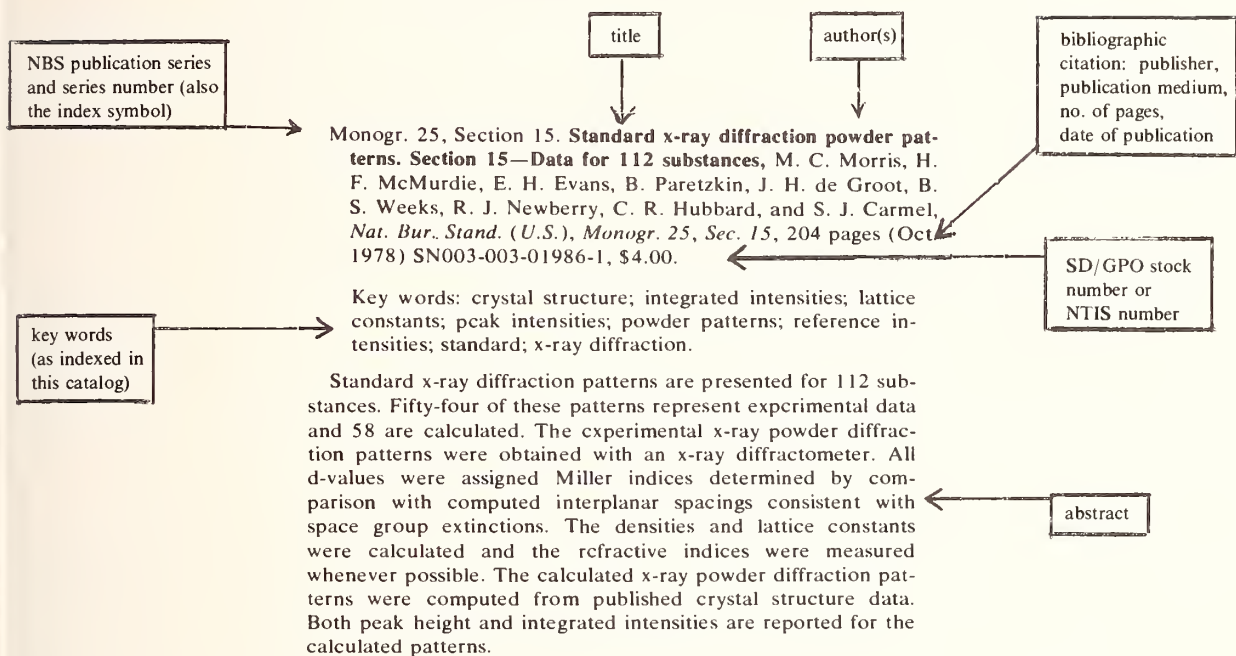
C. Symbols for the Papers Published by Non-NBS Media (1978)

NBS Papers Published by Others (1978)	Index Symbol	Page Number
Professional Journals, Books, Book Chapters, Proceedings, etc.	Five-Digit numbers, 17351 through 18317	186

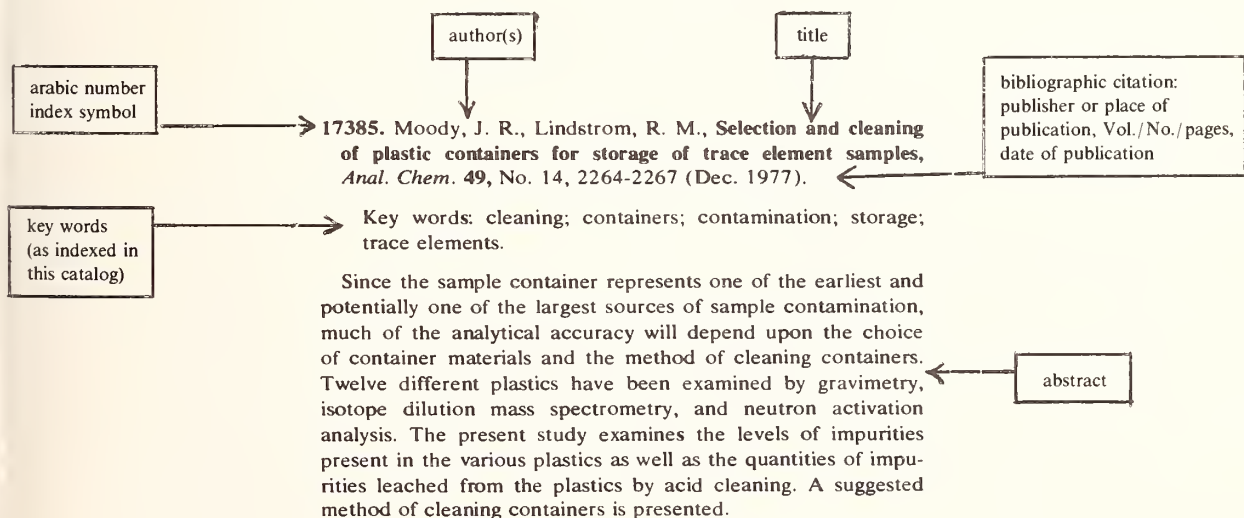
SAMPLE
ENTRIES
FOLLOW

CATALOG ENTRIES: HOW TO READ THEM

A. Abstracts—Sample Entries

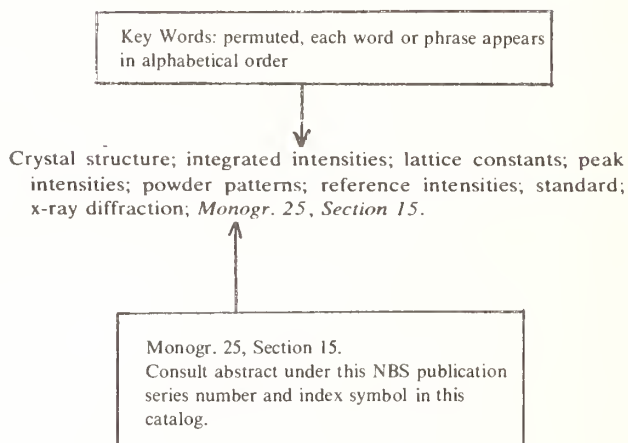


Example of NBS published paper

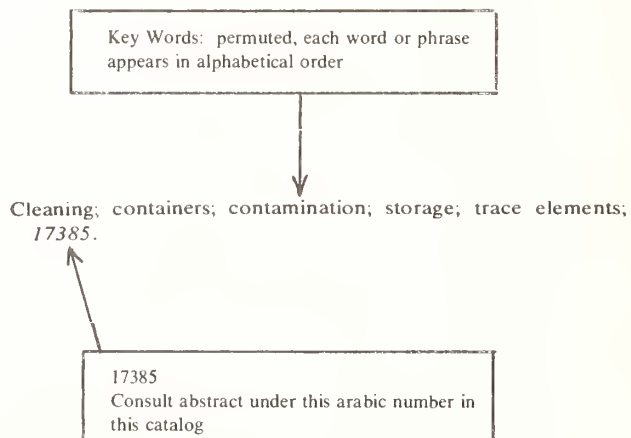


Example of NBS paper published in non-NBS media

B. Key Words—Sample Entries



Example of NBS published paper



Example of NBS paper published in non-NBS media

C. Authors—Sample Entries

Authors: permuted,
in alphabetical order

MORRIS, M. C., MCMURDIE, H. F., EVANS, E. H., PARETZKIN,
B., DE GROOT, J. H., WEEKS, B. S., NEWBERRY, R. J., HUB-
BARD, C. R., CARMEL, S. J., *Monogr. 25, Section 15.*

Monogr. 25, Section 15.
Consult abstract under this NBS publication
series number and index symbol in this
catalog.

Example of NBS published paper

Authors: permuted,
in alphabetical order

MOODY, J. R., LINDSTROM, R. M., 17385.

17385
Consult abstract under this arabic number in
this catalog

Example of NBS paper published in non-NBS media

1. NBS PUBLICATION PROGRAM

1.1. INTRODUCTION

The formal publications of the National Bureau of Standards—some 1900 papers in 1978 provide the primary means of communicating the results of NBS programs to its varied technical audiences, as well as to the general public. Publications thus constitute a major end product of the Bureau's efforts. These take the form of the Bureau's three periodicals, its ten nonperiodical series, interagency reports, and articles in the journals of professional organizations and technological associations.

This annual catalog, *Publications of the National Bureau of Standards*, cites the 1978 output of papers that document the results of the Bureau's current programs. The various media in which these papers appeared are as follows:

1.2. PERIODICALS

1.2.1. JOURNAL OF RESEARCH

The National Bureau of Standards Journal of Research, a bi-monthly, reports NBS research and development in those physical and engineering disciplines where the Bureau is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and on the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Bureau's technical and scientific programs. As a special service to subscribers, each issue contains complete citations for all recent NBS publications. Papers published during 1978 in the Journal are reported in this catalog.

Board of Editors:

Churchill Eisenhart,

Executive Editor (Mathematics)

John W. Cooper (Physics)

Donald D. Wagman (Chemistry)

Andrew J. Fowell (Engineering)

Joseph O. Harrison (Computer Science)

Helmut W. Hellwig (Boulder Labs.)

1.2.2. DIMENSIONS/NBS

This magazine is published to inform both the technical expert and the interested layman of the latest advances in science and technol-

ogy, with primary emphasis on the work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

The table of contents for each issue in 1978 is listed in Section 3.3, pages 58 to 60. Issued monthly.

Editor: Juli Chappell

1.2.3. JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA (JPCRD)

This Journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The objective of the Journal is to provide critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques, whose aim is to assess the accuracy of available data in a given technical area, are also included. The principal source for the Journal is the National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements such as are normally reported in the primary research literature, nor for review articles of a descriptive or primarily theoretical nature. (See also Section 1.3. National Standard Reference Data Series.)

1.3. NONPERIODICALS

Ten categories of nonperiodical publications, described as follows, are listed in this catalog: **MONOGRAPHS**—major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

HANDBOOKS—recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

SPECIAL PUBLICATIONS—include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Special subject-matter subseries include Semiconductor Measurement Technology (SP400-), Standard Reference Materials (SP260-), Precision Measurement and Calibration (SP300-), Law Enforcement Technology (SP480-), and Computer Science and Technology (SP500-).

APPLIED MATHEMATICS SERIES—mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

NATIONAL STANDARD REFERENCE DATA SERIES—provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS, under authority of National Standard Data Act (Public Law 90-396). This series supplements the JPCRD, see also Section 1.2.3.

BUILDING SCIENCE SERIES—disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

TECHNICAL NOTES—studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

Special subject-matter subseries include Optical Radiation Measurements (TN594-) and Self Calibrations Manual for Optical Radiation (TN910-).

VOLUNTARY PRODUCT STANDARDS—developed under procedures published by the Department of Commerce in Part 10, Title 15,

of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the Voluntary Product Standards program as a supplement to the activities of the private sector standardizing organizations.

FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS (FIPS PUBS)—publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

Public distribution of FIPS PUBS is by purchase from the National Technical Information Service, Springfield, VA 22161.

CONSUMER INFORMATION SERIES—practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

1.4. NBS INTERAGENCY REPORTS

A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161 in paper copy or microfiche form. (See pages 33 to 42 for price lists.)

1.5. GRANTEE/CONTRACTOR REPORTS AND NBS PATENTS

Grantee/contractor reports are prepared by non-NBS persons or organizations working under grant or contract from the National Bureau of Standards. Those contract reports not

incorporated into the formal NBS publication series are available directly from the National Technical Information Service (NTIS), Springfield, VA 22161, in paper copy or microfiche form unless otherwise stated. When ordering a report from NTIS you must order it by the "COM, PB, AD, or N" number as indicated.

Patents—are obtained on NBS inventions of high commercial potential, in order to establish Government ownership of the patent rights. The patents are then made available for the grant of nonexclusive licenses to all qualified applicants. A limited exclusive license may be granted under a particular patent, however, if it appears that some period of exclusivity is necessary as an incentive for the investment of risk capital. For information on licensing any of the NBS held patents, write to the Office of the Legal Adviser, National Bureau of Standards, Washington, DC 20234. Copies of patents may be obtained from the U.S. Patent and Trademark Office, Washington, DC 20231 for 50 cents each.

1.6. NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES

The Cryogenic Data Center of the National Bureau of Standards, Boulder, CO has developed specialized bibliographic issuances de-

2. PURCHASE PROCEDURES AND DOCUMENT AVAILABILITY

2.1. PURCHASE PROCEDURES

Publications of the Bureau are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, at the prices listed in this publication. However, prices are subject to change without notice. You may also order through the U.S. Department of Commerce District Office nearest you (see Appendix B for list of District Offices of the U.S. Department of Commerce). Microfiche copies of all recent NBS publications, and paper copies of many nonperiodicals, may be ordered through the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Note that three of the nonperiodical series are available only from NTIS; these are FIPS

signed to provide interested audiences with information on latest developments in certain specialized fields. These issuances, together with subscription information, are listed below:

CRYOGENIC DATA CENTER CURRENT AWARENESS SERVICE (Publications and Reports of Interest in Cryogenics). A literature survey issued weekly. Annual subscription: Domestic, \$25.00; Foreign, \$30.00.

LIQUEFIED NATURAL GAS. A literature survey issued quarterly. Annual subscription: \$20.00.

SUPERCONDUCTING DEVICES AND MATERIALS. A literature survey issued quarterly. Annual subscription: \$30.00.

Send subscription orders and remittances for the preceding bibliographic services to the National Bureau of Standards, Cryogenic Data Center (736.00), Boulder, CO 80303.

1.7. PAPERS PUBLISHED BY OTHERS

Many significant contributions by NBS authors are published in other journals. Up-to-date listings of these articles are carried regularly in the Journal of Research, along with selected abstracts. A complete listing is published annually in NBS SP305, along with abstracts, key words, and author/subject indexes.

PUBS., NBS Interagency Reports (NBSIR's), and Grantee/Contractor Reports (GCR's).

This section includes price lists of available publications, plus instructions on how to acquire reprints of articles by NBS authors, and how to get out-of-print material.

How To Make Remittances. Remittances for publications for which individual sales or subscription prices are shown should be mailed to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, by postal money order, express money order, or check. Postage stamps will not be accepted. Publications cannot be mailed before remittances are received. *Foreign remittances should be made either by international money*

order, draft on an American bank or UNESCO coupons.

The letter symbol, publication number, full title of the publication, SD catalog or SD stock number MUST be given when ordering. The Superintendent of Documents allows a discount of 25 percent on orders of 100 or more copies of one publication.

Persons who make frequent purchases from the Superintendent of Documents may find a deposit account convenient. Deposits of \$50 or more are accepted against which orders may be placed without making individual remittances or first obtaining quotations. Order blanks are furnished for this purpose. After the order has been processed, the order itself is returned, showing the publications supplied, explanations regarding those not sent, the amount of charge, and the balance on deposit.

No charge is made for postage on documents sent to points in the United States and its possessions. In computing foreign postage, the charge is approximately one-fourth of the current selling price of the publication. The charge is to cover the special handling required to comply with the customs and international mailing regulations.

How To Make Remittances to NTIS. Orders for publications purchased from the National Technical Information Service (NTIS) must be accompanied by postal money order, express money order, or check made out to the NTIS and covering total cost of the publications order. NTIS also accepts charges to your American Express Cards. You may also establish an NTIS deposit account by contacting them for this service. All inquiries or orders should be addressed to: National Technical Information Service, Springfield, VA 22161.

SD and NTIS order forms are included at the end of this publication for your convenience in ordering.

2.2. ANNOUNCEMENTS OF NBS PUBLICATIONS

The National Bureau of Standards and the agencies mentioned below regularly issue the following official announcements dealing with NBS publications.

DIMENSIONS/NBS. Issued monthly by the National Bureau of Standards. In addition to

publishing technical news of the Bureau, this periodical announces selected new publications in an NBS series. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription, \$11.00; \$13.75 foreign. Single copies, \$1.10 domestic; \$1.40 foreign each.

NBS JOURNAL OF RESEARCH. The Journal carries a listing of all NBS publications as issued. See Section 2.6. for subscription information.

Monthly Catalog of United States Government Publications. Issued monthly by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription, with consolidated annual index, \$45.00; \$56.00 foreign.

Selected List of U.S. Government Publications. Issued monthly by the Superintendent of Documents. Each list is arranged by subject, with annotations, prices, and order form. May be obtained free from the U.S. Government Printing Office, Superintendent of Documents, Mail List Section, Stop SSOM, Washington, DC 20402.

Recent Commerce Publications. Bi-weekly announcement of publications of the Department of Commerce. Lists titles and prices of National Bureau of Standards publications, as well as those of other offices of the Department of Commerce. Contact the Office of Public Affairs, U.S. Department of Commerce, Washington, DC 20230 for information on how to receive this listing.

NBS Publications Newsletter. This newsletter is issued approximately six times a year. It presents full citations, including abstracts and availability information, for NBS papers announced during the report period. Its primary audience includes librarians, documentalists and science information specialists. However, other NBS audiences also find it useful as a guide to new NBS publications.

Contact: Editor, NBS Publications Newsletter, Technical Information and Publications Division, National Bureau of Standards, Washington, DC 20234.

2.3. CATALOGS OF NBS PUBLICATIONS

The following constitute a complete list of the titles of the Bureau's publications through

December 31, 1978. The catalogs are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, unless otherwise stated, or may be consulted in a library which maintains sets of National Bureau of Standards publications.

Supplement 10 to Special Publication 305: Publications of the National Bureau of Standards, 1978. 679 pages, a citation of titles and abstracts, with key words and author indexes \$11.00

2.4. FUNCTIONS OF DEPOSITORY LIBRARIES IN THE UNITED STATES

The Superintendent of Documents, United States Government Printing Office, is authorized by law to furnish Government publications to designated depository libraries.

Under provisions of Title 44 of the United States Code, certain libraries are designated depositories for Government publications. Through them, Federal Government documents are made available to residents of every State, District of Columbia, Guam, Puerto Rico, and the Virgin Islands. Distribution to the libraries is made by the Office of the Superintendent of Documents.

It is sometimes impossible to obtain desired publications by purchase from the Superintendent of Documents. Stocks may have been exhausted or the document may be permanently out of print. In these instances the depositories render an invaluable service by keeping such publications permanently available. Every Government publication cannot be consulted at all depository libraries. Designated Regional Depositories are required to receive and retain one copy of all Government publications made available to depository libraries either in printed or microfacsimile form. All other libraries are allowed to select the classes of publications best suited to the interest of their particular clientele.

These libraries are now receiving selected publication series of the National Bureau of Standards for general reference use. Whether a given library has a copy of a particular publication can be determined by inquiring at the library.

2.5. FUNCTIONS OF U.S. DEPARTMENT OF COMMERCE DISTRICT OFFICES

Department of Commerce District Offices provide ready access, at the local level, to the services of the Department of Commerce as well as to its reports, publications, statistical statements, and surveys. Each District Office serves as an official sales agent of the Superintendent of Documents, U.S. Government Printing Office, making available for purchase lo-

Circular 460: Publications of the National Bureau of Standards 1901 to June 30, 1947. 375 pages including subject and author indexes. Brief abstracts are included for the period January 1, 1941 to June 30, 1947	*
Supplement to Circular 460: Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957. 373 pages, including subject and author indexes	*
Miscellaneous Publication 240: Publications of the National Bureau of Standards, July 1, 1957 to June 30, 1960. First NBS Catalog to include Titles of Papers published in Outside Journals 1950 to 1959. 391 pages, including subject and author indexes	*
Supplement to Miscellaneous Publication 240: Publications of the National Bureau of Standards published by NBS, July 1960 through June 1966; published by others, 1960 through 1965. 740 pages, including subject and author indexes	*
Special Publication 305: Publications of the National Bureau of Standards, published by NBS, July 1966 through December 1967; published by others, 1966-1967. 223 pages, a citation of titles and abstracts, with key words and author indexes	*
Supplement 1 to Special Publication 305: Publications of the National Bureau of Standards, 1968 through 1969. 497 pages, a citation of titles and abstracts, with key words and author indexes	*
Supplement 2 to Special Publication 305: Publications of the National Bureau of Standards, 1970. 378 pages, a citation of titles and abstracts, with key words and author indexes	*
Supplement 3 to Special Publication 305: Publications of the National Bureau of Standards, 1971. 342 pages, a citation of titles and abstracts, with key words and author indexes	*
Supplement 4 to Special Publication 305: Publications of the National Bureau of Standards, 1972. 449 pages, a citation of titles and abstracts, with key words and author indexes	\$4.20
Supplement 5 to Special Publication 305: Publications of the National Bureau of Standards, 1973. 349 pages, a citation of titles and abstracts, with key words and author indexes	\$4.15
Supplement 6 to Special Publication 305: Publications of the National Bureau of Standards, 1974. 523 pages, a citation of titles and abstracts, with key words and author indexes	\$6.80
Supplement 7 to Special Publication 305: Publications of the National Bureau of Standards, 1975. 595 pages, a citation of titles and abstracts, with key words and author indexes	\$7.55
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Supplement 9 to Special Publication 305: Publications of the National Bureau of Standards, 1977. 601 pages, a citation of titles and abstracts, with key words and author indexes	\$8.00

*Available by purchase from the National Technical Information Service, Springfield, VA 22161. Note: All citations in NBS SP305 and its Supplements 1 through 8 have been accumulated into NBS SP535, Volumes 1 and 2 (see Notice, page 9).

cally a wide range of Government publications. The reference library maintained by each District Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

2.6. AVAILABILITY OF NBS PUBLICATIONS

A. PERIODICAL SUBSCRIPTION RATES

Periodical	Domestic ¹	Foreign ²
Journal of Research of the National Bureau of Standards: Effective July 1977 issued bi-monthly as single section. Separate Sections A and B discontinued with the June 1977 issues. Paper covers . . .	\$17.00	\$21.25
Bound volume (1 volume per year), blue buckram	(3)	(3)
DIMENSIONS/NBS, issued 11 times per year	\$11.00	\$13.75

NOTE.—Send order, with remittance, to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

¹ United States and its possessions.

² Foreign price includes the cost of the publication and postage.

³ Prices of the bound volumes vary. The Superintendent of Documents will furnish prices on request.

B. SUPERSEDED NBS REFERENCE PUBLICATIONS

Those NBS publications not listed in the Price Lists are out of print and are not available from the Superintendent of Documents. Many can be consulted at libraries. Also, in many cases, photoduplicated copies can be purchased from the Library of Congress. For full information concerning this service, write to the Photoduplication Service, Library of Congress, Washington, DC 20540.

Certain NBS publications are out of print because they have been replaced, or partially replaced, by material issued by other organizations. In this connection NBS is able to offer the following information:

Circular 410, National Standard Petroleum Oil Tables. Information in this Circular has been incorporated in the ASTM-IP Petroleum Measurement Tables issued as D1250 by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103. Available at \$12.75, 20% off to ASTM members. Tables 5 and 7 of the ASTM-IP Tables may also be purchased from the ASTM in separate reprint form at \$2.25 and \$2.00 per copy respectively.

Circular 438, Static Electricity. The National Fire Protection Association, 60 Batterymarch Street, Boston, MA 02110, has issued a publica-

tion by the same title, available from them as NFPA Publication 77, at \$3.00.

Circular 499, Nuclear Data. Replaced by Atomic and Nuclear Data Tables, published by Academic Press, 111 Fifth Avenue, New York, NY 10003. Available by subscription for \$108.00 per year.

Circular 576, Automotive Antifreezes. For information on this subject consult American National Standards Institute, 1430 Broadway, New York, NY 10018.

Circular 577 and Supplement, Energy Loss and Range of Electrons and Positrons. These have been superseded by NASA Special Publication 3012, available from the National Technical Information Service, Springfield, VA 22161, at \$6.75 hardcopy and \$3.00 microfiche, number N65-12506.

Miscellaneous Publication 179, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. The American National Standards Institute, 1430 Broadway, New York, NY 10018, has issued a publication on this subject. Available from them as A58.1-1969-1972, at \$7.50.

Miscellaneous Publication 187, Directory of Commercial and College Laboratories. A new Directory of Testing Laboratories issued as 333D is published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, at \$3.75.

Miscellaneous Publication 211, American Standards Building Code Requirements for Masonry. The American National Standards Institute, 1430 Broadway, New York, NY 10018, has issued a publication on this subject. Available from them as A41.1-1953-R1970, at \$4.50.

NBS Handbook 28, Part 1, 2, and 3, Screw Thread Standards. Responsibility for screw thread standards for Federal Government has been transferred to General Services Administration (GSA). Standards will be promulgated as Federal Standard 28 by GSA. Technical questions should be addressed to Directorate of Engineering and Standardization, Defense Logistics Agency (DISC), 700 Robbins Ave., Philadelphia, PA 19111, telephone (215) 697-3325. Questions regarding administration of

the program should be addressed to Standards Control and Support Division, General Services Administration (Federal Supply Service), attn: FMHS, Washington, DC 20406, telephone (703) 557-7595.

Handbook 30, National Electrical Safety Code (also H81 and its Supplements and H110-1). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2, at \$6.50.

Handbook 46, Code for Protection Against Lightning. A United States of America Standards Institute Code for Protection Against Lightning (NFPA-78-1969) is available from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at \$4.25, as C5.1-1969-1975.

Handbook 48, Control and Removal of Radioactive Contamination in Laboratories. Reprints of this Handbook can be purchased as NCRP Report at \$3.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 49, Recommendations for Waste Disposal Phosphorus-32 and Iodine-131 for Medical Users. Reprints of this Handbook can be purchased as NCRP Report 9 at \$3.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 53, Recommendations for the Disposal of Carbon-14 Wastes. Reprints of this Handbook can be purchased as NCRP Report 12 at \$3.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 55, Protection Against Betatron-Synchrotron Radiations up to 100 Million Electron Volts. February 26, 1954 has been combined with NBS Handbook 97. Available as NCRP Report 51, Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities from NCRP Publications, Post Office Box 30175, Washington, DC 20014 at \$6.00.

Handbook 58, Radioactive Waste Disposal in the Ocean. Reprints of this Handbook can be purchased as NCRP Report 16 at \$3.00 from

NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 59, Permissible Dose from External Sources of Ionizing Radiations. Reprints of this Handbook can be purchased as NCRP Report 39 at \$5.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 63, Protection Against Neutron Radiation up to 30 MeV. Reprints of this Handbook can be purchased as NCRP Report 38 at \$6.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 65, Safe Handling of Bodies Containing Radioactive Isotopes. Reprints of this Handbook can be purchased as NCRP Report 37 at \$4.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 69, Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure. Reprints of this Handbook can be purchased at \$3.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 71, Specifications for Dry Cells and Batteries. Available as C18.1-1972 from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at \$6.25.

Handbook 73, Protection Against Radiations from Sealed Gamma Sources (Supersedes H54). Reprints of this Handbook can be purchased as NCRP Report 40 at \$5.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 74, Building Code Requirements for Reinforced Masonry. The American National Standards Institute, 1430 Broadway, New York, NY 10018 has issued a publication on this subject. Available from them as A41.2-1960 (R1970), at \$3.25.

Handbook 75, Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays. Reprints of this Handbook can be purchased as NCRP Report 25 at \$3.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 76, Medical X-ray Protection Up to Three Million Volts. Now available as NCRP 33. Purchase from NCRP Publications, Post Office Box 30175, Washington, DC 20014 at \$4.00.

Handbook 80, A Manual of Radioactivity Procedures. Reprints of this Handbook will be available as NCRP Report 58 (in press). For more information write to NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 81 and Its Supplements, Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines (also H30 and H110-1). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2, at \$6.50.

Handbook 84, Radiation Quantities and Units. Reprints of this Handbook can be purchased as ICRU Report 19 at \$5.00 per copy from ICRU Publications, Post Office Box 30165, Washington, DC 20014.

Handbook 89, Methods of Evaluating Radiological Equipment and Materials. Reprints of this Handbook can be purchased as ICRU Report 10F at \$2.50 per copy from ICRU Publications, Post Office Box 30165, Washington, DC 20014.

Handbook 96, Inspection of Processed Photographic Record Films for Aging Blemishes. Reprints of this Handbook can be purchased as PH 1.28-1973 at \$4.00 per copy from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

Handbook 97, Shielding for High-Energy Electron Accelerator Installations. July 1, 1964 has been combined with NBS Handbook 55. Available as NCRP Report 51, Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities from NCRP Publications, Post Office Box 30175, Washington, DC 20014 at \$6.00.

Handbook 102, ASTM Metric Practice Guide. Available as Z 210.1-1976 from the American National Standards Institute, 1430 Broadway, New York, NY 10018 at \$4.00.

Handbook 110-1, National Electrical Safety Code. Part 1. Rules for Installation and Maintenance of Electric Supply and Communication Lines (also H30 and H81 and its Supplements). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2, at \$6.50.

Technical Note 938, Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction, has been superseded by ASTM E 621-78, Standard Practice of the Use of Metric (SI) Units in Building Design and Construction. It is available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103. Price \$5.00.

C. PRICE LISTS FOR NONPERIODICALS

The lists on the following pages give the numbers and prices of all NBS publications issued from 1901 through 1978 which are still in print. Those items in **boldface** denote the 1978 publications cited in this supplement. The prices shown herein supersede prices quoted in previous catalogs of NBS publications. The prices shown are those in effect as of the date this publication went to press. Prices are subject to change without notice, and the prices that will be charged on your order will be those in effect as of the date your order is processed. Except for the Federal Information Processing Standards Series and the National Bureau of Standards Interagency Reports which are only available by purchase from the National Technical Information Service, Springfield, VA 22161, publications may be ordered from the Superintendent of Documents, U.S. Government Printing Office or from the U.S. Department of Commerce District Office nearest you. SD order forms are included at the end of this publication.

For availability and price of Patents see page 3.

Publications not listed are out of print. In such cases, your nearest depository library may still have a copy of that item. (See Section 2.4 and Appendix A.) Some NBS publica-

tions may be purchased from the National Technical Information Service. (See Section 2.1.)

Publications shown as available from NTIS are represented by the NTIS price schedule in effect at the time of purchase. NTIS prices as of this date are given below. Again, prices are subject to change.

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A11	9.50	E11	22.50	T11	600.00
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A13	11.00	E13	28.00	T13	675.00
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NBS Special Publication 535, Catalog of NBS Publications, 1966-1976. Volumes 1 (2 parts) and 2 (2 parts). Consolidated reprint of citations, abstracts, and key words from NBS SP 305, and its Supplements 1-8. For sale in sets only by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

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3	*	43 (COM75-10173)	*	69 (SN003-003-	
4	*	44 (SN003-003-		01622-5)	4.60
5 Pt. 2	*	01071-5)65	70 (SN003-003-	
6	*	45 (COM73-50275)	*	71 (SN003-003-	
7	*	46 (COM73-50188)	*	01459-1)	2.25
8 (COM73-10487)	*	47 (COM73-50975)	*	72 (SN003-003-	
9 (PB193-907)	*	48 (SN003-003-		01474-5)	1.80
10	*	01212-2)	4.85	73 (SN003-003-	
11	*	49 (COM74-50353)	*	01479-6)	1.25
12	*	50 (SN003-003-		74 (SN003-003-	
13	*	01282-3) .....	.55	01477-0)	1.55
14	*	51 (SN003-003-		75	*
15	*	01267-0) .....	.90	76 (SN003-003-	
16	*	52 (COM74-50537)	*	01644-6)	1.45
17	*	53 (SN003-003-		77 (SN003-003-	
18 (PB193-736)	*	01284-0) .....	.85	01539-3)	2.35
19	*	54 (SN003-003-		78 (SN003-003-	
20 (PB189-639)	*	01307-2)	1.25	01537-7)	1.25
21 (PB189-459)	*	55 (COM74-51188)	*	79 (SN003-003-	
22 (PB189-456)	*	56 (SN003-003-		01546-6)	1.15
23	*	01335-8)	2.35	80 (SN003-003-	
24	*	57 (SN003-003-		02183-1)	1.15
25 (PB188-789)	*	01364-1)	1.20	81 (SN003-003-	
26	*	58 (SN003-003-		01591-1) .....	.45
27 (PB191-304)	*	01349-8)	2.00	82 (SN003-003-	
28 (PB193-924)	*	59 (SN003-003-		02185-7) .....	.50
29 (PB190-603)	*	01392-7)	1.30	83 (SN003-003-	
30 (COM71-00141)	*	60 (SN003-003-		01592-0) .....	.55
31 (PB193-601)	*	01352-8)	1.05	84 (SN003-003-	
32 (COM71-50078)	*	61 (COM75-10473)	*	01687-0)	3.50
33 (COM71-00159)	*	62 (SN003-003-		85 (SN003-003-	
34 (COM75-10286)	*	01738-8)	1.90	01619-5)	2.25
35 (COM71-50591)	*	63 (SN003-003-		86 (SN003-003-	
36 (SN003-003-		01407-9) .....	.70	01637-3)	1.05
00850-8)	1.55	64 (SN003-003-		87 (SN003-003-	
37 (SN003-003-		01360-9)	1.35	01642-0)	4.40
00857-5)	1.25	65 (SN003-003-		88 (SN003-003-	
38 (COM71-50345)	*	01394-3)	1.00	01693-4) .....	.65
39 (COM72-50068)	*	66 (SN003-003-		89 (SN003-003-	
		01417-6)	2.10	01706-0)75
				90 (PB257-5810)	*

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No.	Price	No.	Price	No.	Price
91 (SN003-003-01690-0).....	1.40	100-3 (SN003-003-01719-1).....	2.00	108 (SN003-003-02026-5).....	3.00
92 (SN003-003-01692-6).....	.70	100-4 (SN003-003-01720-5).....	1.50	109 (SN003-003-01892-9).....	2.75
93 (SN003-003-01691-8).....	.45	100-5 (SN003-003-01721-3).....	1.50	110 (SN003-003-01888-1).....	2.75
94 (SN003-003-01696-9).....	1.55	102 (SN003-003-01863-5).....	2.30	111 (SN003-003-01934-8).....	3.25
96 (SN003-003-01698-5).....	4.65	103 (SN003-003-01859-7).....	1.30	112 (SN003-003-01936-4).....	2.50
97 (SN003-003-01768-0).....	2.10	104 (SN003-003-01794-9).....	3.75	113 (SN003-003-01980-1).....	2.75
98 (SN003-003-01765-5).....	1.30	105 (SN003-003-01885-6).....	3.00	114 (SN003-003-01952-6).....	2.30
100-1 (SN003-003-01717-5).....	1.40	106 (SN003-003-01782-4).....	6.00	116 (SN003-003-01992-5).....	2.50
100-2 (SN003-003-01718-3).....	1.30			117 (SN003-003-02008-7).....	3.00

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2 (COM73-10942)	*	71 (COM73-10968)	*	118 (COM73-11014)	*
5 (COM73-10943)	*	76 (COM73-10969)	*	119 (COM73-11016)	*
7 (COM73-10944)	*	78 (COM73-10970)	*	120 (COM73-11054)	*
17 Suppl. 1 & 2, see Mono 77		79 (COM73-10971)	*	123 (COM73-11050)	*
(PB180646)	*	81 (COM73-10972)	*	124 (COM73-11051)	*
19 see BMS116	OP	82 (COM73-10973)	*	126 (COM73-11052)	*
21 (COM73-10945)	*	92 (COM73-10974)	*	132 (COM73-11053)	*
23 (COM73-10946)	*	93 (COM73-10975)	*	133 (COM73-11055)	*
24 (COM73-10947)	*	94 (COM73-10978)	*	134 (COM73-11056)	*
32 (COM73-10948)	*	96 (COM73-10979)	*	135 (COM73-11057)	*
41 (COM73-10949)	*	100 (COM73-10980)	*	136 (COM73-11058)	*
45 (COM73-10961)	*	101 (COM73-10981)	*	138 (COM73-11059)	*
52 (COM74-50537)	*	103 (COM73-10982)	*	141 (COM73-11060)	*
54 (COM73-10963)	*	104 (COM73-10983)	*	142 (COM73-11062)	*
55 (COM73-10964)	*	106 (COM73-10984)	*	143 (COM73-11061)	*
56 (COM73-10965)	*	108 (COM73-10985)	*	144 (PB180647)	*
63 (COM73-10966)	*	109 (COM73-10986)	*	146 (COM73-11063)	*
64 (PB177986)	*	114 (COM73-10987)	*	147 (COM73-11064)	*
65 (COM73-10967)	*	115 (COM73-10988)	*	149 (COM73-11065)	*
6680	117 (COM73-11015)	*	150 (COM73-11066)	*
				151 (PB177987)	*

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15-69 (SN003-003-00188-1)40	57-73 (SN003-003-01182-7)40	67-76 (SN003-003-01813-5)70
20-70 (SN003-003-00192-9)40	58-73 (SN003-003-01295-5)40	68-76 (SN003-003-01854-6)70
38-70 (CN003-003-00842-7) .....	.45	59-73 (SN003-003-01255-6) .....	.45	69-76 (SN003-003-01851-1)	1.00
39-70 (SN003-003-00840-1) .....	.65	60-73 (SN003-003-01248-3) .....	.40	70-76 (SN003-003-01853-8) .....	.70
42-70 (SN003-003-00901-6) .....	.65	61-74 (SN003-003-01421-4) .....	.45	71-76 (SN003-003-01702-7)	1.40
46-71 (SN003-003-00936-9) .....	.35	62-74 (SN003-003-01375-7) .....	.55	72-76 (SN003-003-01702-7)	1.40
48-71 (SN003-003-00925-3) .....	.35	63-75 (SN003-003-01415-0) .....	.50	73-77 (SN003-003-01877-5) .....	.80
50-71 (SN003-003-00877-0)35	64-75 (SN003-003-01583-1)35		
51-71 (SN003-003-00963-6)35	65-75 (SN003-003-01585-7)35		

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3-1	3.50	22-1	4.00	41	3.50
4	3.50	23	3.50	42-1	3.50
5-1	3.50	24	4.00	43	4.50
6-2	4.00	25	3.50	44	3.50
7	3.50	26	3.50	45	4.00
8-4	3.50	27	3.50	46	3.50
9	3.50	28	3.50	47	4.00
10-2	4.00	29	3.50	48	4.00
11-1	4.00	30	3.50	49	3.50
12-2	7.50	31	5.00	50	4.50
13	3.50	32	5.00	51	4.50
14	3.50	33	4.00	52	4.50
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3 (PB251-959)	*	25	*	47 (PB251-902)	*
4 (PB251-962)	*	26 (PB178-415)	*	48 (PB176-119)	*
5 (COM73-10501)	*	27 (AD694-116)	*	49 (PB251-903)	*
6 (PB251-862)	*	28 (AD695-952)	*	50 (PB176-520)	*
7 (PB251-863)	*	29 (AD695-953)	*	51 (PB248-467)	*
8 (PB251-864)	*	30 (PB175-817)	*	52 (PB251-904)	*
9 (COM73-10498)	*	31 (COM74-11112)	*	53 (PB186-430)	*
10 (PB251-960)	*	32 (COM73-10499)	*	54 (COM73-11111)	*
11 (AD702-411)	*	33 (PB175-818)	*	55 (SN003-003-	
12 (PB184-887)	*	34 (SN003-003-		00279-8)	12.65
13 (PB251-865)	*	00272-1)	4.70	56 (PB190-608)	*
14 (SN003-003-		35 (PB251-103)	*	57 (PB266-263)	*
00270-4)	11.70	36 (PB251-871)	*	58 (AD700-470)	*
15 (PB251-866)	*	37 (PB251-872)	*	59 (SN003-003-	
16 (PB251-867)	*	38 (PB251-900)	*	00282-8)	6.80
17 (PB251-868)	*	39 (PB251-901)	*	60 (SN003-003-	
18 (PB175-819)	*	40 (PB186-428)	*	00283-6)	1.45
19 (PB175-815)	*	41 (PB176-521)	*	61 (PB188-790)	*
20 (PB251-870)	*	42 (PB175-819)	*	62 (SN003-003-	
21 (PB178-392)	*	43 (PB176-127)	*	00993-8)	1.20
22 (PB192-337)	*	44 (AD698-954)	*	63 (SN003-003-	
				00988-1)	3.45

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3 (SN003-003-00682-3)60	6 (SN003-003-01536-9)	1.70	9 (SN003-003-01947-0)80
4 (SN003-003-00920-2)	1.10	7 (SN003-003-01688-8)35	10 (SN003-003-01969-1)90

TECHNICAL NOTES

No.	Price	No.	Price	No.	Price
1 (PB151-360)	*	18-19 (PB195-218)	*	40-9 (PB189-933)	*
2 (PB151-361)	*	18-20 (PB168-044)	*	40-10 (PB189-934)	*
2-2 (PB151-361-2)	*	18-21 (PB195-219)	*	40-11 (PB189-935)	*
3 (PB151-362)	*	18-22 (N661-3994)	*	40-12 (PB189-936)	*
4 (PB151-363)	*	18-23 (COM74-10437)	*	40-13 (PB151-399-13)	*
5 (PB151-364)	*	18-24 (COM74-10438)	*	41 (PB151-400)	*
6 (PB151-365)	*	18-25 (COM74-10473)	*	42 (PB151-401)	*
7 (PB151-366)	*	18-26 (COM74-10439)	*	43 (PB151-402)	*
8 (PB151-367)	*	19 (PB151-378)	*	44 (PB151-403)	*
9 (PB151-368)	*	20 (PB151-379)	*	45 (PB151-404)	*
10 (PB151-369)	*	21 (PB151-380)	*	46 (PB151-405)	*
11 (PB151-370)	*	22 (PB151-382)	*	47 (PB151-406)	*
12 (PB151-371)	*	23 (PB151-382)	*	48 (PB151-407)	*
13 (PB151-372)	*	24 (PB151-383)	*	49 (PB151-408)	*
14 (PB151-373)	*	25 (PB151-384)	*	50 (PB151-409)	*
15 (PB151-374)	*	26 (PB151-385)	*	51 (PB161-552)	*
16 (PB151-375)	*	27 (PB151-386)	*	52 (PB161-553)	*
18 (PB151-377)	*	28 (PB151-388)	*	53 (PB161-554)	*
18-2 (PB151-377-2)	*	29 (PB151-388)	*	54 (PB161-555)	*
18-3 (PB151-377-3)	*	30 (PB151-389)	*	55 (PB161-556)	*
18-4 (PB151-377-4)	*	31 (PB151-390)	*	56 (PB161-557)	*
18-5 (PB151-377-5)	*	33 (PB151-392)	*	57 (PB161-558)	*
18-6 (PB151-377-6)	*	34 (PB151-393)	*	58 (PB161-559)	*
18-7 (PB151-377-7)	*	35 (PB151-394)	*	59 (PB161-560)	*
18-8 (PB151-377-8)	*	37 (PB151-396)	*	60 (PB161-561)	*
18-9 (PB151-377-9)	*	38 (PB151-397)	*	61 (PB161-562)	*
18-10 (PB151-377-10)	*	39 (PB151-398)	*	62 (PB161-563)	*
18-11 (PB151-377-11)	*	40-1 (PB151-399-1)	*	63 (PB161-564)	*
18-12 (PB151-377-12)	*	40-2 (PB151-399-2)	*	64 (PB161-565)	*
18-13 (PB151-377-13)	*	40-3 (PB151-399-3)	*	66 (PB161-567)	*
18-14 (PB195-273)	*	40-4 (PB151-399-4)	*	67 (PB161-568)	*
18-15 (PB195-215)	*	40-5 (PB151-399-5)	*	68 (PB161-569)	*
18-16 (PB195-216)	*	40-6 (PB151-399-6)	*	69 (PB161-570)	*
18-17 (PB195-217)	*	40-7 (PB151-399-7)	*	70 (PB161-571)	*
18-18 (PB168-058)	*	40-8 (PB189-932)	*	71 (PB161-572)	*

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73 (PB161-574)	*	121 (PB161-622)	*	197 (AD419-866)	*
74 (PB161-575)	*	122 (PB161-623)	*	199 (AD683-408)	*
75 (PB161-576)	*	123 (PB161-624)	*	200 (N64-14272)	*
76 (PB161-577)	*	124 (PB161-625)	*	201 (PB182-539)	*
77 (PB161-578)	*	125 (PB161-626)	*	202	*
78 (PB161-579)	*	128 (PB161-629)	*	204 (PB184-118)	*
79 (PB161-580)	*	129 (PB161-630)	*	205 (COM73-10634)	*
80 (PB161-581)	*	129A	*	206-1 (COM73-10684)	*
81 (PB161-582)	*	130 (PB161-631)	*	206-2 (COM73-10685)	*
82 (PB161-583)	*	131 (PB161-632)	*	206-3 (COM73-10686)	*
83 (PB161-584)	*	132 (PB161-633)	*	206-4 (COM73-10687)	*
84 (PB161-585)	*	133 (PB161-634)	*	206-5 (COM73-10688)	*
85 (PB161-586)	*	134 (PB161-635)	*	207 (COM73-10689)	*
86 (PB161-587)	*	135 (PB161-636)	*	209 (PB168-043)	*
87 (PB161-588)	*	136 (PB161-637)	*	210 (PB189-930)	*
88 (PB161-589)	*	137 (PB161-638)	*	211	*
89 (PB161-590)	*	138 (PB161-639)	*	214 (PB189-931)	*
90 (PB161-591)	*	139 (PB161-640)	*	215 (PB188-808)	*
91 (PB161-592)	*	140 (PB161-641)	*	217 (PB189-103)	*
92 (PB161-593)	*	141 (PB161-729)	*	218 (PB188-809)	*
93 (PB161-594)	*	142 (PB161-643)	*	219 (PB186-279)	*
94 (PB161-595)	*	143 (PB161-644)	*	220 (COM74-11077)	*
95 (PB161-596)	*	146 (PB161-647)	*	221 (COM71-00690)	*
96 (PB161-597)	*	147 (PB161-648)	*	223 (PB168-051)	*
97 (PB161-598)	*	148 (PB161-649)	*	224 (PB184-119)	*
98 (PB186-280)	*	151 (PB191-730)	*	225 (AD614-056)	*
99 (PB186-431)	*	154 (PB172-217)	*	226 (PB168-042)	*
100 (COM74-10393)	*	154A (PB182-435)	*	227 (PB184-473)	*
100-A	*	160	*	228 (PB191-731)	*
101-1 (AD687-820)	*	163 (COM71-01002)	*	229 (PB188-805)	*
101-2 (AD687-821)	*	164 (N-6314864)	*	231 (COM72-10587)	*
102 (PB161-603)	*	165 (AD401-044)	*	233 (COM75-10054)	*
106 (PB161-607)	*	166 (PB181-454)	*	234 (COM73-10485)	*
107 (PB161-608)	*	172 (PB193-915)	*	235 (COM73-10481)	*
108 (PB161-609)	*	173 (COM75-10523)	*	236 (AD437-308)	*
109 (PB161-610)	*	174 (COM72-10376)	*	237 (COM75-10166)	*
110 (PB161-611)	*	177 (COM72-10514)	*	245 (PB184-177)	*
111 (PB161-612)	*	178 (PB190-917)	*	249 (PB168-046)	*
112 (PB161-613)	*	179 (PB190-610)	*	252 (AD612-812)	*
113 (PB161-614)	*	180 (COM75-10083)	*	253 (PB184-176)	*
114 (PB161-615)	*	182 (COM75-10283)	*	255 (AD614-257)	*
115 (PB161-616)	*	183 (COM75-10052)	*	260 (PB168-041)	*
116 (PB161-617)	*	187 (PB188-807)	*	262-A (COM73-10486)	*
117 (PB161-618)	*	191 (PB182-538)	*	263 (COM75-10486)	*
118 (PB161-619)	*	194 See NSRDS1	.55	266 (PB195-214)	*
119 (PB161-620)	*	195 (COM73-10418)	*	267 (AD628-586)	*
120 (PB161-621)	*				

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268	*	347	*	414 (PB176-109)	*
270-1 See TN270-3	3.25	349	*	416	*
270-2 See TN270-3	3.25	355	*	417	*
270-3 (SN003-003-00406-5)	3.25	360 (PB190-125)	*	419 (PB179-432)	*
270-4 (SN003-003-00407-3)	2.10	361 (COM75-50052)	*	420	*
270-5 (COM71-50171)	*	361 (SN003-003-01321-8)	1.25	421	*
270-6 (SN003-003-00932-6)	1.90	(Metric Version)		423	*
270-7 (COM73-50435)	*	362 (COM74-10482)	*	425	*
273 (PB248-534)	*	363	*	426	*
275 (COM73-10484)	*	364	*	428	*
277	*	365	*	431	*
278	*	365-1 (COM71-00048)	*	432	*
279 (COM75-10375)	*	366	*	434	*
280 (COM72-10590)	*	367	*	435	*
285 (AD633-354)	*	368	*	436	*
287 (PB182-436)	*	370 (AD688-697)	*	437	*
288	*	372	*	438 (AD665-245)	*
291	*	373	*	439	*
292 (COM75-10335)	*	374	*	440	*
293 (COM75-10335)	*	375	*	444	*
294 (PB176-289)	*	377	*	445	*
295	*	378	*	461	*
297 (PB188-657)	*	379 (SN003-003-00834-6)	.65	464	*
298 (PB186-238)	*	381	*	465	*
300 (PB168-048)	*	382	*	467 (COM72-50871)	*
303 (AD611-400)	*	383	*	469	*
304 (AD615-936)	*	384 (COM75-10174)	*	470	*
307 (PB168-040)	*	385 (PB190-548)	*	472 (AD681-330)	*
309 (N-65-24999)	*	386 (PB191-638)	*	473	*
310 (AD615-937)	*	387 (COM74-50059)	*	474 (AD681-351)	*
318 (COM75-10374)	*	388 (COM71-50077)	*	475 (AD683-808)	*
319	*	389	*	476	*
321 (COM75-10238)	*	390 (PB191-639)	*	477	*
322 (COM75-10236)	*	391	*	478 (PB190-609)	*
323 (COM75-10237)	*	392 (COM74-50057)	*	479	*
324 (AD654-887)	*	393 (COM75-10043)	*	480	*
331	*	397 (COM71-50060)	*	483	*
334 (PB173-291)	*	398 (SN003-003-00814-1)	.40	484 (AD692-231)	*
341	*	399 (COM71-50294)	*	485	*
343	*	400	*	486	*
345	*	403	*	487	*
346 (PB194-282)	*	406	*	488 (AD692-232)	*
		409	*	490	*
		410	*	491	*
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		412	*	496 (PB284-674)	*

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497 (AD695-821)	*	569 (COM74-10436)	*	604 (SN003-003-00861-3)	.65
498 (SN003-003-00590-8)	.65	570 (COM71-50075)	*	605 (COM71-50332)	*
498-1 (SN003-003-00774-9)	.60	572 (COM71-50150)	*	606 (COM71-50325)	*
498-2 (SN003-003-00686-6)	.70	573 (COM71-50227)	*	607 (AD734-035)	*
500 (PB191-352)	*	575 (COM75-10280)	*	609 (AD730-357)	*
503	*	577 (COM71-50264)	*	610 (COM72-50059)	*
510	*	578 (COM75-10185)	*	612 (COM72-50205)	*
511	*	579 (COM75-10184)	*	613 (COM72-50020)	*
513 (AD702-871)	*	584 (COM71-50635)	*	614 (COM72-50523)	*
515 (SN003-003-00606-8)	.65	585 (COM72-50066)	*	615 (COM72-50688)	*
517	*	589 (COM71-50061)	*	616 2nd Rev. (SN003-003-01798-1)	1.30
519 (PB190-760)	*	590 (COM71-50292)	*	617 (COM72-50688)	*
520 (AD702-833)	*	591 (COM75-10168)	*	618 (COM72-50695)	*
522 (PB191-024)	*	592 (SN003-003-00892-3)	1.15	619 (COM72-50955)	*
523 (PB191-057)	*	593 (COM72-50031)	*	620 (COM73-50584)	*
524 (PB191-277)	*	594-1 (COM72-50674)	*	621 (SN003-003-01055-3)	1.10
525 (PB191-050)	*	594-2 (COM72-51003)	*	622 (COM72-51039)	*
527 (AD710-906)	*	594-3 (COM75-10183)	*	623 (COM72-51040)	*
528 (PB191-305)	4.50	594-4 (COM73-50224)	*	624 (COM72-51041)	*
529 (PB192-153)	*	594-5 (SN003-003-00159-7)	.55	625 (COM72-51081)	*
530 (COM71-00047)	*	594-6 (SN003-003-01253-0)	.95	626 (COM73-50038)	*
532 (SN003-003-00776-5)	.75	01244-1)	.75	627 (SN003-003-01108-8)	1.00
533 (PB192-875)	*	594-7 (SN003-003-01244-1)	.75	628 (COM73-50263)	*
534 (PB192-877)	*	594-8 (SN003-003-01285-8)	.95	629 (COM73-50100)	*
535 (PB193-794)	*	594-9 (SN003-003-01342-1)	1.10	631 (COM75-10334)	*
536 (PB192-953)	*	594-10 (SN003-003-01453-2)	.85	632 (COM73-50238)	*
543 (COM71-00081)	*	594-11 (SN003-003-01675-6)	1.15	633 (COM73-60239)	*
544 (PB194-960)	*	594-12 (SN003-003-01676-4)	.75	634 (COM73-50339)	*
547 (COM71-00082)	*	594-13 (SN003-003-01709-4)	1.40	635 (COM75-10177)	*
550 (COM71-00068)	*	595 (COM71-50362)	*	637 (COM75-10082)	*
551 (COM71-50076)	*	596 (SN003-003-00904-1)	1.05	638 (COM73-50727)	*
552 (SN003-003-00918-1)	3.25	597 (COM75-10176)	*	640 (COM73-50805)	*
554 (PB194-750)	*	598 (AD732-553)	*	641 (COM75-10281)	*
555 (AD718-534)	*	599 (COM71-50399)	*	642 (COM73-50973)	*
557 (COM74-10405)	*	600 (COM71-50297)	*	643 (COM73-50885)	*
558 (COM71-50072)	*	602 (SN003-003-00880-0)	.55	644 (COM73-50972)	*
560 (AD719-976)	*			645 (COM74-50133)	*
562 (COM71-00128)	*			646 (COM74-50842)	*
563 (COM71-50341)	*			647 (COM74-50267)	*
566 (COM71-50062)	*			648 (SN003-003-01246-7)	1.25
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650 (COM74-50430)	*	685 (SN003-003-		716 (COM72-50361)	*
652 (SN003-003-		01789-2)65	717 (AD740-674)	*
01299-8) .....	.50	686 (PB260-666)	*	718 (COM73-50206)	*
653 (COM74-50637)	*	687 (SN003-003-		720 (SN003-003-	
654 (COM74-50698)	*	01714-1) .....	.75	00989-0) .....	.65
655 (COM74-51542)	*	688 (SN003-003-		721 (COM72-50467)	*
657 (COM75-50069)	*	01715-9) .....	.65	723 (COM72-50535)	*
658 (COM75-50161)	*	689 (PB263-104)	*	725 (SN003-003-	
659 (SN003-003-		690 (PB262-551)	*	01003-1) .....	.75
01442-7) .....	.85	691 (PB263-103)	*	726 (AD748-788)	*
660 (SN003-003-		692 (SN003-003-		727 (COM72-50538)	*
01383-8)	1.00	01734-5) .....	.55	728 (COM72-50666)	*
661 (SN003-003-		693 (SN003-003-		729 (COM72-50667)	*
01350-1) .....	.80	01710-8)	1.20	731 (SN003-003-	
662 (SN003-003-		695 (PB269-220)	*	01023-5) .....	.95
01413-3) .....	.70	696 Rev. 1977 SN003-		732 (SN003-003-	
663 (SN003-003-		003-01850-3)	1.50	01029-4) .....	.75
01405-2)	1.10	697 (SN003-003-		733 (COM72-50812)	*
664 (COM75-10289)	*	01862-7)	2.20	734 (COM72-50732)	*
665 (SN003-003-		698 (SN003-003-		735 (COM72-50873)	*
01403-6)	1.00	01864-3)	1.30	736 (COM72-50924)	*
666 (COM75-10288)	*	699 (SN003-003-		737 (COM75-10170)	*
667 (SN003-003-		01865-1)	2.75	738 (COM72-50810)	*
01560-1)	1.85	700 (COM73-50015)	*	739 (COM72-50925)	*
668 (SN003-003-		702 (AD734-427)	*	740 (SN003-003-	
01449-4)	1.05	703 (COM71-50607)	*	01210-6) .....	.55
669 (COM75-10918)	*	706 (COM72-50892)	*	742 (SN003-003-	
670 (SN003-003-		707 (COM72-50054)	*	01058-8) .....	.95
01586-2)	1.60	708 (COM72-50062)	*	743 (COM73-50036)	*
672 (SN003-003-		710-1 (COM72-50276)	*	744 (COM72-51037)	*
01550-4)	2.40	710-2 (COM72-50346)	*	745 (COM73-50178)	*
673 (PB246-934)	*	710-3 (COM72-50520)	*	746 (COM73-50051)	*
674 (SN003-003-		710-4 (COM72-50521)	*	747 (SN003-003-	
01559-8)	1.50	710-5 (COM72-50694)	*	01065-1)	1.25
675 (SN003-003-		710-6 (SN003-003		01065-1)	1.25
01596-2)	1.30	01087-1)	1.00	748 (COM73-50209)	*
677 (SN003-003-		710-7 (COM73-50483)	*	749 (COM73-50103)	*
01597-1)	1.20	710-8 (SN003-003-		750 (COM72-51080)	*
680 (SN003-003-		01897-0)	2.30	751 (SN003-003-	
01616-1) .....	.50	710-9 (SN003-003-		01093-6) .....	.85
681 (SN003-003-		01898-8)	1.60	752 (COM73-50624)	*
01652-7)	1.05	710-10 (SN003-003-		753 (SN003-003-	
682 (SN003-003-		01896-1)	2.40	01097-9)	1.10
016553-5) .....	.80	711 (COM72-50064)	*	754 (COM73-50225)	*
683 (SN003-003-		713 (COM72-50204)	*	755 (SN003-003-	
01657-8)	1.00	714 (SN003-003-		01094-4)70
684 (SN003-003-		00974-1)	1.50	756 (COM73-50257)	*
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758 (SN003-003-01115-1)	2.10	789-1 (SN003-003-01439-7)80	821 (SN003-003-01257-2)60
759 (SN003-003-01102-9)65	790 (COM73-50678)	*	822 (COM74-50340)	*
760 (SN003-003-01112-6) .....	.90	791 (COM73-50665)	*	823 (SN003-003-01264-5) .....	.60
761 (SN003-003-01132-1)	1.15	792 (SN003-003-01183-5) .....	.80	824 (SN003-003-01258-1) .....	.65
763 (SN003-003-01114-2) .....	.65	793 (COM73-50831)	*	826 (COM74-50346)	*
764 (SN003-003-01131-2) .....	.65	794 (COM73-50927)	*	827 (COM74-50457)	*
765 (SN003-003-01135-5) .....	.60	795 (COM73-50842)	*	828 (SN003-003-01287-4)	2.05
766 (COM73-50374)	*	796 (COM73-50876)	*	829 (SN003-003-01201-3)	1.10
767 (AD758-981)	*	797 (SN003-003-01192-4) .....	.50	830 (COM74-50532)	*
768 (COM73-50379)	*	798 (COM73-50930)	*	831 (SN003-003-01291-2) .....	.95
769 (COM73-50677)	*	799 (COM74-50135)	*	832 (SN003-003-01327-7) .....	.70
770 (SN003-003-01136-3)	1.40	800 (COM74-50141)	*	833 (SN003-003-01302-1)	1.20
771 (SN003-003-01137-1) .....	.95	801 (SN003-003-01292-1) .....	.60	834 (SN003-003-01294-7) .....	.55
772 (SN003-003-01140-1)	1.25	802 (SN003-003-01217-3) .....	.60	835 (SN003-003-01353-6)	1.95
773 (COM73-50534)	*	803 (COM75-10279)	*	836 (COM74-50567)	*
774 (COM73-50535)	*	804 (SN003-003-01229-7)	2.00	837 (COM74-50636)	*
775 (SN003-003-01141-0) .....	.50	805 (SN003-003-01231-9)	1.20	838 (COM74-50841)	*
776 (AD760-676)	*	806 (COM73-50928)	*	839 (SN003-003-01303-0)	1.85
777 (COM73-50792)	*	807 (COM73-50971)	*	840 (SN003-003-01315-3) .....	.55
778 (COM73-50523)	*	808 (COM74-50085)	*	841 (SN003-003-01312-9) .....	.60
779 (COM73-50571)	*	809 (COM74-50174)	*	842 (SN003-003-01310-2)	1.25
780 (SN003-003-01158-4) .....	.55	810 (SN003-003-01211-4) .....	.50	843 (SN003-003-01316-1)	*
781 (COM73-50536)	*	811 (SN003-003-01245-9)	1.00	844 (SN003-003-01316-1) .....	.70
782 (SN003-003-01286-6) .....	.90	812 (SN003-003-01247-5) .....	.65	845 (COM74-50926)	*
785 (COM73-50682)	*	814 (SN003-003-01235-1)	1.10	847 (SN003-003-01340-4) .....	.80
786 (SN003-003-01194-1) .....	.50	815 (SN003-003-01232-7) .....	.60	848 (COM74-50943)	*
787 (SN003-003-01161-4)90	816 (COM74-50181)	*	849 (COM74-50998)	*
788 (COM73-50683)	*	817 (SN003-003-01265-3)60	850 (SN003-003-01366-8)85
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854 (SN003-003-01381-1)	2.00	879 (SN003-003-01432-0)	1.10	903 (SN003-003-01578-4)85
855 (SN003-003-01367-6)	1.05	880 (SN003-003-01447-8)85	904 (SN003-003-01617-9)75
856 (SN003-003-01371-4) .....	.65	881 (SN003-003-01469-9)	1.10	905 (SN003-003-01610-1)	1.10
857 (SN003-003-01423-1)	1.05	882 (SN003-003-01462-1) .....	.85	906 (SN003-003-01630-6)	1.35
858 (SN003-003-01433-8)	3.75	883 (SN003-003-01475-3)	1.45	908 (SN003-003-01643-8)	1.55
859 (SN003-003-01543-1)	4.15	884 (SN003-003-01471-1) .....	.45	909 (SN003-003-01615-2)	1.05
860 (SN003-003-01401-0)	2.05	885 (SN003-003-01476-1)	1.45	910-1 (SN003-003-01590-3)	2.10
861 (SN003-003-01380-3) .....	.80	886 (SN003-003-01470-2) .....	.65	910-2 (SN003-003-01880-5)	3.00
862 (SN003-003-01402-8) .....	.80	887 (SN003-003-01545-8)	1.45	910-3 (SN003-003-01785-0)	2.10
863 (SN003-003-01404-4)	1.15	888 (SN003-003-01482-6)	1.65	912 (SN003-003-01613-6)	2.00
864 (SN003-003-01400-1)	1.20	889 (SN003-003-01574-1)	1.80	913 (SN003-003-01645-4)	1.00
865 (SN003-003-01411-7)	1.35	890 (SN003-003-01548-2)	1.10	914 (SN003-003-01636-5) .....	.85
866 (SN003-003-01441-9)	1.85	891 (SN003-003-02186-5)	1.10	915 (SN003-003-01631-4) .....	.75
867 (SN003-003-01427-3)	1.25	892 (SN003-003-01549-1)	1.70	916 (SN003-003-01626-8)	2.80
868 (SN003-003-01430-3)	1.50	893 (SN003-003-01561-0)	1.30	917 (SN003-003-01640-3) .....	.85
869 (SN003-003-01424-9) .....	.80	894 (SN003-003-01570-9)	1.45	918 (SN003-003-01661-6)	1.15
870 (SN003-003-01434-6)	1.05	895 (SN003-003-01564-4)	2.30	919 (SN003-003-01658-6)	1.25
871 (SN003-003-01435-4)	1.40	896 (SN003-003-01562-8)	2.15	920 (SN003-003-01648-9)	1.15
872 (SN003-003-01436-2)	2.10	897 (SN003-003-01589-0)	1.15	921 (SN003-003-01660-8)	2.20
873 (SN003-003-01555-5) .....	.75	898 (SN003-003-01584-9) .....	.55	922 (SN003-003-01668-3)	1.75
874 (SN003-003-01438-9)	1.00	899 (SN003-003-01579-2)	4.00	923 (SN003-003-01679-9) .....	.75
875 (SN003-003-01448-6) .....	.65	900 (SN003-003-10611-0) .....	.75	924 (SN003-003-01671-3)	1.05
876 (COM75-11113)	*	901 (SN003-003-01607-1)	1.15	925 (SN003-003-01680-2)	1.70
877 (SN003-003-01455-9)80			927 (SN003-003-01683-7)	1.15

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929 (SN003-003-01694-2)85	953 (SN003-003-01796-5)	2.00	974 (SN003-003-01945-3)	1.40
930 (SN003-003-01672-1)55	954 (SN003-003-01805-8)	1.10	975 (SN003-003-01959-3)	3.00
931 (SN003-003-01689-6)	1.85	955 (SN003-003-01816-3)	2.00	976 (SN003-003-01937-2)	2.40
932 (SN003-003-01703-5)	1.35	956 (SN003-003-01840-6)	2.00	977 (SN003-003-01940-2)	2.30
933 (SN003-003-01746-9)	1.10	957 (SN003-003-01834-0)	1.50	978 (SN003-003-01968-2)	1.60
934 (SN003-003-01740-0) .....	.85	958 (SN003-003-01866-0)	1.40	981 (SN003-003-01999-2)	2.30
935 (SN003-003-01741-8) .....	.75	959 (SN003-003-01878-3)	1.40	982 (SN003-003-01976-3)	2.50
936 (SN003-003-01752-3)	1.45	960 (SN003-003-01860-1)	2.30	983 (SN003-003-01988-7)	2.75
937 (SN003-003-01763-9)	1.30	961 (SN003-003-01875-9)	2.30	984 (SN003-003-01982-8)	1.70
938	*	962 (SN003-003-01931-3)	1.60	986 (SN003-003-01977-1)	2.50
939 (SN003-003-01769-8)	2.75	963 (SN003-003-01983-6)	6.00	988 (SN003-003-02000-1)	1.20
940 (SN003-003-01790-6)	2.00	964 (SN003-003-01914-3)	2.20	990 (SN003-003-02001-0)	2.50
941 (SN003-003-01727-2)	2.30	965 (SN003-003-01944-5)	2.40	1000 (SN003-003-01876-7)	2.30
943 (SN003-003-01799-0)	2.30	966 (SN003-003-01963-1)	1.60	1001 (SN003-003-01902-0)	2.20
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946 (SN003-003-01801-5)	2.30	969 (SN003-003-01907-1)	3.50	1003 (SN003-003-01899-6)	2.20
947 (SN003-003-01776-1)	2.20	970 (SN003-003-01974-7)	2.50	1004 (SN003-003-01956-9)	1.60
948 (SN003-003-01779-5)	3.25	972 (SN003-003-01954-2)	2.30	1005 (SN003-003-01920-8)	2.75
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73-108 (COM74-10701)	A02	73-172 (COM73-11175)	A05
73-109 (COM74-10701-01)	A05	73-173 (COM73-10844)	A03
73-110 (COM73-11191)	A07	73-175 (COM74-10395)	A04
73-112 (COM74-10702-03)	A04	73-176 (AD761-197)	A03
73-113 (COM74-10702-01)	A13	73-177 (COM75-10336)	A03
73-114 (COM74-10702-02)	A13	73-180 (COM74-10130)	A03
73-115 (PB226-907)	A04	73-182 (COM73-11284)	A05
73-116 (COM73-10859)	A04	73-183 (COM73-11177)	A04
73-119 (AD757789)	A04	73-184 (COM73-11110)	A05
73-121 (COM73-10860)	A06	73-185 (COM73-11287)	A03
73-123 (PB275-435)	A04	73-187 (PB221-188)	A04
73-125 (COM73-11189)	A04	73-188 (PB221-183)	A05
73-126 (COM73-10854)	A06	73-189 (COM73-11173)	A03
73-127 (COM73-10857)	A05	73-190 (COM73-10813)	A02
73-128 (AD760150)	A04	73-191 (PB221-695)	A02
73-129 (COM73-10853)	A05	73-192 (COM73-10832)	A02
73-131 (COM73-10863)	A04	73-196 (PB273-941)	A03
73-132 (PB222300)	A07	73-197 (COM74-10468)	A04
73-135 (COM73-10840)	A03	73-198 (COM74-11289)	A02
73-136 (PB273-995)	A02	73-199 (COM74-10129)	A06
73-138 (COM73-10868)	A03	73-200 (COM74-10478)	A03
73-140 (COM73-10842)	A02	73-201 (COM73-11221)	A05
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73-152 (AD914258)	A07	73-211 (COM74-10950)	A08
73-153 (AD758-730)	A02	73-212 (COM74-11909)	A07
73-154 (COM73-10865)	A02	73-213 (COM74-11771)	A07
73-156 (COM73-11286)	A04	73-214 (COM74-11239)	A06
73-157 (COM74-10394)	A03	73-215 (COM74-11010)	A06
75-159 (COM73-11174)	A02	73-216 (COM74-11011)	A07
73-160 (PB243-540)	A03	73-217 (COM74-10470)	A03
73-161 (PB225310)	A04	73-218 (COM75-10144)	A03
73-163 (COM74-10542)	A06	73-219 (PB273-939)	A03
73-164 (COM73-10834)	A03	73-220 (PB222-437)	A02
73-165 (COM73-10837)	A02	73-221 (COM73-11113)	A05
73-166 (COM73-10835)	A02		

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
73-223 (COM73-11220)	A05	73-318 (N73-27390)	A09
73-228 (PB222-425)	A02	73-320 (COM73-11971)	A02
73-231 (PB224-645)	A03	73-322 (COM73-11464)	A03
73-232 (PB273-947)	A03	73-326 (COM73-11465)	A02
73-233 (COM74-11770)	A04	73-329 (COM74-10608)	A05
73-234 (COM74-10128)	A03	73-330 (COM74-10609)	A04
73-239 (PB273-962)	A02	73-331 (COM74-10238)	A05
73-240 (COM74-10986)	A03	73-335 (COM74-11051)	A05
73-242 (PB224-654)	A03	73-338 (COM73-11660)	A03
73-244 (AD-A003-900)	A04	73-339 (COM73-11985)	A13
73-246 (COM74-10989)	A02	73-341 (COM74-10885)	A03
73-248 (COM74-10474)	A05	73-342 (COM73-11978)	A13
73-251 (PB224-688)	A03	73-343 (COM75-10282)	A05
73-252 (AD775-082)	A12	73-344 (COM74-10749)	A03
73-254 (COM74-10987)	A02	73-345 (COM74-10239)	A04
73-256 (COM75-11443)	A02	73-346 (COM74-10240)	A03
73-257 (COM75-11444)	A02	73-347 (COM74-10674)	A04
73-258 (COM75-11445)	A02	73-348 (COM74-10241)	A03
73-259 (COM75-11446)	A02	73-349 (COM74-11374)	A04
73-260 (COM75-11440)	A02	73-351 (COM74-10784)	A04
73-261 (COM75-11441)	A02	73-402 (COM74-10472)	A07
73-262 (COM75-10370)	A04	73-403 (COM74-10016)	A07
73-263 (PB225-284)	A04	73-404 (PB230-952)	A03
73-264 (PB243-541)	A02	73-405 (COM74-10131)	A02
73-265 (COM73-11453)	A04	73-406 (COM74-11352)	A02
73-266 (PB225-286)	A03	73-407 (COM74-11078)	A05
73-267 (COM73-11955)	A04	73-412 (COM74-10512)	A03
73-268 (AD768-303)	A03	73-413 (COM74-10750)	A04
73-273 (PB243-542)	A02	73-414 (COM74-10866)	A03
73-275 (COM74-10126)	A04	73-415 (COM75-11448)	A09
73-277 (PB225-278)	A04	73-416 (COM74-10511)	A04
73-280 (AD782-094)	A06	73-417 (COM74-10477)	A03
73-281 (AD782-028)	A06	73-418 (COM74-11783)	A07
73-287 (COM73-11928)	A02	73-420 (COM74-11092)	A04
73-288 (COM73-11861)	A04	73-421 (COM74-11224)	A03
73-289 (COM74-10475)	A03	73-422 (COM74-11240)	A04
73-290 (COM74-10974)	A02	73-423 (COM74-11722)	A08
73-291 (PB272-376)	A03	73-424 (COM74-10867)	A02
73-294 (AD787-327)	A04	74-355 (N74-30195)	A04
73-295 (COM74-10471)	A02	74-357 (COM74-10551)	A04
73-297 (AD772-066)	A02	74-359 (AD780-596)	A24
73-299 (PB243-543)	A03	74-361 (COM74-11222)	A04
73-301 (COM73-10762)	A03	74-363 (COM74-11053)	A07
73-302 (COM73-10869)	A05	74-364 (COM74-11298)	A05
73-303 (AD759-374)	A04	74-365 (COM74-11375)	A03
73-304 (COM74-10281)	A05	74-366 (COM74-11076)	A05
73-308 (COM73-10761)	A03	74-369 (COM74-11688)	A03
73-309 (COM73-11981)	A05	74-371 (COM74-11567)	A04
73-312 (COM73-11893)	A03	74-372 (ADA006-037)	A05
73-316 (COM73-11954)	A05	74-374 (N75-22497)	A04

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
74-375 (COM74-11657)	A04	74-488 (COM75-10088)	A06
74-377 (COM74-11449)	A03	74-493 (PB243-545)	A02
74-378 (COM74-11450)	A04	74-495 (COM74-11575)	A05
74-379 (PB247-658)	A03	74-496 (COM74-11576)	A05
74-380 (COM74-11686)	A06	74-497 (COM74-11269)	A02
74-381 (COM75-10522)	A04	74-499 (COM74-11378)	A03
74-382 (AD783-433)	A10	74-500 (PB265-694)	A05
74-387 (COM74-11643)	A03	74-501 (COM75-10131)	A02
74-388 (COM74-11687)	A07	74-506 (COM74-11632)	A05
74-389 (COM74-11717)	A08	74-507 (AD/A0001343)	A03
74-390 (COM74-11718)	A06	74-509 (COM74-11377)	A02
74-391 (COM74-10258)	A03	74-510 (AD782-793)	A03
74-393 (COM75-10768)	A13	74-511 (COM74-11448)	A02
74-394 (COM75-10126)	A03	74-514 (COM75-10102)	A04
74-395 (COM75-10161)	A03	74-515 (COM74-11498)	A09
74-396 (COM74-11766)	A03	74-516 (COM74-11384)	A04
74-398 (COM75-10130)	A15	74-517 (COM74-10470)	A03
74-426 (COM74-11074)	A06	74-518 (PB239-633)	A05
74-430 (COM74-10724)	A06	74-519 (PB238-284)	A03
74-432 (COM74-10751)	A04	74-520 (COM74-11480)	A07
74-434 (COM74-11079)	A02	74-521 (COM75-10187)	A04
74-438 (COM74-10980)	A03	74-522 (COM75-10080)	A02
74-439 (COM74-10985)	A02	74-523 (COM75-11126)	A02
74-442 (AD787-743)	A03	74-524 (COM74-11568)	A03
74-443 (COM74-11003)	A02	74-525 (AD782-564)	A02
74-444 (COM74-10548)	A03	74-526 (COM75-10087)	A04
74-449 (COM75-10049)	A03	74-527 (COM74-11720)	A04
74-451 (COM74-11385)	A02	74-529 (COM74-11495)	A04
74-452 (PB204-486)	A06	74-530 (COM75-10041)	A03
74-454 (COM74-10988)	A02	74-533 (PB238-573)	A06
74-455 (COM74-10865)	A03	74-535 (COM74-11659)	A05
74-456 (COM74-11793)	A02	74-537 (COM74-11577)	A02
74-457 (COM74-11792)	A05	74-539 (COM74-11574)	A05
74-458 (AD776-337)	A02	74-541 (COM75-10618)	A03
74-461 (PB246-623)	A03	74-542 (COM75-10081)	A03
74-464 (COM74-10785)	A05	74-543 (COM74-11772)	A07
74-465 (COM75-10417)	A04	74-544 (COM74-11525)	A03
74-466 (COM74-10700)	A21	74-545 (COM74-11656)	A04
74-467 (COM74-11754)	A04	74-550 (COM74-11721)	A05
74-469 (PB234-348)	A04	74-551 (COM74-11658)	A06
74-470 (PB232-629)	A05	74-552 (COM74-11644)	A05
74-471 (COM74-10981)	A02	74-553 (COM75-10058)	A04
74-473 (COM74-11719)	A04	74-554 (COM74-10703)	A03
74-474 (AD778-340)	A03	74-555 (COM74-10704)	A03
74-477 (COM74-11784)	A03	74-556 (COM74-10703)	A05
74-479 (PB239-420)	A07	74-557 (COM75-11439)	A03
74-481 (COM74-11794)	A04	74-561 (COM75-10413)	A03
74-482 (COM75-10147)	A10	74-564 (COM74-11726)	A04
74-486 (AD780-705)	A04	74-567 (COM74-11631)	A13
74-487 (COM74-10886)	A23	74-568 (COM74-11578)	A04

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
74-569 (AD/A002-289)	A03	75-652 (COM75-11399)	A05
74-572 (COM74-11791)	A04	75-653 (PB248-097)	A03
74-577-1 (COM74-11723)	A09	75-654 (COM75-10367)	A02
74-577-2 (COM74-11724)	A14	75-658 (AD/A007-445)	A03
74-578 (COM74-11765)	A02	75-659 (AD/A008-538)	A03
74-580 (PB248-465)	A02	75-660 (COM75-10669)	A03
74-581 (COM75-10127)	A03	75-661 (COM75-10763)	A03
74-582 (COM74-11645)	A03	75-662 (COM75-10420)	A02
74-583 (AD/A003-900)	A05	75-664 (AD/A007-447)	A03
74-586 (COM75-10525)	A02	75-665 (COM75-10421)	A03
74-588 (COM75-10040)	A03	75-666 (COM75-11381)	A03
74-590 (COM75-11434)	A02	75-667 (PB241-267)	A03
74-594 (PB243-546)	A02	75-672 (COM75-10338)	A03
74-591 (COM75-10101)	A02	75-673 (COM75-10921)	A03
74-595 (COM75-10057)	A02	75-675 (COM75-10686)	A03
74-596 (COM75-10209)	A03	75-676 (COM75-10697)	A05
74-597 (COM75-11069)	A03	75-677 (COM75-10516)	A04
74-600 (AD/A008-935)	A09	75-678 (PB248-687)	A04
74-601 (PB273-948)	A02	75-679 (COM75-10419)	A03
74-602 (COM75-10048)	A03	75-680 (COM75-10423)	A06
74-605 (COM75-10464)	A03	75-682 (COM75-10524)	A02
74-606 (COM75-10340)	A05	75-685 (COM75-10690)	A05
74-608 (COM75-10056)	A02	75-687 (COM75-11137)	A07
74-610 (COM75-10973)	A03	75-688 (COM75-11222)	A06
74-612 (COM75-10414)	A02	75-689 (COM75-11190)	A04
74-613 (COM75-10059)	A03	75-690 (COM75-11207)	A05
74-614 (COM75-11013)	A03	75-691 (COM75-11015)	A05
74-618 (COM75-11014)	A02	75-692 (PB250-385)	A06
74-619 (COM75-10047)	A02	75-693 (COM75-11194)	A02
74-620 (PB246-622)	A02	75-696 (COM75-10527)	A05
74-621 (COM75-10422)	A03	75-697 (COM75-10920)	A04
74-623 (COM75-10210)	A05	75-699 (COM75-11016)	A03
74-624 (COM75-10412)	A03	75-700 (COM75-11280)	A04
74-625 (PB243-547)	A03	75-701 (COM75-11282)	A02
74-626 (COM75-10411)	A02	75-702 (COM75-11433)	A03
74-627 (COM75-10134)	A02	75-703 (COM75-11278)	A03
74-628 (COM75-10514)	A02	75-705 (COM75-11277)	A03
74-629 (COM75-11281)	A03	75-706 (PB248-640)	A02
74-631 (COM75-10208)	A02	75-707 (COM75-11017)	A03
74-632 (PB246-554)	A05	75-708 (COM75-10817)	A02
74-633 (COM75-10691)	A04	75-710 (COM75-11030)	A02
74-634 (COM75-10685)	A03	75-711 (COM75-10689)	A04
74-635 (COM75-10276)	A04	75-712 (COM75-11070)	A03
75-637 (COM75-10055)	A02	75-713 (COM75-11134)	A04
75-638 (AD/A011-485)	A04	75-715 (COM75-11208)	A02
75-639 (AD/A005-410)	A02	75-716 (COM75-11210)	A08
75-641 (COM75-11209)	A05	75-718 (COM75-10750)	A03
75-647 (COM75-10418)	A03	75-719 (PB251-410)	A03
75-649 (PB241-237)	A02	75-721 (PB246-864)	A03
75-651 (COM75-11211)	A05	75-722 (PB248-641)	A03

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
75-723 (COM75-10753)	A04	75-794 (PB247-203)	A03
75-728 (AD/A014-830)	A03	75-795 (PB246-866)	A04
75-729 (PB246-858)	A03	75-796 (PB247-656)	A02
75-730 (AD/A018451)	A03	75-797 (COM75-11465)	A02
75-731 (COM75-11071)	A03	75-801 (PB252-044)	A08
75-732 (COM75-11022)	A02	75-804 (COM75-10395)	A03
75-733 (COM75-11139)	A02	75-805 (PB252-971)	A03
75-734 (COM75-11212)	A03	75-806 (COM75-10368)	A04
75-735 (PB256-295)	A07	75-807 (COM75-10396)	A05
75-736 (COM75-11018)	A02	75-809 (COM75-10989)	A03
75-737 (COM75-11472)	A03	75-810 (COM75-10919)	A06
75-738 (COM75-11279)	A03	75-812 (AD/A012889)	A03
75-739 (COM75-11189)	A02	75-814 (COM75-11132)	A04
75-740 (COM75-11127)	A03	75-816 (AD/A001250)	A04
75-741 (COM75-11136)	A03	75-818 (PB245439)	A03
75-742 (PB248-744)	A04	75-819 (PB258554)	A06
75-744 (COM75-11072)	A02	75-820 (PB246436)	A04
75-745 (PB347-657)	A03	75-822 (PB246933)	A03
75-746 (COM75-11432)	A04	75-823 (PB246658)	A05
75-747 (COM75-11131)	A03	75-825 (PB258-913)	A04
75-748 (COM75-11031)	A05	75-827 (PB247-938)	A02
75-750 (PB249-934)	A03	75-828 (PB249-041)	A09
75-751 (AD-A017-626)	A03	75-829 (PB248-855)	A03
75-755 (PB248-642)	A03	76-844 (PB264-300)	A04
75-757 (PB248-914)	A03	75-900 (PB250-859)	A03
75-760 (AD/A016-843)	A10	75-901 (PB246-860)	A03
75-761 (COM75-11377)	A06	75-902 (PB249-539)	A03
75-763 (COM75-11276)	A10	75-903 (PB246859)	A03
75-766 (COM75-11376)	A04	75-908 (PB247-270)	A02
75-767 (PB246-879)	A03	75-909 (PB246-863)	A02
75-768 (PB247-943)	A03	75-910 (PB248-646)	A06
75-769 (PB246-978)	A11	75-913 (PB248-911)	A03
75-770 (COM75-11370)	A03	75-914 (PB275-158)	A03
75-771 (AD/A017-626)	A03	75-915 (PB249-775)	A02
75-772 (PB246-861)	A04	75-916 (AD/A019648)	A05
75-774 (COM75-11364)	A04	75-917 (PB247-655)	A02
75-775 (PB248-864)	A04	75-918 (PB251-412)	A05
75-778 (PB246-435)	A04	75-920 (PB248-913)	A03
75-779 (PB249-935)	A06	75-923 (PB250-767)	A02
75-781 (AD/A015630)	A02	75-924 (PB248-686)	A05
75-782 (PB248-643)	A03	75-925 (PB256-622)	A03
75-784 (PB246-862)	A04	75-926 (PB257-467)	A06
75-785 (PB246-345)	A03	75-927 (PB255-809)	A04
75-786 (PB251-411)	A04	75-928 (PB283-169)	A04
75-787 (AD/A016-844)	A04	75-929 (PB261-498)	A03
75-788 (PB250-843)	A03	75-930 (PB258-250)	A04
75-789 (PB275-159)	A03	75-931 (PB261-030)	A03
75-790 (PB250-848)	A16	75-932 (PB257-425)	A04
75-791 (PB253-229)	A04	75-933 (PB248-983)	A04
75-793 (PB247-538)	A04	75-937 (PB265-614)	A02

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
75-938 (PB264-290)	A05	76-983 (PB251-213)	A03
75-939 (PB274-643)	A03	76-984 (PB262-020)	A07
75-940 (PB276-020)	A06	76-985 (PB250-755)	A04
75-941 (PB269-535)	A04	76-986 (PB250-858)	A04
75-942 (PB256-644)	A04	76-987 (PB250-857)	A03
75-943 (PB258-914)	A05	76-988 (PB254-469)	A05
75-944 (PB258-372)	A03	76-990 (PB251-769)	A02
75-945 (PB264-258)	A05	76-991 (AD/A021255)	A02
75-946 (PB280-564)	A07	76-992 (AD/A021295)	A04
75-947 (PB276-494)	A04	76-993 (PB253-227)	A03
75-948 (PB274-049)	A03	76-994 (PB263-100)	A09
75-949 (PB274-048)	A07	76-996 (PB251-998)	A03
75-950 (PB250-664)	A03	76-997 (PB254-298)	A05
75-951 (PB249-094)	A03	76-998 (PB253-228)	A03
75-952 (PB248-910)	A03	76-999 (PB268-130)	A05
75-953 (PB256-219)	A03	76-1000 (PB251-219)	A04
75-954 (PB253-242)	A03	76-1002 (PB257-469)	A04
75-955 (PB248-685)	A08	76-1003 (PB251-211)	A02
75-956 (PB247-654)	A02	76-1005 (PB273-120)	A04
75-957 (PB250-769)	A02	76-1007 (PB252-021)	A04
75-958 (PB248-743)	A02	76-1008 (PB251-218)	A03
75-960 (PB249-774)	A04	76-1010 (PB250-654)	A03
75-961 (PB257-466)	A11	76-1011 (PB259-641)	A03
75-962 (PB247-639)	A02	76-1012 (PB257-197)	A04
75-966 (PB250-768)	A02	76-1013 (PB256-130)	A03
75-967 (PB251-413)	A02	76-1014 (PB251-414)	A02
75-968 (PB250-845)	A03	76-1015 (PB249-530)	A13
75-971 (PB249-776)	A03	76-1016 (PB254-177)	A04
75-972 (PB259-630)	A05	76-1017 (PB251-917)	A03
75-973 (PB249-255)	A04	76-1018 (PB257-779)	A04
75-974 (PB249-777)	A06	76-1019 (PB251-944)	A02
75-975 (PB253-113)	A03	76-1020 (PB258-256)	A03
75-976 (PB248-986)	A03	76-1021 (PB257-101)	A04
75-977 (PB251-220)	A03	76-1022 (PB259-628)	A02
76-833 (PB250-846)	A03	76-1023 (PB256-191)	A02
76-834 (PB250-666)	A03	76-1024 (PB255-876)	A04
76-836 (PB254-459)	A03	76-1025 (PB251-753)	A05
76-837 (PB261-709)	A07	76-1027 (PB253-243)	A03
76-839 (PB252-013)	A08	76-1028 (PB251-415)	A02
76-840 (PB258-324)	A03	76-1029 (PB261-199)	A03
76-841 (PB256-319)	A03	76-1030 (PB263-633)	A03
76-842 (PB258-331)	A02	76-1031 (PB253-932)	A02
76-846 (PB258-327)	A03	76-1034 (PB254-460)	A05
76-847 (PB265-007)	A09	76-1037 (PB253-933)	A03
76-848 (PB261-996)	A14	76-1038 (PB251-918)	A02
76-850 (PB266-945)	A04	76-1039 (PB254-047)	A03
76-851 (PB263-124)	A02	76-1040 (PB254-178)	A02
76-979 (PB248-992)	A02	76-1041 (PB257-086)	A04
76-980 (PB250-849)	A10	76-1043 (PB254-347)	A06
76-982 (PB248-699)	A15	76-1046 (PB256-476)	A06

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
76-1049 (PB256-600)	A04	76-1124 (PB261-846)	A05
76-1050 (PB253-111)	A04	76-1125 (PB273-666)	A13
76-1052 (PB258-118)	A05	76-1126 (PB260-878)	A04
76-1053 (AD-A029-426)	A04	76-1128 (PB259-199)	A03
76-1054 (PB253-110)	A06	76-1129 (PB274-712)	A03
76-1056 (PB254-179)	A03	76-1130 (PB257-347)	A09
76-1058 (PB262-097)	A07	76-1131 (PB259-242)	A03
76-1059 (PB257-086)	A08	76-1132 (PB260-363)	A05
76-1060 (PB253-934)	A03	76-1133 (PB261-228)	A08
76-1061 (PB256-328)	A04	76-1135 (PB263-630)	A03
76-1063 (PB257-102)	A03	76-1136 (PB261-965)	A04
76-1064 (PB257-102)	A04	76-1137 (PB257-770)	A05
76-1066 (PB254-473)	A02	76-1138 (PB259-522)	A04
76-1067 (PB257-195)	A03	76-1140 (PB259-626)	A19
76-1069 (PB256-296)	A03	76-1141 (AD/A031530)	A03
76-1070 (PB260-913)	A07	76-1142 (PB263-099)	A02
76-1072 (PB255-446)	A04	76-1143 (PB257-769)	A03
76-1074 (PB261-497)	A03	76-1144 (PB259-243)	A02
76-1075 (PB274-653)	A02	76-1145 (PB265-110)	A03
76-1076 (PB254-180)	A03	76-1146 (PB269-355)	A10
76-1078 (PB264-125)	A04	76-1147 (PB259-637)	A03
76-1081 (PB256-329)	A05	76-1148 (PB264-689)	A03
76-1082 (PB258-235)	A08	76-1149 (PB266-925)	A08
76-1083 (PB255-803)	A06	76-1152 (PB265-719)	A06
76-1084 (PB257-180)	A03	76-1153 (PB259-638)	A02
76-1087 (PB257-202)	A03	76-1154 (PB260-400)	A03
76-1088 (PB273-949)	A04	76-1154 (PB260-401)	A07
76-1089 (PB254-475)	A10	76-1159 (PB261-994)	A03
76-1090 (PB255-505)	A03	76-1162 (PB260-879)	A04
76-1091 (PB257-768)	A03	76-1169 (PB273-306)	A04
76-1092 (PB265-961)	A05	76-1170 (AD-A034-723)	A04
76-1093 (PB256-318)	A02	76-1172 (PB261-217)	A03
76-1094 (AD/A030-098)	A03	76-1174 (PB262-366)	A04
76-1095 (PB255-808)	A05	76-1175 (PB276-530)	A05
76-1096 (PB257-076)	A04	76-1176 (PB261-995)	A03
76-1097 (PB257-141)	A03	76-1177 (PB267-829)	A03
76-1098 (PB259-523)	A03	76-1178 (PB246-211)	A03
76-1099 (PB258-612)	A06	76-1179 (PB276-536)	A08
76-1100 (PB258-371)	A04	76-1180 (PB265-087)	A05
76-1102 (PB257-729)	A08	76-1182 (PB263-883)	A06
76-1103 (PB268-425)	A04	76-1184 (PB267-221)	A03
76-1107 (PB258-322)	A04	76-1186 (PB264-693)	A04
76-1108 (PB269-337)	A04	76-1187 (PB262-114)	A06
76-1109 (PB257-194)	A04	76-1189 (PB279-373)	A03
76-1110 (PB257-073)	A03	76-1190 (PB264-917)	A05
76-1112 (PB259-636)	A03	76-1191 (PB263-534)	A03
76-1113 (PB263-526)	A05	76-1193 (PB265-103)	A02
76-1115 (PB257-196)	A02	76-1194 (PB264-368)	A02
76-1117 (PB269-341)	A02	77-852 (PB263-776)	A03
76-1120 (PB257-837)	A02	77-853 (PB265-076)	A05

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
77-855 (PB265-076)	A02	77-1249 (PB269-345)	A05
77-856 (AD-A038725)	A03	77-1250 (PB268-150)	A05
77-857 (PB266-944)	A03	77-1251 (PB269-531)	A06
77-858 (PB272-358)	A02	77-1253 (PB268-424)	A06
77-859 (PB274-186)	A03	77-1254 (PB269-354)	A04
77-860 (PB272-355)	A11	77-1256 (PB269-845)	A03
77-861 (PB274-057)	A03	77-1257 (PB271-973)	A03
77-862 (PB274-058)	A04	77-1259 (PB268-873)	A06
77-863 (AD-A046831)	A08	77-1260 (PB268-112)	A04
77-866 (PB274-456)	A03	77-1261 (PB270-867)	A04
77-867 (PB276-047)	A04	77-1262 (PB269-346)	A03
77-868 (PB274-457)	A03	77-1263 (PB273-946)	A03
77-1195 (PB263-771)	A08	77-1264 (PB272-475)	A07
77-1196 (PB274-647)	A03	77-1265 (PB271-097)	A03
77-1197 (PB268-081)	A02	77-1270 (PB269-518)	A04
77-1202 (PB276-652)	A02	77-1271 (PB280-107)	A05
77-1203 (PB287-805)	A02	77-1272 (PB271-758)	A08
77-1207 (PB264-427)	A02	77-1273 (PB276-004)	A03
77-1208 (PB264-286)	A06	77-1274 (PB269-847)	A08
77-1209 (PB269-866)	A03	77-1275 (PB270-523)	A03
77-1210 (PB264-297)	A04	77-1276 (PB270-855)	A09
77-1211 (PB285-452)	A03	77-1277 (PB269-965)	A02
77-1212 (PB265-697)	A04	77-1278 (PB270-868)	A03
77-1213 (PB265-102)	A07	77-1279 (PB270-863)	A03
77-1214 (PB269-878)	A10	77-1282 (PB273-575)	A03
77-1215 (PB269-534)	A11	77-1286 (PB276-473)	A02
77-1217 (PB264-691)	A03	77-1287 (PB273-576)	A04
77-1218 (PB264-666)	A06	77-1290 (PB272-064)	A07
77-1219 (PB264-692)	A03	77-1291 (PB271-744)	A04
77-1221 (PB264-919)	A04	77-1293 (PB271-745)	A09
77-1222 (PB265-089)	A03	77-1294 (PB272-507)	A04
77-1225 (PB270-856)	A08	77-1295 (PB275-170)	A03
77-1227 (PB267-608)	A02	77-1297 (PB273-899)	A12
77-1228 (PB265-950)	A03	77-1300 (PB273-171)	A05
77-1229 (PB265-477)	A02	77-1301 (PB279-218)	A05
77-1230 (PB269-344)	A04	77-1302 (PB275-173)	A02
77-1231 (PB267-780)	A04	77-1303 (PB274-331)	A04
77-1232 (PB265-672)	A04	77-1304 (PB272-478)	A03
77-1233 (PB265-436)	A04	77-1305 (PB272-500)	A04
77-1234 (PB267-828)	A03	77-1306 (PB276-531)	A03
77-1235 (PB273-634)	A03	77-1307 (PB273-175)	A06
77-1236 (PB268-902)	A03	77-1308 (PB273-589)	A09
77-1237 (PB267-281)	A03	77-1309 (PB274-334)	A03
77-1239 (PB269-281)	A11	77-1310 (PB272-690)	A02
77-1240 (PB266-238)	A02	77-1312 (PB274-330)	A03
77-1241 (PB272-945)	A03	77-1313 (PB273-944)	A04
77-1243 (PB269-517)	A08	77-1314 (PB273-305)	A06
77-1244 (PB270-854)	A04	77-1315 (PB273-945)	A03
77-1246 (PB268-389)	A05	77-1316 (PB274-404)	A08
77-1247 (PB280-182)	A07	77-1317 (PB274-333)	A03

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
77-1318 (PB273-942)	A04	78-1425 (PB280-361)	A07
77-1380 (PB280-071)	A04	78-1426 (PB279-066)	A08
77-1381 (PB273-943)	A03	78-1427 (PB276-907)	A02
77-1383 (PB275-574)	A07	78-1428 (PB281-725)	A05
77-1385 (PB277-984)	A06	78-1429 (PB281-730)	A04
77-1386 (PB277-982)	A02	78-1430 (PB278-633)	A03
77-1387 (PB284-704)	A03	78-1434 (PB277-074)	A03
77-1388 (PB276-747)	A03	78-1435 (PB277-539)	A02
77-1390 (PB274-335)	A06	78-1436 (PB279-372)	A02
77-1394 (PB274-650)	A02	78-1438 (PB285-173)	A11
77-1396 (PB274-648)	A03	78-1440 (PB281-464)	A03
77-1397 (PB275-392)	A05	78-1442 (PB278-622)	A03
77-1399 (PB275-390)	A05	78-1443 (PB279-046)	A04
77-1402 (PB275-410)	A04	78-1444 (PB284-809)	A02
77-1403 (PB275-527)	A09	78-1444-2 (PB284-478)	A02
77-1404 (PB276-534)	A03	78-1446 (PB279-661)	A08
77-1409 (PB276-005)	A02	78-1148 (PB281-537)	A03
77-1411 (PB279-403)	A05	78-1449 (PB281-563)	A02
77-1413 (PB280-113)	A07	78-1450 (PB281-628)	A04
77-1437 (PB280-114)	A04	78-1452 (PB281-801)	A02
78-874 (PB279-684)	A03	78-1454 (PB280-311)	A03
78-877 (PB285-231)	A07	78-1456 (PB283-682)	A03
78-879 (PB284-589)	A12	78-1457 (PB281-158)	A02
78-880 (PB282-887)	A03	78-1458 (PB280-301)	A04
78-881 (PB285-206)	A10	78-1459 (PB280-291)	A03
78-882 (PB282-487)	A03	78-1460 (PB284-491)	A03
78-883 (PB282-505)	A03	78-1463 (PB281-828)	A04
78-884 (PB282-444)	A16	78-1466 (PB282-254)	A04
78-885 (PB283-729)	A08	78-1467 (PB282-260)	A02
78-886 (PB286-489)	A03	78-1468-1 (PB283-428)	A06
78-888 (PB285-233)	A05	78-1468-2 (PB283-429)	A07
78-891 (PB258-238)	A03	78-1471 (PB284-044)	A03
78-895 (PB288-567)	A09	78-1472 (PB285-360)	A07
78-1143A (PB283-237)	A04	78-1473 (PB283-222)	A02
77-1238 (AD-A041-668)	A17	78-1474 (PB281-723)	A05
77-1382 (PB275-561)	A03	78-1475 (PB283-722)	A03
78-1395 (PB289-783)	A05	78-1476 (PB288-661)	A03
77-1405 (PB283-011)	A03	78-1477 (PB284-711)	A04
78-1525 (PB289-927)	A04	78-1479 (PB284-659)	A08
78-1554 (PB291-797)	A04	78-1482 (PB283-223)	A02
78-1562 (PB289-967)	A06	78-1483 (PB283-707)	A06
78-1563 (PB291-441)	A03	78-1484 (PB284-044)	A03
78-1305A (PB283-721)	A04	78-1485 (PB284-864)	A02
78-1414 (PB276-397)	A04	78-1486 (PB283-708)	A04
78-1415 (PB277-536)	A04	78-1487 (PB282-406)	A03
78-1416 (PB276-398)	A03	78-1488 (PB283-881)	A03
78-1421 (PB281-383)	A02	78-1490 (PB284-819)	A03
78-1422 (PB280-027)	A03		
78-1423 (PB278-618)	A03		
78-1424 (PB280-581)	A04		
			Supp. to NBSIR 76-1140
		78-1493 (PB287-861)	A03

NBS INTERAGENCY REPORTS (Continued)

No.	Price	No.	Price
78-1495 (PB286-096)	A03	78-1530 (PB291-844)	A08
78-1497 (PB285-186)	A03	78-1531 (PB291-444)	A06
78-1499 (PB284-492)	A04	78-1532 (PB287-772)	A03
78-1500 (PB284-495)	A04	78-1534 (PB286-933)	A03
78-1502 (PB287-870)	A03	78-1535 (PB289-729)	A03
78-1503 (PB284-685)	A10	78-1537 (PB288-857)	A03
78-1504 (PB284-462)	A02	78-1541 (PB287-936)	A05
78-1508 (PB284-959)	A03	78-1542 (PB287-410)	A05
78-1512 (PB287-510)	A03	78-1543 (PB289-484)	A06
78-1513 (PB287-519)	A02	78-1544 (PB287-496)	A03
78-1514 (PB289-272)	A07	78-1548 (PB288-793)	A04
78-1520 (PB289-961)	A04	78-1549 (PB288-762)	A03
78-1522 (PB291-426)	A04	78-1552 (PB288-804)	A03
78-1524 (PB291-410)	A02	78-1553 (PB288-763)	A03
78-1528 (PB287-405)	A04	78-1557 (PB289-755)	A03
		78-1559 (PB288-730)	A03
		78-1568 (PB289-813)	A04

GRANTEE/CONTRACTOR REPORTS

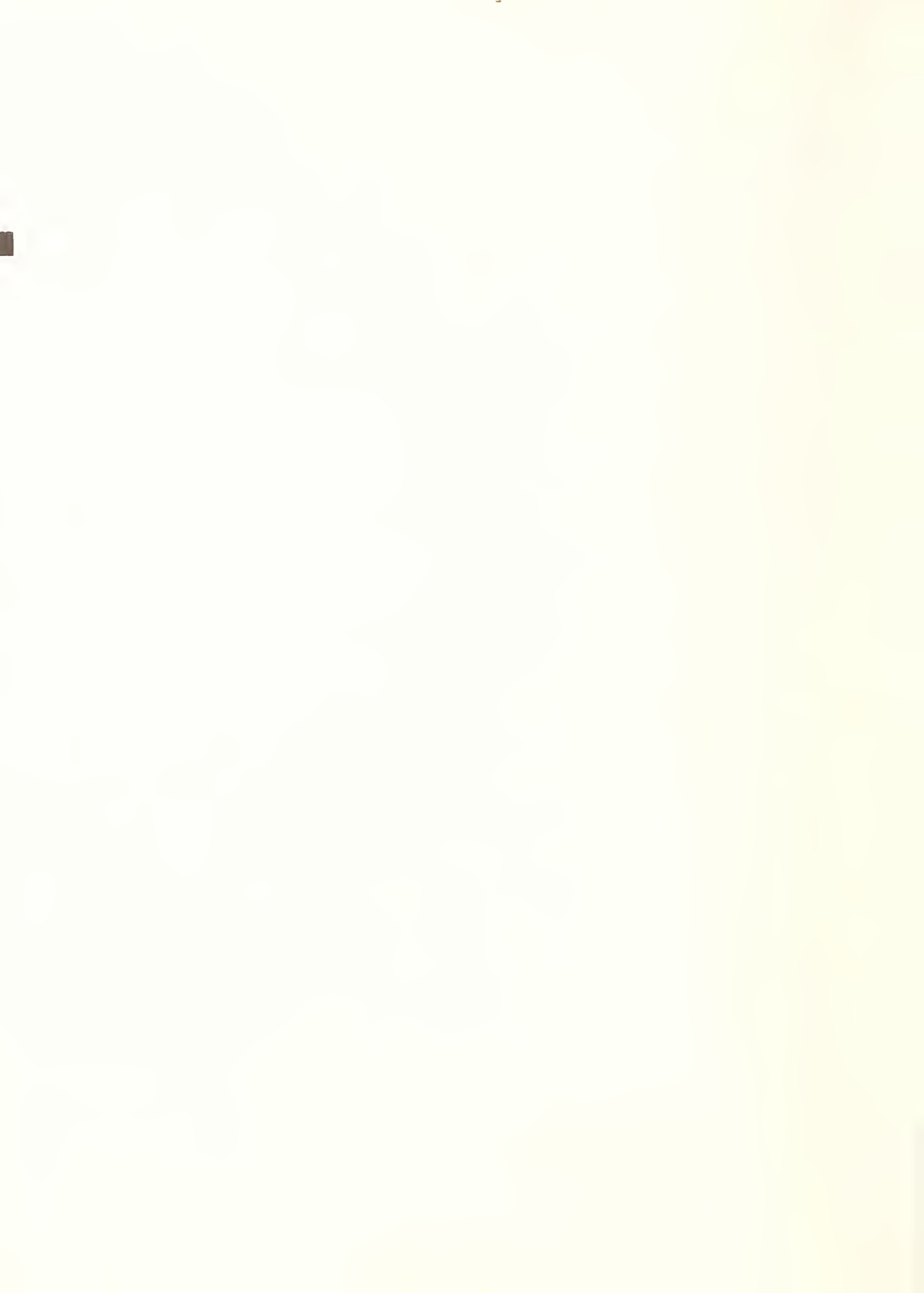
No.	Price	No.	Price
73-1 (PB192-365)	A03	76-57 (PB250-573)	A06
73-2 (PB194-614)	A05	76-58 (PB256-291)	A07
73-3 (COM71-00605)	A10	76-59 (PB256-639)	A10
73-4 (COM73-10323)	A04	76-60 (PB253-588)	A05
73-5 (COM73-10951)	A08	76-61 (PB253-553)	A05
73-6 (COM73-10959)	A04	76-63 (PB256-440)	A06
73-7 (COM73-10958)	A04	76-64 (PB255-445)	A05
73-8 (COM73-10954)	A10	76-69 (PB254-276)	A06
73-9 (COM73-10953)	A03	76-70 (PB254-748)	A04
73-10 (COM73-10952)	A08	76-71 (PB254-751)	A04
73-11 (PB242-597)	A12	76-72 (PB256-190)	A06
73-12 (COM73-10955)	A06	76-73 (PB257-424)	A08
73-13 (COM73-10957)	A05	76-74 (PB256-771)	A03
73-14 (COM73-10950)	A04	76-75 (PB261-201)	A03
73-15 (PB242-582)	A15	76-76 (PB261-200)	A06
73-16 (COM73-11265)	A04	76-77 (PB257-767)	A05
73-17 (COM74-10932)	A07	76-78 (PB257-836)	A06
73-18 (COM73-11783)	A03	76-79 (PB259-127)	A03
73-19 (COM74-10481)	A04	76-80 (PB259-126)	A04
73-21 (COM74-10722)	A07	77-82 (PB263-882)	A17
74-22 (COM74-10934)	A16	77-83 (PB265-228)	A06
74-23 (COM74-10929)	A02	77-84 (PB267-278)	A06
74-24 (COM74-10983)	A05	77-85 (PB267-233)	A14
74-25 (COM74-11075)	A07	77-86 (PB272-882)	A10
74-26 (COM74-11633)	A06	77-87 (PB268-132)	A04
74-27 (COM75-10143)	A06	77-88 (PB268-131)	A06
74-28 (PB176-912)	A12	77-89 (PB268-517)	A08
74-29 (PB176-913)	A04	77-90 (PB269-489)	A09
74-30 (COM74-11732)	A03	77-91 (PB268-904)	A05
74-31 (COM74-11733)	A02	77-92 (PB273-166)	A04
74-32 (COM75-10039)	A04	77-93 (PB271-980)	A09
75-33 (COM75-10133)	A11	77-94 (PB271-755)	A14
75-34 (COM75-10128)	A04	77-95 (PB272-883)	A07
75-35 (COM75-10341)	A05	77-97 (PB272-069)	A06
75-36 (PB261-144)	A16	77-98 (PB280-746)	A05
75-37 (PB261-145)	A06	77-99 (PB273-977)	A12
75-38 (PB261-021)	A05	77-100 (PB284-517)	A04
75-40 (COM75-10696)	A03	77-101 (PB284-500)	A06
75-42 (COM75-10805)	A24	77-102 (PB273-165)	A03
75-43 (AD-16782)	A06	77-103 (PB273-174)	A06
75-44 (COM75-10991)	A10	77-104 (PB276-102)	A04
75-45 (PB257-835)	A02	77-105 (PB275-083)	A04
75-46 (PB247-235)	A09	77-106 (PB275-155)	A03
75-47 (PB247-236)	A17	77-107 (PB275-524)	A09
75-48 (PB248-781)	A09	77-108 (PB278-634)	A03
75-50 (PB247-939)	A07	77-109 (PB275-576)	A05
75-51 (PB247-483)	A15	77-110 (PB278-648)	A05
76-54 (PB251-682)	A05	77-111 (PB278-643)	A05
76-55 (PB250-571)	A04	77-112 (PB278-644)	A02
76-56 (PB250-572)	A04	77-116 (PB276-549)	A06

GRANTEE/CONTRACTOR REPORTS (Continued)

No.	Price	No.	Price
78-114 (PB284-502)	A03	78-121 (PB278-605)	A05
78-115 (PB278-661)	A11	78-123 (PB279-091)	A12
78-117 (PB275-999)	A03	78-125 (PB280-025)	A05
78-118 (PB276-926)	A09	78-126 (PB281-451)	A11
78-119 (PB276-865)	A05	78-130 (PB285-260)	A99
78-120 (PB277-773)	A03	78-139 (PB287-801)	A06

EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM REPORTS

No.	Price	No.	Price
73-01 (COM73-11373)	A12	76-16 (PB256-129)	A11
73-02 (COM73-11375)	A08	76-17 (PB254-233)	A10
73-03 (COM73-11374)	A06	76-18 (PB256-642)	A03
73-04 (COM74-10256)	A02		
73-05 (COM74-10257)	A04	76-19 (PB256-643)	A03
		76-22 (PB257-884)	A20
73-06 (COM74-10258)	A03	76-23 (PB258-991)	A03
73-07 Vol. 1 (COM74-10939)	A05	76-24 (PB258-093)	A11
73-07 Vol. 2 (COM74-10940)	A14	76-25 (PB264-386)	A05
75-01 (COM75-11369)	A07		
76-03 (PB251-266)	A04	76-26 (PB259-998)	A03
		76-27 (PB260-523)	A03
76-04 (PB251-683)	A15	76-28 (PB264-387)	A08
76-05 (PB253-108)	A03	76-29 (PB264-388)	A10
76-06 (PB253-918)	A09	76-30 (PB264-389)	A06
76-07 (PB262-123)	A99		
76-08 (PB254-078)	A03	76-31 (PB264-390)	A11
		76-32 (PB264-391)	A12
76-09 (PB252-488)	A03	76-33 (PB264-392)	A17
76-10 (PB253-260)	A03	76-34 (PB263-275)	A05
76-11 (PB253-115)	A06	76-35 (PB263-273)	A03
76-12 (PB254-996)	A19		
76-13 (PB253-475)	A03	77-36 (PB264-393)	A12
		77-37 (PB268-162)	A06
76-14 (PB253-476)	A03	77-38 (PB272-700)	A10
76-15 (PB253-477)	A03	77-39 (PB273-950)	A03



3. TITLES AND ABSTRACTS OF NBS PUBLICATIONS, 1978¹

3.1. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 83, JANUARY-DECEMBER 1978

January-February 1978

Tubular flow reactors with first-order kinetics, R. L. Brown, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 1, 1-8 (Jan.-Feb. 1978).

Key words: first-order kinetics; flow reactor; gas phase kinetics; laminar flow reactor; reactor; wall reactions.

A method is presented for automatically calculating true first order rate constants for gas phase and wall reactions from experimentally observed decay parameters in tubular flow reactors. It includes the effects of axial and radial diffusion and Poiseuille flow.

Comments on units in magnetism, L. H. Bennett, C. H. Page, and L. J. Swartzendruber, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 1, 9-12 (Jan.-Feb. 1978).

Key words: magnetism; units.

Suggestions are given on how to express magnetic quantities in SI units.

The first spectrum of ytterbium (Yb I), W. F. Meggers and J. L. Tech, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 1, 13-70 (Jan.-Feb. 1978).

Key words: energy levels, Yb I; spectrum, Yb I; wavelengths, Yb I; Yb I; ytterbium; Zeeman effect.

Wavelengths and estimated intensities for 1791 lines of neutral ytterbium in the region 2155 to 31,308 Å are reported. The Zeeman effect has been investigated for 249 of these lines. Analysis of the data has resulted in classification of 787 lines as transitions between 102 even and 77 odd levels. Even levels have been assigned to the electron configurations $4f^{14}6s^2$ (the ground state), $4f^{14}6sns$, $4f^{14}6snd$, $4f^{14}6s^26p$, $4f^{14}6p^2$, $4f^{14}5d^2$, and $4f^{14}5d6s6p$. Odd levels have been assigned to $4f^{14}6snp$, $4f^{14}6snf$, and $4f^{14}5d6s^2$. Many odd levels are still unassigned, but the majority undoubtedly belong to the configuration $4f^{14}5d^26s$.

Norm approximation problems and norm statistics, D. R. Shier and C. J. Witzgall, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 1, 71-74 (Jan.-Feb. 1978).

Key words: approximation; curve-fitting; least-squares; L_p problems; minimization; norm; residuals; statistic.

This paper explores a relation between various approximation problems (arising from fitting linear models to data) and corresponding statistical measures (norm statistics). It is established that for any optimal solution to an approximation problem defined with respect to a norm, the resulting residuals have zero as their norm statistic. This result holds whenever the underlying design matrix has a column of ones. An extension to the case of arbitrary design matrices is also considered.

Vector-valued entire functions of bounded index satisfying a differential equation, L. F. Heath, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 1, 75-80 (Jan.-Feb. 1978).

Key words: bounded index; C^n -valued functions; entire functions; linear differential equations.

The concept of complex valued entire functions of bounded index is extended to C^n -valued entire functions by replacing the absolute value in the definition of an entire function of bounded index by the maximum of the absolute values of the components. If the components of a C^n -valued entire function are of bounded index, then the function is also of bounded index; however a C^n -valued function may be of bounded index without all of its components being of bounded index. Solutions of certain linear differential equations are related to C^n -valued functions of bounded index.

March-April 1978

TEA laser induced multiphoton dissociation of ethylene in a collisional regime: Model and experiment, N. C. Peterson, R. G. Manning, and W. Braun, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 117-125 (Mar.-Apr. 1978).

Key words: infrared; kinetics; lasers; model; multiphoton; photochemistry.

The focused beam of a pulsed CO₂ TEA laser was used to photodissociate ethylene gas at total pressures of 100-300 torr. The laser pulse induces molecular hydrogen elimination to yield primarily C₂H₂ and H₂ in a large excess of helium to eliminate heating. An investigation was made of the dependence of product yield on wavelength, inert gas pressure, ethylene pressure and intensity. Photochemical yield was followed over a 10,000 fold range. Its dependence was investigated employing alternate methods of focusing the laser beam, one of which results in a constant volume geometry. A photometric method of characterizing this focal zone is described.

A "structureless" computer model of the laser pumping process involving coupled rate equations and phenomenological absorption and stimulated emission coefficients is described. The model assumes rapid intramolecular energy transfer between the various vibrational modes throughout the entire vibrational manifold, and rapid equilibration of rotational states. The model includes stimulated emission and deactivating collisions, and predicts a product yield versus intensity dependence that does not exhibit threshold behavior in agreement with experiment. Calculated dependences of product yield on laser power for various parameters are given in order to relate the model to various photolysis experiments.

Thermodynamic study of the $\alpha \rightarrow \beta$ phase transformation in titanium by a pulse heating method, A. Cezairliyan and A. P. Müller, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 127-132 (Mar.-Apr. 1978).

Key words: electrical resistivity; high-speed measurements; high temperature; solid-solid phase transformation; thermodynamics; titanium; transformation energy; transformation temperature.

Measurements of the temperature and energy of the $\alpha \rightarrow \beta$ transformation, and the electrical resistivity near and at the transformation point of titanium by means of a subsecond duration pulse heating technique are described. The results yield 1166 K for the transformation temperature and 4170 J·mol⁻¹ for the transformation energy. Electrical resistivity is found to decrease by about 9 percent during the $\alpha \rightarrow \beta$ transformation. Estimated inaccuracies of the measured properties are: 7 K for the transformation temperature, 5 percent for the transformation energy, and 2 percent for the electrical resistivity.

¹The various NBS publications series are grouped under subheadings within this section. If a particular publications series is sought, consult the table of contents or the edge index on the back cover.

An intensity standard for electron paramagnetic resonance using chromium-doped corundum (Al_2O_3 : Cr^{3+}), T. Chang, D. Foster, and A. H. Kahn, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 133-164 (Mar.-Apr. 1978).

Key words: absolute measurement; intensity standard; paramagnetic resonance; ruby; spin concentration; standard reference material (SRM).

We report on the preparation of a standard reference material (SRM), made of single-crystal chromium-doped corundum (synthetic ruby), for use as an intensity standard in electron paramagnetic resonance (EPR) experiments. The SRM can be used to measure, by comparison, the number of spins in an unknown test sample.

We selected the above material for the standard because its magnetic resonance properties are well understood and because it is physically and chemically stable under common laboratory conditions. To prepare samples which gave satisfactory EPR signals, it was necessary to perform annealing and chemical etching after cutting. This removed strains and surface damage. After treatment, the Cr^{3+} resonance lines were sharper and the intensities were in good agreement with the theoretically predicted values. To aid in application, the theoretical resonance fields and line intensities were calculated and tabulated for arbitrary orientations of the sample, at several commonly used microwave frequencies. The concentration of Cr^{3+} in the samples was determined by measurement of the static susceptibility. A quantitative EPR intensity experiment, based on measuring the microwave power absorbed during resonance, gave the same concentration. This proves, that within experimental error the EPR experiment detects all the Cr^{3+} ions in the sample, which makes the ruby a useful SRM.

Behavior of an isolated polymer chain residing in a density gradient of segments, E. A. DiMarzio and C. M. Guttman, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 165-167 (Mar.-Apr. 1978).

Key words: functional integrals; path probability integrals; polymer conformations; polymer interface; polymer surface; Wiener integrals.

The Wiener integral (path integral, functional integral) technique is used to determine the equation describing the probability distribution of a polymer molecule immersed in a nonuniform distribution of monomer units. This result should be useful whenever there is a spatial variation of polymer density such as at an interface or surface.

The characterization of linear polyethylene SRM's 1482, 1483, and 1484. I. Introduction, P. H. Verdier and H. L. Wagner, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 169-177 (Mar.-Apr. 1978).

Key words: fraction; limiting viscosity number; narrow molecular weight distribution; number-average molecular weight; polyethylene; standard reference material; weight-average molecular weight.

The National Bureau of Standards has issued a series of three linear polyethylene Standard Reference Materials, SRM 1482, 1483, and 1484. These polyethylenes have molecular weights of the order of 10,000, 30,000, and 100,000 g/mol, respectively, and ratios M_w/M_n of weight- to number-average molecular weight of the order of 1.2. Their number-average molecular weights (by membrane osmometry), weight-average molecular weights (by light scattering), and limiting viscosity numbers in two solvents (by capillary viscometry) are certified; the procedures employed are described in subsequent papers in this series. In the present paper, we describe the preparation of the materials and some of their general properties.

The characterization of linear polyethylene SRM's 1482, 1483, and 1484. II. Number-average molecular weights by membrane osmometry, H. L. Wagner and P. H. Verdier, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 179-184 (Mar.-Apr. 1978).

Key words: fraction; limiting viscosity number; membrane osmometry; narrow molecular weight distribution; number-average molecular weight; polyethylene; standard reference material; weight-average molecular weight.

Linear polyethylene Standard Reference Materials SRM 1482, 1483, and 1484 are certified for number-average molecular weight M_n . In this paper the experimental procedures employed for the determination of M_n for these materials by membrane osmometry are described, and the techniques used to analyze the data and to estimate limits of systematic error are discussed.

The characterization of linear polyethylene SRM's 1482, 1483, and 1484. III. Weight-average molecular weights by light scattering, C. C. Han, P. H. Verdier, and H. L. Wagner, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 185-193 (Mar.-Apr. 1978).

Key words: fraction; light scattering; limiting viscosity number; narrow molecular weight distribution; number-average molecular weight; polyethylene; standard reference material; weight-average molecular weight.

Linear polyethylene Standard Reference Materials SRM 1482, 1483, and 1484 are certified for weight-average molecular weight M_w . In this paper the experimental procedures employed for the determination of M_w for these materials by light scattering are described, and the techniques used to analyze the data and to estimate limits of systematic error are discussed.

The characterization of linear polyethylene SRM's 1482, 1483, and 1484. IV. Limiting viscosity numbers by capillary viscometry, H. L. Wagner and P. H. Verdier, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 2, 195-201 (Mar.-Apr. 1978).

Key words: capillary viscometry; fraction; limiting viscosity number; narrow molecular weight distribution; number-average molecular weight; polyethylene; standard reference material; weight-average molecular weight.

Linear polyethylene Standard Reference Materials SRM 1482, 1483, and 1484 are certified for limiting viscosity number in 1,2,4-trichlorobenzene and 1-chloronaphthalene at 130 °C. In this paper the experimental procedures employed for the determination of limiting viscosity numbers for these materials by capillary viscometry are described, and the techniques used to analyze the data and to estimate limits of systematic error are discussed.

May-June 1978

Spectrum and energy levels of triply ionized ytterbium, J. Sugar, V. Kaufman, and N. Spector, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 3, 233-245 (May-June 1978).

Key words: energy levels; parametric calculations; resonance lines; spectrum analysis; ytterbium.

Spectra of Yb IV produced with a low voltage sliding spark discharge were photographed in the range of 700-2200 Å with a 10.7 m normal incidence spectrograph. Wavelengths for 944 spectral lines identified as Yb IV were measured. Of these, 535 were classified as transitions between 95 even and 51 odd energy levels of the $4f^{13}$, $4f^{12}5d$, $4f^{12}6s$, and $4f^{12}6p$ configurations. Values for the interaction parameters were derived by a least squares fit to the known levels.

An investigation of the stability of thermistors, S. D. Wood, B. W. Mangum, J. J. Filliben, and S. B. Tillet, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 3, 247-263 (May-June 1978).

Key words: clinical laboratory; medical thermometry; resistance thermometer; semiconductor thermometer, aging; thermistor; thermometer.

In order to better characterize thermistors, a group of 405 bead-in-glass and disc thermistors were aged in constant temperature baths. Samples of 135 thermistors were aged in each of three constant temperature baths held at 0, 30, and 60 °C. Each sample was composed of 65 bead-in-glass and 70 disc thermistors which represented a total of six manufacturers and six resistance values. The thermistors were maintained at temperature for 550 to 770 days and their resistances and the bath temperatures were periodically monitored.

Analysis of the data revealed systematic differences between bead-in-glass and disc thermistors upon aging and indicated a dependence of aging behavior on bath temperature and resistance value. Drift rates within groups of thermistors from each manufacturer were fairly uniform. Large initial changes in the drift rate for the disc thermistors at 30 and 60 °C (and to a much lesser extent in the bead-in-glass thermistors) require that thermistors for use at an accuracy level of a few tens of millikelvins be aged prior to use.

Photovoltaic technique for measuring resistivity variations of high resistivity silicon slices, D. L. Blackburn, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 3, 265-271 (May-June 1978).

Key words: automation; computer control; homogeneity; measurement method; photovoltage, bulk; power semiconductor materials; resistivity; semiconductors; silicon; thyristors; transistors, power.

A description of an automated, photovoltaic system for measuring the resistivity variation of high resistivity, large diameter silicon wafers is given. The photovoltaic technique utilizes a scanning light spot to induce a bulk photovoltage and a change in resistance from which is calculated the local variation in resistivity. This nondestructive technique requires no contacts to the useful fabrication area of the wafer, and measured results have a good correlation with the results of the four-probe technique. Specific examples of measured resistivity gradients are presented along with a discussion of the theory, measurement conditions and limitations, and description of a calculator-based automated system to perform the measurements.

Detection of deep levels in high power semiconductor materials and devices, R. Y. Koyama, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 3, 273-281 (May-June 1978).

Key words: deep level measurements; defect distribution; power semiconductor materials; power thyristors; semiconductor measurements; thermally stimulated measurements.

TSM and other deep level measurement techniques are used to detect, characterize, and identify deep level defects which control lifetime and leakage in semiconductor devices. These measurements are performed on an apparatus which is capable of handling full-sized wafers as well as die-sized devices. Measurements of "wafer maps" of the gold acceptor defect density in silicon reveal inhomogeneity in the defect distribution which is directly reflected in the leakage current distribution. The wafer handling capabilities make this apparatus a useful extension of routine fabrication-line diagnostic tools.

The thermodynamics of the glassy state. I. The heat capacity of one-dimensional disordered harmonic systems from moments, F. I. Mopsik and C. M. Guttman, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 3, 283-295 (May-June 1978).

Key words: disordered chain; glass; heat capacity; one-dimension; thermodynamic bounds; thermodynamics; thermodynamics of disordered systems.

Upper and lower bounds on the thermodynamic quantities of disordered one-dimensional systems are computed using the spectral moments of Domb et al. and a modification of a computational technique of Wheeler and Gordon. The heat capacity so produced is defined to be better than 0.01 percent for all temperatures. Models for glasses in one dimension are presented. The difference in the heat capacity between a disordered state and a comparable ordered one is examined. Normal low temperature behavior of heat capacity differences between glasses and crystals is seen. From models for glasses in one dimension it is argued that when the measured heat capacity of a glass exceeds that of its crystal, the glass must have regimes of higher density than that of the crystal. Various approximation schemes and bounds for the heat capacity of glasses in one and higher dimensions are also proposed.

The equations of motion for thermally driven, buoyant flows, R. G. Rehm and H. R. Baum, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 3, 297-308 (May-June 1978).

Key words: buoyant flow; fire research; gravity-driven flows; model equations; nonadiabatic flow.

In this paper a set of approximate equations is derived which is applicable to very nonadiabatic, nondissipative, buoyant flows of a perfect gas. The flows are assumed to be generated by a heat source in which the heat is added slowly. The study is motivated by the occurrence of such flows in fires. There, the time scale associated with the fire growth and resultant fluid motion is usually long compared with the transit time of an acoustic signal (based on the temperature derived from the heat added) across the spatial extent of the fire. The approximate equations are characterized by a spatially uniform mean pressure appearing in both the energy equation and the equation of state with the spatially nonuniform portion of the pressure only appearing in the momentum equation. Therefore, the pressure remains almost constant in space while significant density and temperature variations, such as might occur in a fire, are allowed. The approximate equations are shown to reduce to the Boussinesq equations when the heat addition is mild. These equations are also shown in general to admit internal-wave motions while "filtering out" high-frequency, acoustic waves. In addition, they are shown to be expressible in conservation form, the pressure satisfying an elliptic equation whose homogeneous terms are derivable from the wave equation by letting the sound speed become infinite. An equation for the mean pressure is also obtained. For the special case of a room heated at a uniform rate with a small leak to the outside, an approximate solution for the mean pressure is determined explicitly.

July-August 1978

Modification of the nonanalytic equation of state for the limit of low densities, R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 4, 325-327 (July-Aug. 1978).

Key words: equation of state; ethylene; internal energy; saturated vapor densities; thermodynamic properties; vapor pressures.

As described in previous reports, this equation is constrained to the liquid-vapor coexistence boundary. Integration of the "thermodynamic equation of state" along isotherms involves a term for the compressibility factor of saturated vapor in the limit of low densities, which in previous work was not adequately defined. The present, brief report assumes familiari-

ty with previous work, and presents a solution for the problem, which is to describe saturated-vapor densities in terms of the compressibility factor for saturated vapor, utilizing a given, vapor-pressure equation.

Implementation of scaling and extended scaling equations of state for the critical point of fluids, M. R. Moldover, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 4, 329-334 (July-Aug. 1978).

Key words: critical point; equation of state; scaling equation of state.

An explicit, practical procedure is suggested for transforming from the laboratory variables density (ρ) and temperature (T) into the parametric variables r and θ , which occur in various scaled representations of equations of state and of transport properties of fluids near critical points. A reasonably efficient and versatile computer program illustrating this procedure is provided. With this program, the parametric equations of state which occur in several formulations of simple, extended, and/or revised scaling are as easy to use as any other equation of state for which T and ρ are the independent variables.

The enthalpy of formation of $\text{MoF}_6(\ell)$ by solution calorimetry, R. L. Nuttall, K. L. Churney, and M. V. Kilday, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 4, 335-345 (July-Aug. 1978).

Key words: $\text{F}^-(\text{aq})$, enthalpy of formation; $\text{MoF}_6(\ell)$, enthalpy of formation and enthalpy of reaction in NaOH soln.; $\text{MoO}_3(\text{cr})$, enthalpy of soln. in NaOH; $\text{NaF}(\text{cr})$, enthalpies of soln. and diln. in H_2O , and enthalpy of soln. in $\text{MoO}_3\text{-NaOH}$; thermochemistry.

Enthalpies of reaction of $\text{MoF}_6(\ell)$ in NaOH solutions, of $\text{MoO}_3(\text{cr})$ in NaOH solutions, of $\text{NaF}(\text{cr})$ in $\text{MoO}_3\text{-NaOH}$ solutions, and of $\text{NaF}(\text{cr})$ in $\text{H}_2\text{O}(\ell)$ were measured to obtain the enthalpy of reaction of $\text{MoF}_6(\ell)$ in infinitely dilute NaOH solution:



$$\Delta H^\circ(298.15 \text{ K}) = (-641.23 + 1.8, -4.0) \text{ kJ mol}^{-1}$$

From this were calculated $\Delta H_f^\circ[\text{MoF}_6(\ell)] = (-1593.3 + 5.6, -4.3) \text{ kJ mol}^{-1}$, $\Delta H_f^\circ[\text{F}^-(\text{aq})] = (-334.05 + 0.34, -0.69) \text{ kJ mol}^{-1}$.

From the measurements of $\text{NaF}(\text{cr})$ in H_2O , values for apparent molal enthalpy, ϕ_L , were tabulated at concentrations from 0 to 0.2 mol·kg⁻¹. $\Delta H_{\text{soln}}^\circ(298.15 \text{ K}) = (937 \pm 36) \text{ J mol}^{-1}$.

Enthalpies of solution of nucleic acid bases. 1. Adenine in water, M. V. Kilday, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 4, 347-370 (July-Aug. 1978).

Key words: adenine; calorimetry; density, enthalpy of solution, entropy of formation; nucleic acid bases; thermochemistry; 6-amino purine.

An adiabatic solution calorimeter was used to measure the enthalpy of solution in water of various adenine samples for which a large amount of analytical information is reported.

The experimental imprecision of the measurements was 1.1 percent. However, it was necessary to assign an overall uncertainty of 3 percent because of impurity uncertainties. Thus, the best value for the enthalpy of solution is

$$\Delta H^\circ(\infty, 298.15 \text{ K}) = (33.47 \pm 1.00) \text{ kJ mol}^{-1}$$

$\Delta C_p = (78.7 \pm 10.4) \text{ J mol}^{-1} \cdot \text{K}^{-1}$ in the range 298 to 328 K at 5 mmol·kg⁻¹, and the enthalpy of dilution is $-(316 \pm 208) \text{ kJ mol}^{-1} (\text{mol} \cdot \text{kg}^{-1})^{-1}$ in the range 1 to 7 mmol·kg⁻¹.

The entropy of solution for adenine was calculated to be $\Delta S^\circ(298.15 \text{ K}) = (72.1 \pm 3.9) \text{ J mol}^{-1} \cdot \text{K}^{-1}$, and the partial

molar heat capacity at infinite dilution, $C_{p2}^\circ = (226 \pm 11) \text{ J mol}^{-1} \cdot \text{K}^{-1}$.

The density of adenine was measured by displacement as 1.47 g·mL⁻¹ with an estimated uncertainty of 1 percent.

Pyrolysis of monodisperse poly- α -methylstyrene, L. A. Wall, R. E. Florin, M. H. Aldridge, and L. J. Fetters, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 4, 371-380 (July-Aug. 1978).

Key words: degradation; deuterated poly- α -methylstyrene; molecular weight; poly- α -methylstyrene; pyrolysis; termination; transfer; zip length.

Pyrolysis of monodisperse poly- α -methylstyrene of wide molecular weight range (M:25,000—5,000,000) was studied isothermally under vacuum in the temperature range 240-280 °C. Thermogravimetric analysis was used for measuring the rate of degradation, and gel permeation chromatography for analyzing the molecular weight and molecular weight distribution as a function of conversion.

The initial rate of monodisperse poly- α -methylstyrenes, and the deuterated samples (poly- α -trideuteromethyl- β , β -dideuterostyrene) increases with increasing molecular weight. At molecular weight higher than 1×10^6 , the initial rate continues to increase almost linearly instead of being constant as concluded from earlier work. The molecular weight distribution ratio, M_w/M_n , increases as a function of conversion and approaches the most probable distribution. The results conform to a degradation mechanism with random initiation.

The curves of initial rate as a function of molecular weight lead to higher zip lengths than previous estimates. Attempts at simultaneous estimation of zip length and transfer constant from the rate and molecular weight data led to inconsistent results. If the variation of termination rate with molecular weight plays a role, this variation must be less than that derived naively from melt viscosity. Bimodal molecular weight distributions were not found.

The configurational statistics of a polymer confined to a wedge of interior angle α , J. I. Lauritzen and E. A. DiMarzio, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 4, 381-385 (July-Aug. 1978).

Key words: polymer in a wedge; polymer interface; polymer statistics; polymer surface problem; probability distribution of polymer near surface.

The probability distribution for the end-to-end length of a polymer of N segments confined in a wedge of interior angle α is obtained ($2\pi \geq \alpha > 0$). The result is used to evaluate the partition function, Q , for the cases: (1) one end free—one end tied to the vertex, Q is proportional to $\gamma^N N^{-\pi/2\alpha}$ both ends tied to each other at the vertex, Q , is proportional to $\gamma^N N^{-3/2-\pi/2\alpha}$.

September-October 1978

Direct determination of air density in a balance through artifacts characterized in an evacuated weighing chamber, W. F. Koch, R. S. Davis, and V. E. Bower, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 407-413 (Sept.-Oct. 1978).

Key words: buoyancy of air; density; mass comparisons in vacuo; precise weighing; vacuum; vacuum weighing.

This paper describes a simple device which permits mass comparisons in air without appeal to the correction for air buoyancy. The device consists of a canister which is evacuated and weighed on a laboratory balance with a mass inside. A second weighing of another mass in the evacuated canister provides the desired mass comparison. The method was used to determine the mass difference between two stainless steel weights of widely differing densities. With knowledge of this

mass difference and of the volume difference one may, by a simple air weighing of the two objects, determine directly the density of the air in the balance case. Densities of air determined by this method were compared with those calculated from the barometric pressure, the temperature, and the relative humidity of the laboratory air. The experimental and calculated values agree throughout to within $1.0 \mu\text{g cm}^{-3}$ (where the normal air density is about 1.2 mg cm^{-3}). The calculated and experimental values of day-to-day fluctuations in air density agree to within $0.5 \mu\text{g cm}^{-3}$.

Density of ultra-pure air at 298.15 K for mass transfer buoyancy corrections, M. Waxman and H. Davis, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 415-418 (Sept.-Oct. 1978).

Key words: Burnett method; low pressures; PVT; ultra-pure air; 298.15 K.

Within the context of the general problem to attain improved accuracy for the transfer of apparent mass values, the PVT properties of ultrapure air at 298.15 K for low pressures have been determined. At 0.1 MPa, the accuracy of the molar density is estimated to be 0.001 percent. Our application of the isothermal Burnett method to obtain the "PVT" measurements, the analysis of these measurements, and the effects of systematic Burnett errors on the PVT results are discussed.

The air density equation and the transfer of the mass unit, F. E. Jones, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 419-428 (Sept.-Oct. 1978).

Key words: air buoyancy; air density; mass unit transfer; real gas equation.

A new formulation of the equation for calculation of air density has been developed. The Cohen and Taylor value of the gas constant, currently accepted values of the atomic weights, and recent determinations of abundances of the various constituents of air have been used. The abundance of carbon dioxide has been treated as a variable and a factor enabling convenient adjustment of the apparent molecular weight of air for deviation of carbon dioxide abundance from a background value has been derived. A new table of the compressibility factor for the range of pressure and temperature of interest in standards laboratories has been calculated using recently determined values of virial coefficients. The enhancement factor, which has usually been ignored, has been explicitly included. A simple equation for the calculation of enhancement factor has been fitted to values in the range of pressure and temperature of interest. A simple equation for the calculation of saturation water vapor pressure has been fitted. Uncertainties, random and systematic, in the parameters and in the measurement of environmental variables and consequent uncertainties in calculated air density have been estimated.

Application of the equation to air buoyancy determination and the transfer of the mass unit at the various national standards laboratories has been made.

A microprocessor controlled potentiostat for electrochemical measurements, M. I. Cohen and P. A. Heimann, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 429-443 (Sept.-Oct. 1978).

Key words: control; converter (digital and analog); electrochemical measurements; microcomputer; microprocessor; potentiostat.

A system, utilizing a microprocessor, intended for the control and unattended operation of a standard laboratory potentiostat is described. The system consists of a central processing unit, 16 kilobytes of random access memory, peripheral interfacing, a timer and digital to analog and analog to digital converters. It allows flexible operation of the potentiostat by programming of the central processor.

Hashing with linear probing and frequency ordering, G. Lyon, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 445-447 (Sept.-Oct. 1978).

Key words: hashing; linear probing; nonuniform frequencies; open addressing; optimal packing; retrieval improvement.

A simple linear probing and exchanging method of Burkhard locally rearranges hash tables to account for reference frequencies. Examples demonstrate how frequency-sensitive rearrangements that depend upon linear probing can significantly enhance searches.

Specific heats of saturated and compressed liquid propane, R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 449-458 (Sept.-Oct. 1978).

Key words: constant volume; heat capacities; liquid; propane; saturated liquid; specific heats.

Experimental specific heats for saturated liquid propane, along the coexistence path, have been determined from the triple-point temperature ($\sim 85 \text{ K}$) to 289 K. Specific heats for the compressed liquid at constant molal volume have been determined along isochores at nine different densities ranging from near the triple-point liquid density to about twice the critical-point density (at pressures up to 300 bar). Comparisons with previous experimental- and/or derived-data show agreement within combined uncertainties of about three percent.

A cost/benefit framework for Consumer Product Safety Standards, C. O. Muehlhause, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 459-483 (Sept.-Oct. 1978).

Key words: consumer; cost-benefit; fire hazard; market; regulation safety standards; upholstered furniture.

The effect of a mandated consumer product safety standard on the net public benefit is expressed in terms of the difference between two well characterized market states (pre- and post-standard), each of which is assumed to be in static equilibrium. The analysis is facilitated by treating the post-standard state as one which can be "derived" from the pre-standard state by 1) expanding the production cost and demand functions around their initial market values and 2) introducing modifications in the production cost function required for compliance with the standard.

A gain in net benefit would imply that promulgation of the standard is favorable; however, a variety of uncertainties are encountered in estimating the incremental changes in production, demand, compliance, and regulatory costs. These are discussed, some of the simpler situations which may prevail are disclosed, and the sources of expertise required to effect the analysis are identified.

The detailed portion of the analysis undertaken in this paper is one which attempts to derive a market factor such that when it is multiplied by the basic increment in manufacturing cost necessary to comply with the standard yields the loss in net benefit due to the market system. The results are then applied to a case involving the manufacturing and retailing of upholstered furniture, which industries may be subject to a certain fire prevention standard.

Some comments on Shier's paper for inverting sparse matrices, J. M. McNamee, *J. Res. Nat. Bur. Stand. (U.S.)*, **83**, No. 5, 485-487 (Sept.-Oct. 1978).

Key words: sparse equations; tree partitions.

A paper by Shier (J. Res. NBS 80B) shows how to partition the graph of a matrix into a tree so as to minimize the number of operations required to invert the matrix. The present paper

shows how to economically solve a sparse system of linear equations after the application of Shier's method to the coefficient matrix.

November-December 1978

Enthalpies of solution of the nucleic acid bases. 2. Thymine in water, M. V. Kilday, *J. Res. Nat. Bur. Stand. (U.S.)*, **83, No. 6, 529-537 (Nov.-Dec. 1978).**

Key words: calorimetry; density; enthalpy of solution; nucleic acid bases; thermochemistry; thymine; 5-methyl-uracil; 5-methyl-2,4 (1H, 3H)-pyrimidinedione.

An adiabatic solution calorimeter was used to measure enthalpies of solution in water of 8 samples of thymine for which analytical data are reported. Our best values for the enthalpy of solution and the change in heat capacity are

$$\Delta H^\circ = (\infty, 298.15 \text{ K}) = (24.32 \pm 0.70) \text{ kJ} \cdot \text{mol}^{-1}$$

$$\Delta C_p^\circ = (106 \pm 26) \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}, 298 \text{ K} < T < 328 \text{ K}.$$

These were used to calculate $\Delta S^\circ = (53.1 \pm 3.6) \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ for the entropy of solution, and $C_{p2}^\circ = (256 \pm 26) \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ for the apparent molal heat capacity at infinite dilution. No change in the enthalpy of solution with concentration was observed in the range of 5 to 35 mmol·kg⁻¹.

Enthalpies of solution of the nucleic acid bases. 3. Cytosine in water, M. V. Kilday, *J. Res. Nat. Bur. Stand. (U.S.)*, **83, No. 6, 539-546 (Nov.-Dec. 1978).**

Key words: calorimetry; cytosine; density, enthalpy of solution, entropy of solution; nucleic acid bases; thermochemistry; 4-amino-2(1H)-pyrimidinone.

An adiabatic solution calorimeter was used for measuring enthalpies of solution in water of seven samples of cytosine for which analytical data are given.

Our best values are:

$$\Delta H^\circ(\infty, 298.15 \text{ K}) = (27.2 \pm 4.0) \text{ kJ} \cdot \text{mol}^{-1},$$

and

$$\Delta C_p = (76 \pm 21) \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1},$$

$$298 \text{ K} < T < 324 \text{ K} \text{ at } (24 \pm 2) \text{ mmol} \cdot \text{kg}^{-1}.$$

Evidence is given for an unidentified side reaction at low concentrations which is responsible for the large uncertainty assigned to the enthalpy of solution at infinite dilution. An approximate value of $(1.44 \pm 0.08) \text{ g} \cdot \text{mL}^{-1}$ for the density of cytosine was also measured. Values are calculated for ΔG° and ΔS° for the solution reaction.

Enthalpies of solution of the nucleic acid bases. 4. Uracil in water, M. V. Kilday, *J. Res. Nat. Bur. Stand. (U.S.)*, **83, No. 6, 547-554 (Nov.-Dec. 1978).**

Key words: calorimetry; density, enthalpy of solution, entropy of solution; nucleic acid bases; thermochemistry; uracil; 2,4-dioxypyrimidine; 2,4(1H, 3H)-pyrimidinedione.

An adiabatic solution calorimeter was used to measure enthalpies of solution in water of 7 uracil samples in a concentration range of 3 to 45 mmol·kg⁻¹ and over a temperature range of 298 K to 325 K. Analytical data for the samples are given.

Our best value for the enthalpy of solution is

$$\Delta H^\circ(\infty, 298.15 \text{ K}) = (29.3 \pm 1.2) \text{ kJ} \cdot \text{mol}^{-1}$$

and for the change in heat capacity for the reaction with temperature,

$$\Delta C_p^\circ = (57 \pm 13) \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}.$$

No change in the enthalpy of solution with concentration was found in this range. Values were calculated for the entropy of solution, $\Delta S^\circ = (68.1 \pm 4.2) \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$, and for the apparent molal heat capacity at infinite dilution, $C_{p2}^\circ = (178 \pm 15) \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$.

Neutron flux intercomparison at NBS, K. C. Duvall, M. M. Meier, O. A. Wasson, and V. D. Huynh, *J. Res. Nat. Bur. Stand. (U.S.)*, **83, No. 6, 555-561 (Nov.-Dec. 1978).**

Key words: calibration standards; efficiency; international comparisons; neutron detectors; neutron flux.

National Bureau of Standards (NBS) participation in an International Bureau of Weights and Measures (BIPM) sponsored neutron flux intercomparison is described. The efficiencies of two transfer instruments, a gas-filled ³He proportional counter and a BF₃ counter imbedded in a polyethylene sphere, were determined at neutron energies of 250 keV and 560 keV. The efficiency of the ³He detector was determined by placing it in the flux monitored by the NBS "black" detector. Since the polyethylene sphere detector shadows the "black" detector, a secondary BF₃ counter was calibrated and it normalized the sphere and "black" detector runs. The efficiencies are reported and compared to the quantities determined at other participating standards laboratories.

A critical review of comparisons of mathematical programming algorithms and software (1953-1977), R. H. F. Jackson and J. M. Mulvey, *J. Res. Nat. Bur. Stand. (U.S.)*, **83, No. 6, 563-584 (Nov.-Dec. 1978).**

Key words: code comparison; comparison of mathematical programming software; evaluation; testing.

Since the introduction of general-purpose computers during the early 1950's, competing techniques of mathematical programming have been developed, analyzed empirically, and compared. In this paper we survey fifty articles (spanning the period 1953-1977) which report the computational testing of mathematical programming algorithms. Our intention is to document the performance measures which were used, the standards which were maintained, and the forms in which the results were reported for these experiments. Trends in methodology are noted, and suggestions for improving the current state of affairs are offered.

Partitioned and Hadamard product matrix inequalities, C. E. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **83, No. 6, 585-591 (Nov.-Dec. 1978).**

Key words: Hadamard product; inversion; matrix inequality; partitioned matrix; positive semi-definite.

This note is partly expository. Inequalities relating inversion with, respectively, extraction of principal submatrices and the Hadamard product in the two possible orders are developed in a simple and unified way for positive definite matrices. These inequalities are known, but we also characterize the cases of equality and strict inequality. A by-product is, for example, a pleasant proof of an inequality due to Fiedler. In addition, it is shown that the Hadamard product preserves inequalities in a generalization of Schur's observation. In the process, many tools for dealing with the positive semi-definite partial ordering are exhibited.

The phase-shifting limit cycles of the van der Pol equation, P. J. Melvin, *J. Res. Nat. Bur. Stand. (U.S.)*, **83, No. 6, 593-601 (Nov.-Dec. 1978).**

Key words: analytical solutions; differential equations; mathematical software; nonlinear oscillations.

The van der Pol limit cycles are generated at small amplitudes by the computer implementation of the Poincaré-Lindstedt method. The formal algebraic solution is accomplished by manipulations of Poisson series, and the FORTRAN programming of the inductive algorithm yields the phase-shifting limit cycles to graphical accuracy over the range $0 \leq \lambda \leq 1.5$. This improves upon the method of Deprit and Rom in two ways. First, because the formal solution is carried out by hand, an algebraic processor is not necessary. Second, the standard solutions which they generated are only valid for $0 \leq \lambda \leq 1.2$ whereas the phase-shifting limit cycles are still valid at $\lambda = 1.5$; that is, they do not exhibit the Gibbs phenomenon even at $\lambda = 1.5$.

3.2. PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 7, JANUARY-DECEMBER 1978

This journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The objective of the Journal is to provide critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques, whose aim is to assess the accuracy of available data in a given technical area, are also included. The principal source for the Journal is the National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements such as are normally reported in the primary research literature, nor for review articles of a descriptive or primarily theoretical nature.

Volume 7, No. 1

Tables of atomic spectral lines for the 10000 Å to 40000 Å region. M. Outred, *J. Phys. Chem. Ref. Data* 7, No. 1, 1-262 (1978).

Key words: atomic spectra; infrared spectra; optical spectra.

This compilation of atomic spectral lines for the 10000 Å to 40000 Å region tabulates 8885 selected lines, belonging to 57 elements, extracted from computer based data records. The tables are divided into three sections. In section I the strong lines in the 10000 Å to 25000 Å range are listed for 27 elements. Section II is a table of classified and unclassified lines, arranged in order of increasing vacuum wavenumber. Section III consists of vacuum wavenumber tables, with appropriate energy level and J values for the classified lines, listed by element. Detailed explanation of the data and sources used for the compilation are given.

Evaluated activity and osmotic coefficients for aqueous solutions: The alkaline earth metal halides. R. N. Goldberg and R. L. Nuttall, *J. Phys. Chem. Ref. Data* 7, No. 1, 263-310 (1978).

Key words: activity coefficient; alkaline earth metal halides; critical evaluation; electrolyte; excess Gibbs energy; osmotic coefficients; solutions; thermodynamic properties.

A critical evaluation of the mean activity and osmotic coefficients in aqueous solutions of the alkaline earth metal halides at 298.15 K is presented. Osmotic coefficients were calculated from direct vapor pressure measurements, from isopiestic measurements, and from freezing point depression measurements. Activity coefficients were calculated from electromotive force measurements on galvanic cells, both with and without transference, and from diffusion data. Given are empirical coefficients for three different correlating equations, obtained by a weighted least squares fit of the experimental data, and tables consisting of the activity coefficients of the halides, the osmotic coefficients and activity of water, and the excess Gibbs energy of the solution as a function of the molality for each electrolyte system. The literature coverage is through September 1976.

Microwave spectra of molecules of astrophysical interest. XII. Hydroxyl radical. R. A. Beaudet and R. L. Poynter, *J. Phys. Chem. Ref. Data* 7, No. 1, 311-362 (1978).

Key words: hydroxyl radical; interstellar molecules; line strengths; microwave spectra; molecular properties; radio astronomy.

The available data on the microwave spectrum of the hydroxyl radical are critically reviewed for information applicable to radio astronomy. Molecular properties such as the rotational constants, spin-orbit, spin-spin and hyperfine coupling constants and centrifugal distortion parameters employed in or derived from the analysis are tabulated. All the observed and predicted transitions of ^{16}OH , ^{16}OD , and ^{18}OH below 300 GHz and lower state energy levels less than 4000 cm^{-1} are presented for the ground vibrational state. The laboratory data on ^{17}OH is included, but no predicted transitions are presented due to the limited data available. In addition to the transition frequencies the table contains the calculated line strengths and energies of the levels involved in the transition. An extensive bibliography of laboratory and astronomical studies of the hydroxyl radical is presented as an aid to workers in both fields.

Ideal gas thermodynamic properties of methanoic and ethanoic acids. J. Chao and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* 7, No. 1, 363-378 (1978).

Key words: dimer; enthalpy; entropy; equilibrium constant of formation; ethanoic (acetic) acid; Gibbs energy of formation; heat capacity; ideal gas thermodynamic properties; internal rotational barrier height; methanoic (formic) acid; monomer; torsional frequencies.

The thermodynamic properties [$H^\circ - H^\circ_0$, $(G^\circ - H^\circ_0)/T$, $(H^\circ - H^\circ_0)/T$, S° , C_p° , ΔH_f° , ΔG_f° , and $\log K_f$] for methanoic (formic) and ethanoic (acetic) acid monomers and dimers in the ideal gaseous state over the temperature range from 0 to 1500 K at 1 atm have been calculated by the statistical thermodynamic method using the most recent and reliable molecular and spectroscopic constants. The internal rotational contributions of $-\text{OH}$ and $-\text{CH}_3$ rotors to the thermodynamic properties were evaluated based on internal rotation partition functions formed by summation of calculated internal rotation energy levels. On an assumption that the vapor contains only monomers and dimers, the thermodynamic properties for the monomer-dimer equilibrium mixture of methanoic and ethanoic acids in ideal gaseous state were derived. The results are in agreement with available experimental data.

Volume 7, No. 2

Critical review of hydrolysis of organic compounds in water under environmental conditions. W. Mabey and T. Mill, *J. Phys. Chem. Ref. Data* 7, No. 2, 383-416 (1978).

Key words: acid; base; environmental conditions; freshwater systems; hydrolysis; organic compounds; rate constants.

This review examines the rate constants for hydrolysis in water of 12 classes of organic compounds with the objective of using these data to estimate the persistence of these compounds in freshwater aquatic systems. Primary data were obtained by literature review through most of 1975 and some of 1976. These data, which include values for acid, base, and water promoted rate constants (k_A , k_B , k_N) and temperature coefficients are presented in 18 tables in section 4. Estimated rate constants for hydrolysis under environmental conditions are presented in 13 tables in section 5, including rate constants at 298 K and pH 7 for acid, base, and water promoted reactions together with values for the estimated rate constant (k_R) and the half-life ($t_{1/2}$).

Ideal gas thermodynamic properties of phenol and cresols, S. A. Kudchadker, A. P. Kudchadker, R. C. Wilhoit, and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* 7, No. 2, 417-424 (1978).

Key words: ideal gas thermodynamic properties; internal rotation; *m*-cresol; *o*-cresol; *p*-cresol; phenol; potential barrier heights; rotational isomers; torsional frequencies.

The standard chemical thermodynamic properties of phenol, *o*-cresol, *m*-cresol, and *p*-cresol were calculated by use of the rigid rotor harmonic oscillator approximation. The partition functions for internal rotation of $-OH$ and $-CH_3$ groups were calculated as a direct sum over the internal rotation energy levels. It was assumed that *o*-cresol is a mixture of two rotational isomers. Values of molecular parameters, fundamental frequencies, potential barriers to internal rotation and enthalpies of formation were selected from among those reported in the literature and from some additional molecular orbital calculations.

Densities of liquid $CH_{4-a}X_a$ ($X=Br, I$) and $CH_{4-a+b+c+d}F_aCl_bBr_cI_d$ halomethanes, A. P. Kudchadker, S. A. Kudchadker, P. R. Patnaik, and P. P. Mishra, *J. Phys. Chem. Ref. Data* 7, No. 2, 425-440 (1978).

Key words: critically evaluated data; halomethanes; liquid density.

The available density data for the air-saturated liquid and for the liquid at its saturation vapor pressure have been critically reviewed and the "best" data selected for the following halomethanes: CHF_2Cl , CH_2FCl_2 , CF_3Cl , CF_3Br , CF_2Cl_2 , $CFCl_3$, (data up to the critical point are available for these compounds); CH_3Br , CH_2Br_2 , $CHBr_3$, CBr_4 , CH_3I , CH_2I_2 , CH_2FCl , (data up to the normal boiling point are available for these compounds); $CHCl_2Br$ (data over a small temperature range); CHI_3 , Cl_4 , CH_2FI , CH_2ClBr , CH_2CIH , CHF_2Br , CHF_2I , $CHFBr_2$, $CHFCl_2$, $CHCl_2I$, $CHClBr_2$, $CHClI_2$, CF_3I , CF_2Br_2 , $CFBr_3$, CCl_3Br , CCl_3I , (few scattered data points are available for these compounds). The literature survey is complete up to June 1974. Selection of "best" data was arrived at by carefully evaluating each set of data for its accuracy, method of experimentation, sample purity, etc. The selection procedure is discussed. The uncertainty in the selected values is reported. For interpolation and limited extrapolation, the selected density data for each compound have been correlated through simple equations in temperature. The regression errors and the computed regression constants are reported in tables 2 and 4, respectively.

Microwave spectra of molecules of astrophysical interest, XIII. Cyanoacetylene, W. J. Lafferty and F. J. Lovas, *J. Phys. Chem. Ref. Data* 7, No. 2, 441-494 (1978).

Key words: cyanoacetylene; interstellar molecules; line strengths; microwave spectra; molecular constants; radio astronomy; rotational transitions.

The microwave spectrum of cyanoacetylene is critically reviewed for information applicable to radio astronomy. Molecular data such as the derived rotational constants, centrifugal distortion parameters, hyperfine coupling constants, electric dipole moment and molecular structure are tabulated. The observed rotational transitions are presented for the astrophysically interesting isotopic forms and low-lying vibrational states of cyanoacetylene. Calculated rotational transitions up to 300 GHz are presented for the ground vibrational state of $H^{12}C^{12}C^{12}C^{14}N$, $H^{13}C^{12}C^{12}C^{14}N$, $H^{12}C^{13}C^{12}C^{14}N$, $H^{12}C^{12}C^{13}C^{14}N$, $H^{12}C^{12}C^{12}C^{15}N$, and $D^{12}C^{12}C^{12}C^{14}N$, and for the vibrationally excited states ν_5 , ν_6 , ν_7 , $2\nu_7$, and $3\nu_7$ of $H^{12}C^{12}C^{12}C^{14}N$.

Transition probabilities for vanadium, chromium, and manganese (A critical data compilation of allowed lines), S. M.

Younger, J. R. Fuhr, G. A. Martin, and W. L. Wiese, *J. Phys. Chem. Ref. Data* 7, No. 2, 495-630 (1978).

Key words: allowed transitions; chromium; *f*-values; isoelectronic sequence; line strengths; manganese; oscillator strengths; systematic trends; transition probabilities; vanadium.

Atomic transition probabilities for about 2700 spectral lines of the elements vanadium, chromium, and manganese through all stages of ionization have been critically evaluated and compiled. All available literature sources have been utilized. Systematic trends along isoelectronic sequences have been extensively exploited to predict oscillator strengths (*f*-values) whenever no data were available in the literature. The data are presented in separate tables for each element and stage of ionization and are arranged according to multiplets and, when appropriate, also to transition arrays and increasing quantum numbers. For each line, the transition probability for spontaneous emission, the absorption oscillator strength, and the line strength are given, along with the spectroscopic designation, the wavelength, the statistical weights, and the energy levels (when available) of the upper and lower atomic states. In addition, the estimated accuracy and the literature reference are indicated. In short introductions, which precede the tables for each spectrum, the main justifications for the choice of the adopted data and for the accuracy rating are discussed. A general introduction contains some more details on our evaluation procedure.

Volume 7, No. 3

Thermodynamic properties of ammonia, L. Haar and J. S. Gallagher, *J. Phys. Chem. Ref. Data* 7, No. 3, 635-792 (1978).

Key words: ammonia; correlation; equation of state; gas; liquid; phase equilibria; thermodynamic properties.

An analytic thermodynamic surface has been fitted to the experimental data for ammonia for the temperature range extending from the triple point to 750 kelvins and for the pressure range extending from the dilute gas to 500 MPa (5000 bar). Values for the thermodynamic properties are tabulated at closely spaced intervals. A major part of the correlation was devoted to a study of the extent to which thermodynamic inconsistencies degrade the accuracy of the derived properties. This study focused as much on methods for correlating the data as on the data themselves. As a consequence, we are able to assign close tolerances to the tabulated thermodynamic properties over the range of the surface, including properties for the coexisting phases and even close to the liquid-vapor critical point.

JANAF Thermochemical Tables, 1978 supplement, M. W. Chase, Jr., J. L. Curnutt, R. A. McDonald, and A. M. Syverud, *J. Phys. Chem. Ref. Data* 7, No. 3, 793-940 (1978).

Key words: critically evaluated data; enthalpy, entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables.

The thermodynamic tabulations previously published in NSRDS-NBS 37, the 1974 Supplement (*J. Phys. Chem. Ref. Data* 3, 311 (1974)), and the 1975 Supplement (*J. Phys. Chem. Ref. Data* 4, 1 (1975)) are extended by 131 new and revised tables. The JANAF Thermochemical Tables cover the thermodynamic properties over a wide temperature range with single phase tables for the crystal, liquid, and ideal gas state. The properties given are heat capacity, entropy, Gibbs energy function, enthalpy, enthalpy of formation, Gibbs energy of formation, and the logarithm of the equilibrium constant for formation of each compound from the elements in their standard

reference states. Each tabulation lists all pertinent input data and contains a critical evaluation of the literature upon which these values are based. Literature references are given.

Viscosity of liquid water in the range -8°C to 150°C , J. Kestin, M. Sokolov, and W. A. Wakeham, *J. Phys. Chem. Ref. Data* 7, No. 3, 941-948 (1978).

Key words: critically evaluated data; critical review; data compilation; liquid water; viscosity.

The paper re-analyzes the results of earlier, very precise measurements of the viscosity of water at essentially atmospheric pressure. This is done in terms of a new, theoretically-based equation for the operation of a capillary viscometer rather than in terms of semi-empirical equations used by the original authors. The new analysis eliminates possible systematic errors and permits the establishment of realistic error bounds for water in its role as a standard reference substance for viscosity. The latter are smaller than those embodied in the most recent International Formulation. Standard values of the ratio of viscosity at a temperature T to its value at 20°C have been derived from the re-analyzed data because the uncertainty of this ratio is an order of magnitude smaller than that of the absolute values. The ratios are used to generate absolute values with the aid of the standard NBS datum $\mu = 1002.0 \mu\text{Pa s}$ at 20°C . The viscosity ratios have been correlated with the aid of two empirical equations. The more accurate equation covers the range $0^{\circ}\text{C} \leq t \leq 40^{\circ}\text{C}$ with an uncertainty of ± 0.05 percent. The less accurate equation covers the wider range $-8^{\circ}\text{C} \leq t \leq 150^{\circ}\text{C}$ with the more limited accuracy of ± 0.2 percent. The two empirical equations are compatible with each other to 0.09 percent.

The molar volume (density) of solid oxygen in equilibrium with vapor, H. M. Roder, *J. Phys. Chem. Ref. Data* 7, No. 3, 949-958 (1978).

Key words: density; molar volume; oxygen; phase transition; solid.

Data from the literature on the molar volume of solid oxygen have been compiled and critically analyzed. A correlated and thermodynamically consistent set of molar volumes, including the volume changes at the various solid phase transitions, is presented. Evidence for the existence of a δ -solid phase is reviewed. Uncertainties in the data and in the recommended set of values are discussed.

Thermal conductivity of ten selected binary alloy systems, C. Y. Ho, M. W. Ackerman, K. Y. Wu, S. G. Oh, and T. N. Havill, *J. Phys. Chem. Ref. Data* 7, No. 3, 959-1178 (1978).

Key words: conductivity; critical evaluation; data analysis; data compilation; data synthesis; electrical resistivity; metals; recommended values; thermal conductivity; thermo-electric power.

This work reviews and discusses the available data and information on the thermal conductivity of ten selected binary alloy systems and presents the recommended values resulting from critical evaluation, analysis, and synthesis of the available data. The ten binary alloy systems selected are the systems of aluminum-copper, aluminum-magnesium, copper-gold, copper-nickel, copper-palladium, copper-zinc, gold-palladium, gold-silver, iron-nickel, and silver-palladium. The recommended values given include values of the total thermal conductivity, electronic thermal conductivity, and lattice thermal conductivity. The uncertainty of the values is generally of the order of ± 10 percent. The values for each of the alloy systems except two are given for 25 alloy compositions: 0.5, 1, 3, 5, 10(5)95, 97, 99, and 99.5 percent. For most of the alloy compositions, the values cover the temperature range from 4 K to the solidus

temperature or 1200 K. In addition, reliable methods for the estimation of the electronic and lattice thermal conductivities of alloys have been developed in this study.

Semi-empirical extrapolation and estimation of rate constants for abstraction of H from methane by H, O, HO, and O_2 , R. Shaw, *J. Phys. Chem. Ref. Data* 7, No. 3, pp. 1179-1190 (1978).

Key words: estimated rate constants; hydrogen abstraction; methane combustion.

It has been concluded that for extrapolating rate constants of atom transfer reactions to and from high temperatures, a useful form of the rate constant is $k = AT^2 \exp(-C/T)$, where A and C are fitted constants. For $k/[\text{cm}^3/(\text{mol s})]$ and T/K , on the basis of previous experimental data, the values of $\log A$ and C for the following reactions are: $\text{H} + \text{CH}_4 = \text{H}_2 + \text{CH}_3$, $\log A = 7.15$, $C = 4449$; $\text{O} + \text{CH}_4 = \text{OH} + \text{CH}_3$, $\log A = 6.71$, $C = 3240$; $\text{HO} + \text{CH}_4 = \text{H}_2\text{O} + \text{CH}_3$, $\log A = 6.93$, $C = 1485$ and $\text{O}_2 + \text{CH}_4 = \text{O}_2\text{H} + \text{CH}_3$, $\log A = 6.93$, $C = 26153$. At all temperatures, abstraction by HO is faster than by O. The form of the rate constant is equivalent to assuming that ΔC_p^{\ddagger} , the heat capacity at the constant pressure of activation, is zero. When ΔC_p^{\ddagger} was estimated and assumed to be constant (in principle, a more accurate assumption than $\Delta C_p^{\ddagger} = 0$), the fit to the experimental data was slightly worse. It is confirmed that at 400 to 700 K, the kinetic and thermodynamic equilibrium constants for the reaction $\text{H} + \text{CH}_4 = \text{H}_2 + \text{CH}_3$ are significantly different. (At 1340 K, they are in agreement.)

Energy levels of vanadium, V I through V xxiii, J. Sugar and C. Corliss, *J. Phys. Chem. Ref. Data* 7, No. 3, 1191-1262 (1978).

Key words: atomic energy levels; atomic spectra; vanadium.

The energy levels of the vanadium atom in all of its stages of ionization, as derived from the analyses at atomic spectra, have been critically compiled. In cases where only line classifications are given in the literature, level values have been derived. The percentages for the two leading components of the calculated eigenvectors of the levels are given where available. Ionization energies and experimental g -values are also given.

Volume 7, No. 4

Recommended atomic electron binding energies, 1s to $6p_{3/2}$, for the heavy elements, $Z = 84$ to 103, F. T. Porter and M. S. Freedman, *J. Phys. Chem. Ref. Data* 7, No. 4, 1267-1284 (1978).

Key words: atomic electron binding energies; binding energies; core electron binding energies; heavy elements; transuranic elements.

Recent experimental measurements of atomic electron binding energies, 1s to $6p_{3/2}$, for certain of the transuranic elements are incorporated into interpolation and extrapolation procedures yielding new recommendations for the electron binding energies from $Z = 84$ to 103.

Ideal gas thermodynamic properties of $\text{CH}_{4-a+b+c+d}\text{F}_a\text{Cl}_b\text{Br}_c\text{I}_d$ halomethanes, S. A. Kudchadker and A. P. Kudchadker, *J. Phys. Chem. Ref. Data* 7, No. 4, 1285-1308 (1978).

Key words: critically evaluated data; estimated enthalpies of formation; estimated molecular parameters; ideal gas thermodynamic properties; mixed halomethanes.

The available molecular parameters, fundamental frequencies, and enthalpies of formation at 298.15K ($\Delta H_f^\circ(298)$) for halomethanes of the type $\text{CH}_{4-a+b+c+d}\text{F}_a\text{Cl}_b\text{Br}_c\text{I}_d$ have been critically evaluated and recommended values selected. Molecular parameters and $\Delta H_f^\circ(298)$ for some halomethanes have been estimated as the experimental values for these compounds are not available. This information has been utilized to calculate the ideal gas thermodynamic properties C_p° , S° , $H^\circ - H_0^\circ$ ($G^\circ - H_0^\circ$)/ T , ΔH_f° , ΔC_f° , and $\log K_f$ from 0 to 1500 K and at a pressure of one atmosphere using the rigid rotor-harmonic oscillator approximation for the following compounds: CH_2FBr , CH_2ClBr , CH_2ClI , CH_2BrI , CHF_2Br , CHFClBr , CHFBr_2 , CHCl_2Br , CHClBr_2 , CF_3Br , CF_3I , CF_2ClBr , CF_2Br_2 , CF_2I_2 , CFCl_2Br , CFCIBr_2 , CFBr_3 , CCl_2Br , CCl_3I , CCl_2Br_2 , CClBr_3 .

Critical review of vibrational data and force field constants for polyethylene. J. Barnes and B. Fanconi, *J. Phys. Chem. Ref. Data* 7, No. 4, 1309-1322 (1978).

Key words: force field refinement; lattice dynamics; n -alkanes; nonbonded potential functions; polyethylene; vibrational data.

The results of a critical review of vibrational data, their assignments, and force field constants of polyethylene and the related homologous series of n -alkanes are presented. The vibrational frequencies derived from Raman spectroscopy, infrared spectroscopy, and neutron inelastic scattering were collected from the literature. We have reviewed the vibrational band assignments starting from the comprehensive treatment of the n -alkanes by Schachtschneider and Snyder and including subsequent reassignments. Theoretical calculations of the vibrational frequencies were reviewed with emphasis on the various models used for molecular structure and force fields. Lattice dynamical calculations of polyethylene were performed using a valence force field for intramolecular interactions and a force field derived from a nonbonded atom-atom potential function for intermolecular interactions. The molecular and lattice structural parameters were taken from x-ray and neutron diffraction studies of polyethylene and selected n -alkanes. A refinement procedure was carried out by the method of least squares on intramolecular force field constants and on parameters of a phenomenological nonbonded atom-atom potential energy function. The resulting force field constants and associated standard deviations are presented.

Tables of molecular vibrational frequencies—Part 9. T. Shimanouchi, H. Matsuura, Y. Ogawa, and I. Harada, *J. Phys. Chem. Ref. Data* 7, No. 4, 1323-1444 (1978).

Key words: force constants; fundamental frequencies; infrared spectra; normal vibrations; polyatomic molecules; Raman spectra; vibrational frequencies.

Fundamental vibrational frequencies of 109 molecular forms of 38 polyatomic chain molecules consisting of the CH_3 , CD_3 , CH_2 , CD_2 , CHD , O , and S groups are given as an extension of tables of molecular vibrational frequencies published in the NSRDS-NBS publication series and in this journal. On preparing the tables in this part, an approach, different from that in the previous parts, based on the calculations of normal vibration frequencies was adopted. A set of force constants which explains all the frequencies of small molecules for which the assignments had been established was obtained and then the frequencies of larger molecules were calculated and compared with the frequencies observed in the infrared and Raman spectra. The tables provide a convenient source of information for those who require vibrational energy levels and related properties in molecular spectroscopy, thermodynamics, analytical chemistry, and other fields of physics and chemistry.

Microwave spectral tables. II. Triatomic molecules. F. J. Lovas, *J. Phys. Chem. Ref. Data* 7, No. 4, 1445-1750 (1978).

Key words: dipole moments; hyperfine structure; internuclear distance; microwave spectra; rotational constants; rotational spectral lines; triatomic molecules.

All of the rotational spectral lines observed and reported in the open literature for 54 triatomic molecules have been tabulated. The isotopic molecular species, assigned quantum numbers, observed frequency, estimated measurement uncertainty and reference are given for each transition reported. In addition to correcting a number of misprints and errors in the literature cited, the spectral lines for approximately 15 molecules have been refit to produce a comprehensive and consistent analysis of all the data extracted from various literature sources. Both measured and predicted transition frequencies are listed for several isotopic forms of HCN , H_2O , H_2S , OCS , SO_2 , and O_3 . The derived molecular properties, such as rotational and centrifugal distortion constants, hyperfine structure constants, electric dipole moments, and rotational g -factors are listed with one standard deviation uncertainty for all values.

3.3. DIMENSIONS/NBS, ARTICLE TITLES ONLY

This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS.

DIMENSIONS/NBS highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, DIMENSIONS/NBS reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

January 1978

DIM/NBS 62, No. 1, 1-32 (1978).

Key words: CIPM report; electrical measurements; energy; hourly solar radiation; ionizing radiation; ion-molecule reactions; metric; molecular structure; perspectives on NBS; solar energy; SRM's.

It's Never Too Late to Insulate, M. Jacobs
Perspectives on NBS:

The Future of NBS, J. J. Baruch

Problems, Prospects, and the Search for a Proper Balance, E. Ambler

Warnings and Recommendations, C. E. Peck

A Current Assessment, W. O. Baker

Progress Is Being Made in Solar Energy Standards Development, M. Jacobs

CIPM Meeting Report, E. Ambler

Vibrational Chemiluminescence Detected from Ion-Molecule Reactions, S. R. Leone

New Understanding of Molecular Structure, D. L. Ederer and T. B. Lucatorto

Standard Reference Material Issued for Purity of Drinking Water

Conferences

Publications

News Briefs

February 1978

DIM/NBS 62, No. 2, 1-28 (1978).

Key words: bottle safety; catalytic activity; computer performance; crystal growth; information systems; LNG; magnetic auditory; ozone calibration; piezoelectric polymer; pressure; ultraviolet photometer.

Working Under Pressure: The Varied World of the Piezoelectric Polymer, M. Jacobs

Dynamics of Information Systems and Users: Prognosis made by Information, S. A. Rossmassler

Bottle Safety Now the Subject of Two Voluntary Standards, D. Chaffee

New Techniques in the Measurement of Catalytic Activity, R. D. Kelley and T. E. Madey

NBS Detects Magnetic Auditory Evoked Responses, J. E. Zimmerman

Ultraviolet Photometer for Ozone Calibration, A. M. Bass

Conferences

Publications

News Briefs

March 1978

DIM/NBS 62, No. 3, 1-28 (1978).

Key words: biological tissue; computers; electromagnetic interference; firing ranges; flow measurement; fluorescence; laser-raman; measurements; metric myth; metric speakers; oxygen; phase transition; radiologic imaging; solar energy; space shuttle.

A Problem of Growing Concern: EMI, F. P. McGehan
Copyright and the Computer, S. Radack

Exploding a Metric Myth—Dual Usage, J. V. Odom

Metric Speakers Are Available, J. Tascher

Ambler Becomes NBS Director

Cleaner Air Depends on Accurate Measurements, M. Jacobs

Stimulated Collision-Induced Fluorescence Observed, J. L.

Carlsten and M. G. Raymer

Laser-Raman Probe Microanalysis of Biological Tissue Made,

E. S. Etz and K. F. J. Heinrich

New Phase Transition in Oxygen Discovered, H. Roder

NBS Expands Data for Space Shuttle, N. A. Olien

Budget Increase Requested for NBS

Conferences

Publications

News Briefs

April 1978

DIM/NBS 62, No. 4, 1-32 (1978).

Key words: attic ventilation; chemical kinetics; computers; fusion reactors; gas flow; microwaves; smoke detectors; spectroscopic tool; stainless steel; standards; telescope; time and frequency.

The Fly's Eye Telescope, F. McGehan

Measuring With Microwaves, K. Armstrong

Fusion Reactors in Our Future?, M. Baum

New Instrument for Field Testing Smoke Detectors, D. Chaffee

Standard for Coding Cities, Towns, Related Places, S. Lichtenstein

Non-Intrusive Technique Measures Concentration Fluctuations in Turbulent Gas Flow, I. Chabay, G. Rosasco, and T. Kashiwagi

The Central Role of Chemical Kinetics Research in Atmospheric Modeling and Environmental Regulation, M. Kurylo

A New Analytical and Spectroscopic Tool: The Opto-Galvanic Effect, P. Schenck, J. Travis, K. Smyth, and D. King

Stainless Steel Standard Reference Materials

Conferences

Publications

News Briefs

May 1978

DIM/NBS 62, No. 5, 1-28 (1978).

Key words: Congress; electromagnetic interference; fire behavior; flow measurement; metric; radar; spectroscopy; time; universe.

A Scientist on Capitol Hill, F. Clark

Time and Astronomy, J. Jespersen
Metric Milk and Bread: What Sizes?, J. Odom
NBS Research Associate Maurice Ducloux: The French Connection, D. Chaffee
Group Formed on Electromagnetic Interference, F. McGehan
New Gas Flow Measurement Method Uses Cryogenic Technique, K. Higgins
Research Begun on Police Radar and Other Speed Measuring Equipment, M. Treado
Strain Tide Spectroscopy, J. Levine
Conferences
Publications
News Briefs

June 1978

DIM/NBS 62, No. 6, 1-32 (1978).

Key words: computer network; fuel economy; graphite; metallic corrosion; metric; phase alloy; reorganization; thermal expansion.

Reorganization: A New Look for NBS, M. Jacobs
The Economic Effects of Corrosion, M. Baum
Metric vs. Customary: Which Is More Accurate?, J. Odom
NBS, ASM Join to Improve Phase Alloy Information, M. Baum
NBS Investigates Graphite as Future Standard Reference Material, K. Higgins
The NBS Computer Network Measurement System, S. Raddack
Advances in Understanding of Laser Spectra of Symmetric Molecules, D. Orr
New NBS Standards Aid Measurements of Fuel Economy
New Thermal Expansion SRM Available
Conferences
Publications
News Briefs

July-August 1978

DIM/NBS 62, No. 7/8, 1-32 (1978).

Key words: cereal foods; computers; cryogenic measurements; electronics standards; encryption standard; fire safety; lasers; microcircuit fabrication; nickel standard; rheology; time signals.

Automation in the Marketplace, S. M. Radack and G. G. Burns
Science for Life's Sake, D. Chaffee
Time: Who Needs It?, C. Smith
NBS Assists Electronics Firm in Meeting European Standard, F. P. McGehan
Standards Save Tax Money, S. Lichtenstein
Encryption Standard: Validating Hardware Techniques, J. Gait
New Apparatus for Cryogenic Measurements, W. M. Haynes
A Simple Model for Stable High Density Discharges for Lasers, A. C. Gallagher
Standard Polymer Solutions for Rheology
Superconducting Microcircuit Fabrication, R. E. Harris, C. A. Hamilton, R. L. Kautz, and D. G. McDonald
Standard Reference Materials for Cereal Foods
Two Nickel Standard Reference Materials
Conferences
Publications
News Briefs

September 1978

DIM/NBS 62, No. 9, 1-32 (1978).

Key words: corrosion; electronics industry; insulation; National Measurement System; nuclear safeguards; plastics migration; SRM's-metals; SRM's-steel; temperature scale.

Corrosion Facts for the Consumer, J. Kruger
Insulation Insomnia: A Cure, M. Heyman
The National Measurement System, L. Hagan and A. Whitmore
Nuclear Safeguards and NBS, D. Chaffee
New Measurement Concept for the Electronics Industry, C. Smith
Program on Migration Behavior of Plastic Food-Packaging Materials, L. Smith
Toward a New Scale of Temperature, J. F. Schooley
New Steel Standard Reference Material
Standard Reference Material for Metals Industry
Conferences
Publications
News Briefs

October 1978

DIM/NBS 62, No. 10, 1-32 (1978).

Key words: computers; digital-cosine; information resources; insulation; ion metal; metric; standard reference data.

Going Metric—What's In It for Me?, J. Odom
Information Systems Revisited, F. Huddle
Are You on the Wanted List?, M. Jacobs
The State of Standard Reference Data, D. Johnson
NBS Researchers Win Three 1978 I-R 100 Awards, M. Baum
Digital Sine-Cosine Mini-Stepping Drive, H. Layer
Iron Metal Standard Reference Material
Managing Information Resources, B. Leong-Hong
Conferences
Publications
News Briefs

November 1978

DIM/NBS 62, No. 11, 1-24 (1978).

Key words: diffractometer; neutron activation analysis; SRM; surface science; weights and measures; x-ray powder diffraction.

For Good Measures, G. Lupton
Probing the Past with Neutrons, G. Lupton
Chemical Fingerprints on File, J. Chappell
Fibrous Glass, Board Standard Reference Material
FAST Facility Available for Engineering, T. Vorburger
New NBS-NIH Large-Molecule Diffractometer, A. Wlodawer
Standard Reference Material for Electron Experiments
Conferences
Publications
News Briefs

December 1978

DIM/NBS 62, No. 12, 1-32 (1978).

Key words: calibration; coal gasification; corrosion; EMI; heating and cooling; radio frequency; solar heating; weights and measures.

Testing for EMI, F. McGehan
Solar Heating and Cooling: Standards for a Maturing Industry, M. Heyman
News from the International Bureau of Weights and Measures
Corrosion Test Methods for Coal Gasification Materials, S. Schneider

3.4. MONOGRAPHS

Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

Monogr. 25, Section 15. **Standard x-ray diffraction powder patterns. Section 15—Data for 112 substances**, M. C. Morris, H. F. McMurdie, E. H. Evans, B. Paretzkin, J. H. de Groot, B. S. Weeks, R. J. Newberry, C. R. Hubbard, and S. J. Carmel, *Nat. Bur. Stand. (U.S.)*, Monogr. 25, Sec. 15, 204 pages (Oct. 1978) SN003-003-01986-1.

Key words: crystal structure; integrated intensities; lattice constants; peak intensities; powder patterns; reference intensities; standard; x-ray diffraction.

Standard x-ray diffraction patterns are presented for 112 substances. Fifty-four of these patterns represent experimental data and 58 are calculated. The experimental x-ray powder diffraction patterns were obtained with an x-ray diffractometer. All d-values were assigned Miller indices determined by comparison with computed interplanar spacings consistent with space group extinctions. The densities and lattice constants were calculated and the refractive indices were measured whenever possible. The calculated x-ray powder diffraction patterns were computed from published crystal structure data. Both peak height and integrated intensities are reported for the calculated patterns.

Monogr. 161. **The nicrosil versus nilsil thermocouple: Properties and thermoelectric reference data**, N. A. Burley, R. L. Powell, G. W. Burns, and M. G. Scroger, *Nat. Bur. Stand. (U.S.)*, Monogr. 161, 167 pages (Apr. 1978) SN003-003-01856-2.

Key words: calibration drift; chemical analyses; nickel-base alloys; nickel-chromium alloys; nickel-silicon alloys; oxidation; temperature; thermal electromotive force; thermocouple reference tables; thermocouples; thermoelements; thermometry.

This monograph deals with the formulation and development of the new highly stable nickel-base thermocouple alloys *Nicrosil* (Ni-14.2Cr-1.4Si) and *Nilsil* (Ni-4.4Si-0.1Mg) under the leadership of the Materials Research Laboratories (MRL) of the Australian Government Department of Defence, and their standardization by the National Bureau of Standards (NBS) of the U.S. Department of Commerce.

In the formulation of the new alloys, the main method was to use basic thermodynamic data to predict the conditions of solute concentration, temperature and oxygen pressure under which certain discrete oxide layers could form on the surface as highly efficacious passivating films. This work was the culmination of extensive research in which thermoelectric instability in existing nickel-base thermocouple alloys was correlated with their physical, chemical and metallurgical properties (section 2). The basic thermoelectric properties of *Nicrosil* and *Nilsil* more recently have been the subject of a joint research project between NBS and MRL. The aim of this project, which was conducted under the terms of an Arrangement under the U.S./Australia Agreement relating to Scientific and Technical Co-operation, was to establish a body of standard reference data on the thermoelectric and other properties of the new thermocouple alloys which could be recognized by various standards authorities around the world.

Descriptions of the prototype materials and experimental methods used in the joint research are given in sections 3 and

4, while the mathematical methods used to analyze the experimental results are described in section 5. The principal thermoelectric reference data for *Nicrosil* and *Nilsil*, comprising tabular values of thermoelectric voltages, Seebeck coefficients and derivatives versus temperature, are given in Section 7, while other material characteristics, in particular their highly stable thermoelectric properties, are summarized in section 6.

3.5. HANDBOOKS

Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

H111. Revised. **American National Standard N43.2; Radiation safety for x-ray diffraction and fluorescence analysis equipment.** (ANSI N43.2-1977), S. Block, Chairman, ANSI Subcommittee N43-1, *Nat. Bur. Stand. (U.S.), Handb. 111 Revised*, 20 pages (May 1978) SN003-003-01917-8.

Key words: radiation safety; x-ray equipment.

This standard reviews the types of injuries resulting from accidental exposure to ionizing radiation resulting from the operation of x-ray diffraction and fluorescence analysis equipment, establishes equipment design criteria, sets up requirements for approved operating procedures, and recommends the establishment of health surveillance, and personnel monitoring programs. The circumstances under which operation of equipment must be limited to specially designated areas equipped with radiation barriers and warning signs are set forth. Maximum permissible dose limits established by the National Council on Radiation Protection and Measurement are stated. A list of references to selected articles on various aspects of radiation safety is given and notes on the detection and measurement of radiation from x-ray diffraction and fluorescence analysis equipment are included in an appendix.

H124. **Energy management for furnaces, kilns, and ovens**, L. A. Wood, J. F. Ward, and K. G. Kreider, *Nat. Bur. Stand. (U.S.), Handb. 124*, 44 pages (Jan. 1978) SN003-003-01811-2.

Key words: energy conservation, industrial; furnaces, energy conservation; heat balance; industrial energy conservation; kilns, energy conservation; ovens, energy conservation.

This handbook, part of the EPIC Energy Management Series, is directed to the user of direct-fired heating equipment in light industry. Other publications in this series outline steps to plan and establish an energy conservation program in a business or industry. This handbook is a guide to making decisions as to just what actions are appropriate and effective for energy savings in equipment such as furnaces, kilns, and ovens. The major technique described is the heat balance. Examples of heat balances are used to identify energy losses on a batch furnace, a continuous paint dryer oven, and a slot forging furnace. Typical energy conservation opportunities in combustion control, insulation, etc. are discussed. Simplified methods of calculation and measurement are given. Benefit/cost analysis and the time required to recoup investment are described as means of evaluating energy-saving investments.

H125. **OMNIDATA—An interactive system for data retrieval, statistical and graphical analysis, and data-base management.** A user's manual, J. Hilsenrath and B. Breen, *Nat. Bur. Stand. (U.S.), Handb. 125*, 294 pages (Sept. 1978) SN003-003-01972-1.

Key words: Boolean search system; computer programs; curve fitting; data analysis; data base management; data retrieval; file handling; graphic analysis; IMS information retrieval; KWOC indexing; least-squares; linear regression; MIS; plotting; statistical analysis.

The Omnidata system, consisting of 45 individual programs written in XBASIC, provides an interactive user-oriented facility for: data retrieval and report generation; plotting and other graphical analysis; arithmetic and statistical analysis; curve fitting and multiple linear regression; data coding and decoding; survey and questionnaire analysis; author, title, and keyword indexing of bibliographic files; a variety of univariate analyses and two-way crosstabulations; and numerous utility modules for file definition, file updating, and file maintenance.

The SEARCH module which performs a serial search through a file allows for: the usual Boolean operations; string searching on text fragments, stems, or roots in either the anchored or unanchored mode; specification of syntactical order and proximity of words or phrases, as well as variable length *ellipsis*; and ignoring one or more of a specified list of characters in its matching operation.

Four of the modules interface with the OMNITAB II system for versatile plotting, very accurate least-squares fitting, and a comprehensive statistical analysis.

H126. **American National Standard N542; Sealed radioactive sources, classification.** (ANSI N542-1977), E. H. Eisenhower, Chairman, ANSI Subcommittee N43-3.3, *Nat. Bur. Stand. (U.S.), Handb. 126*, 28 pages (July 1978) SN003-003-01903-8.

Key words: classification; leak test; national standard; radiation safety; radiation sources; radioactive sources; radioactivity; sealed sources; standard.

This standard establishes a system of classification of sealed radioactive sources based on performance specifications related to radiation safety. It provides a manufacturer of sealed sources with a series of tests for evaluating the safety of his product under specified conditions, and also assists a user of such sources to select a type which suits the intended application insofar as maintenance of source integrity is concerned. Tests are prescribed for temperature, external pressure, impact, vibration, and puncture over a range of severity. Sealed source performance requirements are identified for a variety of source applications, in terms of a specific degree of severity of each test. Appendixes are included on the subjects of leak test methods, quality assurance and control, brachytherapy sources, self-luminous light sources, and special form radioactive material.

H127. **American National Standard N433.1; Safe design and use of self-contained, dry source storage gamma irradiators (Category I).** (ANSI N433.1-1977), E. H. Eisenhower, Chairman, ANSI Subcommittee N43-3.4, *Nat. Bur. Stand. (U.S.), Handb. 127*, 22 pages (July 1978) SN003-003-01913-5.

Key words: gamma radiation; irradiation; irradiator; national standard; radiation safety; radiation source; safety standard.

This standard applies to self-contained, dry source storage irradiators (Category 1) that contain sealed gamma emitting sources for the irradiation of objects or materials. It establishes the criteria to be used in the proper design, fabrication, installation, use, and maintenance of these irradiators which will ensure a high degree of radiation safety at all times. The requirements of the standard are grouped as 1) general considerations, 2) manufacturer's responsibility, and 3) owner's responsibility. Included in the first group are general radiation protection criteria, sealed source performance requirements, and radiation

survey needs. Among the manufacturer's responsibilities are criteria for maximum external radiation levels, integrity of shielding, and controls and indicators. The requirements for users include safety-related servicing, administrative procedures, operator qualifications, and routine safety tests.

3.6. SPECIAL PUBLICATIONS

Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

SP250, 1978 Edition. **Calibration and related measurement services of the National Bureau of Standards**, B. C. Belanger, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 250, 1978 Edition*, 104 pages (Apr. 1978) SN003-003-01916-0.

Key words: calibration; measurement assurance; measurement services; standards; traceability.

This publication provides detailed descriptions of the currently available NBS calibration services, measurement assurance programs, and other measurement services. In addition, each section describing specific services contains references to additional publications giving even more detail about the measurement techniques and procedures used. This revised edition reflects the services available as of the fourth quarter of 1977. NBS Special Publication 250 was last issued in 1970. The Appendix to SP 250 is reviewed every six months (April and October). It lists current prices for the services described in this publication and the NBS points of contact (addresses and phone numbers) from whom additional information can be obtained.

SP260-56. **Standard reference materials: Standard thermocouple material, Pt-67: SRM-1967**, R. L. Powell, L. L. Sparks, and J. G. Hust, *Nat. Bur. Stand. (U.S.), Spec. Publ. 260-56*, 50 pages (Feb. 1978) SN003-003-01886-4.

Key words: chemical composition; effect of imperfections; high purity platinum; high temperature thermoelectric measurements; low temperature thermoelectric measurements; platinum; Pt 67; residual resistivity ratio; standard reference material; temperature coefficient of resistors; thermocouple; thermoelectric standard; thermo-electric voltage.

Industry-wide standardization of thermocouple wire depends in part on thermoelectric comparisons of commercial wires to a standard. In this paper we describe a thermoelectric standard, designated Pt-67, which is available in wire form as a Standard Reference Material (SRM 1967). High purity platinum meets the requirements of a thermoelectric reference material for temperatures from 77K (-197 °C) up to 2040K (1767 °C). Thermoelectric voltages, residual resistance ratios, temperature coefficients of resistance, and chemical composition are reported for a high purity, highly characterized lot of platinum that has been developed as a thermoelectric standard, Pt-67. A review of the historical development of the material is followed by characterization data on the material and descriptions of the cryogenic and high temperature apparatus. The important effects of impurities are also described. Recommendations and precautions for usage of the reference material conclude the discussion.

SP260-57. **Standard reference materials: Guide to United States reference materials**, J. P. Cali and T. Plebanski, *Nat. Bur. Stand. (U.S.), Spec. Publ. 260-57*, 55 pages (Feb. 1978) SN003-003-01883-0.

Key words: measurement; reference materials; standardization; standard reference materials.

Summarized is a list of reference materials produced and distributed by U.S. manufacturers, both public and private. Extensive tables are indexed by use to which reference materials may be put. Properties covered include: chemical composition (analytical chemical purposes), chemical composition (high purity), physical properties, engineering and technological properties, and biochemical properties. Names and addresses of 93 U.S. producers and/or distributors are included.

SP260-59. **Standard reference materials: Electron paramagnetic resonance intensity standard: SRM-2601; Description and use**, T. Chang and A. H. Kahn, *Nat. Bur. Stand. (U.S.), Spec. Publ. 260-59*, 60 pages (Aug. 1978) SN003-003-01975-5.

Key words: absolute measurement; intensity standard; paramagnetic resonance; ruby; spin concentration; standard reference material (SRM).

This publication provides information concerning the use of ruby samples, of known Cr^{3+} concentration, supplied as a Standard Reference Material (SRM) for intensity measurements in electron paramagnetic resonance (EPR) experiments. By comparing the measured intensities of EPR absorption lines of a test sample and of the SRM, it is often possible for the user to obtain a determination of the number of spins in the test sample. Procedures and data on ruby necessary for carrying out this process are presented. Examples of the use of the SRM in typical cases are offered.

SP260-60. **Standard reference materials: A reference method for the determination of sodium in serum**, R. A. Velapoldi, R. C. Paule, R. Schaffer, J. Mandel, and J. R. Moody, *Nat. Bur. Stand. (U.S.), Spec. Publ. 260-60*, 106 pages (Aug. 1978) SN003-003-01978-0.

Key words: clinical analysis; clinical chemistry; definitive method; electrolytes; flame atomic emission spectroscopy; reference method; semiautomated pipetting; serum sodium analysis.

Guided by a committee of experts in clinical chemistry, a reference method was established for the determination of serum sodium based on flame atomic emission spectroscopy (FAES). Its accuracy was evaluated by comparing the values obtained by use of the method in twelve laboratories against the results obtained by a definitive analytical method based on an ion-exchange sodium separation followed by gravimetry as Na_2SO_4 . Seven serum pools with sodium concentrations in the range 113.2 to 158.6 mmol/L were analyzed. Manual and semiautomated pipetting alternatives were tested using sample sizes of 5.0 and 0.25 mL, respectively.

The laboratories used several different FAES instruments. The results showed that the standard error for a single laboratory's performance of the procedure ranged from 0.46 to 0.86 mmol/L with a maximum bias of 1.0 mmol/L over the range of concentrations studied. These values were within the accuracy and precision goals that had been set by the committee. There were no significant differences in the results from the two pipetting techniques. The calibration curve data showed excellent linearity over the total concentration range, with 21 of 26 curves having standard deviations of fit of 0.5 mmol/L or less.

With appropriate experimental design, the reference method may be used to establish the accuracy of field methods as well as to determine reference sodium values for pooled sera.

SP260-61. **Standard reference materials: The characterization of linear polyethylene SRM's 1482, 1483, and 1484**, P. H. Verdier and H. L. Wagner, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 260-61*, 41 pages (Dec. 1978) SN003-003-02006-1.

Key words: capillary viscometry; fraction; light scattering; limiting viscosity number; membrane osmometry; narrow molecular weight distribution; number-average molecular weight; polyethylene; standard reference material; weight-average molecular weight.

The National Bureau of Standards has issued a new series of three linear polyethylene Standard Reference Materials, SRM 1482, 1483, and 1484. These polyethylenes have molecular weights of the order of 10,000, 30,000, and 100,000 g/mol, respectively, and ratios M_w/M_n of weight-to number-average molecular weight of the order 1.2. Their number-average molecular weights (by membrane osmometry), weight-average molecular weights (by light scattering), and limiting viscosity numbers in two solvents (by capillary viscometry) are certified; the procedures employed are described in these collected papers previously published in the Journal of Research of the National Bureau of Standards.

SP305. **Supplement 9. Publications of the National Bureau of Standards 1977 catalog. A compilation of abstracts and key word and author indexes**, B. L. Burris, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 9*, 601 pages (June 1978) SN003-003-01951-8.

Key words: abstracts, NBS publications; key words; publications.

This supplement to Special Publication 305 supplements 1 through 8 of the National Bureau of Standards lists the publications of the Bureau issued between January 1-December 31, 1977. It includes an abstract of each publication (plus some earlier papers omitted from Special Publication 305 Supplement 8), key-word and author indexes; and general information and instructions about NBS publications.

Miscellaneous Publication 240 (covering the period July 1, 1957 through June 30, 1960) and its supplement (covering the period July 1, 1960 through June 30, 1966), Special Publication 305 (covering the period July 1966 through December 1967), and Special Publication 305 Supplement 1 (covering the period 1968-1969), Special Publication 305 Supplement 2 (covering the period 1970), Special Publication 305 Supplement 3 (covering the period 1971), Special Publication 305 Supplement 4 (covering the period 1972), Special Publication 305 Supplement 5 (covering the period 1973), Special Publication 305 Supplement 6 (covering the period 1974), Special Publication 305 Supplement 7 (covering the period 1975), Special Publication 305 Supplement 8 (covering the period 1976), remain in effect. Two earlier lists, Circular 460 (Publications of the National Bureau of Standards, 1901 to June 1947) and its supplement (Supplementary List of Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957) are also still in effect.

SP366. **Supplement 3. Bibliography on atomic line shapes and shifts (June 1975 through June 1978)**, J. R. Fuhr, B. J. Miller, and G. A. Martin, *Nat. Bur. Stand. (U.S.), Spec. Publ. 366, Suppl. 3*, 83 pages (Dec. 1978) SN003-003-02007-9.

Key words: atomic; instrumental broadening; line shapes; line shifts; pressure broadening; resonance broadening; Stark broadening; van der Waals broadening.

This is the third supplement to the NBS Special Publication 366, *Bibliography on Atomic Line Shapes and Shifts (1889 through March 1972)*. It contains about 600 references and

covers the literature from June 1975 through June 1978. As before, the bibliography contains five major parts: (1) All general interest papers are catalogued according to the broadening mechanisms (and, further, according to special topics under several of the mechanisms) and as to whether the work is a general theory, a general review, a table of profiles or parameters, a comment on existing work, a study of general experimental measurement techniques, or an experimental effort of general importance. Also included are selected papers on important applications of line broadening and on miscellaneous topics relating to atomic spectral line shapes and shifts. (2) In Part 2 all papers containing numerical data are ordered as to element, ionization stage, and broadening mechanism (in the case of foreign gas broadening the perturbing species are listed), and it is indicated whether the data are experimentally or theoretically derived. (3) While in the two preceding parts of the bibliography the references are listed for brevity by identification numbers only, in Part 3 all references are listed completely by journal, authors, and title and are generally arranged by year of publication and alphabetically by authors' names within the year. (4) This section contains a list of all authors and their papers. (5) A final section provides corrections or additions to the second supplement to the original bibliography.

SP380. **Supplement 1. Photonuclear Data Index, 1973-1977**, E. G. Fuller and H. M. Gerstenberg, *Nat. Bur. Stand. (U.S.), Spec. Publ. 380 Suppl. 1*, 102 pages (Aug. 1978) SN003-003-01967-4.

Key words: bibliography; data index; elements; isotopes; nuclear physics; photonuclear reactions.

This index, a supplement to NBS Special Publication 380, *Photonuclear Reaction Data, 1973*, primarily covers data published in the period from January 1965 through December 1977. Organized by element and isotope, each entry in the index is for a specific reaction reported in a given reference. Information is given on the type of measurement, excitation energies studied, source type and energies, detector type and angular ranges covered in the measurement. Also included is an index to the more than 1000 data sets currently available in the Photonuclear Data Center's digital data library.

SP400-30. **Semiconductor measurement technology: Automated scanning low-energy electron probe (ASLEEP) for semiconductor wafer diagnostics**, A. Christou, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-30*, 38 pages (Apr. 1978) SN003-003-01905-4.

Key words: automated scanning low-energy electron probe; lateral inhomogeneity; oxide uniformity; scanning low-energy electron probe; semiconductor defect density; semiconductor resistivity; semiconductor wafer diagnostics.

This report summarizes the results of a three-year effort in the development of a computer Automated Scanning Low-Energy Electron Probe (ASLEEP) for semiconductor wafer diagnostics. Experiments designed to explore the measurement capabilities of ASLEEP for measurements on silicon, gallium arsenide, and indium phosphide are described. Four areas were emphasized: 1) semiconductor resistivity, 2) semiconductor defect density, 3) lateral inhomogeneities, and 4) oxide uniformity. Although oxide charging problems limit the utility of ASLEEP in its present form for silicon, defects and lateral inhomogeneities could be readily detected in gallium arsenide and indium phosphide.

SP400-32. **Semiconductor measurement technology: Microelectronic test pattern NBS-4**, W. R. Thurber and M. G. Buehler, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-32*, 66 pages (Apr. 1978) SN003-003-01906-2.

Key words: dopant density; microelectronics; MOS capacitors; *n-p-n* transistor fabrication; *p-n* junctions; resistivity; semiconductor electronics; sheet resistors; silicon; test pattern; test structures.

Microelectronic test pattern NBS-4 is a revision of test pattern NBS-3 which was designed primarily for evaluation of the resistivity-dopant density relationship in silicon. Major changes include the addition of optional BASE-CONTACT and GATE masks and the incorporation of several new structures, some useful for the resistivity-dopant density work, and others, mostly sheet resistors, included for evaluation of new designs.

The NBS-4 pattern contains 38 test structures such as planar four-probe resistors, sheet resistors, MOS capacitors, *p-n* junctions, bipolar and MOS transistors, Hall effect device, and process control structures. The overall pattern is a square 200 mil (5.08 mm) on a side and is divided into four quadrants which are separated by scribe lines. A detailed layout of each structure is presented including both a top view and a cross sectional view. Photomicrographs of each quadrant and the quadrants of the six masks used in the fabrication of the pattern are shown in an appendix.

SP400-36. Semiconductor measurement technology. Progress report, July 1 to September 30, 1976, W. M. Bullis and J. F. Mayo-Wells, Eds., Nat. Bur. Stand. (U.S.), Spec. Publ. 400-36, 78 pages (July 1978) SN003-003-01955-1.

Key words: Auger electron spectroscopy; capacitance-voltage methods; dew-point sensing; dragging-stylus probe; electrical properties; electronics; four-probe method; hermeticity; hole mobility; infrared reflectance; ion implantation; ion microprobe mass analysis; line-width measurements; nuclear-track technique; particle-impact noise detection; photolithography; photovoltaic method; *p-n* junction; power-device grade silicon; resistivity; resistivity variations; resistors, sheet; safe operating area, transistor; scanning, acoustic microscope; second breakdown; semiconductor materials; semiconductor process control; silicon; silicon dioxide; silicon-on-sapphire; spreading resistance; test patterns; test structures; thermally stimulated current and capacitance; thermal properties, transistor; thermal response; thyristors; transistors, power; ultraviolet reflectance; x-ray photoelectron spectroscopy.

This progress report describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Both in-house and contract efforts are included. The emphasis is on silicon device technologies. Principal accomplishments during this reporting period included (1) completion of the systematic study of the effects of surface preparation and probe material on the empirical calibration between specimen resistivity and spreading resistance of *n*- and *p*-type silicon; (2) initial evaluation of the nuclear-track technique for quantitative determination of trace amounts of boron in silicon; (3) development of procedures for using an optical research microscope to make accurate measurements of the width of a clear line as narrow as 0.5 μm in a completely or nearly opaque background; (4) design of a compact cross-bridge test structure for electrical measurement of line width and sheet resistance in minimum line-width geometries; (5) completion of the initial phase of the study of the particle-impact noise detection test for screening devices for the presence of loose particles in the package; (6) demonstration of a greater-than-expected line resolution capability for the scanning acoustic microscope; and (7) development of a nondestructive technique to measure the onset of second breakdown in forward-biased, medium-power transistors. Also reported is other ongoing work on materials characterization by electrical and physical analysis methods, materials and procedures for wafer processing, photolithography, test pat-

terns, and device inspection and test procedures. Supplementary data concerning staff, publications, and technical services are included as appendices.

SP400-46. Semiconductor measurement technology: Automated photomask inspection, D. B. Novotny and D. R. Ciarlo, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-46, 38 pages (Apr. 1978) SN003-003-01912-7.

Key words: alignment tolerance; automated photomask inspection; dimensional inspection; flying-spot scanner; microdensitometer; optical overlay; photomask; spatial filtering; TV-microscope; visual defect inspection.

Methods that may be suitable for automated photomask inspection for visual defects (spots, pinholes, etc.) or dimensional compliance are analyzed and discussed. The analysis of each method includes examinations of the physical principles upon which it is based and the amount of misalignment that can be tolerated. The size of the minimum visual defect to be detected was taken as 2 μm . The methods analyzed for visual defect inspection are the optical-overlay; the dual-beam, flying-spot-scanner; the TV-microscope; and the spatial-filtering methods. For dimensional inspection, an analysis of line-edge location and operating criteria for the microdensitometer are presented. The fabrication of photomasks with intentionally introduced and controlled defects is described together with preliminary results of automated inspections of these photomasks. It was concluded that: automated inspection systems should be dedicated either to inspection for visual defects or dimensional compliance, not both; and the dimensional tolerances on masks, both those of the feature dimensions in the die patterns as well as those in the dimensions between the dice, must be significantly smaller than the size of the minimum defect to be detected.

SP400-49. Semiconductor measurement technology: Angular sensitivity of controlled implanted doping profiles, R. G. Wilson, H. L. Dunlap, D. M. Jamba, and D. R. Myers, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-49, 61 pages (Nov. 1978) SN003-003-01997-6.

Key words: profiling; controlled doping profiles; critical channelling angle; C-V profiling; ion beam scanning; ion channelling; ion implantation; Rutherford backscattering alignment; silicon crystallographic orientation.

Ion implantation can be used to produce accurately controlled doping profiles for silicon devices and integrated circuits. The work reported here determines the angle at which the ion beam must strike the substrate in order to maintain control over the channeled and random equivalent depth distributions of carriers as measured by 1-MHz differential capacitance-voltage (C-V) profiling. A method to calculate the classical critical angle for channeling (ψ_c) is presented. Data are presented that characterize the variation in the depth distribution of carriers with substrate orientation, incident ion species, and incident ion energy, for a range of critical angles. This study establishes the degree of control of the angle between the ion beam and the crystallographic orientation needed to produce the limiting cases of either optimal channeling or maximum randomization of ion trajectory in the substrate. For the cases studied here, the angle between the ion beam and the substrate or orientation must be controlled to within 0.5 ± 0.2 deg to obtain the optimally channeled depth distribution for implantation directly into the low index crystallographic orientations. Alternatively, to minimize unintentional channeling, the substrate must be oriented so that the nearest low index crystallographic direction is at least twice the classical critical angle away from the beam direction. The substrate tilt angles required to satisfy these conditions can exceed the 7- to 10-deg

tilt commonly used in ion implantation. The implications of these results for uniform and reproducible ion implantation within the semiconductor industry are discussed.

SP400-53. Semiconductor measurement technology: Microelectronic processing laboratory at NBS, T. F. Leedy and Y. M. Liu, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-53*, 33 pages (Dec. 1978) SN003-003-02004-4.

Key words: diffusion; metallization; oxidation; photolithography; silicon; transistors.

This report describes the facilities and processes used at NBS for the fabrication of *npn* silicon transistors in support of the Electron Devices Division's program in process control and measurement technology. The description of the processes includes details of techniques used for contamination control and the various steps required for the preparation of planar silicon transistors. A description of the electrical properties of the devices is also presented.

SP457-2. Building technology publications 1977—Supplement 2, J. R. Debelius, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457-2*, 113 pages (Aug. 1978) SN003-003-01962-3.

Key words: abstracts; Center for Building Technology; key words; publications.

This report presents the National Bureau of Standards' (NBS) Center for Building Technology (CBT) publications for 1977. It is the second supplement to Special Publication 457, *Building Technology Publications 1965-1975* and covers the period from January 1, 1977 to December 31, 1977. It includes an abstract of each NBS publication, titles and abstracts of papers published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

This report provides the primary means of communicating the results of CBT programs to its varied technical audiences, as well as to the general public. Publications constitute a major end product of CBT's efforts and in 1977 appeared in several NBS publication series (Building Science Series, Technical Note, Special Publication, Handbook and NBS Interagency Report).

SP480-15. The police patrol car: Economic efficiency in acquisition, operation, and disposition, R. T. Ruegg, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-15*, 135 pages (Apr. 1978) SN003-003-01837-6.

Key words: fleet management; life cycle costing; patrol cars; police fleets; vehicle leasing; vehicle management.

This study uses the techniques of life cycle costing to analyze some of the decision problems of police fleet management. It addresses the following questions: (1) What are the cost effects of purchasing different sizes of patrol cars and different optional equipment?, (2) What are the advantages and disadvantages of direct ownership of vehicles as compared with leasing vehicles?, (3) How do the costs of contracting out maintenance compare with costs of an in-house shop?, (4) What are the effects of alternative utilization practices on fleet costs?, (5) How often should vehicles be replaced?, (6) What method of vehicle disposition is most efficient? The techniques used to compare costs of alternative systems are described in a chapter on life cycle costing methodology. Cost estimates and empirical data are presented in the many tables, exhibits, and charts which support the study. Existing fleet practices are described. Findings of the study are expressed as general guidelines for fleet management. The focus of the study is on police patrol cars, but the methods are applicable to other kinds of vehicles.

SP480-16. Emergency vehicle warning lights: State of the art, G. L. Howett, K. L. Kelly, and E. T. Pierce, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-16*, 167 pages (Sept. 1978) SN003-003-01901-1.

Key words: color; conspicuity; emergency vehicle; flashing light; lights; motor vehicle; photometry; signal light; standards; vehicle, emergency; vision, peripheral; warning signal.

Information is presented concerning all aspects of emergency-vehicle warning lights (EVWLs). A survey of the present situation includes: the nonuniformity of state EVWL laws; the factors entering into the choice of an EVWL configuration; a list and photographs of a variety of EVWL types; and a list of EVWL manufacturers and distributors. Background material relating to the perception of EVWL signals includes: an analysis of general warning-signal perception; a description of the visual stimulus pattern confronting a driver being approached by an emergency vehicle from various directions; and a summary of the characteristics of peripheral vision (including luminous efficiency, color perception and discrimination, and flicker and movement perception). Perceptual factors affecting the conspicuity of EVWL signals are discussed, including: effective intensity; flash-rate; on-off ratio; pulse shape and flash duration; spatial sweep of beam; color; number and spatial pattern of lights; cross-sectional area; motion; temporal phase relations; and the role of the background. Physical measurements on EVWL units are described, including: angular intensity distribution and beamspread; flash rate; pulse shape and flash duration; effective intensity; color; and variables in rotating devices. A glossary, extensive enough to be helpful in reading the technical literature, is included.

SP480-17. Auto headlight glass: Visible features of forensic utility, H. L. Steinberg, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-17*, 137 pages (Feb. 1978) SN003-003-01857-1.

Key words: accident investigation; fluting pattern; forensic science; headlight glass; hit-and-run accidents; sealed beam headlights; visual classifications.

This report documents those visual aspects of sealed beam headlights which may be of use in criminal investigations involving such evidence. These visual aspects include fluting pattern, lampmaker monogram, mold markings, beam and lamp type markings, and curvature. Only sealed beam headlights used in passenger vehicles having significant U.S. sales are considered.

SP480-20. Directory of law enforcement and criminal justice associations and research centers, Law Enforcement Standards Laboratory, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-20*, 51 pages (Mar. 1978) SN003-003-01904-6.

Key words: associations; criminal justice; law enforcement; research centers.

The directory lists national, nonprofit professional and volunteer social action associations and research centers which are active in the fields of law enforcement and criminal justice. The international and foreign organizations which are listed, either have a large number of American members, have a U.S. chapter, or are doing work which is applicable to the United States. The local organizations which are listed, either cover several States or are of national interest. The organizations are listed alphabetically. The format of an entry is: title of organization; mailing address; officer; telephone number; year founded; number of members; number of staff; description of purpose and activities; affiliations; publications; meetings. A subject index is included.

SP480-28. **The development and testing of a highly directional dual-mode electronic siren**, R. L. Fisher, D. D. Toth, D. S. Blomquist, and J. S. Forrer, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-28*, 51 pages (Feb. 1978) SN003-003-01925-9.

Key words: acoustics; broadside array; directional siren; loudspeaker array; phased array; siren; sound; warning device.

NBS has developed a dual-mode directional electronic siren which can be electrically switched under manual control from a strong narrow beam of sound in the forward direction for open highway usage to a broader beam for use near roadway intersections. The intense beam of sound is produced by a vehicular-roof-mounted broadside array consisting of four compact commercial 100 watt electronic siren loudspeakers spaced 15.2 cm (6.0 in) apart. Two electronic systems were developed to broaden the inherently narrow beam of the broadside array. One system swept the beam from side to side. The second system involved the use of a filter network. A-weighted sound pressure level measurements made in an anechoic chamber and outdoors on a vehicle showed that the maximum sound pressure level of the NBS dual-mode siren is 7 to 10 dB higher in the desired directions than a single 100 watt commercial electronic siren.

SP480-29. **Survey of clothing requirements for uniformed law enforcement officers**, Welton & Co., *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-29*, 22 pages (Apr. 1978) SN003-003-01919-4.

Key words: clothing survey; law enforcement officer's uniforms; police; police clothing; police uniforms; user requirements for police uniforms.

Until recently, the police uniform has largely been considered or designed primarily for identification. There is, however, a growing realization in the law enforcement community that uniforms should also be designed and constructed to serve other requirements, namely: comfort, durability, and weather and hazard protection. This document reports the results of a survey of user requirements from 307 police agencies and provides guidance to law enforcement officials in the design, construction and materials used in police uniforms.

SP480-31. **Transfer of monochrome video information from magnetic tape to motion picture film for archival storage**, J. C. Richmond, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-31*, 14 pages (May 1978) SN003-003-01932-1.

Key words: archival storage; electron beam recording; kinescope recording; laser scanning; magnetic tape; mid-field splice; motion picture film; rapid pulldown; video tape.

Magnetic tape, and particularly video magnetic tape, is not an archival material. Measurable deterioration occurs in a period of five years, and noticeable deterioration in 20 years. Motion picture film, on the other hand, is considered to be an archival material when properly processed, handled and stored. This report describes several methods used to transfer video information from magnetic tape to motion picture film, which include kinescope recording, using the mid-field splice or rapid pulldown method of synchronizing frame rates, electron beam recording and laser scanner recording.

SP480-32. **The role of behavioral science in physical security**. Proceedings of the Second Annual Symposium, Mar. 23-24, 1977, J. J. Kramer, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-32*, 93 pages (June 1978) SN003-003-01950-0.

Key words: adversary characteristics; animal research; behavioral science; collusion; ergonomics; human factors;

human reliability; physical security; physiological psychology; threat analysis; terrorism; training.

This document contains the proceedings of the Second Annual Symposium "The Role of Behavioral Science in Physical Security." The symposium provided a forum for presenting and discussing continuing, current behavioral science contributions to physical security. Nine papers were presented; timely questions and challenges were explored at the end of the first day; and, the proceedings concludes with a Panel Session devoted to synthesis and future research directions. *These proceedings include the following papers (indented):*

The inadvertent adversary to nuclear security—Ourselves, D. D. Darling, *SP480-32*, pp. 1-5 (June 1978).

A behavioral analysis of the adversary threat to the commercial nuclear industry—A conceptual framework for realistically assessing threats, P. A. Karber and R. W. Mengel, *SP480-32*, pp. 7-19 (June 1978).

Behavior and misbehavior of terrorists: Some cross-national comparisons, D. J. Pratt, *SP480-32*, pp. 21-26 (June 1978).

Attributes of potential adversaries to U.S. nuclear programs, A. M. Fine, *SP480-32*, pp. 27-33 (June 1978).

Some ideas on structuring the problem of collusion, J. NiCastro and H. Kendrick, *SP480-32*, pp. 35-40 (June 1978).

Response force selection and training, S. L. Galloway, *SP480-32*, pp. 41-44 (June 1978).

Uses of animal sensory systems and response capabilities in security systems, R. E. Bailey and M. B. Bailey, *SP480-32*, pp. 49-62 (June 1978).

Physiological correlates of information processing load—Ongoing research and potential applications of physiological psychology, T. E. Bevan, *SP480-32*, pp. 63-68 (June 1978).

Toward the collection of critically evaluated ergonomics data, H. P. Van Cott and J. J. Kramer, *SP480-32*, pp. 69-75 (June 1978).

SP480-34. **Test method for the evaluation of metallic window foil for intrusion alarm systems**, G. N. Stenbakken, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-34*, 10 pages (Aug. 1978) SN003-003-01961-5.

Key words: alarm; burglar alarm; detector; intrusion alarm; metallic window foil; test method; window foil.

This report describes a test method to evaluate metallic foil used as a sensor in intrusion alarm systems to detect the breakage of glass. Laboratory tests demonstrated that metallic window foil may not break when the glass upon which it is installed is broken. In addition to presenting a detailed test procedure for metallic window foil, evaluation criteria are also recommended.

SP480-35. **Catalog of security equipment**, J. V. Fechter and E. M. Robertson, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-35*, 58 pages (Nov. 1978) SN003-003-01970-4.

Key words: alarms; burglary; catalogs; crimes of opportunity; intrusion detectors; physical security; robbery; security equipment; target hardening equipment; theft.

This catalog is concerned primarily with security equipment which can be used to prevent "crimes of opportunity" against homes and businesses. The purpose of the catalog is to make

readers aware of the available types of security equipment and to identify their manufacturers. Equipment is classified into four functional areas: physical security, access control, alarm systems, and business and industry equipment. Within each functional area, each item of equipment is identified and described in terms of its cost range, usual application, and manufacturers.

SP496, Vols. 1 and 2. **Applications of phase diagrams in metallurgy and ceramics.** Proceedings of a Workshop held at the National Bureau of Standards, Gaithersburg, MD, Jan. 10-12, 1977, G. C. Carter, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 496/1*, 767 pages; *496/2*, 847 pages (Mar. 1978) SN003-003-01895-3.

Key words: ceramics; computer predictions; critical evaluations; data compilations; electronic materials; industrial needs; metallurgy; phase diagrams; theory of phase diagrams; thermodynamics.

The proceedings of a Workshop on Applications of Phase Diagrams in Metallurgy and Ceramics, held at the National Bureau of Standards, Gaithersburg, Maryland, on January 10-12, 1977, is presented in this NBS Special Publication. The Workshop was co-sponsored by the Institute for Materials Research and the Office of Standard Reference Data, NBS, and the National Science Foundation, the Defense Advanced Research Projects Agency, the Office of Naval Research, the National Aeronautics and Space Administration, the Energy Research and Development Administration, and the U.S. Army Research Office.

The purpose of the Workshop was to assess the current national and international status of phase diagram determinations and evaluations for alloys, ceramics and semiconductors; to determine the needs and priorities, especially technological, for phase diagram determinations and evaluations; and to estimate the resources being used and potentially available for phase diagram evaluation. These proceedings reflect the detailed contents of the Workshop for both the tutorial and review sessions as well as four poster sessions and four panel sessions covering the subjects; critical phase diagram availability, user needs of phase diagrams, experimental methods of determination, theoretical methods of calculation and prediction, methods of phase diagram representations of calculation and prediction, methods of phase diagram representations (especially multicomponent) and distribution to the user. Three of the panels addressed the subject of phase diagram needs in industrial applications.

These proceedings represent documentation of this assessment, and constitute a valuable resource to workers in these areas, especially those planning to initiate phase diagram programs. Most subjects within the overall scope have been dealt with substantially in these proceedings; a few specialized topics such as surface and small particle phases, needed for the study of catalysis, have not been treated in detail. As the Alloy Data Center maintains a continuing phase diagram program, we would like to receive suggestions for similar topics of current and future interest, descriptions of new needs, or addenda and corrigenda to these proceedings. A tear-off sheet has been provided at the end of these proceedings for this purpose to be sent to the NBS Alloy Data Center. *These proceedings include the following papers (indented):*

Phase diagram compilation activities in ceramics, R. S. Roth, L. P. Cook, T. Negas, G. W. Cleek, and J. B. Wachtman, Jr., *SP496/1*, pp. 1-22 (Mar. 1978).

Present status of phase diagram compilation activity for semiconductors, C. D. Thurmond, *SP496/1*, pp. 23-35 (Mar. 1978).

Phase diagram compilations for metallic systems—An assessment of ongoing activities, G. C. Carter, *SP496/1*, pp. 36-89 (Mar. 1978).

Organization of phase diagram information in the Soviet Union, N. V. Ageev, D. L. Ageeva, T. P. Kolesnikova, and L. A. Petrova, *SP496/1*, pp. 90-99 (Mar. 1978).

A survey of high pressure phases of materials, L. Merrill, *SP496/1*, pp. 100-120 (Mar. 1978).

Phase diagram information from computer banks, I. An-sara, *SP496/1*, pp. 123-141 (Mar. 1978).

An overview of the determination of phase diagrams, F. N. Rhines, *SP496/1*, pp. 142-163 (Mar. 1978).

Proposal for a comprehensive handbook on "Ternary Phase Diagrams of Metals", F. Aldinger, E. T. Henig, H. L. Lukas, and G. Petzow, *SP496/1*, p. 164 (Mar. 1978).

Phases and phase relations in the binary oxide systems containing WO_3 , L. L. Y. Chang, *SP496/1*, pp. 165-225 (Mar. 1978).

RIC in phase with rare-earth constitutional diagrams, K. A. Gschneidner, Jr., M. E. Verkade, and B. L. Evans, *SP496/1*, pp. 226-228 (Mar. 1978).

Evaluations of phase diagrams and thermodynamic properties of ternary copper alloy systems, Y. A. Chang, J. P. Neumann, and U. V. Choudary, *SP496/1*, pp. 229-250 (Mar. 1978).

Phase equilibria in variable valence oxide systems, W. B. White, *SP496/1*, pp. 251-256 (Mar. 1978).

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A review of phase equilibria in the Na_3AlF_6 -LiF- CaF_2 - AlF_3 - Al_2O_3 system, D. F. Craig, R. T. Cassidy, and J. J. Brown, Jr., *SP496/1*, pp. 272-345 (Mar. 1978).

Methods of compiling and editing "Structure and Properties of Binary Metallic Systems", A. E. Vol and I. K. Kagan, *SP496/1*, pp. 346-350 (Mar. 1978).

English Translation, *SP496/1*, pp. 351-354 (Mar. 1978).

The determination of phase diagrams for liquid oxides and metallurgical slags by hot-wire microscopy, H. A. Fine, *SP496/1*, pp. 355-374 (Mar. 1978).

Experimental techniques in phase diagram determination of superconducting compounds containing volatile components at temperatures up to 2200 °C, R. Flükiger and J. L. Jorda, *SP496/1*, pp. 375-406 (Mar. 1978).

Application of experimental techniques and the critical determination of phase equilibria in oxide systems, F. P. Glasser, *SP496/1*, pp. 407-422 (Mar. 1978).

Protective coatings for superalloys and the use of phase diagrams, M. R. Jackson and J. R. Rairden, *SP496/1*, pp. 423-439 (Mar. 1978).

Application of the scanning electron microscope to the study of high temperature oxide phase equilibria, L. P. Cook and D. B. Minor, *SP496/1*, pp. 440-449 (Mar. 1978).

Hyperfine techniques and the determination of phase diagrams, R. C. Reno, L. J. Swartzendruber, G. C. Carter, and L. H. Bennett, *SP496/1*, pp. 450-461 (Mar. 1978).

Experimental determination of phase diagrams with the electron microprobe and scanning transmission electron microscope, A. D. Romig, Jr. and J. I. Goldstein, *SP496/1*, pp. 462-482 (Mar. 1978).

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Phase equilibria in the system MgO-RCI (R=Li, Na and K) solution under hydrothermal conditions by means of a capsule bursting method, S. Somiya, K. Nakamura, S. Hirano, and S. Saito, *SP496/1*, pp. 508-515 (Mar. 1978).

High-energy ion beams in phase diagram determination, J. E. Smugeresky and S. M. Myers, *SP496/1*, pp. 516-544 (Mar. 1978).

Phase equilibrium diagrams in terms of electronic structure, F. E. Wang, *SP496/1*, pp. 545-549 (Mar. 1978).

Use of segregation phenomena in solid solutions as a method for determining solidification diagrams. Application to some $\text{Sc}_2\text{O}_3\text{-Ho}_2\text{O}_3$ and $\text{Sc}_2\text{O}_3\text{-Dy}_2\text{O}_3$ systems, J. M. Badie, *SP496/1*, pp. 550-565 (Mar. 1978).

Studies of the Fe-C-B phase diagram by autoradiography, T. B. Cameron and J. E. Morral, *SP496/1*, p. 566 (Mar. 1978).

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Phase diagram of a specimen at high temperatures under external tensile or shear stress or both, K. M. Khanna, *SP496/1*, pp. 575-577 (Mar. 1978).

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Correlations and predictions of metal-boron phase equilibria, K. E. Spear, *SP496/2*, pp. 744-762 (Mar. 1978).

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The mathematical representation of activity data in three component systems, I. Eliezer and R. A. Howald, *SP496/2*, pp. 803-845 (Mar. 1978).

A program for binary phase equilibria using the Redlich-Kister equations, I. Eliezer and R. A. Howald, *SP496/2*, pp. 846-906 (Mar. 1978).

Polynomial representation of the excess free energy of multicomponent systems and their use in phase diagram calculations, H. Gaye and C. H. P. Lupis, *SP496/2*, pp. 907-908 (Mar. 1978).

Thermodynamic data for the Fe-O system evaluated using a new computer-aided strategy, J. L. Haas, Jr. and J. R. Fisher, *SP496/2*, pp. 909-910 (Mar. 1978).

Analysis and synthesis of phase diagrams of the Fe-Cr-Ni, Fe-Cu-Mn and Fe-Cu-Ni systems, M. Hasebe and T. Nishizawa, *SP496/2*, pp. 911-954 (Mar. 1978).

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Synthesis of binary metallic systems I. Isomorphous Systems II. Simple Eutectic Systems, S. S. Balakrishna and A. K. Mallik, *SP496/2*, pp. 1200-1219 (Mar. 1978).

Quantitative fits to phase lines and high temperature thermodynamic data for systems forming semiconductor compounds, R. F. Brebrick, *SP496/2*, pp. 1220-1236 (Mar. 1978).

Table of contents and cumulative subject index for "Phase diagrams of metallic systems," N. V. Ageev, editor, Volumes 1-19, C. M. Scheuermann, *SP496/2*, pp. 1237-1306 (Mar. 1978).

Standards for publication of phase equilibrium studies, E. R. Kreidler, *SP496/2*, pp. 1307-1324 (Mar. 1978).

Formatting and distributing evaluated reference data: The Office of Standard Reference Data at the National Bureau of Standards, S. P. Fivozinsky and G. B. Sherwood, *SP496/2*, pp. 1325-1331 (Mar. 1978).

Needs for phase diagram information in nonferrous industry, P. R. Ammann, *SP496/2*, pp. 1334-1352 (Mar. 1978).

Primary metals production, H. R. Larson, *SP496/2*, pp. 1354-1359 (Mar. 1978).

Use of phase diagrams in iron and steelmaking, R. D. Pehlke, *SP496/2*, pp. 1360-1370 (Mar. 1978).

User needs for phase diagrams for materials processing: Glasses, R. C. Doman and R. N. McNally, *SP496/2*, pp. 1378-1381 (Mar. 1978).

Equilibrium diagrams in nonferrous alloys, L. F. Mondolfo, *SP496/2*, pp. 1382-1408 (Mar. 1978).

Phase equilibria in the development of high temperature structural ceramics, S. Prochazka, *SP496/2*, pp. 1409-1410 (Mar. 1978).

Phase diagram information for processing of superconductors, D. Dew-Hughes, *SP496/2*, pp. 1411-1417 (Mar. 1978).

Importance of phase diagrams in the electric power industry, R. I. Jaffee, *SP496/2*, pp. 1420-1425 (Mar. 1978).

Summary of presentation on user needs of phase diagrams: The solar energy field, A. I. Mlavsky, *SP496/2*, p. 1426 (Mar. 1978).

The use of phase equilibria in the manufacture of spinel ferrites, P. Slick, *SP496/2*, p. 1427 (Mar. 1978).

The application of the phase diagram to thermal energy storage technology, J. E. Beam and J. E. Davison, *SP496/2*, pp. 1428-1439 (Mar. 1978).

The needs for phase equilibria data in the development of magnetohydrodynamics, R. A. Howald and I. Eliezer, *SP496/2*, pp. 1440-1450 (Mar. 1978).

Summary remarks, J. F. Elliott, *SP496/2*, pp. 1453-1469 (Mar. 1978).

Evaluation of conference, R. A. Howald and J. E. Selle, *SP496/2*, pp. 1470-1471 (Mar. 1978).

Comments on the phase diagram workshop, D. de Fontaine, *SP496/2*, pp. 1472-1478 (Mar. 1978).

The relation between bond length and crystal structures in metals, A. P. Miodownik, *SP496/2*, pp. 1479-1505 (Mar. 1978).

On computerized construction of multidimensional phase diagrams in a factographic IRS, I. V. Tulupova and V. S. Stein, *SP496/2*, pp. 1506-1519 (Mar. 1978).

SP497. Hydraulic research in the United States and Canada, 1976, P. H. Gurewitz, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 497*, 377 pages (Apr. 1978) SN003-003-01884-8.

Key words: fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1975-1976 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

SP498. Science on its way to work, M. A. Baum and S. A. Washburn, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 498*, 44 pages (Apr. 1978) SN003-003-01943-7.

Key words: basic research; building technology; computer technology; energy conservation and research; fire research; radiation safety; standard reference data; standard reference materials; standards development; technology transfer; weights and measures.

This report describes the activities of the National Bureau of Standards during the fiscal year ending September 30, 1977. Particular attention is paid to the impact of these programs on industry, government, and the international scene, as well as our everyday lives. Emphasis is also placed on the transfer mechanisms—how technology gets from here to there. The report includes a people section, a list of selected publications, a financial statement, staff statistics, a summary of legislation on which NBS missions are based, and a directory listing the Bureau's major programs and divisions with managers and their phone numbers.

SP499. Noise criteria for buildings: A critical review, S. L. Yaniv and D. R. Flynn, *Nat. Bur. Stand. (U.S.), Spec. Publ. 499*, 82 pages (Jan. 1978) SN003-003-01870-8.

Key words: building acoustics; building codes; isolation; noise; noise criteria; rating scheme; sound transmission.

A review is given of existing criteria that could be applied to rating the noise environment in dwellings, to rating noise isolation between dwellings, and to rating noise isolation from outside to inside a dwelling. It is concluded that the central problem is to select appropriate criteria for rating the interior noise environment. Once this is done, criteria for noise isolation can be derived directly and these in turn can be used to derive performance requirements for building elements, such as partitions and exterior walls.

SP500-21, Vol. 1. **Computer science & technology: Design alternatives for computer network security**, G. D. Cole and D. K. Branstad, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-21, Vol. 1*, 173 pages (Jan. 1978) SN003-003-01881-3.

Key words: access control; authentication; communication; computer networks; cryptography; encryption; security.

The security problems associated with a network of computers are an extension of those of stand-alone computer systems, but require additional security controls due to the distributed and autonomous nature of the network components. The purpose of this investigation was to generate a pre-development specification for such security mechanisms by determining the issues and tradeoffs related to network security over a broad range of network applications, topologies and communications technologies.

The approach which was taken was that of utilizing a dedicated network Security Controller (minicomputer) for checking the authentication of requestors, and, to some extent, for authorization checking as well. The enforcement of the Security Controller functions would be by means of Intelligent Cryptographic Devices, which could be remotely keyed by the Security Controller when a requested communication was authorized. The Intelligent Cryptographic Device would incorporate the National Bureau of Standards Data Encryption Standard algorithm.

The investigation showed that this approach is a viable solution to the network security problems of a large class of computer networks, and that such security mechanisms should be developed for operational usage.

SP500-21, Vol. 2. **Computer science & technology: The Network Security Center: A system level approach to computer network security**, F. Heinrich, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-21, Vol. 2*, 69 pages (Jan. 1978) SN003-003-01881-3.

Key words: access authorization; access control; authentication; computer network security; cryptography; end-to-end encryption; inter-computer network; internetting; NBS Data Encryption Standard; Network Cryptographic Devices; Network Security Center.

This report describes a unique approach to the solution of computer network security problems, and provides guidance in the areas of network security architectural issues and implementation options. The approach is based on a network resource, called a Network Security Center (NSC), which performs the functions of user identification/authentication and access request authorization. The NSC works in concert with Network Cryptographic Devices (NCDs) to enforce access control policy through the creation or denial of logically separate cryptographic connections between subjects (users) and objects (resources). The use of a NSC in a network permits effective control over network access, provides for audit data collection, and provides protection against tampering or modification of the access control data base. The architecture presented permits multiple NSCs to operate together, thus addressing issues such as modular expandability, regional subnets, and local control over resources. Network Cryptographic Devices that use the NBS Data Encryption Standard algorithm and are capable of being remotely keyed are a vital part of the NSC security approach. NCDs provide end-to-end cryptographic message protection, source-destination authentication of identity and, through the remote keying capability, the enforcement mechanism for NSC access control decisions. Implementation options for an NSC are presented, covering the areas of data structures, I/O structure, control structure, and size and performance limitations.

SP500-24. **Computer science & technology: Performance assurance and data integrity practices**, R. L. Patrick and R. P. Blanc, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-24*, 53 pages (Jan. 1978) SN003-003-01879-1.

Key words: best practice; data integrity; data processing; error correcting; high integrity; performance assurance.

This report identifies the approaches and techniques now practiced for detecting, and when possible, correcting malperformance as it occurs in computer information systems.

This report is addressed to two audiences: to the systems designer using stock commercial hardware and software who is creating a system which will tax the available hardware, software, or staff skills; and to the manager who wishes to chronicle the deficiencies in an existing system prior to improvement. It enumerates 67 items of current practice which prevent computer malperformance.

SP500-25. **Computer science & technology: An analysis of computer security safeguards for detecting and preventing intentional computer misuse**, B. Ruder, J. D. Madden, and R. P. Blanc, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-25*, 80 pages (Dec. 1977) SN003-003-01871-6.

Key words: computer crime; computer fraud; computer misuse; computer safeguards; computer security; computer security model; privacy.

Stanford Research Institute (SRI) has an extensive file of actual computer misuse cases. The National Bureau of Standards asked SRI to use these cases as a foundation to develop ranked lists of computer safeguards that would have prevented or detected the recorded intentional misuses.

This report provides a working definition of intentional computer misuse, a construction of a vulnerability taxonomy of intentional computer misuse, a list of 88 computer safeguards, and a model for classifying the safeguards. In addition, there are lists ranking prevention and detection safeguards with an explanation of the method of approach used to arrive at the lists.

This report should provide the computer security specialist with sufficient information to start or enhance a computer safeguard program.

SP500-26. **Computer science & technology: COBOL instrumentation and debugging: A case study**, G. Lyon, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-26*, 33 pages (Jan. 1978) SN003-003-01873-2.

Key words: COBOL; execution monitoring; symbolic debugging; timesharing.

Traditionally COBOL has been run in batch execution and debugged through abnormal terminations; indeed, whole books have been devoted to deciphering COBOL core dumps. With modern equipment there is little excuse for writing COBOL source code this way. A carefully chosen example (a COBOL program to tally reserved words and cross-reference other tokens) is used as a vehicle for an examination of a contemporary COBOL coding experience. COBOL can be written quite fast interactively, and COBOL programs can be easily tuned if good timing facilities are available. Strengths and limitations of a current debugging package are highlighted in the case study.

SP500-27. **Computer science & technology: Computer security and the Data Encryption Standard**. Proceedings of the Conference on Computer Security and the Data Encryption Standard held at the National Bureau of Standards in Gaithersburg, MD, Feb. 15, 1977, D. K. Branstad, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-27*, 135 pages (Feb. 1978) SN003-003-01891-1.

Key words: computer security; cryptography; Data Encryption Standard; encryption; key management; network security.

These proceedings include papers or summaries of presentations of the fifteen speakers who participated in the Conference on Computer Security and the Data Encryption Standard held at the National Bureau of Standards on February 15, 1977. Representatives from Federal agencies and private industry presented technical information and guidance with respect to computer security and the Data Encryption Standard. Subjects of the papers and presentations include physical security, risk assessment, software security, computer network security, applications and implementation of the Data Encryption Standard. The questions raised at the conference and their answers are included in the proceedings. *These proceedings include the following papers (indented):*

The Data Encryption Standard in perspective, R. M. Davis, *SP500-27*, pp. 4-13 (Feb. 1978).

Key words: computer security; encryption; standard.

The Data Encryption Standard was approved as a Federal Information Processing Standard by the Secretary of Commerce on November 23, 1976. This Standard was developed as a part of the Computer Security Program within the Institute for Computer Sciences and Technology at the National Bureau of Standards. This paper places this standard in perspective with other computer security measures that can and should be applied to Federal computer systems either before or coincident to using the Data Encryption Standard.

NBS initiated the standards development effort leading to adoption of the DES in 1972. During this period, NBS solicited for algorithms and information upon which a standard could be based, published for comment the algorithm which best satisfied the requirements of an encryption standard, and coordinated the effort with both the potential using communities and supplying communities.

This paper outlines the environment surrounding and the history of the Data Encryption Standard and discusses the objectives of additional standards to be developed within the computer security program.

Computer security risk assessment, R. H. Courtney, *SP500-27*, pp. 15-17 (Feb. 1978).

Data encryption and its relationship to physical security planning, R. V. Jacobson, *SP500-27*, pp. 18-24 (Feb. 1978).

Key words: data security; encryption.

Data encryption is a powerful tool for protecting data against discovery by an unauthorized person. However, use of data encryption does not automatically solve all security problems. The ADP security planner must examine the attacker's perception of an encryption protected system if he is to select other security measures wisely.

Computer systems security and the NBS-DES (beyond line encryption), C. Weissman, *SP500-27*, pp. 25-36 (Feb. 1978).

Key words: cryptography; end-to-end encryption; key management.

The recent adoption of the Data Encryption Standard (DES) by the National Bureau of Standards has created significant interest in the area of cryptography. There are numerous considerations to be made when designing a cryptographic system. The NBS-DES must be embodied in a system employing automatic, down-like key management and end-to-end encryption to be truly effective in a com-

puter network. This paper reviews several issues in this area and suggests solutions.

Considerations in applying an encryption device to a communications network, B. Morgan, *SP500-27*, pp. 38-45 (Feb. 1978).

Key words: cipher feedback; codebook form; forbidden characters.

This paper outlines the basic considerations which must be met in applying a data encryption device to a communications network. Although the following information applies to most enciphering devices, the DES algorithm does have several unique features which merit special attention.

The management of encryption keys, D. J. Sykes, *SP500-27*, pp. 46-53 (Feb. 1978).

Key words: encryption keys; key distribution; key generation; key loading; key storage.

In a system where the details of the encryption algorithm are publicly known, the overall security of the system is heavily dependent on the security of the keys. This paper discusses the various aspects of key management such as key generation, key storage, key distribution and key loading. Techniques to perform these functions are described with emphasis on data communications applications. Rather than recommend a general solution to the key management problem, numerous factors are presented for consideration by the system planner. The need for a trade-off between complexity and practicality in a real world environment is stressed.

Design and specification of cryptographic capabilities, C. M. Campbell, Jr., *SP500-27*, pp. 54-66 (Feb. 1978).

Key words: cryptography; data security; encryption.

Cryptography can be used to provide data secrecy, data authentication, and originator authentication. Non-reversible transformation techniques provide only the last. Cryptographic check digits provide both data and originator authentication, but no secrecy. Data secrecy, with or without data authentication, is provided by block encryption or data stream encryption techniques. Total systems security may be provided on a link-by-link, node-by-node, or end-to-end basis, depending upon the nature of the application.

A bit-slice, 4-chip implementation of the Data Encryption Standard, K. Rallapalli, *SP500-27*, pp. 67-68 (Feb. 1978).

Federal Reserve communications security project, H. Crumb, *SP500-27*, pp. 70-73 (Feb. 1978).

ARPA Network security project, S. T. Walker, *SP500-27*, pp. 74-79 (Feb. 1978).

Key words: ARPA computer network; computer network; network security; security, network; switched communications.

The ARPA computer network has become an operational Defense Department packet switched communications system. A recent ARPA research project has developed techniques for achieving end-to-end encryption processes in a sophisticated networking environment such as the ARPA network. The National Bureau of Standards' (NBS) Data Encryption Standard (DES) Algorithm has been employed as the basic encryption mechanism for the initial demonstration of this capability. This paper gives the background and current status of that research project.

Electronic funds transfer application, J. McDonnell, *SP500-27*, pp. 80-82 (Feb. 1978).

Implementation and use of the Data Encryption Standard within the data communications environment, E. Lohse, *SP500-27*, pp. 84-93 (Feb. 1978).

Key words: encryption; security devices; standards.

With the standardization of the DES, product and system designers can proceed to implement various security devices. Applications for link and end-to-end protection can and will be accommodated. However, if these applications are likely to involve communication within a system containing equipment from different manufacturers, additional standards are needed: key management, electrical interface, encryption mode, initialization and resynchronization. This standards development effort is already started.

Integrated system design, W. Tuchman, *SP500-27*, pp. 94-96 (Feb. 1978).

An LSI implementation of the Data Encryption Standard, H. O. Wright, *SP500-27*, pp. 97-106 (Feb. 1978).

Key words: encryption; LSI; MOS; security.

This paper describes an LSI circuit designed to perform data encryption using the algorithm adopted by the National Bureau of Standards as the Data Encryption Standard. The encryption unit enciphers/deciphers data in 64-bit blocks. Both input data and output data are buffered, allowing the unit to sustain a data rate up to 1.6 Mb/s. The unit has tri-state busing capability and is a versatile LSI unit, designed for use in a wide variety of applications. The unit is sufficiently small in size and low in power consumption and cost that it will allow data encipherment to be used in systems in which the use of encipherment was previously economically unfeasible.

A microprocessor controlled LSI implementation of the Data Encryption Standard, K. Warble and D. Hillis, *SP500-27*, pp. 107-115 (Feb. 1978).

Key words: communication; encryption; LSI; microprocessor; MOS.

Presented is an LSI implementation of the Data Encryption Standard. The device has been developed for use with microcomputer based data processors, with encryption or decryption of 64 bit blocks inputted and outputted through a single 8 bit tri-state bus port. A single +5 volt supply powers the LSI chip; block processing time is 160 microseconds, allowing typical MPU configurations to operate over 200 Kb/s. The unit possesses two key registers to facilitate downline loading of encrypted key, with on-chip decryption and error checking under the control of a resident master key. Continual checking of the operating key during algorithm execution as well as during key load provides an economical degree of security for many applications.

SP500-28. Computer science & technology: Database administration: Concepts, tools, experiences, and problems, B. Leong-Hong and B. Marron, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-28*, 48 pages (Mar. 1978) SN003-003-01900-3.

Key words: computer software; database administration; database administrator (DBA); database management system (DBMS); data element dictionary/directory (DED/D).

In this report the concepts of database administration, the role of the database administrator (DBA), and computer soft-

ware tools useful in database administration are described in order to assist database technologists and managers. A study of DBA's in the Federal Government is detailed in terms of the functions they perform, the software tools they use, the problems they have encountered, and advice they offer. Finally, some guidelines are presented on what database administration should do for management, and what management must do for their DBA's.

SP500-29. Computer science & technology: NBS/RIA robotics research workshop. Proceedings of the NBS/RIA Workshop on Robotic Research held at Williamsburg, VA, July 12-13, 1977, J. M. Evans, Jr., J. S. Albus, and A. J. Barbera, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-29*, 40 pages (Apr. 1978) SN003-003-01909-7.

Key words: control systems; Delphi Forecast; industrial robots; robot applications; robotics research; sensors.

The NBS/RIA Robotics Research Workshop had two objectives: (1) to provide a forum for structured discussions between researchers in robotics and manufacturers and users of robot systems; and (2) to develop a consensus forecast of future developments in sensors and control systems for industrial robots.

The two day Workshop brought together 31 researchers, manufacturers, and users of industrial robots in order to determine the needs and priorities for future research in sensors and control techniques for industrial robots. There were no formal papers; instead, small group discussions and presentations and the preparation of a Delphi Forecast were used to address research needs and priorities.

SP500-30. Computer science & technology: Effective use of computing technology in vote-tallying, R. G. Saltman, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-30*, 142 pages (Apr. 1978) SN003-003-01915-1.

Key words: computer security; computing technology; election administration; public administration; state and local government; systems analysis; technology utilization; vote-tallying.

The results of a systems analysis and evaluation conducted on the role of automatic digital processing in vote-tallying are presented. Included in the report are descriptions of hardware, software, and administrative problems encountered in fourteen elections in which electronic computing technology was utilized.

Methods of assuring more confidence in the accuracy and security of the vote-tallying process are presented and described. These methods include aids to audits of calculations, physical controls over ballots and computer records, and guidelines for the use of computer programs, computer facilities, and teleprocessing. Methods of improving the election preparation process also are presented and described. These involve the development and implementation of design specifications and acceptance tests for computer programs, election equipment and supplies, and guidelines for pre-election checkout of vote-tallying systems and for assurance of management control.

Institutional factors are discussed which should be considered if improved accuracy and security controls and more effective election preparations are to be implemented. Recommendations for additional research and other activities including a possible Federal role are provided.

SP500-31. Computer science & technology: Local area networking. Report of a Workshop held at the National Bureau of Standards, Gaithersburg, MD, Aug. 22-23, 1977, I. W. Cotton, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-31*, 82 pages (Apr. 1978) SN003-003-01918-6.

Key words: computer communications; computer networks; data communications; operating systems; performance evaluation; protocols.

This is the report of a workshop convened at the National Bureau of Standards on August 22-23, 1977, to discuss the different technologies applicable to computer networks serving a limited geographic area, such as a single campus, factory or office complex. A number of short presentations were made by active researchers and implementers in this area, afterwards the group broke up into a number of working sessions for intensive discussion of specific topics. A recorder at each session prepared a session report with the session chairman. The sessions were as follows: 1. Subnet architecture; 2. Protocols for local area networks; 3. Local network applications; 4. Network architecture; 5. Network operating systems; 6. Analysis and performance evaluation.

A list of attendees and bibliography on local area computer networks is included in the report. *These proceedings include the following papers (indented):*

A comparative evaluation of the performance of alternative communications technologies, A. K. Agrawala, *SP500-31*, p. 5 (Apr. 1978).

Real-time network for the control of a very large machine, J. Altaber, *SP500-31*, p. 5 (Apr. 1978).

A local network for the National Bureau of Standards, R. J. Carpenter and R. Rosenthal, *SP500-31*, pp. 7-9 (Apr. 1978).

Application of hyperchannel, G. Christensen, *SP500-31*, p. 10 (Apr. 1978).

Mitrenet—Introduction and overview, J. P. Hanks, *SP500-31*, p. 10 (Apr. 1978).

Data ring at computer laboratory, University of Cambridge, A. Hopper, *SP500-31*, pp. 11-16 (Apr. 1978).

Local mission-oriented network, R. L. Larsen, *SP500-31*, p. 17 (Apr. 1978).

Interconnection of local networks using satellite broadcast technology, D. L. Mills, *SP500-31*, p. 17 (Apr. 1978).

Ethernet: Distributed packet switching for local computer networks, R. M. Metcalfe and D. R. Boggs, *SP500-31*, p. 18 (Apr. 1978).

The ARPA local network interface, P. V. Mockapetris, M. R. Lyle, and D. J. Farber, *SP500-31*, pp. 18-19 (Apr. 1978).

Computer cells—High performance multi computing, D. L. Nelson, *SP500-31*, pp. 19-20 (Apr. 1978).

The MIT laboratory for computer science network, K. T. Pogran and D. P. Reed, *SP500-31*, pp. 20-22 (Apr. 1978).

Current summary of Ford activities in local networking, R. H. Sherman, M. Gable, and G. McClure, *SP500-31*, pp. 22-23 (Apr. 1978).

Local area networks at Queen Mary College, A. R. West, *SP500-31*, pp. 23-26 (Apr. 1978).

DECNET: Issues related to local networking, S. Wecker, *SP500-31*, pp. 26-31 (Apr. 1978).

SP500-32. Computer science & technology: FORTRAN IV enhanced character graphics, N. M. Wolcott, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-32*, 57 pages (Apr. 1978) SN003-003-01921-6.

Key words: alphabets; COM; computer graphics; computerized typesetting; digital plotting; plotting; type fonts; type setting; vectorized characters.

A FORTRAN IV subroutine is described which allows the drawing of six styles of alphabetic characters, three styles of numbers, and 48 special mathematical symbols from the enhanced graphic character set of Dr. A. V. Hershey. Twenty-two symbols for graph plotting are also provided. Output is by linkage to an external subroutine PLOT. The program requires a computer which can accommodate a 30 bit word-length.

SP500-33. Computer science & technology: Considerations in the selection of security measures for Automatic Data Processing systems, M. J. Orceyre, R. H. Courtney, Jr., and G. R. Bolotsky, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-33*, 33 pages (June 1978) SN003-003-01946-1.

Key words: auditing; authorization; computer security; cryptography; device identification; distributed processing; identification; personal identification; security; surveillance.

The authors introduce the readers to presently known methods and techniques for protecting data in an ADP facility and during transmission. The material is presented as an aid in evaluating and selecting security measures following the identification of existing risks and potential losses via a risk analysis.

SP500-34. Computer science & technology: UNIVAC 1108 EXEC Level 32R2 Performance Handbook, J. C. Kelly and G. P. Route, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-34*, 144 pages (June 1978) SN003-003-01948-8.

Key words: computer performance management; measurement tools; operating system performance; performance guidelines; performance measurement; tuning guides; UNIVAC 1108.

This is a report prepared for the Army Military Personnel Center (MILPERCEN). It describes a set of hypotheses for evaluating the performance of UNIVAC 1100 Computer Systems. The hypotheses specifically apply to EXEC Level 32R2 operating on UNIVAC 1108 Computer Systems. Attempts to apply the guidelines to different UNIVAC 1100 models or to different levels of the EXEC may lead to erroneous results.

The report contains sections on each major complex within the EXEC. Each section (1) states the performance hypotheses associated with that complex, (2) explains how the available measurement tools may be used to determine if the hypotheses are true, and (3) identifies which performance parameters need to be changed to correct the problem situation. All of the performance hypotheses discussed in the body of the report are collected together in Appendix A. Appendix B summarizes the performance parameters and Appendix C contains an introduction to the Software Instrumentation Package (SIP).

SP500-35. Computer science & technology: The design and implementation of the National Bureau of Standards' Network Access Machine (NAM), R. Rosenthal and B. D. Lucas, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-35*, 50 pages (June 1978) SN003-003-01949-6.

Key words: command languages; communications; computer access; computer networks; intelligent terminals; minicomputers; protocols.

The Network Access Machine (NAM), a programmed minicomputer designed to assist interactive on-line terminal users of computer network services and resources, is discussed in detail. The minicomputer allows the user to specify (or to have specified) network command sequences for execution on

a specified network and host connected to that network. Computer responses are analyzed to assure agreement with those anticipated for specific commands. Experience with the NAM and specific examples of NAM use including a common command language for bibliographic retrieval are presented.

SP500-36. Computer science & technology: The LX39 latent fingerprint matcher, J. H. Wegstein and J. F. Rafferty, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-36*, 18 pages (Aug. 1978) SN003-003-01958-5.

Key words: automated fingerprint identification; pattern recognition.

A procedure is described for automatically determining if a latent scene-of-crime fingerprint matches an inked, rolled file fingerprint. The procedure uses the x and y coordinates and the individual directions of the minutiae (ridge endings and bifurcations). The identity of the latent print with a print on file is indicated by a high score resulting from computations based on differences in angle and coordinate values of minutiae that are found in going from one of the fingerprints to the other.

SP500-37. Computer science & technology: Common command language for file manipulation and network job execution: An example, M. L. Fitzgerald, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-37*, 32 pages (Aug. 1978) SN003-003-01965-8.

Key words: command language; computer network; file manipulation; macros; network access; network job execution; network operating systems.

Computer networks provide the capability for sharing resources across many diverse computer systems. Utilizing this capability is inhibited by the requirement that the user become familiar with all the varied command languages and protocols of each accessed system. This report presents a general approach to solving this problem using an intermediary system to support a set of Common Commands for File Manipulations and Network Job Execution. To show the feasibility of this approach, common commands were implemented for four systems using the NBS Network Access Machine.

SP500-40. Computer science & technology: Guideline on major job accounting systems: The System Management Facilities (SMF) for IBM systems under OS/MVT, G. Durbin, T. Kinney, P. Lamasney, E. Newman, and E. Syrett, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-40*, 170 pages (Oct. 1978) SN003-003-01989-5.

Key words: computer performance analysis; computer performance measurement; CPU time; EXCP counts; IBM OS/MVT; job accounting systems; resource utilization measurement; System Management Facilities; system wait time.

This document reports the results of a study which was commissioned in response to the need for a better understanding of how job accounting systems work, what they measure, and how accurately they measure. The accounting system described is IBM's System Management Facilities (SMF) for 360/370 environments operating under OS/MVT. Considerable detail is provided on SMF's activity in collecting the data necessary to account for resource utilization by the individual jobs in a multiprogramming system and to provide some indicators of the performance of the system itself. Included within the scope of this study was an investigation of the accuracy, both absolute and relative, of SMF as a measurement tool and the costs entailed in the use of SMF. The experimental methodology used to explore these questions is summarized in the report, as are the conclusions reached. Performance analysts, system programmers, and users interested in optimal use of their computer resources will find much help here in the application of a valuable measurement tool. (Includes chart in a pocket at end of publication.)

SP500-41. Computer science & technology: Computer performance evaluation users group (CPEUG). Proceedings of the Fourteenth Meeting held at Boston, MA, Oct. 24-27, 1978, J. E. Weatherbee, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-41*, 353 pages (Oct. 1978) SN003-003-01985-2.

Key words: ADP life cycle; computer performance evaluation; computer performance measurement; computer performance prediction; computer system acquisition; conference proceedings; CPEUG; hardware monitoring; on-line system evaluation; prediction methods; queueing models; simulation; software monitoring; workload definition.

The *Proceedings* record the papers that were presented at the Fourteenth Meeting of the Computer Performance Evaluation Users Group (CPEUG) held October 24-27, 1978 in Boston. The technical presentations were organized around the three phases of the ADP Life Cycle: the Requirements Phase (workload definition), the Acquisition Phase (computer system and service selection), and the Operational Phase (performance) measurement and prediction methods. The program of CPEUG 78 is also included and serves as an Appendix to the *Proceedings*. These proceedings include the following papers indented:

Incorporating remote terminal emulation into the Federal ADP procurement process, T. F. Wyrick and G. W. Findley, *SP500-41*, pp. 5-14 (Oct. 1978).

Key words: benchmarking; performance evaluation; procurement; remote terminal emulation; remote terminal emulators; selection; teleprocessing.

Remote terminal emulation is a benchmarking technique that can be used to validate the performance of teleprocessing (TP) systems or services for which it would be impractical to conduct a Live Test Demonstration with the total proposed network of computers, terminal devices, and data communications facilities. A Government program, now underway, is developing regulations and guidance documents that will (1) restrict when and how Federal agencies can use emulation during procurement and (2) describe the emulation benchmark capabilities that vendors must have to be qualified to bid on certain Federal TP procurements. The program is being conducted by the General Services Administration, Automated Data and Telecommunications Service, with assistance from both the Federal Computer Performance Evaluation and Simulation Center and the National Bureau of Standards, Institute of Computer Sciences and Technology. This paper describes the Government's program to incorporate remote terminal emulation into the Federal ADP procurement process and presents the program's background, objectives, schedule, and current status. Significant intermediate results, recommendations, and decisions are summarized. The paper also outlines the regulations and guidance documents to be produced. Selected technical and policy references are cited to encourage further investigation.

Application of a network monitor to the selection of a time shared computing system, M. D. Abrams and H. P. Hayden, *SP500-41*, pp. 15-25 (Oct. 1978).

Key words: benchmark; computer performance evaluation; network measurement system; response; selection; service quality.

This paper discusses the use of network service measurement techniques in the evaluation of system responses as part of the competitive selection of a multi-user time shared computing system for David Taylor Naval Research

and Development Center (DTNSRDC). The selection of measured system responses was based on the assumption that there would be a direct relationship between the responses and the "quality of service" to the system's user community.

Benchmarking in selection of timesharing systems, D. J. M. Davies, *SP500-41*, pp. 27-36 (Oct. 1978).

Key words: benchmarking; computer system selection; response times; timesharing systems.

This paper discusses the role of benchmark performance evaluation tests in selecting systems for timesharing and general purpose computation. Since performance evaluations can be expensive for both customer and vendor, and since they provide only limited information, a methodology is required for making them economical as well as effective. This is discussed with respect to the evaluations performed during a recent computer selection process at The University of Western Ontario.

Problems in remote terminal emulation, V. Trehan, *SP500-41*, pp. 37-61 (Oct. 1978).

Key words: benchmark; clustering; job initiation; job selection; multivariate regression analysis; multivariate stochastic process; performance measures; remote terminal emulator; scenario; steady state; system under test; workload characterization.

RTEs are being increasingly used in performance studies. Performance predictions based on RJE experiments usually have greater credibility than similar predictions based on simulation/analytical models. However, significant problems exist in the areas of workload characterization, workload emulation and subsequent data analysis. This paper discussed the problems in remote terminal emulation. Alternative approaches for resolving these problems are suggested (including pros and cons for each approach).

A formal technique for analyzing the performance of complex systems, J. Sanguinetti, *SP500-41*, pp. 67-82 (Oct. 1978).

Key words: formal modeling; message sequence; message transfer expression; modeling language; MTE; performance evaluation; PPML; system analysis.

This paper describes a technique for modeling the temporal behavior of systems which are composed of asynchronous, concurrent processes. The structure of the system can be represented in a procedure-oriented modeling language, from which an expression describing the system's state transition behavior can be derived. The derived expression can be analyzed to yield the time required to make a state transition. The time is typically a random variable, whose distribution and moments can be determined. This analysis technique is presented as a promising performance modeling method. Finally, the limitations of this method are pointed out.

Performance evaluation with Petri nets, Y. W. Han, *SP500-41*, pp. 83-92 (Oct. 1978).

Key words: concurrency; bottlenecks; overload; peakload; queue length; waiting time.

Petri net-like models depict the concurrency of a system precisely and concisely, and are especially suitable for modeling distributed data processing systems. After expressing a system by a Petri net-like model, this paper suggests and discusses methods to: (1) Identify system bottlenecks, (2) Derive the maximum subsystem utilization of

every subsystem, (3) Define quantitatively a measure for the cost-effectiveness of a system, (4) Formulate the "peakload" of a system, and (5) Calculate the waiting time, maximum queue length, and average queue length of every queue in a system.

Every transition (subsystem) in this study takes a fixed amount of time to fire (activate), and only closed systems are considered. If the activation time of a subsystem is not fixed, then the maximum, the minimum, or the mean activation time can be used to provide insights into system performance.

Control-theoretic approach to computer systems performance improvement, R. K. Jain, *SP500-41*, pp. 93-100 (Oct. 1978).

Key words: control theory; CPU scheduling; memory management; modeling; operating systems; performance; queueing theory; resource allocation.

The paper presents arguments in favor of applying modern control-theoretic techniques like stochastic filtering, estimation, prediction, and time series analysis, etc., for performance optimization. It is argued that the queueing theory, which has been the most commonly used tool for computer systems modeling and performance studies, is limited in its scope due to its steady-state nature. Further improvement in performance can be obtained by dynamic optimization. Therefore, control theory provides a promising approach for performance improvement. A general methodology for formulation of operating systems resource management policies using this approach is presented. The methodology is illustrated with an example of CPU management policy.

An investigation of several mathematical models of queueing systems, R. Turner, *SP500-41*, pp. 103-111 (Oct. 1978).

Key words: Markov model; network model; queueing systems.

A number of simple mathematical models were used to predict average response time of a timesharing system. The target system was a very simple trace driven simulation model, but the workloads were trace files obtained from a real system in normal operation. As such, the workloads were characterized by very high coefficients of variation in resource demands and think times. Mathematical models of the system included independent arrival models (M/M/1 and M/G/1, closed network models) admitting product form solutions, and a more general Markov model. Only the final model produced reasonable accuracy.

A number of experiments were performed, in an effort to determine what properties of the system being modeled were responsible for the failure of all the simple mathematical models. The large variance in CPU time and the fact that the system was a closed network were found to be critical factors, and appeared to be the major causes for failure of models that do not take them into account.

On the busy period of a queueing network of two service stages with exponentially distributed service time, R. K. Ma and G. J. Stroebel, *SP500-41*, pp. 113-116 (Oct. 1978).

Key words: analytic modeling; computer systems; performance evaluation; queueing network.

The recursive formula for the expected length of busy periods of a queueing network is derived. The closed queueing network consists of two queues, one being the infinite server (IS), the other single server, both of which have exponentially distributed service time with the First Come First Served (FCFS) queueing principle. The results

are compared with the infinite source queuing model with different load conditions.

A Markovian model of a job, A. K. Agrawala and J. M. Mohr, *SP500-41*, pp. 119-126 (Oct. 1978).

Key words: Markov model; workload modeling.

A Markov model may be used to characterize a sequence of states. In this paper we explore the use of such models for modeling the sequence of job steps of a job. The job population is first divided into several clusters and then a separate Markov model is created for jobs from each cluster. The results of an experimental study conducted on a large UNIVAC machine at the Computer Science Center of the University of Maryland are presented.

Case study in capacity planning: Analysis of an automated bibliographic retrieval system, R. P. Goldberg, A. I. Levy, and H. S. Schwenk, Jr., *SP500-41*, pp. 127-141 (Oct. 1978).

Key words: BALLOTS; BEST/1TM; bibliographic retrieval system; capacity planning; computer performance analysis; computer system modeling; library automation; response time; throughput.

This paper discusses a computer system capacity planning analysis of an automated bibliographic retrieval system. A major focus of the study was to determine the computer system requirements necessary to support anticipated bibliographic workloads (through 1983). The paper addresses the methodology used in obtaining performance data and the use of an interactive capacity planning tool, BEST/1TM, to assimilate the data and predict the performance impact of the anticipated workloads.

How multidimensional data analysis techniques can be of help in the study of computer systems, A. Schroeder, *SP500-41*, pp. 149-165 (Oct. 1978).

Key words: clustering; correspondence analysis; data base organization; multidimensional data analysis; principal components analysis; workload characterization.

Various measurements of computing systems have some common features: the phenomenon to be observed depends on several factors the influences of which cannot be considered individually and also the samples can be very large. The purpose of this paper is to give general ideas on Multidimensional Data Analysis methods which are able to process such samples. They are descriptive statistical techniques dealing with multidimensional samples which ensure their ability to take multiple factors into account. Some applications in the field of computer systems analysis illustrate the use that can be made of those methods: program behaviour, workload characterization, data base organization.

An application of time series analysis in computer performance evaluation, R. W. Kulp and K. Melendez, *SP500-41*, pp. 167-181 (Oct. 1978).

Key words: Box-Jenkins method; computer performance evaluation; workload.

One of the major roles of computer performance evaluation (CPE) in the life cycle is to predict the performance of a computer system. During any stage of the operating phase of a computer system it is possible to model the computer system as a time series and use that model to predict future performance. As an example, accurate prediction of when the computer system will transition to an overutilization or a saturation state will enable manage-

ment to begin the life cycle of a follow-on system well before reaching system saturation on the current system. In this paper we show how the Box-Jenkins method of time series model building can be applied to measures of computer workload to provide predictions of future utilization. This technique is applicable to many measures of computer performance/workload. For this paper we have selected Computer Resource Units as a measure of performance. Actual data from a computer system that operates two computers, a CDC 6600 and a Cyber 74, has been analyzed and modeled using the Box-Jenkins method. The time series models developed are described and we demonstrate the use of these models in prediction.

Estimation of run times using signature table analysis, S. A. Mamrak and P. D. Amer, *SP500-41*, pp. 183-191 (Oct. 1978).

Key words: interval estimation; point estimation; run time prediction; signature table analysis.

Algorithms for managing jobstreams in a complex computer environment often rely on various estimates of job run times. Due to wide variability of run times from one execution of a job to another, point estimations of run times are fairly unreliable. An alternate approach to using point estimations is to use intervals which span the range of possible run time values. In an interval approach run times can be predicted with respect to membership in one of a limited set of run time intervals, with relatively high confidence. This paper presents a formal methodology for run time estimation based on an interval approach. The estimation is done using signature table analysis and is accompanied by a statement of statistical confidence in the results.

Sensitivity analysis and the response surface of a simulation model of a computer system, K. Melendez and A. H. Linder, *SP500-41*, pp. 193-197 (Oct. 1978).

Key words: sensitivity analysis; simulation model.

Prior to experimenting using a simulation model, a sensitivity analysis of the model is necessary. The response of the model to perturbations in the input must be determined. Without a sensitivity analysis of the model, the analyst can not determine what is an acceptable level of error for input parameters, nor can the degree of confidence on the responses be established. In this paper a simulation model of an IBM 370/155 is analyzed by constructing the local response surface for the two primary measures of performance used in the model, CPU Utilization and Gain Factor. The computer system modeled is an operational system, however, sensitivity analysis can and should be a part of the validation of any simulation model of a computer system in any phase of the system life cycle.

A statistical approach to resource control in a time-sharing system, C. A. Mackinder, *SP500-41*, pp. 199-222 (Oct. 1978).

Key words: management of resources; probability of size of usage; rationing; statistical approach to management; time-sharing resource control; usage patterns.

The Edinburgh DECsystem-10 Installation provides interactive computing facilities for some 200 individuals in 44 geographically dispersed groups with a wide range of research projects in science and engineering. In addition to managing resources in the sense of the instantaneous or transient demand on the machine eg: balancing the number of job slots made available and the maximum permitted job size, with the response times experienced by users, there

is a need to measure and control usage over a period, say 4 weeks, both for ensuring an equitable sharing of capacity and to prevent overload. A conventional rationing system was in use but whilst it could limit the usage of the groups individually it could not be used to manage the load on the machine as a whole. A study showed that usage conforms to a gamma probability density function and is highly predictable. This has allowed the determination of an "upper limit" of usage beneath which groups are free to compute as they wish in any 4 week period, within the limit of their project's overall allocation. Groups are inhibited only if overload is threatened. The rationing system has been dispensed with. It is likely that all time-sharing systems will show similar usage characteristics and the resource control method used at Edinburgh could be applied elsewhere.

A statistical comparison of the system performance of several configurations, M. Marathe, *SP500-41*, pp. 227-238 (Oct. 1978).

Key words: ANOVA; regression; statistical comparison; system performance; t-test.

This paper describes a study comparing the performance of four configurations of a system. The four configurations were obtained by selecting 2 levels for each of the two factors under study (main memory size and the type of the disk). Standard statistical techniques like the t-test, ANOVA and regression analysis were used to detect and to quantify the differences in the performance of the four configurations. A program development type workload generated using a remote terminal emulator was used for the comparison. The criterion variable was the elapsed time for certain nontrivial commands in the workload.

It was observed that one configuration performs significantly better than the others. The ANOVA procedure showed that all the factors and their interactions are significant in determining the value of the elapsed time. A regression analysis for each combination of the factors was therefore performed. The analysis was used to quantify the additional number of users that can be supported using the better configuration for the same level of user perceived performance. The confidence interval around this value of the additional number of users was also calculated.

Reliability modeling of computer systems, L. R. Hasche and R. A. Grace, *SP500-41*, pp. 239-242 (Oct. 1978).

Key words: computer system reliability; Mean-Time-To-Failure; reliability engineering; service level management presentations; statistics.

Accomplishment of the Strategic Air Command mission is directly dependent on having reliable computer system support. By having an accurate picture of the expected behavior of each computer system in terms of the probable elapsed time to failure, management can apply the appropriate control to assure a satisfactory level (greater than 98%) of computer system availability. This is accomplished by use of a model that predicts the Mean-Time-To-Failure (MTTF) for a computer system. This paper describes the application of this reliability engineering statistical modeling technique to computer system performance, reviews the mathematical function used, and compares the resulting computer system models to the actual behavior of ten large scale computer systems. The use of this modeling technique has enhanced computer reliability information presentations and contributed to the decisions made on resource allocation to assure computer system reliability.

Analysis of variability in system accounting data, D. J. M. Davies, *SP500-41*, pp. 243-253 (Oct. 1978).

Key words: accounting/computer charges; CPU time; elapsed time; metering; system performance; tuning programs; variations in CPU charges; varying workloads.

Results are reported from a study of variations in program execution times, as reported by the operating system of a DECsystem-10/50 time-sharing system. The execution times reported for apparently identical runs of the same (CPU-bound) program vary significantly from run to run. It is shown in particular that the reported CPU consumption rises with increasing system load, and correlations between different measures of program and system performance are analysed.

Two models are proposed for the nature of variations in CPU charges: a simple Poisson, and a compound Poisson model. The empirical results are shown to be reasonably compatible with the simple Poisson model.

This study is of significance particularly to computer users who wish to use program performance metering tools to decide, for example, where effort is justified in 'tuning' a program. Awareness of the nature of variations in execution times permits guidelines to be drawn up to prevent a waste of effort by striving for unattainable 'accuracy'.

A relative entropy-like measure for system organization, J. A. Chaikin and R. A. Orchard, *SP500-41*, pp. 259-262 (Oct. 1978).

Key words: computer system performance; entropy measure; system organization.

A measure of system organization and disorganization is defined and analyzed. Its potential role in computer system performance tuning and planning studies is indicated.

In the area of computer system performance and tuning studies, one frequently encounters situations in which component workload processing rates (i.e., component utilizations) must be changed in order to remove bottlenecks or increase the work throughput of the system. In some cases a more equal distribution of workload processing over subsystems of the system is desired, while in other cases a predilection for a particular subsystem may be indicated. It has always been difficult to point to some well-defined single valued indicator of improvement in system performance. The system organization measure (index) introduced in this paper may be a candidate for such a performance improvement index.

Preliminary measure of C.mmp under a synthetic load, S. H. Fuller, P. F. McGehearty, and G. Rolf, *SP500-41*, pp. 263-273 (Oct. 1978).

Key words: C.mmp; performance measurement; synthetic load.

This paper discusses the performance of C.mmp, a multiprocessor, under a synthetic load imposed by a remote terminal emulator (RTE). The primary measure of performance is average response time to an interactive request for service. An analytic model is used to predict response time. The model is modified as a function of load and the number of available processors. The actual measurements of C.mmp agreed, to within experimental error, with a simple central server model once three factors were incorporated in the model: (1) 210 milliseconds of operating system overhead for each request for service, (2) Bandwidth limitations in the link between C.mmp and the RTE, and (3) Precise details of the processor scheduling algorithm. Future work will consider using more complete synthetic jobs to better stress primary memory management, secondary storage scheduling, and operating system facilities.

Performance study of a minicomputer system, S. K. Lee, R. B. Maguire, and L. R. Symes, *SP500-41*, pp. 275-283 (Oct. 1978).

Key words: minicomputer system; performance measurement; response time; time-sharing; workload.

The paper describes a study carried out to measure the performance of a time-shared minicomputer system. The system is a PDP-11/34 based RSTS/E system used in an undergraduate Computer Science laboratory. Results of the study have shown that in such an environment a relatively inexpensive minicomputer facility can support a large number of on-line users. Specifically, the study indicated how to expand the system from its current thirty to forty or more terminals through software modifications and minor hardware expansion.

The measurement package is internally driven, thus eliminating the need for human intervention or a front-end computer. The measurement system creates a number of pseudo terminal users. Activities of these pseudo users are controlled on an individual basis and an event trace of all activity is recorded. The technique used requires no external resources and permits the type of load to be varied conveniently. The measurement system incurs little system overhead, thereby giving an accurate characterization of system performance.

To multiprocess or not to multiprocess, M. Lieberman, *SP500-41*, pp. 285-291 (Oct. 1978).

Key words: hardware availability; multiprocessing; present discounted value; software availability; technological matrix; thruput.

A methodology is provided for deciding whether or not to combine two individual central processors as a multiprocessor. This methodology is sensitive to the following: 1. Number of terminals in network; 2. Hardware availability; 3. Software availability; 4. Thruput differences; 5. Staffing impact; 6. Cost differences.

Analysis of a typical configuration reveals that from a hardware point of view a multiprocessor can be expected to offer improved availability; but software availability is lower in the multiprocessor. The expectation of improved thruput that could not have been obtained from two individual processors does not appear justified. This occurs because the primary thruput benefit of a multiprocessor, reduction in segmentation of CPU and I/O capacity, is reduced at moderate utilization levels and the coupling loss resulting from CPU/CPU interference for shared resources increases. Staffing patterns are not particularly sensitive to CPU population, therefore, changes resulting from implementation of a multiprocessor are not large.

In summary, the pre-tax, current value, cost differences did not, in this typical case, justify investing in the equipment to convert two individual processors to a multiprocessor.

The development of a tuning guide, B. M. Wallack, *SP500-41*, pp. 297-303 (Oct. 1978).

Key words: computer; Honeywell 6000; performance evaluation; response time; tuning; turnaround time; WWMCCS.

The Federal Computer Performance Evaluation and Simulation Center under contract to the Command and Control Technical Center has developed a document for Worldwide Military Command and Control Systems that can be used by site personnel to analyze the performance characteristics of their Honeywell 6000 computer systems.

This document, called H-6000 Tuning Guide, incorporates detailed analysis procedures that guide the analyst in applying specific techniques to improve system performance.

Guidance for sizing ADP systems (ADPS'S), D. M. Gilbert, J. O. Mulford, and M. G. Spiegel, *SP500-41*, pp. 305-330 (Oct. 1978).

Key words: benchmarks; sizing techniques; sizing tools; workload.

This paper provides a structured methodology to assist a sizing team in making a thorough definition and analysis of new requirements, ADPS alternative selections, and workload impact. Suggested sizing tools and techniques are presented, and guidance is included to aid a sizing team in obtaining accurate and timely results. While this paper is not a complete text on sizing, it can be used as a basic guide for requirements identification, feasibility, and impact studies, and should be enhanced with a sizing team's expertise, consultation from sources with sizing experience, and reference to other sizing literature.

Human performance evaluation in the use of federal computer systems: Recommendations, M. A. Underwood, *SP500-41*, pp. 331-339 (Oct. 1978)

Key words: computer performance; federal systems evaluations; human performance measurements; psychology of computer systems usage.

There has been increased awareness in recent years of the high cost of nonhardware items in the Federal ADP budget in contrast with decreasing costs for much of the hardware. More attention is being given to software development costs, systems design practices, automatic program testing, and the like. Particular commercial and military systems effectiveness and life cycle costs now take into consideration such factors as part of the planning process. It is suggested that not enough attention has been given to measurement of human performance variables as part of the systems procurement and systems evaluation phases of Federal ADP programs. Recommendations are made for the incorporation of such measures along with conventional hardware/software performance measurement.

SP500-43. Computer science & technology: A guide to major job accounting systems: The Logger system of the UNIVAC 1100 Series Operating System, J. M. Mohr, A. K. Agrawala, and J. F. Flannagan, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-43*, 79 pages (Dec. 1978) SN003-003-02003-6.

Key words: computer performance analysis; computer performance measurement; EXEC-8; job accounting systems; Logger system; resource utilization measurement; standard unit of processing; SUP; UNIVAC 1100 Series Operating System.

This report has been prepared to serve as guides to the user of Logger, the job accounting system supplied by Univac for its 1100 Series Operating System, Level 32. Logger provides a capability for the automatic collection of information that may be used both for billing a computer installation's customers on the basis of resources utilized by their programs, and for gaining useful insights into the performance characteristics of the system itself. This report describes the structure of the accounting log system, provides a description of the information contained in the log tapes, and describes how the information is gathered by the Operating System.

SP501. The National Environmental Specimen Bank. Proceedings of the Joint EPA/NBS Workshop on Recommen-

dations and Conclusions on the National Environmental Specimen Bank held at the National Bureau of Standards, Gaithersburg, MD, Aug. 19-20, 1976, H. L. Rook and G. M. Goldstein, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 501*, 59 pages (Feb. 1978) SN003-003-01890-2.

Key words: analytical; National Environmental Specimen Bank; prototype; research; sample bank.

On August 19 and 20th, 1976, the National Bureau of Standards and the U.S. Environmental Protection Agency co-sponsored a Workshop to review technical developments and to make recommendations on implementation of the National Environmental Specimen Bank. The Workshop consisted of a review session where past considerations were discussed; a technical session where recent analytical research relevant to the sample bank was abstracted and discussed; and a planning session where planning and design of a prototype banking system was outlined.

This report is a summary of the presentations, discussion, and conclusions of the Workshop attendees. The attendees represented a wide cross section of interested Federal and Non-Federal research groups as well as International representation including the International Tissue Banking Program (Sponsored by the World Health Organization, The Commission of European Communities and the U.S. Environmental Protection Agency) and the Federal Republic of Germany.

The workshop concluded that with the ever increasing influx of new man-made substances into our ecosystem, that a formalized, systematic approach is needed to assess the environmental impact of these substances on a national as well as international level. The technology to initiate a pilot banking program is presently available and was formulated into a five-year pilot bank program. This program will be evaluated at each stage of development.

This report was submitted in partial fulfillment of EPA Interagency Agreement IAG-D4-0568 by the National Bureau of Standards under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers the period August 19 and 20, 1976, and the work was completed as of January 31, 1977.

SP502. Computers and mathematical programming. Proceedings of the Bicentennial Conference on Mathematical Programming held at the National Bureau of Standards, Gaithersburg, MD, Nov. 29-Dec. 1, 1976, W. W. White, *Nat. Bur. Stand. (U.S.), Spec. Publ. 502*, 383 pages (Feb. 1978) SN003-003-01893-7.

Key words: algorithm evaluation; computer science; computer software; databases; linear programming; management science; mathematical programming; mathematical programming education; nonlinear programming; operations research; software development.

The Bicentennial Conference on Mathematical Programming, held in Gaithersburg on November 29-December 1, 1976, examined the relationship between mathematical programming and the computer. The more than 50 papers and panel discussions exhibited this theme in terms of the design for, use of, implementation of, and implications for mathematical programming software and computations. Particular emphasis was placed on bringing out computer-oriented subject matter not ordinarily presented in a mathematical programming context. These resulting Proceedings document this Conference, which was jointly sponsored by SIGMAP of the ACM and by the Applied Mathematics Division of the Institute for Basic Standards for NBS. *These proceedings include the following papers (indented):*

Energy models and large-scale systems optimization, G. B. Dantzig and S. C. Parikh, *SP502*, pp. 4-10 (Feb. 1978).

The challenge of analytic use of computers for global problems, W. Orchard-Hays, *SP502*, pp. 11-20 (Feb. 1978).

Implementation and application of a nested decomposition algorithm, J. K. Ho, *SP502*, pp. 21-30 (Feb. 1978).

A stepping-stone parallel-cut method for integer programming, T. Cheung, *SP502*, pp. 31-37 (Feb. 1978).

Monomial programming, T. L. Shafel, G. L. Thompson, and Y. Smeers, *SP502*, pp. 38-50 (Feb. 1978).

Implementation and use of nonlinear cost multicommodity flow subroutines, H. H. Hoc, *SP502*, pp. 51-58 (Feb. 1978).

Implicit representation of triangularity constraints in linear programming, G. Gunawardane and L. Schrage, *SP502*, pp. 59-64 (Feb. 1978).

An efficient general algorithm for the computation of linear decision rules, S. F. Thomas, *SP502*, pp. 65-72 (Feb. 1978).

The structure and solution techniques of the project independence evaluation system, F. Murphy, *SP502*, pp. 73-85 (Feb. 1978).

National and interregional programming models of land and water use and the environment, E. O. Heady, K. J. Nicol, and D. Dvoskin, *SP502*, pp. 86-96 (Feb. 1978).

A nonlinear programming approach to preference maximized menu plans, J. L. Balintfy and P. Sinha, *SP502*, pp. 97-105 (Feb. 1978).

On the analysis and comparison of mathematical programming algorithms and software, R. S. Dembo and J. M. Mulvey, *SP502*, pp. 106-116 (Feb. 1978).

The evaluation of unconstrained optimization routines, L. Nazareth and F. Schlick, *SP502*, pp. 117-133 (Feb. 1978).

Large scale mathematical programming: A total system approach, T. Prabhakar, *SP502*, p. 143 (Feb. 1978).

A search enumeration algorithm for a multiplant multiproduct scheduling algorithm, S. Morito and H. M. Salkin, *SP502*, pp. 144-151 (Feb. 1978).

An IMS-gamma 3 database editor, E. B. Brunner, *SP502*, pp. 152-164 (Feb. 1978).

Software tools for combining linear programming with econometric models, M. J. Harrison, *SP502*, pp. 165-170 (Feb. 1978).

Database management techniques for mathematical programming, R. H. Bonczek, C. W. Holsapple, and A. B. Whinston, *SP502*, pp. 171-179 (Feb. 1978).

Convergence of the diagonalized method of multipliers, R. H. Byrd, *SP502*, pp. 180-183 (Feb. 1978).

Direct approaches for the minimax problem, A. R. Conn, *SP502*, pp. 184-193 (Feb. 1978).

Numerical aspects of trajectory algorithms for nonlinearly constrained optimization, W. Murray and M. H. Wright, *SP502*, pp. 194-204 (Feb. 1978).

Optimization algorithms derived from nonquadratic models, J. S. Kowalik, *SP502*, pp. 205-209 (Feb. 1978).

Algorithms for a class of "convex" nonlinear integer programs, R. R. Meyer and M. L. Smith, *SP502*, pp. 210-215 (Feb. 1978).

Extreme point ranking algorithms: A computational survey, P. G. McKeown, *SP502*, pp. 216-222 (Feb. 1978).

A new alternating basis algorithm for semi-assignment networks, R. Barr, F. Glover, and D. Klingman, *SP502*, pp. 223-232 (Feb. 1978).

Recent developments in vehicle routing, B. L. Golden, *SP502*, pp. 233-240 (Feb. 1978).

Balasian-based enumeration procedures: A study in computational efficiency, J. H. Patterson, *SP502*, pp. 241-250 (Feb. 1978).

A study of the effect of LP parameters on algorithm performance, C. H. Layman and R. P. O'Neill, *SP502*, pp. 251-260 (Feb. 1978).

Sensitivity analysis for parametric nonlinear programming using penalty methods, R. L. Armacost and A. V. Fiacco, *SP502*, pp. 261-269 (Feb. 1978).

The generalized inverse in nonlinear programming—Equivalence of the Kuhn-Tucker, Rosen and generalized simplex necessary conditions, L. D. Pyle, *SP502*, pp. 270-274 (Feb. 1978).

Teaching mathematical programming to the consumer, M. L. Fisher, *SP502*, pp. 275-278 (Feb. 1978).

On teaching linear programming fundamentals, J. M. Mulvey and R. D. Shapiro, *SP502*, pp. 279-285 (Feb. 1978).

Experiments with computer aided self paced instruction for mathematical programming education, A. Ravindran, A. Sinensky, and T. Ho, *SP502*, pp. 286-293 (Feb. 1978).

Importance of modelling for interpretation of linear programming models, L. W. Swanson, *SP502*, pp. 294-301 (Feb. 1978).

Interactive computer codes for mathematical programming education, R. P. Davis and J. W. Chrissis, *SP502*, pp. 302-309 (Feb. 1978).

A problem solving system for nonlinear least squares, B. A. Arnoldy and K. Brown, *SP502*, pp. 310-318 (Feb. 1978).

An iteratively reweighted least squares system, V. Klema, *SP502*, pp. 319-327 (Feb. 1978).

An experimental interactive system for integer programming, M. Guignard and K. Spielberg, *SP502*, pp. 328-337 (Feb. 1978).

An accelerated technique for ridge following using conjugate directions, E. H. Neave and T. L. Shaftel, *SP502*, pp. 338-353 (Feb. 1978).

Experiences in the development of a large scale linear programming system, R. Sjoquist, *SP502*, pp. 358-361 (Feb. 1978).

Math programming users vs. the computer center (A personal perspective as seen from a foxhole), J. R. Ellison, *SP502*, pp. 362-363 (Feb. 1978).

Operational management of mathematical programming based planning systems, E. G. Kammerer, *SP502*, pp. 364-367 (Feb. 1978).

Managing a large scale production and distribution scheduling system, K. Goldfisher, *SP502*, p. 368 (Feb. 1978).

SP503. Computer science and statistics: Tenth annual symposium on the interface. Proceedings of the 10th Annual Symposium held at the National Bureau of Standards, Gaithersburg, MD, Apr. 14-15, 1977, D. Hogben and D. W. Fife, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 503*, 467 pages (Mar. 1978) SN003-003-01908-9.

Key words: analysis of variance; computer science; evaluation; graphics; large data files; maintenance and distribution; nonlinear models; numerical analysis; small computers; software; statistical program packages; statistics.

The Proceedings of Computer Science and Statistics: Tenth Annual Symposium on the Interface contains 36 invited and 36 contributed poster session papers. The invited papers were presented in six workshops on Evaluation of Statistical Software, Nonlinear Models, Graphics, Large Data Files, Numerical Analysis in Statistics, and Maintenance and Distribution of Statistical Software. The Evaluation of Statistical Software Workshop was divided into two sessions on Statistical Program Packages for Small Computers and Computing Approaches to the Analysis of Variance for Unbalanced Data. *These proceedings include the following papers (indented):*

An interactive statistical processor for the Unix time-sharing system, P. Bloomfield, *SP503*, pp. 2-8 (Mar. 1978).

Key words: data analysis on minicomputers; interactive data analysis.

An interactive statistical processor has been developed for the Unix time-sharing system. A unified command syntax has been imposed by using a command-interpreting "shell" program, which communicates with user at his or her terminal and initiates execution of separate programs to carry out the required operations. Uniformity of these operational programs has been achieved by using a single structure for files and providing a library of subroutines for analyzing the standard syntax for specification of options.

Since the shell knows nothing about the programs that it executes, except for default places to find them, new commands may be added even during the course of a session. Users may develop and use their own commands without making them publicly available, and if the command has the same name as a publicly available command, the user version is found first and executed, thus effectively redefining the command for that user.

MiniBMD: A minicomputer statistical system, R. Buchness and L. Engelman, *SP503*, pp. 9-13 (Mar. 1978).

Key words: biomedical; Fortran minicomputers; software; statistics.

The falling prices of minicomputers, their evolving capabilities, and their increasing presence in biomedical settings has motivated the Health Sciences Computing Facility to develop a minicomputer statistical package. Minicomputers are commonly used in biomedical research for data acquisition and screening. For statistical analysis, users of minicomputers must either use inadequate vendor packages or write their own software.

The MiniBMD package will be a reliably crafted, well supported statistical system operating on a wide variety of minicomputers. It will be arranged into a set of FORTRAN modules, (such as data input, screening, editing, description and various statistical routines) tied together by a supervisory program having simplified problem specification and tailored output routines. The modular structure will make it easier for the researcher with a specialized problem to modify or plagiarize the necessary routines. Documentation will be provided at both the program and module level.

Because the biomedical researcher requires quality software, meticulous numerical crafting and testing will be used in developing the MiniBMD series. A manual including test runs and annotated output will be provided to assist the investigator in proper program usage. Input and output will be finely tuned for both the batch and interactive investigator.

Experience and recommended principles for the development of software for processing statistical data in the third world, H. Elkins, V. Matthews, and J. Pomeranz, *SP503*, pp. 14-18 (Mar. 1978).

Key words: catalog; communications; software; software development; statistical data processing; third world.

Problems such as diversity, inadequate maintenance, and limited capacity of hardware, lack of trained personnel, installation difficulties, and poor international communications have hampered the implementation of software for statistical processing in the third world. Past experience demonstrates that programs written in low level FORTRAN can overcome some of the problems. Though decreasing hardware costs will yield major benefits, better international communications remains a crucial need. A regularly updated catalog describing available software for statistical processing would help meet that need.

XTALLY—A multi-dimensional cross tabulation package in RPG-2, M. R. Lackner, *SP503*, pp. 19-25 (Mar. 1978).

Key words: cross tabulations; hierarchical order; RPG-2; XTALLY.

XTALLY produces fully-titled cross-tabulations of up to 7 dimensions and 100,000 cells, each summing 1 or 2 variables, complete with all sub-totals, percentages of overall total, and automatic inflation/deflation of values proportionate to 1 or 2 pre-specified overall totals. The system requires only 24K byte primary storage, and 2 megabyte disk storage. XTALLY does not depend on either compilation or sorting, and only 3 statement formats are used with only two major procedures so users can learn XTALLY in only a few hours.

Data record formats and category-sets are recorded in a disk-stored dictionary of variable names and locations, category-set names, and category limits and titles.

A particular cross tabulation is specified with a single statement naming category-sets in hierarchical order for rows and for columns, identifying the 1 or 2 accumulation variables, and associated inflation/deflation totals if desired. Tabulation proceeds at from 15,000 to 150,000 records/hour, depending on the computer configuration and the dimensions of the table. Timing is a linear function of data file length.

XTALLY has been operational on the IBM System 3 since 1974 and the IBM System 32 since 1975, and has been used for survey or census processing in half a dozen countries. RPG-2 will enable its implementation on the IBM 360/370 (DOS), Honeywell-Bull 6000, ICL 2903, Hewlett-Packard 3000-II, Univac 9400, Burroughs 1700, NCR Century and Criterion Series, and other small to medium range computers. The portability of RPG-2, and the array and file access operations it offers, have led to its selection as the programming language for developing an edit package and a data-base package for census data processing on small computers.

Constraints in the design and implementation of interactive statistical systems for minicomputers, R. F. Ling, *SP503*, pp. 26-34 (Mar. 1978).

Key words: interactive statistical systems; minicomputer; statistical software design.

In this paper, attention is focussed on issues and problems relating to the design and implementation of interactive statistical systems (as opposed to batch systems or small batch or interactive programs) for minicomputers. In particular, constraints imposed by certain characteristics of existing minicomputers (such as size of main storage and data format) as well as related operating systems software and programming languages are discussed. Efforts to relax or eliminate these constraints may be considered as prospects for statistical systems for future generations of minicomputers.

Invited contribution to the discussion statistical program packages for small computers, J. H. Maindonald, *SP503*, pp. 35-36 (Mar. 1978).

Key words: algorithms; program flexibility; statistical computer packages; statistical programs.

Designers of existing statistical systems have in most cases aimed too directly at providing capabilities at the level required by the ordinary user. Later attempts to modify the initial version of the command language in a way that will give needed flexibility then lead to highly complicated forms of statement. Such modifications will still not satisfy the user who wants access to part only of the total computation so that he can use it for his own purposes.

Computing approaches to the analysis of variance for unbalanced data, R. M. Heiberger and L. L. Laster, *SP503*, pp. 37-39 (Mar. 1978).

Key words: analysis of variance; unbalanced data.

Questions are raised on the appropriate analysis for cross-classified data with unequal and disproportionate sample sizes. A set of answers is offered.

BMD and BMDP approaches to unbalanced data, J. W. Frane, *SP503*, pp. 40-47 (Mar. 1978).

Key words: ANOVA; contrast; hypothesis; mixed model; repeated measures; unbalanced.

Appropriate treatment of balanced and unbalanced data is a function of the circumstances and the research questions being asked. BMD and BMDP provide a wide variety of approaches, but also report (as standard results) tests of hypotheses that are independent of cell sizes, as recommended by several authors. The same (orthogonal) hypotheses are tested for unequal cell size problems as are tested for equal cell size problems. Repeated measures (BMDP2V) and mixed model (BMDP3V) problems with unequal cell sizes are given special treatment. (P3V will be distributed for the first time in the fall of 1977.)

Hypothesis testing in multi-way ANOVA models, J. H. Goodnight, *SP503*, pp. 48-53 (Mar. 1978).

Key words: ANOVA; hypothesis testing; missing cells; unbalanced data.

Over the years various terms have been associated with the data or analysis arising from experimental designs. Some of the terms, for example are: balanced, unbalanced, orthogonal, nonorthogonal, missing cells, and messy data. All of these terms are used in an attempt to categorize the data or analysis resulting from experimental designs. However, none of the terms are indicative of whether or not the questions for which the experiment was carried out can be answered.

Analyses of variance of unbalanced data from 3-way and higher-order classifications, S. R. Searle, *SP503*, pp. 54-57 (Mar. 1978).

Key words: automatic interaction procedures; default decisions; hypothesis testing; interactions; orthogonal contrasts; unbalanced data.

Answers are given to three questions about 3-way and higher-order classifications that were asked of the panel members of the workshop session "Computing Approaches to the Analysis of Variance for Unbalanced Data."

ANOVA for non-orthogonal data, G. N. Wilkinson, *SP503*, pp. 58-65 (Mar. 1978).

Key words: covariance analysis; expected mean squares; factorial models; multiple error strata; nonorthogonal ANOVA.

An ANOVA is primarily an information summary and screening device. One pass with a model-fitting algorithm provides both a *forward* ANOVA and a *backadjusted* ANOVA. The forward ANOVA depends on the order of fit of the model terms, but if main effects are ranked in importance on either prior information or the magnitude of unadjusted mean squares, and interactions are assigned the corresponding induced order, these two ANOVA's often suffice for interpreting the data. It is not necessary to consider all possible ANOVA's that could arise from arbitrary reordering of model terms. The question of hypothesis testing does not arise at the stage of presenting estimated values but only at the prior stage of determining an adequate model fit. The extension to multiple error strata, covariates and missing values is briefly considered.

The analysis of linear models with unbalanced data, R. R. Hocking, O. P. Hackney, and F. M. Speed, *SP503*, pp. 66-70 (Mar. 1978).

Key words: linear models; tests of hypotheses; unbalanced data.

The purpose of this paper is to describe the hypotheses commonly tested in linear models with unbalanced data, including the case of zero cell frequencies. Historically, the sums of squares for the test statistics have been developed either on heuristic principles or because of computational convenience. Precise statements of the corresponding hypotheses are rarely found in the literature and, in those cases where the hypotheses are stated, they are usually described in terms of the parameters of the non-full rank model which may be difficult to interpret. In this paper, the hypotheses associated with the R notation for general sets of conditions are described in terms of the means of the observed populations. The discussion is restricted to two-way models.

Discussion from workshop on analysis of variance for unbalanced data, R. M. Heiberger, Ed., *SP503*, pp. 71-75 (Mar. 1978).

Key words: analysis of variance; minimal model; two way classification; unbalanced data.

The discussion, except as noted, was recorded and then transcribed and edited for smoothness. The speakers have not reviewed the comments attributed to them.

Nonlinear statistical data analysis, R. E. Welsch, *SP503*, pp. 77-86 (Mar. 1978).

Key words: convergence; covariance; diagnostics; influence; leverage; nonlinear; regression; robust; sensitivity analysis.

This paper discusses how recent progress in nonlinear optimization methods can help data analysts working with nonlinear models and nonlinear estimation procedures. Some advances in estimation for linear models such as robust methods and diagnostic sensitivity analysis have been partially generalized to nonlinear models, but many problems remain. These problem areas are discussed along with certain ways in which nonlinear optimization algorithms could be modified to help the statistician.

MLP, a maximum likelihood program, G. J. S. Ross, *SP503*, pp. 87-91 (Mar. 1978).

Key words: analysis of variance; minimal model; two way classification; unbalanced data.

MLP is designed to make it easy for the nonspecialist to fit appropriate nonlinear models to data. The program includes a wide range of standard models for fitting curves, distributions and assays, with appropriate statistics and graphical output. There is a user's language for fitting other models specified as functions of parameters. The methods used depend on both the model and the data. Optimization is used, but care is taken to ensure that the objective function is well-conditioned, approximately quadratic and bounded.

Computer graphics available to statisticians, B. F. Ryan, *SP503*, pp. 93-100 (Mar. 1978).

Key words: computer graphics; general purpose statistics packages; histograms; statistics.

This paper surveys the graphics capabilities available to statisticians in most of the widely available general purpose statistics packages and in a few graphics-oriented statistics packages. The emphasis is on pictures for data analysis rather than on pictures for data presentation.

Portable graphics, J. E. George, *SP503*, pp. 101-106 (Mar. 1978).

Key words: device independence; graphics; graphic software; portability.

The portability of graphic software is discussed for the past, present and future. Early methods of portability are examined and contrasted with modern methods; the effects of the current graphic standards effort are surveyed. Representative portable graphic systems are discussed and example applications are utilized for illustration.

Terminal and computer independence for interactive graphics applications software, H. G. Bown, C. D. O'Brien, G. Thorgerison, and W. Sawchuk, *SP503*, pp. 107-116 (Mar. 1978).

Key words: application; computer; displays; graphics; independence; interactive; language; portability; software; standards; terminal.

This paper describes an approach to provide terminal and computer independence for interactive graphics application software. The major goals of the software system are to achieve a high degree of environment dependence through software portability and the concept of a virtual display terminal, and to simplify the writing of interactive graphics programs.

An overview of the programming language, IGPL is presented together with a description of the virtual ter-

minimal software. The commands (Graphical Task Interactions, GTI's) that are communicated between host and terminal are described where their intent is to separate the application-dependent and system-dependent functions.

Dialogue considerations in interactive statistical graphics, J. F. Gentleman, *SP503*, pp. 117-121 (Mar. 1978).

Key words: dialogue; human factors engineering; interactive statistical computer graphics.

Careful human engineering of the dialogue between program and user in interactive statistical computer graphics is encouraged. Six principles are presented, based on experience in the development of such programs. Some of the principles are applicable to the development of computer software in general.

Human factors at the graphics interface, A. Simanis, *SP503*, pp. 122-130 (Mar. 1978).

Key words: allocation of tasks; data display and analysis; graphics interface; human factors; interactive computer graphics; man-computer interface.

The interactive computer graphics package, Pierce, used for data display and analysis was designed with human factors criteria being applied to the functional aspects of the man-computer interface. The human factors are described, and examples from Pierce are used to show how they were applied.

Large scale clinical trials or how do we answer this, G. R. Cutter, *SP503*, pp. 132-136 (Mar. 1978).

Key words: cooperative trials; HDFP; hypertension; large data files; post-stratification; truncation.

Large scale clinical trials generally pose difficult problems in the area of data analyses. Although purely methodological issues often arise, data analyses for papers produce a host of problems from large volume to inappropriateness of the data set to answer certain questions. The Hypertension Detection and Follow-Up Program (HDFP), a major large scale clinical trial of antihypertensive therapy is discussed. Three examples of problems are given: one related to large volume requests; one on post stratification based on treatment response and a third which combines the stratification problem and selection via truncation.

Salvaging experiments: Interpreting least squares in non-random samples, A. E. Beaton, *SP503*, pp. 137-145 (Mar. 1978).

Key words: goodness of fit; least squares; non-random samples; regression analysis; statistical inference; statistical theory.

The test statistics in a regression analysis may be interpreted as measures of goodness-of-fit in data sets that are arbitrarily collected. The regression equation is a parsimonious representation of an aspect of the data. The goodness-of-fit is established by demonstrating that the residuals are so small that changing their signs and permuting their positions could not affect the value of the regression coefficients very much. No assumptions outside of the data set need be made.

Record linkage by bit pattern matching, D. Blaxell, *SP503*, pp. 146-156 (Mar. 1978).

Key words: best matches; bit pattern matching; bit sum; boolean arithmetic compatibility; interpretation; name

searching; ones population count; similarity evaluation; unary numbers; unit hypercube.

Record linkage is non-trivial when records share no common access key. One application is searching for records most similar to a query record; another is bridging two independent files covering similar universes.

Bit pattern matching technique and experience are reported. Every record is preanalyzed into a fingerprint bit pattern of 60 bits. The ones population count of the logical product of two such patterns scores similarity between two records.

Bit pattern generation guidelines and tolerances of data errors and of non-ideal design are considered using unit hypercubes and unary numbers in base one. Use of the similarity scores for linkage criteria depends on the application philosophy.

A Clinical Information System (ACIS) and its application to clinical trials, M. A. Fox, *SP503*, pp. 157-164 (Mar. 1978).

Key words: ACIS; biomedical; clinical information; data base; file generator; retrieval; storage.

With the increase in sophistication of statistical packages, manipulation of raw data prior to analysis has assumed tasks of great complexity.

ACIS is a file generating system in which a compiler accepts a description of the data and structures that are to be applied to this data and generates a series of PL1 programs. These programs are immediately available for use or can be user modified. This is far more powerful than providing the user with the conventional subroutine links.

Relational database models and social science computing, R. F. Teitel, *SP503*, pp. 165-177 (Mar. 1978).

Key words: complex data structures; database systems; high level language; relational model; social science computing; statistical systems.

This paper discusses the applicability of the Relational Model of Data to the data collections in common use today in social science statistical computing. It reviews the structure of the commonly used data collections, presents the basic concepts of the Relational Model of Data, and applies the relational model to the description of contemporary social science data collections. The paper continues with a discussion of high level language concepts for use in social science statistical systems for large and complex data collections. The final section discusses the difference in the patterns of access to data by query and by statistical applications and the implementation implications.

Karl Pearson was right, D. W. Scott, R. A. Tapia, and J. R. Thompson, *SP503*, pp. 179-183 (Mar. 1978).

Key words: computational feasibility; kernel estimates; maximum likelihood; Pearson family; penalized maximum likelihood.

A discussion is made of nonparametric versus parametric methods for the estimation of probability densities. A new algorithm for nonparametric density estimation is given and its performance compared with state-of-the-art kernel estimation algorithms.

Some problems in approximation and estimation, M. Rosenblatt, *SP503*, pp. 184-188 (Mar. 1978).

Key words: bias; bispectra; cubic spline; density function estimate; turbulence; variance.

A density function estimate based on cubic splines is introduced. Some asymptotic properties of the estimate are described. The relationship to a classical spline interpolation problem is noted.

Orthogonal transformations in regression calculations, G. W. Stewart, *SP503*, pp. 189-190 (Mar. 1978).

Key words: computational methods; least squares; numerical stability; QR decomposition; regression; sweep methods.

An approach to time series prediction, M. Pagano, *SP503*, pp. 191-198 (Mar. 1978).

Key words: Bernstein polynomials; prediction; quantile function; regression function.

A new method is presented for predicting stationary time series via the quantile function. The empirical regression distribution is smoothed, using Bernstein polynomials, to yield an estimator of the regression density function. This function, in turn, yields the prediction formulae. Numerical examples are presented.

Some examples of the interface between statistics and numerical analysis, C. P. Tsokos and J. J. Higgins, *SP503*, pp. 199-203 (Mar. 1978).

Key words: Bayesian methods; interface; robust estimation; statistical analysis; statistics and numerical analysis.

The availability of increasingly sophisticated computer hardware and software is changing the nature of statistical research. Increasingly complex statistical models and methods are replacing the overly simplistic models which in the past had to be used because of their computational convenience. New statistical procedures are being developed and some old statistical theories are getting new emphasis because numerical implementation is feasible. Some recent problems and results in statistical methodology are discussed in which numerical methods are an integral part of the solution. Examples are drawn from the areas of Bayesian statistics, robust estimation, nonparametric methods, and stochastic differential equations.

Maintenance and distribution of statistical software: Satisfying diverse needs, M. E. Muller, *SP503*, pp. 205-210 (Mar. 1978).

Key words: computer science; maintenance and distribution; statistical interface; statistical software; statistical software maintenance and distribution.

Reasons for a computer science statistics interface workshop on the maintenance and distribution of statistical software are presented, i.e. a means for 1) fostering the sharing of statistical software among a community of users, 2) promoting a dialogue among computer scientists and statisticians and among users, developers and distributors of software, 3) presenting and promoting significant technical ideas in the presence of constraints and divergent interests, and 4) discussing unmet needs. A formal definition of maintenance is given in order to show the many aspects related to this problem. From the perspective of the workshop organizer, several important considerations for effective maintenance and distribution of software are presented; namely, types of technical documentation, aspects of testing, performance evaluations, and management commitments. The paper concludes with some other relevant technical considerations, such as user-created extensions, and raises some issues about future directions, including minicomputers.

Some testing and maintenance considerations in package design and implementation, J. R. Allen, *SP503*, pp. 211-214 (Mar. 1978).

Key words: development; documentation; implementation; maintenance; package design; reliability; reporting errors; statistical package; STATJOB; testing.

Some approaches taken at the University of Wisconsin to minimize errors prior to distribution of STATJOB are discussed. Included are descriptions of design concepts which help programmers avoid errors and notes on procedures followed to minimize errors during implementation and maintenance. Also discussed are internal accounting methods used to provide STATJOB users with protection against the consequences of serious software errors—those that result in plausible but incorrect results.

The distribution and maintenance of SAS, A. J. Barr, *SP503*, pp. 215-220 (Mar. 1978).

Key words: dated software; diagnostics; distribution; installation parameters; load modules; maintenance; portability; versions.

The SAS system has been optimized for a single family of computers and operating systems. This has reduced the size of our universe of users, although it is still large. New portability problems arise out of our efforts to adapt more closely to the environment than is possible in FORTRAN or COBOL. We have tried to avoid requiring users to compile or link-edit SAS. Identical tape copies of the system are sent to all SAS users. A SAS program copies the tape to disk, optimally blocking the SAS library. The system is then configured by another SAS procedure which writes the installation-dependent configuration data into the disk copy of the program. Information relating to the environment that can be obtained from the operating system is discussed. The SAS communication mechanism between procedures and the supervisor is such that user-written procedures need not be re-linkedited or compiled for new releases of SAS.

Recent developments in the maintenance and distribution of BMDP, J. W. Frane, *SP503*, pp. 221-224 (Mar. 1978).

Key words: errors; improvements; installation; portability; testing.

Health Sciences Computing Facility at UCLA distributes the BMDP series of biomedical computer programs as FORTRAN source and as load modules to IBM 360 and 370 OS facilities. New releases are made approximately twice yearly. The in-house version undergoes constant improvement. Our concerns include error reporting, selection of improvements and new features, extensive testing after modifications have been made, update notices and newsletters, changes in user documentation, interface with other packages, portability and implementation on non-IBM computers, reliability of tape copies, delivery of tapes by the Postal Service and United Parcel, installation documentation, and monitoring actual usage. Our chief concern, beyond correct results, is monitoring the use of our programs to be sure good analysis is being done.

Portable statistical software—In COBOL, J. M. Hewitt, *SP503*, pp. 225-232 (Mar. 1978).

Key words: Census tabulations; COBOL; COCENTS; large files; portable software; program generator; publication-quality tabulations; software distribution; software maintenance; tabulation system.

The paper discusses the search for a means of producing statistical software capable of executing efficiently on a wide variety of computers. The reasons for the selection of COBOL are cited and the suitability of COBOL as a system development language is covered. The paper includes details on maintenance of versions for 16 different mainframes. Mechanics of distribution of the system and updates to over 80 users in more than 40 countries are presented. The paper concludes with a retrospect on the success of the COBOL approach and plans for future COBOL-based statistical software systems.

Discussion: Workshop on maintenance and distribution of statistical software, W. J. Hemmerle, *SP503*, pp. 233-234 (Mar. 1978).

Key words: algorithms for statistics; analytical aids; iterative A.O.V. algorithms; statistical software maintenance and distribution.

A university environment with its diversity of interests and objectives is not well suited to software maintenance. The faculty are apt to be interested in research—new algorithms, techniques, languages, systems constructs. Most of the graduate students are concerned principally with completing their degree requirements and obtaining a permanent position. No one is particularly interested in maintenance and there is a high turnover of personnel at the programming level.

Plotting binary trees, K. J. Schmucker, *SP503*, pp. 236-240 (Mar. 1978).

Key words: cluster analysis; Guttman-Lingoes Program Series; IMP; linked lists; multidimensional scaling; PEP-1; plotting algorithms.

The results of a number of statistical procedures can be summarized in terms of binary trees. This paper describes an algorithm for plotting these trees on electrostatic or incremental plotters. This algorithm has been implemented in IMP, a higher-level language designed for the CDC 6600, and used in conjunction with PEP-1, a hierarchical cluster analysis program included in the Guttman-Lingoes Nonmetric Program Series.

The statistical analyses of Monte Carlo simulation data using the techniques of discrete multivariate analysis, J. J. McArdle, *SP503*, pp. 241-246 (Mar. 1978).

Key words: contingency tables; data analysis; Log-Linear Modelling; Monte Carlo experiment; multivariate frequency.

A paradox is posited which suggests that most statisticians do not appropriately analyze their simulation data. This paper deals with the structural, systematic analysis of Monte Carlo frequencies and associated contingency tables using the techniques of Log-Linear Modelling. Emphasis is on practical problem areas and implications for simulation design and the Monte Carlo research process.

Design and analysis techniques for large data files: The CODAP system, E. N. Siguel and S. F. Sand, *SP503*, pp. 247-251 (Mar. 1978).

Key words: Client Oriented Data Acquisition Process; CODAP; data collection; large data files; statistical analysis; statistical issues; systems design.

This paper describes issues related to the design and analysis of large data files, and indicates how one set of large data files, the Client Oriented Data Acquisition Process (CODAP), is currently maintained and analyzed.

Vehicle routing with probabilistic demands, B. L. Golden and W. Stewart, Jr., *SP503*, pp. 252-259 (Mar. 1978).

Key words: probabilistic demands; vehicle routing.

The vehicle routing problem has been receiving a great deal of attention recently in the operations research and computer science literature. The basic problem is to design a set of vehicle routes of minimal total distance leaving from and eventually returning to a central depot, which satisfies capacity constraints and customer demands that are known in advance. It is generally assumed that a new set of routes will be generated if the demands at the delivery points are varied. In this paper, we treat the more complex problem of determining a fixed set of routes in the case where demands are probabilistic in nature, rather than deterministic. Potential applications include schoolbus routing, municipal waste collection, and daily delivery of dairy goods. We assume that the demands at each node i can be modeled by a Poisson distribution with mean λ_i . We describe two types of error situations which we seek to avoid and point out the close relationship they bear to Type I and Type II errors. The objective is to minimize expected distance traveled subject to the restriction that the probability of a primary error is sufficiently small. Computational results are discussed in detail.

Differences between P-STAT and SPSS, as perceived by the authors of P-STAT, S. Buhler and R. Buhler, *SP503*, pp. 260-264 (Mar. 1978).

Key words: interfacing capabilities; P-STAT; SPSS; social science statistical systems; statistical design decisions; statistical systems.

P-STAT and SPSS are both large, general purpose social science statistical systems. Either can clean data, modify it, compute regressions or crosstabulations, etc., quite well. However, the architecture and some of the design trade-offs of the two systems differ considerably. For example, SPSS works primarily with just one main system file while P-STAT permits a number of system files to be simultaneously accessible. SPSS is in this respect less flexible but is easier for a student to use. This paper discusses three main areas where similar trade-offs permit P-STAT to have, in our opinion, capabilities that differ substantially from those of SPSS. These areas are 1) making a system file, 2) file manipulation and 3) internal representation of missing data.

Instructional use of statistical program packages: BMD, IMP, OMNITAB II, and SPSS, R. E. Wyllys, *SP503*, pp. 265-270 (Mar. 1978).

Key words: BMD; IMP; OMNITAB II; SPSS; statistical program package; statistics, teaching of.

An introduction to inferential statistics forms the major part of a research-methods course taught for students whose backgrounds are predominately non-mathematical and non-scientific. Course objectives include developing the student's confidence in his or her ability to solve practical, library-oriented problems (1) through statistical techniques and/or (2) with the aid of computers. Both objectives are served by the emphasis in the course on using computer program packages that perform statistical tasks. Students begin with OMNITAB II and IMP. The former is available at UT-Austin in the original batch-mode package and also in a somewhat condensed interactive version prepared locally. IMP, based on and very similar to OMNITAB II, was locally written specifically for interactive use. After acquiring moderate facility in interactively

manipulating columns of observed data in OMNITAB II and IMP, and after some experience in batch-mode use of OMNITAB II, students are introduced to the more formal approach required in SPSS, progressing from examples with detailed explanations to the point of setting up their own problems. An exercise using a BMD regression routine introduces the students to this package. Throughout the course the students are made to realize that most of them will be working in environments in which they will have access to a computer with one or more of these statistical packages, and that solutions to on-the-job problems will be "only a keyboard away."

A robust procedure for estimating the trend-cycle component of an economic time series, E. L. Frome and R. D. Armstrong, *SP503*, pp. 271-275 (Mar. 1978).

Key words: cubic spline; data analysis; L_1 norm; least absolute values; linear programming; robust; time series; trend-cycle.

Economic time series are often represented as a composite of trend-cycle, seasonal, and irregular movements. We propose that the cubic spline regression method be used to estimate the trend-cycle component and that parameters be estimated by minimizing the sum of the absolute values of the deviations. If there is a seasonal component present, the regression model can be extended using dummy variables. In both cases, least absolute value estimates are obtained using a special purpose linear programming algorithm. An example of the application of the cubic spline smoothing procedure to monthly Texas construction data is discussed.

Solving the general linear model with linear programming, S. R. Borbash, Jr., *SP503*, pp. 276-282 (Mar. 1978).

Key words: computer method; general linear model; linear programming; regression; residuals; statistical computing.

Solutions of the general linear model giving estimates of regression coefficients and residuals can be obtained by minimizing the sum of the absolute values of the residuals and by minimizing the residual largest in absolute value. These solutions can be easily obtained by solving associated linear programming problems. Problem formulations are reviewed and solutions are illustrated for a quadratic polynomial model.

Analysis of variance incorporating trend analysis, M. H. Kutner, *SP503*, pp. 283-287 (Mar. 1978).

Key words: analysis of variance; polynomial regression; regression analysis with repeated x 's; response curves; trend analysis.

When a factor under investigation is quantitative, the analysis of the factor effects often includes a study of the nature of the response function (trend analysis). Without loss of generality, balanced and unbalanced data from single-factor experiments are considered.

Computerized analysis of quality control for radioimmunoassays, P. J. Munson and D. Rodbard, *SP503*, pp. 288-291 (Mar. 1978).

Key words: clinical chemistry; competitive protein binding assay; data processing; quality control; radioimmunoassay; RIA.

We have developed a new computer program for analysis of Quality Control data arising in the Clinical Chemistry laboratory, applicable to RIAs. Detailed analyses including calculation of within- and between-assay variability, detec-

tion of nonrandom assay behavior, evaluation of indicators of assay instability and "lack of control" are performed automatically. The results allow the laboratory director to make informed decisions concerning the maintenance of assay control.

An interactive graphic program for simulating the distribution of transformations of several independent random variables, C. F. Chung, S. R. Divi, and A. G. Fabbri, *SP503*, pp. 292-296 (Mar. 1978).

Key words: distributions; extremes; interactive graphic program; Monte Carlo technique; simulation; transformations.

An interactive graphic computer program for simulating and displaying the distributions of transformations and extremes of several independent continuous random variables is presented. The parameters and distributions of the initial random variables can be interactively altered. Simulated distributions of transformations and extremes using the Monte Carlo technique are displayed with estimated means and standard deviations.

Multiple incomplete beta integrals in Bayes subset selection procedure for binomial probability parameters, P. N. Bhalla, *SP503*, pp. 297-301 (Mar. 1978).

Key words: Bayes; correct selection; expected size; incomplete integral; parameters; subset.

In the Bayes subset selection procedure for the probability parameters of the binomial distribution we are faced with the problem of evaluation of incomplete beta integrals. By using the relationship between the beta distribution and the binomial distribution the incomplete beta integrals are reduced to a simple computational form.

Numerical solutions of the incomplete Gamma function, H. Bouver, *SP503*, pp. 302-307 (Mar. 1978).

Key words: asymptotic expansion; cumulative density function; fixed-length continued fraction and series; Gamma distribution; Hermite polynomials; probability density function; statistical computation; Taylor series; Wilson-Hilferty approximation.

The purpose of this paper is to present the derivation of standard and newly developed formulas, computational algorithms, and modules for comparison of numerical methods in the evaluation of the Incomplete Gamma function. Different series and continued fraction expansions were compared with the goal of finding the most efficient techniques for different domain of the shape parameter of the Gamma distribution. These methods, in addition to the standard series solutions and continued fraction expansions, include the recent technique of the Hermite expansion around a local maximum which was investigated for large values of the shape parameter of the Gamma distribution along with the standard Wilson-Hilferty approximation. On the basis of time comparison, the most efficient and applicable modules were then combined into a distribution package where computer subprogram function were written in standard FORTRAN to evaluate 1) the cumulative density function, 2) the inverse of the cumulative density function and, 3) the probability density function of the Gamma distribution with guaranteed precision of at least 10 significant digits.

The OPCS Longitudinal Study, T. J. Orchard, *SP503*, pp. 308-311 (Mar. 1978).

Key words: Data Base Management Systems; Longitudinal Data.

The OPCS Longitudinal Study links data on birth, death and cancer registrations with that collected at the 1971 Census, for a 1 percent sample of the England and Wales population. The paper describes the current computer system and the investigations into the possible use of Data Base Management Systems.

Derivative-free nonlinear regression, M. L. Ralston and R. I. Jennrich, *SP503*, pp. 312-322 (Mar. 1978).

Key words: derivative-free; fitting differential equations; nonlinear least squares.

A new derivative-free algorithm for finding the minimum of a function of the form $Q(\theta) = \sum_{j=1}^n (y_j - f_j(\theta))^2$ has been developed. Like the Gauss-Newton algorithm, the new algorithm is based on a sequence of linear approximations to the $f_j(\theta)$. However, unlike the Gauss-Newton algorithm, the new algorithm doesn't use derivatives, and hence is called Dud. Dud uses secants to the $f_j(\theta)$ which pass through $(p+1)$ previous estimates of the solution, where p is the dimension of θ . Since the $f_j(\theta)$ have already been computed for these values of θ , only one new function evaluation is required per iteration. Consequently, Dud is potentially economical in the use of function evaluations. The performance of a FORTRAN implementation of Dud was evaluated on a number of standard test problems from the literature. The results demonstrate that Dud can be used successfully on a variety of problems.

Improving the apparent randomness of pseudorandom numbers generated by the mixed congruential method, P. Peskun, *SP503*, pp. 323-328 (Mar. 1978).

Key words: mixed congruential method; mutually statistically independent random variables; pseudorandom numbers; serial correlation.

This paper deals with sequences of pseudorandom numbers generated by the mixed congruential method. That is, a sequence of integers is started with a value X_0 and continued as $X_{i+1} \equiv \lambda X_i + \mu \pmod{P}$ where λ , μ , P , and X_0 are integers. The fractions $U_i = X_i/P$ or $U_i = X_i/(P-1)$ ($i = 0, 1, 2, \dots$) are derived pseudorandom numbers in the intervals $[0, 1)$ and $[0, 1]$, respectively. If X_0 is a "true" random number, then choices of λ and μ have been based, for example, on making small the serial correlations $\rho_s = \text{Cov}(U_i, U_{i+s})/\text{Var}(U_i)$ $s = 1, 2, \dots$. That is, choices of λ and μ have been made to make the sequence U_0, U_1, U_2, \dots appear random. Exact determinations of the serial correlations ρ_s have been made (Ahrens and Dieter (1971); Jansson (1964/66); Knuth (1969)) except that the evaluation of generalized Dedekind sums is involved making the necessary computations cumbersome. It is the purpose of this paper to indicate how certain subsets of the sequence U_0, U_1, U_2, \dots can each be made to consist of mutually statistically independent random variables, how simple exact expressions for the serial correlations ρ_s , $s = 1, 2, \dots$ can be obtained, and how the ρ_s can be minimized if X_0 (and in general X_0, X_1, \dots, X_r for some r) and μ are chosen randomly, and if λ is chosen appropriately.

Advanced SPSS CROSSTABS: Fitting models to categorical data, E. H. Young, *SP503*, pp. 329-338 (Mar. 1978).

Key words: categorical data; linear models; loglinear models; maximum likelihood; SPSS; statistical package; weighted least squares.

This is a progress report of an effort to integrate into the SPSS CROSSTABS procedure both weighted least squares and maximum likelihood techniques for fitting models to categorical data. It includes a partial draft of a users' manual.

General criteria and considerations for the evaluation of time series program packages and libraries, H. T. Davis, *SP503*, pp. 339-341 (Mar. 1978).

Key words: data structures; graphics; statistical software package; time series algorithms; time series software; user's documentation.

Since the Section of Statistical Computing of the American Statistical Association formed the Committee on Evaluation of Statistical Program Packages in 1973, there has been considerable interest and activity centered around establishing the desirable features of a statistical software package. A recent article documenting general criteria for packages is that of Francis, Heiberger and Velleman. In this document we propose some criteria and considerations for the more specific needs of evaluating computing software for time series analysis.

Comparison of statistical packages: A features matrix approach, K. A. Hardy, W. C. Reynolds, and D. R. Kniefel, *SP503*, pp. 342-351 (Mar. 1978).

Key words: BMDP; DATA-TEXT; features matrix; OMITAB; OSIRIS; SAS; SOUPAC; SPSS; statistical package; TSAR.

A features matrix with accompanying glossary of terms is proposed for the comparison of features of statistical packages available for IBM 360-370 environments. Improved definitions and further enumeration of features are seen as necessary, continuing tasks in the further refinement of such a matrix. The proliferation of statistical packages and their various versions makes such a task quite difficult.

Interactive plotting with the ST package, R. M. Dunn and J. F. Gentleman, *SP503*, pp. 352-356 (Mar. 1978).

Key words: graphics; interactive computing; plots.

The low "overhead" learning philosophy of the ST package is discussed. Examples of the interactive dialogue used to produce plots, and of the resulting plots are presented. A word on the current state of development concludes the report.

Generalizing the function call to statistical routines: An application from the DATATRAN language, J. Brode, *SP503*, pp. 357-361 (Mar. 1978).

Key words: algorithm, attributes; computer; Consistent System; data; DATATRAN; linguistic expression; mnemonics; random number generation; statistical routines; time-sharing.

A standard inconvenience of most statistical computer programs is the awkwardness of passing the results from one routine to another.

Integer programming with a computer: A statistical approach, W. Conley and D. S. Tracy, *SP503*, pp. 362-366 (Mar. 1978).

Key words: computer; integer programming; Monte Carlo techniques; optimum solution; random sample of feasible solutions; statistical approach and justification.

Using Monte Carlo techniques it is possible to solve any and all integer programming problems in a very simple and direct fashion. Starting with problems that have a million or less feasible solutions, the authors write Fortran IV programs to search all possible solutions to obtain and record the optimum one.

When dealing with an integer programming problem with more than a million feasible solutions, which is usually the case in applications, the authors take a random sample of approximately one million feasible points and find the optimum solution of this sample.

It is the authors' contention that the sampling distributions of feasible solutions of practical integer programming problems have thick enough tails, no isolated extreme points, to make this approach useful in obtaining a solution that is very close to the true theoretical optimum. This contention is investigated by finding and graphing the sampling distributions of the feasible solutions of hundreds of integer programming problems. Copies of the graphs are available from the authors.

A system for dictionary-driven data entry using an intelligent terminal, B. A. Blumenstein and R. K. O'Day, *SP503*, pp. 367-372 (Mar. 1978).

Key words: data base dictionary; data editing; data entry; data independence; data management; distributed processing; intelligent terminal; statistical data systems.

This paper discusses a generalized dictionary-driven data entry system which runs on an intelligent terminal in conjunction with a large-scale data base computer. An Input Control Program (ICP) controls the sequencing, branching and edit checking. The ICP is interpreted by a data-independent BASIC program which runs on the intelligent terminal. Data are entered, verified, and recorded on diskettes for later transmittal to the data base computer. The ICP is prepared for the intelligent terminal on the data base computer by a program which runs under control of a data base dictionary. This system of data entry has been found to have significant advantages over more traditional approaches to data entry. The main advantages include flexibility and an orientation to the goal of data analysis. This paper presents an analysis of these advantages and a favorable cost comparison over card punching for one large-scale data entry problem.

Comparisons of algorithms for minimum L_p norm linear regression, W. J. Kennedy and J. E. Gentle, *SP503*, pp. 373-378 (Mar. 1978).

Key words: computer timings; curve fitting; estimation; gradient; Newton-Raphson; perturbation methods; quasi-Newton; simplex method; variable metric method.

Minimization of the p -th power of the residuals as a criterion for fitting regression models has been suggested by a number of authors recently. Various algorithms have been proposed for computing these L_p estimators. Some of the more promising algorithms are considered, and computational experience relating to their speed is reported.

The method of midpoints, F. Yu Lu, *SP503*, pp. 379-383 (Mar. 1978).

Key words: binomial coefficients; COMBINATION subroutine; estimated regression equation; estimated regression line; Fact(N) subroutine; least-squares prediction equation; Mathematical Model; midpoints; midpoints prediction equation.

This Mathematical Model is used for finding an estimated regression line by successive midpoints. It can be applied to computer science, statistics and operations research.

This method would benefit both statistics and computer science in the following ways: (1) The Mathematical Model can be derived easily without using any calculus; (2) The model may be used as an example for teaching

"Model Building"; (3) It is easy to show the estimated regression line by graphing and making the calculations by a simple table; (4) It is a simple example for learning computer programming by using the FACT(N) and COMBINATION routines.

Criteria for evaluation of interactive statistical programs and packages, R. A. Plattsmier, *SP503*, pp. 384-388 (Mar. 1978).

Key words: conversational computing; interactive computing; on-line computing; statistical programs.

With the growth of interactive computing in general, attention needs to be paid to the quality and style of statistical software written or adapted to on-line computing. Criteria are presented for evaluation of interactive statistical software which may be of use to both designers and purchasers of such software.

Two conceptualizations of discriminant analysis and their implementation in computer programs, J. Hohwald and R. M. Heiberger, *SP503*, pp. 389-394 (Mar. 1978).

Key words: canonical variate analysis; classification analysis; discriminant analysis; evaluation of statistical software.

Examination of Discriminant Analysis computer programs in several widely distributed packages (BMDP, GENSTAT, SAS76, SPSS) reveals that two analyses, termed classification and canonical variate analysis, are subsumed under the one phrase. The paper defines the two techniques, shows their relation, and considers how each of the packages handles the two methods.

Significance arithmetic—A Fortran approach, M. J. Tretter and G. W. Walster, *SP503*, pp. 395-399 (Mar. 1978).

Key words: automatic error monitoring; computer calculations; Fortran error analysis; rounding error; significance arithmetic; significant digit algorithms.

The first part of this paper presents a brief history of automatic computer error analysis for uninitiated computer users. A chronological bibliography is also presented for further reference. The second part of the paper briefly describes an improved significance arithmetic system which is implemented by Fortran callable arithmetic routines. The system is never liberal and has special routines to overcome the problem of ultraconservatism. Technical details of this system will appear in a future paper.

Development of a computer terminal based interactive statistical analysis package, R. E. Lund, *SP503*, pp. 400-403 (Mar. 1978).

Key words: interactive; program; statistical analysis.

An interactive package containing about twenty statistical analysis programs has been developed to the user testing stage. Example programs are multiple regression, analysis of variance, chi-square contingency tables, plotting and one and two sample multivariate statistics. Major concepts in program construction and examples of program input-output are provided. The program is written largely in XDS Sigma 7 Extended Fortran but utilizes some assembly language instruction subroutines for input and systems control. It is now being operated on the Montana State University XDS Sigma 7.

Minitab II, 1977, T. A. Ryan, Jr., B. F. Ryan, and B. L. Joiner, *SP503*, pp. 404-408 (Mar. 1978).

Key words: data dependent formats; general purpose statistical computing system; Minitab development; Minitab II; regression output.

Minitab II is a general purpose statistical computing system, written in machine compatible FORTRAN IV. It is designed especially for students and researchers who have no previous experience with computers. It is very easy to use, flexible, and fairly powerful, and has been found especially useful for exploring data, for plotting, and for regression analysis. In this note we review three aspects of the development of Minitab in the past year.

GR-Z: A system of graphical subroutines for data analysis, R. A. Becker and J. M. Chambers, *SP503*, pp. 409-415 (Mar. 1978).

Key words: data analysis; GR-Z; graphical methods; histograms; statistical graphical subroutines; time-series plots.

The GR-Z system is a set of FORTRAN subprograms, designed to provide a basis for the graphical operations useful in data analysis and related areas. They provide a wide range of general and specialized statistical graphical operations, and are designed to facilitate both simple graphical computations and the design of new graphical methods.

An application of a record linkage theory in constructing a list sampling frame, R. W. Coulter and J. W. Mergerson, *SP503*, pp. 416-420 (Mar. 1978).

Key words: address match; blocking; data manipulation; group resolution; identical match; linkage group; linkage model; list sampling frame; record linkage; reformat.

The Statistical Reporting Service (SRS), USDA is presently involved in the task of building a master list sampling frame of farms in each of its field offices. Lists from various sources with various formats and data content are combined to form a composite list in each state. An automated record linkage system is being developed to format and standardize the lists and to detect, display, and remove the duplication from this composite list. An overview of the system is presented with a brief explanation of the functions of the subsystems involved. This is followed by a discussion of the mathematical model employed to detect duplication and the computer processing used to implement this model.

Long Range Planning Models LRPM2, LRPM3, and LRPM4/PDM, J. Quinn, R. Bove, and T. L. Liao, *SP503*, pp. 421-425 (Mar. 1978).

Key words: demographic projections; developing countries; economic projections; long range; planning models; social services.

The Bureau of the Census has built three LRPM (Long-Range Planning Models) packages for use by planners in the developing countries: LRPM2, LRPM3, and LRPM4/PDM (which was originally developed under contract by the Agricultural Economics Department of the University of Purdue). The packages differ in their level of sophistication and data needs—starting with simple population projections and limited and flexible data needs in LRPM2 and going to linear programming optimization and extensive data requirements in LRPM4/PDM.

The subjects treated in submodels include: demographic projections; family planning; projections of urban and rural populations; labor force, health, food, and economic consumers; health services; education projections; housing; social security; electricity, gas, and water; families; mortality

by cause; food consumption and production by crop; energy; social mobility; construction; government budget; regional projections; employment by industry and profession. There are also adaptations of programs developed by others for graphing and data management.

Because the models were designed for use in the developing countries, they were designed to be: easy for social scientists who were not computer technicians to use; small enough to be run on most computers; flexible in their data needs and in allowing many alternative paths to be followed when building a country model; segmented so that submodels such as education projections could be run independently; reasonably accurate in any projection mechanisms used; useful for historical and structural analysis as well as for projections.

A new approach to accessing large statistical data files, G. L. Hill, *SP503*, pp. 426-430 (Mar. 1978).

Key words: generalized; hierarchical; large; software; statistical; survey; tabulation.

The National Institute of Child Health and Human Development (NICHD/NIH) provided funding to DUALabs for the analysis of unique data processing problems posed by large public data files. One mechanism that resulted from this activity was the CENTS-AID II system, which reduces the cost of generating cross-tabulations by as much as 80 percent. This high-speed statistical access system is designed for use with large files and enables users to produce complex cross-tabulations consisting of up to eight dimensions. A powerful retrieval language and full set of data transformations and recode capabilities can be used to prepare any table or set of tables required. CENTS-AID II provides access to rectangular, heterogeneous, and hierarchical file structures, allowing simultaneous analysis of multiple record formats and, in hierarchical structures, direct analysis of data relationships of up to thirty different levels.

Evaluation of nonparametric tests in SPSS and BMDP, F. K. Kuiper and D. L. Nelson, *SP503*, pp. 431-436 (Mar. 1978).

Key words: BMDP; nonparametric statistical tests; SPSS; statistical program package evaluation; TALENT data.

This paper presents the results of comparisons made between the nonparametric tests contained in the packages SPSS and BMDP. These tests were performed using both IBM and CDC versions of each package. The packages are evaluated for accuracy, readability, machine resources used, appropriateness and completeness of the collection of nonparametric tests.

Current use of computers in the teaching of statistics, G. W. Tubb and L. J. Ringer, *SP503*, pp. 437-441 (Mar. 1978).

Key words: computer assisted instruction; computer, statistical texts; demonstrational statistical methods; simulation; statistical, computer texts; statistical content; statistical instruction; statistical interactive packages; statistical noninteractive packages; teaching statistics.

Conceptually, the current use of computers has taken two forms in the teaching of elementary statistics: integrating the *content* of statistics with that of computers; and integrating *methods* of instruction of statistics by use of computers. In the first half of this paper, three computer language textbooks are reviewed. Each uses statistics as a content area presenting programming problems. Also, three textbooks which focus on learning statistics using the computer as an aid are reviewed. The second half of this

paper surveys six published articles that evaluate courses employing "hands-on" computer instruction (CAI) and also, many published articles evaluating courses employing a demonstrational mode of instruction. The generation and use of simulated experimental data and interactive vs. non-interactive computerized statistical packages are reviewed. Extensive recommendations for integrating computers into the teaching of statistics are included. The complete paper has been submitted to ERIC with sixty-two references and thirty-four pages.

SP504. Metric dimensional coordination—The issues and precedent. Proceedings of Joint Conference, Washington, DC, June 6, 1977, S. A. Berry and H. J. Milton, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 504*, 77 pages (Feb. 1978) SN003-003-01887-2.

Key words: dimensional coordination in building; international standards for building; metrication; preferred dimensions and sizes.

These edited proceedings are a summary of a Joint Conference of the Design Sector and Construction Products Sector of the Construction Industries Coordinating Committee of the American National Metric Council, which was held in Washington, DC, on June 6, 1977. They may be used as a general reference document dealing with the background of and precedent in metric dimensional coordination.

As the United States prepares to join the metric building world, both the issues and relevant precedent in dimensional coordination become significant as a basis for an effective and economical change. To this end, the papers presented at this Joint Conference address the following topics: 1. *Dimensional Coordination—An Industrial Management Tool*, which reviews the issues and application of dimensional coordination; 2. *Building Standards Development in Sweden and in the Metric Building World*, which outlines issues in national and international standardization in the context of building design, production and construction dimensions; and 3. *Metrication—The Opportunity for an Industry-wide System of Dimensional Coordination: Precedents and Issues*, which reviews precedent in metrication and the simultaneous change to preferred building dimensions and preferred sizes in component production.

The questions and answers emanating from the Joint Conference reflect the concerns of the United States' design and production communities at the outset of metrication and dimensional coordination. *These proceedings include the following papers (indented):*

Dimensional coordination—An industrial management tool, L. Bergvall, *SP504*, pp. 5-16 (Feb. 1978).

Building standards development in Sweden and in the metric building world, H. Orlando, *SP504*, pp. 19-30 (Feb. 1978).

Metrication—The opportunity for an industry-wide system of dimensional coordination: Precedent and issues, H. Milton, *SP504*, pp. 33-48 (Feb. 1978).

SP505. Bibliography on atomic transition probabilities (1914 through October 1977), J. R. Fuhr, B. J. Miller, and G. A. Martin, *Nat. Bur. Stand. (U.S.), Spec. Publ. 505*, 283 pages (Apr. 1978) SN003-003-01922-4.

Key words: allowed; atomic; discrete; forbidden; intensity; lifetime; line strength; oscillator strength; transition probability.

A revised and updated annotated bibliography on atomic transition probabilities covering the literature from 1914 through October 1977 is presented. It contains approximately

2400 references and is divided into four main sections, with each article assigned a number. The first section contains a listing, by number, of articles of general interest. The second section lists by number all articles containing numerical data; it is arranged by element and stage of ionization and is further subdivided according to theoretical and experimental methods, comments, and compilations. The third section contains a listing of all articles, including number, authors, title, and journal reference; it is arranged by year of publication and alphabetically by authors' names within the year. All foreign language papers are identified, and their titles are translated into English. The final section contains a listing of all authors and the numbers of the papers they have authored or co-authored.

This publication supersedes NBS Special Publications 320, 320 Supplement 1 and 320 Supplement 2.

SP506. Proceedings of workshop on asbestos: Definitions and measurement methods. Proceedings of a Workshop on Asbestos held at the National Bureau of Standards, Gaithersburg, MD, July 18-20, 1977, C. C. Gravatt, P. D. LaFleur, and K. F. J. Heinrich, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 506*, 490 pages (Nov. 1978) SN003-003-01994-1.

Key words: amphibole; asbestos; fibers; light microscopy; mineralogical terminology; scanning electron microscopy; serpentine; talc; transmission electron microscopy.

This document contains invited papers which were given at a workshop on "Asbestos: Definitions and Measurement Methods" which was jointly sponsored by the National Bureau of Standards of the U.S. Department of Commerce and the Occupational Safety and Health Administration of the U.S. Department of Labor. The discussion portions of the Workshop also have been included as has written material appropriate to the topics under consideration which was submitted to the editors at a later date. The Workshop covered four major topics: Mineralogical Aspects, the Relationship Between Chemical and Physical Properties and Health Effects, Analytical Methods, and Regulatory Positions and Criteria. Also included in these Proceedings is a summary of each of these topics. These summaries serve to define those factors for which there was general agreement at the Workshop, identify remaining points of controversy, and, in some cases, describe additional research required to resolve remaining problems. *These proceedings include the following papers (indented):*

History of asbestos-related mineralogical terminology, T. Zoltai, *SP506*, pp. 1-18 (Nov. 1978).

Key words: acicular; amphibole; asbestiform; asbestos; fiber; fibrous; fragments; mineralogical; serpentine; terminology.

Asbestos-related mineralogical terms such as *fiber*, *fibrous*, *asbestiform*, *asbestos-like*, and *asbestos* have been misinterpreted and redefined during the last few years in the literature of environmental and public health studies. The new definitions are inadequate for the proper description and study of various mineral particles and, at the same time, are causing considerable confusion in interdisciplinary communication.

The meaning of these terms is traced through the history of mineralogy. It is demonstrated that: the use of the term *fiber* has always required some resemblance to organic fibers; *fibrous* has been the term describing a crystallization habit in which the mineral appears to be composed of fibers; *asbestiform* has been used, without exception, to describe a special fibrous habit in which the fibers have higher tensile strength and flexibility than crystals in other habits of the same mineral; *asbestos* was initially the name of an independent mineral species and gradually became a

collective term applied to all asbestiform varieties of minerals.

Fibrous and asbestiform minerals, J. R. Kramer, *SP506*, pp. 19-33 (Nov. 1978).

Key words: acicular; asbestiform; asbestos; elemental composition; fibers.

Asbestiform minerals may be differentiated from other elongate minerals by comparing their length and aspect ratio distributions in the greatest percentile level. Individual fiber analyses of UICC and other well-characterized samples suggest a possible 20-40 percent intensity ratio variation relative to Si of major cations. There is a very small amount of evidence to suggest that fibers other than asbestos are toxic.

The crystal structures of amphibole and serpentine minerals, J. Zussman, *SP506*, pp. 35-48 (Nov. 1978).

Key words: amphibole; asbestos; chemistry; cleavage; defects; dusts; environment; fibers; morphology; serpentine; structure.

The crystal structures of the two main asbestos-forming minerals, the amphiboles and serpentines, are surprisingly very different. The amphiboles are "chain silicates" in which SiO_4 tetrahedra are linked to form bands four tetrahedra wide and of very great length. These bands run parallel to the asbestos fiber axis and are linked laterally by cations, mainly Ca and Mg in tremolite; Na, Mg and Fe in crocidolite; Mg and Fe in amosite and anthophyllite. The tempting correlation of the chain unit of crystal structure with asbestiform nature is, however, too facile. Many amphiboles are not asbestiform, and as the serpentine minerals show, some asbestiform minerals do not have a chain structure.

The serpentine minerals are "layered silicates" in which SiO_4 tetrahedra are linked to form thin sheets of great lateral extent. The tetrahedra all point in the same direction and their apical oxygens are part of an (O,OH)-Mg-(OH) sheet which is itself formed by Mg-(O,OH) octahedra. Thus the fundamental serpentine layer is polar and has a tetrahedral and octahedral component. The mismatch in dimensions of these two components generally leads to curvature of the layers and in chrysotile asbestos the layers form either scrolls or concentric cylinders with very high length/breadth ratio and with length parallel to the fiber axis. Other forms of serpentine, however, with chemistry very similar to that of chrysotile, do not exhibit asbestiform morphology.

For all minerals, the physical and chemical properties are important both for industrial usage and environmentally in determining the nature of the dusts produced in manufacturing processes and in subsequent abrasion. Factors which may influence properties in addition to the basic chemistry and "average" x-ray structure are the crystal morphology and mode of aggregation, and also the abundance and nature of structural defects.

The "asbestos" minerals: Definitions, description, modes of formation, physical and chemical properties, and health risk to the mining community, M. Ross, *SP506*, pp. 49-70 (Nov. 1978).

Key words: actinolite; ambient air; amosite; amphibole; amphibolite; anthophyllite; asbestos; asbestos stability; chrysotile; chrysotile emissions; chrysotile mining; crocidolite; cummingtonite; dust levels; grunerite; health risk; Homestake Mines, S.D.; hornblende; Hunting Hill Quarry, Rockville, Md.; lung cancer; mesothelioma; ser-

pentinite; surface chemistry; talcoble; Thetford Mines, Quebec, Canada; tremolite; Urals; U.S.S.R.; Wadsley defects.

The mineralogical description of "asbestos" given here is based on a very special feature common to all forms of commercial "asbestos"—the property that permits the minerals to separate into long tubes or fibrils only a few tens of nanometers thick. This separation can be accomplished by very light grinding or agitation; the common nonfibrous amphiboles do not separate into such fibrils even after intense grinding. The ease of such fibril separation may be caused by the special nature of the crystal structures of the commercial "asbestos" minerals. Repeated twinning on (100) in amosite and crocidolite, the curling of layers of chrysotile to form tubes, and the presence of triple, quadruple, *n*-tuple chains ("Wadsley" defects) in amosite, crocidolite, anthophyllite, and tremolite, are the structural features that probably promote the formation of thin fibrils. Stability diagrams in the system $\text{MgO-SiO}_2\text{-H}_2\text{O}$ indicate possible geochemical processes by which commercial "asbestos" can form.

The relative health risk posed by exposure to the "asbestos" minerals may be related to the fibril composition, crystal structure, size, shape, and total surface area. The relative chemical reactivity of the fibril surface is predicted to be: chrysotile < anthophyllite < amosite < crocidolite, on the basis of the types of oxidation-reduction and exchange reactions that may occur. According to epidemiological studies, the relative health risk appears to be anthophyllite < chrysotile < amosite < crocidolite.

"Asbestos" health risks in the mining and milling industry and environs are reviewed. Health studies done in the chrysotile mining district of Quebec, Canada, have presented good evidence that realistic "asbestos" dust standards can be set that not only protect the workers and residents of the mining areas from undue health risks but probably allow the industry to operate economically.

Epidemiological evidence on asbestos, W. J. Nicholson, A. M. Langer, and I. J. Selikoff, *SP506*, pp. 71-93 (Nov. 1978).

Key words: asbestos; cancer; epidemiology; fibers; mesothelioma; occupational exposure.

Data on the human health effects from occupational and environmental exposure to asbestos will be presented with special emphasis on the role of different asbestos minerals. Further, human tissue burdens of fibers and their association with asbestos related diseases will be discussed. Experimental animal data from various species and utilizing different routes of administration will also be presented, again with emphasis on differing fiber types.

Measurement of asbestos retention in the human respiratory system related to health effects, J. Bignon, P. Sebastien, and A. Gaudichet, *SP506*, pp. 95-118 (Nov. 1978).

Key words: asbestos; carcinogenesis; fibers; pathogenicity; respiratory tract.

The retention pattern of asbestos fibers in the human respiratory system is related to four mechanisms: penetration into the respiratory tract deposition on the surface of respiratory epithelium, clearance, and intra-tissular translocation of asbestos fibers. Knowledge of such retention pattern for people exposed to asbestos dusts could provide useful information concerning the role of these mechanisms and the pathogenicity of fibers. So, asbestos fibers content has been assessed by light and electron microscopy in different samples from the respiratory tract: sputum, broncho-alveolar washing fluid, lung parenchyma,

parietal pleural, and mediastinal lymph nodes from people diversely exposed to asbestos dusts and affected by various asbestos-related diseases. In each sample, asbestos fibers, identified as chrysotile or amphibole, have been counted and measured (length and diameter).

It has been shown that asbestos fibers found in sputum and in broncho-alveolar washing fluid by light and electron microscopy were reliable for the assessment of inhaled asbestos fibers in the workplace or in the environment.

Analytical data concerning asbestos burden in respiratory tissues can be summarized as follows: despite the fact that most of the consumed asbestos is of chrysotile type, amphibole was more frequently found in lung parenchyma than chrysotile, in most cases; most of the fibers retained in lung tissues were less than $0.20\ \mu\text{m}$ in diameter and shorter than $5\ \mu\text{m}$. The intra-alveolar fibers were shorter ($3.3\ \mu\text{m}$) than fibers found in lung parenchyma ($4.9\ \mu\text{m}$). Fibers encountered in mediastinal lymph nodes were shorter ($2.5\ \mu\text{m}$) and of amphibole type, whereas fibers encountered in parietal pleura were the shortest ($2.3\ \mu\text{m}$), and thinnest ($0.06\ \mu\text{m}$ in diameter) and mostly of chrysotile type.

The signification of these data concerning the topographic variation in the fiber type and size are discussed in relationship with adverse health effects, particularly carcinogenesis.

Epidemiologic evidence of the effect of type of asbestos and fiber dimensions on the production of disease in man, W. C. Cooper, *SP506*, pp. 121-131 (Nov. 1978).

Key words: asbestos; asbestosis; carcinoma; epidemiology; fine particles; mesothelioma.

There is epidemiologic evidence to indicate that all types of commercial asbestos, i.e., chrysotile, crocidolite, amosite, tremolite asbestos, and anthophyllite asbestos, when inhaled, can cause pulmonary fibrosis and increase the risk of lung cancer. All but anthophyllite asbestos have been associated with malignant mesothelial tumors. There is also strong evidence to support a decreasing gradient of pathogenicity as one proceeds from crocidolite to amosite to chrysotile, but this evidence does not clearly rule out the interrelated influence of fiber dimension, shape, and co-factors.

Clear-cut epidemiologic evidence related to differing fiber dimensions is scanty. Such information is critically needed. The most pressing need is to determine the pathogenicity of ultrafine fibers in the electron-microscope size range, and for fibers shorter than 5 micrometers, whether inhaled or ingested. It is suggested that there be expanded epidemiologic studies of populations which have been exposed to such fibers, without the presence of long fibers. This will probably occur where the exposures are incidental to operations other than commercial asbestos production. It is also recommended that there be systematic study of the fiber content of human lungs and other tissues, as related to causes of death.

Pathophysiology in relation to the chemical and physical properties of fibers, P. Kotin, *SP506*, pp. 133-140 (Nov. 1978).

Key words: asbestosis; fibers; lung cancer; mesotheliomas; pathophysiology; toxicology.

The array of asbestos-related diseases are reviewed in relation to their pathogenesis, pathology, and natural history. Biological availability following host entry is especially critical for the biological effect of asbestos. Experimental data consistently demonstrate that hazard is related to the

geometry of fibers, with fiber diameter and fiber length being primary determinants. Controversy exists as to the extent of influence of the two major classes of asbestos fiber: chrysotile and amphibole. Considerations affecting the anatomic and metabolic fate of asbestos fibers are also discussed.

The carcinogenicity of fibrous minerals, M. F. Stanton and M. Layard, *SP506*, pp. 143-150 (Nov. 1978).

Key words: aluminum oxide; asbestos; carcinogenicity; Dawsonite; fibers; fibrous glass; phagocytosis; potassium octatitanate.

The carcinogenicities of 37 different dimensional distributions of seven different durable fibrous materials were correlated with fiber dimension. Optimum correlation was attained with fibers that measured $\leq 0.25\ \mu\text{m} \times > 8\ \mu\text{m}$. Morphologic studies suggested that fibers in this dimensional range lie free in interstitial tissues, while fibers of smaller dimension are readily phagocytosed and fibers of larger dimension are sequestered by adherent phagocytes and fused phagocytic giant cells. Fibers that are fine and long may be more carcinogenic than others, simply because they are uncompromised by phagocytic activity.

NIEHS oral asbestos studies, J. A. Moore, *SP506*, pp. 153-158 (Nov. 1978).

Key words: asbestos; bowel cancer; cancer; epidemiology; fibers.

Epidemiologic data clearly associate inhalation of asbestos with an increased incidence of cancer. In addition to pulmonary and thoracic neoplasia, there are data which associate an increased incidence of gastrointestinal and peritoneal tumors. Controversy exists as to whether these latter types of neoplasia result from asbestos fibers that were ingested subsequent to clearance from the respiratory system. Exposure to ingested asbestos does occur in the general population through the presence of fibers in water and food.

The NIEHS oral asbestos studies in rats and hamsters represent a systematic attempt to assess the biological effects associated with primary ingestion of selected asbestos fibers. The objectives of the studies include: assessment of biological (carcinogenic) effects as a consequence of exposure to one of several types of asbestos; assess if an interaction may exist between a chemical carcinogen which is known to produce bowel cancer, and ingestion of asbestos. The specific experimental design of this series of ongoing studies will be presented.

EPA study of biological effects of asbestos-like mineral fibers, D. L. Coffin and L. D. Palekar, *SP506*, pp. 163-174 (Nov. 1978).

Key words: alveolar macrophages; hemolysis; intrapleural injections; intratracheal instillation; multinucleated giant cell; PMP I; PMP II; polyp.

A large amount of the earth's crust is composed of rock containing mineral fibers which resemble asbestos to varying degrees in their physical and chemical properties. Consequently, such materials are likely to be encountered inadvertently during the extraction of various ores, the extraction of rock for commercial purposes, and even from rock moving operations encountered during highway construction, and the like.

Because the air and water may become contaminated by these fibers, it is of interest from the standpoint of environmental protection to know how the biological effect of such material compares with that of asbestos. Con-

sequently, a study has been instituted by EPA to investigate the relative biological potency of such materials. The project is being approached on both *in vivo* and *in vitro* levels. The minerals being studied at the outset are fibrous amphiboles from a taconite mine, but it is the intent to broaden these studies as soon as possible. The animal studies are being conducted in pathogen-free rats by intratracheal instillation (with and without interacting organic carcinogens) and by intrapleural injections. The end points are tumor induction and other chronic diseases. Attention is also being given to early pathogenic sequences.

The *in vitro* studies consist of red cell lysis, pulmonary macrophage systems, and various biological and chemical studies connected with the influence of these agents on cell membranes and interaction with mutagens and carcinogens. The prime objective is to compare the biological effect of the minerals studied to the corresponding asbestos species to determine the comparative influence of such covariables as fiber length, trace element content, surface area, zeta potential, and the like, on the biological outcome. Thus, the study will relate biological activity to mineralogical characterization so that generalization can be made on the basis of such factors.

A study of airborne asbestos fibers in Connecticut, L. Bruckman, *SP506*, pp. 179-190 (Nov. 1978).

Key words: air pollution; air quality data; air quality monitoring; air quality standards; asbestos; health effects; toxic substances.

The following discussion describes actions taken by the Connecticut Air Compliance Unit for the purposes of studying the danger to the public health associated with excessive airborne asbestos fiber concentrations.

In Connecticut, the criteria of mesothelioma was selected as the basis for developing an ambient air quality standard for asbestos (i.e., 30 $\eta\text{g}/\text{m}^3$ or 30,000 fibers/ m^3 , 30-day average) and compatible mass emission standard (i.e., 24 g/day) in lieu of EPA's qualitative asbestos regulations. An ambient air asbestos survey indicated that asbestos concentrations contiguous to manufacturing sources of asbestos emissions exceed Connecticut's proposed standard. Furthermore, asbestos levels adjacent to toll plazas were also elevated relative to levels removed from manufacturing sources, implicating vehicle brake lining decomposition as a significant source of airborne asbestos fibers. In addition to the aforementioned air asbestos survey, a preliminary study of mesothelioma was conducted. There were 133 Connecticut residents diagnosed with mesothelioma between 1935 and 1972. Although subject to diagnostic error, available statistics suggest that the combined sex age-adjusted mesothelioma incidence rate (AAR) per 100,000 Connecticut population has exhibited a possible 10-fold increase since 1935, rising from 0.02 during 1940 to 0.25 from 1960 to 1969. The trends for both men and women also showed sharp increases over the same time period (1940 to 1970). The rapid rise in Connecticut's mesothelioma incidence rate closely follows the increase in the State's cumulative asbestos consumption and suggests a linearly increasing cause-effect relationship which warrants further investigation.

Identification of selected silicate minerals and their asbestiform varieties, W. J. Campbell, *SP506*, pp. 201-220 (Nov. 1978).

Key words: asbestos; cleavage fragments; fibers; silicate minerals.

The problem of asbestiform particulates with its environmental and health implications has been compounded by the lack of precision with which the term "asbestos" has been used. In many instances, nonasbestiform mineral particles have been identified as microscopic fibers of asbestos-related minerals. This lack of precision in identifying these particulates not only works to the disadvantage of the minerals industry, but is also a handicap to rational science-based decision making by regulatory agencies.

This presentation summarizes methods and terminology suggested by the Bureau of Mines for the identification and characterization of asbestiform minerals and also sharpens the distinction between common serpentine and amphibole minerals and their relatively rare asbestiform varieties. The continuing effort of the Bureau's Particulate Mineralogy Unit is to characterize mineral particles by morphological, compositional, and structural data using various instrumental analytical techniques and by developing new methods for identification and characterization.

An overview of electron microscopy methods, C. O. Ruud, *SP506*, pp. 221-233 (Nov. 1978).

Key words: amphibole asbestos; asbestos; chrysotile; electron diffraction; energy-dispersive x-ray spectroscopy; mineral microfibers; scanning electron microscopy; selected-area electron diffraction; transmission electron microscopy.

According to a recent National Academy of Sciences Report, animal deposition model studies have shown the fiber size has some effect upon the toxicity of mineral microfibers, the long thin ones appearing to be most active. However, the extrapolation of these results to the relative carcinogenicity in humans must be tempered by the consideration that an experimental animal model has not been established. Moreover, the size range to be considered long, thin microfibers is not clearly defined, that is to say, the shortest length may be on the order of one micrometer or ten micrometers. For this and other reasons most scientists in the field consider that it is necessary to obtain data on length and width, as well as on concentration and species of mineral fiber fragments in the environment.

Due to these considerations, microscopy methods are necessary for mineral fiber analysis, and because of the small size of the particles, electron microscopy is necessary. This paper will describe the methods and techniques of electron microscopy which are most generally applied. These are the transmission electron microscope-selected area *electron diffraction* (TEM-SAED) and the scanning electron microscope-energy dispersive x-ray spectroscopy (SEM-EDXS) methods. The advantages and disadvantages of these two techniques will be discussed, including their relative proficiency in detecting submicrometer fiber fragments. Their ability to identify the species of mineral, sample preparation techniques, statistical considerations and the cost of analysis will also be reviewed.

The application of various techniques and methods based upon the TEM-SAED or SEM-EDXS systems will be discussed, including situations where one or the other is the optimum method. The advantages of combined systems, scanning transmission electron microscopy with SAED and EDXS, will be discussed. Also new approaches of combination and computer controlled methods using both TEM and SEM will be described.

In conclusion, the state of the art will be discussed in terms of general considerations necessary for the selection of an electron microscopy technique for mineral fiber analysis.

Identification of asbestos by polarized light microscopy, W. C. McCrone, *SP506*, pp. 235-247 (Nov. 1978).

Key words: amphiboles; asbestos; dispersion staining; microscopy.

A number of analytical tools can be used to characterize and identify asbestos: infrared absorption, x-ray diffraction, DTA, SEM, TEM, and the light microscope. Each has advantages and limitations. The polarized light-microscope (PLM) has many advantages, and the only disadvantages are 1) the asbestos particles must be at least a micrometer in largest dimension, and 2) considerable training in optical crystallography is needed.

PLM, on the other hand, is very sensitive (ppm range), extremely rapid (1-5 minutes to identify all components of most samples) and, of all the methods, only PLM will identify the individual amphiboles.

Mineral fiber identification using the analytical transmission electron microscope, D. R. Beaman and H. J. Walker, *SP506*, pp. 249-269 (Nov. 1978).

Key words: carbon contamination; electron diffraction; mineral fibers; transmission electron microscope; x-ray spectroscopy.

In a transmission electron microscope equipped with an energy dispersive spectrometer (EDS), it is possible to obtain the high resolution morphology, crystal structure, and elemental composition of submicron mineral fibers, particulate, and thin films. The reliability of fiber analysis is enhanced when fiber identification is based on the nearly simultaneous determination of these three characteristics because each of the individual modes can yield ambiguous information. Energy dispersive spectrometer data can be converted to elemental fiber compositions using known standard spectra or relative sensitivity factors which can be calculated or experimentally determined for a given instrumental configuration. Calculated and experimental sensitivity factors are found to agree within 15 percent for photon energies above 1.5 keV. The relative error in composition calculated from EDS spectra will generally be better than 10 percent, but only if the TEM column and components have been properly modified to reduce the effects of extraneous x-ray generation and electron scattering. The sources of these problems are described and a procedure for minimizing the effects outlined. Proper aperturing, collimation, selection of materials of construction, and operating conditions can provide useful mineral spectra. It is often necessary to correct for x-ray absorption even in fine mineral fibers, and this may be done using reference standards or sensitivity factors corrected for absorption. The effect of absorption increases rapidly as the difference between the mass-absorption coefficients of the elemental constituents of the mineral increases. Carbon contamination which degrades both EDS spectra and electron diffraction patterns can be minimized by using low current density and short analysis times.

Less than 15 percent of the chrysotile fibrils in a standard provided positive selected area electron diffraction patterns (SAED), but up to 50 percent did have the correct layer line spacing. The fraction of fibers providing good diffraction increases rapidly as the number of fibrils in a fiber increases. The reported differences in SAED quality arise primarily because investigators use differing criterion for defining a positive SAED pattern and the fiber size distribution examined varies. Sample preparation methods were reviewed and it was found that condensation washing is only reliable if loss corrections are applied, particularly in the case of amphibole fibers. In spite of the

many problems, inter-laboratory and multiple sample reproducibility in the measurement of fiber concentrations can be \pm 30 percent when using good procedures.

Transmission electron microscopical methods for the determination of asbestos, I. M. Stewart, *SP506*, pp. 271-280 (Nov. 1978).

Key words: amphibole; analysis; asbestos; electron diffraction; electron microscopy; fibers; transmission electron microscopy; x-ray energy analysis.

Three criteria are given for the identification of a mineral fragment as asbestos: morphology, crystallography, and chemistry. The derivation of this information in the transmission electron microscope is discussed.

Quantification of asbestos fiber content in an environmental sample is considered and currently practiced techniques for quantification both by mass and by number are reviewed.

Statistics and the significance of asbestos fiber analyses, J. P. Leineweber, *SP506*, pp. 281-294 (Nov. 1978).

Key words: analysis; asbestos; electron microscope; errors; fiber; statistics.

The analysis of asbestos fibers by electron microscope methods involves many operations, each of which can affect the final results. Normal random fluctuations can be described by the Poisson distribution, which applies to any truly random process. Deviations from normal statistics, sample preparation losses, identification errors, and laboratory contamination are sources of error which are difficult to quantify. Each, however, can cause variations which will be greater than predicted by the Poisson distribution. The significance of each of the sources of error are discussed together with recommendations for experimental techniques, which should minimize the errors.

Selection and characterization of fibrous and nonfibrous amphiboles for analytical methods development, J. C. Haartz, B. A. Lange, R. G. Draftz, and R. F. Scholl, *SP506*, pp. 295-312 (Nov. 1978).

Key words: amphibole asbestos; cummingtonite; grunerite; thermal analysis; tremolite; x-ray diffraction.

More than 50 mineral specimens of fibrous and prismatic (nonfibrous) amphibole species, including tremolite, grunerite, and cummingtonite, were collected and characterized to determine their suitability for use as reference materials in the development of analytical methods. These methods will be used for the detection and measurement of hazardous materials which are found as workplace contaminants. The specimens have been characterized using light microscopy, x-ray diffraction (XRD), and differential thermal analysis (DTA). Some of these specimens have been purified by appropriate physical or chemical techniques and then ground to provide a material with a mass median particle size of less than 10 μ m (major) diameter. The results of characterization studies of the minerals, including a comparison of the properties determined for each of the specimens, are presented. Differences in physical properties of the fibrous and prismatic tremolite specimens are indicated by the data obtained from DTA and XRD studies. While the prepared quantity of each mineral is quite limited, the source of each of the specimen materials and the appropriate methods of sample preparation have been carefully documented should additional quantities be desired.

Asbestiform minerals in industrial talcs: Commercial definitions versus industrial hygiene reality, J. M. Dement, *SP506*, pp. 313-323 (Nov. 1978).

Key words: amphiboles; anthophyllite; asbestiform minerals; industrial talc; occupational health; tremolite.

As part of its industry-wide study of the talc industry, the National Institute for Occupational Safety and Health (NIOSH) has conducted detailed industrial hygiene studies of mine and mill operations processing talcs contaminated with asbestiform minerals. The principal analytical method used for studies of asbestiform minerals in talc bulk samples and airborne dust samples is analytical transmission electron microscopy utilizing selected area electron diffraction and microchemical analysis for fiber identification. This presentation includes a discussion of the methods of analysis being used by NIOSH and comparisons of results of analysis with other analytical techniques. Also included are results of NIOSH industrial hygiene studies in asbestiform talc operations and comparisons of airborne fiber characteristics (fiber length, diameter, aspect ratios, etc.) in these operations with other industrial processes using asbestos fibers.

The detection and identification of asbestos and asbestiform minerals in talc, H. D. Stanley, *SP506*, pp. 325-337 (Nov. 1978).

Key words: asbestiform; asbestos; chrysotile; detection; fiber; identification; light microscopy; selected area electron diffraction; talc; transmission electron microscopy; tremolite; x-ray diffraction.

Concern with the health hazards associated with the presence of chrysotile asbestos and/or the asbestiform minerals in talc has prompted widespread investigation of methods of analysis which would be consistent with good analytical practices. Of all the currently available techniques examined and evaluated, the two most reliable have been found by us to be Step Scanning X-ray Diffraction and Transmission Electron Microscopy (TEM), with Selected Area Electron Diffraction (SAED). The Step Scanning X-ray Diffraction technique allows quantitative detection and identification of tremolite and the asbestiform minerals down to 0.1 percent by weight. In the absence of chlorite it can detect and quantitatively determine chrysotile asbestos at the 0.5 percent level. Chlorite, however, is often associated with talc ore bodies. When present, chlorite will mask most of the main x-ray diffraction peaks of chrysotile. Additionally, the x-ray diffraction technique cannot distinguish between fibrous and non-fibrous forms of the asbestiform minerals. TEM is ideally suited to determinations of this type because of its high resolution and magnification capabilities, the morphological nature of the problem, and the mineralogical identification capability through SAED.

Misidentification of asbestos in talc, J. B. Krause and W. H. Ashton, *SP506*, pp. 339-352 (Nov. 1978).

Key words: amphiboles; asbestos; chlorite; electron microscopy; fiber; morphology; optical microscopy; talc; x-ray diffraction.

Both optical microscopy and x-ray diffraction (XRD) are widely used to detect minerals associated with talc. Optical microscopy can determine the morphology of a particle, but cannot always fully identify the specific mineral. Although XRD is an excellent screening technique for the detection of minerals associated with talc, the method can misidentify minerals due to interferences, interpretive errors, and the inability to determine morphology.

Methods for reduction or elimination of these problems include special techniques of sample preparation and x-ray diffraction, combined with microscopic examination (both optical and electron).

Ambient air monitoring for chrysotile in the United States, R. J. Thompson, *SP506*, pp. 355-362 (Nov. 1978).

Key words: airborne particulate; air monitoring; asbestos; chrysotile; filters.

The only continuing national air monitoring has been conducted by the National Air Surveillance Network. The objective is long term trend assessment of air quality. The information has proven of value in setting standards, in consideration of health effects, in estimation of economic effects, and in showing patterns of pollutant distribution in both urban and nonurban areas.

In order to provide samples which could be analyzed for constituents not determinable in particulate matter samples collected with glass-fiber filters, a membrane sampling network was instituted. The only analyses of the samples conducted thus far has been for airborne asbestos using in part a method developed under contract which provides for the determination of the mass of chrysotile in the particulate samples.

A viewpoint will be presented on the method needed for air monitoring and an assessment of the mass method as the most suitable for this purpose. Data obtained will be examined which will include information on inter- and intra-laboratory replication.

Environmental Protection Agency interim method for determining asbestos in water, C. H. Anderson, *SP506*, pp. 365-372 (Nov. 1978).

Key words: analytical chemistry; asbestos; environmental pollutants; water.

The discovery of asbestos and asbestiform minerals in water supplies and drinking water has resulted in the requirement for a reliable analytical method. In order to meet this requirement, an interim method, based upon the state-of-the-art in asbestos analytical methodology, has been prepared. In this paper, the broad elements of the method are set forth and discussed.

Inter-laboratory measurements of amphibole and chrysotile fiber concentration in water, K. S. Chopra, *SP506*, pp. 377-380 (Nov. 1978).

Key words: amphibole; asbestos; ASTM; chrysotile; fiber; transmission electron microscope; water.

ASTM Committee E-4 has been experimentally evaluating high magnification microscopic techniques being used for the analysis of fiber contamination in water. This paper will describe the procedures and present status of this technique evaluation.

The standard for occupational exposure to asbestos being considered by ASTM Committee E-34, M. Cossette and A. A. Winer, *SP506*, pp. 381-386 (Nov. 1978).

Key words: asbestos; ASTM; consensus; definitions; exposure limits; monitoring; occupational exposure; record keeping.

This presentation reviews the consensus reached by the Task Group on Naturally Occurring Inorganic Fibers of ASTM Committee E-34. Significant differences with the OSHA regulation are pointed out on the following topics: Definitions, exposure limits, record keeping, monitoring, and the counting method. The reasons for these differences

are outlined and a rationale in support of a dual standard is presented. This Task Group document is now under study according to official ASTM procedures.

Identification and counting of mineral fragments, R. J. Lee, J. S. Lally, and R. M. Fisher, *SP506*, pp. 387-402 (Nov. 1978).

Key words: amosite; amphibole; asbestos; electron diffraction; fibrous; grunerite; mineral identification; nonfibrous.

Positive identification of submicrometer-diameter mineral fragments, especially amphiboles, requires both chemical and crystallographic analysis. At present, only electron optical methods can be used for this purpose, and considerable care must be taken to ensure that (1) the x-ray spectra and diffraction patterns pertain only to the particle in question (that is, spatial-resolution limitations must be recognized); (2) x-ray data are compared with well characterized reference standards; (3) overlapping chemical composition and/or similar crystal structures of mineral series are recognized; (4) crystal fragments are tilted into zone-axis orientation before recording the electron-diffraction pattern; and (5) appropriate statistical criteria are used to evaluate the significance of the results.

The required procedures are time consuming (and costly), but less rigorous methods are subject to considerable uncertainty, which limits the validity of the data and its usefulness in any assessment of biological effects. Adoption of a definition of mineral fibers based on an aspect ratio of 10:1 and parallel edges would eliminate most nonasbestos mineral fragments from consideration, and reduce the analytical problems to more manageable proportions.

Analysis of the face orientations of amosite fibers (commercial amphibole asbestos) and grunerite fragments (nonasbestiform amphibole) reveals pronounced distinctions which originate in their different crystal growth or cleavage characteristics.

Practical aspects of talc and asbestos, C. J. Parmentier and G. J. Gill, *SP506*, pp. 403-411 (Nov. 1978).

Key words: asbestos; scanning electron microscopy; talc; transmission electron microscopy.

The present day controversy and misunderstanding regarding talc and asbestos has existed for many years. This paper reviews some of the reasons for the widespread public misconception that all talcs contain asbestos.

The experiences of a major talc producer are discussed in relation to occurrences of talc and asbestos, and the analytical techniques required to substantiate a talc-asbestos relationship are reviewed.

The Mining Enforcement and Safety Administration—Regulations and methods, A. Goodwin, *SP506*, pp. 423-429 (Nov. 1978).

Key words: asbestos; dust; fiber; metal and nonmetal mines; optical microscopy; phase contrast.

MESA regulations for exposure to asbestos require that no employee be exposed to airborne concentrations greater than 5 fibers/mL (soon to be reduced to 2 fibers/mL) greater than 5 micrometers in length on a time-weighted average basis. We are proceeding with public meetings to obtain necessary data to reduce this permissible exposure even further. We use the membrane filter method for sampling and phase contrast microscopy for counting. Our regulations specify that the term asbestos refers to chrysotile, amosite, crocidolite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos. In order to

analyze for specific minerals we have contracted with Dr. Ruud at the University of Denver.

Occupational Safety and Health Administration methods, W. C. Dixon, *SP506*, pp. 431-439 (Nov. 1978).

Key words: airborne fiber; asbestos; bulk samples; dispersion staining; membrane filter; optical microscope; phase contrast.

Occupational Safety and Health Administration (OSHA) uses the membrane filter method at 400-450X magnification (4 mm objective) with phase contrast illumination for the analysis of asbestos in air. This method is substantially the same as is used by NIOSH.

In an atmosphere known to contain asbestos, all particulates with a length to diameter ratio of 3:1 or greater and a length greater than 5 micrometers are, in the absence of other information, considered to be asbestos fibers and counted as such.

The equipment for optical analysis of asbestos in use at the OSHA Salt Lake City Laboratory includes Zeiss microscopes having 40X objectives and 10X eyepieces, rotating stages, phase contrast illumination, polarized light, and retardation plates. The transmission electron microscope equipment in use by OSHA at the Salt Lake Laboratory is a Jeol model JEM 100C with a side entry goniometer and ASID-45 Model EM-15 SPS-2 scanning image display unit. We also have an Ortec-Delphi x-ray energy dispersive system.

X-ray diffraction, atomic absorption, and other instrumentation are also available.

The techniques used for the identification of asbestos include sight recognition based on morphology, and optical tests including polarized light, index of refraction, angle of extinction, dispersion staining, and retardation. Electron microscopy tests include morphology, selected area diffraction, and a determination of elemental composition by x-ray energy dispersive analysis.

A plan is presented for distinguishing between asbestos and other fibers which may be mistaken for asbestos. A system for differentiating between the various kinds of asbestos fibers is also presented.

FDA projects and methods, J. A. Wenninger, I. M. Asher, and P. McGrath, *SP506*, pp. 441-449 (Nov. 1978).

Key words: asbestos; cosmetic talc; EDXA; fibers; food; parenteral drugs; SEM.

An overview of FDA projects related to asbestos detection and quantitation is presented. The results of a recent FDA symposium on the availability of suitable techniques are included. We then review the technical and regulatory issues in the food and cosmetics area with regard to asbestos contamination with emphasis on the analysis of parenteral drugs and cosmetic talc. For the present, SEM using Nuclepore filters as a substrate and EDXA for chemical analysis appears to be a reasonable, cost effective method for routine detection of asbestos in foods, drugs, and biologicals, although quantitation and reduction in the number of ambiguous fibers is still a problem.

CPSC regulation of non-occupational exposure to asbestos in consumer products, R. M. Hehir, S. P. Bayard, and J. Thompson, *SP506*, pp. 451-459 (Nov. 1978).

Key words: artificial fireplace ash; consumer exposure; Consumer Product Safety Act (CPSA); Consumer Product Safety Commission (CPSC); emberizing material; free-form asbestos; patching compounds; risk assessment.

The Consumer Product Safety Commission (CPSC) has found that exposure to respirable free-form asbestos in two consumer products poses an unreasonable health risk. The Commission has recently voted to propose bans on the use of free-form asbestos in consumer patching compounds and in artificial fireplace ash or emberizing materials under Section 8 of the Consumer Product Safety Act. The broad regulatory provisions under CPSA, as well as those under the Federal Hazardous Substances Act (FHSA) are discussed.

Data on consumer exposure to asbestos are very limited. One study of airborne asbestos resulting from use of consumer spackling/patching compounds has reported levels of airborne asbestos fibers exceeding the occupational exposure levels.

Direct evidence exists of asbestos inhalation in nonoccupationally exposed individuals from autopsy findings of asbestos fibers in lung tissue and indirect evidence of asbestos-related cancers in nonoccupationally exposed individuals from epidemiological studies.

A risk assessment has been made of the potential increase of lung cancer deaths resulting from consumer exposure to asbestos containing patching compounds.

Impact of asbestos regulations on the mining industry, C. S. Thompson, *SP506*, pp. 461-469 (Nov. 1978).

Key words: amphibole; copper; crushed stone; fiber; iron; minerals; mining; quarrying; solid waste.

No one in the mining industry objects to proper regulation of toxic substances. No one in the mining industry has any objection to the reasonable control of asbestos as long as the regulations apply to the truly asbestiform varieties of specific minerals. Unfortunately, the regulators have ignored basic mineralogical data and have included numerous minerals which bear no resemblance to the asbestos upon which essentially all health data have been obtained. This gross extrapolation of the known health hazards of excessive exposures to true asbestos, to the nonasbestiform varieties of common rock-forming minerals is totally unwarranted.

The full assessment of the economic impact of asbestos regulations, as with other restrictive legislation, will undoubtedly take many years. The impact is also greatly dependent upon the outcome and recommendations resulting from this workshop. As of today, if the regulatory agencies apply their present rules and definitions regarding "asbestos," the entire mining industry and those dependent on it face an adverse economic impact unparalleled in its history. Furthermore, proposed regulations, based on the same erroneous definitions and extrapolations, are so restrictive they threaten the existence of major segments in a wide variety of areas within the mining industry. The continued promulgation and enforcement of mineral legislation based on errors and misconceptions will have severe economic effects on the total U.S. economy and on the individual taxpayer.

SP507. Standardization in support of development. Proceedings of a Seminar held at the National Bureau of Standards, Gaithersburg, MD, Oct. 17-18, 1977, H. S. Peiser and J. A. Birch, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 507*, 163 pages (May 1978) SN003-003-01928-3.

Key words: Africa; Agency for International Development (AID); Asia; developing countries; engineering standards; industrialization; Latin America; National Bureau of Standards (NBS); quality control; standards; surveys; U.N. Conference on Science and Technology for Development; workshops.

The National Bureau of Standards held a two-day Seminar in an effort to appraise the benefits derived from six years of a cooperative program with developing countries designed to improve their standardization and measurement services. With financial support from the Agency for International Development, participants came from Argentina, Bangladesh, Bolivia, Egypt, Ghana, Indonesia, Iran, Kenya, Korea, the Philippines, and Thailand; from regional and international organizations; from key U.S. standards writing bodies; and from industries, professional societies and government in the United States. The papers presented and the discussions were organized around the session titles: Six Years of National Bureau of Standards and Agency for International Development Programs, and Standardization in the U.S.A.—A Resource for Development.

It was concluded that the developing countries concerned with this program had benefited in a variety of ways from the standards surveys and workshops conducted by the National Bureau of Standards in cooperation with them, and that efforts should be made to continue the program with full support. Questions were raised, but no consensus reached on the desirability of standardization being proposed as a distinct topic for the U.N. Conference on Science and Technology for Development. *These proceedings include the following papers (indented):*

AID/OST program leading to standardization and measurement services for developing countries, E. L. Brady, *SP507*, pp. 9-18 (May 1978).

Nature and value of NBS/AID programs, C. Sangruji, *SP507*, pp. 21-25 (May 1978).

Nature and value of NBS/AID surveys, R. E. Albuja, *SP507*, pp. 27-34 (May 1978).

Workshops in the United States, R. Oteng, *SP507*, pp. 41-45 (May 1978).

Institution building, R. G. Florez, *SP507*, pp. 47-55 (May 1978).

Other NBS/AID activities, H. S. Peiser, *SP507*, pp. 67-72 (May 1978).

Standardization in the United States, R. O. Simpson, *SP507*, pp. 81-88 (May 1978).

International standards bodies and their relations with developing countries, R. N. Johnson, *SP507*, pp. 89-92 (May 1978).

The mechanism for the development and use of standards to transfer technology and develop business, L. Podolsky, *SP507*, pp. 97-101 (May 1978).

Measurement Science in the United States, A. O. McCoubrey, *SP507*, pp. 109-116 (May 1978).

Standardization as a tool for science and technology transfer in support of industrial development, M. Salama, *SP507*, pp. 119-127 (May 1978).

Standardization as a possible topic for the United Nations conference on science and technology for development, S. Bourgin, *SP507*, pp. 133-138 (May 1978).

SP508. Applications of closed-cycle cryocoolers to small superconducting devices. Proceedings of a Conference held at the National Bureau of Standards, Boulder, CO, Oct. 3-4, 1977, J. E. Zimmerman and T. M. Flynn, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 508*, 238 pages (Apr. 1978) SN003-003-01910-1.

Key words: cryocoolers; refrigeration; superconducting devices.

This document contains the proceedings of a meeting of specialists in small superconducting devices and in small cryogenic refrigerators. Industry, Government, and academia were represented at the meeting held at the National Bureau of Standards (NBS) on October 3 and 4, 1977. The purpose of the meeting was to define the refrigerator requirements for small superconducting devices and to determine if small cryogenic refrigerators that are produced in relatively large quantities can be adapted or developed to replace liquid helium as the cooling medium for the superconducting devices. Because the focus was on small superconducting devices, the discussion was primarily limited to refrigerators with capacities from zero up to a watt or two in the temperature range of 2 to 20 K. The meeting was jointly sponsored by the Office of Naval Research (ONR) and NBS. *These proceedings include the following papers (indented):*

Refrigeration fundamentals: A view toward new refrigeration systems, R. Radebaugh, *SP508*, pp. 7-43 (Apr. 1978).

Key words: available entropy; entropy systems; gas-liquid-solid systems; refrigeration cycles; refrigeration systems; thermodynamic fundamentals.

It is pointed out in this paper that most of the refrigeration techniques used today which are applicable to superconducting devices were conceived over 100 years ago. The paper emphasizes the need to look for new refrigeration systems if great strides in reliability, size and cost are to be made. To stimulate this search, thermodynamic fundamentals and refrigeration cycles applicable to any refrigeration system are discussed. Since refrigeration power of a system is proportional to its available entropy, a comparison of entropies for various systems is made. These systems include such things as electrons, phonons, spins, electric dipoles, mixtures, reversible cells, as well as more familiar gas-liquid-solid systems. The merits of various refrigeration systems are discussed in context with this entropy comparison. Finally, approaches to eliminate some of the troublesome mechanical parts in gas-liquid-systems are discussed.

Concepts for cooling small superconducting devices using closed-cycle regenerative refrigerators, R. C. Longworth, *SP508*, pp. 45-57 (Apr. 1978).

Key words: helium dewar; JT loop, regenerative cryocooler; temperature control; three stages; two stages; vibration isolation.

The use of regenerative type refrigerators to cool small superconducting devices requires solving the following problems: difficulty of cooling below 10K; isolation of the refrigerator vibration; cooling by conduction rather than liquid or gas; maintaining constant temperature.

Air Products and Chemicals, Inc. as a manufacturer of small regenerative type cryocoolers, JT coolers, helium transfer cryostats, and small helium liquefiers which are sold for use in laboratory research, has had appreciable experience in solving many of these problems. This paper describes some of the concepts that have been developed which include: three stage regenerator type cryocoolers for 7K operation; 4.2K JT loop attached to 10K cryocooler; refrigerated helium dewars with low boiloff rates; flexible low loss helium transfer lines; convective gas heat transfer to isolate vibration; temperature cycle attenuators; automatic temperature controllers.

In addition, the characteristics of the Air Products' modified Solvay cycle cryogenic refrigerator are described.

Operation of a SQUID in a very low-power cryocooler, J. E. Zimmerman and R. Radebaugh, *SP508*, pp. 59-65 (Apr. 1978).

Key words: interfering signal; Nb SQUID; self-generated interference spectrum; SQUID; very low-power cryocooler.

A point-contact Nb SQUID has been operated a total of several hundred hours at a temperature of about 8.5 K in a low-power Stirling cryocooler with a four-stage displacer. The system requires the order of 15 W of mechanical drive power. Except for the drive motor, the entire unit is non-magnetic, and the displacer and cold cylinder are made of nonconducting plastics, to minimize ferromagnetic and eddy-current fields, which would interfere with the operation of the SQUID when used as a magnetometer. With the system operating in the earth's field B_e , an ac interfering signal of about $10^{-5} B_e$ (i.e., $\sim 10^{-9}$ T) at the SQUID was seen at the 1 Hz operating frequency of the cryocooler. This signal was probably caused by rotation of the SQUID in the earth's field due to pressure flexing of the cold cylinder, although magnetic impurities in the moving parts would also contribute. Measurements of the complete self-generated interference spectrum, and experiments aimed at reducing interference to levels of 10^{-12} T and below are in progress.

Shuttle heat transfer in plastic displacers at low speeds, R. Radebaugh and J. E. Zimmerman, *SP508*, pp. 67-73 (Apr. 1978).

Key words: displacer; refrigerators; shuttle heat experimental data; shuttle heat transfer; thermal penetration.

Previous analyses of shuttle heat transfer in refrigerators with displacers have neglected radial temperature gradients in the displacer or cylinder. Such analyses are valid when the gas gap is the dominant thermal resistance. We show that with plastic materials for the displacer and cylinder, shuttle heat transfer can be dominated by the thermal penetration depth of the plastic when operating at low speeds. An equation is derived for the shuttle heat transfer in such cases. Experimental data on shuttle heat transfer is obtained for temperatures down to 120 K for different strokes and speeds and the agreement with calculated values is good.

Scaling of miniature cryocoolers to microminiature size, W. A. Little, *SP508*, pp. 75-80 (Apr. 1978).

Key words: cryocooler; heat exchanger design; Joule-Thomson cycle; refrigerator.

The very small size and thermal dissipation of superconducting sensors imposes an extremely small load on the supporting refrigeration system. Present day refrigerators generally are grossly mismatched to such loads. For this reason we have considered the possibility of scaling down a miniature refrigerator to microminiature size. A set of scaling laws is derived. These have been applied to the design of a N_2-H_2 refrigerator which might use a NbN sensor. Such microminiature refrigerators appear to offer a number of attractive design and manufacturing advantages.

Small magnetic refrigerators to pump heat from helium temperatures to above 10 K, W. A. Steyert, *SP508*, pp. 81-91 (Apr. 1978).

Key words: magnetic refrigeration; paramagnetic materials.

A brief summary will be presented of measurements of the thermodynamic properties of several paramagnetic salts useful as magnetic refrigerants in the 1 to 4 K region. A low power "conventional" (two switch) magnetic refrigerator design, using these materials and the magneto-resistive switch elements studied at NBS, Boulder, will be discussed. Also discussed will be less conventional magnetic refrigeration

tors where the paramagnetic refrigerant forms the rim of a wheel; each section of the material rotates into a field, where it expels heat and rotates out of the field where it absorbs heat.

Electrocaloric refrigeration for the 4-20 K temperature range, R. Radebaugh, *SP508*, pp. 93-97 (Apr. 1978).

Key words: electrical polarization; electrocaloric refrigeration; refrigeration; temperature range 4-20 K; theoretical models.

This paper reviews the principles and experimental results on electrocaloric refrigeration. The temperature range of 4-20 K is emphasized. Since work input comes from the electrical polarization of the dielectric material, no moving parts are required for such a refrigeration technique. The paper discusses the various types of materials which have been studied and the disappointingly low values of the electrocaloric effect. The results are shown to be consistent with theoretical models. The paper concludes that practical refrigeration with this method is not possible with present materials. Suggestions for further materials research are given.

One million hours at 4.5 Kelvin, W. H. Higa and E. Wiebe, *SP508*, pp. 99-107 (Apr. 1978).

Key words: cooling capacity monitor; cryogenic heat exchangers; fixed J-T valve; Gifford McMahon; masers.

A decade ago the authors published a paper describing some novel approaches to simplify the construction of a 4.5 K closed cycle refrigerator (CCR). These CCR's are used to cool traveling wave masers (TWM) which are used on the large antennas of the Deep Space Communications Complex which JPL operates for the National Aeronautics and Space Administration.

Since that publication, some thirty of these CCR's have been installed, and a total of more than a million hours of operation have been logged. The purpose of this paper is to review the innovative features, the changes and the improvements which have been made, and to summarize the operational experiences of the past decade.

Design compromises in the selection of closed-cycle cryocoolers, F. F. Chellis, *SP508*, pp. 109-122 (Apr. 1978).

Key words: cryocooler; infrared; Josephson junction; satellite communications; SQUID.

The systems designer is often faced with a dilemma when choosing a closed-cycle cryocooler for a specific application. He must choose between his need for extremely long operating life, and his desire for small size and minimum weight. The perfect all-purpose closed-cycle cryocooler does not exist. Each application has its own special requirements which affect the cryocooler configuration: A paramp cooler in a satellite communications antenna is not limited as to size and weight but must operate 24 hours a day continuously for over two years with hands-off operation; whereas, a cooler in an airborne infrared set must be designed primarily for minimum size and weight.

This paper describes some of the problems in designing a cryocooler for a specific application and stresses early cooperation between the user and the designer of the cryocooler. Actual case histories will be discussed.

Magnetic and vibrational characteristics of a closed cycle refrigerator, J. E. Cox and S. A. Wolf, *SP508*, pp. 123-129 (Apr. 1978).

Key words: closed cycle refrigerator; cryogenic refrigerator; magnetic signature; vibration spectrum.

A hybrid 4.5K refrigerator consisting of a CTI 1020 cryodyne with a Joule-Thomson expansion valve, has been evaluated with regard to its magnetic and vibrational signatures for frequencies up to 500 Hz in both cases. Data suggest that an off-the-shelf system of this type is not compatible with the use of Josephson devices as sensitive detectors of magnetic field changes.

Closed-cycle refrigerator for a superconducting susceptometer, D. A. Vincent, *SP508*, pp. 131-133 (Apr. 1978).

Key words: cryocooler; helium refrigerator; refrigeration, helium; SQUID refrigeration.

A closed-cycle 4.5 K refrigerator has been used to cool a chamber for condensing helium. The liquid helium is transferred to a SQUID superconducting susceptometer dewar by gravity flow with the boil-off gas recirculating to the condensing column. Vibration and electromagnetic noise isolation is maintained between the refrigerator and the susceptometer.

Cryogenic applications of closed-cycle mechanical and adsorption refrigeration, W. H. Hartwig, *SP508*, pp. 135-151 (Apr. 1978).

Key words: adsorption refrigeration; closed-cycle refrigeration; infrared detector cooling; nonmechanical gas compression; superconducting cavities.

Experiments were conducted to observe the effects of the superconducting transition of a lead X-Band cavity cooled to 6.7°K by a closed-cycle Cryodyne refrigerator. The Q changes rapidly below 7.2°K, and both drift and short-term stability undergo large changes near the transition. The refrigerator did not liquify the Helium gas. The overall objective was to develop an experiment chamber to measure photodielectric changes in semiconductors. Cooling time, vibration effects and temperature gradients were among the problems to be overcome. Results of the experiments are analyzed and related to the characteristics of the mechanical refrigerator.

Subsequent research, on a nonmechanical gas compressor, with potential applications to pre-coolers, radiation shields, and the prospects for achieving low temperatures, is also discussed.

Cryogenic cooling requirements of photoconductive infrared detectors for orbiting astronomical telescopes, J. W. Vorreiter and C. R. McCreight, *SP508*, pp. 153-157 (Apr. 1978).

Key words: cryogenic cooling; IR detectors; orbiting telescopes.

Astronomical telescopes designed for high sensitivity require cryogenic cooling for the photon detectors. Recently developed photoconducting detectors show high sensitivity to infrared radiation but, unfortunately, this sensitivity also depends upon the detector temperature. This sensitivity to temperature is discussed for several common infrared photoconducting materials, and temperature levels and temperature stability requirements are suggested. The power dissipated in typical detector circuits is also discussed to define the heat loads that the cryogenic cooling systems must absorb.

Cooling of Josephson mm- and submm-wave systems: Requirements, results and applications, J. Edrich, *SP508*, pp. 159-165 (Apr. 1978).

Key words: amplifiers; closed cycle refrigerators; detectors; Josephson effect; low-noise and broadband communications; millimeter and submillimeter receivers; mixers; radiometry; thermography.

Performance and potentials of Josephson receivers for mm and submm wavelengths are discussed. It is shown that these systems can achieve up to ten times lower noise and several times wider bandwidths than other known systems and will most likely dominate the submm wave range because of low noise and local oscillator power, wide bandwidth and tuning range. In order to find more field applications in certain broadband communications, radiometry and medical thermography small and simple closed cycle refrigerators for $T \leq 9\text{K}$ with more than 100 mW cooling capacity, small vibration and plastic displacers are needed; they could possibly be scaled-up versions of a recently reported miniature Stirling refrigerator for 8K. The influence of High- T_c superconductors and hybrid cooling systems using 20K refrigerators for reduction of liquid helium boiloff rates are discussed. As a practical example, the development and preliminary results on the first closed cycle cooled mm/submm wave system are given which uses permanent point contacts for a mixer in the 220 to 325 GHz range.

Progress report on high- T_c superconducting devices, M. R. Beasley, *SP508*, pp. 167-175 (Apr. 1978).

Key words: high transition temperature superconductors; superconducting devices.

Recent progress in the utilization of high transition temperature superconductors in superconducting electronic devices is reviewed.

Application of SQUID detectors in biomagnetism, S. J. Williamson and L. Kaufman, *SP508*, pp. 177-204 (Apr. 1978).

Key words: biomagnetism; cardiomagnetism; evoked fields; flux transporter; gradiometer; magnetocardiogram; magnetoencephalogram; magnetomyogram; magneto-oculogram; medical applications; neuromagnetism; pneumomagnatism; studies in perceptual psychology; superconducting quantum interference device.

Magnetic fields produced by biological activity in the human body have been studied in a number of laboratories during the past decade using both conventional and superconducting detectors. This paper summarizes the essential features of the techniques and some of the more important results. Sufficient detail is included so that the advantages of refrigerating superconducting detectors by cryocoolers instead of a liquid helium bath can be assessed.

Cryogenic techniques and geophysical measurements, W. D. Stanley, *SP508*, pp. 205-206 (Apr. 1978).

Key words: cryogenic techniques; earth's magnetic micropulsation field; geophysical measurements; remnant magnetization of rock; SQUID's.

Cryogenic techniques have begun to play a large role in geophysical measurements, particularly in measurement of the earth's magnetic field and remnant magnetization of rock samples. Superconducting quantum interference devices (SQUID's) are now being used in the application of a technique known as magnetotelluric sounding.

Cryocoolers for use with superconducting instruments: Some estimates of requirements, M. B. Simmonds, *SP508*, pp. 207-211 (Apr. 1978).

Key words: cryocooler; mechanical refrigeration; superconducting instrument.

The cooling requirements for several types of commercial superconducting instruments are analyzed. The purpose is to obtain operational specifications for cryocoolers

for use with these instruments. The specifications which have been considered include cooling time, cooling power, operating temperature, vibration, magnetic noise, and operating time between service.

Refrigerator requirements for potential Josephson data processing systems, B. J. C. van der Hoeven, Jr. and W. Anacker, *SP508*, pp. 213-219 (Apr. 1978).

Key words: cryogenics; data processing; Josephson; refrigerators.

Josephson Technology offers the potential for data processing systems with ultra-high performance. Such a system would operate in a cryogenic environment at liquid helium temperature. The basic operation of Josephson computer circuits and refrigerator requirements for such a processor are described, with emphasis on cost, size, reliability and power.

Liters, kilograms, watts and seconds: Design goals for a refrigerator for use with superconductive systems, M. Nisenoff, *SP508*, pp. 221-225 (Apr. 1978).

Key words: closed cycle refrigeration systems; cryogenics; superconductive devices; superconductivity; Super-Schottky devices.

A set of design goal values for certain nonthermal characteristics of a closed cycle refrigerator for use with superconductive electronic systems is proposed. These parameters include weight, volume, electrical input power requirements and turn-on-time. Other parameters, such as mechanical vibrations, electromagnetic and radio-frequency interference, which are also crucial to the utility of cryocoolers are not considered here.

Potential scientific uses of cryogenics in space in the temperature range from 1 mK to 10 K, E. Tward and P. V. Mason, *SP508*, pp. 227-241 (Apr. 1978).

Key words: astronomical research in space; cryogenics for space; He³ and He⁴ in space; relativity in space.

In this paper we report the results of a survey of potential users of cryogenics in space. The survey was conducted informally in July, 1976, in order to determine the cryogenic needs of the scientific community for space experiments. The experiments which are described below are restricted to a temperature range extending from the mK region to liquid helium temperatures. Experimental areas identified are experimental relativity, He³ and He⁴ experiments, IR astronomy, microwave astronomy and cosmic ray detection.

Josephson Voltage Standards—An application for cryocoolers?, L. B. Holdeman and C. C. Chang, *SP508*, pp. 243-245 (Apr. 1978).

Key words: ac Josephson effect; Josephson junction; low temperature; superconductivity; voltage calibration; voltage standard.

A Josephson-effect voltage-standard instrument, similar to but less accurate than the instrument used to maintain the U.S. legal volt, has been developed by the Electricity Division of the National Bureau of Standards. The Josephson device incorporated into this instrument operates with a combined rf and dc power input of less than one milliwatt. Microwave radiation is brought to the Josephson device via a small-diameter stainless-steel coaxial cable, so that the thermal load on the cryostat due to heat leaks is minimal.

SP509. Laser induced damage in optical materials: 1977.

Proceedings of a Symposium sponsored by: National Bureau of Standards, American Society for Testing and Materials, Office of Naval Research, Energy Research and Development Administration, Defense Advanced Research Project Agency, NBS Boulder, CO, Oct. 4-6, 1977. A. J. Glass and A. H. Guenther, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 509*, 561 pages (Dec. 1977) SN003-003-01911-9.

Key words: laser damage; laser interaction; optical components; optical fabrication; optical materials and properties; thin film coatings.

The Ninth Annual Symposium on Optical Materials for High Power Lasers (Boulder Damage Symposium) was held at the National Bureau of Standards in Boulder, Colorado, from 4 to 6 October 1977. The Symposium was held under the auspices of ASTM Committee F-1, Subcommittee on Laser Standards, with the joint sponsorship of NBS, the Defense Advanced Research Project Agency, the Department of Energy (formerly ERDA), and the Office of Naval Research. About 185 scientists attended the Symposium, including representatives of the United Kingdom, France, Canada, Australia, Union of South Africa, and the Soviet Union. The Symposium was divided into sessions concerning Laser Windows and Materials, Mirrors and Surfaces, Thin Films, Laser Glass and Glass Lasers, and Fundamental Mechanisms. As in previous years, the emphasis of the papers presented at the Symposium was directed toward new frontiers and new developments. Particular emphasis was given to materials for use from 10.6 μm to the UV region. Highlights included surface characterization, thin film-substrate boundaries, and advances in fundamental laser-matter threshold interactions and mechanisms. The scaling of damage thresholds with pulse duration, focal area, and wavelength were also discussed. Alexander J. Glass of Lawrence Livermore Laboratory and Arthur H. Guenther of the Air Force Weapons Laboratory were co-chairpersons of the Symposium. The Tenth Annual Symposium is scheduled for 12-14 September 1978 at the National Bureau of Standards, Boulder, Colorado. *These proceedings include the following papers (indented):*

Extrinsic absorption in infrared laser-window materials, M. Flannery and M. Sparks, *SP509*, pp. 5-23 (Dec. 1977).

Key words: infrared absorption; laser windows; molecular impurities; molecular ions; molecular spectra; optical materials; surface absorption.

Duthler's analysis and tabulation of molecular-ion-impurity lines is updated and extended to include infrared wavelengths other than 10.6 μm , to include other molecular ions, and to include other types of impurities. The results support our previous suggestion that the most likely explanation of typical lower absorptance at 5.25 μm than at 10.6, 3.8, or 2.8 μm is simply the difference between the extrinsic absorptance at the different frequencies. The results are displayed in correlation-type charts to allow either the identification of impurities to avoid at a given wavelength or the selection of a wavelength at which impurity absorption is likely to be small. Absorption at the low level of $\beta = 10^{-4} \text{ cm}^{-1}$ can occur at frequencies many line widths from an absorption peak.

Possible processes of laser window degradation, W. J. Fredericks, *SP509*, pp. 24-35 (Dec. 1977).

Key words: clusters; deterioration; diffusion; enhanced diffusion; impurity reactions; laser window; precipitate.

When judged by gross characteristics, many crystals appear to be immutable under ambient conditions. However,

most crystals are continuously undergoing changes in their properties through interactions among the impurities they contain and with reactive components in their environment. These changes can cause a decrease in the transparency of the window and lead to its ultimate failure. The purpose of this paper is to consider the processes by which this may occur. A brief discussion of impurities, their interactions, and of various mass transport mechanisms (vacancy, vacancy pair, grain boundary, anomalous) in ionic crystals will be given. But most of the discussion will concern experimental evidence for such changes and their effect on optical properties. Particular attention will be given to the interactions and reactions of OH^- and H_2O and to a variety of impurity clustering effects at various stages in their development. Some of these effects occur in remarkably short times.

Purification of potassium bromide and alkaline earth fluorides for laser components, W. J. Fredericks, *SP509*, pp. 37-55 (Dec. 1977).

Key words: barium fluoride; ion exchange purification; potassium bromide; reactive gas purification; selective ion filters; strontium fluoride.

The use of selective ion filters and reactive gas treatment for purification of KBr , SrF_2 and BaF_2 is considered. The principles of design of selective ion filters and the choice of materials for such systems is discussed. Examples of the construction of such systems are given. A system for removing monovalent impurities from alkaline earth fluorides is shown. A greaseless reactive gas system and a three stage reactive gas seal were developed.

Frequency and temperature dependence of residual infrared absorption in mixed fluoride crystals, H. G. Lipson, A. Hordvik, B. Bendow, S. S. Mitra, and J. J. Martin, *SP509*, pp. 56-61 (Dec. 1977).

Key words: absorption temperature dependence; infrared absorption; intrinsic multiphonon absorption; magnesium fluoride; potassium magnesium fluoride.

We have utilized Fourier spectroscopy and photoacoustic calorimetry to measure infrared absorption of the mixed fluoride crystal KMgF_3 in the 800 to 2400 cm^{-1} frequency range at temperatures from 80 to 535°K and compared the results with those obtained for binary fluorides such as MgF_2 and CaF_2 . KMgF_3 exhibits an exponential-like decrease in absorption as a function of frequency at room and elevated temperatures characteristic of intrinsic multiphonon absorption in most ionic materials. At low temperatures, however, well-defined structural features are observed in the absorption spectrum which may be attributed to phonon density-of-states effects. The data indicate that the Mg-F interaction has the principal influence on the KMgF_3 spectra. We also observe a similar exponential-like absorption vs. frequency for other mixed fluorides such as KZnF_3 . However, in the 2500 to 4000 cm^{-1} range our measurements suggest that residual absorption in both mixed crystals is dominated by extrinsic effects.

Bulk laser absorption homogeneity, T. J. Moravec and E. G. Bernal, *SP509*, pp. 62-73 (Dec. 1977).

Key words: automated calorimetry; calorimetry; Doppler interferometry; laser absorption uniformity.

Doppler Interferometry has been used to measure the optical change in path upon CO_2 laser irradiation and thus the absorption. This absorption has been measured at many points over the full aperture of several laser windows

and materials. The entire experiment is under control of an HP9825A calculator. Details are given of the experiment and its operation.

Refractive properties of infrared window materials, A. Feldman, D. Horowitz, and R. M. Waxler, *SP509*, pp. 74-82 (Dec. 1977).

Key words: BaF₂; CaF₂; KBr; KCl; LiF; NaF; refractive index; SrF₂; thermal coefficient of refractive index; ZnSe.

The results of the Optical Materials Characterization Program at the National Bureau of Standards are reviewed. The techniques for measuring refractive index and the change of refractive index with stress and temperature are enumerated and the materials on which these measurements have been made are listed. Data are presented for the change of refractive index with temperature of single crystal specimens of BaF₂, CaF₂, reactive atmosphere processed (RAP) KCl and KBr, LiF, NaF and SrF₂, and polycrystalline chemical vapor deposited (CVD) ZnSe and ZnS. The measurements were done by the method of Fizeau interferometry over the temperature range -180 to 200 °C at the wavelengths 0.6328 μm, 1.15 μm, 3.39 μm and 10.6 μm. The results were compared to the results of other workers and found to be in general agreement. We attempt to explain disagreements with other workers.

Refractive properties of CVD zinc sulfide, M. J. Dodge, *SP509*, pp. 83-88 (Dec. 1977).

Key words: dispersion; refractive index; temperature coefficient of refractive index; zinc sulfide.

The refractive index of two samples of zinc sulfide made by the technique of chemical vapor deposition (CVD) was determined from 0.5461 to 11.475 μm. Measurements were made relative to air by means of the minimum-deviation method on a precision spectrometer at temperatures near 22 °C and 34 °C. Each set of experimental data was fitted to a Sellmeier-type dispersion equation which permits refractive index interpolation within several parts in 10⁻⁵. The calculated data at the two temperatures was used to determine the temperature dependence of the refractive index of ZnS. The index and dn/dT of the ZnS will be compared with those properties of CVD ZnSe.

Critical orientations for eliminating stress-induced depolarization in crystalline windows and rods, R. E. Joiner, J. H. Marburger, and W. H. Steier, *SP509*, pp. 89-94 (Dec. 1977).

Key words: BaF₂; CaF₂; crystalline windows and rods; depolarization; optical distortion; photo-elastic constants; stress-induced birefringence.

The amount of depolarization resulting from stress-induced birefringence in crystalline materials can be extremely dependent upon orientation. In windows and rods made of certain materials, critical orientations exist for which the depolarization effect is eliminated.

Lattice defect equilibrium in KCl:Eu, J. B. Wolfenstine and T. G. Stoebe, *SP509*, pp. 96-104 (Dec. 1977).

Key words: Eu impurity; ionic conductivity; KCl; laser window materials; optical absorption.

A study of lattice equilibria in Harshaw-grown KCl:Eu laser window material has been undertaken using optical absorption and ionic conductivity. Ionic conductivity was determined using an A.C. method with a Wayne-Kerr bridge on 5 samples each taken from four different regions containing Eu impurity contents between 30 and 60 ppm.

Eu⁺⁺-ion concentrations were determined from the position of the "knee" in the conductivity plots. Optical absorption measurements were undertaken using a Cary 14 spectrometer at room temperature using samples from the same four regions of the original crystal. The optical absorption coefficients, α, were determined at 343 and 243 nm and compared with the Eu⁺⁺ contents determined using ionic conductivity. The results for the 243 nm band indicate a linear relationship between these two measurements such that:

$$\text{Mole \% Eu}^{++} = 4.3 \times 10^{-4} \alpha.$$

For the 343 nm band, the proportionality constant is 4.5 × 10⁻⁴.

This result disagrees with other work using different Eu-ion analysis techniques. This may indicate the presence of additional Eu in some of the crystals, present in a state of agglomeration, which would not be measured using ionic conduction.

Detection of oxygen in calcium fluoride laser window materials by XPS, T. N. Wittberg, J. R. Hoenigman, W. E. Moddeman, and C. L. Strecker, *SP509*, pp. 105-110 (Dec. 1978).

Key words: adsorption; atmospheric contaminants; calcium fluoride coatings; laser window; oxygen contaminants; x-ray photoelectron spectroscopy (XPS); zinc selenide.

The three most important criteria used in evaluating materials for laser window applications are high mechanical strength, high optical transmission, and the existence of applicable antireflective coating systems. In the case of calcium and strontium fluoride, oxygen impurities can play a strong role in determining these characteristics.

XPS data are presented on CaF₂ substrates, ZnSe coatings, and ZnSe/CaF₂ interfaces. XPS data on CaF₂ show the presence of oxygen on surfaces that have been argon ion sputtered and on surfaces that have been cleaved in an inert atmosphere. Oxygen has also been noted at the ZnSe/CaF₂ interface. These data can be related to previous results on the optical transmission of the coated laser windows.

Internal-reflection-spectroscopy study of water adsorbed on CaF₂, J. W. Gibson, R. T. Holm, and E. D. Palik, *SP509*, pp. 112-116 (Dec. 1977).

Key words: adsorbed water; CaF₂ surfaces; infrared spectrum; internal reflection; optical constants; water absorption.

The infrared internal-reflection spectrum of CaF₂ trapezoids in air indicate the presence of an adsorbed water film. The absorption near 3 μm has been studied in a vacuum system in which the trapezoids were cleaned by baking and then water vapor was allowed to the surface. Measurements of the unpolarized absorbance and the s/p polarization ratio of the absorbance indicate that the index of refraction of the film and the product of the extinction coefficient and film thickness can be obtained. Analysis implies that the optical constants are significantly less than those of bulk water. The simplest conclusion is that the film is porous.

Pulsed HF/DF laser damage in window materials, E. W. Van Stryland, M. Bass, M. J. Soileau, and C. C. Tang, *SP509*, pp. 118-125 (Dec. 1977).

Key words: alkali-halides; alkaline earth fluorides; As₂S₃; DF; electric breakdown; HF; laser damage; quartz; sapphire; spinel; ZnSe.

Laser damage thresholds are reported for several alkali-halides, alkaline earth fluorides, ZnSe, As₂S₃, sapphire, spinel and quartz at HF (2.7 μm) and DF (3.8 μm) wavelengths. A low pressure, transversely excited, double discharge laser and two different focal length lenses were used. A Gaussian spatial beam distribution was obtained by spatially filtering out high order modes in the far field of an unstable resonator cavity. Sapphire was found to have the highest bulk damage threshold of the materials tested, 100 GW/cm² at 2.7 μm (peak intensity on axis). The damage threshold was found to vary as the inverse of the spot diameter which supports the model of Bettis, et al. (NBS Spec. Publ. 462). The measurements also show that all of the materials evaluated in this effort are surface damage limited when exposed to pulsed HF or DF laser radiation. Evidence concerning the roles of material manufacture, surface finishing and laser irradiation conditioning in the damage process are presented.

Optical absorption in UV laser window materials, J. A. Harrington, B. L. Bobbs, M. Braunstein, R. Braunstein, R. Y. Kim, and R. Stearns, *SP509*, pp. 127-131 (Dec. 1977).

Key words: extrinsic uv absorption; laser calorimetry; laser windows; Urbach tail; uv laser components; wavelength modulation spectroscopy.

The requirements for low-loss optical components for high-power excimer lasers has stimulated the investigation of optical absorption in a variety of highly transparent materials at visible and uv wavelengths. The absorption coefficient β has been measured, using laser calorimetric techniques, for CaF₂, SrF₂, BaF₂, LaF₃, CeF₃, MgF₂, SiO₂, MgO, Al₂O₃, NaF, LiF, NaCl, and KCl at 3511, 3638, 4579, 4880, and 5145 Å. The absorption was found to decrease with increasing wavelength to a low value of 4×10^{-5} cm⁻¹ for SrF₂ at 5145 Å. In addition, wavelength modulation spectroscopy was used to obtain absorption coefficients for some of the samples. In this technique, the energy derivatives of β are integrated, using the calorimetrically determined values of β as constants of integration to fix β at the laser wavelengths, to obtain absorption coefficients continuously from 2500 to 5000 Å.

UV reflectance, transmission, and photoluminescence of LiYF₄, and the bulk loss coefficient in CaF₂, V. Rehn, D. L. Burdick, and V. O. Jones, *SP509*, pp. 132-136 (Dec. 1977).

Key words: bulk loss coefficient; CaF₂; Ce³⁺; LiYF₄; photoluminescence; prism technique; reflectance; transmission.

Measurements have been made of the bulk loss coefficient in two CaF₂ samples. The measurements were made between 200 and 400 nm using the prism technique. The results show a strong peak at 305 nm against a background loss of 10^{-3} to 10^{-2} cm⁻¹. The peak is tentatively assigned to Ce³⁺. In addition, VUV measurements of the transmission, reflectance, and photoluminescence of LiYF₄ have been performed for the first time. The fundamental absorption edge is at 10.42 eV. The transmission and photoluminescence spectra show structure at 7.1, 8.0 and 8.6 eV.

Fluence dependence of the absorptance of some alkaline earth fluorides at 0.36 μm, P. A. Temple and D. L. Decker, *SP509*, pp. 137-140 (Dec. 1977).

Key words: alkaline earth fluorides; color centers; laser calorimetry; photochromic; polymer films.

The absorptances of MgF₂, SrF₂ and CaF₂ have been measured at 0.351 to 0.364 μm. The absorptance is found to increase with each successive absorptance measurement

due to sample coloring by the 351 to 364 nm beam. This is found to be linear with $\int P dt$ for a given beam diameter over the power range tested. Increases in absorption of nearly two orders of magnitude to 1×10^{-1} were seen after a total central beam fluence of 3.5×10^6 J/cm². Under the beam and sample configuration used all three materials were found to have an absorptance of approximately 1×10^{-2} after approximately 3.5×10^5 J/cm² had been incident upon the sample. Possible absorption mechanisms will be discussed, including photochemically generated polymer films, impurities, and color centers.

Surface statistics of selected optical materials, J. M. Bennett and J. M. Elson, *SP509*, pp. 142-155 (Dec. 1977).

Key words: mirrors; scattering; surface roughness; surface statistics.

In order to understand and predict the scattering properties of laser mirrors and windows, it is necessary to know the statistical properties of the surface microroughness. The rms roughness of the surface determines the total integrated scattering, while the slopes of the surface irregularities determine the autocovariance function and hence the angular dependence of the scattered light. The rms roughness, rms slope, height and slope distribution functions and autocovariance function have been measured for materials of interest in infrared, visible, and ultraviolet laser applications. These include fused quartz, molybdenum, potassium chloride, copper, and silicon carbide. Variations between the statistics of different samples of the same material as well as between samples of different materials have been found. The calculated scattering to be expected from different samples will be discussed and related to that measured for some samples.

Surface roughness statistics of fused silica as a function of surface preparation and treatment, R. A. House, A. H. Guenther, and J. M. Bennett, *SP509*, pp. 157-165 (Dec. 1977).

Key words: correlation length; fused silica; polishing; roughness; slope; surfaces.

Samples of fused silica which had previously been laser damage tested on portions of their surfaces were subjected to a detailed statistical topographic analysis. These samples had been fabricated using a variety of surface preparation techniques, and the primary final characteristic of interest was the rms surface roughness of each sample. The present study focused on the height and slope distribution functions and an autocovariance length evaluation resulting from the differing surface treatments. The basic conclusion of the study is that the type of surface finishing used strongly influences the surface structure, causing a wide variation in light scattering properties and topography.

The effects of surface roughness on 1064-nm, 150-ps laser damage, D. Milam, W. L. Smith, M. J. Weber, A. H. Guenther, R. A. House, and J. R. Bettis, *SP509*, pp. 166-173 (Dec. 1977).

Key words: breakdown field; coating substrate; damage morphology; fused silica; Normarski micrographs; pulse duration; surface damage threshold; surface roughness.

We report the first measurements of the influence of surface roughness on surface damage thresholds for damage induced by subnanosecond 1064-nm laser pulses. Samples included carefully characterized bare polished silica surfaces and glass surfaces which were used as substrates for antireflection coatings. Where possible, data is correlated with earlier work performed with 40-ns, 1064-nm laser pulses.

Low scatter finishing of aspheric optics, W. P. Barnes, Jr. and R. R. McDonough, *SP509*, pp. 174-182 (Dec. 1977).

Key words: aspheric optics; laser damage; low scatter; optical fabrication.

Bowl-feed or settling slurry polishing operations are commonly used for low scatter finishing of flat and shallow spherical optical surfaces. Aspheric surfaces are a powerful optical design option, but they do not permit the development of the closely fitting lap and work surfaces required for effective bowl-feed polishing. Previous IR&D work at Itek had indicated that short term polishing with colloidal silica and a non-woven poromeric lap produced surfaces comparable to bowl-feed surfaces, as determined by scattered light and $1.06\ \mu\text{m}$ damage threshold measurements.

To test the applicability of this approach for low scatter finishing of aspherics, three $f/2$ paraboloids were given a short final polishing using colloidal silica and full sized flexible laps. No degradation of surface figure was detected, and surface scatter was reduced to values nearly equal to best practice in bowl-feed finishing.

Measurement of mirror and window characteristics for use with $10.6\ \mu\text{m}$ lasers, S. Sharma, R. M. Wood, and R. C. C. Ward, *SP509*, pp. 183-194 (Dec. 1977).

Key words: absorptance; dielectric coated mirror; infrared laser windows; laser mirrors; pulsed CO_2 laser damage; reflectance; $10.6\ \mu\text{m}$ optical components.

The absorption, reflectance and transmission characteristics of a range of infra-red mirrors and windows have been measured accurately using apparatus developed at the Hirst Research Centre based on a $10\text{W}\ \text{CO}_2$ c.w. laser. The above characteristics have been related to the methods of fabrication (diamond turning, polishing, etching, dielectric coatings) and to pulsed laser-induced damage thresholds measured using a CO_2 TEA laser, (60 ns FWHH).

The reflectance/transmittance measurement technique will be discussed and the results, together with the absorption data, correlated with the damage threshold measurements. These latter measurements will in turn be shown to correlate with surface quality (measurements made using optical and electron beam microscopy, visible scatter and x-ray topographs) and with surface films or dielectric coatings.

Polishing single point diamond turned mirrors, R. E. Parks, R. E. Sumner, and R. E. Strittmatter, *SP509*, pp. 196-203 (Dec. 1977).

Key words: metal mirrors; microripple; polishing; scattering; single point diamond turned mirrors.

A method of removing the high frequency microripple from single point diamond machined mirrors has been developed. The process uses conventional hand polishing techniques and laps of sufficient rigidity to bridge the microripple yet soft enough not to scratch the metal mirror surface. Substantial material must be removed from the mirror surfaces in some cases and the surface figure may be degraded unless careful testing is done during the process. We present photographs showing the reduction in scattering and improvement in mirror surface roughness as the result of the polishing. Phase-contrast microphotographs also show that the polished surface is almost as free of mechanical defects (scratches and pits) as the original virgin turned metal surface.

Pulsed-laser stress phenomena on highly reflecting metal and alloy surfaces, J. O. Porteus, C. W. Fountain, J. L. Jer-nigan, W. N. Faith, and H. E. Bennett, *SP509*, pp. 204-214 (Dec. 1977).

Key words: Al 7050; crystalline disorder; Cu mirrors; dislocations; laser-induced stress; melt threshold; Mo mirrors; plasma scrubbing; plasma shielding; slip; surface preparation; Ti-6Al-4V.

Modification of bare metal surfaces by laser-induced stress has been observed well below the threshold for melting with 100 nsec, $10.6\ \mu\text{m}$ laser pulses. Resulting optical and mechanical properties may be very significant for the performance of laser-optical systems and for structural components under stress. A multithreshold approach to damage testing is used to interrelate phenomena associated with different damage mechanisms, and to help establish a relationship to material characteristics. In general, the threshold for plastic deformation as indicated by intragranular (banded) slip was found to increase with crystalline disorder, while thresholds for melting and other types of catastrophic damage decrease. The melt threshold calculated from heat-flow considerations is in reasonable good agreement with experiment on a clean, annealed, single-crystal Cu target. Possible effects of elastic and inelastic strain on the melt threshold are considered. Under certain conditions the target plasma may influence the observed slip via shielding, "scrubbing" or compression. Transient reflectance data, single-crystal slip-band patterns and air breakdown thresholds support a discussion of these effects. Finally, multithreshold results are presented for a variety of metal and alloy surfaces prepared by different methods. Target preparation techniques are evaluated in terms of their apparent effectiveness in providing resistance to slip, melting and other forms of damage.

Low-expansion laser mirrors, P. Pirooz, G. Dubé and N. L. Bolog, *SP509*, pp. 215-221 (Dec. 1977).

Key words: copper film; film adhesion; glass-ceramics; IR reflectance; laser mirrors; low-expansion materials.

A unique concept for producing low-expansion IR laser mirrors was evaluated. This concept involved the self-generation of thin copper films on very low-expansion glass-ceramic substrates previously doped with copper. Exploratory studies of two major glass-ceramic systems: $\text{Li}_2\text{O}-\text{Al}_2\text{O}_3-\text{SiO}_2$ and $\text{ZnO}-\text{Al}_2\text{O}_3-\text{SiO}_2$, doped with copper have resulted in the development of mirrors with good film-to-substrate adhesion and high specular reflectance at $10.6\ \mu\text{m}$. The effects of surface finish and process parameters on the film properties were also investigated.

A new chalcogenide-glass antireflection coating for KCl, A. D. McLachlan and W. E. K. Gibbs, *SP509*, pp. 222-228 (Dec. 1977).

Key words: absorptance; antireflection coatings; chalcogenide glasses; laser damage; potassium chloride; $10.6\text{-}\mu\text{m}$ lasers.

The design, preparation and performance of new low-absorption antireflection (AR) coatings for KCl at $10.6\text{-}\mu\text{m}$ wavelength are described. These coatings are of the two-layer type and utilize the chalcogenide glasses As_2S_3 and a newly-developed thin-film material $\text{Ge}_{30}\text{As}_{17}\text{Te}_{30}\text{Se}_{23}$ (GATS) for the low-index layers respectively. The compositional homogeneity, structure, refractive index and optical dispersion of thin-films of the GATS material are reported.

The absorption of the AR coatings at $10.6\text{-}\mu\text{m}$ wavelength was determined by laser calorimetry and found to be in the range 0.02 to 0.07 percent. Fine tuning of the deposition procedures enabled coatings with reflectances of 0.025 percent to be produced. The damage thresholds for pulsed and cw CO_2 -laser radiation were also determined.

Intrinsic and thermal stress modeling for thin-film multilayers, A. M. Ledger and R. C. Bastien, *SP509*, pp. 230-242 (Dec. 1977).

Key words: film stress; infrared interferometer; stress interferometer; thin film thermal expansion coefficient; Young's modulus; zinc selenide.

Theoretical models of stress effects in thin films have been developed that can be used as a framework of a computer model for stress addition in multi-layer films. A system of stress interferometers has been developed which enables intrinsic stress, thermal expansion coefficient, and Young's Modulus to be obtained for thin films. Data on these mechanical properties have been obtained for films of Thorium Tetrafluoride, Zinc Selenide, and Thallium Iodide materials.

Hydroxyl influence and refractive index dependence in picosecond thin-film damage, W. L. Smith, D. Milam, M. J. Weber, A. H. Guenther, J. R. Bettis, and R. A. House, *SP509*, pp. 244-250 (Dec. 1977).

Key words: damage thresholds; half-wave films; hydroxyl content; MgF_2 ; refractive index; SiO_2 ; ThF_4 ; thin-films; ZrO_2 .

Results of a study of the influence of OH^- content of silica substrates on the damage resistance of thin films under $1.06\text{-}\mu\text{m}$, 150-ps pulse illumination are presented. The OH^- content variation was provided by the use of four types of commercial silica (Suprasil-W1, Optosil-2, Homosil, and Suprasil-1) as substrates. The OH^- concentrations, as indicated by IR absorption spectroscopy, are approximately 5, 130, 130, 1200 ppm, respectively. For each of the substrate materials, a set of four samples was made by depositing $\lambda/2$ (at $1.06\ \mu\text{m}$) films of ZrO_2 , SiO_2 , ThF_4 , and MgF_2 . Furthermore, an uncoated but otherwise identical sample of four uncoated silica materials was tested to provide baseline surface damage data. The results of this study are discussed in regard to earlier work of House et al. concerning hydroxyl chemistry at film-substrate interfaces. A new interpretation of the role of OH^- in the breakdown process for nanosecond and picosecond pulses is introduced.

A second important aspect of this study is the correlation of thin-film damage threshold with film material refractive index. On each substrate type, films covered the index range of 1.37 to 2.0. The threshold range observed in this picosecond study is discussed with regard to possible improvements in coating damage thresholds by use of low-index materials.

Further studies of the role of electric field strength in laser damage of dielectric layers, J. H. Apfel, *SP509*, pp. 251-254 (Dec. 1977).

Key words: antireflection coatings; dielectric films; electric fields; laser damage; nonlinear absorption; optical coatings.

In this study a silica/titania quarterwave stack reflector, a four-layer antireflection coating, and a combination of the two were prepared in a single evaporation coating run and damaged with 180-ps, $1.064\ \mu\text{m}$ laser pulses. The peak pulse intensity at the threshold of damage was highest for the reflector stack and lowest for the AR coating. Although relative thresholds of the reflector stack and the combination are in the order predicted by the model of damage occurring at the location of peak field intensity in the titania layers, the AR coating damaged at an anomalously low value.

The results indicate that the substrate/coating interface is vulnerable when illuminated by the laser pulse as in the case of the AR coating.

The effects of barrier layers and surface smoothness on 150-ps, $1.064\text{-}\mu\text{m}$ laser damage of AR coatings on glass, J. H. Apfel, E. A. Enemark, D. Milam, W. L. Smith, and M. J. Weber, *SP509*, pp. 255-259 (Dec. 1977).

Key words: antireflection coatings; barrier layer; damage thresholds; glass substrate; optical coating design; optical coating materials; substrate smoothness.

We observed that the maximum internal electric field at the threshold of damage in antireflection (AR) coatings; as calculated from our measured threshold flux, is lower than for high reflector (HR) coatings. The difference in damage vulnerability is attributed to the coating-substrate interface which is illuminated when AR coated but is protected by interference reflection when HR coated. To test this postulate, experiments were designed using evaporated interference coatings of silicon oxide (silica) and titanium oxide (titania) of different compositions on glass substrates of different surface smoothnesses. These were damage-tested with 150-ps, $1.064\text{-}\mu\text{m}$ laser pulses. We find that for silica/titania AR coatings on Bk-7 glass, a barrier or protecting layer of silica adjacent to the substrate improves the damage threshold whereas the substrate surface smoothness is not critical for short pulses. In one experiment, aluminum oxide (alumina) was used for the barrier layer between the AR coating and the substrate.

Use of non-quarter-wave designs to increase the damage resistance of reflectors at 532 and 1064 nanometers, D. H. Gill, B. E. Newnam and J. McLeod, *SP509*, pp. 260-270 (Dec. 1977).

Key words: damage thresholds; electric fields; laser damage; non-quarter-wave designs; picosecond pulses; standing waves; thin films.

The damage resistance of multilayer dielectric laser reflectors has been increased by using non-quarter-wave thicknesses for the top few layers. These designs minimize the standing-wave electric field in the high-index layers, which are generally the weaker layers. Algebraic equations have been derived for optimum film thicknesses and for the resulting peak electric fields.

Five sets of reflectors for 532 and 1064 nm were fabricated according to these designs by two vendors using two different material combinations. Each set contained one reflector of standard all-quarter-wave design and three reflectors each with a different number of modified layers. The damage thresholds of the modified designs were found to be higher than the all-quarter-wave designs, in some cases by a factor greater than 2. The damage thresholds have been analyzed and explained in terms of standing-wave electric field patterns.

Characteristics of R. F. sputter-deposited zinc selenide films on calcium fluoride, D. A. Walsh and R. V. Bertke, *SP509*, pp. 271-275 (Dec. 1977).

Key words: Auger analysis; bias-sputtering; calcium fluoride; Rutherford backscattering; sputter-etching; zinc selenide.

A study has been made of the optical, physical and chemical properties of R. F. bias-sputtered CVD Zinc Selenide thin films on polycrystalline CaF_2 laser window material as a function of sample preparation and deposition parameters. Optical performance of the coatings has been evaluated by measurement of coating absorption, physical integrity by tople-test and Scotch Tape adhesion, and chemical properties by Rutherford Backscattering and Auger Spectroscopy.

A comparison is made between bias-sputtered and non-bias-sputtered coatings. It is shown that a lower coating absorption is produced when the sample surface is sputter-etched in situ immediately prior to coating. A zinc to selenium ratio of 1.13 to 1 has been found for the initially deposited coating material and the presence of oxygen at the coating/substrate interface has been detected for bias-sputtered films.

A study of infrared absorption in zinc selenide thin films, D. F. O'Brien, *SP509*, pp. 276-280 (Dec. 1977).

Key words: absorption; dielectric coatings; thin films; zinc selenide.

Zinc selenide coatings for infrared laser windows have effective absorption coefficients which are three to four orders of magnitude higher than was predicted from bulk material optical constants. Prior growth studies and theoretical descriptions of binary compound deposition indicated that variations of the stoichiometry of the zinc selenide films were a possible cause for the high absorption measured in these coatings. An experimental program was conducted in which the absorption in zinc selenide deposited onto calcium fluoride under a variety of deposition conditions was measured. It was shown that the infrared absorption decreased as the deposition rate was lowered. This directly correlated with theoretical predictions based upon changes in stoichiometry caused by different film deposition conditions. Surface and chemical analyses using state-of-the-art techniques indicated that the most probable cause for the anomalous absorption in the films was an increase in the zinc to selenium ratio which could be controlled to some degree by the proper selection of the vacuum deposition conditions.

The design and operation of a precise, high sensitivity adiabatic laser calorimeter for window and mirror material evaluation, D. L. Decker and P. A. Temple, *SP509*, pp. 281-285 (Dec. 1977).

Key words: absorption; calorimeter; laser; scattering.

Important design details of a vacuum calorimeter intended for use with low absorption materials and using only low power laser illumination are given. Much attention has been given to the requirements for high sensitivity and to sources of systematic error including bulk and surface scatter, resulting in a number of improvements over existing instruments. Calorimetric measurements are now possible in the visible and ultraviolet, and as a function of temperature. The calorimeter output is capable of absolute electrical calibration, which is ordinarily an integral part of an absorption measurement sequence. The system thermometry is sensitive to a change in temperature of 2×10^{-5} °C. For a typical 1.5-inch-diameter sample, this corresponds to an absorbance sensitivity in the very low 10^{-5} range using one watt of laser power. The design of the instrument permits the variation in absorbance across the sample to be determined. This paper presents examples of the operational capability of the instrument.

Modulated light ellipsometer measurements of strain-induced anisotropy in the refractive index of As_2Se_3 and As_2S_3 films on KCl substrates at 10.6 μm , M. E. Pedinoff, M. Braunstein, and O. M. Stafsudd, *SP509*, pp. 286-296 (Dec. 1977).

Key words: anisotropy; ellipsometer; infrared; refractive index.

The measurement of strain-induced anisotropy in the refractive index of thin films by means of an Elasto-optic modulated light ellipsometer is discussed.

Ellipsometers of this type yield refractive index information indirectly in terms of ratios of signals $V\omega/Vdc$ (R_1) and $V2\omega/Vdc$ (R_2) where ω is the modulation frequency.

Computational routines have been developed that (differentially) relate changes in film and substrate refractive index to changes in the signal ratios R_1 and R_2 . These calculations enable us to estimate the anisotropic change in the refractive index, Δn , of an optical film due to a unidirectional stress applied to the substrate. Assumed anisotropies of 1 percent, give signal ratio changes of 1 percent to 120 percent, depending on the experimental conditions. Preliminary ellipsometric measurements show anisotropies of 0.6 percent generated in films of As_2S_3 and As_2Se_3 on KCl by strains of 4×10^{-5} induced in the substrate.

An exact calculation of the change in signal ratios R_1 and R_2 was obtained using D. Den Engleston's model of reflection from a uniaxial anisotropic film with the strain axis in the film orthogonal to the plane of incidence.

The presence of large refractive index anisotropy cannot be discerned from measurements made on a single film thickness sample by ellipsometric techniques. Experimental data is presented for various thickness samples.

Damage resistance of Ar-coated germanium surfaces for nanosecond CO_2 laser pulses, B. E. Newnam and D. H. Gill, *SP509*, pp. 298-315 (Dec. 1977).

Key words: antireflection coatings; germanium; laser damage; saturable absorber; standing-wave electric field.

An evaluation of the state-of-the-art of AR coatings on gallium-doped germanium, used as a saturable absorber at 10.6 μm , has been conducted. Both 1-on-1 and N-on-1 laser damage thresholds were measured with 1.2 ns pulses on bare and coated surfaces. Only front surface damage was observed. With few exceptions, the thresholds for coated surfaces were centered at 0.49 ± 0.3 J/cm². Bare Ge had a threshold ranging from 0.65 to 0.70 J/cm². No significant differences due to substrate polish, crystallinity or doping level were evident, and multiple-shot conditioning resulted in the same threshold as for single shot tests. From an analysis of standing-wave electric fields, damage of AR-coated Ge appeared to be limited by the surface properties of Ge. Measurements at both 1.2 and 70 ns indicated that the threshold (J/cm²) of both coated and uncoated Ge increases as the square root of the pulse-width.

10.6 μm laser damage in coatings containing As_2S_3 and As_2Se_3 , C. C. Tang, M. Bass, M. J. Soileau, and E. W. Van Stryland, *SP509*, pp. 316-323 (Dec. 1977).

Key words: As_2S_3 ; As_2Se_3 ; coating damage; coating design; defects; laser damage.

The laser damage properties of 10.6 μm coatings containing As_2S_3 and As_2Se_3 are reported. A TEM₀₀ mode CO_2 TEA laser with an intracavity CW CO_2 discharge section was the irradiation source in these experiments. This enabled the study to include a test of the role of mode locked pulses on the damage thresholds of the sample coatings.

Coatings containing As_2S_3 were damaged only after an incandescence or spark was observed during the irradiation. There was no difference in the intensity threshold, ~ 300 MW/cm² (peak intensity on axis) for damage in half wave or full wave thick As_2S_3 coatings, with or without mode locked pulses in the laser waveform. However, evidence for laser irradiation conditioning was found in certain areas of the As_2S_3 coatings.

Two different thresholds were observed for coating containing As_2Se_3 ; one where a spark was observed and a large

damage site produced and a second, at ~ 30 percent lower intensity which produced a very small damage site even though no incandescence was detected. The latter occurred at ~ 12 MW/cm² in both the full and half wave As₂Se₃ coatings. Otherwise, the quantitative behavior of, the threshold was similar to that of the As₂S₃ coatings.

The intensity of threshold for damage to As₂S₃/KCl/As₂S₃ anti-reflection coatings on KCl substrates was as high as 430 MW/cm² and did not depend on the presence of mode locked pulses. Three layer AR coatings containing As₂Se₃ damage at ~ 20 MW/cm². The relationships between the coating damage thresholds and microstructure, design and measured absorption are discussed.

Large-spot DF laser damage of dielectric-enhanced mirrors, D. B. Nichols, R. B. Hall, and R. A. House II, *SP509*, pp. 325-341 (Dec. 1977).

Key words: damage thresholds; dielectric-enhanced mirrors; large-spot laser damage; pulsed DF laser damage; substrate dependence; spot size dependence; surface plasmas.

Large-spot DF laser damage thresholds have been measured for several dielectric-coated mirrors. Five coating designs were tested, using both molybdenum and Cer-Vit substrates. Chemical laser pulses with FWHM of 4 μ sec and energies up to 70 J were focused to a target-spot diameter of 1 cm. Each test site was exposed to pulses of successively larger energies. Measured thresholds in terms of pulse peak irradiance ranged up to 21 MW/cm², which is above the plasma formation threshold for bare aluminum. The mirrors exhibited no surface plasma during small-scale damage, but a well-defined laser-supported absorption wave during catastrophic damage. No threshold differences due to substrate material were apparent. Factor-of-ten spot-size tests were used to investigate the range of validity of the spot-size scaling laws which have successfully correlated damage data over smaller areas. Whole-target and microscopic damage morphology are examined briefly.

Defects and impurities in As₂S₃, As₂Se₃, As₂Te₃, and NaF coatings, T. M. Donovan, A. D. Baer, J. H. Dancy, and J. O. Porteus, *SP509*, pp. 342-351 (Dec. 1977).

Key words: arsenic triselenide; arsenic trisulfide; Auger; damage; defects; electron microscopy; ESCA; optical coatings; thin films.

The damage thresholds of thin films of chalcogenide glasses are known to be lower than the thresholds of thin films of NaF. On the other hand, the absorptance of NaF thin films is high. The mechanisms responsible for this performance are discussed. It is suggested that the low damage threshold of chalcogenide glasses is due to the presence of micron-sized crystallites. These crystallites are not present on a fresh film, but grow on the films over a period of days, and they are an arsenic-rich sulfide, and not an oxide as has been reported. It is suggested that the high absorptance of the NaF thin films is due to a thin layer of water adsorbed on the surface, and that this water layer forms quickly when the coating is exposed to atmosphere.

Optical constants of As₂S₃ by a wedged-film technique, D. L. Burdick, *SP509*, pp. 352-357 (Dec. 1977).

Key words: arsenic trisulfide; optical constants; visible spectrum; wedged film.

A wedged-film technique has been developed to measure the optical constants of thin films. The technique has been applied to an As₂S₃ film. Measurements in the visible spec-

trum have produced absorption coefficients ranging from 3 cm⁻¹ to greater than 10⁴ cm⁻¹, and refractive indices from 2.47 to 2.72 with precisions ranging from 0.3 to 1 percent.

Dielectric coatings for deformable mirrors, J. M. Rowe, *SP509*, pp. 358-361 (Dec. 1977).

Key words: coating stress; deformable mirrors; dielectric enhanced reflectors; laser mirror coatings; stress cycling of coatings; thin films.

Results of an experimental program to determine the optical and physical properties of high-reflectance dielectric coatings subjected to a large number of deformation cycles are reported. The effects of deforming mirrors with film stacks are difficult to predict since too many parameters are involved. Therefore, an experimental evaluation of promising designs was undertaken. Measurements included residual coating stress immediately after deposition, spectral reflectance, absorptance at the design wavelength, and examination by Nomarski microscopy. Mirror properties were evaluated at several points in a schedule of controlled deformation cycling. Coating designs consisted of dielectric enhanced silver at 3.8 μ m deposited on molybdenum substrates. The data obtained provides a basis for choosing multilayer coating designs and deposition methods that may be applied to the fabrication of high-reflectance, deformable mirrors for mid-IR lasers.

Quantitative characterization of coatings: Part I: Adhesion, S. R. Scheele and J. W. Bergstrom, *SP509*, pp. 363-377 (Mar. 1978).

Key words: abrasion; adhesion; optical coating testing; peel test; plug-pull test; topple test.

Methods for quantifying the adhesion of optical coatings have been investigated with the goal of replacing the current pass-fail MIL-Spec cellophane tape tests. Three mechanical pull-off tests were compared on a large number of glass and infrared substrates with various reflection and antireflection coatings. The tests included: the direct pull-off test, in which a plug is bonded to the coating and then pulled perpendicular to the surface; the topple test, in which the top of the bonded plug is pulled parallel to the surface; and the peel test, in which an aluminum strip is bonded to, and then peeled from the surface.

Quantitative characterization of coatings: Part II: Abrasion resistance, R. A. West and C. W. Nichols, *SP509*, pp. 378-383 (Dec. 1977).

Key words: abrasion resistance; coating degradation; coatings; hardness; transmittance degradation.

A new method of quantification of abrasion resistance of antireflection coatings has been developed. The Falling Sand Test of ASTM was modified to abrade optical coatings on witness samples in a controlled manner. Quantification of the abrasion damage was accomplished by measuring transmittance degradation in the abraded area. Approximately 170 samples of antireflection coatings on various substrates including glass, KCl, ZnSe, and CaF₂, were tested using the new method. The existing standard military eraser and cheesecloth abrasion tests were also performed on many of the samples and the degree of correlation between the existing tests and the new method was established.

Dielectric enhanced mirrors for the 2-6 μ m region, S. J. Holmes, *SP509*, pp. 385-398 (Dec. 1977).

Key words: absorptance; cleaning procedures; coating materials; deposition parameters; dielectric enhanced mirrors; reflectance.

This paper reports on work done to define the performance characteristics of a large variety of multilayer dielectric enhanced mirror designs. In particular, dielectric enhanced metallic mirrors have been designed and fabricated which demonstrate reflectivities of 99.9 percent or greater for the 2.8 μm , 3.8 μm , and 5.3 μm wavelengths. Peak reflectance and description measurements are presented along with environmental testing to demonstrate the performance of these mirror coatings.

Temperature and concentration dependence of laser bulk damage to neodymium glass, J. G. Sliney, Jr., and L. G. DeShazer, *SP509*, pp. 399-409 (Dec. 1977).

Key words: damage temperature dependence; damage thresholds; GGG; $\text{La}_2\text{Be}_2\text{O}_5$; LiYF_4 ; Nd glass; YAG.

Bulk damage thresholds of Nd doped materials were measured using a Q-switched Nd:YAG laser with a single transverse and longitudinal mode having 7-ns pulsewidth. Damage was studied in a series of glasses of differing Nd concentrations: 0 percent Nd (ED4), 1 percent Nd (ED2.1), 2 percent Nd (ED2.2) and 3 percent Nd (ED2.3). At room temperature, the threshold decreased linearly by eleven percent as the Nd concentration increased from 0 to 3 percent. This variation could be explained by any one of three processes: single-photon absorption of Nd from the excited state ${}^4\text{I}_{11/2}$ — ${}^4\text{F}_{3/2}$, two-photon absorption of Nd from the ground state ${}^4\text{I}_{9/2}$ — ${}^3\text{G}_{7/2}$ and absorption by impurities such as Sm^{3+} which typically accompany Nd doping. However, we believe the single-photon absorption to be applicable because when the glass temperature is lowered to 110°K, the damage thresholds for all concentrations are nearly equal. Bulk damage thresholds were also measured for a variety of Nd doped crystals. Nd: LiYF_4 had the highest damage threshold with Nd: $\text{La}_2\text{Be}_2\text{O}_5$ (BeL) at 55 percent of LiYF_4 's threshold, YAG at 53 percent and GGG at 30 percent.

Direct measurement of inversion density in silicate and phosphate laser glass, J. A. Abate, D. C. Brown, C. Cromer, S. D. Jacobs, J. Kelly, and J. Rinefield, *SP509*, pp. 409-414 (Dec. 1977).

Key words: inversion density; parasitic oscillation; phosphate laser glass; silicate laser glass; stored energy profiles.

The first direct measurements of the inversion density in ED-2, EV-2, LHG-7, and Q-88 laser glasses are reported. The data presented qualitatively confirm the validity of the Trenholme-Emmett Xe flashlamp Nd:glass pumping model and its extension to phosphate compositions. Comparison of the measured results with previously obtained analytical and computer code formulations of the variation of inversion density with optical thickness are discussed.

Figures of merit and correlations of physical and optical properties in laser glasses, D. C. Brown, S. D. Jacobs, J. A. Abate, O. Lewis, and J. Rinefield, *SP509*, pp. 416-433 (Dec. 1977).

Key words: birefringence; fluorophosphate laser glass; glass density; nonlinear refractive index; phosphate laser glass; physical-optical properties; rupture strength; silicate laser glass; thermo-optic distortion; Young's modulus.

We propose a figure of merit which suggests that phosphate laser glasses have advantages over silicate com-

positions in that they exhibit a lower nonlinear refractive index, higher specific gain, lower thermo-optic distortion and less sensitivity to stress induced birefringence. Disadvantages of the phosphates are their tendency to heat to a greater extent under pumping, a reduced capacity to dissipate this heat, softness, high thermal expansion, low mechanical strength and reduced thermal shock resistance. From physical-optical properties correlations for a broader sampling of 120 commercially available optical glasses, we infer that one might expect lower index glasses to have poorer physical properties than higher index ones, based in part on the following: 1. there is a strong linear decrease in glass refractive index with glass density; 2. appropriate functional dependences exist which relate a low glass density to a small value of Young's modulus, and a small value of Young's modulus to a reduced hardness and rupture strength.

Preliminary data for the fluorophosphates and their high densities suggest that glasses from this composition group will be more durable than the phosphates. This trend is not well understood in light of the low refractive indices of these glasses.

Progress in claddings for laser glasses, R. B. Bennett, K. R. Shillito, and G. J. Linford, *SP509*, pp. 434-439 (Dec. 1977).

Key words: fluorophosphate laser glass; glass cladding; laser fusion; microstructure; parasitic oscillation; refractive index; residual stress.

Cladding glass compositions matched in refractive index have been developed for two commercial neodymium-doped silicate laser-glass-disk amplifiers for the suppression of parasitic oscillations. Coatings based on a copper oxide-doped borate glass system satisfied specifications for single-pass optical transmission, xenon flashlamp damage threshold level, scatter, and thermal-expansion match. Commercial application for Owens-Illinois' ED-2 laser glass and Hoya Optics' LSG-91H laser glass achieved gain levels surpassing those of previously tested commercial glass claddings and equivalent to that of liquid cladding systems. Compositions and cladding design criteria are presented.

The feasibility of glass claddings for neodymium-doped fluorophosphate laser glass is also reported. Claddings based on copper oxide-doped alkali phosphate glass systems having softening temperatures below 400 C, linear thermal-expansion coefficients between 14 and $18 \times 10^{-6}/\text{C}$, refractive indices of 1.48-1.50, and good chemical durability have been identified. Technology is being developed to meet specific design and performance goals and to reveal the nature and extent of potential problems associated with claddings for fluorophosphate laser glass for advanced laser systems. Compositional ranges and pertinent data along with design considerations are presented.

Damage history of Argus, a 4TW Nd laser system, I. F. Stowers and H. G. Patton, *SP509*, pp. 440-454 (Dec. 1977).

Key words: Argus; coated optics; damage; disks; laser; uncoated optics.

Argus is a two arm Nd:glass laser built for laser fusion experiments. It operates at a power level of 4 terawatts with 100 ps pulses and has placed 2KJ on a fusion target with 1 ns pulses.

To minimize spatial modulations on the beam and damage to coated and uncoated optics, the system uses five spatial filters on each arm and the beam fluence is maintained below 2 J/cm². Despite these precautions, coated optics and uncoated disks occasionally still damage. Damage limits the useful life of the system and determines the frequency of maintenance.

This paper discusses the several forms of damage that have been observed, their morphology, severity and frequency of occurrence. Three distinctly different forms of damage have been observed in the system. They are: A) contamination induced damage to Nd:glass disks caused by broad-band xenon flashlamps, B) optically obscuring films on disks and C) damage to coated optics by the laser beam.

New results on avalanche ionization as a laser damage mechanism in transparent solids. A. A. Manenkov, *SP509*, pp. 455-463 (Dec. 1977).

Key words: avalanche ionization; damage thresholds; laser damage; optical materials; temperature dependence of damage thresholds.

Recent theoretical and experimental investigations carried out in the P. N. Lebedev Physical Institute of the Academy of Sciences of the USSR on electron avalanche ionization as a laser damage mechanism of solid transparent dielectrics are discussed. Formulas obtained on the basis of solution of the kinetic equation for electrons in the conduction band are given for the threshold (critical) fields E_c . The fundamental characteristics of the avalanche mechanism, namely, dependence of E_c on the sample temperature, radiation frequency and pulse duration are noted. Experimental results on the temperature dependence of damage thresholds for a number of alkali-halide crystals and other crystals used in laser optics are analyzed on the basis of avalanche ionization theory. These include NaCl, KCl, KBr, CsI, KI, RbCl, CsPr, Al_2O_3 , YAG, SiO_2 , CaF_2 , $LiIO_3$, BaF_2 , NaF and LiF. Damage results were obtained with CO_2 (10.6 μm), Nd:YAG (1.06 μm , 0.53 μm) and ruby (0.69 μm) laser radiation, in pulses with duration of a few ns.

This analysis shows that for those crystals of NaCl, KCl and KBr having the highest damage thresholds, the avalanche ionization can be responsible for laser damage in the range of $\lambda = 0.69 - 10.6 \mu m$. This conclusion is supported by a rather good agreement between the theory and the experiment for the frequency dependence of the damage threshold over that frequency range at room temperatures and for the temperature dependence in the 100°K to 800°K range at high frequencies ($\lambda = 10.6 \mu m$ and 0.69 μm). However, the theory does not explain the temperature dependence of the damage thresholds observed above 300°K at low frequency ($\lambda = 10.6 \mu m$).

It is shown that at $\lambda = 0.53 \mu m$, the laser damage of alkali halide crystals is not explained by avalanche ionization, and it is probably attributed to multiphoton ionization.

For the other crystals investigated (in particular, for Al_2O_3 , NaF, and LiF with high damage thresholds) the observed frequency and temperature dependence of the damage threshold at $\lambda = 0.69 \mu m$ and $\lambda = 1.06 \mu m$ do not correspond to values predicted by avalanche ionization theory. The question of the nature of the damage mechanism of these crystals is still open.

Finally, we shall discuss the previously published results on the dominant role of avalanche ionization in laser damage of the alkali halides and some other crystals. The qualitative arguments on which this conclusion was based, are shown not to be confirmed by our data, which was obtained in more detailed experiments, and analyzed using a consistent theory of avalanche ionization.

Multiphoton theory of optical breakdown in alkali halides. A. Schmid, P. Kelly, and P. Bräunlich, *SP509*, pp. 465-472 (Dec. 1977).

Key words: breakdown flux and field strength; frequency dependence; intrinsic laser damage; linear and nonlinear refractive indices; multiphoton absorption; polaron; pulse length dependence.

A theory of optical breakdown in dielectrics is presented; based on multiphoton carrier generation and energy transfer from the radiation field to the lattice via polaron-photon absorption. This mechanism represents a clear alternative to avalanche breakdown models as no lattice impact ionization is involved. Breakdown field strengths calculated for various laser pulse lengths and frequencies, are fully corrected for the nonlinear refractive index n_2 as well as for contributions to the refractive index resulting from a sharp increase in polaron density during a damaging pulse.

The role of carrier diffusion in laser damage of semiconductor materials. M. Kruer, L. Esterowitz, F. Bartoli, and R. Allen, *SP509*, 473-479 (Dec. 1977).

Key words: carrier diffusion; laser damage; semiconductor damage; time dependence; wavelength dependence.

The role of carrier diffusion in laser damage of semiconductors is investigated for various laser wavelengths. The results indicate that carrier diffusion significantly affects the magnitude of the damage threshold when the optical absorption coefficient is greater than 10^5 cm^{-1} .

Multiphoton-induced conductivity in ultraviolet-transmitting materials. 1. Free carrier lifetime. R. T. Williams, P. H. Klein, and C. L. Marquardt, *SP509*, pp. 481-487 (Dec. 1977).

Key words: dielectrics; free carrier; laser damage; lifetime; multiphoton; ultraviolet; window materials.

Fast photoconductivity measurements are being used to characterize free-carrier recombination and trapping rates in insulators. Carriers are generated in these experiments by multiphoton absorption of a 20-ps, 347-nm laser pulse. At low carrier densities, lifetimes governed by extrinsic traps are measured to be typically 10-20 ns. Material preparation and subsequent treatments are shown to have measurable effects on carrier lifetime in the extrinsic limit. Published optical data are cited as evidence that the free carrier lifetime in alkali halides is strongly dependent on carrier concentration, changing from the extrinsic nanosecond range to less than 10 ps when the concentration is increased to about 5×10^{17} carriers per cm^3 . Physical mechanisms giving concentration-dependent recombination times are discussed. An investigation by photoconductivity of the carrier concentration range intermediate between the two cases just cited has been attempted within limitations imposed on the present technique by space charge buildup.

Absolute two-photon absorption coefficients at 355 and 266 nm. P. Liu, W. L. Smith, H. Lotem, J. H. Bechtel, N. Bloembergen, and R. S. Adhav, *SP509*, pp. 489-495 (Dec. 1977).

Key words: alkali-halides; avalanche ionization; breakdown; calcite; KDP; multiphoton absorption; sapphire; silica; transparency; two-photon absorption; ultraviolet windows.

The absolute two-photon absorption coefficients of ultraviolet-transmitting materials have been measured using well-calibrated single pulses at 355 nm and 266 nm from a mode-locked Nd:YAG laser system. Two-photon absorption coefficients of the order $10^{-3} \text{ cm}^2/\text{MW}$ were found for alkali-halides, and of order $10^{-4} \text{ cm}^2/\text{MW}$ for KDP and its isomorphs. Several other materials— Al_2O_3 , $CaCO_3$, SiO_2 , and CaF_2 —were also tested. In materials with band gap

greater than $2 \hbar \omega$, no nonlinear absorption was detected up to the threshold of surface breakdown. The effects of multiphoton absorption on the breakdown of ultraviolet window materials is discussed.

Statistical considerations in laser damage measurements, J. A. Detrio and A. P. Berens, *SP509*, pp. 496-505 (Dec. 1977).

Key words: laser damage testing; probit analysis; sensitivity testing; statistics; up and down method.

The measurement of the laser damage threshold for a given material or optical component is usually accomplished by testing at predetermined power levels and irradiation times and then observing whether or not damage occurs. This experimental procedure is known as sensitivity testing which attempts to determine the percentage of specimens which are damaged at the various power levels. It is not practical to determine the complete cumulative distribution curve for a given sample population because of the limited number of specimens normally available. The variability in damage level for a given optical component will influence the number of specimens required to measure the damage threshold with a given precision and with a known level of confidence or to achieve a desired degree of discrimination in comparing two different materials, preparation methods or production runs. A statistical method applicable to sensitivity testing is analyzed to permit the experimenter to determine the number of specimens required in accordance with the desired level of precision and confidence. A novel nonparametric method which is applicable to damage testing and requires few samples is also analyzed.

Multithreshold measurement and analysis of pulsed laser damage on optical surfaces, J. O. Porteus, J. L. Jernigan, and W. N. Faith, *SP509*, pp. 507-515 (Dec. 1977).

Key words: damage thresholds; failure modes; laser-optical components; Mo mirrors; optical coatings; pitting; ripples; standard sample Au mirrors; surface characterization; surface uniformity; threshold estimation; windows.

The methodology of multithreshold analysis, a new approach to laser-damage research, is described. The comparison of thresholds for various damage-related effects identifies dominant failure mechanisms and provides better guidance for laser-materials technology. After a brief description of apparatus, the procedure for routinely measuring up to eight different thresholds per sample is given. The maximum-likelihood principle is used to derive an algorithm for computing thresholds and standard deviations. The use of a standard gold sample to verify reproducibility and to maintain long-term calibration is discussed. Examples of multithreshold results on uncoated and coated infrared optical components are presented. The following are some of the effects for which thresholds are compared: slip, roughening, cracking, pits, melting, craters, delamination of coatings, ion and light emission, and work function change.

SP510. Tentative provisions for the development of seismic regulations for buildings, *Nat. Bur. Stand. (U.S.), Spec. Publ. 510*, 514 pages (June 1978) SN003-003-01939-9.

Key words: building; building codes; building design; disaster mitigation; earthquakes; engineering; standards.

This document contains tentative seismic design provisions for use in the development of seismic code regulations for design and construction of buildings. The provisions represent the result of a concerted effort by a multidisciplinary team of

nationally recognized experts in earthquake engineering. Design professionals, researchers, Federal agency representatives, staffs from the model code organizations and representatives from state and local governments from throughout the United States were involved. The provisions are comprehensive in nature and deal with earthquake resistant design of the structural system, architectural and nonstructural elements and mechanical-electrical systems in buildings. Both new and existing buildings are included. They embody several new concepts which are significant departures from existing seismic design provisions. An extensive commentary documenting the basis for the provisions is included.

SP511-1. Economic effects of metallic corrosion in the United States. Part I. A report to the Congress by the National Bureau of Standards, L. H. Bennett, J. Kruger, R. L. Parker, E. Passaglia, C. Reimann, A. W. Ruff, H. Yakowitz, and E. B. Berman, *Nat. Bur. Stand. (U.S.), Spec. Publ. 511-1*, 65 pages (May 1978) SN003-003-01926-7.

Key words: Battelle Columbus Labs; corrosion; cost of corrosion; economic effects; I/O Model; metallic corrosion.

In response to a Congressional directive, this study of the cost of metallic corrosion to the United States was undertaken by the National Bureau of Standards (NBS). The analysis required in this study was placed under contract to the Battelle Columbus Laboratories (BCL). The overall study was conducted jointly by BCL and NBS. The study was designed to provide a reference to allow the economic impact of corrosion to be compared with other factors affecting the economy.

In 1975, corrosion cost the United States an estimated \$70 billion. This was 4.2 percent of the estimated Gross National Product for that year. Of this total, about 15 percent or \$10 billion was avoidable. An uncertainty of about ± 30 percent for the total corrosion cost figure results from inadequate data in some areas and unsure technical and economic judgments. The uncertainty in the avoidable costs is considerably greater.

This study used a modified version of the BCL National Input/Output Model. The model quantitatively identifies corrosion-related changes in resources (material, labor, energy, value added), changes in capital stock, and changes in replacement lives of capital stock for all sectors of the economy. The use of this model is well suited for estimating the total direct and indirect costs of corrosion.

SP511-2. Economic effects of metallic corrosion in the United States—Appendix B. Part II. A report to NBS by Battelle Columbus Laboratories, J. H. Payer, D. G. Dippold, W. K. Boyd, W. E. Berry, E. W. Brooman, A. R. Buhr, and W. H. Fisher, *Nat. Bur. Stand. (U.S.), Spec. Publ. 511-2*, 249 pages (May 1978) SN003-003-01927-5.

Key words: capital; corrosion costs; dollar flow; economics; input/output; interindustry; replacement; resources; transactions.

The purpose of this study was to determine the economic effect of corrosion in the United States. The results provide a basis for development of technological, legislative, and other initiatives to promote effective economic savings. The study was confined to corrosion of metals. For the year 1975 as the base year, total costs of corrosion were estimated as follows: Total costs to U.S.—\$82 billion—1.9% GHP; Avoidable costs—\$33 billion—2.9% GHP; Unavoidable costs—\$49 billion—2.0% GHP.

Input/Output analysis, which provided the methodological framework for this study, permitted detailed and comprehensive treatment of all elements of the costs of corrosion. Production costs, capital costs, changes in replacement lives, etc. were treated in a coordinated and systematic manner. The corrosion

I/O Model can be used to assess proposed means to reduce costs.

SP512. Energy-effective windows. Proceedings of a Joint DOE (ERDA)/NBS Conference/Round Table on Energy-Effective Windows held in Washington, DC, Apr. 13, 1977, H. R. Trechsel, Technical Coordinator, *Nat. Bur. Stand. (U.S.), Spec. Publ. 512*, 53 pages (Apr. 1978) SN003-003-01929-1.

Key words: daylighting; energy conservation; glass; thermal performance; windows.

On April 13, 1977, a Joint DOE/NBS Conference/Round table was held on Energy-Effective Windows. The conference was attended by 30 participants and speakers and auditors representing all major interests in window industry, government, academia, professions, and the media. *These proceedings include the following papers (indented):*

An overview of window research at NBS, B. L. Collins, *SP512*, pp. 6-12 (Apr. 1978).

DOE (ERDA)/LBL window research, S. M. Berman, *SP512*, pp. 14-19 (Apr. 1978).

An architect's view of energy-effective windows, H. Taylor, *SP512*, pp. 20-25 (Apr. 1978).

Window research in the United Kingdom and in Europe, D. A. Button, *SP512*, pp. 26-32 (Apr. 1978).

SP513. Reaction rate and photochemical data for atmospheric chemistry—1977, R. F. Hampson, Jr. and D. Garvin, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 513*, 111 pages (May 1978) SN003-003-01924-1.

Key words: air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant.

A table of data for gas phase chemical reactions and photochemistry of neutral species is presented. Specifically, it gives preferred values for reaction rate constants, photoabsorption cross sections, and quantum yields of primary photochemical processes and also cites recent experimental work (to December 1977). It is intended to provide the basic physical chemical data needed as input data for calculations modeling atmospheric chemistry. An auxiliary table of thermochemical data for the pertinent chemical species is given in the appendix.

SP514. MFPG: Product durability and life. Proceedings of the 27th Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Gaithersburg, MD, Nov. 1-3, 1977, T. R. Shives and W. A. Willard, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 514*, 188 pages (May 1978) SN003-003-01935-6.

Key words: design quality; durability; durability technology; materials conservation; product life; product performance; product testing; wear analysis.

These proceedings consist of a group of nineteen submitted papers from the 27th meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards in Gaithersburg, Maryland, on November 1-3, 1977. The central theme of the proceedings pertains to the durability of consumer products. Special emphasis is on durability technology, product testing, product performance, the economics of extending product life, and labeling products for durability. *These proceedings include the following papers (indented):*

Opportunities and implications of extending product life, R. T. Lund and W. M. Denney, *SP514*, pp. 3-11 (May 1978).

Key words: consumer usage; product design; product durability; product life; remanufacturing.

This paper begins by discussing the various benefits associated with extended product life, and possible negative impacts are noted, as well. It is pointed out that the factors influencing product life are not only technological in nature, but also include product usage behavior by consumers. The discussion then turns to a fourfold classification scheme for policy alternatives for extending product life. This scheme is built on the distinction between consumer versus product-related influences on product life, and a distinction between short-term and long-term policy impacts. The final section of the paper identifies options available to policymakers attempting to prolong life. The concept of remanufacturing, as a strategy deserving more careful attention, is particularly stressed.

Economic considerations and product life, P. Lerman, *SP514*, pp. 12-18 (May 1978).

Key words: discounted cash flow; financial analysis; product durability; product life; tax effects.

The economic and financial considerations associated with all product decisions have become increasingly important in recent years due, in large part, to relatively high capital costs and the resulting desire on the part of corporate decision makers to invest their capital funds in those projects yielding acceptable returns.

Most cases involving an improvement in product durability will require a commitment of managerial, engineering, and production resources, all of which will ultimately be measured in financial terms. Thus, the final decision regarding product durability would seem to be based on economic and financial considerations, assuming technological feasibility.

The paper discusses the economic and financial considerations that must be recognized in determining the viability of an improvement in product durability. Included in this discussion are current accounting and tax policies that affect the decision.

Labeling products for durability, M. J. Raabe, *SP514*, pp. 19-28 (May 1978).

Key words: congressional action; consumer product testing; durability; labeling products; Performance Life Disclosure Act.

Review of Congressional Action with respect to past consideration and current bills dealing with labeling products for durability, as well as for other characteristics. Discussion of present governmental action in the overall product labeling area, including comments on primary problems being encountered. A focus specifically on durability labeling along with comments on prospects for future congressional action.

Methodology of product life testing, J. Cohen, *SP514*, pp. 31-41 (May 1978).

Key words: consumer products; reliability engineering; testing methodology; useful life.

A methodology was formulated for estimating, through laboratory testing, useful life and associated performance of consumer products. Excerpts from two key parts—concepts of reliability engineering and procedure to guide the formulation of tests—are given here. Criteria for assessing tests are presented.

Small appliance life testing, K. W. Yee, *SP514*, pp. 42-53 (May 1978).

Key words: consumer product testing; life test method; useful life.

Work has been underway at the National Bureau of Standards, Center for Consumer Product Technology, to determine the feasibility of and methodology for developing standard test methods to estimate the useful life of consumer products. Initial efforts have been on small appliances. The hand-held blow hair dryer was selected for the demonstration product. The status of current work on the hair dryer will be described. A similar effort on a major appliance has been undertaken and will be described.

Product life testing and durability, N. R. Pugh, *SP514*, pp. 54-65 (May 1978).

Key words: consumer product life; durability; testing.

This paper considers testing for product failure prevention from the standpoint of a laboratory in a retailing system based on "private-label" product lines.

The point of view of such a laboratory in product design evaluation and testing programs is described briefly.

Some thoughts are presented about the need for consumer product durability testing, considering the present level of product life, and the state of the art in consumer product technology.

Some of the challenges in predicting durability, and minimizing failures, through laboratory and field test programs, are explored. Examples of testing for durability evaluation are discussed. The relationship of design quality evaluation to conformance quality, both as-manufactured and after extended use, is examined. Examples of testing for durability evaluation are discussed.

The interaction of factual information and consumer receptivity; and the effectiveness of durability and life information, is considered.

Lastly, some opportunities for real accomplishment through better teamwork among various elements—governmental institutions, academe, and the private sector are described.

Hydraulic pump contaminant life evaluation, L. E. Bensch, *SP514*, pp. 66-75 (May 1978).

Key words: abrasive wear; accelerated wear testing; contaminant tolerance; contaminant wear; hydraulic pump wear; service life.

The hydraulic pump is one of the most critical components in any fluid power system. It is also generally thought to be one of the most sensitive to abrasive wear. The Fluid Power Research Center has been investigating accelerated test methods for evaluating pump contaminant sensitivity for several years. An associated wear theory has also been developed for predicting long-range pump contaminant service life based upon these accelerated tests and field operating conditions. During the past two to three years, a number of tests have been performed to verify the contaminant life predictions by conducting extended life tests under controlled contaminant environments. Tests were conducted over a broad range of service lives, ranging from 22 to 1430 hours utilizing both gear and piston pumps.

This paper presents the results of this extensive research investigation, including details of the life evaluation methods. Also included are brief descriptions of the accelerated test methods and contaminant life prediction techniques. The paper discusses the expected accuracy of the life predictions revealed by the test results.

Control of design quality, A. W. Dorney, *SP514*, pp. 76-81 (May 1978).

Key words: product failure; product testing; quality control; quality of design; reliability.

Manufacturers often find that even though their products have been processed utilizing stringent manufacturing controls, their customers are still receiving and reporting poor quality. The function of an independent Reliability Section is discussed covering its relationship with Design, Manufacturing and Quality Control. This section does not fully utilize the statistical aspects of Reliability, but controls the quality of the design as required, by determining the end use of the product and testing accordingly. Responsibility for the design and manufacturing in the various stages is discussed as is the testing and decision making associated with it. A typical consumer product is followed from Marketing concept through acceptance for shipment to the customer.

Factors affecting product lifetime: Preliminary results of a research study, W. D. Conn, C. Inge, B. Sanyal, and E. Warren, *SP514*, pp. 82-89 (May 1978).

Key words: consumers; durability; product lifetime; second-hand markets; small household electrical appliances; solid waste management; waste reduction.

A possible method of reducing solid waste (to alleviate problems of solid waste management, resource depletion, and environmental degradation) is to increase the lifetimes of durable products. Recognizing that in practice these lifetimes are determined not only by the physical durability "built in" by the manufacturers but also by a variety of other factors, an NSF-sponsored research project at UCLA is currently seeking information to assist government decision-makers in developing cost-effective waste reduction policies. Consumers have been surveyed to obtain data about their acquisition and disposal of small household appliances (such as irons, toasters, etc.); manufacturers have been asked about their actions affecting product lifetimes; and the nature and extent of second-hand markets have been examined. Preliminary results are presented.

Brake wear, S. K. Rhee, *SP514*, pp. 93-98 (May 1978).

Key words: automotive friction materials; brake wear; friction materials wear; friction material test methods; wear equation; wear mechanisms.

Automotive and truck friction materials are described, and their wear characteristics are discussed. The wear rates of these friction materials are dependent upon many independent and dependent variables such as brake temperature, brake pressure, deceleration rate, weight, terrain, climate, engine conditions, drivers, traffic conditions, road dust, dust shield, surface roughness of the rotor and others. Test methods are described, and an equation is given for determining wear rate of automotive friction materials at a given temperature. The paper concludes by noting the difficulties of developing standardized techniques for durability testing of friction materials.

Accelerated testing of compressors, F. E. Kalivoda, *SP514*, pp. 99-106 (May 1978).

Key words: compressor failures; compressor testing; operating conditions; reliability tests; temperature effects.

Refrigeration, heat pump and air-conditioning compressors are expected to have long operating lives and low failure rates. Accelerated tests are, therefore, a practical

necessity, but, care must be taken not to introduce extraneous failure modes. This paper discusses a test plan used to qualify these compressors and some of the complexities which must be considered.

Automobile durability, C. J. Brady and H. W. Larsen, *SP514*, pp. 107-120 (May 1978).

Key words: automobile durability; automobile testing; design analysis; electronic field data collection program; vehicle service life.

The automobile industry is designing and testing vehicles to meet increasing requirements for durability, safety, emission control, and fuel efficiency. Recent technical developments at General Motors have provided previously unavailable quantitative information on usage of vehicles by customers. This presentation discusses an electronic field data collection program and the way General Motors is combining the resulting information with modern design analysis and test methods to estimate the service life of vehicles.

Wear analysis in office machines, P. A. Engel, *SP514*, pp. 121-127 (May 1978).

Key words: gear-type transmissions; input-output devices; one-body wear; tribological problems; two-body wear; wear analysis of business machines.

In many input-output devices, such as printers, impact combined with sliding between mechanical components is the chief cause of wear. This paper first describes the phenomenological aspects of this type of wearing and then analytical formulation is discussed. Wear prediction for industrial design purposes hinges on the recognition of the wear mechanism and on the determination of the wear parameters by simple tests. Computation of the contact loading intensity and of the wear formation geometry are the analytical aspects of the wear prediction process.

Household retention of consumer appliances: USDA actuarial estimates, M. D. Ruffin and K. S. Tippett, *SP514*, pp. 131-138 (May 1978).

Key words: actuarial table; clothes dryer; consumer appliance retention; dishwasher; freezer; kitchen range; refrigerator; service-life expectancy; television set; washing machine.

Methodology and results of USDA studies of appliance service life, under one owner, are discussed. Since the 1950's USDA has estimated the retention period of most major appliances by means of actuarial or life tables constructed from ownership and discard data obtained in nationwide household surveys. The most recent such estimates are based on a 1972 survey of 11,696 households and include seven major consumer appliances: range, refrigerator, freezer, dishwasher, washer, dryer, television. The best-known use of the actuarial or life table method is in estimating the life expectancy of persons in the population. The advantages of this method for estimating the service life of appliances are that it minimizes the effect of trends in appliance saturation and population change, minimizes the effect of year-to-year variation in the number of units marketed, and reflects the experience of units remaining in service as well as of those that have been discarded. For life study by the actuarial method, the product must have been on the market long enough for the maximum life span to have elapsed; there must be sufficient numbers in the population to provide a reasonable sample; and the item must be of sufficient importance that the owner-user will be likely to recall the date of acquisition.

Application of historical repair data in life cycle costing analysis, S. W. Stiefel and W. B. Beine, *SP514*, pp. 139-155 (May 1978).

Key words: electric clothes dryer; frequency of failure; life cycle costing; repair cost analysis.

Historical repair data are useful for estimating life cycle costs as well as guiding development of life cycle performance laboratory tests. A general model is discussed which integrates available data for electric clothes dryers to estimate repair costs. Results are presented and their implications for various purposes are considered. The applicability of the model and extension of the technique to other appliances is also discussed.

Environmental and economic impacts of product durability and life, P. L. Fontaine, *SP514*, pp. 156-161 (May 1978).

Key words: appliance durability; environmental impact; tire durability.

The economic and environmental impacts of increasing the durability of major domestic appliances and automobile tires in Canada were assessed. Increased durability was also compared to other major alternatives such as recycling and reuse. Energy, solid waste, resources consumption, air and water pollution, employment and industry sales were considered. Also, approaches which the federal government might follow to affect product durability were evaluated. Basic data were developed by examination of published data, through personal interviews with members of a wide range of related organizations, manufacturers, distributors, reconditioners, commercial users, etc., and from a national consumer survey conducted to establish how and why people dispose of major appliances. The study concluded that increased durability is practical and does decrease materials and energy usage for passenger car tires. However, the same comments cannot be made for major appliances for a number of reasons. These reasons include the difficulty of insuring that increased durability will in fact be used by consumers and the lack of hard technical data on the materials and energy costs of increasing appliance durability.

Technical durability of products, E. Passaglia, *SP514*, p. 175 (May 1978).

Key words: product testing; simulated service tests; technical durability; technical durability magnitude.

When considering durability, it is useful to make a distinction between two different aspects of it. These aspects may be called economic durability and technical durability. Economic durability means the length of time a durable good lasts in service. Technical durability may be defined as the number of services embodied in the durable good. Examples of technical durability are the number of shaves in a razor blade, or the number of miles of travel in an automobile tire. Economic durability is thus the quotient of technical durability and the rate of use of the services embodied in the durable good. Technical durability is not always easy to define, and one of the main technical challenges is the determination of its magnitude. When the physical basis for loss to service is known, technical durability can in principle be determined quite easily. An example is the number of cycles a spring will operate before failure by fatigue. In other cases, when the physical basis is not known, technical durability is more difficult to determine. In such cases, simulated service tests or exposure tests, which are a special case of simulated service tests, are used to determine technical durability. In both cases

the reliability of the durable good (the ability to perform in service) must be considered. One problem of design is to increase durability and reliability within the constraints of economics.

Materials conservation through increased durability, M. B. Peterson, *SP514*, p. 176 (May 1978).

Key words: materials conservation; product durability; product life; wear.

OTA has been conducting a study on materials conservation in which it is considering ways in which materials could be saved if and when it becomes necessary to do so. At the beginning of this study it was felt that extending product life would result in substantial savings of material. Figuratively speaking, if all products lasted forever, no more materials would be needed. More realistically, even one year of extended life would on the surface appear to save appreciable materials. For this reason, a considerable amount of time was spent investigating the potential for product life extension. Basic approaches were followed: 1) A workshop was held to discuss product durability. To provide a focus, wear control was chosen as the means of achieving improved product durability; 2) A contractual study was undertaken to investigate materials savings using refrigerators, automobiles, and containers as case examples; 3) A study was conducted of the product end uses of a variety of metals. From this, an analysis was made of the potential metal savings possible.

The general conclusion from all of these studies was that increasing product durability would not be an efficient means of saving materials. Products are retired from service for many reasons other than poor durability. The material savings which would result would not be fully realized until all existing products had been retired (construction machinery, electrical equipment, etc., already have long lives). A more effective strategy would appear to be the reuse of discarded parts and components.

The concepts of product life and consumer product safety, J. H. Langston, *SP514*, p. 177 (May 1978).

Key words: consumer product safety; CPSC; product life; product performance; safety regulations.

This presentation highlights some of the needs for and uses of product life information in the development of consumer product safety regulations. These needs include calculation of exposure rates, determination of time until full compliance with a regulation and evaluation of the effects of a standard on product performance, product demand, and product safety. In the event of a product recall, this information is needed to determine the number of affected products in the environment and the appropriate refund deduction based on use of the product. This presentation also presents the problems of choosing appropriate definitions for product life and of gathering product life data at the appropriate level of detail. To date, most of the research in this area has focused on industrial products and consumer durables which have measurable usage rates. The universe of products over which CPSC has jurisdiction is subject to many variations in use.

SP515. **International Project Catalog of Modular Integrated Utility Systems**, M. H. Nimmo and C. W. Phillips, *Nat. Bur. Stand. (U.S.)*, *Spec. Publ. 515*, 455 pages (July 1978) SN003-003-01953-4.

Key words: catalog; CCMS-MIUS Project Catalog; International Project Catalog; project catalog; project summary forms; reporting system.

The International Project Catalog prepared for the Committee on the Challenges of Modern Society—Rational Use of Energy Pilot Study—Modular Integrated Utility Systems (CCMS-MIUS Project) is a compilation of project descriptions on more than 200 Modular Integrated Utility Systems (MIUS) type of projects being conducted in the participating countries. Each project description includes a description of each project, its status, the approach, expected results, some technical data, the principal investigator, an indication whether or not data is/or will be available and other miscellaneous project information. The catalog is useful to the experts in identifying the various projects being conducted and seeking further technical information on those particular projects in which they are interested.

The catalog is the first of a three level reporting system to report on MIUS type of projects. The second and third level reporting systems, which are expected to be improved and completed in future activities under another international organization, will provide information and guidelines for reporting progress and supplying data. The catalog consists of three parts: an Introduction, list of Projects by Country, and Project Descriptions, one for each project reported.

SP516. **Color in the health care environment**. Proceedings of a Special Workshop held at the National Bureau of Standards, Gaithersburg, MD, Nov. 16, 1976, B. C. Pierman, Ed., *Nat. Bur. Stand. (U.S.)*, *Spec. Publ. 516*, 35 pages (Sept. 1978) SN003-003-01957-7.

Key words: architecture; buildings; color; design; hospitals; light.

The proceedings contain invited papers regarding the use of color in Health Care Environments. The subject matter includes the perspective of medical doctors, architects, designers, researchers, and standards writers concerning proper and effective color and light selection and use in all phases of hospitals and medical facilities. Particular problems and cautions are related regarding the use of colors in surgical theaters and pediatric as well psychiatric wards. *These proceedings include the following papers (indented):*

Overview of the Center for Building Technology, NBS, R. N. Wright, *SP516*, pp. 1-3 (Sept. 1978).

Hospital light and color from the physician's standpoint, W. C. Beck, *SP516*, pp. 5-7 (Sept. 1978).

Health facilities: Color them caring, M. Graham, *SP516*, pp. 9-12 (Sept. 1978).

Studies of the subjective influence of light and color, J. E. Flynn, *SP516*, pp. 13-18 (Sept. 1978).

Some relationships of color and light to patient care, T. R. C. Sisson, *SP516*, pp. 19-24 (Sept. 1978).

The relationship of color planning in designing a pediatric oncology unit to the symbolic meaning of colors as seen in patients' graphic productions, S. Castelluccio, *SP516*, pp. 25-26 (Sept. 1978).

Lighting and color in health care facilities—From a designer's viewpoint, A. F. Styne, *SP516*, pp. 27-28 (Sept. 1978).

SP517. **Report of the 62d National Conference on Weights and Measures 1977**. Proceedings of the 62d National Conference on Weights and Measures, held in Dallas, TX, July 17-22, 1977, H. F. Wollin, Ed., *Nat. Bur. Stand. (U.S.)*, *Spec. Publ. 517*, 303 pages (Aug. 1978) SN003-003-01966-1.

Key words: consumer affairs; education; electronic devices; enforcement; Grain Standards Act; International Organization of Legal Metrology; labeling insulation and polyethylene products; metrication; model laws and regulations; national type approval; specifications and tolerances; vapor recovery; weights and measures.

This is a report of the proceedings (edited) of the Sixty-Second National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Dallas, Texas, July 17-22, 1977, and attended by State, county, and city weights and measures officials, the Federal Government, business, industry, and consumer organizations.

Major issues discussed at this Conference included metric conversion in the United States; problems relating to the quantity fill, labeling, and inspection of packaged commodities; requirements covering the design and performance of new weighing and measuring technology; and recommendations for improvement in weights and measures administration. *These proceedings include the following papers (indented):*

Grain weighing under the U.S. Grain Standards Act, L. Bartelt, *SP517*, pp. 1-4 (Aug. 1978).

Recommended standards for self-contained scales, D. E. Tonini, *SP517*, pp. 5-10 (Aug. 1978).

AAR Status Report on stenciled tare weights of freight cars, J. J. Robinson, *SP517*, pp. 11-12 (Aug. 1978).

Vapor recovery—A challenge for weights and measures, D. Guensler, *SP517*, pp. 13-23 (Aug. 1978).

Opportunities, effects, and benefits of OIML: An industry viewpoint, E. Fitzgerald, *SP517*, pp. 24-27 (Aug. 1978).

Quantity package statement: Sheets and pillowcases, A. T. Nance, *SP517*, pp. 28-30 (Aug. 1978).

Consumers and the R-value of insulation, C. I. Siu, *SP517*, pp. 31-39 (Aug. 1978).

Technical aspects of polyethylene products: Relating to consumers and standards, T. Zeller, *SP517*, pp. 40-45 (Aug. 1978).

Metric packaging experiences in Canada, A. R. Chadsey, *SP517*, pp. 46-50 (Aug. 1978).

Mail order shipping problems, W. Korth, *SP517*, pp. 51-59 (Aug. 1978).

New horizons in metrology, E. Prideaux, *SP517*, pp. 60-65 (Aug. 1978).

Critical path for Handbook 44 Metric, O. K. Warnlof, *SP517*, pp. 66-71 (Aug. 1978).

Task force report on national type approval, E. Delfino, *SP517*, pp. 72-73 (Aug. 1978).

The Supreme Court decision: Where do we go from here?, A. J. Farrar, *SP517*, pp. 74-78 (Aug. 1978).

NBS Handbook 67: Where the paths have led, C. S. Brickenkamp, *SP517*, pp. 97-103 (Aug. 1978).

The creation and challenge of a State metric board, J. J. Bartfai, *SP517*, pp. 104-109 (Aug. 1978).

Weights and measures program evaluation: The State's viewpoint, M. L. Kinlaw, *SP517*, pp. 110-112 (Aug. 1978).

SP518. Research and innovation in the building regulatory process. Proceedings of the Second NBS/NCSBCS Joint Conference, held in Bozeman, MT, Sept. 20, 1977, P. W. Cooke, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 518*, 406 pages (Aug. 1978) SN003-003-01960.

Key words: administrative procedures; building codes; building regulations; buildings; economic impacts; environmental considerations; innovative practices; regulatory research; standards development.

The Second NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process was held in Bozeman, Montana on September 20, 1977. The proceedings contain the 25 papers presented at the eight technical sessions. The technical sessions addressed the following issues: implementation of solar and energy conservation building standards; issues in building regulation; considerations in the development of energy conservation building standards; developing new approaches for formulating building regulations; state experiences in the development of energy conservation building standards; the expanding role of the building official; application and impact of building energy conservation standards; administration of building regulations. *These proceedings include the following papers (indented):*

The National Solar Heating and Cooling Information Center: Meeting the code officials' information needs, G. Mara, *SP518*, pp. 1-8 (Aug. 1978).

Key words: building regulations; data collection; demonstration program; dissemination; information needs; residential construction; solar energy; space heating; technology.

Under the provisions of the Solar Heating and Cooling Demonstration Act of 1974, a National Solar Heating and Cooling Center was established in 1976 by the Department of Housing and Urban Development, in cooperation with the Department of Energy. It is the express mission of the Center to gather information about the practical feasibility of solar heating and cooling systems in homes and buildings and to disseminate this information to the general public and to specialized technical or professional groups including building code officials.

Recent developments are accelerating code officials' need for solar information. Solar homes are being built in all geographic areas of the country. Architects, engineers, designers and contractors are gaining solar experience or showing an interest in solar. In addition, many State legislatures are taking direct or indirect action in the solar area which will affect building codes. Some States include general or specific solar considerations in State building codes. Others are making solar familiar by requiring life-cycle cost estimates of competing forms of energy, including solar, in new or substantially renovated State buildings.

Implementation of energy conservation building standards, T. B. Brown, *SP518*, pp. 9-15 (Aug. 1978).

Key words: building code official; buildings; education level; energy conservation; evaluations; upgrading, certification.

Codes and Standards for Energy Conservation in Buildings are currently being written and adopted by States and model code organizations. These Standards are necessary as one of the means of buying the time required to develop alternate energy sources to continue our life style.

But codes and standards are only as effective as their implementation. Who will enforce them in new buildings and monitor them in existing buildings? The logical person for

this immense task is the local building code enforcement officer, who in most cases has neither the training nor the background to deal with the terms and concepts involved. He must be upgraded if our nation is to gain time to become energy self-sufficient.

This paper deals with what the code enforcement officer has to know and how he can attain the required level of knowledge to competently enforce energy conservation standards.

A proposal for the implementation of energy conservation building standards and codes, J. R. Groves, Jr., *SP518*, pp. 17-24 (Aug. 1978).

Key words: built environment; education and training; energy conservation; enforcement; legislation; promulgation; regulation; standards.

This paper deals with the mechanics of application, monitoring, and enforcement of State adopted energy conservation standards. It will be presumed that the administrative or legislative process has mandated an energy code for the respective State.

The issues to be examined are: (1) the complexity of the energy standard and its appropriateness for the (a) climatic factors of the respective State and (b) general level and magnitude of building construction within the State; (2) the process of educating and informing the various design professional groups who will integrate the code requirements into new and existing structures, on both an initial and continuing education basis; (3) the process of training and educating the enforcing agency's personnel and the factors to consider in first choosing the appropriate State agency; (4) the necessity for prescriptive and performance components of the code itself and enforcement implications; and (5) the impact of energy standards on (a) architectural design flexibility and (b) building costs, including "tradeoff" possibilities.

Research on natural and man-made hazards: Impacts on building regulations, D. L. Schodek, *SP518*, pp. 25-47 (Aug. 1978).

Key words: building design; building regulatory system; decision processes; hazards-related phenomena; innovations; research findings; scientific methods; socio-political system; technical expertise.

A crucial problem facing the building regulatory system in the United States today is the question of how the results of current technical engineering and scientific research into different natural and man-made hazards that are dealt with by building regulations are to be specifically reflected or incorporated into codes or standards. Ad hoc responses of the building regulatory system to pressures from different research groups, albeit well-meaning pressures, to incorporate research findings with respect to specific hazards, may lead to piecemeal implementation in which there is no underlying logic which attempts to bring about a fundamentally consistent method of dealing with all of the different hazards involved.

This paper speculates in an argumentative way on the role of the building regulatory system with respect to new research and the emergence of increasingly sophisticated scientific methods of analysis. The paper addresses possible bases on which code structures could be developed with the view of treating all hazard-related measures consistently. Some conceptual difficulties are noted along with more pragmatic concerns. In particular the point is addressed that if regulations become more sophisticated in response to more increasingly sophisticated scientific or

engineering methods of analysis, then the possibilities for innovation and creative approaches to reducing hazards are increased, but at the same time the technical expertise of all those charged with enforcing the code must also be increased. Therein lies a basic conflict.

A very fundamental issue raised is that the role of the law on which building regulations are based and what it can or should be in relation to the scientific methods embodied in new research is unclear. It is hypothesized that many of the dilemmas currently facing the building regulatory system in regard to new research can be resolved only by considerations involving a greatly extended socio-political context.

Response to building innovation by building codes and regulations, S. Winter, *SP518*, pp. 49-66 (Aug. 1978).

Key words: building codes; code changes; incentives; innovations; log homes; minimum property standards; model code agencies; regulations.

The major U.S. building codes are updated intermittently (e.g., MPS issues updates as they are processed, BOCA issues supplements annually, etc.). The States and other regulatory bodies which adopt these codes do so sometime after the updates are issued. The result is that there is a considerable time span for the process of: recognition of the need for a code change; adoption of the code change; revision of the code; adoption of the revision by regulatory bodies; and implementation of the revision.

Innovations in the building industry, however, are constantly occurring, and there is frequently no allowance in the language of codes or in their interpretation for items not specifically identified.

The position of the author is that building codes and regulatory agencies must be more responsive to innovative materials and methods in order to foster, rather than hinder, improvements and efficiencies in the building process.

A consulting engineer's view of building code process from conception to adoption, N. J. Kornsand, *SP518*, pp. 67-76 (Aug. 1978).

Key words: building codes, due process; legislation; model codes; promulgation; regulatory process; standards development.

The author has been attending the meetings of the model code groups for the past several years. During that time period, he has observed the process, noted the changes that are taking place in the process, identified forces responsible for the changes, analyzed the problems and has formulated possible areas to refine, streamline and be more efficient in the building code promulgation process.

The paper will present the building code process from the standpoint of the designers and engineers who must work with its provisions. The paper will show a significant trend in the past few years that is complicating the process. This includes more code changes, more complex code changes, expansion of the codes into more areas of control, and attempts to keep pace with the plethora of new products, devices and designs flooding the building materials market.

Standards/codes for energy conservation in lighting design, R. L. Smith, *SP518*, pp. 77-94 (Aug. 1978).

Key words: artificial illumination; buildings; criteria; energy conservation; energy consumption; environmental design; lighting levels; standards.

There is a general agreement on the need to eliminate unnecessary energy use in providing artificial illumination for buildings. However, there is widespread disagreement on the procedure that should be promulgated to achieve that need. This paper suggests a method to evaluate building standards/codes and compares three procedures developed to achieve energy efficient lighting systems. The procedures compared are (1) a standard developed by the Illuminating Engineering Society and published as Section 9 of ASHRAE Standard 90-75; (2) a guideline published by the General Services Administration; and (3) a code being developed by a State building code commission.

The need for a more explicit definition in building regulations of the internal thermal environment in buildings, D. R. Heerwagen, A. F. Emery, C. J. Kippenhan, and G. B. Varey, *SP518*, pp. 95-134 (Aug. 1978).

Key words: building performance simulation; building regulations; computer applications; energy conservation; thermal comfort; thermal performance of buildings.

A survey of several widely-accepted or newly-proposed building codes or standards has been conducted to determine (1) what guidelines for establishing occupant thermal comfort currently exist, and (2) whether these guidelines may inhibit the achievement of energy conservation in building operation. This review has shown that the present requirements pertaining to thermal comfort afford nonoptimal conditions, from the points of view of both the provision of thermal comfort and the achievement of energy conservation. In this essay, the authors have cited results from three groups of researchers who have provided definitive work on human thermal comfort. It is suggested that such results be used in writing future building regulations and that energy conservation will result from their inclusions. Additionally, the authors have also suggested that future regulations require the use of several devices or strategies (for building operation or control) and these are discussed.

A thermal simulation computer program UWENSOL is described and its application is displayed as a means of accurately predicting both heating and cooling loads and thermal conditions within buildings during their design.

Implementation of energy conservation building standards—The verification problem for HVAC systems, D. E. Tonini and T. E. Sluiter, *SP518*, pp. 135-144 (Aug. 1978).

Key words: balancing; building code official; code requirements; energy conservation; performance specifications; testing; verification.

This paper outlines the parameters and procedures which should be considered in the preparation of energy conservation performance specifications and verification for building mechanical systems.

The trend toward implementation of energy conservation standards, particularly for commercial building, carries with it the question of how the building code official is to determine whether or not an energy conservation standard has been met. For prescriptive standards, e.g., insulation thickness requirements, this may be readily ascertainable. For performance standards for HVAC systems, this becomes a very significant problem for the code writer as well as the building code official.

It has been shown that significant energy savings may be achieved by careful balancing and optimization of building mechanical systems for new buildings or retrofit of existing inefficient systems. It is anticipated that code writers concerned with energy conservation standards may wish to address this important subject area in their codes.

Systematic organization of standards and codes, J. R. Harris and R. N. Wright, *SP518*, pp. 145-160 (Aug. 1978).

Key words: building codes; classification; index; organization; outline; standards; systems engineering.

The ease and confidence with which a code or standard can be used depends on how well it is organized. A systematic method for organization of design standards and codes is described and illustrated with an example. The method provides checks on the uniqueness and completeness of the organization, where organization is taken to include both the scope and the arrangement of the provisions. The method promotes the use of technically valid provisions and improves the efficiency of standards generating activities. The illustrative example is the organization of a performance specification for the structure of residential buildings.

The method is based upon objective qualities of an organization. The key element of the method is the systematic classification of provisions. Each provision is related by its syntax and semantics to several classifiers. Requisite properties of uniqueness and completeness are achieved in the overall organization by requiring them in subsets of the classification and then building the overall organization in a systematic fashion.

Consensus standards formulation, J. V. Tyrrell, *SP518*, pp. 161-164 (Aug. 1978).

Key words: economics; formulation; innovation; market aggregation; performance requirements; prescriptive standards; standards development.

The charge has been made that the existence of standards inhibits innovation and consequently hampers technological advances. On the other hand, standards provide obvious benefits in consumer protection and economics through aggregation of markets. One possible remedy that has been advanced is provisions for accepting nonconforming products by exception. While such procedures would make introduction of new products easier, it would to a large extent destroy the fundamental purpose of a standard.

Another proposed remedy is to base all standards on performance requirements. While performance standards may be satisfactory in some cases, they are not a panacea that will easily solve all standards problems. Adequate definition of performance requirements and equally important acceptance requirements is a major problem. The pure performance standard opens the doors to unwanted features if it is not very carefully constructed.

The concept of standards is not wholly compatible with innovation, but standards provide sufficient benefit to warrant continued use. Their effectiveness depends upon procedures for formulation to make their purpose clear and identify their limitations.

The role of fire prevention and control on building construction and regulations, W. H. McLain, *SP518*, pp. 165-176 (Aug. 1978).

Key words: building codes; control measures; fire codes; fire safety; governmental actions; life safety; regulation; risk assessment; societal goals.

Fire prevention and control is an important feature of the modern building codes. Building set-back limits, structural design, and limitations on interior finish materials are among the building design parameters that reflect the public need for fire safety. Historically, codes have been developed to reduce mass urban fires and to limit property

damage from the structural collapse of single building units. For example, a standard time-temperature curve has been developed and widely used (ASTM E119) for classification of building structural components in terms of a fire-time rating. More recently, there has developed an increased concern about life safety. Smoke and toxic gas produced by materials subjected to fire exposures are being evaluated and in some cases form part of a developing set of new regulations. The implementation of these new regulations poses a number of difficult problems to the local code regulatory and enforcement officials. An analysis is made of some of the alternative approaches which may be considered to aid the local building official in this important area of control.

Building regulation in the twenty-first century, H. J. Milton, *SP518*, pp. 177-190 (Aug. 1978).

Key words: building regulations; innovation; international standards; metrication; performance standards; research; technological trends.

Many research papers have been devoted to proposals dealing with innovation and rationalization in the building regulatory process.

This paper has two special features—it takes a broad and uninhibited look at the entire field of building controls, and it does so from an imaginary future date in September 2002, a quarter of a century after the Bozeman, Montana, conference. Instead of proposing changes, the paper takes a novel approach and discusses “retrospectively” the major changes that “have occurred” in the intervening 25 years. It thus provides food for thought without running into the gamut of reasons why changes cannot be made.

The Texas approach to energy conservation building standards, M. N. Hart, J. W. Jones, and W. Bowen, *SP518*, pp. 191-204 (Aug. 1978).

Key words: alternatives; ASHRAE 90-75; building standards; energy conservation; performance standards.

In 1975 the State of Texas Legislature mandated that energy conservation standards be developed for new State Buildings. The legislation called for the development of performance criteria and for guidelines for energy efficient design for different classes of state owned or financed buildings. In complying with the requirements of the law, the State Building Commission sought to minimize any adverse impact of the new standards on the design process.

The State of Texas Building Energy Conservation Standard is divided into sections on the envelope, mechanical equipment, lighting, and service hot water. The standard is similar to ASHRAE 90-75 in the mechanical equipment and service hot water sections, but differs in the lighting and envelope sections. The lighting section specifies watts per square foot for most task areas with foot-candle designations for unusual areas. The building envelope section provides a new approach. It assures a minimal thermal performance of the shell by specifying an Energy Envelope Index which is a function of building size and location. The EEI calculations are similar to standard procedures for estimating loads (such as those published by ASHRAE) and is presented in the State Energy Conservation Manual. These procedures are summarized in this paper.

It is felt that the State of Texas procedure, while innovative, provides a flexible and workable standard acceptable to both the State and the design professionals and introduces a new approach toward performance standards.

The need to implement energy conservative insulation standards based on average energy use rather than peak energy

use—The New Mexico experience, W. J. van der Meer and L. W. Bickle, *SP518*, pp. 205-218 (Aug. 1978).

Key words: ASHRAE Standard; climatic conditions; energy conservation; glass area; heat transfer; insulation standards; U-values.

All Federal insulating standards for residence walls, ceiling and glazing are based on steady state U-values which govern the heat transfer rate only under conditions of peak energy use. Even the Component Design section of ASHRAE Standard 90-75 considers only steady state U-values as the basis for their requirements at arriving at stipulated average heat transmission values. Theoretical studies on heat transfer through walls and glazing, and studies of actual energy use for heating for a group of approximately 20 residences of different insulation amounts, made by the authors for the New Mexico Energy Resources Board, indicate that while added insulation may reduce heat transfer during peak energy use periods there is no proof that insulating for peak energy use periods reduces the overall or average energy consumption during the heating season. Quite the contrary, we find that insulation for peak energy use may be counterproductive and result in a greater amount of energy used for the heating season than if one insulates for average energy use conditions.

A study of the effect of existing energy conservation regulations to assist in the selection of more comprehensive energy conservation standards, C. H. Fafard, *SP518*, pp. 219-250 (Aug. 1978).

Key words: ASHRAE standards; building envelope; building regulations; data collection; energy budget; energy conservation; heat loss; thermal performance.

The State of Wisconsin has had, since 1914, a statewide Administrative Building Code, administered and enforced by the Department of Industry, Labor and Human Relations (DILHR). This code regulates construction of all buildings except one- and two-family residences, farm buildings and temporary buildings. The rules contained in the code carry the stature of law.

An Energy Conservation Advisory Committee was appointed to DILHR by the Division Administrator, John Wenning, in December 1973, at the peak of the energy crisis. The committee made several recommendations, including lowering of inside temperatures and reducing the minimum ventilation from 7.5 c.f.m./person to 5 c.f.m./person. The committee also recommended a thermal performance standard which limited the heat loss through above-grade envelope areas to 13 Btu's per hour per square foot. These recommendations were incorporated into the Wisconsin Administrative Code in stages in 1974 and 1975. The thermal performance requirements generated strong opposition in the glass and masonry industries. These groups convinced a committee within the Wisconsin State Legislature to rescind the thermal performance section (May 1975) after five months of enforcement. The thermal performance requirements were reinstated in April 1976, when the full legislature did not act on the permanent suspension of the rules.

Rehabilitation as an instrument in meeting housing need: Can it really work? J. Heron, *SP518*, pp. 251-257 (Aug. 1978).

Key words: decision criteria; demolition; housing needs; physical condition rehabilitation.

There is an increasing trend in city planning toward rehabilitating older buildings and conserving neighborhoods that might have become slums, but the rehabilitation process is slow and unreliable. Few builders are interested in rehabilitation, most preferring new construction in the suburbs. A major question is: can the rehabilitation process be changed to attract more builders and become a high-volume business?

The suggested answer is that criteria to identify buildings needing rehabilitation and to specify what repairs need to be made must be developed, using the cumulative knowledge of builders who have done such work and the insight of people involved in building regulation. These criteria should deal with the fundamental structural and safety characteristics of buildings, to provide a yardstick for selecting the right buildings and deciding how much work is required.

The National Fire Incident Reporting System: Some uses of fire loss data, H. Tovey, *SP518*, pp. 259-283 (Aug. 1978).

Key words: building codes; data collection; fire hazards; fire protection; National Fire Data Center; regulation; reporting system; scenarios; system design.

The National Fire Data Center of the National Fire Prevention and Control Administration is directed by law to collect, analyze, and disseminate data on the occurrence, control, and results of fires of all types. One of the major objectives of this activity is to provide the building code community with information it needs for writing and updating building codes so that they provide as much protection at as low a cost as possible. The fire experience data collected by the National Fire Incident Reporting System of the Center has a high potential utility for that purpose. However, the initial data collected need significant improvement in completeness and accuracy. This paper describes the basic design of the National Fire Incident Reporting System, and illustrates several ways in which the data collected by the system can be used to identify and rank fire hazards associated with building structures. The current status of the system, including efforts to validate the data, are described.

Proposed draft for noise control abatement for the City of New Orleans, C. C. Mann, *SP518*, pp. 285-295 (Aug. 1978).

Key words: awakening to problems; deceptive sounds; establish legal limits; tolerance level differences.

The everyday sounds of simply existing can be very deceptive to us as individuals. Music, for example, is soothing and refreshing to some persons while to others, the same music may be distracting and unpleasant. The rock-and-roll that brings pleasure to one individual might be found distasteful by another individual. We, as individuals "on the street" do not think of noise unless it becomes irritating to us or "gets on our nerves." It has been said that sound is not a "noise" unless it annoys.

This paper is a search into some of the large cities' approaches to their noise problems, with an added proposal to this same noise problem for the City of New Orleans. Many controls are being generated, developed and perfected, and as a result, future generations should have a quieter environment in which to live and work. Much is yet to be accomplished, however, and efforts toward this goal should not be lessened or allowed to become diminished.

Residential energy conservation building regulations and their impact on the building process, M. Green, *SP518*, pp. 297-312 (Aug. 1978).

Key words: building regulations; enforcement; energy conservation; legislation; standards development; survey findings; training.

In early 1977, a study was conducted under contract to the State of California. This work was a portion of a larger contract from ERDA to document the history problems and success of the California residential energy regulations adopted in February 1974. The resulting report, based on personal interviews with code enforcement officials, architects, developers, contractors, material suppliers and manufacturers, and homeowners, describes the impact and changes caused by these regulations on segments of the building industry. This paper will briefly discuss these impacts within the context of statewide energy conservation building regulations.

In addition, the paper will summarize the procedures of the State to develop and implement residential energy regulations. The paper concludes with procedural recommendations for Federal, State, and local government.

The energy conservation code: Implementation in New Mexico, J. O. Dritt, *SP518*, pp. 313-322 (Aug. 1978).

Key words: building code; code officials; effective "U" values; energy conservation; implementation; professional competence; training program.

Officials of the State of New Mexico agreed in September 1976 to adopt the proposed Chapter 53 of the Uniform Building Code (UBC) published by the International Conference of Building Officials (ICBO) with scheduled implementation of July 1, 1977. This paper describes the key elements of an implementation scheme through the utilization of innovative research, development of code Applications Manual, and the conduct of a formal statewide training program for all building officials.

Impact of State mandated thermal efficiency standards on counties, S. Guenther and A. Twitchell, *SP518*, pp. 323-358 (Aug. 1978).

Key words: buildings; counties; energy conservation; enforcement; insulation; regulations; standards; State legislation; thermal efficiency.

Nineteen States have adopted energy-related building regulations since the 1973 Arab oil embargo, but there is considerable variation among the States according to performance and prescriptive criteria, mandatory and voluntary regulations, etc.

The remaining States will soon be adopting thermal efficiency codes as part of their State Energy Conservation Plans, and the Department of Housing and Urban Development is currently developing a national standard for new buildings.

Hundreds of counties have been required to enforce the existing State-mandated codes, and many hundreds more will become involved in the near future.

The National Association of Counties Research Foundation studied the effects of State-mandated thermal efficiency codes on five counties. We found that those codes requiring only a minimal amount of insulation and double glazing for windows appeared to present no major legal, political, operational, or financial problems for counties. Experience with more sophisticated codes is limited.

Regulatory administration: A function of perceived priorities, costs and benefits, N. S. Remmer, *SP518*, pp. 359-369 (Aug. 1978).

Key words: building codes; cost-benefit; decision making; priorities; regulatory agency; resources; risk.

This paper discusses the problems of building regulatory agencies in facing rapid advances in the technology and scope of building regulation and the implied increase in volume of work. The paper attempts to identify distinct classes of obligation for the regulatory agency based on a range of requirements starting with those proven critical to life safety and those mandated by legislation and highly visible to the public to those which represent the possibility of applying wide discretion in judging risk and assigning a priority based on community benefits. The paper gives examples of how decisions affecting risks versus benefit might be implicitly applied in every day operations of an agency and the significance of these judgments in terms of an acceptable risk level. As workloads increase and technology and mandatory legislation increase in scope and volume, local regulatory agencies, faced with limited resources, must make decisions which reflect a systematic prioritization of functions based on judgments of risk, costs, and benefits.

Development of interface between the regulator and the manufacturer's quality control personnel, E. Starostovic, *SP518*, pp. 369-379 (Aug. 1978).

Key words: certification; compliance assurance programs; industrialized building construction; inspection; personnel qualifications; quality control manual; regulations; third party agencies; training.

The subject of this paper encompasses the manufacturer's commitment to quality control including designation of inspectors who are held accountable. Other aspects will include coverage of: development of inspection aids; regular monitoring of both product and inspection personnel; training of personnel in a formal classroom environment including required annual recertification; classroom written examination, grading process, and PFS Quality Assurance Council review; progress reports after classroom training and as a prerequisite for final written certification; maintenance of year-to-year certification; decertification procedures; case histories of decertification; impact on product quality.

Legal aspects of the building regulatory process, P. J. Moriarty, *SP518*, pp. 381-390 (Aug. 1978).

Key words: building official; building regulations; code enforcement; construction; court decisions; disasters; economics; legal approach; regulatory process; violations.

Building regulations had a beginning, a middle and will have no end. Since the time man first built a shelter which in some way affected the shelter of another, building and housing regulations out of necessity arose. As man progressed and his needs improved, laws were enacted to control his activities and a few of these laws regulated the use and construction of his shelter. It will be attempted here to briefly illustrate the ways in which this shelter has been regulated and misregulated and to show that in several years we have not yet reached an atomic age in the building regulatory process. As the building regulatory process becomes more complex and technical, the building official must become more knowledgeable and technical. It will also be seen how the courts have reminded the building official that the public need not tolerate a building code requirement simply because it is so written.

SP520. Applications of space flight in materials science and technology. Proceedings of a Conference held at the National Bureau of Standards, Gaithersburg, MD, Apr. 20-21, 1977, S. Silverman and E. Passaglia, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 520*, 128 pages (Sept. 1978) SN003-003-01973-9.

Key words: containerless processing; materials science; micro-g; skylab; space processing; space shuttle.

This conference was held to review the materials science experiments carried out in space, and to assess the possible future applications of space in materials science and technology with the advent of the space shuttle. Experiments carried out on Skylab, the Apollo-Soyuz Test Project, and recent sounding rocket experiments were reviewed. Specific discussions were directed at possible future applications in metals and alloys, ceramics, semiconductor materials, biological materials, crystal growth, transport properties, critical phenomena, thermodynamic data, containerless processing, combustion, and convection effects. *These proceedings include the following papers (indented):*

Uses of space flight for materials research, J. E. Naugle, *SP520*, pp. 3-6 (Sept. 1978).

The National Research Council study, W. P. Slichter, *SP520*, pp. 7-9 (Sept. 1978).

Materials processing experiment capabilities in space, E. C. McKannan, *SP520*, pp. 10-13 (Sept. 1978).

Metallurgical studies in Skylab & Apollo-Soyuz flights, D. J. Duquette, *SP520*, pp. 14-16 (Sept. 1978).

Fluid behavior in a microgravity environment, J. R. Caruthers, *SP520*, pp. 17-24 (Sept. 1978).

Crystal growth in micro-gravity—An overview, H. Wiedemeier, *SP520*, pp. 25-39 (Sept. 1978).

Direct observation of dendrite remelting and macrosegregation in low-gravity, M. H. Johnston, *SP520*, pp. 40-43 (Sept. 1978).

Thermal migration of bubbles and their interaction with solidification interfaces, J. M. Papazian and W. R. Wilcox, *SP520*, pp. 44-48 (Sept. 1978).

Space processing rocket experiment 74-5 space solidification of Pb-Sb eutectic, R. B. Pond, Sr., *SP520*, p. 50 (Sept. 1978).

Agglomeration in immiscible liquids, S. H. Gelles and A. M. Markworth, *SP520*, pp. 51-58 (Sept. 1978).

Containerless processing of beryllium, G. Wouch, *SP520*, pp. 59-66 (Sept. 1978).

Implications of metal foam experiments for fluid flow effects on materials systems processed in zero gravity, J. W. Patten, *SP520*, pp. 67-68 (Sept. 1978).

Materials processing in space experimental capabilities in the space shuttle/space lab, R. Adams, *SP520*, pp. 70-74 (Sept. 1978).

Materials applications of space flight—Metals, R. A. Oriani, *SP520*, pp. 76-77 (Sept. 1978).

Applications of space flight in materials science and technology—Ceramics and glasses, G. E. Rindone, *SP520*, pp. 78-79 (Sept. 1978).

Electronic materials, A. Witt, *SP520*, pp. 80-82 (Sept. 1978).

Applications of space flight in materials science and technology. The future—Biological materials applications, G. V. F. Seaman, *SP520*, pp. 83-88 (Sept. 1978).

Critical phenomena and condensation, P. H. E. Meijer, *SP520*, pp. 89-93 (Sept. 1978).

Thermodynamics and purification, J. Margrave, *SP520*, pp. 94-96 (Sept. 1978).

Future research applications in crystal growth, M. E. Glicksman, *SP520*, pp. 98-99 (Sept. 1978).

Comments on solidification in space, R. F. Sekerka, *SP520*, pp. 100-101 (Sept. 1978).

Transport properties in fluids, J. R. Manning, *SP520*, pp. 102-103 (Sept. 1978).

Fluid and combustion dynamics, A. L. Berlad, *SP520*, pp. 105-107 (Sept. 1978).

The future fluid flow research applications, S. Ostrach, *SP520*, p. 108 (Sept. 1978).

SP522. Control systems readiness for munitions plants: A first pass. Proceedings of the Workshop on Control Systems Readiness for Munitions Plants held at Purdue University, West Lafayette, IN, Sept. 19-20, 1977, T. J. Williams, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 522*, 192 pages (Oct. 1978) SN003-003-01981-0.

Key words: automatic control systems; dormant storage; layaway; magnetic tape; reactivation; readiness; reliability; sensors; simulation; standby.

Experts in the field of Industrial Process Control were asked to assist the U.S. Army and address a most challenging and unique problem. Large capacity munitions manufacturing production facilities are required only in times of national emergency. These production facilities are complex manufacturing processes normally operated by sophisticated industrial process control systems.

Long periods of dormant storage may occur between facility construction and required operation. Guidance is required for the Army to properly plan for appropriate technical activity which will assure the readiness of these industrial processes at the time of national emergency. The Workshop which is reported upon in this document was held to help provide some of the needed background to this problem. It also generated a set of recommendations to be considered by the U.S. Army when setting up its procedures in this area. In addition to a set of background papers, discussions were held in the areas of transducers, magnetic media reliability, electronic and mechanical element needs, testing and proving of control system components, reliability enhancement techniques, simulation for personnel training purposes, and the effect of initial control system design of personnel skill requirements. The recommendations developed treat each of these. Further work is needed to refine and verify these recommendations. *These proceedings include the following papers (indented):*

Past experience in the reactivation of army ammunition plants, A. J. Zahatko, *SP522*, pp. 1-10 (Oct. 1978).

Current procedures and problems in the layaway and reactivation of process control systems, F. T. Beiwel, *SP522*, pp. 11-17 (Oct. 1978).

An overview of the performance characteristics of sensory transducers, P. S. Lederer, *SP522*, pp. 18-28 (Oct. 1978).

Production base response required to meet mobilization requirements, J. Nemanich, *SP522*, pp. 29-35 (Oct. 1978).

Layaway, standby and reactivation procedures for computer magnetic media, S. B. Geller, *SP522*, pp. 36-47 (Oct. 1978).

Environmental effects on electrical and electronic devices and equipment under long storage conditions, A. J. Graf and L. W. Doremus, *SP522*, pp. 48-53 (Oct. 1978).

A layaway program for control valves, J. Van Damme, *SP522*, pp. 54-62 (Oct. 1978).

The independent testing and proving of hardware and software elements of plant computer control systems on reactivation of munitions plants, D. Zobrist, *SP522*, pp. 63-72 (Oct. 1978).

The layaway and reactivation problems of beet sugar mills for their annual campaigns including management, manpower and training aspects, T. J. Williams and D. D. Lesser, *SP522*, pp. 73-83 (Oct. 1978).

High reliability design techniques for distributed digital systems, M. P. Lukas and J. J. Steinkirchner, *SP522*, pp. 85-105 (Oct. 1978).

Use of simulation and other related techniques for the training of startup crews for reactivation of laid-away plants, W. B. Field, *SP522*, pp. 106-123 (Oct. 1978).

Operating today's plant design tomorrow, M. C. Beaverstock, *SP522*, pp. 124-152 (Oct. 1978).

SP523. Wind and seismic effects. Proceedings of the Ninth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, May 24-27, 1977, Tokyo, Japan, H. S. Lew, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 523*, 518 pages (Sept. 1978) SN003-003-01979-8.

Key words: accelerograph; codes; design criteria; disaster; earthquake hazards; earthquakes; ground failures; seismicity; solids; standards; structural engineering; structural responses; wind loads; winds.

The Ninth Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held in Tokyo, Japan on May 24-27, 1977. The proceedings of the Joint Meeting include the program, the formal resolutions, and the technical papers. The subjects covered in the paper include (1) characteristics of strong winds; (2) wind loads on structures and design criteria; (3) earthquake prediction; (4) earthquake ground motions and soil failures; (5) seismic loads on structures and design criteria; (6) design of special structures; (7) earthquake hazard reduction program; and (8) quantitative evaluation of damages caused by winds and earthquakes. *These proceedings include the following papers (indented):*

Distribution models of pressure and wind over stationary typhoon fields, S. Fujiwhara and K. Kurashige, *SP523*, pp. 1-1-1-9 (Sept. 1978).

Key words: distribution models; pressures; sea surface; stationary typhoon.

For pressure and wind distributions on the sea surface over typhoon and hurricane area, many trials have been proposed in order to adapt distribution models for observational data. These models have been utilized widely in many scientific and technical applications. For example, theoretical analysis, storm surge, disaster evaluation, protective measurement against typhoon damage, and so on.

The above models proposed are simple models. Unfortunately, however, the better adaptation for observed data requires more complicated models. However, the advent of the electronic computer has brought about the methods which can shorten the computational time tremendously. Therefore, the models no longer have to be simple.

In this paper, several new models are introduced and their characteristics are discussed. Then, basic differences between the formulas by various models are pointed out clearly. In order to increase the accuracy of model adaptation, a technique of revising the formulas is discussed. Tak-

ing into account the computation time of the electronic computer, a new model formula is presented and examined by comparing it with other formulas.

Extreme winds in the United States, T. D. Potter and M. Changery, *SP523*, pp. I-10—I-15 (Sept. 1978).

Key words: design requirements; design standards; extreme winds; hurricanes; property damage.

Each year extreme winds in the U.S. cause extensive property damage and occasionally the loss of lives. This paper will first review the patterns of extreme winds in the U.S. and the associated wind damage. The types of maximum wind speed data currently available are then discussed. Finally, problems associated with using these maximum wind speed data in U.S. design standards are considered.

Aerodynamic stability of a long-span suspension bridge at construction stage, T. Kunihiro, N. Narita, and K. Yokoyama, *SP523*, pp. II-1—II-19 (Sept. 1978).

Key words: aerodynamic stability; construction stages; suspension bridge.

Wind accidents on bridge structures have so far occurred at their construction stage, and this necessitates confirming the safety of a structure under construction as well as after completion. The aerodynamic safety of a suspension bridge at construction stage is especially important, because the rigidity and the relevant dynamic characteristics of the structure alter gradually as the construction work proceeds.

The aerodynamic stability of suspension bridges at construction stages for the Seven Bridge (1), the Kanmon Bridge (2), the Honshu-Shikoku Bridge (3,4) and the Narrows Bridge (5) has already been examined by others. These studies demonstrated the importance of the problem.

However, the erection method of a bridge depends largely on the conditions that, how much clearance is necessary for navigation during construction period and what kinds of erection machines are available, etc. Therefore, the results of this study cannot be applied directly to other bridges.

This paper describes the design wind speed and the aerodynamic stability of suspended structure of the Hirado Ohashi Bridge.

Present situation of earthquake prediction research in Japan, K. Hamada, H. Takahashi, H. Sato, and A. Suwa, *SP523*, pp. III-1—III-19 (Sept. 1978).

Key words: earthquake prediction; Japan National Program; present state.

An outline of the Japanese National Program of Earthquake Prediction is introduced here. First, the progress up to date of the national program of earthquake prediction; second, the organizations related to the prediction, their main roles, and the organizational structure; third, the strategy of earthquake prediction by the coordinating Committee for Earthquake Prediction (CEEP); fourth, the activities of the CEEP; fifth, the present state of earthquake prediction; sixth, the promotion of the prediction program, including the authors' points of view and finally, the following items of research and observations are introduced: 1. Geodetic survey; 2. Tidal observation; 3. Continuous observation of crustal movement; 4. Seismic observation; 5. Velocity change of seismic waves; 6. Active faults and folding; 7. Geomagnetic and geoelectric observations; 8. Laboratory experiments; 9. Works related to ground water; 10. Data processing and monitoring system.

The complementary importance of earthquake prediction and structural response estimation in seismic design and planning decisions, R. K. McGuire, *SP523*, pp. III-20—III-29 (Sept. 1978).

Key words: design decisions; minimum cost; seismic risk.

The present uncertainty in estimating the responses of manmade and natural structures to earthquake threats is translated into cost penalties reflecting costs associated with possible failure of the structure due to underestimated response, and costs associated with overdesign of the structure (or over-conservative reaction to a hazard) due to overestimated levels of motion. The important uncertainties for seismic design and planning decisions are those associated with the size, location, and time of future earthquakes, and those associated with estimating ground motion and structural response during these events. It is shown that reducing the uncertainties in one part of the problem has only a minor effect on reducing the (social and economic) cost of earthquakes unless significant and complementary advances are also made in reducing the uncertainties of the other part.

Research and development of permanent ocean-bottom seismograph observation system off the Pacific Coast to central Honshu, Japan, A. Suwa, N. Yamakawa, and T. Iinuma, *SP523*, pp. III-30—III-43 (Sept. 1978).

Key words: cables; development of submarine equipment; earthquake prediction; ocean-bottom seismograph.

Eighty to ninety percent of all the earthquakes in the world occur in the sea area. However, there is not a single permanent ocean-bottom seismograph yet; this is the weakest point in seismic activity monitoring and earthquake prediction. The Seismology and Volcanology Division of the Meteorological Research Institute has been engaged in the development of a permanent ocean-bottom seismograph observation system off the Pacific coast of Tokai District, central Honshu, which is one of the major items included in the 3d Five-Year Plan of the National Program of Earthquake Prediction Research in Japan (1974-1978).

The observation system being developed consists of the combination of submarine and land equipment. The submarine equipment consists of one terminal apparatus and several intermediate apparatus, i.e., pressure vessels containing seismograph and tsunami-meter sensors, and signal transmitters, which are connected in series by a submarine co-axial cable. This equipment is laid one hundred and twenty kilometers off Omaezaki, Shizuoka Prefecture, at the ocean-bottom down to 3,000 m below sea level. On the other hand, the land equipment consists of receiving and repeating apparatus in the shore station (Omaezaki Weather Station), and receiving and data processing apparatus at the Earthquake and Tsunami Center (Japan Meteorological Agency in Tokyo).

This development project has been progressively implemented. Trial layings of the submarine equipment have been carried out already and actual layings are planned in 1978.

Vertical distribution of the seismic S-wave velocities at the site of the Iwatsuki Deep Borehole Observatory of Crustal Activities, F. Yamamizu and H. Takahashi, *SP523*, pp. III-44—III-54 (Sept. 1978).

Key words: deep borehole; earthquake, in-situ velocity measurement; S-wave; vertical distribution of seismic wave.

From the earthquake engineering point of view, in-situ velocity measurement of the seismic S-wave was carried out down to a depth of 3500 meters at the site of the Iwatsuki Deep Borehole Observatory constructed by the National Research Center for Disaster Prevention.

S-waves were produced mainly by ordinary small chemical explosions in a shallow borehole and supplementarily by an SH-wave generator (an S gun) firmly pressed on the ground surface. A set of three-component seismometers of moving-coil type with natural frequency of 4.5 Hz was installed in a capsule which could be fixed at any depth in the borehole. Repeated measurements were made at 16 different depths from the surface to the bottom. The S-wave by the S gun was clearly recorded down to the depth of 1500 m. Identification of the S-wave onset on the record of the explosion was unexpectedly easy, even for depths deeper than 1500 m, because very good phase correspondence between the S phase from the S gun and the S phase from the explosion was obtained. Therefore, the reading of the S-wave onset was most reliable.

The estimated S-wave velocity structure was 0.44, 0.76, 1.3, 1.6 and 2.6 km/sec with the boundary depths of 300, 1000, 2000 and 2800 m, respectively, from the surface to the bottom of the borehole. The boundary at 2000-m depth was uncertain unlike the other three boundaries. This boundary may not exist, or the velocity may change gradually with depth.

The P-wave velocity structure was estimated at the same time, and the velocity values were 1.8, 2.1, 2.9 and 4.7 km/sec with the boundaries very close to those of S-wave velocity. But the 2000-m depth boundary was not found.

Research on active faults in the metropolitan area, H. Sato and T. Kakimi, *SP523*, pp. III-55—III-62 (Sept. 1978).

Key words: detection of active faults; earthquake prediction; research on active fault.

The present state of research on active faults in the metropolitan area is discussed. The paper describes the discovery of two active faults, the Tachikawa Fault and the Arakawa Fault, in the Kanto plain. The paper also points out that at present there is no definitive method(s) to detect active faults covered by thick sediment. The geophysical methods commonly employed in underground research work present problems when the methods are used for research on active faults in urban areas. Geochemical methods should be considered.

Characteristics of vertical components of strong-motion accelerograms, T. Uwabe, S. Noda, E. Kurata, and S. Hayashi, *SP523*, pp. IV-1—IV-19 (Sept. 1978).

Key words: design; horizontal acceleration; seismic coefficients; stability; strong-motion accelerogram; structures; vertical acceleration.

Characteristics of vertical components of the 574 strong-motion accelerograms were studied in order to determine the effects of vertical ground motions on dynamic stability of structures. The following were made clear.

1) According to accelerograms with the maximum acceleration of over 50 gals the ratio of the maximum acceleration on the vertical component to that on the horizontal component was less than 1/2.

2) The occurrence time of the maximum acceleration on the horizontal component was different from that on the vertical component. At the time when the safety factors against sliding and overturning were the smallest, the ratio of the vertical acceleration to the horizontal acceleration was less than 1/3.

3) The stability analysis of the gravity type quaywalls based on a current design method of port facilities was performed considering the vertical seismic coefficient. Consequently, the vertical seismic coefficient was found to have little influence on the safety factor for gravity type quaywalls.

Developments in strong-motion data management, A. G. Brady, *SP523*, pp. IV-20—IV-27 (Sept. 1978).

Key words: accelerograms; digitization; high frequencies; low frequencies.

Some recent developments in the procedures for digitization and subsequent analysis of strong-motion earthquake accelerograph records are described. The standard digitizing and analysis procedures of the California Institute of Technology's Earthquake Engineering Research Laboratory have been well documented for several years now and apply well to the long-duration, high-amplitude recordings that were the main content of the project. This paper provides further descriptive material dealing with the care needed in using standard analysis procedures on records which cannot be described as standard. In particular, short duration records, where except for a few peaks the amplitudes are low, have noise problems that can only be reduced by considerable reduction of the frequency range containing valid data. The Seismic Engineering Branch of the U.S. Geological Survey, in continuing the digitization and analysis of significant records, has modified the standard procedures where experience has shown such adjustments are necessary, and plans to make further modification where appropriate.

On a method for synthesizing the artificial earthquake waves by using the prediction error filter, K. Ohtani and S. Kinoshita, *SP523*, pp. IV-28—IV-47 (Sept. 1978).

Key words: accelerogram; artificial earthquake; covariance; filter; finite Fourier expansion; prediction error; random variables; synthesis; wave.

Several methods for synthesizing the artificial earthquake waves have been reported for the purpose of dynamic analysis and earthquake-resistant design of structures. In the present report, the authors discuss a method by using "the prediction error filter," in which there are less numbers of the required parameters than those in other methods and also these parameters are more easily estimated. This method is based on the linear prediction model for the earthquake wave in the time domain. Therefore, parameters by which the prediction error filter is constructed are computed from the sequence of covariance matrices that represent the characteristics of earthquake waves in the time domain.

As compared with the methods using the finite Fourier expansion by harmonic functions, this method uses the finite Fourier expansion by uncorrelated random variables, and the filter is designed in the time domain. Also, the number of terms of this expansion is automatically determined by using "An Information Criterion" (AIC) proposed by Akaike. The relationship introduced by the authors for synthesizing correlated multi-dimensional waves show an example of synthesis by using an observed strong-motion accelerogram.

Statistical analysis of strong-motion acceleration records, M. Ohashi, T. Iwasaki, S. Wakabayashi, and K. Takida, *SP523*, pp. IV-48—IV-77 (Sept. 1978).

Key words: design; earthquake magnitude; epicentral distance; statistical analysis; strong-motion acceleration records.

This paper briefly discusses the present status of strong-motion observation for engineering structures in Japan. Next, it presents the results of the multiple regression analysis of 301 strong-motion acceleration records to evaluate the effects of earthquake magnitude, epicentral distance and subsoil condition on characteristic variables of ground accelerations such as maximum horizontal acceleration, time duration of major motion, ratio of vertical to horizontal accelerations, etc. The paper also shows the results of a quantification analysis of average response accelerations obtained from 277-component horizontal acceleration records to clarify the effects of seismic and subsoil conditions on average response spectra.

From the analysis performed, empirical formulas which can statistically estimate maximum horizontal acceleration, duration of major motion, and number of zero-crossing in terms of earthquake magnitude, epicentral distance, and subsoil condition, are proposed. Frequency characteristics of horizontal motions and ratios of vertical to horizontal accelerations are evaluated and averaged depending on subsoil conditions. Furthermore, various average response spectrum curves for a linear single-degree-of-freedom system are proposed in terms of earthquake magnitude, epicentral distance, and subsoil condition.

Research on design earthquake, M. Watabe, *SP523*, pp. IV-78—IV-95 (Sept. 1978).

Key words: design earthquake; deterministic intensity function; historical data; maximum values; random characteristics; seismic zoning; spectral shapes; theoretical analysis.

The maximum values of accelerations, velocities and displacements of the ground motions due to earthquakes are first discussed utilizing the historical data as well as some theoretical approaches. Then, duration time and the deterministic intensity function of the accelerograms are introduced. The predominant periods and spectral shapes of the strong motion accelerograms are also reported. Historical earthquake data were utilized to assess the earthquake risks in Japan. Finally the explanation of proposed "design earthquake" concludes this report.

Determination of wave propagation velocities in subsurface soil layers, Y. Shioi and T. Iwasaki, *SP523*, pp. IV-96—IV-114 (Sept. 1978).

Key words: harmonic wave; Love waves; model structure; Rayleigh waves; soil-structure interaction; vibrator.

Activities of the Committee on Earthquake Observation on Soil-Structure Interaction have been described. One of the committee's research activities is the research involving the construction of a model structure, soil investigations, dynamic tests and analysis of dynamic soil-structure interaction.

This paper discusses the results of forced vibration tests conducted on a model structure with a vibrator which generated harmonic waves. These waves were then compared with the Rayleigh and Love waves.

Studies on soil liquefaction related to earthquake resistant design of structures, M. Ohashi, T. Iwasaki, and F. Tatsuoka, *SP523*, pp. IV-115—IV-157 (Sept. 1978).

Key words: bridge foundations; dynamic triaxial tests; liquefaction; model tests; pile foundations; sand; shake table; standard penetration test.

In order to evaluate dynamic behavior of structural foundations and embedded structures during earthquakes, it is essential to estimate the effects of the surrounding soils on

these structures. The authors have conducted a literature survey on the effects of liquefied soils on bridge foundations and also conducted laboratory experiments using models of pile foundations including surrounding soils.

Furthermore, a simplified method to evaluate liquefaction potential of sand deposits was investigated on the basis of numbers of blows (so called N-values) by the standard penetration test. Proposed herein are the critical N-values which can be used in determining liquefaction potential. This method can estimate whether the sand deposit may likely liquefy or not during future severe earthquakes by means of comparing N-values measured at the site of interest with the critical values proposed. These critical values were determined on the basis of dynamic triaxial tests on undisturbed sand samples and N-values measured at the points where the undisturbed samples were obtained.

These studies are to clarify the effects of liquefied soils on pile foundations and to establish design methodology of pile foundations considering the effects of soil liquefaction.

Earthquake resistant design based on ground motions at base-rock, E. Kuribayashi and K. Kawashima, *SP523*, pp. IV-158—IV-179 (Sept. 1978).

Key words: analytical method; base-rock; bridge foundations; deconvolution procedure; earthquake records; ground conditions; ground transfer functions; shear wave.

It is generally known that dynamic behaviors of structures are influenced by their ground conditions and that earthquake ground motions recorded are dependent on their ground conditions. In order to specify common input earthquake motions for design of every structure on and under ground, it is useful to select base-rocks in ground, where effects of grounds near surface are small enough to be ignored, as an input terminal where earthquake motions are to be specified. In order to improve such seismic designs, discussions on necessary conditions of base-rock and on accuracies of base-rock motions estimated by theoretical calculations are presented. Earthquake responses of bridges are also presented as a numerical example.

Basic earthquake for dam design, J. S. Dodd, *SP523*, pp. V-1—V-13 (Sept. 1978).

Key words: earthquakes; dams; dynamic analysis.

Modern computational techniques permit mathematical dynamic analysis of concrete and embankment dams. Steps in the analysis are: (1) specify location, depth, and magnitude of critical specifically located earthquakes, (2) attenuate seismic waves to site, (3) determine site response to seismic waves, (4) analyze response of structure, (5) evaluate results. This discussion addresses the first step and proposes the establishment of a minimum earthquake—the basic earthquake—for damsites in the western United States.

Study on regional distribution of maximum earthquake motions in Japan, M. Ozaki, Y. Kitagawa, and S. Hattori, *SP523*, pp. V-14—V-44 (Sept. 1978).

Key words: earthquake danger; Gumbel's theory of extremes, literature review; regional seismic coefficient map; statistical analysis.

Research activities in the earthquake danger have been critically reviewed. Many researchers concentrated on the study of the past earthquake data and statistical analyses of these data.

This paper presents an application of Gumbel's theory of extremes for the prediction of the intensity of future earthquakes. The paper concludes with a new regional seismic coefficient map of Japan.

Treatments on seismic force in designing earth structures, K. Sawada, *SP523*, pp. V-45—V-52 (Sept. 1978).

Key words: culverts; design principle; earth structure; earthwork manual; fill slope; priority; retaining wall; seismic forces.

Treatment of earthquake forces in the design of retaining walls and of embankment slopes is discussed. The discussion centers around the philosophy and considerations given when Japan Road Association revised its Earth Work Manual in Road Construction.

Studies on the aseismic properties of underground pipes, K. Ohtani, N. Ogawa, and C. Minowa, *SP523*, pp. V-53—V-68 (Sept. 1978).

Key words: dynamic water pressure; shaking table; underground pipes; vibration experiments.

This paper describes the experiments of underground pipes by using the large-scale shaking table of the National Research Center for Disaster Prevention, the analysis results of dynamic water pressure on pipelines caused by earthquake motions, and the problem of the slip between the surface of pipe and the soil.

Two kinds of experiments were executed. In the first experiment a linear pipeline (steel) was buried in the ground at the vicinity of this shaking table. The test pipeline was excited by the waves which were generated from the shaking table and transmitted through the ground. The behaviors of this pipeline and the ground would not always be similar because of the differences in the rigidities between pipe and soil and in the boundary conditions of pipeline ending. In this experiment, slight differences were measured between the behaviors of the test pipeline and the ground.

In the second experiment, a steel pipeline with a branch pipe was set on this shaking table and one end of the main pipe was clumped in the shaking table foundation. And this pipeline was buried in the sand pit. The bending strains and restoring forces of this pipeline were measured. The dynamic strains had the values similar to those of static strains for the same displacements. The hysteresis loops, drawn by the restoring force and displacement at the clumped end, had the energy absorption. The necessity for the second experiment was based on the slip which had grown around the pipe surface in disastrous earthquakes. The slip values of the infinite length pipeline with a branch pipe were calculated for sinusoidal ground waves.

In addition to these problems concerning water supply pipelines, etc., the water pressure in the pipelines has to be considered. In this paper, the procedure for estimating the distributions of dynamic water pressures caused by earthquakes without the so-called water hammer has been developed. For example, the dynamic water pressures for model pipelines are calculated.

Observation of dynamic behavior of Kinuura Submerged Tunnel during earthquakes, S. Nakayama, O. Kiyomiya, and H. Tsuchida, *SP523*, pp. V-69—V-79 (Sept. 1978).

Key words: accelerometer; axial force; bar stress transducer; bending moment; displacement meter; dynamic behavior of tunnel; power spectrum; strain meter; submerged tunnel.

Kinuura Submerged Tunnel, which is located at Kinuura Port and Aichi Prefecture, is equipped with a number of instruments comprising of accelerometers, strain meters, bar stress transducers, and a displacement meter, which are intended to serve the purpose of the tunnel main-

tenance and to provide data for studying the behavior of the submerged tunnel during earthquakes.

The measurement of earthquake response of the tunnel has been carried out since August, 1973 when the tunnel was opened to traffic. Fifteen earthquakes have been recorded up to January, 1977. A part of the data thus obtained and its analysis have already been reported by the authors. This paper describes the analysis of the data and the result of earthquake response calculations carried out by using these earthquake records.

A proposal for earthquake resistant design methods, K. Nakano and M. Ohashi, *SP523*, pp. V-80—V-101 (Sept. 1978).

Key words: coefficients in aseismic design; design method; proposed earthquake resistant design method; seismic hazard zoning map.

This paper describes the outline of a Proposal for Earthquake Resistant Design Methods, which was completed by the Ministry of Construction in March, 1977.

The earthquake response of hysteretic structures, W. D. Iwan and N. C. Gates, *SP523*, pp. VI-1—VI-14 (Sept. 1978).

Key words: ductility; earthquake response; empirical formula; hysteretic structures; inelastic response spectra.

The earthquake response of a broad class of hysteretic structures is investigated. Inelastic response spectra are determined. Based on these spectra, an effective linear period and damping are defined for each type of hysteretic structure as a function of ductility. A simple empirical formula is presented which may be used to estimate the response of a general hysteretic structure given the linear response spectrum of the excitation. The predictions obtained from this formula are compared with those of another frequently used scheme for estimating the response of hysteretic structures.

On the object postulate for earthquake-resistant code, K. Nakano, Y. Ishiyama, Y. Aoki, and K. Watanabe, *SP523*, pp. V-102—V-116 (Sept. 1978).

Key words: acceptable level of human risk; construction costs; earthquake resistant code; expected seismic force; object postulate; reliability theory; social utility.

What the object of the earthquake-resistant code should be and how to define the object are the concerns of the object postulate. Since the seismic forces and the earthquake-resistant capacity of the buildings have certain dispersions, it is necessary to introduce the concept of the reliability to define the object postulate. This report deals with research on 1) dispersions, 2) relation between the earthquake-resistant capacity and the construction cost, 3) acceptable level of human risk, and 4) principle of social utility to optimize the importance factor, in order to define the object postulate for the earthquake-resistant code.

Earthquake resistant design of high-rise buildings in Japan, K. Ohtani, *SP523*, pp. VI-15—VI-24 (Sept. 1978).

Key words: building height limitation; building volume limitation; earthquake resistant design; flexural-shear model; high-rise buildings; histogram for building uses; shear model.

In January, 1964, the building height limitation which had been stipulated in the Structural Standard Law of Japan since 1921 was replaced with the building volume limitation. Number of high-rise buildings exceeding 45 meters in height came out to be about 300 cases. These

buildings are examined thoroughly for the aseismic safety by dynamic analysis instead of static analysis, and received judge-and-rating as to the propriety of structural design from the committee consisting of specialists.

In this report, I discuss the present state of design, especially of dynamic analysis, using the design specification presented to the above committee. The number of data used in this report is 78 for SRC (composite steel and reinforced concrete structure) and 160 for S (steel structure) omitting special type structures such as high chimneys, towers, etc. As this study is the research of materials based on the actual design specification, I refer to the problems of aseismic design or the future subjects of research and development by considering the trend of design.

Racking strength of wood-frame walls, R. L. Tuomi, *SP523*, pp. VI-25—VI-34 (Sept. 1978).

Key words: corner brace; inplane shear forces; racking stiffness; racking strength; windloads.

Evaluation of the racking strength of wall systems has generally been limited to performance testing. Acceptance criteria for ultimate racking strength of sheathed walls are based on the strength of a wall with a let-in corner brace and horizontal board sheathing.

An analytical method for predicting racking performance has been developed that appears promising. It is independent of panel size, and small-scale tests can be used to augment the more costly standard tests. A small-scale loading apparatus was designed for rapid testing of wall sections.

Let-in corner braces using today's construction methods and materials no longer meet even the minimum level of acceptance. This is due to the elimination of horizontal board sheathing and the reduction in actual lumber sizes which took place since the racking performance standards were established.

Racking stiffness is an important performance consideration that has not been investigated. New testing apparatus has been designed that will make possible future evaluations of racking stiffness.

Examination for an evaluation method of damage to existing wooden houses caused by earthquakes, K. Ichihara, E. Kuribayashi, T. Tazaki, and T. Hadate, *SP523*, pp. VII-1—VII-15 (Sept. 1978).

Key words: damages of structure by earthquake; disaster mitigation; probability theory; ratio of razed houses; wooden houses.

In an effort to help draft an earthquake disaster mitigation program, an evaluation method for damages of structures by earthquakes is proposed. Concepts of the ratios of razed houses and probability theories with number of razed houses have been employed in the method.

Relationship between modified Mercalli intensity and wood frame dwelling earthquake insurance, K. V. Steinbrugge and S. T. Algermissen, *SP523*, pp. VII-16—VII-28 (Sept. 1978).

Key words: earthquake insurance; earthquake losses; intensity-loss relationships; loss simulation.

Traditionally, earthquake insurance rates have been based on business judgment tempered by engineering input obtained from analyses of observed earthquake damage. The development of loss simulation techniques has provided important new input for improvement of the basis for earthquake insurance rates. Some important loss simulation results are reviewed. Modified Mercalli intensity can be directly related to dwelling loss and is an important parameter in dwelling loss simulation studies. Careful addi-

tional study of existing dwelling loss data (such as is available for the 1971 San Fernando, California, earthquake) together with well planned damage studies after future earthquakes will lead to greatly improved loss estimates. Probabilistic loss models should also be developed for dwelling loss studies and the effects of parameter uncertainties taken into account.

Warrants for retrofitting highway bridges, A. Longinow, E. Bergmann, and J. D. Cooper, *SP523*, pp. VIII-1—VIII-21 (Sept. 1978).

Key words: bridges; earthquake; retrofit decision.

A methodology for determining whether or not to seismically retrofit an existing bridge is presented. The method is based on the concept of identifying and comparing the importance of the bridge to its structural integrity. Criticality factors which are expressed in terms of bridge classification and its importance to the social, medical, economic, and security needs of a geographical area following a natural disaster are developed. Structural factors, which estimate a bridge's ability to withstand an earthquake, are determined analytically or by inspection. The criticality and structural factors are compared to determine if a bridge warrants retrofitting. The method is demonstrated by example.

Criterion on the evaluation of seismic safety of existing reinforced concrete buildings, K. Nakano, M. Hiroswa, and S. Okamoto, *SP523*, pp. VIII-22—VIII-41 (Sept. 1978).

Key words: evaluation method of seismic safety; nonstructural elements; reinforced concrete buildings; seismic safety index; structural elements.

The outline of "Criterion on the Evaluation of Seismic Safety of Existing Reinforced Concrete Buildings" by the Ministry of Construction is discussed in detail. The evaluation method consists of three steps with use of various seismic indices.

Transferring the technology for wind-resistant buildings to developing countries, N. J. Raufaste, Jr., *SP523*, pp. VIII-42—VIII-46 (Sept. 1978).

Key words: buildings; design criteria; developing countries; technology transfer; windloads.

The National Bureau of Standards project to develop improved design criteria for low-rise buildings to better resist high winds was recently completed. It contained two essential parts. The first included developing technology to reduce wind damage to buildings through improved building practices. The second part centered around making sure these improved building practices actually reached the individuals who construct and live in buildings. The latter has traditionally received minimum attention. This paper presents a method for getting the results of the NBS wind research to the building community which includes building owners and users who need it most. A 3-level approach to this method is described. The method used can be a model for other research projects aimed at technical, semi-technical, or even semi-literate audiences.

SP524. Assessment of current building regulatory methods as applied to the needs of historic preservation projects, R. V. Keune, *Nat. Bur. Stand. (U.S.), Spec. Publ. 524*, 87 pages (Oct. 1978) SN003-003-01990-9.

Key words: architecture; building regulatory system; codes; health and safety; historic buildings; historic preservation; impacts; performance-based standards; research.

To meet contemporary health and safety requirements as defined by the building regulatory system, conflicts frequently occur with the needs of historic building preservation projects. This project: (1) identified, evaluated and proposed historic preservation categorical definitions as applied to buildings; (2) developed performance objectives, requirements, criteria and tests for each definition category; and (3) identified and assessed those current methods most commonly used by regulatory jurisdictions to mitigate adverse impacts on building preservation projects.

SP526. 12th informal conference on photochemistry. Proceedings of the 12th Informal Conference on Photochemistry, held at the National Bureau of Standards, Gaithersburg, MD, June 28-July 1, 1976, M. J. Kurylo and W. Braun, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 526*, 411 pages (Oct. 1978) SN003-003-01984-4.

Key words: chemical kinetics; energy transfer; fluorescence; lasers; photochemistry; solar energy; spectra.

The 12th Informal Conference on Photochemistry was held at the National Bureau of Standards Laboratories in Gaithersburg, Maryland, from June 28-July 1, 1976. Nearly 300 members of the international scientific community attended the 123 individual research papers presented. Extended abstracts of these presentations (many revised after the Conference) comprise the present proceedings. The wide range of highly specialized topics include Environmental Chemistry (both Photochemical Smog and Upper Atmosphere/Ozone Layer), Laser Photochemistry, Photochemical Isotope Separation, Photochemical Conversion of Solar Energy, Actinometric and Radiometric Measurements, Chemiluminescent Processes, Primary Photochemical and Photophysical Processes, Inorganic Photochemistry, and Elementary Reaction Processes. *These proceedings include the following papers (indented):*

A modern approach to accurate radiometry, E. Zalewski, *SP526*, pp. 1-2 (Oct. 1978).

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NBS ultraviolet radiometric standards, W. R. Ott, *SP526*, pp. 5-7 (Oct. 1978).

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Kinetics of the chemiluminescence accompanying metal atom oxidation reactions, W. Felder and A. Fontijn, *SP526*, pp. 14-17 (Oct. 1978).

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Energy-dependent cross sections for quenching of $\text{Li}(^2\text{P})$ and $\text{Na}(^2\text{P})$, J. R. Barker, S. M. Lin, and R. E. Weston, Jr., *SP526*, pp. 348-350 (Oct. 1978).

Electronic-to-vibrational energy transfer reactions: $\text{Na}(^3\text{P}) + \text{CO}(\text{X}^1\Sigma^+, v = 0)$, D. S. Y. Hsu and M. C. Lin, *SP526*, pp. 351-353 (Oct. 1978).

Energy transfer in the collision of metastable excited $\text{Ar}(^3\text{P}_2)$ atoms with ground state H^2S atoms, P. B. Monkhouse, K. D. Bayes, and M. A. A. Clyne, *SP526*, pp. 354-358 (Oct. 1978).

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V-V energy transfer in H_2 -additive gas mixtures using a stimulated Raman excitation technique, R. G. Miller and J. K. Hancock, *SP526*, pp. 364-366 (Oct. 1978).

Experiments concerning the laser enhanced reaction between O_3^+ and NO , K. K. Hui and T. A. Cool, *SP526*, pp. 368-369 (Oct. 1978).

Infrared laser enhanced reactions: Chemistry of $\text{NO}(v = 1)$ with O_3 , J. C. Stephenson and S. M. Freund, *SP526*, pp. 370-372 (Oct. 1978).

Kinetic energy—and internal state dependence of the $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2^* + \text{O}_2$ reaction, A. E. Redpath and M. Mensinger, *SP526*, pp. 373-375 (Oct. 1978).

The effect of infrared laser excitation on reaction dynamics: $\text{O} + \text{C}_2\text{H}_4$ and $\text{O} + \text{OCS}^+$, R. G. Manning, W. Braun, and M. J. Kurylo, *SP526*, pp. 376-379 (Oct. 1978).

Reaction of flash photolytically produced $\text{CN}(\text{X}^2\Sigma^+, v)$ radicals with $\text{O}(^3\text{P})$ atoms, K. J. Schmatjko and J. Wolfrum, *SP526*, pp. 380-383 (Oct. 1978).

Vibrational photochemistry: The relaxation of $\text{HCl}(v = 1)$ and $\text{DCI}(v = 1)$ by bromine atoms, R. D. H. Brown, I. W. M. Smith, and S. W. J. Van der Merwe, *SP526*, pp. 384-387 (Oct. 1978).

Vibrational relaxation of $\text{HF}(v = 1,2,3)$ in the presence of H_2 , N_2 , and CO_2 , J. F. Bott, *SP526*, pp. 388-389 (Oct. 1978).

Quenching of $\text{NO}(\text{B}^2\Pi_{1/2})_{v'=0}$ produced by the reaction of $\text{N}(^2\text{D})$ with N_2O , G. Black, R. L. Sharpless, and T. G. Slinger, *SP526*, pp. 390-394 (Oct. 1978).

CW infrared laser isotope separation: $\text{Cl} + \text{CH}_2\text{Br}(v_0) \rightarrow \text{HCl} + \text{CH}_2\text{Br}$, T. J. Manuccia, M. D. Clark, and E. R. Lory, *SP526*, pp. 395-396 (Oct. 1978).

SP528. Analytical methods for safeguards and accountability measurements of special nuclear materials. Proceedings from American Nuclear Society Topical Meeting held in Williamsburg, VA, May 15-17, 1978, H. T. Yolken and J. E. Bullard, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 528*, 304 pages (Nov. 1978) SN003-003-01996-8.

Key words: accountability; analysis; gamma-ray; neutron; nuclear safeguards; special nuclear materials; x ray.

This book contains proceedings of the American Nuclear Society's (co-sponsored by the National Bureau of Standards) topical meeting entitled, "Analytical Methods for Safeguards and Accountability Measurements of Special Nuclear Materials." The meeting was held in Williamsburg, Va. on May 15-17, 1978. The two objectives of the meeting were to discuss the latest techniques for chemical analysis of special nuclear materials and to strengthen lines of communication among scientists working in this field.

The presentations deal with advanced analytical chemistry techniques such as x-ray spectrometry for elemental content, neutron interrogation and gamma ray techniques for isotopic content, mathematical correction models, and wet chemistry methods for elemental content. Examples of remote systems for handling highly radioactive samples for analysis are given. Progress is being made on the problems associated with obtaining high precision and accuracy for analysis of special nuclear materials while at the same time maintaining short turnaround time and reduced possibility of diversion. Various approaches are described which emphasize computer-controlled operating systems with built-in safeguards and quality assurance programs. Current trends in the fuel cycle, along with future approaches to control and accountability of special nuclear materials, are discussed. *These proceedings include the following papers (indented):*

The chemical and isotopic analysis of uranium, plutonium and thorium in nuclear fuel materials, C. E. Pietri, J. S. Paller, and C. D. Bingham, *SP528*, pp. 1-18 (Nov. 1978).

Key words: automation; chemical analysis; chemical separations; dissolution; isotopic analysis; plutonium assay; quality assurance programs; thorium assay; uranium assay.

The New Brunswick Laboratory (NBL) has developed or modified and used highly precise and accurate methods for the determination of uranium, plutonium and thorium content and isotopic abundances in a wide variety of nuclear fuel cycle materials in support of nuclear safeguards programs. The dissolution, separation and subsequent precise chemical analysis of these materials with an accuracy of 0.1 percent or less is achieved using gravimetric, titrimet-

ric, spectrophotometric and coulometric techniques. Isotopic abundance measurements on uranium and plutonium are accurately measured with a relative limit of error (95% confidence limit) of approximately 20 to 0.007 percent for the isotope weight range of 0.001 to 97 weight percent using thermal ionization mass spectrometers. Other methods such as isotope dilution mass spectrometry, fluorimetry and radiochemical analysis are used where the uranium and plutonium sample content is in the microgram range. Many of the analytical methods used at NBL are in various stages of automation or mechanization to provide greater efficiency and productivity at existing levels of accuracy and precision. Quality assurance programs employing unknown control standards for the analysis of nuclear materials are used at NBL to maintain a high level of reliability.

Analytical methods and laboratories for safeguards and accountability: Present and future, L. T. Corbin, *SP528*, p. 19 (Nov. 1978).

Key words: accountability; analyses; plutonium; remote; safeguards; uranium.

Accountability for special nuclear materials at ORNL requires a number of different analyses depending upon the kind and source of the material. The determination of uranium and plutonium in highly radioactive reactor fuel dissolver solutions must be performed remotely in hot cells or in glove boxes after a separation of the heavy elements from the bulk of the fission products. These determinations can be made by several different chemical techniques or radioactive solutions may be measured simultaneously and accurately by isotope dilution mass spectrometry.

Measurements where accuracy is essential are subject to a quality assurance program for all phases of the operation: equipment, standards, sampling, aliquoting, documentation and reporting.

Special material samples are stored either in hot cells or in glove boxes for analyses. The analytical laboratories are in zones that are not readily accessible to unauthorized personnel.

Future safeguards analytical laboratories will operate under the premise that if samples always remain in the hot-cell and glove-box systems, diversion of material will be difficult. Analytical procedures will be highly automated to minimize the need for human sample handling, and sample storage and retrieval will be under computer control.

Hot cells and glove boxes must and will be designed to optimize automated operations. Thus, they will have a very different appearance from hot cells of today.

Analytical techniques not previously used for automated radioactive operations must be adopted. Spark-source mass spectrometers are already being converted for hot cell use. Thus, there will be many opportunities for new and innovative approaches to chemical and radiochemical techniques in the years to come.

An automated x-ray spectrometer for mixed oxide pellets, M. C. Lambert, M. W. Goheen, M. W. Urie, and N. Wynhoff, *SP528*, pp. 20-36 (Nov. 1978).

Key words: automation; energy dispersion; faster counting; in-line; nuclear fuel assay; x-ray spectrometer.

This paper discusses the development of an energy dispersive x-ray (EDX) spectrometer for the rapid, automated, close-coupled analysis of solid mixed plutonium-uranium oxide fuel pellets. Reasons are given for the system design, which is intended to give a relative precision (RSD) of ± 0.2 percent in a total analysis time of two

minutes. The principal problems in an EDX system are in maximizing the plutonium count rates.

Mechanisms for assuring accurate measurement of nuclear materials, H. T. Yolken, *SP528*, pp. 37-40 (Nov. 1978).

Key words: measurements; nuclear safeguards; standards.

A review of the procedures available to provide assurance of meaningful measurements of nuclear materials is presented. These procedures include the use of reference data, document or written standards, reference materials and instrument calibration services. Examples are given that demonstrate the determination of measurement uncertainty relative to nationally accepted standards. A clear case is made for the necessity of building a nuclear materials measurement system on a firm foundation of accuracy.

Design of a Cf-252 neutron assay system for evaluation at the Savannah River Plant fuel fabrication facility, T. W. Crane, S. Bourret, G. W. Eccleston, H. O. Menlove, L. G. Speir, and R. V. Studley, *SP528*, pp. 41-48 (Nov. 1978).

Key words: Cf-252; delayed neutrons; enriched uranium; neutron interrogation; nondestructive assay; U-235.

A nondestructive assay (NDA) unit will be evaluated at the Savannah River Plant (SRP) reactor fuel fabrication facility for measurement of a range of highly enriched uranium materials. The unit employs cyclic neutron interrogation with a Cf-252 neutron source followed by delayed-neutron counting to assay the U-235 content of fuel alloys with up to 2.4 kg U-235 per item in addition to scrap and waste with a lower U-235 content. The accuracy goal for the majority of the measurements is 1-3 percent.

Gamma spectrometric methods for measuring plutonium, R. Gunnink, *SP528*, pp. 49-63 (Nov. 1978).

Key words: computer analysis; gamma-ray analysis; plutonium analysis; plutonium safeguards.

Nondestructive analyses of plutonium can be made by detecting and measuring the gamma rays emitted by a sample. Although qualitative and semiquantitative assays can be performed with relative ease, only recently have methods been developed, using computer analysis techniques, that provide quantitative results. This paper reviews some new techniques developed for measuring plutonium. The features of plutonium gamma-ray spectra are reviewed and some of the computer methods used for spectrum analysis are discussed. The discussion includes a description of a powerful computer method of unfolding complex peak multiplets that uses the standard linear least-squares techniques of data analysis. This computer method is based on the generation of response profiles for the isotopes composing a plutonium sample and requires a description of the peak positions, relative intensities, and line shapes. The principles that plutonium isotopic measurements are based on are also developed, followed by illustrations of the measurement procedures as applied to the quantitative analysis of plutonium liquid and solid samples.

Rapid nondestructive plutonium isotopic analysis, J. E. Fager and F. P. Brauer, *SP528*, pp. 64-70 (Nov. 1978).

Key words: gamma-ray spectrometry; nondestructive analysis (NDA); plutonium isotopes; x-ray spectrometry.

Methods for plutonium isotopic measurements have been evaluated for nuclear safeguards inventory verification. A mobile, real-time, nondestructive assay, gamma-ray spec-

trometric measurement system has been assembled, moved and operated at several nuclear storage facilities to perform rapid, real-time plutonium isotopic measurements on Pu metal, Pu nitrate and Pu oxide.

Non-destructive assay of leached hulls in a nuclear fuel reprocessing plant, K. J. Hofstetter, B. C. Henderson, J. H. Gray, and G. A. Huff, *SP528*, pp. 71-77 (Nov. 1978).

Key words: design of experiments; evaluation, calibration; leached hull monitor; nondestructive assay.

In a nuclear fuel reprocessing plant, the spent light water reactor fuel elements are chopped into approximately 2-4 inch lengths and the irradiated fuel dissolved from the Zircaloy hulls in a nitric acid dissolver solution. From the dissolver, the empty hulls are transferred batchwise to a leached hull monitor to be assayed for undissolved uranium and plutonium. After the assay, the hulls may be recycled back to the nitric solution for continued dissolution or disposed of as solid nuclear waste using the assay results to provide accountability data for special nuclear material content.

The hull monitor at the Barnwell Nuclear Fuel Plant (BNFP) will be a remotely controlled, fully automated system designed to quantitatively assay leached hulls for undissolved uranium and plutonium. The hull monitor will assay the hulls from one metric ton of fuel per dissolver basket with the design goal of detecting 0.1 percent undissolved fuel and yet remain within the framework of the BNFP materials flow, i.e., handle five hull baskets per day.

The nondestructive assay will be accomplished using a computer-based gamma-ray pulse height analysis system employing a 5 x 5 inch NaI(Tl) scintillation detector. The intense radiations from the fission product isotopes and the activation product isotopes produced in the reactor prevent direct assay of the undissolved fuel left in the hulls. The measurement will be made indirectly by demonstrating a correlation between the amount of ^{144}Ce undissolved and the remaining uranium. The isotope ^{144}Ce is a direct fission product with high (6%) cumulative yield. The daughter isotope ^{144}Pr has a gamma ray at 2.18 MeV well above other predominant radiations in the spectrum from the major interferences ^{60}Co , ^{58}Co , ^{95}Zr (^{95}Nb), ^{137}Cs and ^{106}Ru (^{106}Rh).

Segmented scanning operation of the hull monitor is accomplished by rotation and vertical transversal of the hulls container past the detector station. Proper collimation and absorbers are required to maximize the ^{144}Ce (^{144}Pr) to background ratio. A basket indexer is provided which monitors the scanning rate and ensures repositioning.

The leached hull monitor system will be interfaced to a computer-based multichannel analyzer for ease of operation and data handling. A calibration basket has been fabricated to accommodate radioactive sources and inactive Zircaloy hulls. Experiments to be performed with the hull monitor using this basket will simulate operation prior to plant startup. The system, calibration, geometry and hull attenuation, spectral interferences, quantitative limits of assay, and the role of the hull monitor in nuclear materials accountability will be discussed.

Safeguards and nonproliferation, S. C. T. McDowell, *SP528*, pp. 78-82 (Nov. 1978).

Key words: active and passive fuel cycle safeguards concepts; integrated safeguards systems; safeguards and nonproliferation.

U.S. nonproliferation objectives cannot be achieved without the development and implementation of modern

safeguards systems that are timely, sensitive and perhaps most important, inspectable by the International Atomic Energy Agency. In the nonproliferation context, the purpose of safeguards is to deter or reveal national intentions to obtain nuclear weapons capability by providing the time required to enact international sanctions. The Department of Energy is developing safeguards concepts and systems based on minimizing the opportunity for diversion and maximizing the probability of timely detection to allow for the necessary communication and control actions. The current U.S. nonproliferation policy can afford the time to make available practical, active safeguards for assuring the world that nuclear materials are being used only for peaceful purposes.

Decision analysis for dynamic accounting of nuclear material, J. P. Shipley, *SP528*, pp. 83-97 (Nov. 1978).

Key words: alarm-sequence chart; CUSUM; decision analysis; Kalman filter; materials accounting; nuclear safeguards; plutonium nitrate-to-oxide conversion.

Effective materials accounting for special nuclear material in modern fuel cycle facilities will depend heavily on sophisticated data-analysis techniques. *Decision analysis*, which combines elements of estimation theory, decision theory, and systems analysis, is a framework well suited to the development and application of these techniques. Augmented by pattern-recognition tools such as the alarm-sequence chart, decision analysis can be used to reduce errors caused by subjective data evaluation and to condense large collections of data to a smaller set of more descriptive statistics. Application to data from a model plutonium nitrate-to-oxide conversion process illustrates the concepts.

Analytical Chemistry Measurements Quality Control Program using computer applications, J. P. Clark and G. A. Huff, *SP528*, pp. 98-111 (Nov. 1978).

Key words: assurance; measurement quality control; real-time quality control; reliability; replicates; standards.

An Analytical Chemistry Measurements Quality Control Program assures the reliability of analytical measurements performed at the Barnwell Nuclear Fuel Plant. The program includes training, methods quality control, replicate samples and measurements, mass measurements, inter-laboratory sample exchanges, and standards preparation. This program has been designed to meet the requirements of 10CFR70.57. Portions of the program have been automated by using a PDP 11/35 computer system to provide features which are not readily available in manual systems. These include such items as realtime measurement control, computer calculated bias and precision estimates, various surveillance applications, and evaluation of measurement system variables.

The efficiency of the computer system has been demonstrated in gathering and assimilating the results of over 1100 quality control samples during a recent cold chemical checkout campaign. These data were used to determine equations for predicting measurements reliability estimates; to evaluate measurement performance of the analysts, equipment, and measurement period; and to provide directions for chemistry methods modifications and additional training requirements. A procedure of replicate sampling and measuring provides random error estimates. The analytical chemistry measurement quality control activities during the campaign represented about 10 percent of the total analytical chemistry effort.

Actinide determination by Rockwell Hanford Operations' Analytical Laboratories, G. Burch, *SP528*, pp. 112-120 (Nov. 1978).

Key words: actinide; alpha energy analysis; x-ray diffraction techniques; x-ray emission.

A review of the procedures currently used by the Analytical Laboratories Department of Rockwell Hanford Operations for the determination of actinide composition. Methods used include extraction followed by alpha energy analysis, visible spectrophotometric, x-ray emission and x-ray diffraction techniques.

X-ray diffraction sample holder for radioactive samples or samples that react with air or light, H. W. Dunn, *SP528*, pp. 121-124 (Nov. 1978).

Key words: analysis of radioactive materials; handling radioactive materials; transporting radioactive samples; x-ray diffraction.

A very versatile sample holder for an x-ray diffractometer will be described. It provides double containment while in operation on the diffractometer and triple containment while being transported from a hot cell or dry box to the diffractometer and back to a disposal area. This cell is suitable for fairly high alpha activity or mild beta-gamma activity. It is also good for materials that react with air or light. Either solid or liquid samples can be used.

Feasibility study of a high-precision XRF system for analysis of solutions and slurries, C. R. Hudgens and B. D. Craft, *SP528*, pp. 125-132 (Nov. 1978).

Key words: analysis of solutions and slurries; high-precision, wavelength dispersive x-ray spectrometer; nuclear safeguards; rotating target x-ray tube; x-ray fluorescence analysis; x-ray liquid and slurry sample cell; x-ray monochromator.

Wavelength dispersive x-ray fluorescence (XRF) is uniquely applicable to the analysis of dissolver solutions because of its high immunity to the intense gamma emissions of the solutions, its inherently high signal-to-noise (S/N) ratios, and its adaptability as an on-line, tamper-resistant, accurate analysis of both dilute and concentrated plutonium in dissolver solutions.

The taking of aliquots and transfer of samples would be eliminated by placing the system on-line. Sampling thereby would become total: during the progress of the analysis the entire contents of the dissolver tank—or its logical equivalent, a large, thoroughly mixed fraction of its contents—would be circulated through the sample cell. Internal standards would be used for realization of the highest accuracy of analysis. The addition of standards would impose no complications to subsequent chemical processing.

The use of monochromatic exciting radiation would further improve the S/N ratio, and, by eliminating useless radiation, would reduce photochemically formed gas bubbles which perturb sample geometry. For rapid analysis a rotating target, high-power x-ray generator would be necessary.

Control and monitoring of the equipment, the analytical process, and data processing would be done by a minicomputer for error-free operation, and for prompt detection of all but the most sophisticated attempts at tampering with the analytical process.

The specifications of the system components have been conservatively estimated so that the r.m.s. variation of the entire system during a single determination would not exceed 0.20 percent. Counting statistics is considered separately because it is a function of fluorescent intensity, and therefore may be limited by available time for dilute solutions. For concentrated solutions with strong fluorescent emissions the total variation of a single deter-

mination could approach the 0.20 percent level. By using the usual strategy of repeated determinations, any arbitrary precision could be reached.

The performance specifications have been written with awareness of the capabilities and limits of modern technology. The capabilities are exploited and the limits are not strained. The conservative designs thus permitted will allow the construction of an XRF system of high reliability and advanced capability.

Establishing the traceability of a uranyl nitrate solution to a Standard Reference Material, J. P. Clark and C. H. Jackson, *SP528*, pp. 133-148 (Nov. 1978).

Key words: calibration; characterization; reference materials; traceability standards; uranyl nitrate solution.

A uranyl nitrate solution for use as a Working Calibration and Test Material (WCTM) was characterized, using a statistically designed procedure to document traceability to National Bureau of Standards Reference Material (SRM-960). A Reference Calibration and Test Material (RCTM) was prepared from SRM-960 uranium metal to approximate the acid and uranium concentration of the WCTM. This solution was used in the characterization procedure. Details of preparing, handling, and packaging these solutions are covered.

Two outside laboratories, each having measurement expertise using a different analytical method, were selected to measure both solutions according to the procedure for characterizing the WCTM. Two different methods were also used for the in-house characterization work. All analytical results were tested for statistical agreement before the WCTM concentration and limit of error values were calculated. A concentration value was determined with a relative limit of error (RLE) of approximately 0.03 percent which was better than the target RLE of 0.08 percent.

The use of this working material eliminates the expense of using SRMs to fulfill traceability requirements for uranium measurements on this type material. Several years' supply of uranyl nitrate solution with NBS traceability was produced. The cost of this material was less than 10 percent of an equal quantity of SRM-960 uranium metal.

Preparation of uranium standard solutions for x-ray fluorescence analysis, C. M. Wong, J. L. Cate, and W. L. Pickles, *SP528*, pp. 149-155 (Nov. 1978).

Key words: actinides; freeze dried; gravimetric standards; high accuracy; particle size effects; radioactive samples; x-ray fluorescence analysis.

A method has been developed for gravimetrically preparing uranium nitrate standards with an estimated mean error of 0.1 percent (1 sigma) and a maximum error of 0.2 percent (1 sigma) for the total uranium weight.

Two source materials, depleted uranium dioxide powder and NBS Standard Reference Material 960 uranium metal, were used to prepare stock solutions. The NBS metal proved to be superior because of the small but inherent uncertainty in the stoichiometry of the uranium oxide. These solutions were used to prepare standards in a freeze-dried configuration suitable for x-ray fluorescence analysis. Both gravimetric and freeze-drying techniques will be presented. Volumetric preparation was found to be unsatisfactory for 0.1 percent precision for the sample size of interest.

One of the primary considerations in preparing uranium standards for x-ray fluorescence analysis is the development of a technique for dispensing a 50- μ l aliquot of a

standard solution with a precision of 0.1 percent and an accuracy of 0.1 percent. The method developed corrects for variation in aliquoting and for evaporation loss during weighing.

Two sets, each containing 50 standards have been produced. One set has been retained by LLL and one set retained by the Savannah River Project (SRP).

Use of a non-linear method for including the mass uncertainty of gravimetric standards and system measurement errors in the fitting of calibration curves for XRFA with freeze-dried UNO_3 standards, W. L. Pickles, J. W. McClure, and R. H. Howell, *SP528*, pp. 156-160 (Nov. 1978).

Key words: non-linear least squares; two-dimensional calibration; uranium; x-ray fluorescence analysis.

At LLL we have used a sophisticated non-linear multiparameter fitting program to produce a best fit calibration curve for the response of an x-ray fluorescence analyzer to uranium nitrate, freeze dried, 0.2 percent accurate, gravimetric standards. The program is based on unconstrained minimization subroutine, VAO2A. The program considers the mass values of the gravimetric standards as parameters to be fit along with the normal calibration curve parameters. The fitting procedure weights with the system errors and the mass errors in a consistent way. The resulting best fit calibration curve parameters reflect the fact that the masses of the standard samples are measured quantities with a known error. Error estimates for the calibration curve parameters can be obtained from the curvature of the "Chi-Squared Matrix" or from error relaxation techniques. We have shown that nondispersive XRFA of 0.1 to 1 mg freeze-dried UNO_3 can have an accuracy of 0.2 percent in 1000 sec.

Future approaches to material control and accounting, T. S. Sherr, G. D. Smith, and L. F. Wirfs, *SP528*, pp. 161-169 (Nov. 1978).

Key words: fuel-cycle regulation; material control and accounting; nuclear safeguards.

This paper presents a short description of the safeguards responsibilities and activities of the U.S. Nuclear Regulatory Commission (NRC), the NRC regulatory requirements for safeguards in the area of material control and accounting (MC&A), and the current NRC efforts which may result in significant changes in the current U.S. safeguards system. The preliminary results of NRC staff and contractor MC&A activities will be discussed, as well as the recommendations of a recent NRC task force on MC&A.

Evaluation of analytical capabilities for accurate prediction of isotopic correlation ratios, E. H. Ottewitte, *SP528*, pp. 170-200 (Nov. 1978).

Key words: burnup calculations; isotope correlation ratios; reactor history deduction; reactor history verification; safeguards.

This study looks at the feasibility of using existing physics methods and data to verify and/or deduce reactor history as in safeguards applications. Investigation indicates that adequate physics methods exist for verification calculations but that they are sophisticated, requiring care to achieve the necessary precision. The accuracy of the physics data (therefore, the adequacy) will vary with isotope; this imposes restrictions and necessitates care in the choice of isotopes. Deductive calculations will rely on mostly the same physics methods and data as the verification calculations. Limited study of deductive (backwards) calculations to date shows that they provide valuable in-

sight into the isotope ratios best suited for the verification (forward) calculations.

In-situ transuranium element measurement technique for wastes associated with power reactor fuels, K. K. Nielson, R. L. Brodzinski, and N. A. Wogman, *SP528*, pp. 201-206 (Nov. 1978).

Key words: americium; detection limits; gamma rays; germanium detector; in-situ analysis; plutonium; x rays.

A planar, 19 cm^2 intrinsic germanium detector has been used for in-situ analysis of plutonium and americium in contaminated laboratories and buildings. Detection limits depend on local background activity, but in typical surface measurements for decontamination work are about 0.005 nCi/ cm^2 for ^{241}Am (59.5 keV) and 0.5 nCi/ cm^2 for ^{239}Pu (17.2 keV). Specific analyses of ^{238}Pu , ^{239}Pu , ^{240}Pu , and ^{241}Pu are also possible using various gamma-rays. Attenuations equivalent to 10 cm of concrete can be tolerated for high levels of ^{239}Pu and ^{241}Am .

Experiences with a counter for plutonium in crates, R. A. Harlan, *SP528*, p. 207 (Nov. 1978).

Key words: analyses; counter; neutron; plutonium; waste.

Some contaminated waste generated at the Rocky Flats Plant has been put into crates for shipment to storage and disposal. Previous estimates of plutonium contamination in these wastes has been conducted with hand-held survey instruments. That practice was time consuming and expensive in terms of manpower.

A counter to assay plutonium in 1.22 by 1.22 by 2.13 mm crates was constructed. A previous report described the counter and preliminary experiments which indicated the counter could detect 0.7 grams of ^{239}Pu in 6 hours or 10 grams in 20 minutes at a 0.95 confidence level. These sensitivities assumed the plutonium would be reasonably well distributed throughout a crate as opposed to concentrated in the center or in a corner.

The counter was made with 51 mm thick polyethylene walls. A standard crate was rolled inside and measurements of instrument response made with PuO_2 sources in various locations. Ten detectors, installed outside the walls, were lithium-loaded zinc sulfide screens (NE-422^B) 305 mm diameter. These detectors responded to thermal neutrons. Their scintillations were passed through conical light pipes to 127 mm diameter photomultiplier tubes. Signals from the tubes were processed through conventional amplifying electronics. Discriminators were used to practically eliminate any response to gamma rays. The standards crate for the counter was used to simulate combustibles waste crates which have had a mean weight and standard deviation of 658 ± 200 kg, respectively.

Since the previous report, experiments have been conducted to better measure the counter responses with plutonium concentrated in unfavorable locations and responses with plutonium in noncombustibles matrices. These laboratory-type experimental results will be described. Operating history of the counter under routine conditions will be discussed.

Requirements for near-real-time accounting of strategic nuclear materials in nuclear fuel reprocessing, E. A. Hakkila, D. D. Cobb, R. J. Dietz, J. P. Shipley, and D. B. Smith, *SP528*, pp. 208-220 (Nov. 1978).

Key words: dynamic materials accounting; in-line analysis; nuclear fuel reprocessing; nuclear safeguards.

A Purex-based nuclear fuel reprocessing plant has been studied for possible incorporation of near-real-time ac-

counting to supplement conventional accounting procedures. Near-real-time accounting of special nuclear materials relies on in-line or at-line flow measurements and plutonium assay of product and waste streams, complemented by conventional analytical chemistry for daily instrument calibrations. In-line alpha monitors could be used for waste stream measurements of plutonium, even in the presence of high beta-gamma fluxes from fission products. X-ray absorption edge densitometry using either K- or L-absorption edges could be used for plutonium concentration measurements in main product streams. Some problem areas identified in waste stream measurements include measurements of leached hulls and of centrifuge sludge. Conventional analytical chemical methods for measuring plutonium in weapons grade material can be modified for reprocessed plutonium. Analytical techniques requiring special precautions will be reviewed.

Some suggested areas for improvements in process design to facilitate materials accountability in future plants will be discussed.

Verification of ^{235}U enrichment in SNM receipts at the DOE Feed Materials Production Center, H. W. Humphrey, *SP528*, pp. 221-246 (Nov. 1978).

Key words: gamma spectrometry; isotopic verification; nondestructive analysis; sodium iodide detection; ^{235}U enrichment.

A diversity of uranium-bearing, nonirradiated materials with ^{235}U assays from fully depleted to a maximum of 10 wt % ^{235}U , is routinely returned to this DOE site for reprocessing. It is necessary to confirm the ^{235}U isotopic content of Special Nuclear Material (SNM) receipts both for accountability and nuclear criticality safety purposes.

Methods and instrumentation have been developed for an isotopic verification facility by which ^{235}U isotopic content is rapidly and nondestructively determined. The 185 keV gamma photon emitted by ^{235}U is measured using a dual-channel gamma spectrometer which incorporates automatic background subtraction and an optimized collimator/Nal(Tl) detector assembly. Measured activities are then related to ^{235}U isotopic content by means of appropriate standards that have been destructively analyzed in the laboratory.

Use of the described facility for the past seven years has resulted in improved nuclear safety procedures, better use of storage space and more stringent nuclear materials accountability.

Accurate determination of 5-25 mg of uranium by Redox titrimetry, S. D. Reeder and J. R. Delmastro, *SP528*, pp. 247-252 (Nov. 1978).

Key words: computer controlled titration; low-level analyses; uranium determination.

A precise and selective potentiometric titration method for determining 5-25 mg of uranium has been developed. The method is essentially a scaled-down version of the modified Davies-Gray titrimetric method. Our investigations extend the work of Slanina et al. by identifying several critical steps where careful control of conditions is essential to obtain high precision. The method has been automated by interfacing a 10-mL Mettler buret with a pre-programmed HP-9830 calculator. The calculator controls the delivery of titrant so that the end point is approached as rapidly as possible, but delivers only small increments of titrant near the equivalence point. A hard copy of the data (mL of titrant vs. Electrode Potential) is printed as the titration proceeds, and the volume of titrant

equivalent to the uranium in the sample is computed from the first derivative of the titration curve.

A precision and accuracy of 0.05 percent or better is obtainable with this method. The method is especially useful for the determination of uranium when the quantity available for analysis is limited. It has been used for verification of the uranium concentration of various standards used in analyses performed at the Idaho Chemical Processing Plant.

In situ quantitative determination of transuranic elements in areas of high-level gamma radiation, R. L. Brodzinski and N. A. Wogman, *SP528*, pp. 253-260 (Nov. 1978).

Key words: neutron monitoring; transuranics.

A technique is described for passive neutron monitoring of transuranic elements. The method provides quantitative determinations of transuranic element concentrations in a variety of field situations where no other measurement method is possible. The technique can measure concentrations of transuranic oxides as low as 8 nCi/cm³ and is capable of operating in gamma radiation fields up to megarads per hour. Information on chemical and isotopic composition can also be obtained from the data. Several successful applications of the technique are discussed.

Neutron correlation counting for the nondestructive analysis of nuclear materials, M. S. Zucker, *SP528*, pp. 261-283 (Nov. 1978).

Key words: neutron coincidence counting; neutron correlation counting; plutonium nuclear material assay; spontaneous fission.

The technique of correlating the neutron pulse train from spontaneously fissioning material as an assay tool for nuclear material, its advantages, problems, and the underlying theory are discussed.

An instrument for monitoring the transuranic content of chopped leached hulls from spent nuclear fuel elements, N. A. Wogman, R. L. Brodzinski, and D. P. Brown, *SP528*, pp. 284-288 (Nov. 1978).

Key words: design of hull monitor; nuclear fuel; nuclear waste; plutonium.

A leached hull monitor featuring high sensitivity for direct transuranic element analysis of various kinds of reactor fuels has been designed for the Commercial Nuclear Waste Vitrification Program (CNWVP) at Battelle-Northwest Laboratories. The instrument can detect the presence of transuranics in undissolved fuel embedded in the chopped hulls following a leaching process, or in undissolved fines or other liquid or solid effluents associated with the CNWVP chemistry. The monitor detects neutrons arising from spontaneous fission and from (α ,n) reactions on oxygen in the hulls and wastes. The system is constructed using a massive external neutron shield, an internal lead gamma-ray shield between the sample and the neutron detectors, and an electronic system which records all single and coincidence neutron events which occur during a preset time interval. Both the transuranic neutron flux and the cosmic-ray produced neutron background are determined simultaneously. The system is calibrated with known sources of uranium and plutonium oxides and metals with isotopic compositions typical of each reactor fuel to be processed. The estimated detection limit of the system is 2 mg of Pu in a 10⁴ second counting period.

SP529. Interagency comparison of ultraviolet photometric standards for measuring ozone concentrations, J. Wendt, J.

Kowalski, A. M. Bass, C. Ellis, and M. Patapoff, *Nat. Bur. Stand. (U.S.)*, *Spec. Publ. 529*, 25 pages (Dec. 1978) SN003-003-02002-8.

Key words: air pollution; atmospheric monitoring; calibration; ozone; ultraviolet photometry.

In August 1977, an interlaboratory comparison study was initiated after the California Air Resources Board and the Environmental Protection Agency, Research Triangle Park independently designed and constructed ozone absolute ultraviolet photometers. These units augmented the photometers already designed and in use by the National Bureau of Standards and the Jet Propulsion Laboratory. Previous ozone comparisons involving indometry, ultraviolet photometry and gas phase titration have reported results differing by as much as ± 30 percent. The protocol of this study, performed at the California Air Resources Board, Haagen-Smit Laboratory, El Monte, was a multipoint comparison using the NBS photometer as the standard. The results of the data analysis indicate excellent agreement with a total variation of 2.8 percent. Compared to the NBS photometer the EPA-RTP photometer read 1.3 percent low, the JPL photometer read 1.5 percent high and the ARB photometer read 0.4 percent low. The correlation coefficients of the same data sets were 1.0000, 1.0000 and 0.9999 respectively.

SP530. **Metrication in building design, production, and construction—A compendium of 10 papers**, H. J. Milton, *Nat. Bur. Stand. (U.S.)*, *Spec. Publ. 530*, 188 pages (Sept. 1978) SN003-003-01971-2.

Key words: economics of metric conversion; harmonization; management of change; metrication; metric familiarization; rationalization; SI; standardization; transitional period.

This publication is a compendium of ten papers prepared by Hans J. Milton, Technical Consultant on metrication and dimensional coordination to the NBS Center for Building Technology. It may be used as an information and general reference document in the metric subject area.

International experience has enabled the author to refer to precedent in other English-speaking countries which have preceded the United States in the change to metric (SI). The papers are directed at the disciplines of building design, production, and construction. However, they contain much information which could be adapted for use in other sectors of the economy.

Some of the subject areas addressed are: management and economics of metrication; specific product metrication; public construction sector role in metrication; building standards and codes in metrication; graphic design in metrication; and, United States' opportunities in metrication.

A subject index has been included for ready reference to specific metric topics. *This compendium includes the following papers (indented):*

More efficient technology, research, industry and commerce—The metric opportunity, H. J. Milton, *SP530*, pp. 1-9 (Sept. 1978).

Metrication in the construction community—The role of the Federal agencies and the public construction sector, H. J. Milton, *SP530*, pp. 11-20 (Sept. 1978).

The principal management considerations in metrication of construction standards and codes, H. J. Milton, *SP530*, pp. 21-37 (Sept. 1978).

Managerial and economic considerations in the change to a metric production environment, H. J. Milton, *SP530*, pp. 39-60 (Sept. 1978).

Metrication and the contracting community, H. J. Milton, *SP530*, pp. 61-80 (Sept. 1978).

Metrication—A concrete opportunity, H. J. Milton, *SP530*, pp. 81-99 (Sept. 1978).

Metric sizes for building lumber and other wood products: The issues, international precedent, and suggestions for the U.S. wood products industry, H. J. Milton, *SP530*, pp. 101-133 (Sept. 1978).

New measures in graphic design and publications—The advance of the metric system, H. J. Milton, *SP530*, pp. 135-146 (Sept. 1978).

Metric training and familiarization of personnel, H. J. Milton, *SP530*, pp. 147-163 (Sept. 1978).

Guidelines for the metric transitional period in building design and construction, H. J. Milton, *SP530*, pp. 165-181 (Sept. 1978).

SP531. **Summary report on the workshop on high temperature chemical kinetics: Applications to combustion research**, D. Garvin, R. L. Brown, R. F. Hampson, M. J. Kurylo, and W. Tsang, *Nat. Bur. Stand. (U.S.)*, *Spec. Publ. 531*, 89 pages (Dec. 1978) SN003-003-02005-0.

Key words: assessment of needs; chemical kinetics; combustion; high temperature chemistry; measurement techniques; reaction rate constants.

The proceedings at a workshop on the applications of high temperature chemical kinetics to combustion research are summarized. This workshop, held Dec. 12-13, 1977 at the National Bureau of Standards, provided a forum for the exchange of views on the needs for kinetics research during the next five to ten years. Experimental techniques, measurements, theoretical developments and data evaluation were treated in four review papers and two discussion sessions.

This report contains the program of the meeting, abstracts of the review papers, a commentary by the organizers of the meeting, summaries of the discussions, formal comments submitted by the participants and an attendance list.

SP535, Vol. 1, Pts. 1 and 2. **Catalog of National Bureau of Standards Publications 1966-1976. Citations and abstracts**, B. L. Burris and R. J. Morehouse, Eds., *Nat. Bur. Stand. (U.S.)*, *Spec. Publ. 535, Vol. 1, Pts. 1 and 2*, 1908 pages (1978) SN003-003-02010-9.

Key words: catalog of NBS publications; citations and abstracts of NBS publications; NBS publications program; eleven-year keyword index (1966-1976); index to NBS publications.

The published output of NBS for 1966 through 1976 is cataloged and indexed in this two-volume publication. Parts 1 and 2 of Volume 1 consist of reprints of abstracts and full citations of all published papers during the 11-year period as they originally appeared in the NBS annual publication catalogs—NBS SP 305 and its Supplements 1 through 8. Volume 2 is a consolidated permuted keyword index which directs the researcher of NBS literature either to the citations and abstracts of Volume 1 or to the same information in the nine annual catalogs issued during the 11-year period. Annual supplements to SP 305 will continue to update the NBS published output; the 1977 supplement is now available as NBS SP 305, Supplement 9.

SP535, Vol. 2, A-L and M-Z. **Catalog of National Bureau of Standards Publications 1966-1976. Key word index**, B. L. Burris and R. J. Morehouse, Eds., *Nat. Bur. Stand. (U.S.)*

Key words: catalog of NBS publications; citations and abstracts of NBS publications; NBS publications program; eleven-year keyword index (1966-1976); index to NBS publications.

The published output of NBS for 1966 through 1976 is cataloged and indexed in this two-volume publication. Parts 1 and 2 of Volume 1 consist of reprints of abstracts and full citations of all published papers during the 11-year period as they originally appeared in the NBS annual publication catalogs—NBS SP 305 and its Supplements 1 through 8. Volume 2 is a consolidated permuted keyword index which directs the researcher of NBS literature either to the citations and abstracts of Volume 1 or to the same information in the nine annual catalogs issued during the 11-year period. Annual supplements to SP 305 will continue to update the NBS published output; the 1977 supplement is now available as NBS SP 305, Supplement 9.

3.7. APPLIED MATHEMATICS SERIES

Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

No publications issued in this series during this period.

3.8. NATIONAL STANDARD REFERENCE DATA SERIES

Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS. Program under the authority of National Standard Data Act (Public Law 90-396).

NSRDS-NBS60. Atomic energy levels—The rare-earth elements.

The spectra of lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium, W. C. Martin, R. Zalubas, and L. Hagan, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 60, 422 pages (Apr. 1978) SN003-003-01712-4.

Key words: atomic energy levels; atomic spectroscopy; electron configurations; ionization potentials; lanthanides; rare earths; spectra; Zeeman effect.

Energy level data are given for 66 atoms and atomic ions of the 15 elements lanthanum ($Z = 57$) through lutetium ($Z = 71$). These data have been critically compiled from published and unpublished material. Only experimentally determined energy levels are included; the energies being restricted to excitations of outer-shell electrons and to inner-shell excitations up to the soft x-ray range. The levels were taken from analyses of the spectra of atomic gases wherever possible; however, the levels for several of the triply ionized rare earths are from analyses of the spectra of the ions in crystals or solutions. In addition to the level value (usually in units of cm^{-1}) and the parity, the J value, configuration and term assignments, and the experimental g value are listed wherever available. Leading percentages from the calculated eigenvector are also tabulated for each level if available. The levels are grouped into spectroscopic terms of appropriate coupling schemes where such groups appear meaningful. Ionization potentials are tabulated for most of the spectra. Complete references for the tabulated data are given for each spectrum.

NSRDS-NBS61, Part 1. Physical properties data compilations relevant to energy storage. I. Molten Salts: Eutectic data, G. J. Janz, C. B. Allen, J. R. Downey, Jr., and R. P. T. Tomkins, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 61, Part 1, 244 pages (Mar. 1978) SN003-003-01825-2.

Key words: data compilation; eutectic; eutectic composition; eutectic data; eutectic temperature; inorganic compound; melting point; molten salt; phase diagrams.

The present compilation provides an authoritative compendium of melting points, and compositions of molten salt eutectic mixtures. Data for mixtures melting in the range -138 °C to 2800 °C are reported. Value judgments have not been attempted. Titles of the articles in the literature citations and a system index are included for approximately 6000 eutectic entries.

NSRDS-NBS62. Compilation of rate constants for the reactions of metal ions in unusual valency states, G. V. Buxton and R. M. Sellers, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 62, 78 pages (June 1978) SN003-003-01882-1.

Key words: aqueous solution; chemical kinetics; complex ions; electron transfer; metal ions; radiation chemistry; rates; transients.

Kinetic data have been compiled for reactions of uncommon oxidation states of metals which are produced by radiolysis of aqueous solutions of metal ions. Most of the reaction rates are for transient species, and the rates were determined by pulse radiolysis; some data were obtained by flash photolysis and gamma radiolysis. Metal ions from Groups IB, IIB, IIIA, IVA, VIB, VIIB, VIIIB, and the lanthanides are included in the compilation.

NSRDS-NBS63, Volumes 1-4 and 1978 Index. EPA/NIH mass spectral data base—Molecular weights 30-1674 and 1978 indexes to EPA/NIH mass spectral data base, S. R. Heller and G. W. A. Milne, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 63, Volumes 1-4 and 1978 Index, 4685 pages (Dec. 1978) SN003-003-01987-9.

Key words: analytical data; mass spectra; organic substances; verified spectra.

This publication presents a collection of 25,556 verified mass spectra of individual substances compiled from the EPA/NIH mass spectral file. The spectra are given in bar graph format over the full mass range. Each spectrum is accompanied by a Chemical Abstracts Index substance name, molecular formula, molecular weight, structural formula, and Chemical Abstracts Service Registry Number.

3.9. BUILDING SCIENCE SERIES

Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

BSS84. Design Guide for reducing transportation noise in and around buildings, D. S. Pallett, R. Wehrli, R. D. Kilmer, and T. L. Quindry, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 84*, 176 pages (Apr. 1978) SN003-003-01687-0.

Key words: acoustics; architectural acoustics; building acoustics; environmental noise; noise; noise control; sound; transportation system noise.

This design guide presents a unified procedure for the selection of noise criteria in and around buildings, for the prediction of exterior and interior noise levels arising as a consequence of transportation systems operations, and for the evaluation of the adequacy of building designs with regard to environmental noise. Noise criteria levels are suggested in terms of equivalent sound levels (Leq). Simplified predictive methods enable the estimation of noise levels arising as a consequence of highway, railway, and aircraft operations. The sound isolation provided by the building shell is estimated by means of a new single-figure rating system. Finally, design manipulations which may make possible the improvement of the acoustic conditions in and around buildings are suggested.

BSS102. The thermal performance of a two-bedroom mobile home, G. J. Tietsma and B. A. Peavy, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 102*, 59 pages (Feb. 1978) SN003-003-01863-5.

Key words: air infiltration; energy conservation; mobile home; part-load efficiency; thermography.

Tests were conducted on a mobile home located in an Environmental Climatical Laboratory for the purpose of evaluating its thermal performance. The heating demand greatly affected the part-load efficiency of a gas-fired, forced-air, sealed-combustion furnace system. The practice of installing oversized heating plants was shown to result in low seasonal operating efficiencies. Air leakage measurements were performed using a pressurization technique to quantify the amount of air leakage through the various parts of the mobile home. Separate air infiltration tests using the SF₆ tracer-gas technique showed that somewhat higher air infiltration rates were induced by operation of the mobile home heating plant. A thermographic survey of interior surfaces showed that the technique used to install the wall insulation may allow wrinkles formed in the surface of the insulation to form air paths running the height of the wall cavity. Convective air flow through these paths may create heat leaks on the building surface which can have an impact on the overall heat-loss rate. Separate tests were also conducted to identify places in the mobile home envelope having high condensation potential.

BSS105. Retrofitting an existing wood-frame residence for energy conservation—An experimental study, D. M. Burch and C. M. Hunt, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 105*, Supercedes NBSIR 77-1274, 82 pages (July 1978) SN003-003-01885-6.

Key words: air infiltration; condensation in buildings; energy conservation; energy measurements; fuel savings; heat-loss reduction; insulation properties; residential heat loss; retrofitting houses; thermal conductivity; thermal insulation; thermography.

A wood-frame residence having only limited insulation in the attic was retrofitted in three stages to reduce its energy requirements for heating and cooling. The three retrofit stages comprised: reducing air leaks; adding storm windows; and installing insulation in the floor, ceiling, and walls. The house was extensively instrumented to evaluate energy savings and other performance factors. An economic model was used to evaluate the cost effectiveness of the retrofit options and the number of years to pay back their initial investment.

The walls of the test house were insulated with three different types of insulating material: fibrous glass wool, cellulose fiber, and urea-formaldehyde foam. The thermal performance of those three insulating materials was measured and compared, both in the field and laboratory.

"Recommended good practices" for moisture protection were applied when insulation was installed in the test house. The effectiveness of these measures in preventing damaging moisture accumulation in crawl spaces and attics was evaluated.

Finally, thermographic surveys were performed before and after the retrofit. Based on the results of these surveys, criteria for distinguishing between insulated and uninsulated wood-frame cavity walls were presented.

BSS108. Safety on stairs, D. H. Carson, J. C. Archea, S. T. Margulis, and F. E. Carson, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 108*, 122 pages (Nov. 1978) SN003-003-02026-5.

Key words: accidents; architectural psychology; consumer products; environmental factors; home safety; occupant behavior; survey technique.

Stairways are commonplace in U.S. homes. Stairway design and construction standards are based on custom, common sense, and experience. Stairways, however, are hazardous. A large number of stairway accidents have been reported, raising questions about the adequacy of stairway design and construction standards. This study is a first attempt to rationalize stairway standards by applying well established statistical methods to a significant sample of stairways and people using them. A pilot study on a sample of 253 residences in Milwaukee County, Wisconsin, was undertaken. The study included a survey of stairway use and behavior and an inventory of residential stairways. This information was obtained from the total sample. In a subsample of 54 residences, direct field observations and physical measurements of stairways were obtained. The results of the pilot study include a description of existing stairways, inferences about interactions that produce accidents, and guidelines which address reasons for accidents (hence should result in a reduction of accidents). The best strategy for making stairways safer, according to the study, is to remove factors that influence accident rates. Specifically, by systematically reducing hazards, careless stairway habits, and frequency of use, patterns of factors responsible for accidents can be broken and accident rates can be reduced.

BSS109. Simplified analysis of thermal and lighting characteristics of windows: Two case studies, T. Kusuda and B. L.

Key words: daylighting; energy conservation; fenestration design; solar heat gain; window management.

Results of a simplified analysis for annual heating, cooling, and lighting requirements associated with windows are presented. The analysis includes the effects of window size, heat transfer, solar shading, and compass orientation for typical commercial and residential modules located in a climate typical of Washington, D.C. Three different modes of operation with respect to heating and cooling requirements through windows were assessed: external loads only; external and internal; and external, internal, and daylight. In addition, the effects of selective fenestration heat-transfer management, such as planned employment of thermal shutters and shading devices, and off-hour temperature setback were considered. This analysis assumed that daylight could replace or supplement artificial light whenever it could supply a specified minimum level of illumination. The use of daylight was found to offer the greatest potential for reducing energy costs, particularly when combined with selective fenestration management.

BSS110. Reliability basis of load and resistance factors for reinforced concrete design. B. Ellingwood, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 110*, 101 pages (Feb. 1978) SN003-003-01888-1.

Key words: buildings (codes); concrete (reinforced); design (criteria); loads; probability theory; reliability; statistical analysis; structural engineering.

Engineering decisions must be made in the presence of uncertainties which arise as a consequence of imperfect information and knowledge and inherent randomness in many design parameters. It is on account of these uncertainties and potential risks arising therefrom that safety margins provided by load and resistance factors are required in design. Reliability methods are employed in this study to facilitate the selection of criteria for reinforced concrete design. These methods, which are based on probability theory, provide a logical basis for determining the manner in which uncertainties in resistance and loads affect design safety and how their effects should be controlled in building standards. Following a comprehensive analysis of uncertainty measures, safety indices associated with existing reinforced concrete design are evaluated. Design criteria commensurate with levels of uncertainty and required reliability are then presented. Simplification of these leads to practical reliability based criteria which retain the relatively simple characteristics of existing criteria and yet have a well established and documented rationale.

BSS111. Investigation of standards, performance characteristics and evaluation criteria for thermoplastic piping in residential plumbing systems. R. S. Wyly, W. J. Parker, E. T. Pierce, D. E. Rorrer, J. R. Shaver, G. C. Sherlin, and M. Tryon, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 111*, 152 pages (May 1978) SN003-003-01934-8.

Key words: acoustical performance (plumbing piping); fire performance (plumbing piping); plumbing performance evaluation (piping); structural performance (thermoplastic plumbing piping); thermoplastic pipe usage (residential plumbing).

The application of the performance concept to the evaluation of piping systems of innovative materials is explored. User needs are considered and several material-related physical parameters are studied that might be used as measures of satisfaction of the user needs.

Information was reviewed on usage, performance characteristics and standards for thermoplastic pipe and fittings, and special laboratory tests were made to study selected characteristics and test methods. A number of performance statements and evaluation methods are recommended or discussed that relate to characteristics associated with polyvinyl chloride (PVC), acrylonitrile-butadiene-styrene (ABS) and chlorinated polyvinyl chloride (CPVC). This approach was taken to illustrate the application of performance evaluation methodology to plumbing materials.

The results indicate that PVC, ABS, and CPVC can be used satisfactorily in a number of residential plumbing applications if appropriate attention is given to the selection of the materials, to the design of the piping system and to important installation details. Further research and education are needed for the general application of performance evaluation methodology as a basis for wider and more uniform acceptance of the above-mentioned thermoplastics as well as other materials for plumbing piping. However, the results of this study can be useful in expediting the systematic performance evaluation of future innovative piping materials.

BSS112. Window blinds as a potential energy saver—A case study. A. I. Rubin, B. L. Collins, and R. L. Tibbott, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 112*, 85 pages (May 1978) SN003-003-01936-4.

Key words: energy conservation; office buildings; orientation; photographic method; season; venetian blinds; view; windows; window usage.

Window usage at the National Bureau of Standards was studied by photographing venetian blind positions in offices at different times of the day and year. While blind positions were quite stable during the week of each study phase, they were quickly altered by the room occupants when deliberately set at extreme positions by the researchers. Significant differences were observed among blinds depending on compass orientation of the window, view type, season, and nature of experimental treatment. The greatest determinant of blind position was orientation, with blinds on north-facing windows being more open than on the south. The results suggest that energy conservation programs which rely on the activities of building occupants may be feasible. Suggestions are made for improvements in blind use and design.

BSS113. Life-cycle costing. A guide for selecting energy conservation projects for public buildings. R. T. Ruegg, J. S. McConnaughey, G. T. Sav, and K. A. Hockenbery, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 113*, 76 pages (Sept. 1978) SN003-003-01980-1.

Key words: building economics; economic analysis; energy conservation; engineering economics; investment analysis; life-cycle cost analysis.

This report provides a step-by-step guide for conducting life-cycle cost evaluations of energy conservation projects for public buildings. It explains the use of life-cycle costing analysis to evaluate and rank the cost effectiveness of alternative energy conservation retrofit projects to existing public buildings, and to select the most cost-effective design for new buildings. Worksheets, illustrated with a realistic example, and a computer program are provided.

This guide is compatible with a life-cycle costing guide prepared for the Department of Energy for use in the Federal Energy Management Program by Federal Agencies. The purpose of this report is to provide a guide to state and local governments for use in their energy conservation programs.

BSS114. The effect of "resource impact factors" on energy conservation standards for buildings. S. F. Weber, *Nat. Bur.*

Key words: building economics; economic efficiency; economics; energy; energy conservation; life-cycle cost; optimization; performance standards; resource impact factors; resources; social optimum; standards.

This report addresses the question of the proper price for energy to be used in the development of optimum (i.e., cost-effective) energy conservation performance standards for buildings. This study finds that the appropriate price for energy is its social value, which should be determined through the development and application of Resource Impact Factors (RIF's). Some guidelines are provided for the formulation and development of RIF's. A life-cycle cost minimization model for determining the optimum conservation standard is employed to show how the use of RIF's would generally lower the maximum allowable energy consumption specified in the standard. Indeed, it is found that the higher the RIF value, the lower the energy consumption allowed by the standard, although this effect steadily diminishes as the RIF value increases. Moreover, the additional energy savings resulting from using RIF's are shown to increase as the severity of the climate increases. When two important restrictive assumptions of the model are relaxed, these same relationships between energy consumption and the RIF value on the one hand, and between the extra energy savings due to RIF's and the climate on the other hand, are both maintained. Finally, geometric and algebraic measures are derived for the net gain in economic efficiency that would result from using RIF's in developing energy conservation performance standards.

BSS116. Geographical variation in the heating and cooling requirements of a typical single-family house, and correlation of these requirements to degree days, E. A. Arens and W. L. Carroll, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 116, 58 pages (Nov. 1978) SN003-003-01992-5.

Key words: building energy conservation; climatic effects on building energy consumption; computer modeling of building energy consumption; energy conservation; geographical variation of building consumption; residential energy consumption.

The report has three main purposes: First, it assesses 'Test Reference Year' (TRY) hourly climate data tapes to determine how well they represent long-term average climate when used for estimating average annual heating and cooling requirements. The report presents a method to adjust heating and cooling requirements that are computed using TRY data, in order to make them represent long-term average heating and cooling requirements.

Second, the report quantifies the geographic variation of annual heating and cooling requirements across the U.S. by computing the heating and cooling requirements of a typical ranch-style residence for the 8760 hours of each of the 60 TRY tapes, and adjusting the results by the method described above.

Third, the effectiveness of 'degree-day' data for predicting these computed annual heating and cooling requirements is examined, and the variability of heating and cooling requirements within degree-day 'zones' of 1000 degree day width is presented.

3.10. FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS

Publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations). This series is available only from the National Technical Information Services, Springfield, VA 22161. See page 24 for price list.

FIPS PUB 50. Recorded magnetic tape for information interchange, 6250 cpi (246 cpmm), group coded recording. M. D. Hogan, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 50*, 4 pages (1978).

Key words: communications; computers; computer system hardware; data processing; data processing equipment; information systems; magnetic tape recording; magnetic tapes; magnetic tape transports; standards.

This FIPS PUB announces the adoption, with one exception, of the American National Standard X3.54—1976, Recorded Magnetic Tape for Information Interchange (6250 CPI, Group-Coded Recording). This standard specifies the recorded characteristics of 9-track, one-half inch (12.7 mm) wide magnetic computer tape, including the format for implementing the Standard Code for Information Interchange (ASCII) at the recording density of 6250 characters per inch (246 characters per millimeter). It is one of a series of Federal Standards implementing ASCII on magnetic tape media.

FIPS PUB 51. Magnetic tape cassettes for information interchange (3.810 mm [0.150 in] tape at 32 bpmm [800 bpi], PE). M. D. Hogan, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 51*, 4 pages (1978).

Key words: communications; computers; computer system hardware; data processing; data processing equipment; information systems; magnetic tape recording; magnetic tapes; magnetic tape transports; standards.

This FIPS PUB announces the adoption of the American National Standard X3.48—1977, Magnetic Tape Cassettes for Information Interchange (3.810-mm [0.150-in] Tape at 32 bpmm [800 bpi], PE). This standard specifies the physical, magnetic, and recorded characteristics of a 3.810 mm (0.150 in) magnetic tape cassette in order to provide for data interchange between information processing systems at a recording density of 32 bits per millimeter (800 bits per inch) using phase encoding techniques. The magnetic tape cassette consists of a twin hub co-planar type cassette containing 3.810 mm (0.150 in) wide magnetic tape. It is one of a series of Federal Standards implementing the Standard Code for Information Interchange (ASCII) on magnetic tape media.

FIPS PUB 53. Transmittal form for describing computer magnetic tape file properties. H. E. McEwen, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 53*, 4 pages (1978).

Key words: computer magnetic tape file properties; computers; data processing; Federal Information Processing Standards; information processing.

This publication provides a standard magnetic tape transmittal form (SF-277), together with instructions for providing the necessary information on the form. The standard magnetic tape transmittal form, Computer Magnetic Tape File Properties (SF-277), will be used by Federal agencies to document the physical properties and characteristics of a recorded magnetic tape file needed by the receiving agency to process the tape.

FIPS PUB 54. Computer output microform (COM) formats and reduction ratios, 16 mm and 105 mm. T. C. Bagg, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 54*, 15 pages (July 15, 1978).

Key words: COM formats and reduction ratios; communications; computer output microform; computer system hardware; computers; data processing; data processing equipment; information systems; microfiche; microfilm; standards.

This FIPS PUB specifies the image arrangement, size, and reduction ratios for 16 mm and 105 mm microforms generated by Computer Output Microfilm. It is limited to systems using business-oriented fonts similar to line printer output. This standard covers microform formats and reduction ratios for Computer Output Microforms using business-oriented fonts.

FIPS PUB 55, Vols. 1 and 2. Codes for named populated places and related entities of the States of the United States. H. E. McEwen, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 55*, Vol. 1, 980 pages; Vol. 2, 986 pages (June 1, 1978).

Key words: cities; data file; data processing; demography; geographic areas; geographic coding; geography; information systems; named places; standard location codes; towns.

Included are standard codes for named populated cities, towns, villages, whether incorporated or unincorporated, important military and naval installations, townships, Indian reservations, named places that form parts of other places, places important for transportation, industrial, or commercial purposes, i.e., unpopulated railroad points, airports, and shopping centers.

The standard code is seven characters in length, the first two of which identify the State. The last five numeric characters identify the place within the State and provide an alphabetic ordering of the place numbers. In addition to the place name and its code, the list also provides the name and code for the county (or counties) in which the place is located, the ZIP code of the servicing post office (or offices), cross-references to former or alternate names, an inclusion code, a class designator code, and a cross-reference to the Worldwide Geographic Location Codes issued by the General Services Administration.

FIPS PUB 56. Guideline for managing multivendor plug-compatible ADP systems. J. M. Bakshi, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 56*, 18 pages (1978).

Key words: ADP systems; multivendor systems; plug-compatible systems; procurement regulations; standards.

To an increasing extent, Federal automatic data processing (ADP) systems are being configured with components obtained from multiple sources and ADP managers are being provided

with services from multiple suppliers. This multivendor environment has led to both increased competition in the marketplace and substantial procurement savings by the Federal Government. This document is intended for the Federal ADP manager who is responsible for the planning, acquisition, and operation of multivendor ADP systems—particularly multivendor plug-compatible ADP systems. Its main purpose is to facilitate the planning and operation of multivendor systems by providing guidance based upon actual Federal agency experiences with problems in such installations and recommend ways through which they may be resolved.

FIPS PUB 57. *Guidelines for the measurement of interactive computer service response time and turnaround time*, M. D. Abrams, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 57*, 25 pages (1978).

Key words: evaluation; interactive; measurement; response time; selection; service; turnaround time.

These guidelines are primarily directed to the person who will be writing specifications for or conducting evaluation and selection of interactive computer network services. Response time and turnaround time are defined. Measurement methodologies are described, and recommendations are made concerning their applicability. The methodologies include accounting logs, stopwatches, communications monitors, live users at terminals, ASR terminals, intelligent terminals, internal measurement drivers, and remote terminal emulators.

3.11. PRODUCT STANDARDS

Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the Voluntary Product Standards program as a supplement to the activities of the private sector standardizing organizations.

No publications issued in this series during this period.

3.12. TECHNICAL NOTES

Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other Government agencies.

TN710-8. Building research translation: French acoustical comfort standards, S. G. Weber, Translation Ed., *Nat. Bur. Stand. (U.S.)*, *Tech. Note 710-8*, 67 pages (Mar. 1978) SN003-003-01897-0.

Key words: acoustics; codes; CSTB; French compliance techniques; translations.

This report offers methods of providing levels of residential acoustical comfort which meet French specifications contained in the French order of June 1969, and some methods which may facilitate meeting the more stringent requirements of the Acoustical Comfort Standard.

Two levels of solutions are thus identified: first, those which meet the basic French building code regulations; and, second, those which can bring dwelling units up to the French Acoustical Comfort Standard.

Recent advances in acoustical knowledge as applied to residential construction created a need for this revision to the earlier edition to provide new examples of solutions which meet building code requirements as well as solutions qualifying for the Acoustical Comfort Standard Label.

TN710-9. Building research translation—Discomfort due to wind near buildings: Aerodynamic concepts, J. Gandemer, *Nat. Bur. Stand. (U.S.)*, *Tech. Note 710-9*, 48 pages (Mar. 1978) SN003-003-01898-8.

Key words: air flow; CSTB; discomfort, wind; France; translations; wind discomfort; wind flow around buildings.

Flow patterns at ground level in groups of buildings result from the complex interaction between the wind (impact, average speed distribution with height, and turbulence) and the buildings themselves (shapes, sizes, arrangements, etc.).

The increase in the number of very tall structures and the more or less arbitrary, with respect to wind, placing of large structures have frequently demonstrated the lack of adaptation of the structural environment to wind phenomena. Manifestation at ground level, such as zones of high speeds or eddies, make the approach to buildings uncomfortable (sometimes even dangerous) for the pedestrian.

Elimination of these problems requires better knowledge of air flows around structures and formulation of practical plans that the architect or city planner can use in designing larger structural units. This report summarizes work carried out at the CSTB institute in Nantes in 1973 and 1974 and gives the main results of the study.

A guide is included which furnishes simple rules or practical advice that can be used by architects and city planners.

TN710-10. Building research translation: The behavior of concrete structures in fire—A method for prediction by calculation, S. G. Weber, Translation Ed., *Nat. Bur. Stand. (U.S.)*, *Tech. Note 710-10*, 83 pages (Mar. 1978) SN003-003-01896-1.

Key words: calculating concrete fire resistance; codes; concrete fire resistance; CSTB; fire; fire codes; France; translations.

This method provides a means for predicting, by calculation, the resistance to fire of a reinforced or prestressed concrete element of construction, in accordance with 1959 French directives.

The method is useful in allowing builders to design structures which show the degree of fire resistance required by the various French construction regulations in force. According to those regulations, only a test furnishes legal proof of fire resistance.

French researchers hope this first step will lead to the acceptance in France of fire resistance calculations as legal proof of satisfactory resistance.

TN910-2. Self-study manual on optical radiation measurements: Part I—Concepts, chapters 4 and 5, F. E. Nicodemus, Ed., *Nat. Bur. Stand. (U.S.)*, *Tech. Note 910-2*, 118 pages (Feb. 1978) SN003-003-01880-5.

Key words: measurement equation; optical radiation measurement; photometry; radiometry; spectroradiometry.

This is the second in a series of Technical Notes (910-2) entitled "Self-Study Manual on Optical Radiation Measurements." It contains the fourth and fifth chapters of this Manual. Additional chapters will continue to be published, similarly, as they are completed. The Manual is a comprehensive tutorial treatment of the measurement of incoherent optical radiation that is complete enough for self instruction. Detailed chapter summaries make it also a convenient authoritative reference source.

The following radiometric quantities are defined and discussed in chapter 4: radiant energy, radiant exposure, radiant fluence, radiant density, radiant intensity, radiant flux (surface) density, irradiance, radiant exitance, radiant fluence rate, radiant steriscent, as well as spectral radiant energy, and the other corresponding spectral quantities. In particular, each quantity is related to the quantities previously introduced in chapters 1-3: radiant flux or power, radiance, and the corresponding spectral quantities. Important interrelationships between the different quantities are also presented, particularly where they help to clarify their significance and the distinctions between them. Treatment of one of the most important interrelationships, the inverse-square law, also covers commonly used approximations involving actual (extended) sources and receivers.

TN959. Calibration of time response of thermometers: Concepts and model calculations, R. D. Mountain and G. W. Mulholland, *Nat. Bur. Stand. (U.S.)*, *Tech. Note 959*, 34 pages (Jan. 1978) SN003-003-01878-3.

Key words: calibration; response time; temperature; thermal response; thermometer; time response function.

Some of the conceptual problems associated with the calibration of the time response of a temperature sensor are examined in this report. This discussion is in terms of a time response function which characterizes the way a given sensor responds to changes in the temperature of its surroundings. A series of model calculations of the response function for idealized sensors are used to investigate the general features of the response

functions. Important features are the sensitivity of these functions to (i) material properties of the sensor, (ii) the type of thermal coupling of the sensor with the environment and (iii) the geometry of the sensor. These features must be considered in the design of procedures for calibrating the time response of thermometers.

TN962. Contact deformation in gage block comparisons, J. S. Beers and J. E. Taylor, *Nat. Bur. Stand. (U.S.), Tech. Note 962*, 46 pages (May 1978) SN003-003-01931-3.

Key words: calibration; comparator; deformation; gage blocks; length; metrology.

When calibrating gage blocks or when gaging objects with contact type comparators, local deformation occurs where the probe tip contacts the gaging surface. This deformation results in a measurement error only if the gage blocks or objects being compared are of different materials having different mechanical properties. This document presents formulas and nomographs for determining deformation magnitude, and instructions for applying deformation corrections. The formulas and nomographs are valid only for spherical probe tips. A method is given for evaluating tip geometry and it is recommended that nonspherical or flawed tips be replaced.

TN963. Air and water pollution—Annual report, FY 74-76, W. H. Kirchhoff and E. Myers, *Nat. Bur. Stand. (U.S.), Tech. Note 963*, 387 pages (Oct. 1978) SN003-003-01983-6.

Key words: air pollution; measurement; SRM; water pollution.

Water—Evaluation of the accuracy of methods for measuring water velocity and flow in open and closed channels; Development of radioactivity standards; Development of Standard Reference Materials for evaluating the accuracy of instruments and methods for measuring the concentration of pollutants in water and sediments; Measurement evaluation and compilation of physical and chemical properties of known pollutants.

TN964. Fire alarm and communication systems, R. W. Bukowski, R. L. P. Custer, and R. G. Bright, *Nat. Bur. Stand. (U.S.), Tech. Note 964*, 49 pages (Apr. 1978) SN003-003-01914-3.

Key words: control units; fire alarm systems; fire detectors; high-rise communication systems; multiplex systems; NFPA standards; residential fire detector; sprinkler supervisory devices.

The operation and use of all current types of fire alarm and communication systems are discussed. This includes the differences between and operating features of local, auxiliary, remote station, proprietary, and central station systems, high-rise communication systems and residential fire detection devices. A discussion of commonly used fire detectors is given including operation, installation and application considerations. Indicating devices, sprinkler supervisory devices, maintenance, reliability and code/standard compliance are also covered.

TN965. Effects of moisture in built-up roofing—A state-of-the-art literature survey, H. W. Busching, R. G. Mathey, W. J. Rossiter, Jr., and W. C. Cullen, *Nat. Bur. Stand. (U.S.), Tech. Note 965*, 78 pages (July 1978) SN003-003-01944-5.

Key words: bituminous roof membranes; built-up roofs; moisture; moisture dissipation; nondestructive detection of moisture; performance criteria; roofing moisture.

A literature review of the effects of moisture on built-up roofing was made. Quantitative data were summarized for some properties of membrane roofing including: permeability, absorption, thermal expansion, thermal resistance, tensile

strength, modulus, and fungus attack resistance. Example calculations of possible temperature and moisture gradients for two typical roof sections were presented.

Nondestructive evaluative methods to locate moisture in roofing systems were summarized and include gravimetric, nuclear, capacitance, infrared imagery, electrical resistance, and microwave methods. A review of techniques to dissipate moisture in roofing is presented.

TN966. Performance criteria and plumbing system design, M. J. Orloski and R. S. Wyly, *Nat. Bur. Stand. (U.S.), Tech. Note 966*, 61 pages (Aug. 1978) SN003-003-01963-1.

Key words: performance; plumbing systems; reduced-size venting.

An overview is presented indicating how the performance approach to plumbing system design can be used to extend traditional methods to innovative systems. Identification of the plumbing performance needed in a built system is used to classify current design criteria intended to furnish this level of performance. Some current design criteria may provide a higher level of performance than is actually needed by the user. In other cases, no standard test method, criterion, or evaluation technique exists. Putting existing knowledge into a performance format increases the utility of this knowledge and facilitates identification of needed research to fill the gaps. Some of the mathematical models now used for system design and pipe sizing in plumbing codes are reviewed in the context of performance-oriented research. The results of experimental work in plumbing systems with reduced-size vents (smaller than allowed by codes) are presented as an example of the use of the performance approach, and illustrate a case where performance criteria permit relaxing of vent design practice. Conceivably the reexamination by plumbing designers of traditional design criteria against measured user needs could be beneficially extended to other areas of plumbing design such as water distribution, storm drainage, and plumbing fixtures. Beyond this, it has been recognized that uniform guidelines for evaluation of innovative systems, based on research findings, are essential for wide acceptance of performance methods, particularly by the regulatory community.

TN968. Total photon absorption cross section measurements, theoretical analysis and evaluations for energies above 10 MeV, H. A. Gimm and J. H. Hubbell, *Nat. Bur. Stand. (U.S.), Tech. Note 968*, 77 pages (June 1978) SN003-003-01941-1.

Key words: Coulomb corrections; pair production cross section; screening corrections; total photon absorption cross section; total photonuclear absorption cross section; triplet production cross section.

Atomic photoabsorption cross sections have been calculated in the energy range from 10 MeV to 350 MeV. For Pb, Ta, Sn and Cu total γ -ray absorption cross sections were measured between 10 MeV and compared with the theoretical results. An estimate of the uncertainties in the calculated atomic cross sections is given.

TN969. NBS Reactor: Summary of activities July 1976 to June 1977, F. J. Shorten, Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 969*, 188 pages (Apr. 1978) SN003-003-01907-1.

Key words: activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation.

This report summarizes all those programs which depend on the NBS reactor. It covers the period from July 1976 through June 1977. The programs range from the use of neutron beams

to study the structure and dynamics of materials through nuclear physics and neutron standards to sample irradiations for activation analysis, isotope production, radiation effects studies, neutron radiography and nondestructive evaluations.

TN970. Aseismic design of building service systems: The state-of-the-art, C. W. C. Yancey and A. A. Camacho, *Nat. Bur. Stand. (U.S.), Tech. Note 970*, 83 pages (Sept. 1978) SN003-003-01974-7.

Key words: aseismic design; building service systems; codes; earthquake; hospitals; standards.

A search for information was conducted to define the state-of-the-art of aseismic design of building service systems and to identify areas of needed research. The study focused primarily on service systems essential to the continuous operation of hospital facilities in post-earthquake periods. A review of the literature pertaining to seismic performance of nonstructural systems is presented. An evaluation of code and standard regulations applicable to the aseismic design of service system components is also presented. Information obtained from direct contact with several federal agencies, the State of California, and practicing architects and engineers is summarized. The findings from a field visit of two hospitals currently under construction in earthquake-prone areas are reported. Deficiencies in current design/evaluation practice are identified and recommendations for research are presented.

TN972. Elastomeric roofing: A survey, W. J. Rossiter, Jr. and R. G. Mathey, *Nat. Bur. Stand. (U.S.), Tech. Note 972*, 54 pages (July 1978) SN003-003-01954-2.

Key words: application guidelines; elastomeric; materials; membranes; performance factors; review; roofing.

In recent years the use of elastomeric roofing systems in the United States has been increasing. A survey was conducted to ascertain the current state-of-the-art of these roofing systems. The information obtained in the survey was gathered from a literature search complemented by the opinions of people knowledgeable in the field including researchers, contractors, manufacturers and users. A listing of the current elastomeric roofing materials was compiled, along with test methods for determining the properties of membranes fabricated with these materials. The principal materials, available in either liquid or sheet applied systems, included acrylic, butyl, chlorosulphonated polyethylene, EPDM (ethylene propylene diene terpolymer), neoprene, polyvinyl chloride (PVC) and vinyl, silicone and urethane. In addition to these materials some composite membranes were also available.

Factors affecting the performance of the membranes were identified including durability, design of the roofing system, substrate condition at the time of application attachment of the membrane to the substrate and workmanship during application. The performance of elastomeric roofing was discussed based on its advantages, disadvantages and limitations. Guidelines to assist the user in the selection and use of elastomeric roofing were prepared for both new and remedial roofing applications.

Criteria were not available to evaluate or predict the performance of elastomeric roofing. As a first step in the development of criteria, preliminary performance characteristics were suggested.

TN973. Smoke detector design and smoke properties, R. W. Bukowski and G. W. Mulholland, *Nat. Bur. Stand. (U.S.), Tech. Note 973*, 51 pages (Nov. 1978) SN003-003-01991-7.

Key words: aerosol generators; detector testers; fire detectors; ionization detectors; light-scattering detectors; particle size distribution; smoke; smoke detectors.

The importance of a reference photometer and reference ionization detector in improving the reliability of smoke detectors is discussed. Recent developments in smoke detector technology are highlighted and theoretical as well as practical experience in regard to detector performance is summarized. Comparison of the theoretically predicted response of smoke detectors as a function of particle size with measured values is given. A monodisperse aerosol generator, an electrical aerosol analyzer with a size sensitivity from 0.01 to 1 μm , and an optical particle counter are described. The size distribution, mass and number concentration, optical density, and coagulation frequency for smoke from burning heptane and smoldering cotton lamp wick are presented. It is shown that a Junge type size distribution provides a good fit to the measured size distribution for both fresh and aged smoke.

TN974. Corrosion of metallic pipes transporting potable water—Laboratory testing methods, J. N. Andre and J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 974*, 36 pages (June 1978) SN003-003-01945-3.

Key words: copper pipe; corrosion; corrosion measurement; galvanized steel pipe; metallic pipes; potable water; resistance polarization.

Many factors affect both the form of and the corrosion of pipes transporting potable water including the composition, temperature and flow rate of the water, type of metal and the physical condition of the pipe. A pipeline was constructed and experimental methods developed to determine the effects of the above factors on the corrosion of pipes. Components of the pipeline were carefully selected or designed to prevent the occurrence of extraneous corrosion.

The rate of corrosion of galvanized steel and copper pipes were measured by direct weight losses measurements and by polarization resistance methods. It appears that the polarization resistance technique is a useful tool which may be used in a variety of corrosion studies of pipe in aqueous media.

TN975. Results and analysis of a round-robin test program for liquid-heating flat-plate solar collectors, E. R. Streed, W. C. Thomas, A. G. Dawson III, B. D. Wood, and J. E. Hill, *Nat. Bur. Stand. (U.S.), Tech. Note 975*, 119 pages (Aug. 1978) SN003-003-01959-3.

Key words: measurement; modeling; solar; standards; testing.

A round-robin test program was conducted at 21 United States test facilities, using a common test procedure, to determine the intercomparability of thermal performance data pertaining to two liquid-heating flat-plate solar collectors.

The statistical analysis of the data revealed a relatively large spread in the measured values of collector efficiency. Data from approximately half the facilities were then selected for detailed analysis. A collector analytical model was used to show that less than one-third of the mean-square distance could be attributed to different environmental conditions from facility to facility. It was found that the data showed less scatter for one of the two collectors than for the other. In general, the data were consistent for any single facility; most of the scatter was therefore attributed to systematic uncertainties from facility to facility. When the data from six participants reportedly adhering to the requirements of ASHRAE Standard 93-77 were analyzed, the scatter was found to be within normal limits expected for the test procedure.

TN976. International trends and developments of importance to the metrication plans of the U.S. construction community, C. T. Mahaffey, *Nat. Bur. Stand. (U.S.), Tech. Note 976*, 72 pages (June 1978) SN003-003-01937-2.

Key words: international building performance standards; internationally harmonized building regulations; metrication impact on construction.

In 1974 the National Bureau of Standards' Center for Building Technology began an investigation of international developments in the construction field seeking to identify those of importance to U.S. metrication planning. This report identifies and describes a group of related developments selected on the basis of their importance and potential impact on the metric future of the U.S. construction community. The purpose of the report is not to discuss the merits of going metric, but rather to display the trends and developments in the metric building world that the U.S. is preparing to join.

The report suggests that many nations, recognizing unique opportunities in a world that will soon have a common measurement system, have already begun to capitalize on the global adoption of SI—the International System of Units. The report describes the extensive efforts underway to reduce obstacles to trade caused by incompatible national regulations, standards, and certification to standards. It describes the trade implications of the Helsinki international agreements reached at the Helsinki meeting of the Conference on Security and Cooperation in Europe and being advanced in the proposed Standards Code developed by the negotiators involved in the General Agreement on Tariffs and Trade (GATT). It describes the changes in the marketplace for building components brought about by the worldwide adoption of the international standard dimensioning module of 100 mm. It describes the launching and the status of the United Nations project aimed at the international harmonization of national building regulations; the involvement and reorganization of the building standards activity of the International Organization for Standardization (ISO); the significance of the international evaluation mechanisms developed by the European Union of Agreement; and, the initiation of international performance standards developed through ISO Technical Committee 59—Building Construction. All of which should be of special interest to those concerned with the development of a remarkably similar program assigned to the National Institute of Building Sciences (NIBS).

U.S. metric conversion plans could be designed to take advantage of the opportunities uniquely associated with an SI world or they could treat metrication simply as the adoption of a more modern U.S. measurement system. The report identifies this choice as a major metrication issue for the U.S. construction community. For this reason the report should be of interest to members of the American National Metric Council and of the U.S. Metric Board.

The appendix to this report contains a brief description of 22 international organizations considered to be of future significance to the U.S. as it joins the SI metric building world.

TN977. Methods for characterizing adobe building materials, J. R. Clifton, P. W. Brown, and C. R. Robbins, *Nat. Bur. Stand. (U.S.)*, *Tech. Note 977*, 59 pages (June 1978) SN003-003-01940-2.

Key words: adobe building materials; adobe soil; color determination; microfabric analysis; mineralogical analysis; particle size distribution; pH; plastic and liquid limits; soluble salts.

Methods are described for the characterization of those physical properties and mineralogical features of adobe which appear to have the most significant effect on the durabilities of adobes. These methods include determinations of color, pH, soluble salts, particle size distribution, liquid and plastic limits, and the x-ray "fingerprint" of adobe. In addition, methods are given for the identification of the mineralogy of adobe soils and for the examination of the microfabric of adobe.

TN978. Nationwide survey of cobalt-60 teletherapy dosimetry, C. G. Sores and M. Ehrlich, *Nat. Bur. Stand. (U.S.)*, *Tech. Note 978*, 40 pages (Aug. 1978) SN003-003-01968-2.

Key words: absorbed dose; cobalt-60 gamma radiation; computation check; dose interpretation; mailings; survey; teletherapy; thermoluminescence dosimeters; water phantom.

Between September 1974 and December 1977 the National Bureau of Standards, in cooperation with the Bureau of Radiological Health, performed a study of the accuracy with which a prescribed absorbed dose of cobalt-60 gamma radiation is delivered to a specified point in a water phantom. Approximately two-thirds of the cobalt-60 teletherapy units in the U.S. were surveyed by mail, using a rugged thermoluminescence dosimetry system. The dose given by participants was evaluated from dosimeter response, and information supplied by participants was used to check their computations of the dose delivered. In this nationwide study, 83 percent of the units surveyed yielded dose interpretations within 5 percent of the requested dose, 13 percent yielded differences between 5 and 10 percent, and 4 percent of the dose interpretations differed by more than 10 percent from the dose requested. Sources of discrepancies are discussed, and the results of this survey are compared with those of other dosimetry surveys.

TN981. The calibration of a burn room for fire tests on furnishings, K. Tu and V. Babrauskas, *Nat. Bur. Stand. (U.S.)*, *Tech. Note 981*, 59 pages (Dec. 1978) SN003-003-01999-2.

Key words: buoyant plumes; convection; fire tests; flammability; furnishings; heat transfer; radiation.

A series of ten tests, using a diffusion flame gas burner as heat source, was conducted in a full-size room designed for furnishings flammability tests. The gas burner was used to release known heat rates and to permit steady state measurements of energy and mass flow. The gas burner fires simulated preflashover conditions, with peak temperatures outside the burner plume of around 300 °C. The measurements obtained were compared with available theoretical room fire descriptions and published heat transfer values. The results showed the importance of a precise determination of the inflow and exhaust velocities at the doorway. It was demonstrated that a large number of doorway velocity probes is required to accurately obtain a room heat and mass balance. A calculational procedure was developed for analyzing the results which should be useful for future analysis of furnishings experiments.

TN982. Criteria for retrofit materials and products for weatherization of residences, W. J. Rossiter, Jr. and R. G. Mathey, Eds., *Nat. Bur. Stand. (U.S.)*, *Tech. Note 982*, 75 pages (Sept. 1978) SN003-003-01976-3.

Key words: caulks and sealants; clock thermostats; energy conservation; insulation; replacement windows; retrofitting; storm doors; storm windows; vapor barriers; weatherization; weatherstripping.

The Department of Energy requested the National Bureau of Standards to develop criteria for materials and products to be included in the DOE Weatherization Assistance Program. This program was established by Congressional legislation and directed toward financially assisting low-income persons in retrofitting residences to conserve energy. For most cases, only energy-saving materials and products for which specifications and/or standards are available are to be included in the Weatherization Assistance Program. Because of statutory requirements labor costs for installing weatherization materials and products are not included in the program.

The report identifies criteria for materials and products eligible under the DOE Weatherization Assistance Program. The materials included are insulation and vapor barriers, storm windows and doors, caulking and weatherstripping, clock thermostats, and replacement windows, and replacement glazing. The retrofit materials are listed by generic type and recommendations are made for their installation.

During the course of the investigation and based upon interactions with industry representatives, materials and products other than those considered eligible under the DOE Weatherization Assistance Program were also given consideration. Those materials and products having energy savings potential but which are considered not eligible are discussed in the Appendices.

TN983. Properties of selected superconductive materials—1978 Supplement, B. W. Roberts, *Nat. Bur. Stand. (U.S.), Tech. Note 983*, 99 pages (Oct. 1978) SN003-003-01988-7.

Key words: bibliography; composition; critical fields; critical temperature; crystallographic data; data compilation; low temperature; superconductive materials; superconductivity.

This report includes data on additional superconductive materials extracted from the world literature up to fall 1977 and is an addendum to the data set published in *J. Phys. Chem. Ref. Data* 5, No. 3, 581-821 (1976) (Reprint No. 84). The data presented are new values and have not been selected or compared to values (except for selected values of the elements) previously assembled by the Superconductive Materials Data Center. The properties included are composition, critical temperature, critical magnetic field, crystal structure and the results of negative experiments. Special tabulations of high magnetic field materials with Type II behavior and materials with organic components are included. All entries are keyed to the literature. A list of recent reviews centered on superconductive materials is included.

TN984. Evaluation of plastic wallcovering materials, E. J. Clark and P. G. Campbell, *Nat. Bur. Stand. (U.S.), Tech. Note 984*, 43 pages (Oct. 1978) SN003-003-01982-8.

Key words: abrasion; Federal Specification CCC-W-408A; fungus resistance; stain resistance; surface roughness; vinyl wallcoverings; wallcovering materials; washability.

The suitability of various test methods for measuring performance of plastic wallcovering materials was studied. This report contains the results of performance tests including abrasion resistance, surface texture, fungus resistance, washability and stain resistance. Based on the test results, tentative recommendations for the revision of Federal Specification CCC-W-408A, Wall Covering, Vinyl-Coated, have been developed. These recommendations are based upon the results of tests conducted on seventy-two wallcovering materials from seven manufacturers.

TN986. NBS Special Foreign Currency Program in Yugoslavia 1973-1978, D. M. Bluebond, R. S. Marvin, and H. S. Peiser, *Nat. Bur. Stand. (U.S.), Tech. Note 986*, 75 pages (Sept. 1978) SN003-003-01977-1.

Key words: binational research cooperation; international scientific cooperation; physical science research administration; research planning; scientific research abstracts; Special Foreign Currency Program; Yugoslavia science and technology.

An overview is given of grants awarded by the National Bureau of Standards under the Special Foreign Currency Program (SFCP) or by the U.S.-Yugoslavia Joint Board. Each grant is identified by title, principal investigator, institution in Yu-

goslavia, NBS monitor, and the Monitor's organizational unit within NBS. The work is then described briefly under the three headings "Summary Description of Project Goals," "Results and Implications to Date," and "List of Publications that Resulted from the Project." To demonstrate the relevance of such grants to the programs of NBS, the grant descriptions are ordered by NBS institutes and divisions. The significance and purpose of the NBS/SFCP grant programs are discussed in the Foreword and the Introduction. The NBS monitors and the program manager judge this grant program to have had a high benefit to cost ratio from the viewpoint of NBS.

TN988. Detector spectral response from 350 to 1200 nm using a monochromator based spectral comparator, A. Corrons and E. F. Zalewski, *Nat. Bur. Stand. (U.S.), Tech. Note 988*, 21 pages (Dec. 1978) SN003-003-02000-1.

Key words: detector; detector radiometry; detector spectral comparator; detector spectral response; filter transmittance test; photodetector; photometer; radiometer; spectral responsivity.

The method of relative spectral detector response measurement based on filters of known transmittance and a spectral irradiance standard lamp was used to measure the responsivity of a thermopile. The thermopile was then used in conjunction with a monochromator based spectral comparator to measure the relative spectral response from 350 to 1200 nm of several other detectors. Several auxiliary experiments to evaluate the accuracy of these techniques are described. The estimated accuracy of relative spectral response measurements using these techniques and this particular instrumentation was found to range from 3 to 7 percent depending upon the type of detector being measured and the spectral region under study. Finally, the effective transmittance of several filters was measured to evaluate the accuracy of the relative spectral detector response measurements. It was concluded that the effective transmittance test is not a reliable way to judge the accuracy of detector response measurements.

TN990. The selection of preferred metric values for design and construction, H. J. Milton, *Nat. Bur. Stand. (U.S.), Tech. Note 990*, 83 pages (Dec. 1978) SN003-003-02001-0.

Key words: convenient numbers; metrication; number systems; preferred numbers; rationalization; selection of metric values; series of numbers; SI.

This Technical Note contains a comprehensive examination of considerations involved in the selection of preferred metric values during the change to SI in the U.S. construction community. It has been prepared to assist those engaged in the conversion and rationalization of technical data for use in design and production to make informed judgments during the selection of metric values.

The adoption of preferred metric values and the concomitant rationalization of the technical data base will be one of the main benefits of the change to metric (SI) units. The principal aim is to encourage the choice of simple, convenient, or preferred metric values and ranges of rational values, rather than exact or marginally rounded soft conversions of existing values which will generally require a second change to more workable numbers at a later stage. The Technical Note has three parts: 1) background information on number systems and properties of numbers, metric impact, and alternative conversion strategies; 2) alternative preferred number concepts for individual values, sets of related values, and series of preferred values; and, 3) a methodology for the determination and selection of preferred metric values in technical information by means of a manual or an automated approach.

TN1000. **A direct approach to the derivation of electric dyadic Green's functions**, A. D. Yaghjian, *Nat. Bur. Stand. (U.S.), Tech. Note 1000*, 68 pages (Jan. 1978) SN003-003-01876-7.

Key words: dyadic Green's function; electromagnetic theory; principal values; source region.

A straightforward approach that does not require delta-function techniques is used to derive a generalized electric dyadic Green's function which remains valid within the source region. Although the electric field expressed by the dyadic Green's function proves to be unique, the exact form of the dyadic itself depends, in the source regions, upon the geometry of its "principal volume." The dependence on principal volume is determined explicitly, and the different Green's dyadics derived by a number of previous authors are shown to emerge merely through the appropriate choice for the principal volume. Moreover, delta-function techniques, which by themselves are shown to be inadequate to extract uniquely the proper electric dyadic Green's function in the source region, can be supplemented by a very simple procedure to yield unambiguously the correct Green's function and associated fields.

TN1001. **Laser far-field beam-profile measurements by the focal plane technique**, G. W. Day and C. F. Stubenrauch, *Nat. Bur. Stand. (U.S.), Tech. Note 1001*, 52 pages (Mar. 1978) SN003-003-01902-0.

Key words: beam divergence; beam profile; lasers; optical propagation.

An analysis of laser far-field beam-profile measurements by the focal plane technique is given. Particular attention is paid to systems at $\sim 1 \mu\text{m}$ wavelength and having apertures up to 10 cm. The basic mathematics is reviewed and approximations are evaluated. Using geometrical optics techniques, it is shown that an $f/20$ plano-convex lens is an appropriate choice for the focusing element. For two arbitrarily chosen laser beam profiles the errors associated with the choice of this lens are discussed through the use of computed far-field and focal-plane irradiance distributions. Experimental procedures including methods of testing the optical elements are also given.

TN1002. **Measurements of combined axial mass and heat transport in He II**, W. W. Johnson and M. C. Jones, *Nat. Bur. Stand. (U.S.), Tech. Note 1002*, 84 pages (Feb. 1978) SN003-003-01889-9.

Key words: axial heat transport; forced convection; helium II; measurements; pressure drop; 1.4-2.1 K.

An experiment was performed that allowed measurements of both axial mass and heat transport of He II in a long tube. The apparatus allowed the pressure difference and the temperature difference across the flow tube to each be independently adjusted, and the resulting steady-state values of net fluid velocity and axial heat transport to be measured. For the larger Reynolds numbers, it was found that the relation between pressure difference and net fluid velocity was nearly indistinguishable from that of an ordinary fluid in turbulent flow. The axial heat transported was found to be suppressed from the values that were calculated by assuming that "mutual friction" was unchanged by the net fluid flow, but it was always found to be larger than the "enthalpy rise" value. Taking this second value as a lower limit, it is shown that a mild extrapolation of these results suggests that (in appropriate circumstances) forced convection would allow much greater heat to be transported in long cooling channels than could be transported by "natural" convection alone.

TN1003. **Automatic path delay corrections to GOES satellite time broadcasts**, J. V. Cateora, D. W. Hanson, and D. D. Davis, *Nat. Bur. Stand. (U.S.), Tech. Note 1003*, 52 pages (Feb. 1978) SN003-003-01899-6.

Key words: broadcast; delay correction; microprocessor; satellite; scientific calculations; time of year.

In support of the environmental data collection by the National Oceanic and Atmospheric Administration's (NOAA's) Geostationary Operational Environmental Satellites (GOES), a time code has been incorporated into an interrogation message from these satellites by the National Bureau of Standards (NBS). This message is directed to data-collection platforms engaged in seismic, tsunami, hydromet and other related monitoring activities. The NBS has developed this time-code system to serve environmental data users who require only a few tenths of a second accuracy as well as those who need a more accurate time reference.

The time code is available continuously from two geostationary satellites and provides a coverage of the Atlantic and Pacific Ocean Basins as well as the North and South American Continents. The time code includes the necessary information to compensate for free-space propagation delays between the master clock located at Wallops Island, Virginia, and the user. Preliminary results indicate a timing resolution of 10 μs .

The time-code system is supported by atomic clocks maintained at Wallops Island, Virginia, the point of origin for all signals to be sent through the satellites. A data-logging system monitors three television networks and Loran-C to provide a comparison link between the Wallops Island clocks and reference standards at the NBS.

A microprocessor "smart" clock has been developed for the user that automatically corrects for path and equipment delays and places its recovered time in synchronism with Coordinated Universal Time (UTC) generated by NBS. This clock, associated recovery equipment, and measured results are discussed in detail in this report.

TN1004. **Calibrating two 6-port reflectometers with only one impedance standard**, C. A. Hoer, *Nat. Bur. Stand. (U.S.), Tech. Note 1004*, 46 pages (June 1978) SN003-003-01956-9.

Key words: calibration; current; impedance; network analyzer; power; reflection coefficient; reflectometer; scattering parameters; six-port; voltage.

This paper describes a technique for calibrating a pair of 6-port reflectometers for measuring the reflection coefficient of 1-port devices, or the scattering parameters of reciprocal 2-port devices. The operations in the calibration consist of connecting the two 6-ports together, connecting each 6-port to a calibration circuit consisting of two terminations of unknown impedance and a leveling loop, and then connecting the standard. The standard can be one termination whose complex impedance is known, or a precision length of transmission line whose cross-sectional dimensions are known. The length and loss of the line are not required. The solution for the constants which characterize each 6-port is closed, requiring no iteration.

TN1005. **Publications and services of the Cryogenics Division, National Bureau of Standards, 1953-1977**, D. J. Frizén and J. R. Mendenhall, *Nat. Bur. Stand. (U.S.), Tech. Note 1005*, 112 pages (Apr. 1978) SN003-003-01920-8.

Key words: author indexes; bibliography; cryogenics; liquefaction; metrology; properties of fluids; properties of solids; subject indexes; superconductivity; transport processes.

This NBS Technical Note catalogs the publications of the Cryogenics Division, along with author and subject indexes, for the period 1953 through 1977. It also contains a listing of available thermodynamic properties charts, bibliographies, and miscellaneous reports of cryogenic interest.

A resumé of the activities of and services provided by the Cryogenics Division is also included.

3.13. CONSUMER INFORMATION SERIES

Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

CIS9. **Corrosion**, J. Kruger and S. Halpin, Ed., *Nat. Bur. Stand. (U.S.), Consum. Inf. Ser. 9*, 12 pages (Mar. 1978) SN003-003-01947-0.

Key words: corrosion; crevice corrosion; galvanic corrosion; inhibitors; pitting corrosion; rust; stress corrosion.

This document explains what corrosion is, how it affects certain metals and, how to prevent it.

CIS10. **Automation in the marketplace**, S. M. Radack, G. G. Burns, and S. Halpin, Ed., *Nat. Bur. Stand. Consum. Inf. Ser. 10*, 12 pages (Mar. 1978) SN003-003-01969-1.

Key words: computerized banking; computerized checkout; computerized retail checkout; computers; electronic funds transfer; optical character recognition; Universal Product Code.

This document describes the Universal Product Code (UPC), Electronic Funds Transfer (EFT), and the Optical Character Recognition (OCR) point-of-sale system.

3.14. NBS INTERAGENCY REPORTS

A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution by the National Technical Information Service (NTIS), Springfield, VA 22161, in paper copy or microfiche form unless otherwise stated. When ordering this series from NTIS you must order it by the "COM, PB, or AD" number listed at the end of each entry.

NBSIR 73-123. Resistance of human skin to puncture and laceration, B. J. McGuire, J. R. Sorrells, and J. D. Moore, 48 pages (Feb. 10, 1973). Order from NTIS as PB275435.

Key words: adults; Bureau of Product Safety; children; experimental studies; injury potential; lacerations; mechanical force; mechanical properties; NBS; punctures; sampling; sharp edges; simulation; skin; TIPS Thesaurus.

Information is provided on the following topics: 1. Human skin tensile properties measured on 14 cadavers age 1 day to 25 years. Skin strength increases rapidly during first year of life. 2. Human skin resistance to puncture by conical tips measured on 21 cadavers age 45 to 89 years. Results described by equations of form $y = u + ax_1 + bx_2 + cx_1^2 + dx_2^2$. 3. Hand velocities and weights measured on 5 subjects age 5 to 50 years. Maximum measured velocity during "grabbing" motion was 4.2 meters/sec. 4. Relative laceration ability of selected sheared steel edges measured on pigskin. 5. Preliminary data on resistance of pigskin to puncture by conical tips under impact conditions.

NBSIR 75-789. Graffiti-resistant coatings: Methods of test and preliminary selection criteria, M. Godette, M. Post, and P. G. Campbell, 42 pages (Nov. 1975). Order from NTIS as PB275158.

Key words: color retention; ease of removal; graffiti; graffiti-resistant coatings; performance.

The performance of graffiti-resistant coatings was evaluated and performance tests and criteria were developed to aid the selection of these materials.

From preliminary tests of 48 commercially-available coatings, 19 were selected for more detailed tests. The 19 coatings were evaluated for ability to release common markings and to resist ultraviolet radiation, high humidity, condensing moisture, abrasion and graffiti removers. The flexibility and water vapor permeance of the coatings were also determined. The substrates used were clay brick and a matte tile. Seven of the coatings were highly resistant to defacement by spray paint, and five were highly resistant to felt-tip pen, crayon and lipstick.

NBSIR 75-914. Graffiti removers: Evaluation and preliminary selection criteria, M. Godette, M. Post, and P. G. Campbell, 42 pages (Dec. 1975). Order from NTIS as PB275158.

Key words: effectiveness; graffiti; graffiti removers; materials; paint; remover; remover-substrate compatibility; spray paints; substrate.

A program was undertaken to determine the performance of graffiti removers so that performance criteria for selection of these types of materials could be recommended. The results of laboratory tests of removal efficiency, range of effectiveness, remover-substrate compatibility, migration (spreading), and flash point are presented. From the results obtained, tentative criteria for selection of graffiti removers are recommended.

The marking materials (graffiti) used were spray paints of major generic types, crayon and felt-tip pen markers. The substrates used were clay brick, ceramic tile, limestone, sandstone, aluminum and wood. Ninety-nine commercial materials which are marketed for use as graffiti removers were used in the study.

This report is on the removal of marking materials from brick. The results showed that all markings can be removed with a high degree of effectiveness. No single remover was effective on all markings, but a set of five selected removers used in sequence, was effective against all.

The compatibility of the most effective removers with various building materials was also studied. Care must be taken to select a remover which will neither discolor the substrate being cleaned nor adjacent areas.

NBSIR 75-925. Final summary report—Study of the National Measurement System 1972-75, R. C. Sangster, 46 pages (Dec. 1976). Order from NTIS as PB265622.

Key words: acoustics; economics of measurement; electrical quantities; electromagnetic quantities; ionizing radiation; measurement needs; measurement system structure; mechanical quantities; National Measurement System; optical quantities; thermal quantities; time and frequency.

This is the summary report for the 1972-75 NBS Study of the National Measurement System; i.e., the activities and mechanisms that provide physical measurement data for creation of objective, quantitative knowledge for use in our personal lives, society, science, and technology. It includes structural and economic overviews of the system and summarizes results of microstudies of specific measurement sectors. The structural model of the system has five levels: conceptual system, basic technical infrastructure, realized measurement capabilities, institutional dissemination and enforcement network, and end-use measurement activities. Transactions in the system have been described in a matrix format. Measurement-related activities account for about 6 percent of Gross National Product and pervade all economic sectors. Indicative cost-benefit analyses are described. Measurement sectors covered by 24 microstudies include time and frequency; mechanical, thermal, electrical, electromagnetic acoustic, and optical quantities, and ionizing radiation. Major system trends are toward increased complexity and integration, improved quality control and information resources, automation, metrication, and consolidation of the recent scientific revolution in metrology. Deficiencies exist in assurance of measurement quality, communication of needs and capabilities, missing structure in newer measurement fields, measurements for technical regulations, and measurements made with newer transducers or under dynamic or adverse environmental conditions. NBS is the central measurements standards institution supporting our National Measurement System.

NBSIR 75-928. The National Measurement System for mass, volume and density, P. E. Pontius, J. R. Whetstone, and J. A. Simpson, 72 pages (May 1978). Order from NTIS as PB283169.

Key words: density measurements; mass measurements; National Measurement System; volume measurements.

This document, one of several similar documents resulting from the NBS study of the National Measurement System,

reflects the results of intensive studies carried out from 1972-1975 relative to Mass, Volume and Density measurements in the United States. The history and the current status of these measurements is discussed as well as the relative role of NBS. A bibliography is included.

NBSIR 75-940. The national measurement system for spectrophotometry, W. H. Venable, Jr., 101 pages (Nov. 1977). Order from NTIS as PB276020.

Key words: absorption spectra; automation; chemical analysis; colorimetry; heat transfer; reflectance; remote sensing; retroreflectance; spectrophotometry; transmittance.

A special study of the spectrophotometric measurement system was made in order to determine what could be done to improve these measurements and what benefits would result from the improvements. It was found that improvements in the measurements could make large contributions to productivity, health, and safety in the U.S., and that, because of the fragmented nature of this measurement community, the improvements in spectrophotometric measurements can be realized most efficiently through the efforts of a centralized agency such as NBS. With the aid of this study, the program in spectrophotometry at NBS has been revised in order to bring about these improvements more rapidly and effectively.

NBSIR 75-946. The National Measurement System for ionizing radiations, R. S. Caswell, 134 pages (Apr. 1978). Order from NTIS as PB280564.

Key words: dissemination; ionizing radiation; measurement assurance; National Measurement System; standards; users of radiation.

In this study the structure of the National Measurement System for Ionizing Radiation has been investigated for eight classes of radiation users: medical, nuclear power, industrial radiation processing, defense, environmental, science, chemical analysis, and miscellaneous radiation applications. In addition two fields of increasing importance to all radiation users were investigated: regulatory control of radiation and personnel monitoring. Needed major actions on the part of the National Bureau of Standards were identified particularly for nuclear power and its related environmental and safety impacts, medical applications of radiation, assistance to regulatory control of radiation and measurement assurance for personnel monitoring.

NBSIR 75-947 (Revised December 1977). Collected executive summaries studies of the National Measurement System 1972-75, R. C. Sangster, 53 pages (Dec. 1977). Order from NTIS as PB276494.

Key words: acoustics; atomic properties; economics; electrical quantities; ionizing radiation; mechanical quantities; national measurement system; optical quantities; surface properties; thermal quantities; time and frequency.

This report contains the Executive Summaries of the reports of the 1972-75 study by the NBS Institute for Basic Standards of the U.S. National Measurement System, which consists of all of the activities and mechanisms which provide physical measurement data required by our society. A series of microstudies focused on specific technical measurement sectors. A macroeconomic study looked at costs of instrumentation and labor for measurement-related activity in our economy. University economists were retained to assist the microstudy authors and to prepare an overall economics report. A central coordinator set a basic pattern for the microstudies, prepared an overall summary report, and generated several documents relating to the system as a whole. Abbreviated titles of the executive summaries are: Final summary report. Direct measurements transactions matrices. Economic analysis. Structure and func-

tions of measurement system. Time and frequency. Length and related dimensional measurements; vibration and shock. Surface finish. Mass, volume and density. Force. Fluid flow. Pressure. Temperature. Humidity and moisture. Thermodynamic properties of fluids. Cryogenics. Electricity. Electromagnetics. Medical ultrasonics. Acoustics. Radiometry and photometry. Spectrophotometry. Far ultraviolet radiometry. Optics. Physical properties of atoms and molecules. Surface properties. Ionizing radiation.

NBSIR 76-1129. An improved photographic edge-artifact, W. R. Smallwood and R. E. Swing, 50 pages (Aug. 1976). Order from NTIS as PB274712.

Key words: densitometry; edge objects; microdensitometry; photographic edges; photographic process.

The history of edge-objects for use in optical and photographic testing is briefly reviewed and culminates in a short summary of the techniques developed at NBS in 1965 for producing photographic edges by x-ray exposures of High Resolution Plates with a tantalum strip to generate the discontinuity. The report then covers the development of an improved method for producing these edge-artifacts. It is shown that with x-ray exposure, the relation of density to exposure is linear up to densities of approximately 2.0. This linear relation is then exploited to produce two kinds of edge-artifacts. Both artifacts contain ten (10) values of density and three edge-discontinuities. The edges on one artifact have the same value of contrast, with different mean densities, while the edges on the other have different values of contrast. The use of each type is discussed. Techniques for determining exposures, for determining the transmittances of the aluminum step tablets used to modulate x-ray exposure and for determining the linear relation between density and exposure are presented in mathematical detail and exemplified in subsequent illustrative experiments. Some inherent limitations of the method are discussed. It is concluded that there is sufficient flexibility to the process and procedures to provide sharp edges, in a wide range of contrasts, on demand.

NBSIR 76-1189. Report of the workshop on estimation of significant advances in computer technology, P. Meissner, 34 pages (Dec. 1976). Order from NTIS as PB279373.

Key words: computer architecture; computer security; computer technology; encryption; semiconductor technology; technology advances.

A workshop on the estimation of significant advances in computer technology was conducted by the Institute for Computer Sciences and Technology at the National Bureau of Standards on August 30-31, 1976. The workshop was attended by 20 representatives from industry, research organizations, universities and Government agencies. The workshop was held to obtain current scientific and technical information on advances in computer technology which could significantly impact the Federal Government's knowledge and use of computer technology developments in relation to computer security and export administration. Presentations were made on anticipated advances in computer architecture and semiconductor technology. It was indicated that the present trends in component density for LSI will continue to increase at the current rate for at least five years. The speed of logic circuitry has been increasing at a rate of about 1.5 megaHertz per year, and a speed of 30 megaHertz is presently attainable. Speed-power ratios have been improving by a factor of 10 about every 4 years, and a similar improvement appears likely in the next 4 years. The current emphasis in development work is on achieving high density at low cost. In order to provide a vehicle around which to organize its discussions, the workshop con-

sidered the design of a hypothetical machine for extracting the key used for encrypting data under the proposed NBS Data Encryption Standard. Several designs were postulated and engineering estimates were developed for operating speed, size, development time, cost, and other factors.

NBSIR 77-867. A comparison of mathematical models for the prediction of LNG densities, R. D. McCarty, 64 pages (Oct. 1977). Order from NTIS as PB276047.

Key words: computer program; density; equation of state; LNG; mixtures; PVTx.

Four mathematical models of the equation of state for LNG like mixtures are compared. Each model has been optimized to the same experimental data set. The experimental data consist of over 175 new PVTx data points taken in this laboratory. The objective of the study was to obtain a mathematical model which would predict LNG densities to within 0.1 percent of the true value. The extent to which the objective has been achieved is not clear at this time. Additional experimental data are needed to resolve some discrepancies between the present data and all models investigated to date. Computer program listings for all four models are presented.

NBSIR 77-1203. Central-axis ⁶⁰Co ionization measurements in graphite as a function of phantom diameter, depth, and field size, S. R. Domen, 21 pages (Sept. 1978). Order from NTIS as PB287805.

Key words: absorbed dose; calorimeter comparisons; cobalt-60; graphite; phantom size.

Ionization measurements along the central axis were made in a graphite phantom irradiated with cobalt-60 gamma rays. The measurements were made under the following conditions: phantom diameters of 15, 20, and 30 cm; 15 depths from 1 to 39 g/cm²; and square field sizes of 8.3, 10.5, 12.4, and 17.4 cm at a fixed detector position of 1 m from the source. Empirical fits to the data aid in correcting calorimeter comparisons to a common geometry.

NBSIR 77-1211. Evaluation of x-ray fluorescence analysis for the determination of arsenic, vanadium, cadmium, lead and mercury in various matrices, P. A. Pella, R. L. Myklebust, M. M. Darr, and K. F. J. Heinrich, 31 pages (June 1977). Order from NTIS as PB285452.

Key words: arsenic; cadmium; detection limits; lead; mercury; vanadium; x-ray fluorescence spectrometry.

Limits of detection for arsenic, vanadium, cadmium, lead and mercury have been determined with a wavelength-dispersive or energy-dispersive x-ray spectrometer, or with both, in various matrices consisting of cupric oxide, ferric oxide, lead oxide, coal and fly ash. Limits of detection for mercury in coal have already been determined and reported in NBSIR 75-675 and are included as an addendum to this report.

NBSIR 77-1238. Technical guidelines for energy conservation, Building Environment Division of NBS, 406 pages (June 1977). Order from NTIS as ADA041668.

Key words: Air Force facilities; building energy conservation; energy management; evaluation and monitoring; survey of buildings.

This report provides detailed technical material on various energy conservation actions for existing Air Force facilities and utility systems. It is specifically tailored to serve as a working document for Base engineers and technical personnel. The report covers energy conservation for Air Force facilities, including the equipment for providing hot water, space heating and cooling, lighting, and humidification. It also covers central plant

systems and underground distribution systems (hot water, steam, and chilled water). It does not cover energy conservation measured for tactical or mission-related equipment such as ground vehicles or fighter aircraft.

NBSIR 77-1241. Seismic detection of motor vehicles, J. M. Kenney, 35 pages (Mar. 1977). Order from NTIS as PB272945.

Key words: ceramic transducers; motor vehicle sensing; piezoelectric polymers; road lane markers; road vibration; seismic detection; traffic noise.

The technical feasibility of detecting the approach of motor vehicles by seismic means was determined by the recording and analysis of road vibration, and verified by the construction of a seismic switch which was reliably triggered at a distance of 50 metres (164 ft) along the pavement by vehicles travelling at 50 km/h (30 mph).

NBSIR 77-1247. Proposed technical data requirements for the National Solar Heating and Cooling Demonstration Program, 138 pages (Apr. 1977). Order from NTIS as PB280182.

Key words: data requirements; noninstrumented data; solar buildings; Solar energy; solar heating and cooling; solar hot water.

Public Law 93-409, the "Solar Heating and Cooling Demonstration Act of 1974" calls for the development of interim performance criteria for solar heating and cooling systems and the buildings in which they will be used. Section 8 of the law provides for the use of data from the demonstration program to develop definitive performance criteria, as well as testing procedures whereby manufacturers can certify that their products conform to definitive performance criteria. Responsibility for the development of these definitive performance criteria has been assigned by the Energy Research and Development Administration and the Department of Housing and Urban Development to the National Bureau of Standards (NBS).

The plan presented in this document was prepared in order to define the technical noninstrumentation (TNI) data required by NBS in order to effectively monitor the residential and commercial demonstration programs, mandated by PL 93-409, for feedback. These data either cannot be collected electronically or can be gathered more effectively by other means.

This plan is intended to be a companion document to a similar plan published by NBS in August 1976 which identified the instrumentation data required by NBS to monitor and evaluate the "thermal effectiveness" and reliability of solar heating, cooling and hot water systems.

NBSIR 77-1271. Method of testing, rating and estimating the seasonal performance of central air conditioners and heat pumps operating in the cooling mode, G. E. Kelly and W. H. Parken, Jr., 78 pages (Apr. 1978). Order from NTIS as PB280107.

Key words: central air conditioners; heat pumps; rating procedure; seasonal cost of operation; test method.

The National Bureau of Standards has made a study of the part-load and seasonal performance of residential central air conditioners and heat pumps operating in the cooling mode. This document outlines methods for testing and rating these units which account for the variation in performance due to part-load operation and change in outdoor air temperature. A calculation procedure is presented which can be used to estimate the seasonal performance and seasonal cost of operation of residential central-cooling equipment.

NBSIR 77-1273. Directions to improve application of systems approach to fire protection requirements for buildings, H. E.

Nelson, 38 pages (July 1977). Order from NTIS as PB276004.

Key words: "and" gate; behavior; critical events; decision; decision tree; dominant factors; episode; event; fire; fire behavior; fire growth; fire safety; human behavior; models; phase; probability; rate constant; realm; sequence; state; states-transition; system's approach.

This paper covers an examination of the recent and ongoing work in the development of systems' approaches for design of fire protection in buildings, as carried out in the United States. The scope of coverage includes: (1) a brief review of the development of fire safety systems' approaches in the United States, to the degree felt important to understanding the current situation; (2) an overview of the more extensive and pertinent fire growth systems' analysis approaches; (3) a discussion of systems for the analysis of building fire safety design directed at establishing building requirements; (4) a review of the directions and activities now underway to integrate the fire growth models and the total building performance models into a combined approach.

This paper proposes a model of fire and its impact based on a "states-transition" concept. The fire is viewed as two separate sequences (Fire Behavior and Human Behavior). Each sequence consisting of connected realms of consistent behavior. The concept views these sequences as interrelating, with a distinct rate consistent for each realm. The concept of "state-conditions" is also evaluated. A matrix relating the factors, conditions, and development phase of fire is presented. Finally, a plan for the derivation of a viable fire protection engineering technology is presented.

NBSIR 77-1286. Characterizing the interfiber bond strength of paper pulps in terms of a breaking energy: Effect of beating. J. C. Smith and E. L. Graminski, 18 pages (Dec. 15, 1976). Order from NTIS as PB276473.

Key words: adhesion of paper fibers; bonding of paper fibers; paper; paper fibers, bonding; paper pulps, characterization; paper, tensile tests.

Handsheets in the form of a thin web of basis weight 2.5 g/cm² were prepared from Northern and Southern softwood kraft pulps. The pulps were unbeaten and beaten to 1,000, 2,000 and 5,000 revolutions in a laboratory beater. The relative density of bonding between fibers and the relative strength of the bonds were estimated from tensile test data. Bond strengths of the two unbeaten pulps were equal, but density of bonding was greater in the web made from the Northern pulp. Bond density and strength for both pulps increased with increases in the degree of beating to approximately the same value for pulps beaten 5,000 revolutions, but differences were observed in the rate of change of these quantities.

NBSIR 77-1301. Interface standards for automated coal mining equipment. B. M. Smith, R. W. Markley, L. Costrell, G. E. Clark, I. W. Cotton, and J. M. Bakshi, 81 pages (July 1977). Order from NTIS as PB279218.

Key words: coal mining; computers; control systems; industrial equipment; interface standards; microcomputers; standards.

This report describes interface standards applicable to the use of computer control systems with automated mining equipment. The report identifies, analyzes, and recommends interface standards applicable to the modular control system of an Automated Extraction System (AES) being built by the U.S. Bureau of Mines (USBM). The work serves both as a technical guide and as a summary of existing and forthcoming standards applicable to computer control systems.

Since the system configuration of the AES control system has not yet been defined, this report uses several alternative architectures to illustrate various interfaces that may be encountered. The benefits and limitations of the formal and de facto standards which apply to these interfaces are then discussed. In this context, standards are recommended for the supervisory computer—local control computer interfaces and the local control computer—sensor and actuator interfaces. The best use of these standards and important trade-offs are identified and explained.

NBSIR 77-1306. Levels of illumination and legibility. G. T. Yonemura, W. M. Benson, and R. Tibbott, 31 pages (Nov. 1977). Order from NTIS as PB276531.

Key words: energy conservation; illumination levels; lighting; lighting design; task lighting.

The visibility of tasks encountered in the working world ranges from easy to difficult to see objects. The assumption that experiments performed for threshold targets (difficult to see) can be extrapolated to higher contrast tasks (easy) was tested. The experiments indicate that threshold level studies should not be extrapolated to suprathreshold levels. The performance of the eye is not the same at the two levels. The threshold function is monotonic, that is, contrast required for detection decreases monotonically as luminance is increased, whereas the suprathreshold experiments result in a function with a minimum or optimum luminance level. Recommendations are made to expand the empirical base from which lighting level recommendations are derived to include the more commonly occurring situation involving visual task performance for suprathreshold tasks.

NBSIR 77-1314. Solar energy systems—Survey of materials performance. L. F. Skoda and L. W. Masters, 114 pages (Oct. 1977). Order from NTIS as PB273305.

Key words: absorber coatings; absorber plates; cover plates; enclosure; insulation; materials performance; reflective surfaces; seals; selection of materials; solar energy systems; standards.

A study was performed to obtain data regarding the performance of materials in operational solar energy systems, to identify and assess available standards for evaluating materials, to provide recommendations for the development of test method standards for materials and to provide guidelines to aid the selection of materials for use in solar energy systems. During the study, field inspections of approximately twenty-five operational solar energy systems were performed and a questionnaire was sent to 459 manufacturers and installation contractors to obtain materials performance data. This report contains the findings of the study. A primary conclusion is that the process of selecting materials for specific applications within solar energy systems is hindered by the lack of an adequate data base of materials performance under the conditions experienced in solar systems and subsystems. Recommendations are made that would help in establishing an improved data base.

NBSIR 77-1380. Experimental determinations of temperatures and power losses at the electrical connections of some duplex receptacles. G. W. Burns, M. G. Scroger, G. A. Evans, R. W. Beausoliel, and W. J. Meese, 65 pages (Apr. 1978). Order from NTIS as PB280071.

Key words: branch circuits; duplex receptacles; electrical connections; power loss; temperatures; thermocouples; wire.

The data presented in this report compare the reliability of power loss determination with the reliability of temperature

measurements as a means for determining the quality and adequacy of electrical connections on wiring devices used in branch circuit wiring. The basic premise for the tests presented here is that in the laboratory the determination of power loss is easier, quicker, and not nearly as dependent on environmental factors as temperature. This research indicates that, if power at a specific current level does not exceed some set value(s), temperatures will not be excessive.

This investigation also illustrates the overheating problems associated with copper-wire electrical connections. No. 14 copper wire connections frequently showed significant rises in temperatures and significantly increased power losses when tightened to a torque of only 2 lbf-in, as compared to nominally tight connections (6 lbf-in or more).

NBSIR 77-1382. Visiting team report on 1977 industrial survey in Korea on precision measurements and standards, K. M. Chung, H. S. Peiser, and R. C. Sangster, 28 pages (Nov. 1977). Order from NTIS as PB275561.

Key words: development assistance; industrialization; industry survey; Korea south; metrology; questionnaire; standards institute; survey.

The Korean Standards Research Institute is a recently founded organization that is to serve functions in Korea generally equivalent to those of the Institute for Basic Standards of NBS in the U.S.A. To plan K-SRI's metrological services to industry and other Korean laboratories, a survey of industrial needs is being conducted with advice from NBS. This report describes some basic facts about K-SRI, the survey plan, as well as principally, conclusions and recommendations given by the authors during their brief consultation visit to Korea, May 22-28, 1977.

A main questionnaire was drafted, with an accompanying letter for subsequent translation and adaptation to Korean public/private sector interaction. The survey should provide visibility for K-SRI, awareness of industrial needs to its staff, and means to develop a sound plan for its priority programs.

NBSIR 77-1383. Interactive computer program for the determination of reverberation time, T. W. Bartel, 127 pages (Dec. 1977). Order from NTIS as PB275574.

Key words: automated data acquisition; computer; reverberation room; reverberation time; software.

A description of the computer program used to measure the reverberation time in a reverberation room is presented. The program controls the operation of a real-time analyzer, a random noise generator, and a microphone multiplexer. The reverberation time for each digitally recorded decay curve is determined from a straight line least-squares fit. The program is written in FORTRAN V and requires approximately 35,000 eight-bit bytes of core memory. Flow charts, source listings, and sample printouts are included.

NBSIR 77-1385. Report to AID on an NBS/AID workshop on standardization and measurement services, H. S. Peiser, C. C. Raley, and C. A. Schroyer, Eds., 113 pages (Dec. 1977). Order from NTIS as PB277984.

Key words: AID; assistance; developing economies; foreign relations; industrializing nations; international relations; LDC's; measurement services; standardization.

From October 16-30, 1976, a Workshop was held at the National Bureau of Standards, Gaithersburg, and at selected universities, research institutes, standards developing organizations, test centers, and industrial companies, under the sponsorship of AID. The object of the Workshop was to give standards officials of industrializing nations insight into the standards and measurement systems of the United States and the role of the

National Bureau of Standards, so that these officials might consider what parts of the U.S. system might usefully be adapted to conditions in their home countries. An exchange of standardization experience in each of the participant's countries was presented by delivered papers which are reproduced here. Countries represented included Afghanistan, Bangladesh, Bolivia, Ecuador, Ghana, Guyana, India, Indonesia, Iran, Jordan, Kenya, Korea, Nigeria, and Yemen.

NBSIR 77-1386. Problems in world-wide standardization of the units of altitude measurement, J. F. Gilsinn, 25 pages (Feb. 1978). Order from NTIS as PB277982.

Key words: altimetry; altitude; aviation; height measurement; measurement units; metric; standardization; vertical separation.

The U.S. commitment to a voluntary conversion to metric units raises changeover problems in the fields of air traffic control and airspace management. This report begins by discussing current practice in altitude measurement and the rules for height maintenance now in effect worldwide. Four desirable features are given for an altitude measurement system, encompassing both the units of height measurement and the designation of cruising levels. Three alternative bases for the design of such a system are discussed and related to the desirable characteristics. Problems associated with each of the approaches are discussed and the many factors to be considered and the many interrelationships involved are examined.

NBSIR 77-1387. Evaluation of a test method for measuring microwave oven cooking efficiency, O. B. Laug, 34 pages (Sept. 1977). Order from NTIS as PB284704.

Key words: energy efficiency; microwave oven.

A standard test procedure for measuring the energy efficiency of microwave ovens has been developed and tested on current representative products. The test method is based on the International Electrical Commission (IEC-SC-59H) procedure for measuring performance of microwave cooking appliances. The results of laboratory tests show that the method is repeatable, easy to perform, and requires a minimum of special techniques or apparatus. A technique was developed to measure the efficiency of cooking various foods in the ovens. The efficiencies determined by the standard test method are shown to be realistic and correlate well with the efficiencies determined by cooking a variety of foods.

NBSIR 77-1388. A new look at windows, B. L. Collins, R. T. Rugg, R. Chapman, and T. Kusuda, 40 pages (Jan. 1978). Order from NTIS as PB276747.

Key words: daylighting; energy conservation; life-cycle costs; residential; solar heat gain; window; window management.

Recent design recommendations have called for reduced window area in buildings to conserve energy. This article presents new information on thermal loads, daylighting, management, and life-cycle costs which indicates that such recommendations may neglect important design and operational aspects of windows which can conserve energy resources and reduce life-cycle building costs. A case example is described in which energy consumption and life-cycle costs are given for windows in a typical house in the Washington, D.C. area. Noticeable reductions in overall energy consumption and life-cycle costs are found if daylight is used, and if the window is managed. It is suggested that lending institutions and builders consider the long-term effects of window design and operation decisions.

NBSIR 77-1397. Properties and interactions of oral structures and restorative materials, J. M. Cassel, 96 pages (Dec. 1977). Order from NTIS as PB275392.

Key words: adhesive; base metal; composites; dental alloy; dental materials; polymerization; resins; restorative materials; wear.

Previous encouraging results with titanium and silicon based coating agents for coupling dental resins to tooth surfaces have been reinforced with accelerated aging data. Accelerated aging data for bone bonded to bone specimens indicates that a viscous isoamyl cement may be worthy of clinical evaluation. Procedures for synthesis and purification of crystallizable aromatic aldehyde dimethacrylates are given. These highly purifiable materials offer promise as adhesion promoters through reaction with collagen and may have utility as diluent comonomers with Bis-GMA in composites or sealants. The feasibility of generating free radical induced polymerization of dental resins by using more thermally stable organic peresters or hydroperoxides and an ascorbic acid ester has been demonstrated. Design, assembly and debugging of a new multi-specimen wear instrument has been completed. Judging by their thermal expansion characteristics, high copper type amalgams show little or no evidence of phase changes at temperatures less than 90 °C. The technique sensitivity of the higher melting nonprecious porcelain bonding alloys has been demonstrated by examining quantitatively the goodness of fit attained by manufacturers of such alloys who made castings to a standard die and wax pattern that we supplied. A technique to fabricate oversize Ni-Cr crown castings is described.

NBSIR 77-1399. Performance of a water-thinned polyurethane seamless flooring system, M. Godette and P. Campbell, 79 pages (Dec. 1977). Order from NTIS as PB275390.

Key words: field demonstration; high traffic areas; laboratory findings; maintenance engineers; service conditions; solvent-thinned polyurethane system; vinyl tile; water-thinned polyurethane system.

This paper summarizes the work of a two-year project to evaluate the performance of a water-thinned polyurethane seamless flooring system. The goals of this project included: 1) To evaluate by laboratory tests and field demonstrations the performance and durability characteristics of a water-thinned polyurethane seamless flooring system; 2) To compare the performance of a water-thinned polyurethane system with solvent-thinned polyurethane systems and other conventional flooring materials; and 3) To recommend performance criteria for the selection of water-thinned polyurethane seamless flooring systems.

The project was divided into two phases, laboratory evaluation and field demonstration. Data obtained from local maintenance engineers at the 20 demonstration sites confirmed laboratory findings that the system did not compare favorably with conventional flooring systems for use in high traffic areas.

NBSIR 77-1402. The National Cancer Institute's Emergency Virus Isolation Facility: A case study for use in developing a methodology of post-occupancy evaluation, G. E. Turner, J. Elder, and A. I. Rubin, 72 pages (Dec. 1977). Order from NTIS as PB275410.

Key words: architectural analysis; architectural evaluation; architectural process; architectural research; building evaluation; building research; man and environment relations; people and buildings; post-construction evaluation.

The National Cancer Institute's Emergency Virus Isolation Facility is a laboratory building designed to provide an experimental research environment for all levels of hazardous work related to virus-cancer research. This report represents an attempt to develop a generalizable model for building evaluation through the analysis of the pre-design programming process and the post-construction operation management of the facility.

NBSIR 77-1403. A standard ergonomics reference data system: The concept and its assessment, H. P. Van Cott, J. J. Kramer, V. J. Pezoldt, L. G. Porter, C. Fried, J. V. Fechter, J. J. Pensky, and W. H. Teichner, 183 pages (Dec. 1977). Order from NTIS as PB275527.

Key words: anthropometry; consumer product technology; engineering psychology; ergonomics; human engineering; human factors; human performance; product safety; standard reference data.

This report culminates a feasibility study effort aimed at assessing the needs of industry, government and the research community for standard ergonomics (human factors) data, proposing a system concept and preliminary plan for the development and operation of a standard ergonomics reference data system (SERDS) and assessing the scientific and technical challenges to be met in system implementation. The data base proposed here would provide, for the first time, a single point of access to reliable, current anthropometric, behavioral and physiological data for application to technology design. Critically evaluated numeric data, standardization and the conduct of a National Ergonomics Survey are the major focal points of the system concept.

NBSIR 77-1404. Control of mobile-ion contamination in oxidation ambients for MOS device processing, S. Mayo, R. Y. Koyama, and T. F. Leedy, 44 pages (Jan. 1978). Order from NTIS as PB276534.

Key words: double-wall oxidation tube; dry oxidation; mobile-ion contamination; MOS device processing; MOS devices; oxidation ambient control; oxide growth; semiconductor device processing; silicon dioxide; thermal silicon dioxide films.

An alternative method for controlling the mobile-ion contamination in the oxidation ambients for MOS device processing is explored. Mobile-ion contamination in silicon dioxide films thermally grown in dry oxygen at 1000 °C on silicon substrates has been studied by use of a double-wall fused-silica oxidation tube. The space between the tubes were alternatively filled with chlorine, room air, or sodium hydroxide gas to determine if a correlation exists between the presence of these substances in the jacket and the mobile-ion density in the oxide films. MOS capacitors were prepared on these films and mobile-ion densities were measured using conventional C-V techniques. The ion densities ranged from 10^{13} to 10^{10} cm⁻² as a function of the jacket atmosphere. These preliminary results suggest that there is a correlation between the presence of cleaning or contaminating agents in the jacket and the mobile-ion density in the oxide films. Both cleaning and contaminating actions occur through the tube wall.

NBSIR 77-1405. Determination and verification of thermal response factors for thermal conduction applications, B. A. Peavy, 33 pages (Apr. 1978). Order from NTIS as PB283011.

Key words: dynamic conduction heat transfer; heat transfer; thermal response factor; verification.

New formulas for calculating thermal response factors for multiple-layer construction have been developed by a rigorous derivation. A comparison was made of the time for computation between the presently used matrix algebra method and the method given in this paper. Results were obtained using the new method in one-fiftieth to one-half of the computational time necessary to obtain solutions from the matrix algebra method. Comparisons with another analytical method were performed to verify the accuracy of the response-factor technique.

NBSIR 77-1409. **The equation of state for ammonia**, L. Haar and J. Gallagher, 23 pages (Dec. 1977). Order from NTIS as PB276005.

Key words: ammonia; correlation; gas; liquid; thermodynamic properties; thermodynamic surface.

An outline is presented of the basic results of the extensive correlation for the thermodynamic properties of ammonia recently completed at this laboratory. Computer programs are presented for the calculation of thermodynamic properties in the range including the triple point temperature to 5/3 the critical temperature and pressures from the dilute gas to 8000 bar.

NBSIR 77-1411. **International research—The FY 1977 survey of CBT's international programs**, M. Olmert, Ed., 84 pages (Mar. 1978). Order from NTIS as PB279403.

Key words: building practices; building research; codes and standards; housing; international cooperation; technology transfer.

This report presents the international research activities of the Center for Building Technology during the transition quarter and Fiscal Year 1977. In general, the objectives of this work were to spread the results of building research worldwide in hopes of creating a better built environment. Last year CBT continued working closely with less-developed countries to improve their building practices. The Center also continued cooperative research efforts with a number of countries that have acknowledged expertise in particular areas of building research, such as England, Israel, and France, to name but a few. On such projects, the Center pursued common research goals alongside the building researchers from other nations on studies of critical importance to all nations, such as energy and natural resources conservation.

NBSIR 77-1413. **Proceedings of the 8th Annual Conference of the National Conference of States on Building Codes and Standards**, S. A. Berry, Ed., 146 pages (Jan. 1978). Order from NTIS as PB280113.

Key words: ASHRAE 90-P; building codes; mobile homes; National Conference of States on Building Codes and Standards; NCSBCS; proceedings; 8th Annual Conference.

This document contains the edited proceedings of the 8th Annual Conference of the National Conference of States on Building Codes and Standards (NCSBCS), held in Santa Fe, New Mexico, April 27-May 1, 1975.

In addition, it includes listings of the State Delegates and Committee members for the 8th Annual Conference Year, and the Committee Reports, as finalized, submitted and approved by the State Delegates to NCSBCS, meeting in Annual Session.

NBSIR 78-874. **Disseminating standards of time and frequency: Issues in the evaluation of alternative systems**, R. H. F. Jackson, 32 pages (Mar. 1978). Order from NTIS as PB279684.

Key words: cost-benefit; cost-effectiveness; dissemination; frequency standard; time standard.

Since 1923 the National Bureau of Standards (NBS) has broadcast standards of time and frequency over dedicated radio stations. Recently, the Bureau's Time and Frequency Division (TFD) has implemented programs of cost reduction at these radio stations. In addition, TFD undertook a study to identify and evaluate alternative modes of disseminating these standards in a search for methods to reduce costs further and to improve the quality of services offered. The primary purpose of this report is to document the economic issues involved in this study by discussing the problem in terms of both cost-benefit analysis

and cost-effectiveness analysis. Preliminary cost studies for some of the dissemination alternatives are also included.

NBSIR 78-877. **Helium heat transfer and refrigeration in support of magnetic fusion energy systems**, V. Arp, J. A. Brennan, P. J. Giarratano, W. R. Parrish, W. G. Steward, T. R. Strobridge, and R. O. Voth, 138 pages (Feb. 1978). Order from NTIS as PB285231.

Key words: efficiency; heat transfer; helium; pressure measurement; refrigeration; stability; superconducting magnets; transient heat transfer.

This is the first year-end report on a program of studies on cryogenic engineering data in support of magnetic fusion energy projects. The report is divided into four parts: (1) an assessment of the cryogenic engineering data base used in the MFE community, and recommendations for needed work for that base, (2) experimental progress on measurement of transient helium heat transfer; the data are of importance for magnet stability analysis; (3) presentation of a newly developed general technique for analyzing the efficiency of helium refrigerators of any configuration and thereby identifying sources of inefficiency, and (4) progress towards setting up a data bank on refrigeration system reliability. The technology assessment, item (1), is a revision of a preliminary version dated May 13, 1977, with inclusion of feedback received from both within and outside the MFE community.

Both the technology assessment, Part One, and the efficiency study, Part Three, have been formatted for individual publication subsequent to this report. The technology assessment will be distributed to those who received copies of the preliminary edition. The efficiency study will be submitted for publication in Cryogenics. Because of our fairly recent publication on transient heat transfer (Part Two, appendix A), it is appropriate to do further research in this field before writing it up for a follow-up publication in an outside journal.

NBSIR 78-879. **Earth Terminal Measurement System operations manual**, D. F. Wait, 268 pages (Apr. 1978). Order from NTIS as PB284589.

Key words: earth terminal; effective isotropic radiated power; figure of merit; measurement procedure; noise temperature; satellite communication.

The Earth Terminal Measurement System (ETMS) was developed by the National Bureau of Standards to make accurate measurements of earth terminal and satellite parameters such as figure of merit (G/T), antenna gain relative to a reproducible reference level, satellite effective isotropic radiated power (EIRP), and ratio of carrier power to the operating noise temperature (C/kT). Because of difficulties of using the standard earth terminal parameters to precisely characterize the earth terminal, the parameters noise equivalent flux (NEF) and noise ulterior flux (NUF) are introduced. NEF characterizes the earth terminal hardware, and it is defined so that it is largely independent of frequency and antenna elevation angle. Thus, it is easier to evaluate the "reasonableness" of a particular set of results in light of the other results taken at various frequencies and elevation angles. This manual includes the theory of the measurements, measurement procedures, measurement troubleshooting, interpretation of the results, and a discussion of the ETMS software.

NBSIR 78-880. **UHF impulse generator**, J. R. Andrews and E. E. Baldwin, 30 pages (Apr. 1978). Order from NTIS as PB282887.

Key words: avalanche transistor; impulse; impulse generator; pulse generator; spectrum; spectrum amplitude.

This UHF Impulse Generator generates a narrow impulse with a flat spectrum up to 1 GHz. The impulse amplitude is 55 volts and the duration is 365 ps. The maximum repetition rate is 1 MHz. This report describes the generator in detail and includes a complete parts list and printed circuit artwork.

NBSIR 78-881. Applications of the homomorphic transformation to time domain measurement problems, S. M. Riad and N. S. Nahman, 207 pages (June 1978). Order from NTIS as PB285206.

Key words: antenna scattering; deconvolution; dielectric spectroscopy; homomorphic transformation; modeling of sampling gates; signal processing; time domain measurements; time domain reflectometry.

This report presents a study of the theory and application of the homomorphic transformation to deconvolution problems occurring in time domain measurements in the picosecond time domain. A homomorphic deconvolution transform was developed and applied successfully to remove the time-windowing restriction required in many time domain measurements. Examples were presented including problems in time domain analysis of linear networks and dielectric spectroscopy, and scattering and multiple reflection in antenna (radiation) systems were considered and treated. Also considered was the development of a model for a 28 picosecond resolution feedthrough sampling-head, and the model's step response was computed. Simulation studies were performed using typical input waveforms and the oscilloscope model. The homomorphic transformation was used to deconvolve the model's impulse response from the simulated output. Comparison of the deconvolved output waveforms with the input waveforms showed agreement within the accuracy of the sampled-data simulation.

NBSIR 78-882. A modified Benedict-Webb-Rubin equation of state for gaseous and liquid oxygen, L. A. Weber, 37 pages (Apr. 1978). Order from NTIS as PB282487.

Key words: density; enthalpy; entropy; equation of state; oxygen; property computer program; PVT; saturation properties; specific heat.

New PVT data on oxygen at pressures to 800 atmospheres have been recently reported. These data, along with other NBS data on oxygen, have been fitted with 32 term modified Benedict-Webb-Rubin equation of state. This equation is valid for gaseous and liquid oxygen at temperatures from the triple point (54.36 K) to 300 K and for pressures up to 800 atm. Thermophysical properties calculated via this equation are compared with the most reliable values available. The vapor pressure equation has also been updated to be consistent with more recent experimental work near the triple point. A computer program is available which calculates the thermophysical properties of oxygen.

NBSIR 78-883. Atmospheric propagation equations used in the NBS Earth Terminal Measurement System, W. C. Daywitt, 45 pages (Apr. 1978). Order from NTIS as PB282505.

Key words: atmosphere; downlink carrier-to-noise density ratio (C/kT); earth-terminal gain-to-noise-temperature ratio (G/T); error analysis; refraction angle; satellite communications; satellite effective isotropic radiated power (EIRP); transmission coefficient.

A derivation of equations for approximating the atmospheric refraction angle and transmission coefficient is outlined. The approximations apply in the 1 GHz to 10 GHz frequency range and are accompanied by systematic error estimates. They are used in the NBS Earth Terminal Measurement System for quasi-real-time calculations concerned with the measurement of

earth-terminal gain-to-noise-temperature ratio (G/T), satellite effective isotropic radiated power (EIRP), and downlink carrier-to-noise-density ratio (C/kT).

NBSIR 78-884. Materials studies for magnetic fusion energy applications at low temperatures—I, F. R. Fickett and R. P. Reed, 361 pages (Apr. 1978). Order from NTIS as PB282444.

Key words: data compilation; low temperatures; mechanical properties; physical properties; stainless steel; welding.

The reports presented here summarize the work of the low temperature materials research project for the first year of the program. The various projects are outlined and the research results are presented. The major thrust of the measurements has been the evaluation of the low temperature properties of stainless steel base metal and welds, with particular emphasis on the nitrogen strengthened stainless steels. Some initial work has also been done on the production and properties of non-metallics, primarily industrial laminates, for low temperature applications. A handbook of material properties is also planned. A survey of low temperature materials needs and problems related to magnetic fusion energy, performed by NBS as ground-work for the program, is included as is a brief description of the first workshop held in October 1977.

NBSIR 78-885. The role of superconductivity in the space program: An assessment of present capabilities and future potential, D. B. Sullivan, Ed., 163 pages (May 1978). Order from NTIS as PB283729.

Key words: computers; digital electronics; gravitational studies; high-Q cavities; infrared detectors; magnetometers; magnets; microwave detectors; space; superconductivity.

This report describes the results of a study designed to assess the role which superconductivity might play in the U.S. Space Program. The study was performed by members of the staff of the Boulder Laboratories of the National Bureau of Standards. Six technical subject areas were considered; high field magnets, magnetometers, digital electronics, high-frequency detectors, instruments related to gravitational studies and ultra high-Q cavities. The study identifies a number of applications of superconductivity which are of potential interest to NASA. Wherever possible, the devices are related to specific types of space missions.

NBSIR 78-886. Feasibility study of orbiting standards platform, A. J. Estin and R. C. Baird, 47 pages (June 1978). Order from NTIS as PB286489.

Key words: antenna gain; antenna measurements; antenna pattern; antenna sidelobes; EIRP; G/T ; metrology for satellite communications.

This report consists of four components of a feasibility study for a satellite-based measurement system for determining important operational parameters of satellite communications systems and its major sub-systems. We have addressed the questions of required accuracy, methods of attaining and maintaining measurement accuracy and traceability, system tradeoffs, and economic impacts and benefits.

NBSIR 78-888. SHF impulse generator, J. R. Andrews and E. E. Baldwin, 77 pages (June 1978). Order from NTIS as PB285233.

Key words: avalanche transistor; impulse generator; J band; microwave; picosecond; spectrum amplitude; step recovery diode; time domain.

A super-high-frequency (SHF) impulse generator designed and built by the National Bureau of Standards is described in

detail. The generator produces three different waveforms. The first is a simple impulse of 1 volt amplitude (3 V option) and 60 ps duration with a useful spectrum (15 dB down) extending from low frequencies out to 9 GHz. The second waveform is a single cycle 5 GHz sine wave (doublet) of 0.8 volts peak-to-peak amplitude (1.6 V option). Its useful spectrum extends from 0.5 GHz to 11.7 GHz. The third waveform is an exponentially damped rf pulse. It has a center frequency of 12.5 GHz and a damping time constant of 1/4 ns. The peak-to-peak amplitude is 0.8 volts. The useful spectrum extends from 6 GHz to 18 GHz.

NBSIR 78-891. Guidelines for specification and procurement of measurement instrumentation, J. King, H. S. Peiser, and R. C. Sangster, 27 pages (June 1978). Order from NTIS as PB285238.

Key words: developing countries; instrumentation; measurement; procurement; purchasing; technical specifications.

Guidelines are presented for specification and procurement of measurement instrumentation, for use by establishments in developing countries. They were developed in conjunction with a short course on this subject, presented in 1976 to a group of measurement experts from developing countries, by the Denver Research Institute of the University of Denver, Denver, Colorado, USA, under contract from the National Bureau of Standards, with funding from the Agency for International Development. Topics covered include trends in instrumentation, responsibilities of technical and purchasing staff members, motivation for purchase and specific purposes or goals, development of functional specifications, search for and evaluation of suppliers and candidate instruments, development of detailed specifications, identification of conditions of sale, issuance of requests for quotation and evaluation of bids, purchase order issuance and follow-up, formal acceptance of purchased equipment, and post-sale relations with seller.

NBSIR 78-895. Earth terminal measurement system maintenance manual, J. P. Wakefield, 195 pages (Sept. 1978). Order from NTIS as PB288567.

Key words: earth terminal measurement system; effective isotropic radiated power; figure of merit; noise temperature; satellite communication.

This manual describes the equipment and maintenance procedures to support the earth terminal measurements system (ETMS) developed by the National Bureau of Standards for making measurements of earth terminal and satellite parameters such as figure of merit (G/T), antenna gain relative to a reproducible reference level, ratio of carrier power to the operating noise temperature (C/kT), and satellite effective isotropic radiated power (EIRP). System equipment specifications, site set-up instructions, equipment theory of operation, troubleshooting and maintenance are included. This manual does not include measurement theory nor measurement operating procedures that are described in the Earth Terminal Measurement System-Operation Manual.

NBSIR 78-1143A. Plan for the development and implementation of standards for solar heating and cooling applications, D. Waksman, J. H. Pielert, R. D. Dijkers, E. R. Streed, and W. J. Niessing, 58 pages (June 1978). Order from NTIS as PB283237.

Key words: buildings; solar energy; standards.

The plan, concerning the need, implementation and general scope of standards which may be required for solar heating and cooling applications, has been updated to reflect the progress made in the development of these standards. Overviews of the

building regulatory system in the United States are given along with a listing of the various standards which will be required for the various solar systems, subsystems, components and materials. These include Test Method Standards, Recommended Practice Standards and Specification Standards. Activities relative to standards implementation include laboratory accreditation and certification. A list of training activities and manuals of accepted practice is presented. The development of standards for solar applications by the Federal Government are outlined, as well as the potential interface and utilization of the existing consensus standards generating organizations.

NBSIR 78-1305A. Provisional flat plate solar collector testing procedures: First revision, D. Waksman, E. R. Streed, T. W. Reichard, and L. E. Cattaneo, 65 pages (June 1978). Supercedes NBSIR 77-1305. Order from NTIS as PB283721.

Key words: durability/reliability; fire safety; rating criteria; solar collectors; structural performance; testing procedures; thermal performance.

This document represents the first revision to NBSIR 77-1305. The test methods contained in this report and the provisional rating criteria presented in an appendix are intended for use in determining the thermal performance, and to aid in the assessment of the safety and durability/reliability of flat plate solar collectors. These test methods and rating criteria have been selected after the review of over 400 accepted industry standards and are consistent with the intent of the U.S. Department of Housing and Urban Development (HUD) Minimum Property Standards (MPS) and the Interim Performance Criteria (IPC) prepared by the National Bureau of Standards (NBS) for the Department of Energy (DoE) and HUD respectively. Many of the test methods and rating criteria contained in this report are preliminary in nature and will be evaluated during a collector testing program being sponsored by DoE. It is, therefore, recommended that regulatory agencies consider the developmental status of these procedures in evaluating their suitability for adoption. It is intended that revisions will be made as more experience is gained and inputs received from appropriate industry representatives, testing laboratories, designers, etc.

NBSIR 78-1395. Performance guidelines for a modular integrated utility system, D. J. Mitchell, 92 pages (Nov. 1978). Order from NTIS as PB289783.

Key words: conservation; integrated utilities; performance guidelines; residential utilities; total energy; utilities.

Performance Guidelines for a Modular Integrated Utility System (MIUS) is an aid to construct conceptual, preliminary and final designs for a specific MIUS to be built in a particular geographic location.

This document defines generic performance of a MIUS serving a residential/commercial development. These performance requirements, criteria, and evaluations identify engineering parameters and other constraints associated with electrical service, thermal energy, solid waste management, potable water management, and wastewater management provided by a single, local, integrated source. There are also performance requirements, criteria, and evaluations for end-use considerations such as environmental impact, health, safety, and subjective acceptability. It is recognized that in view of the many possible combinations of MIUS designs, ownership, methods for implementation, local regulations, a MIUS implementor may wish to omit and/or greatly simplify many of the remaining performance requirements, criteria and evaluations contained herein.

NBSIR 78-1414 (CPSC). An evaluation of safety standards for gasoline and kerosene cans, C. E. Jones, 73 pages (Sept. 1977). Order from NTIS as PB276397.

Key words: children; containers; failure analysis; flammable fluids; gasoline; hazards; kerosene; safety; standards.

Accidents involving home use of gasoline and other flammable and combustible liquid containers were analyzed to define the functions a safe container should perform and how the containers failed to perform these functions. Safety standards were evaluated for applicability to these functional failures. The standards were considered inadequate to prevent child access to fluids in the containers, somewhat adequate for fluid management and isolation from ignition sources and very adequate for container structure and materials.

NBSIR 78-1415. Fire endurance tests of residential walls containing branch circuit wiring—Preliminary findings, L. A. Issen, 66 pages (Feb. 1978). Order from NTIS as PB277536.

Key words: branch circuits; electrical codes; fire endurance; fire tests; PVC; smoke; walls; wiring.

Two fire endurance tests were performed to study the effects of branch circuit electric wiring and wiring devices on the fire resistance of a gypsum board and wood stud one-hour fire-rated wall. The tests simulated potential fire spread between (a) horizontally adjacent occupancies and (b) vertically adjacent occupancies. Each test wall assembly included both non-metallic sheathed cable (type NM) and armored cable (type AC), with and without 3-1/2 inch thick glass fiber insulation. The tests were conducted with a slightly positive pressure in the furnace, to represent the overpressure generated in room fires.

The tests showed that the presence and penetrations of electric branch circuit cables and wiring devices lowered the fire resistance of a one-hour rated gypsum board and wood-stud wall by 13 minutes when based on flame penetration of the unexposed surface wallboard and by 23 minutes when based on flame penetration at the wiring devices. The tests showed no significant difference in the performance of the different cable types.

NBSIR 78-1416. Analyses of riding tests for evaluating the wet braking performances of bicycles, L. Mordfin, 32 pages (Apr. 1977). Order from NTIS as PB276398.

Key words: bicycles; brakes, bicycle; braking, wet; error analysis; friction, brake; friction, tire/pavement; kinetics, bicycle; measurements, bicycle braking; road tests; standards, bicycle safety; test methods, bicycle; wet braking.

The Consumer Product Safety Commission has expressed interest in the development of a riding test method for evaluating the braking performances of bicycles in wet weather. In this report three different testing approaches for caliper-braked bicycles are examined using kinetic analyses, a review of the literature, and an evaluation of available domestic and foreign test results. On the basis of the findings it is recommended that the riding test include the intentional wetting of both the bicycle brakes and the test pavement; the former to obtain meaningful results and the latter to enhance the repeatability of the test results. A tentative pass-fail criterion is also offered, based on a maximum wet stopping distance which, at this time, appears to be generally attainable only with bicycle wheels having aluminum-alloy rims. Error analyses of the test methods are presented.

NBSIR 78-1421. Fire hazard evaluation of BART vehicles, E. Braun, 23 pages (Mar. 1978). Order from NTIS as PB281383.

Key words: BART; fire accidents; fire hazards; fire safety; fire scenarios; mass transportation; material fire performance; rail vehicles; subway car design; UMTA.

A fire hazard evaluation of the subway cars used on the San Francisco Bay Area Rapid Transit District was performed. After analyzing the cars' interior and exterior design, five recommendations were made that, if implemented, would improve passenger safety by decreasing the probability of developing a hazardous fire situation. Among these recommendations were the upgrading of current upholstered urethane seat assemblies and the need for the development of a fire detection system appropriate for rapid rail transit vehicles. Those system improvements would not only provide passengers a safer traveling environment but would also provide a modest level of protection for the heavy investment in rail vehicles.

NBSIR 78-1422. Development of a data base for assessing plastics fire hazards, J. A. Slater, 38 pages (Apr. 1978). Order from NTIS as PB280027.

Key words: accident analyses; fire hazards assessment; flammability tests; hazard analysis; human behavior; plastic fires; plastics; product safety; residential fires.

The growing use of plastics has, in recent years, produced an increased concern over the potential flammability of plastics materials and products. In order to assess some of the real-life hazards associated with fire incidents involving plastics, a data base of residential fire accidents is being developed. The data consist of detailed case history reports based on a questionnaire form developed at the National Bureau of Standards and laboratory tests of samples retrieved at the fire scene. The major criteria for a fire incident to be included in the data base are that (1) an identifiable plastic product played a significant role in the fire and (2) the sequence of events can be partially reconstructed. Information is collected about the building environment in which the fire occurred, the products and the persons involved in the incident, the fire development and extinguishment. The field data are being coded and computerized. Sample tabulations of field and laboratory data from the first 25 accident cases are shown.

NBSIR 78-1423. ICST/IAT automation project experimental investigation of drill-bit wear, J. S. Hilten, C. F. Vezzetti, J. F. Mayo-Wells, and P. S. Lederer, 26 pages (Feb. 1978). Order from NTIS as PB278618.

Key words: cutting force; drill bit; drill press; dynamic; force; load; machine tool; measurement; on-line; tool wear; torque; transducer.

The development of an experimental instrumentation system for a small drill press is described. The parameters measured are spindle speed, vertical spindle displacement, vertical spindle load, drilling torque, and drilling time. Several test fixtures were instrumented and used in drilling experiments. These experiments were conducted to examine the relationship between variations in the measured parameters and drill performance, more specifically to drill wear. Experimental data show a 10-percent increase in drilling time from the first hole to the last for a single set of 500 holes drilled in cold-rolled steel at a nominally constant load, although the drilling time began to decrease slightly after hole 300. Changes in drilling torque were also detected during the test runs, and in similar runs with a brass workpiece. It is suggested that with respect to the anomalous results in steel under the unlubricated, constant-force conditions employed, the cutting surfaces of the drill bit were in a sense being renewed as microflakes of material departed to reveal fresh, sharp unburnished sites.

NBSIR 78-1424. ICST/IAT automation project—Bibliography and brief review of literature on machine-tool measurements for automatic control, C. F. Vezzetti, J. F. Mayo-Wells, J. S. Hilten, and P. S. Lederer, 55 pages (Apr. 1978). Order from NTIS as PB280581.

Key words: adaptive control; bibliography; control; cutting force; dynamic; force; load; machine tool; measurement; review; tool wear; torque.

An English-language literature survey focused on machine-tool measurements related to wear was undertaken to ascertain the types of sensors used and measurements made by investigators throughout the world in support of machine-tool automation. The resulting review and bibliography constitute this document.

NBSIR 78-1425. Institute for Computer Sciences and Technology publications, 1966-1976, A. G. Chattic, 140 pages (Apr. 1978). Order from NTIS as PB280361.

Key words: bibliography; computer literature; computer science publications; Institute for Computer Sciences and Technology publications.

This bibliography consists of the publications authored by personnel in the Institute for Computer Sciences and Technology (ICST), National Bureau of Standards (NBS), during the period from 1966 through 1976. The references, which total more than two hundred, are to publications in NBS media only. There are three cross-reference indexes to the bibliography: personal author index, key word index, and key word out-of-context (KWOC) index. Also included is a list of publications in the National Bureau of Standards Special Publication 500-series.

NBSIR 78-1426. Comparison of the performance of three algorithms for use in an automated transit information system (ATIS), J. F. Gilsinn, E. L. Leyendecker, and D. R. Shier, 164 pages (Mar. 1978). Order from NTIS as PB279066.

Key words: algorithms; algorithm testing; mass transit; routing; shortest paths; transit; transit information systems; transit routing; transportation; urban transportation.

This paper compares the performance of three algorithms for computing trip itineraries for use in an automated transit information system. One of the approaches (TIMEXD) is based on a time-expanded network. The other two both compute paths in a bipartite route/stop network; one algorithm (LABCOR) is based on the label-correcting approach and the other (LABSET) on the label-setting approach. The transit networks upon which the performance comparison is based are of two types: a grid network with specified, possibly nonuniform, distances between streets, and a spider web type of network. TIMEXD is fastest on all the larger networks, but it requires most computer storage and outputs paths with more transfers. LABCOR is the slowest, but is guaranteed to produce the best routing, since it always outputs an optimal path with fewest transfers. Computation time estimates extrapolated to large transit networks indicate times of 1.5 to 2.5 seconds per itinerary for TIMEXD and LABSET respectively, well within the acceptable range for such networks.

NBSIR 78-1427. Impact of the new copyright law on interlibrary loan in a research library, E. Cerutti and J. C. Tucker, 21 pages (Jan. 26, 1978). Order from NTIS as PB276907.

Key words: CONTU guidelines; copyright law; interlibrary loan; library cost-effectiveness analysis.

A study of interlibrary loan borrowing at the National Bureau of Standards Library in 1976 was made, to forecast the impact of the new copyright law on the Library budget. The study indicates that the majority of journals are requested only once, and that a number of foreign journals are requested. An analysis of subscription cost compared to interlibrary loan cost suggests criteria for management decisions on subscription, as well as testing the fairness of the CONTU guidelines in their economic impact on libraries.

NBSIR 78-1428. Survey of the occurrence of mercury, lead, and cadmium in the Washington, D.C. area, E. P. Scheide, J. J. Filliben, and J. K. Taylor, 98 pages (Sept. 1977). Order from NTIS as PB281725.

Key words: cadmium; computer techniques for environmental data; environmental data; environmental surveys; mercury; toxic materials.

This report describes the development of a plan to comprehensively survey the occurrence of potentially toxic substances in a defined geographical area and its application to the determination of the concentration levels of mercury, lead, and cadmium in various aspects of the environment in the Washington, D.C. area. It describes the basic philosophy of such a survey, the development of a sampling plan, and the identification of analytical methods adequate to obtain the required measurements. Methods of data reduction using the NBS computer are also described. The data are presented in tables and unique computer-generated plots which show the overall concentration profiles and spots of elevated concentration levels. No significantly hazardous conditions were found to exist. The approach followed and the data reduction techniques developed should be useful to surveys of these elements in other areas and also for surveys of ubiquitous hazardous materials in general.

NBSIR 78-1429 (Navy). The role of passive film growth kinetics and properties in stress corrosion and crevice corrosion susceptibility, J. Kruger, J. R. Ambrose, J. J. Carroll, and A. J. Melmed, 68 pages (Nov. 1977). Order from NTIS as PB281730.

Key words: crevice corrosion; field ion microscopy; iron; noncrystalline films; passive films; repassivation; sensitization; stainless steel; uranium; x-ray photoelectron spectroscopy.

This report consists of the following four parts: 1) Field Ion Microscopy Studies of the Interaction of Hydrogen with Selected Metals and Alloys; 2) The Role of Noncrystalline Films in Passivation and Breakdown of Passivation; 3) Effect of Chromium Depletion on the Repassivation Kinetics 18-10 Austenitic Stainless Steel in Sodium Chloride Solutions; 4) Composition of Surface Films Formed During the Repassivation of Iron and Iron-Molybdenum Alloys.

NBSIR 78-1430. An instrument to evaluate installed smoke detectors, T. G. K. Lee, 37 pages (Feb. 1978). Order from NTIS as PB278633.

Key words: aerosol generators; detector sensitivity; detector testers; light obscuration; particle size distribution; polydisperse aerosol; smoke detector.

An inexpensive portable instrument has been constructed to test the sensitivity response of installed fire smoke detectors. The test stream consists of impactor-selected small particles from aerosol generated by a pneumatic nebulizer and dilution air. The flow rate of the test stream is 140 L/min and its aerosol concentration can be varied from 10 to 60 mg/m³, sufficient to cover the sensitive ranges of the nine typical detectors tested. The aerosol mass median particle diameter of 0.46 μm and the breadth of the size distribution in terms of geometric standard deviation, is 1.5. The size distribution of the polydisperse aerosol at the output is independent of the aerosol concentration in the range of interest and is comparable to some fire smokes. Aerosol light obscuration as measured by a standardized photometer is linear with respect to the aerosol mass concentration (mg/m³) and has a ratio 2.3 m²/g for this aerosol compared to 1.5 m²/g for cotton lampwick smoke in the UL 217 chamber.

NBSIR 78-1434. **The macroscopic detection of corrosion in aluminum aircraft structures with thermal neutron beams and film imaging methods**, D. A. Garrett, 42 pages (Dec. 7, 1977). Order from NTIS as PB277074.

Key words: aircraft corrosion; corrosion; corrosion characterization; corrosion detection; corrosion quantification; hidden corrosion detection with neutron beams; neutron radiography.

The primary objective of this investigation was to determine the feasibility of detecting corrosion in aluminum Naval aircraft components with neutron radiographic interrogation and the use of standard corrosion penetrameters. Secondary objectives included the determination of the effect of object thickness on image quality, the defining of minimum levels of detectability and a preliminary investigation of means whereby the degree of corrosion could be quantified with neutron radiographic data.

All objectives were met and may be summarized as follows: (1) Environment-induced corrosion can be detected with high sensitivity by thermal neutron radiographic interrogation, (2) the fluence at the image plane required to visualize corrosion with conventional imaging methods e.g., a gadolinium converter in conjunction with a medium contrast industrial x-ray film at density of 2.5, is approximately 4×10^8 n-cm⁻². Assuming that a transportable neutron radiography system were capable of producing a flux of 1.5×10^4 n-cm⁻²-sec⁻¹ at an L/D ratio of 40:1, an exposure of 7.2 hours would be required, (3) at an L/D ratio of 40:1, the corrosion signatures of both surfaces of a thick object, e.g., a wing or airfoil, must be interrogated individually. This is due to the fact that geometrical unsharpness obliterates signature detail on the surface opposite the cassette. (4) The possibility of corrosion quantification does exist. This conclusion is based on an investigation with standard corrosion plaque penetrameters, and (5) although the use of ⁶LiF/ZnS light emitting converters is the most efficient method by which thermal neutron beams can be imaged, the results are inadequate for unambiguous signature analysis with presently available converters.

NBSIR 78-1435. **A decision model for U.S. computer export administration, a preliminary investigation**, P. L. Eagan, 24 pages (Feb. 1978). Order from NTIS as PB277539.

Key words: computer export model; computer model; decision model; export administration; export model; model; Soviet Union; U.S.S.R.

This is a preliminary report on the feasibility of designing a statistical decision model of U.S. computer export administration.

The study is based upon interviews with U.S. government officials involved in export administration and with academic analysts of U.S. and Soviet decision-making. Published materials related to East-West trade in high technology were also consulted.

The report addresses three general questions: 1) Is a statistical decision model of U.S. computer export administration feasible? 2) What method(s) will be required in developing a model? 3) How can the model assist those responsible for U.S. computer export administration?

Interviews and research materials indicate that a decision model of U.S. computer export is feasible. The major difficulty in designing such a model arises from the lack of commensurable indicators of the national security. Political and economic priorities are at stake in computer export administration. Without comparable measures of these priorities, operational utility statements for a decision model must be derived from estimates and informed value judgments of persons having substantive expertise in the strategic, political, and economic ramifications of U.S. high technology exports.

NBSIR 78-1436. **Flammability testing for carpet**, I. A. Benjamin and S. Davis, 14 pages (Apr. 1978). Order from NTIS as PB279372.

Key words: carpet systems; criteria; fire growth; flammability; flooring radiant panel test; testing.

As use of carpet has increased in recent years, more and more attention has been focused on different test methods for measuring its flammability.

The carpet industry, as well as regulatory agencies have been working on test procedures which would provide consumer protection and not be overly burdensome.

All carpet sold in this country must pass the "pill test." The pill test provides "first-to-ignite" protection for carpet flooring systems located within rooms or undivided building spaces.

Criteria have been proposed using the new Flooring Radiant Panel Test which provide equivalent safety to that level provided by the Life Safety Code. The Flooring Radiant Panel Test is both reproducible and related to "real world" performance. This publication explains the features of this test.

NBSIR 77-1437. **Solar energy systems—Standards for rubber seals**, R. D. Stiehler, A. Hockman, E. J. Embree, and L. W. Masters, 64 pages (Mar. 1978). Order from NTIS as PB280114.

Key words: rubber seals; solar collectors; solar energy systems; standards; test methods.

A study was performed to develop standards for rubber seals used in solar systems. Thirty preformed and liquid applied seals were evaluated in the laboratory using modified ASTM standard test methods to obtain data needed to prepare the standards. Also, studies were performed to develop a test method for determining the effects of outgassing on the transmittance of solar collector covers.

The results of the laboratory tests are presented and standards for rubber seals in solar energy systems are proposed.

NBSIR 78-1438. **Back-up report for the proposed standard for the flammability (cigarette ignition resistance) of upholstered furniture**, PFF 6-76, J. J. Loftus, 240 pages (June 1978). Order from NTIS as PB285173.

Key words: cigarette ignition; fabric classification; mock-up furniture samples; smoldering; upholstered furniture; upholstery fabrics.

This report brings together data, information, and reports generated by the Center for Fire Research (CFR) at the National Bureau of Standards (NBS) and by others during four years of work on the development of the test method. All of this information was used in the preparation of a recommended Proposed Standard for the Flammability (Cigarette Ignition Resistance) of Upholstered Furniture, PFF 6-76.

NBSIR 78-1440. **A literature review of fire and live load surveys in residences**, L. A. Issen, 28 pages (May 1978). Order from NTIS as PB281464.

Key words: design loads; fire; fire loads; household surveys; live loads; residential surveys; statistics of extremes.

A search of the literature shows that most load surveys have been concerned with commercial and industrial occupancies and only a few have dealt with residences. Many surveys have been inadequately reported from a statistical viewpoint, and the data have been misapplied. A common error has been to assume that the largest observed load is the largest expected load. The statistics of extremes should be used to determine reasonable design values. Methods for estimating the sampling size (for a prescribed accuracy) are given and illustrated with examples.

NBSIR 78-1441. **State metrication activities**, S. A. Berry, 25 pages (Mar. 1978). Available from author.

Key words: Construction Industries Coordinating Committee; Interstate Metric Committee; metrication; NCSBCS; State metric coordinators.

On October 19, 1976, the Chairman of the American National Metric Council's Construction Industries Coordinating Committee (CICC) requested the Center for Building Technology to conduct an inquiry of the States relative to their metric activities. The Center agreed to conduct this inquiry and the information gleaned from it, as well as some State information from the American National Metric Council and the NBS Office of Weights and Measures, is contained in this publication.

NBSIR 78-1442. **Algorithms for image analysis of wood pulp fibers**, R. A. Kirsch, 30 pages (Jan. 1978). Order from NTIS as PB278622.

Key words: algorithms; artificial intelligence; image analysis; morphological analysis; paper fibers; pattern recognition; pulp characterization.

Image analysis technology can be used to measure the visible morphology of pulp fibers. But before such measurements can be accepted, it is necessary to achieve precise definition of the necessary measurements in the form of suitable algorithms that have been experimentally tested on images of actual fiber data. We present such measurement results on both semiautomatically traced fiber data and on automatically scanned images. We explore the variety of definitions possible for some simple well known properties of wood fiber morphology by applying suitable algorithms to fiber image data. Finally, we suggest that this exploratory approach to the specification of the precise image analysis measurements needed in paper manufacturing can facilitate the introduction of a technology for process control that will result in savings in paper manufacturing cost and in reduction of energy requirements.

NBSIR 78-1443. **The effects of temperature and moisture on the accelerated aging of paper**, E. L. Graminski, E. J. Parks, and E. E. Toth, 75 pages (Mar. 1978). Order from NTIS as PB279046.

Key words: accelerated aging; alkali solubility; fiber degradation; paper degradation; paper permanence; wet strength.

The rate of paper degradation at elevated temperatures appears to be directly proportional to the partial pressure of atmospheric water up to 50 percent relative humidity. This linear relationship continues to exist at higher humidities at 60 °C but not at 80 °C. It is uncertain at this time whether the water in question is bound to cellulose or is atmospheric moisture. Additional degradation studies at relative humidities above 50 percent must be conducted in order to identify the type of water affecting the degradation rate. There is also an indication that either an optimum temperature exists for accelerated aging of paper or that the cellulose-water interaction at the higher temperatures and lower humidities differs significantly from that at ambient temperatures.

NBSIR 78-1444. **Semiconductor technology program—Progress briefs**, W. M. Bullis, Ed., 10 pages (Mar. 1978). Order from NTIS as PB284809.

Key words: electronics; integrated circuits; measurement technology; microelectronics; semiconductor devices; semiconductor materials; semiconductor process control; silicon.

This report provides information on the current status of NBS work in measurement technology for semiconductor materials, process control, and devices. Results of both in-house and contract research are covered. Highlighted activities include: analysis of X-levels in indium-doped silicon; evaluation of an electrical alignment test structure; correlations of gold density with leakage current in silicon; initial application of resonance ionization spectroscopy; calibration of second-generation line-width measurement artifacts; dopant profiling by dc measurements on MOSFETs; observation of an isotope shift in the sulfur deep level in silicon; development of a non-destructive test for second breakdown; analysis of scanning acoustic microscopy; and the third pacemaker workshop. In addition, brief descriptions of new and selected on-going projects are given. The report is not meant to be exhaustive; contacts for obtaining further information are listed. Compilations of current publications, publications in preparation, and scheduled talks are also included.

NBSIR 78-1444-2. **Semiconductor technology program—Progress briefs**, W. M. Bullis, Ed., 11 pages (July 1978). Order from NTIS as PB284478.

Key words: electronics; integrated circuits; measurement technology; microelectronics; semiconductor devices; semiconductor materials; semiconductor process control; silicon.

This report provides information on the current status of NBS work in measurement technology for semiconductor materials, process control, and devices. Results of both in-house and contract research are covered. Highlighted activities include: profiling of the Si-SiO₂ interface by Auger electron and x-ray photoelectron spectroscopies; use of the laser scanner to detect hairline cracks in solar cells; use of gated diodes in evaluation of CCD imager wafers; availability of silicon resistivity standard reference materials; observation of unintentional channeling effects in low-fluence random equivalent ion implantations; initiation of a comparative study of deep level measurements; implementation of the NBS-designed circuit for determining safe-operating-area limits of forward-biased transistors; observation of acoustic material signatures; availability of test pattern NBS-4; conduct of a workshop on moisture measurements; and comparison of carrier lifetimes as measured by the surface photovoltage and photoconductive decay methods. In addition, brief descriptions of new and selected on-going projects are given. The report is not meant to be exhaustive; contacts for obtaining further information are listed. Compilations of recent publications and publications in press are also included.

NBSIR 78-1446. **Management of data elements in information processing**. Proceedings of the Third National Symposium, held at NBS on 1977 September 28-30, H. E. McEwen, Ed., 154 pages (Apr. 1978). Order from NTIS as PB279661.

Key words: American National Standards; American National Standards Institute; data; data base systems; data elements; data management; data processing; Federal Information Processing Standards; information interchange; information processing; information systems.

Accelerated technological advances in computers and communications make possible the integration of data systems and the exchange of data among them on an expanding scale. However, the full effect of these advances cannot be realized unless the need for uniform understanding of the common information (data elements) and their expression in data systems is recognized and a means provided to effectively manage this information. The increasing interrelationships among data systems of Federal, State and local governments, and with industry and the

public add emphasis and dimension to the need for the improved management of data in information processing.

These Proceedings are for the Third National Symposium on the Management of Data Elements in Information Processing held at the National Bureau of Standards on 1977 September 28-30. In these Proceedings, 27 speakers discuss data element management in the field of health care, energy, paperwork management, data dictionary/directories, data resource management, trade data standards and museum data. *These proceedings include the following papers (indented):*

Energy information—Top priority for today, T. M. Albert, *NBSIR 78-1446*, pp. 1-5 (Apr. 1978).

Key words: economic impact; energy; energy problems; information gathering; oil embargo.

Standardization of data elements and machine-readable symbol to facilitate blood banking, E. Brodheim, *NBSIR 78-1446*, pp. 7-18 (Apr. 1978).

Key words: blood banking; machine-readable symbols; optical bar codes; standardization.

A technical profile of representative government developed data element dictionary/directory systems, P. K. Brown, *NBSIR 78-1446*, pp. 19-23 (Apr. 1978).

Key words: data element dictionary; data element directory; data element dictionary/directory; data resource management; requirements definition; software selection.

Cargo Data Interchange System (CARDIS), R. J. Cavanaugh, *NBSIR 78-1446*, pp. 25-33 (Apr. 1978).

Key words: CARDIS; cargo data interchange system; common database facilities; information exchange; international trade.

American National Standards Institute (ANSI), W. Duel, *NBSIR 78-1446*, pp. 35-37 (Apr. 1978).

Key words: accredited organization method; American National Standards Committee method; American National Standards Institute; ANSI; canvass method; standardization.

Management of data elements in information processing. (Needs for standards in the health care field and a sampling of current applications), G. J. Duffy, *NBSIR 78-1446*, pp. 39-41 (Apr. 1978).

Key words: health care; information processing; management of data elements; standards for health care.

Data processing in natural history museums, T. G. Gautier, S. G. Shetler, and C. Black, *NBSIR 78-1446*, pp. 47-57 (Apr. 1978).

Key words: collections; data elements; data problems; data standardization; museums; natural history; networks.

Standards for electronic data interchange, E. A. Guilbert, *NBSIR 78-1446*, pp. 67-70 (Apr. 1978).

Key words: electronic data exchange; standards; TDCC; Transportation Data Coordinating Committee.

General concept of a data resource directory system, C. E. Hankerson, *NBSIR 78-1446*, pp. 71-89 (Apr. 1978).

Key words: Data Resource Directory System; data resource management; DRDS; functional requirements; hierarchy of functions; records management.

International standards activities of the Economic Commission for Europe, E. A. Hemley, *NBSIR 78-1446*, pp. 91-95 (Apr. 1978).

Key words: alignment; automatic data processing; common access reference number; dangerous goods; data requirements; Department of Transportation; documentation standardization; Economic Commission for Europe; export documents; import documents; legal questions; National Committee on International Trade Documentation (NCITD); Office of Facilitation; United Nations; Working Party on Facilitation of International Trade Procedures.

The Federal Information Locator System, F. W. Horton, Jr., *NBSIR 78-1446*, pp. 97-112 (Apr. 1978).

Key words: duplication study; Federal Information Locator System; Federal Reports Act; information directory; information processing standards.

The urgent need for energy information standards. (To "Btu" or not to "Btu"), R. W. Kline, Jr., *NBSIR 78-1446*, pp. 113-118 (Apr. 1978).

Key words: energy information standards; energy programs; Federal Interagency Council on Energy Information; National Energy Information System.

Criteria for the selection of data dictionary/directory systems, B. K. Plagman, *NBSIR 78-1446*, pp. 119-134 (Apr. 1978).

Key words: data base management systems; data dictionary/directory system; DD/DS; evaluation and selection process; evaluation of DD/DS packages.

Some history of traditional trade documents, R. J. Porter, *NBSIR 78-1446*, pp. 135-137 (Apr. 1978).

Key words: bill of lading; CARDIS; commercial invoice; computerized international documentation system; data; drafts; general average; inventory records; letters of credit; Shipper's Export Declaration; trade data; trade documents.

Data resource management, D. B. Schneider, *NBSIR 78-1446*, pp. 139-140 (Apr. 1978).

Key words: data directories; data resource management; management; records keeping.

NBSIR 78-1448. Full-scale burning behavior of curtains and draperies, L. D. Moore, 44 pages (Mar. 1978). Order from NTIS as PB281537.

Key words: curtains; draperies; flammable fabrics; full-scale fires.

To better understand the burning in room fire development, 38 full-scale drapery and curtain burn experiments were conducted in a 3×4.9 (10×16 ft) room. The variables investigated included fabric and lining type, fabric weight, and position of the draperies (open vs. closed). As each burning experiment progressed a number of conditions were continuously monitored such as rate of drapery consumption, air temperature increase, smoke and toxic gas generation, and radiant energy developed. Ignition of sample wall and ceiling panels was also monitored.

NBSIR 78-1449. The effects of herbicides on masonry, J. E. Fearn, 25 pages (May 1978). Order from NTIS as PB281563.

Key words: acidic; alkaline; degradation; herbicide; historic structures; masonry.

In preserving historic structures, the control of obnoxious vegetation is a serious problem. To deal with this problem, a number of organic herbicides have been developed by industry. The efficacy of herbicides in the control of plant life has been studied to a great degree; but heretofore, very little has been reported about the possible effects of these chemical plant killers on the materials they are designed to protect. In this work, an exhaustive survey of pertinent literature has been undertaken. Obtaining very little specific information from literature, a correlation has been drawn between the effects of masonry of materials similar in chemistry to herbicides and the effects that would be expected from the herbicides themselves. Methods for checking the validity of conclusions are suggested.

NSBIR 78-1450. Product selection for the voluntary consumer product information labeling program, E. C. McDowell, E. M. Robertson, and S. M. Spivak, 58 pages (Mar. 1978). Order from NTIS as PB281628.

Key words: consumer information; consumer products; labeling; selection.

The U.S. Department of Commerce has commenced a voluntary consumer product information labeling program (CPILP). Any person may propose products to be labeled under that program. This document presents a method for screening proposed products to determine whether they are appropriate for labeling. The method also provides a foundation for documenting a finding of need for a label.

NSBIR 78-1452. An evaluation of children's biting strength for toy safety criteria, Y. Wu, 18 pages (Mar. 1978). Order from NTIS as PB281801.

Key words: bite opening; biting force; biting strength; cusps; dentitions; duration of sustained maximum biting force; hardness of enamel; occlusal area.

Children's biting strength (biting force over the occlusal area) is one of the major parameters in evaluating the bite induced broken-toy hazard. The estimation of biting strength includes the assessments of controlling factors that influence the maximum biting force and the occlusal area. Values for biting strength are discussed accordingly. Since only the maximum biting forces (over a constant area of measuring device) of the deciduous molars or the first permanent molars are given in the literature, and since the biting strength of single opposing molars is approximately equal to that of two adjacent opposing molars, the maximum biting forces for single molars are evaluated. In the interest of child safety, the highest biting strength (biting force and area) of upper age group in a given age bracket is recommended. Other parameters, such as molar bite opening, time for sustaining maximum biting force, and the hardness of the enamel of teeth are also discussed.

NSBIR 78-1454. The evaluation of search units used for ultrasonic reference block calibrations, D. J. Chwirut and G. D. Boswell, 30 pages (Feb. 1978). Order from NTIS as PB280311.

Key words: ASTM standards; calibration; nondestructive evaluation; reference blocks; search units; specifications; transducers; ultrasonics.

The effects of using different (nominally identical) quartz search units in the evaluation of ASTM-type standard reference blocks are determined. Various characteristics of the search units are measured and correlated with the amplitude of the ultrasonic response from reference blocks to determine which characteristics must be specified if reproducible results are to be obtained. It is shown by a series of experiments that the exact shape of the distance-amplitude curve in water (axial profile) is a primary characteristic that must be considered.

When operational corrections for differences in axial profiles are made, the variability in ultrasonic responses from reference blocks, measured with different search units, is reduced from about 25 percent to 4 percent.

NSBIR 78-1456. Comments on the analysis of total photoabsorption measurements in the energy range 10-150 MeV, L. C. Maximon and H. A. Gimm, 33 pages (June 1978). Order from NTIS as PB283682.

Key words: atomic screening corrections; Coulomb corrections; pair production; photonuclear data; total photon absorption cross section; triplet production.

This note deals with details of the procedure used to extract photonuclear cross sections from total photon absorption measurements. We examine closely some of the approximations implicit in the expressions available for the purely electromagnetic cross sections, most especially pair production, triplet production and the Compton effect, which must be subtracted from the measured photoabsorption in order to obtain photonuclear cross sections. We single out those aspects of the expressions for these electromagnetic processes which most warrant further theoretical research in that they constitute the principal source of uncertainty in the extraction of nuclear data.

NSBIR 78-1457. Statistical model for random errors of position location based on lines of position, J. R. Rosenblatt, 14 pages (Mar. 1978). Order from NTIS as PB281158.

Key words: aids to; least squares; navigation; position location; statistics.

The U.S. Coast Guard's Aids to Navigation Positioning Project has proposed that procedures for routine determination of positions be revised to include redundant observations for assessing precision and accuracy of the results. This report provides a statistical model and a method for calculating a confidence region for the position location.

NSBIR 78-1458. Projecting the age distribution of full-time permanent professional staff at the National Bureau of Standards, L. S. Joel, 71 pages (Mar. 1978). Order from NTIS as PB280301.

Key words: data analysis; discrete Markov models; manpower planning models; simple Markov models.

This report presents a simple mathematical model to project the age distribution of the full-time permanent professional (FTPP) staff of the National Bureau of Standards. The report includes a brief description of types of models currently in use for manpower analyses, discussion of the probable data requirements for reliable models, some staff profile information which supplements material in recent administrative reports, and the description of our model. The principal projection is that under "status quo" assumptions, (FTPP staff size, age distribution of hires, and the separation rates from age cohorts remain constant) the FTTP staff will in about 25 years reach a steady-state age distribution with average age about 1/2 year higher than its current level (just over 42 yrs.). Comparison of this distribution with the present one shows moderate increases in the fractions of staff in ages 21-30 and 51-60, a fractional rise in turnover, and a general decrease in the groups 31-50 years old. A near term effect is the intensified loss of senior scientists.

NSBIR 78-1459. Characterizing the interfiber bonding of paper pulps: Effect of preparation pressure on tensile test specimens, J. C. Smith and E. L. Graminski, 36 pages (Oct. 1977). Order from NTIS as PB280291.

Key words: mixed waste paper; paper, interfiber bonding; paper, low-density handsheets; paper, pulp characterization; paper recycling; paper, tensile testing.

Handsheets in the form of low-density open webs of grammage 2.5 g/m² were prepared from Northern and Southern softwood kraft pulps. These handsheets, from pulps unbeaten and beaten for 5,000 revolutions in a laboratory beater, were pressed at 44, 350 and 660 kPa (6.4, 51.2 and 96 lb/in²) during preparation. The relative density of bonding between fibers and the relative strength of the bonds were estimated from tensile strength data. It was found that the quality of bonding between fibers in the webs was not affected by preparation pressures between 44 kPa and 660 kPa, but webs prepared at the higher pressure tended to stick to the backing plate, thus incurring some damage upon removal.

NBSIR 78-1460. The degradation of gas-fired water heaters, G. F. Sushinsky, 45 pages (June 1978). Order from NTIS as PB284491.

Key words: degradation; energy efficiency; mineral deposits; performance degradation; test methods; water heaters (gas-fired).

The energy efficiency degradation of gas-fired water heaters was measured in laboratory tests of old water heaters collected from different sections of the country. Three other forms of degradation (lifetime, safety, and performance degradation) were also identified. The causes and potential effects of each degraded condition were assessed through literature surveys. Supplementary laboratory evaluations were conducted in the areas of energy efficiency and performance degradation. Reductions in the recovery efficiency of water heaters of 5 percentage points were measured, while simulated performance declines in excess of 20 percent were noted. Larger decreases in recovery efficiency are expected for water heaters containing significant deposits of scale or sediment.

NBSIR 78-1462. Elasticity of transit demand with respect to price: A case study, R. E. Schofer, 45 pages (Mar. 1978). Available from author.

Key words: elasticity; elasticity of transit demand; pricing; transit planning; transit pricing.

This report describes the methodology and the results of an empirical study of peak-period transit demand elasticity with respect to price (fare). Field observations were structured to capture the reactions of morning (in-bound) commuters to a peak-period fare increase introduced on September 1, 1975. The study is limited to bus and automobile travelers on the Shirley Highway and bus passengers on the Lee Highway, both in Northern Virginia. The Shirley buses provide express service on exclusive freeway lanes, whereas the Lee Highway buses provide traditional service on a signalized radial arterial. Various impacts are identified, quantified and compared.

Demand for service on the Shirley Highway Express buses is less elastic (-0.274 to -0.218) than that for the traditional Lee Highway bus service (-0.535 to -0.273). There was little evidence of passengers on either service shifting travel outside the peak-periods to avoid higher fares. The fare increase had no effect on auto travel. These results suggest applying different pricing policies to different types of transit service.

NBSIR 78-1463. Studies on the photodegradation of poly(methyl methacrylate), M. Abouelezz and P. F. Waters, 62 pages (May 1978). Order from NTIS as PB281828.

Key words: degradation; photodegradation; poly(methyl methacrylate); UV.

Although poly(methyl methacrylate), PMMA, is known to degrade when exposed to ultraviolet radiation, studies at wavelengths other than 253.7 nm have not been done. The lack of knowledge about the mechanism of degradation of PMMA at wavelengths other than 253.7 nm hinders efforts to develop

short-term test methods for predicting the long-term performance of PMMA in applications in which it is exposed to sunlight. This study was performed to determine the effect of ultraviolet radiation on PMMA and to identify mechanisms of degradation induced by radiation.

Thin films of PMMA of two different molecular weights were irradiated with radiation nominally of 253.7 nm and 300 nm. The irradiations were conducted in air and under vacuum. Exposure at 253.7 nm caused a rapid decrease in molecular mass and loss of a small amount of volatile products, which is a characteristic of random chain scission. The quantum yield was greater in air than in vacuum. Changes in the molecular mass and the glass transition temperature as well as weight loss data indicating that wavelengths bands at greater than 253.7 nm also cause degradation. The data further indicate that the degradation at the longer wavelengths may not be completely random scission.

NBSIR 78-1466. Evaluation of new portable x-ray fluorescent lead analyzers for measuring lead in paint, A. P. Cramp and H. W. Berger, 59 pages (May 1978). Order from NTIS as PB282254.

Key words: accuracy; calibration; evaluation; lead; paint; poisoning; portable; precision; radiation; references; substrates; x-ray fluorescent.

Portable x-ray fluorescent lead analyzers offer the most cost-effective and adaptable means for the nondestructive detection and measurement of lead in paint in housing. However, commercially available portable lead analyzers have had poor accuracy and precision below lead levels of about 3.0 milligrams of lead per square centimeter of surface area. This is particularly serious because the current operational criteria for lead paint hazard abatement, 1.5 or 2.0 mg/cm of lead maximum (used in many communities) is in this range. They have also performed relatively unsatisfactorily with regard to serviceability and maintenance. Two new portable lead analyzers based on x-ray fluorescence have been developed under HUD contracts. The prototypes of one of these devices have shown considerable improvement over previously available instruments in terms of accuracy, portability, and user characteristics. This report discusses the performance and operating characteristics of the new lead analyzers.

NBSIR 78-1467. Influence of some wetting parameters on bicycle braking performance, L. Mordfin, 14 pages (Jan. 1978). Order from NTIS as PB282260.

Key words: bicycles; braking, bicycle; braking, wet; consumer product safety; measurements, bicycle braking; riding tests; safety, bicycle; standards, bicycle safety; test methods, bicycle; wet braking.

One approach toward evaluating the braking capability of a bicycle in wet weather involves riding tests in which the stopping distance of the bicycle with wet brakes is measured from a preselected initial speed. The results of some domestic and foreign riding tests of this kind are reviewed. It is found that the amount of water available at the brake surfaces, above some small minimum, is not significant. There are some sparse data that suggest that the manner of wetting (e.g., hose, trough or rain) may affect the test results but this evidence is questionable due to the uncharacterized influences of other test parameters. Recommendations for additional tests are given.

NBSIR 78-1468-1. Committee on the challenges of modern society rational use of energy pilot study modular integrated utility systems project, Vol. 1: Description, activities and products, M. H. Nimmo and C. W. Phillips, 101 pages (June 1978). Order from NTIS as PB283428.

Key words: CCMS, CCMS-MIUS project; information exchange; integrated utility systems; international information exchange; MIUS; report to CCMS plenary.

This report by the Committee on the Challenges of Modern Society—Modular Integrated Utility Systems (MIUS) Project includes a description of the project, its objectives, the chronology of the project, a description of its activities and products, copies of its products (appendices A-E), and minutes of its meetings. This report further discusses the progress of each activity and product and gives the committee's recommendations, which call for the continuation of the project activities.

The objectives of the CCMS-MIUS Project were to identify MIUS Type of Projects in participating countries and to develop a mechanism for transferring technical data concerning these products to experts in the participating countries. The project had its first meeting in Brussels, April 10-11, 1975 and its last meeting in Turin, July 12-14, 1977.

The project produced a glossary of special terms, a project summary form for the International Project Catalog, and a list of research needs in MIUS Type of Projects. It began development of a project progress/evaluation report, a standard methodology for measuring the performance of MIUS Type of Projects and a paper on "Incentives and Barriers." The glossary is expected to promote a greater understanding of terms unique to MIUS and the project summary form was developed to seek project descriptions for the catalog. The catalog identifies MIUS Type of Projects and the project progress/evaluation report provides progress of a project and technical information for purposes of evaluation and comparison. The standard methodology identifies the type of information required for measuring the performance of a MIUS Type of Project and the collecting and reporting of data.

NBSIR 78-1468-2. Committee on the challenges of modern society rational use of energy pilot study modular integrated utility systems project, Vol. 2: Minutes of project meetings, M. H. Nimmo and C. W. Phillips, 144 pages (June 1978). Order from NTIS as PB283429.

Key words: CCMS; CCMS-MIUS project; information exchange; integrated utility systems; international information exchange; MIUS; report to CCMS plenary.

This report by the Committee on the Challenges of Modern Society—Modular Integrated Utility Systems (MIUS) Project includes a description of the project, its objectives, the chronology of the project, a description of its activities and products, copies of its products (appendices A-E), and minutes of its meetings. This report further discusses the progress of each activity and product and gives the committee's recommendations, which call for the continuation of the project activities.

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formance of a MIUS Type of Project and the collecting and reporting of data.

NBSIR 78-1471. The role of economic analysis in the development of energy standards for new buildings, S. R. Petersen, 48 pages (July 1978). Order from NTIS as PB284044.

Key words: benefit-cost analysis; building economics; building standards; energy conservation; life-cycle building costs; performance standards.

The Federal Government and a number of states are currently developing energy conservation standards for new buildings. This report suggests that economic considerations be incorporated directly into the standards development process. A life-cycle benefit-cost approach to standards development can provide a systematic and objective framework for standards specification. Differences in climate, building type, energy cost, and operational requirements can be directly incorporated into the standard as they impact energy-related benefits and costs. It is shown that the life-cycle costs associated with any given overall conservation goal can be reduced by developing an economically balanced standard. In addition, it suggests that a standard which has as its goal the minimization of life-cycle costs will likely lead to greater effective energy savings than alternative approaches. Specific suggestions for the incorporation of economic analysis into the standards development process are made.

NBSIR 78-1472. Materials for fuel cells, L. H. Bennett, M. I. Cohen, A. L. Dragoo, A. D. Franklin, A. J. McAlister, and K. F. Young, 133 pages (July 1978). Order from NTIS as PB285360.

Key words: cerium dioxide; electrocatalysis; electrochemical measurements; fuel cells; phosphoric acid; polarization; refractory hard metals; sodium beta alumina; solid electrolytes.

Research is described on hydrogen oxidation electrocatalysis on a number of compounds related to WC. Compounds in the series of $Mo_{1-x}W_xC$, with $x \sim NO_2$, were found to be active, although some uncertainty exists as to the purity of the samples. Some activity was also noted in $W_{0.5}Ti_{0.5}C$ and rhenium metal. Experiments on the preparation of MoP and FeP₂ are described.

The microprocessor-controlled potentiostat for electrochemical measurements was completed and is described in detail.

Experiments on several techniques for the preparation of very finely-divided Y-doped CeO₂ powder are described. The powders to serve as raw materials for hot-pressing pure, dense, homogeneous ceramics. Straight sintering of some of these specimens yield densities of 95-97 percent theoretical.

The equivalent circuit previously suggested appears to fit very well the frequency-dependence of the impedance of sintered specimens of Ce_{0.9}Y_{0.1}O_{1.95} with sputtered or evaporated Pt electrodes. The bulk part of the data is independent of Po₂ and varies with porosity as expected. An activation energy for the crystal conduction were obtained in agreement with literature values. High temperature instability in the Pt electrodes was observed. The electrode polarization impedance is well-fitted by a Cole-Cole expression. It cannot be attributed to a model proposed earlier involving oxygen atom diffusion in the Pt electrode.

Internal friction experiments on a single crystal of Na β -Al₂O₃ are interpreted in terms of the Na⁺ ion motion.

NBSIR 78-1473. Optical materials characterization, A. Feldman, D. Horowitz, R. M. Waxler, and M. J. Dodge, 23 pages (May 1978). Order from NTIS as PB283222.

Key words: BaF₂; CdF₂; MgF₂; NaCl; SrF₂; linear thermal expansion; photo-elastic constants, CaF₂; piezo-optic constants; thermal coefficient of refractive index; thermo-optic constant.

The piezo-optic constants of CaF₂, BaF₂, and SrF₂ have been measured at 0.6328 μm and 1.15 μm . The temperature dependence of the refractive indices of CdF₂, MgF₂, and NaCl have been measured at several wavelengths in the infrared by the method of Fizeau interferometry. The linear thermal expansion coefficients of NaCl and CdF₂ as a function of temperature are also presented.

NBSIR 78-1474. Measurement techniques for high power semiconductor materials and devices: Annual Report, January 1 to December 31, 1977. F. F. Oettinger, Ed., 85 pages (May 1978). Order from NTIS as PB281723.

Key words: d-c transmission; deep level measurements; energy conservation; measurement methods; photovoltaic method; power-device grade silicon; resistivity variations; silicon; spreading resistance measurements; thermally stimulated measurements; thyristor materials measurements; thyristor measurements.

This annual report describes NBS activities directed toward the development of measurement methods for semiconductor materials and devices which will lead to more effective use of high power semiconductor devices in applications for energy generation, transmission, conversion, and conservation. It responds to national needs arising from rapidly increasing demands for electricity and the present crisis in meeting long-term energy demands. Emphasis is on the development of measurement methods for thyristors and rectifier diodes.

The major tasks under this project are (1) to evaluate the feasibility of the photovoltaic method as a rapid, nondestructive technique for characterizing the resistivity uniformity of high-resistivity, large-diameter silicon wafers, (2) to evaluate the use of thermally stimulated current and capacitance measurements and other deep level measurement techniques as a means for characterizing lifetime controlling or leakage source defects in power grade silicon material and devices, and (3) to develop procedures to enable spreading resistance measurements of thyristor starting material and layer profiles to be made on a reliable basis.

NBSIR 78-1475. Air leakage measurements in three apartment houses in the Chicago area. C. M. Hunt, J. M. Porterfield, and P. Ondris, 27 pages (June 1978). Order from NTIS as PB283722.

Key words: air infiltration; air leakage; low income housing; sulfur hexafluoride tracer.

Air infiltration measurements were made in three apartment houses in the Chicago area using SF₆ as a tracer gas. Two were in tenement districts and one was suburban. Data were collected in selected apartments in each building, and these data were used to estimate the infiltration rate for the entire building. Whole building estimates of 0.94 and 1.2 air changes per hour were obtained under the conditions of tests in the tenement apartments, and 0.82 air changes per hour in the suburban apartment.

Comparisons of the tightness of individual dwelling units by fan pressurization-depressurization techniques were also made. The suburban apartment was found to be much tighter than the other two apartments. The difference was much greater than predicted by the tracer tests.

An analysis of the ASHRAE Crack Method is also made.

NBSIR 78-1476. Precision laboratory standards of mass and laboratory weights. T. W. Lashof and L. B. Macurdy, 27 pages (Oct. 1978). Order from NTIS as PB288661.

Key words: laboratory weights; mass standards; precision laboratory weights; precision mass standards; weights.

National Bureau of Standards, Circular 547, Section 1, "Precision Laboratory Standards of Mass and Laboratory Weights," served for many years as a defining authority for various classes of weights and associated adjustment tolerances. Technological and organizational changes which occurred within a few years after the issuance gradually led to its obsolescence and consequently, it has been out of print for some time. In the interim, a new standard ASTM E617-78, "Lab Weights Precision Mass Standards," has been issued updating the same subject matter. There are still numerous requests for Circular 547 since it is widely referenced in the literature. While the document is reprinted in its entirety in NBS Handbook 77, this source is also out of print and available only at certain depository libraries. Because of technical content and historical value of Circular 547, it is being issued in the NBSIR series of documents, to be available through NTIS. It should be noted, however, that for matters concerning calibration, one should refer to the latest copy of NBS SP250, "Calibration and Test Services of the National Bureau of Standards," available from the Office of Measurement Services.

NBSIR 78-1477. Exploratory study of temperatures produced by self-heating of residential branch circuit wiring when surrounded by thermal insulation. R. W. Beausoliel, W. J. Meese, and L. S. Galowin, 54 pages (July 1978). Order from NTIS as PB284711.

Key words: branch circuit wiring; electrical fires; heat generation in receptacles; insulated buildings; overheating conductors; residential branch circuit wiring; thermal insulation and electrical wiring.

The purpose of the work presented in this paper was to make preliminary determination under laboratory conditions of temperatures that might develop on residential electrical wiring covered by thermal insulation when carrying rated currents or currents slightly above rated values.

The results show that temperatures on conductors surrounded by thermal insulation can greatly exceed the maximum service temperatures for the wire insulation. Results also show that some types of insulation currently used to retrofit buildings may fill wall outlet boxes and contact the current carrying elements and connections of duplex receptacles.

This study indicates need for a concentrated study of temperatures that might develop on residential electrical wiring covered by thermal insulation.

NBSIR 78-1479. Thermodynamic data for waste incineration. E. S. Domalski, W. H. Evans, and T. L. Jobe, Jr., 165 pages (Aug. 1978). Order from NTIS as PB284659.

Key words: heat of combustion; heat of explosion; miscellaneous materials; specific heat; vapor pressure.

A table of thermodynamic data of 331 selected materials has been compiled for the purpose of providing engineers with information on materials which are not easily identifiable by a stoichiometric formula. Examples of such materials are: foods, wood species, oils, animals, plants, polymers, etc. The table is arranged alphabetically according to the names of the various materials, and whenever possible, the chief components or all readily identifiable components are supplied. In addition, the physical state, the kind of thermodynamic property, specific-property values, and citations to a list of 142 references are furnished. In order to assist the reader with finding a specific material or property, a material name and property index has been put together. A section on Units and Definitions explains the various thermodynamic properties being reported and the condition under which they apply. An appendix supplies aux-

iliary information on symbols for thermodynamic quantities, units, physical constants and atomic weights.

The table is oriented more toward engineers involved in the disposal of municipal wastes than any other group; however, applications in other engineering and scientific sectors can easily be made.

NBSIR 78-1482. Government programs on advanced technology and manufacturing techniques: Comments on U.S.A., Japan, and Europe. W. M. Bullis, 16 pages (June 1978). Order from NTIS as PB283223.

Key words: cooperative technology; electronics; foreign competition; integrated circuits; semiconductor technology; VLSI.

For many years the U.S. semiconductor industry benefited significantly from government-financed technology developments, principally in the areas of defense and space. In recent years, however, government policies and actions have tended to reduce both the level of direct government support of device research and the incentives for private sector investment in this area. At the same time intense competition from foreign producers and major government-financed programs to advance integrated circuit technology, especially in Japan, have threatened the U.S. technological lead in semiconductor device technology. These international challenges are being viewed by many in the industry as requiring responsive efforts by the Federal Government. One such response could be in the form of technological cooperation between government and industry in areas where the industry may desire assistance in solving generic design, manufacturing, or testing problems. The Department of Commerce is considering new mechanisms for carrying out such cooperative efforts. These mechanisms are described following a brief review of other past and present government programs in advanced technology and manufacturing techniques—both here and abroad.

NBSIR 78-1483. NBS: Properties of electronic materials, J. R. Manning and R. L. Parker, 116 pages (June 1978). Order from NTIS as PB283707.

Key words: convection; corrosive reactions; crystal perfection; flame inhibition; microgravity; solidification; solutal convection; surface tensions.

This report describes NBS work for NASA in support of NASA's (Materials Processing in Space) Program covering the period April 1, 1977 to March 31, 1978.

The results obtained for each task are given in detailed summaries in the body of the report. Briefly, in Task 1—Surface Tensions and their Variations with Temperature and Impurities—surface tension measurements have been made for gallium using the pendant drop technique and some complex effects ascribed to impurities were observed. In Task 2—Solutal Convection and Liquid Diffusion Coefficients—the onset of convective and interfacial instabilities during the vertical directional solidification of a binary alloy has been determined theoretically by means of a linear stability analysis. In Task 3—Determination of Crystal Perfection—a study has been performed on the improvement in resolution of x-ray imaging systems for real-time assessment of crystal perfection. In Task 4—A Thermochemical Study of Corrosion Reactions in Oxide Materials—the system $KFeO_2-Fe_2O_3$ has been examined over portions of the subsolidus region, and the occurrence of a beta alumina structure-type at 85.2 mole percent Fe_2O_3 has been observed. In Task 5—Gravity Effects on Flame Inhibition—a high pressure sampling mass spectrometer facility has been designed and construction on it is nearly completed.

NBSIR 78-1484 (HEW). Arousal from sleep by emergency alarms: Implications from the scientific literature, V. J.

Pezoldt and H. P. Van Cott, 37 pages (June 1978). Order from NTIS as PB284044.

Key words: alarms; arousal; auditory arousal thresholds; emergency signals; fire alarms; sleep research.

A review of the sleep research and other scientific literature pertaining to the arousal of sleeping individuals by external stimuli is reported. This effort was undertaken to provide information about the characteristics of emergency alarms which will reliably awaken a sleeping population, especially nursing home residents, in the event of fire. The literature reviewed does not provide an adequate basis for specifying signal characteristics which will offer a high assurance of producing arousal. Among the factors that influence the intensity of a signal which will produce arousal are the age and physical/mental condition of the sleeper, drug use, sleep stage, time of night, and meaningfulness or personal significance of the signal. Data relevant to these variables are discussed as is the problem of performance following abrupt arousal. Recommendations regarding stimulus characteristics, measures of arousal and the experimental environment for future studies of arousal by emergency alarms are presented.

NBSIR 78-1485. Low velocity performance of a ball bearing vane anemometer, L. P. Purtell, 20 pages (June 1978). Order from NTIS as PB284864.

Key words: airflow; anemometer; laser velocimeter; low velocity; performance; vane anemometer; wind tunnel.

Performance of a ball bearing vane anemometer is evaluated over the speed range of 23 to 724 feet per minute including starting speed and stopping speed. The tests were performed in the NBS Low Velocity Airflow Facility which provides a uniform flow of low turbulence and utilizes a laser velocimeter as the velocity standard.

NBSIR 78-1486 (DOE). Development of in-situ techniques for the detection and measurement of corrosion of copper concentric neutrals in underground environments, J. Kruger, U. Bertocci, E. Escalante, and J. L. Mullen, 60 pages (June 1978). Order from NTIS as PB283708.

Key words: buried cables; copper concentric neutral wires (CCN); corrosion detection methods; current-potential measurements; underground corrosion.

The report describes the work done on the second year of a three-year project whose purpose is to develop in-situ methods for detecting corrosion on buried copper concentric neutral (CCN) wires. Potential and polarization measurements on buried cables have been performed, and methods for distinguishing the signals of interest from interference due to a.c. applied to the cables, as well as d.c. earth currents, have been developed. The soil around one of the buried cables has been modified in order to make the environment more corrosive.

Laboratory measurements to test possible corrosion detection techniques have been performed. Current-potential data so far obtained have been analyzed. Impedance measurements have also been tested, but results indicate that the method is not very well suited for corrosion detection. Analysis of electrochemical noise has been developed and tested, and measurements on some electrochemical systems carried out.

NBSIR 78-1487. A cost benefit analysis of proposed Federal input/output channel level computer interface standards, T. Pyke, Ed., 37 pages (June 1978). Order from NTIS as PB282406.

Key words: computer peripherals; computer standards; computer systems; interface standards.

This report summarizes the results of an analysis of the cost savings that are expected to accrue to the Federal Government through use of four proposed Federal input/output channel level computer interface standards. The analysis is based on the best available data, and the results are intended to be a best conservative estimate of the potential Federal Government cost savings that will occur through the use of the proposed interface standards to increase competition in the procurement of computer peripheral equipment. The analysis concludes that the Federal Government will accrue cost savings through use of this standard of over \$55 million during the five year period beginning in FY 1979.

NBSIR 78-1488. Measurement techniques for solar cells, Quarterly Report: September 15 to December 31, 1977, D. E. Sawyer, H. K. Kessler, and H. A. Schafft, 32 pages (July 1978). Order from NTIS as PB283881.

Key words: device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurement; sheet resistance; solar cells; solar cell stability.

This is the quarterly report of the work performed in the three month period September 15-December 31, 1977. The objectives of the program are to assist the DOE thin-film photovoltaic effort by developing solar cell device and material measurement techniques using the NBS-developed laser flying-spot scanner, and by assisting DOE in organizing and hosting appropriate workshops and symposia and providing general consultation and liaison services.

Several possible applications of the laser flying-spot scanner to solar cells are discussed including measurement of the spatial variation in cell response versus bias light to map cell behavior under various insolation conditions, measuring magnitude and spatial variation in cell emitter sheet resistance, and determining emitter metallization regions making poor ohmic contact. Additions and modifications to the optical and mechanical portions of the scanner made to enhance its usefulness for solar cells are described. An analysis is presented for scanning, with light modulated at high frequencies, the most common solar cell geometry. The results predict that the cell emitter sheet resistance can be obtained by analyzing the laser display screen presentation. Scanner background information is included in an appendix.

The outline of the Workshop on the Stability of (Thin Film) Solar Cells and Materials is presented. This workshop is scheduled to be held May 1-3, 1978 at NBS, Gaithersburg.

NBSIR 78-1490. Standards referenced in the National Building Code, J. M. Hicks, Jr., Suppl. to NBSIR 76-1140, 43 pages (July 1978). Order from NTIS as PB284819.

Key words: building codes; building regulations; building regulatory systems; model building codes; standards.

This report is a supplement to NBSIR 76-1140, "Standards Referenced in Selected Building Codes," published by the U.S. Department of Commerce, National Bureau of Standards, and is intended to provide a base for assisting the building community in updating, utilizing and maintaining the standards referenced in the 1976 edition of the National Building Code promulgated by the American Insurance Association. In addition to identifying each standard referenced in the code, this publication lists the current date of the standard, its title, the date of the code and the locations within the code where the standard is referenced.

NBSIR 78-1493. Cutting experiments with plastic edges, S. K. Wakamiya, 40 pages (June 1978). Order from NTIS as PB287861.

Key words: cut; edge; force; injury; pig skin; plastic; velocity.

An investigation was conducted to determine the skin lacerating ability of plastic edges. The purpose of this study was to obtain quantitative experimental data on which to base a test procedure and a safety criteria for identifying potentially hazardous plastic edges found on toys and children's articles.

A variety of plastic edges including plastic replicas of edges taken from toys were used to cut excised, defatted pig skin. Cutting experiments were performed at various forces and velocities and the depth of the resulting cuts were measured.

Test results indicate that over the range 5 cm/s to 127 cm/s the relative velocity between the test edge and the skin sample apparently does not significantly affect the cutting of skin whereas the normal force exerted by the edge on the skin has a definite effect on the cutting performance of plastic edges.

The experimental data obtained in this study shows that there are some types of plastic materials, which when broken, form edges with lacerating abilities similar to that of the reference sheared steel edges, which were judged "marginally safe" when tested with the Consumer Product Safety Commission (CPSC) Metal Sharp Edge Test. However, the results of this study indicate that most plastic edges found on toys are less likely to cause laceration injuries than these reference steel edges.

NBSIR 78-1495. Factors affecting the durability of adobe structures, P. W. Brown, C. R. Robbins, and J. R. Clifton, 41 pages (July 1978). Order from NTIS as PB286096.

Key words: adobe; clay; particle size distribution; soluble salt analysis; weathering; x-ray analysis.

Adobe samples from three sites of historic interest in the State of Arizona were analyzed to determine their mineral assemblages, particle size distributions, soluble salt contents, and porosities. These analyses were accompanied by microscopic observations of polished sections and thin sections. These data were correlated with the weathering observed and it was found that soluble salt action was responsible for the deterioration of the adobe from one of the sites. The nature of the particle size distribution has resulted in the rapid deterioration of the adobe from a second site. The adobe from a third site was found to be well consolidated due to the presence of large amounts of calcite.

NBSIR 78-1497. A preliminary study of the fire safety of thermal insulation for use in attics or enclosed spaces in residential housing, D. Gross, 48 pages (July 1978) Order from NTIS as PB285186.

Key words: attics; Federal specifications; fire test; flame spread; loose-fill; mineral fiber; residences; smoldering; thermal insulation.

An evaluation was made of the appropriateness of the flammability requirements in Federal specifications for loose-fill cellulosic and mineral fiber insulations and mineral fiber batts and blankets. This included an analysis of currently used standard test methods for measuring insulation flammability or combustibility and their principal limitations. To provide for more meaningful evaluations, a review was made of fire statistics and of likely fire occurrences, particularly for retrofit insulation in attic and enclosed spaces of residential buildings. A series of laboratory tests was conducted using an attic floor radiant panel test and a cigarette smoldering test to simulate flaming and smoldering exposures. Mockup tests on attic floor sections were conducted to validate the extent of flame spread on attic insulation and the initiation of smoldering ignition from covered recessed light fixtures. Based on these tests, changes were recommended to Federal Specifications HH-1-515C, HH-1-521E and HH-1-1030A.

NBSIR 78-1499. **An evaluation of existing models describing the migration of additives in polymers**, I. C. Sanchez, S. S. Chang, F. L. McCrackin, and L. E. Smith, 69 pages (July 1978). Order from NTIS as PB284492.

Key words: additives; diffusion; food additives; indirect additives; migration; models; regulation.

The objective of this work is the development of mathematical models that describe the migration of a variety of small molecules in polymers that have applications in food contact uses. In the most general cases, these models will be able to predict the amount of additive migration given any particular time and temperature history. These models can serve as the technical basis for more efficient regulatory methods under existing frameworks or in the design and implementation of new indirect additive regulations or policy.

The first steps in the development and assessment of such models are given in this report. The first section presents a preliminary survey of migration data applicable to food contact situations that are available in the current literature. The second section surveys available models describing migration and evaluates their present and potential utility.

NBSIR 78-1500. **Application of life cycle costing to hand-held hair dryers: A field demonstration for small appliances**, S. W. Stiefel, P. C. Goodman, and W. B. Beine, 50 pages (May 1978). Order from NTIS as PB284495.

Key words: field data collection techniques; hair dryers; instrumented usage data; life cycle costing; repair data; small appliances.

This report describes a demonstration project on hair dryers which applied the life cycle costing technique to a small appliance where the consumer is a significant factor in its usage. Described are the field data collection techniques: including an experiment to collect use, energy consumption and repair data from participants provided with specially instrumented hair dryers. Repair and repair cost data were also obtained from collecting used hair dryers for failure mode analysis and from repair agency surveys.

The lessons learned provide insights into the application of the life cycle costing technique to other small appliances. This study indicated individuals' recalled estimates for usage significantly exceed the metered values. It is important, therefore, that measurement instruments be used as much as possible to collect usage data. The importance of developing test methods based upon controlled field use experience was in part substantiated by the inability to obtain failure rate data. Some of the individuals who contributed failed hair dryers still under warranty did not want to be troubled by the nuisance, delay and expense involved with obtaining a repair. If such an attitude is pervasive, feedback of failure rate data for inexpensive appliances may be incomplete even during warranty periods.

NBSIR 78-1502. **Smoke measurements in large and small scale fire testing**, R. W. Bukowski, 40 pages (Oct. 1978). Order from NTIS as PB278870.

Key words: fire testing; ionization chamber; light extinction; light scattering; Mie scattering; Rayleigh scattering; smoke measurements.

The extinction beam photometer is the most widely used instrument for taking smoke measurements in fire testing. Most existing designs were found to be inaccurate and unreliable for measurements where smoke detection performance is evaluated due to the low levels of smoke present at activation. Accordingly, a new extinction beam photometer design was developed which will provide the stability and accuracy necessary for these measurements. The paper describes the new design and proposes its adoption as an industry standard.

The paper also discusses the need for a reference ionization chamber instrument and a reference measurement which relates to gas sensing fire detectors.

NBSIR 78-1503. **State adopted building regulations for the construction of manufactured buildings—An analysis**, P. W. Cooke and R. M. Eisenhard, 215 pages (July 1978). Order from NTIS as PB284685.

Key words: building regulation; construction; enforcement; inspection; legislation; manufactured building; rules and regulations; standards.

This report summarizes the status and characteristics of State adopted building regulatory programs specific to the construction of manufactured buildings. Included are tabularized data and summary information relative to: technical codes upon which regulations are based; extent to which established technical provisions contained in recognized national model codes have been amended by certain States; differences from a regulatory standpoint between each State's treatment of manufactured building construction and conventional construction; occupancy classifications and type of compliance assurance activities covered by each State's program; definitions for "manufactured building" and related terms as defined in State regulations.

NBSIR 78-1504. **Fire research publications, 1977**, N. H. Jason, 13 pages (July 1978). Order from NTIS as PB284462.

Key words: bibliographies; building fires; carpets; compartment fires; fire detection systems; fire suppression; fire tests; flame research; flammability tests; smoke; smoke detectors; standards; toxicity.

"Fire Research Publications, 1977" is a supplement to the previous editions: 1969-72, NBSIR 73-246 (NTIS Order No. COM-74-10989, \$3.25); 1973, NBSIR 74-511 (NTIS Order No. COM-74-11448, \$3.25); 1974, NBSIR 75-736 (NTIS Order No. COM-75-11018, \$3.25); 1975, NBSIR 76-1120 (NTIS Order No. PB-257837, \$3.50); 1976, NBSIR 77-1277 (NTIS Order No. PB-269965, \$3.50).

Only publications prepared by members of the Center for Fire Research (CFR), by other National Bureau of Standards (NBS) personnel or external laboratories under contract or grant from the CFR are cited. Articles published in NBS house organs also are cited.

NBSIR 78-1508. **Human response to fire: Three designs for research**, F. I. Stahl, 33 pages (Mar. 20, 1978). Order from NTIS as PB284959.

Key words: architectural psychology; environmental psychology; fire escape; fire safety; human research; research design.

As a group, empirical investigators of the responses of building occupants to emergencies employ idiosyncratic, nonreplicable techniques for research design, data acquisition, and data analysis. As a result, it has been difficult to explain the influence of many, often uncontrolled, variables. This shortcoming has frequently rendered research findings indeterminate and noncumulative. This paper explores three exemplary research design strategies, each aimed at mitigating these problems by introducing a greater degree of rigor into the study of human responses to fires. Both exploratory and experimental designs are considered in various problem contexts.

NBSIR 78-1512. **Some theoretical aspects of fire induced flows through doorways in a room-corridor scale model**, J. G. Quintiere and K. DenBraven, 37 pages (Oct. 1978). Order from NTIS as PB287510.

Key words: buoyancy flows; compartment fires; corridor; experiment; flow coefficients; room; scale-model; theory.

Fire induced flows were measured in a 1/7th scale model room-corridor by measuring velocity and temperature profiles in the room and corridor exit doorways. The corridor exit door width was varied by a factor of 10 as an experimental parameter while the average fire room temperature was held constant. The applicability of an orifice flow model to predict the doorway flows was examined. The ratio of measured to theoretical mass flow rate, defined as the flow coefficient, was found to vary with door width and flow direction. The coefficient ranged from 0.4 to slightly greater than 1. No explanation has been developed to account for this variation.

NBSIR 78-1513. Measurement techniques for solar cells—Quarterly report: January 1 to March 31, 1978, D. E. Sawyer, H. K. Kessler, and H. A. Schafft, 18 pages (Sept. 1978). Order from NTIS as PB287519.

Key words: device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cells; solar cell stability.

This is the quarterly report of the work performed in the three month period January 1-March 31, 1978. The objectives of the program are to assist the DOE thin-film photovoltaic effort by developing solar cell device and material measurement techniques using the NBS-developed laser flying-spot scanner, and by assisting DOE in organizing and hosting appropriate workshops and symposia and providing general consultation and liaison services.

A technique simpler than the one using light modulated at high frequencies, described in the previous quarterly report, is set forth which employs forward-biasing solar cells during scanning to pin-point certain cell defects and to obtain values of cell quantities such as emitter sheet resistance. An analysis appropriate for laser scanning forward-biased cells with a line source is presented. Results from initial experiments suggest that the new technique should work quite well on real-world solar cells. Apparatus development work included the design and initial construction of a high-sun insolation source for forward-biasing cells by light while scanning, and the construction of a matching network to couple the low-impedance illuminated cell to the scanner display electronics.

The announcement and program for the May 1-3, 1978 Workshop on the Stability of (Thin Film) Solar Cells and Materials at NBS is presented.

NBSIR 78-1514. A computer simulation of human behavior in building fires: Interim report, F. I. Stahl, 133 (Sept. 1978). Order from NTIS as PB289272.

Key words: architectural psychology; architectural research; building fires; computer-aided design; fire computer program; fire research; fire safety; human performance; model documentation; modeling technique; programming; simulation.

This interim report presents the conceptual development, structure, and function of BFIREs, a computer program designed to simulate human movement behavior during building fires. The basic model underlying BFIREs is derived from a nonstationary, discrete time Markov Process. This model postulates that occupants construct their emergency responses and behavioral decisions dynamically, in response to continually changing social and environmental information fields. The simulation of this process is accomplished through BFIREs, a computer program written in FORTRAN V. Directions for further study are discussed.

NBSIR 78-1520. Ultrasonic transducer power output by modulated radiation pressure (with details), M. Greenspan, F. R. Breckenridge, and C. E. Tschiegg, 53 pages (July 1978). Order from NTIS as PB289961.

Key words: calibration of transducers; medical ultrasonics; modulated radiation pressure; nondestructive evaluation; radiation pressure; transducers; ultrasonic transducers.

We have set up and are using an apparatus for the measurement of total sound power output of a piezoelectric transducer radiating into water. This apparatus combines the better features of previously used methods which depend on radiation pressure. The input is modulated at a low frequency and the output power is intercepted by a target which experiences a force at the modulation frequency. The target is mounted on the armature of an electromagnetic receiver provided with an independent coil through which a current at the modulation frequency is adjusted in amplitude and phase, either manually or automatically by feedback, to arrest the motion of the armature. When the armature is stationary the force depends only on the current, and the apparatus can be calibrated using direct current and dead weights. It is thus absolute. In practice, the carrier frequency is swept over any part of the range 0.1 to 15 MHz while a recording of power output versus frequency is made. The results of comparisons made with those of other methods are encouraging. Examples of curves from normal and defective transducers are shown.

NBSIR 78-1522. Characteristics of incidental fires in the living room of a mobile home, D. P. Klein, 69 pages (Sept. 1978). Order from NTIS as PB291426.

Key words: chairs; compartment fires; crib fires; fire tests; ignition source; incidental fires; mobile homes; repeatability; source fires; upholstered furniture.

A series of fire tests was conducted in the corner of a mobile home living room. The corner was lined with interior finish materials which did not contribute to the fires. The test series was designed to examine the fire characteristics of typical incidental (low intensity) fires which may be used as the ignition source for tests to evaluate the effects of interior finish materials.

This test series involved three types of source fires: standardized wood cribs ranging in weight from 2.3 kg to 13.6 kg (5 lb to 30 lb), identically constructed upholstered chairs and polyethylene waste containers filled with crumpled newsprint. Experimental measurements were made of burn rate, temperature, heat flux, flame height, smoke density, and concentrations of oxygen, carbon monoxide, and carbon dioxide.

Under the test conditions employed, it was found that the fire severities for the several sizes of standardized wood cribs fell between those for the polyethylene waste containers filled with crumpled newsprint and the more severe incidental fires produced by the 16 kg (35 lb) upholstered chairs in terms of characteristics such as maximum temperature and heat flux levels, flame height, and changes in oxygen, carbon monoxide and carbon dioxide concentrations. Of the fires with wood cribs, it was found that the fires with 13.6 kg (30 lb) standardized wood cribs were most similar to the fires with 16 kg (35 lb) upholstered chairs, although the peak burning rate was generally higher for fires with upholstered chairs than for fires with wood cribs. It was also found that the time to reach the period of active burning was more reproducible for fires with wood cribs than fires with upholstered chairs.

NBSIR 78-1524. Low velocity performance of a jewel bearing vane anemometer, L. P. Purtell, 21 pages (Sept. 1978). Order from NTIS as PB291410.

Key words: airflow; anemometer; laser velocimeter; low velocity; mine ventilation; performance; vane anemometer; wind tunnel.

Performance of a jewel bearing vane anemometer is evaluated over the speed range of 60.6 to 752 feet per minute including starting and stopping speed. The tests were performed in the NBS low Velocity Airflow Facility which provides a uniform flow of low turbulence and utilizes a laser velocimeter as the velocity standard.

NBSIR 78-1525. Climate data abbreviation for the computerized calculation of heating and cooling requirements in buildings, E. A. Arens and D. H. Nall, 67 pages (Dec. 1978). Order from NTIS as PB289927.

Key words: climate data; computer; energy; load-calculation; residential; weather.

This paper documents the development of a climate data abbreviation technique for building thermal analysis. The paper first discusses the characteristics of computerized building thermal simulations and the requirements for abbreviated data. The technique is then described together with the statistical analyses used to develop it. A series of tests of the representativeness of the abbreviated climate data are documented. Finally, the limitations and potentials of the abbreviation technique are discussed.

NBSIR 78-1528. An economic analysis of building code impacts: A suggested approach, J. S. McConnaughey, Jr., 67 pages (Oct. 1978). Order from NTIS as PB287405.

Key words: benefit-cost analysis; benefit-risk analysis; building codes and standards; building regulations; building safety; economic analysis; economics of safety; electric shock; ground fault circuit interrupters.

This report suggests an evaluation approach which can be used by building officials and legislative bodies faced with making building code decisions. A method to evaluate many of the potential benefit and cost impacts of specific building code provisions is developed. The report also defines and categorizes the economic impacts of building codes. While no approach to classifying building code impacts will be fully appropriate for all uses, the definitions and categories proposed may help to clarify or reconcile some of the differing opinions concerning the impact of building codes. Finally, the report illustrates the suggested approach by evaluating the 1975 *National Electrical Code* requirement for the use of Ground Fault Circuit Interrupters (GFCIs) in residences. Based on sensitivity analysis, estimates are made of how much it costs society in order to save one life through the GFCI code provision. This case study concludes that the estimated cost to save a life is nearly \$4 million. A lower bound estimate of the cost to save a life is about \$2.5 to \$3.5 million.

NBSIR 78-1530. Mobile home living room fire studies: The role of interior finish, E. K. Budnick, 163 pages (Sept. 1978). Order from NTIS as PB291844.

Key words: ASTM E-84 Tunnel Test; carbon dioxide; carbon monoxide; fire growth; fire tests; flame spread; flashover; interior finishes; life safety; mobile homes; radiant heat flux; room fires.

A series of sixteen full-scale fire tests was conducted in the living room of a typically constructed single-wide mobile home. These tests were designed (1) to evaluate the effect of a variety of combinations of wall and ceiling materials on fire growth and spread and the production of smoke and toxic gases when exposed to an incidental fire, and (2) to determine the relationship between the surface flame spread properties of the interior

finish materials as determined by the ASTM E-84 Tunnel Test and the behavior of the materials as installed under actual full-scale conditions.

The test procedure was based on a fire scenario in which the interior wall finish was exposed to an incidental fire from a standardized 6.4 kg (14 lb) wood crib or a 16 kg (35 lb) upholstered chair positioned in a corner in the living room.

Performance of the various combinations of wall and ceiling materials was evaluated based on (1) the rate of fire buildup and extent of living room involvement, and (2) changes in the environment in the corridor and bedroom areas which may adversely affect the life safety of the occupants. Measurements utilized in the evaluation of changes in the environment due to fire growth and spread included gas temperatures, irradiance, concentrations of carbon monoxide, carbon dioxide and oxygen, and smoke densities. Under this set of conditions it was found that the fire properties of the interior finish materials directly affected the rate of fire growth and spread, the severity of the fire, and the resulting effects on life safety.

NBSIR 78-1531. Mobile home bedroom fire studies: The role of interior finish, E. K. Budnick, D. P. Klein, and R. J. O'Laughlin, 107 pages (Sept. 1978). Order from NTIS as PB291444.

Key words: ASTM E-84 Tunnel Test; fire growth; fire tests; flame spread; flashover; incidental fire; interior finish; life safety; mattress; mobile home; radiant heat flux; room fires; upholstered chairs.

A series of nine full-scale fire tests was conducted in the master bedroom of a typically constructed single-wide mobile home to (1) evaluate the effect of a variety of combinations of wall and ceiling materials on fire growth and spread and the production of smoke and toxic gases when exposed to an incidental fire, and (2) determine the relationship between the surface flame spread properties of the interior finish material as determined by the ASTM E-84 Tunnel Test and behavior of the materials under actual full-scale conditions.

The primary fire scenario selected was the exposure of the interior finish materials to an incidental fire from a burning upholstered chair in a corner in the master bedroom. Performance of the various combinations of wall and ceiling materials was evaluated on the basis of (1) whether and at what time flashover was reached, and (2) changes in the environment outside the bedroom which adversely affect life safety. Measurements included gas temperatures, irradiance, concentrations of carbon monoxide and carbon dioxide, oxygen depletion, and smoke densities.

Supplemental testing indicated that while the fire properties of the interior finish materials played a dominant role in spreading an incidental fire from a chair, the impact of the interior finish materials was less evident when the exposure fire was from the burning of a polyurethane mattress, which provided an exposure fire of greater intensity. When a bed was used instead of the chair as the initial burning item, flashover occurred in the room from involvement of the mattress and bedding materials, with no apparent contribution from the low flame spread interior finish.

NBSIR 78-1532. Environmental and safety considerations for solar heating and cooling applications, D. Waksman and J. Holton, 35 pages (Sept. 1978). Order from NTIS as PB287772.

Key words: fire safety; health; physical hazards; safety; solar heating and cooling; structural performance; toxicity.

The HUD Minimum Property Standards (MPS) and the "residential" and "commercial" interim performance criteria (IPC) prepared by the National Bureau of Standards address

many health and safety considerations that need to be considered by solar heating and cooling system designers. For example, factors such as the toxicity and flammability of heat transfer fluids are often not considered in the design of systems. Similarly, attention is seldom paid to the safe disposal of these fluids. These problems are compounded by the lack of clear guidelines as to which fluids constitute hazards that warrant special consideration. This report is intended to create an increased sense of awareness of the health and safety aspects of solar heating and cooling applications by extracting and amalgamating pertinent provisions of the MPS and IPC documents. Some of the areas that are addressed include: structural safety, heat transfer fluid toxicity and flammability considerations including the protection of potable water, effects of solar equipment on the fire resistance of buildings, and protection from physical hazards.

NBSIR 78-1534. Monte Carlo studies of electron and photon transport at energies up to 1000 MeV. S. M. Seltzer and M. J. Berger, 49 pages (July 1978). Order from NTIS as PB286933.

Key words: electron; electron photon showers; energy deposition; Monte Carlo method; photon; straggling; transport theory.

This report describes calculations of electron-photon showers initiated by electron beams with energies from 50 to 1000 MeV. Results obtained with the Monte Carlo program ETRAN are presented for diverse problems including: (1) the spatial distribution of energy deposited in water, air and lead targets; (2) the escape of scattered electrons and secondary bremsstrahlung from air and lead targets; (3) energy-loss straggling of primary electrons in air; (4) depth-dependent electron spectra (differential tracklength distributions) in air.

NBSIR 78-1535. Laboratories technically qualified to test solar collectors in accordance with ASHRAE Standard 93-77: A summary report. W. J. Niessing, 39 pages (Nov. 1978). Order from NTIS as PB289729.

Key words: collector; evaluation; laboratories; qualification; solar; testing.

In fulfilling its responsibilities under the National Program for Solar Heating and Cooling of Buildings established as a result of the Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409) and related legislation, the Energy Research and Development Administration (ERDA) requested the National Bureau of Standards (NBS) to develop criteria for assessing the capabilities of laboratories for testing solar collectors, to identify those laboratories qualified to test solar collectors, and to develop a plan for the certification of solar collectors.

NBS engaged the professional services of ARI Foundation, Inc. (ARIF), a subsidiary of the Air-Conditioning and Refrigeration Institute (ARI), to identify laboratories qualified to test solar collectors and to develop documentation for a solar collector certification program. ARI is a national trade association of manufacturers of air-conditioning and refrigeration equipment with established experience and background in standards development for HVAC equipment and the conduct of certification programs for such equipment.

This summary report covers the identification of qualified solar collector testing laboratories. It discusses the procedures used by ARIF, the results of their evaluation and lists the laboratories evaluated as qualified to test solar collectors in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 93-77.

NBSIR 78-1537. An exploratory study of dielectric breakdown voltages for residential wiring. J. E. V. Raduan, R. W. Beausoliel, and W. J. Meese, 34 pages (Oct. 1978). Order from NTIS as PB288857.

Key words: dielectric breakdown voltages; dielectric withstand voltage tests; residential wiring; surge voltages.

Residential electric circuits are subjected to surge voltages resulting from load switching in buildings, and from external causes such as lightning. Laboratory test data are presented on high voltage breakdown values for armored cable (type AC cable), nonmetallic-sheathed cable (type NM), flat conductor cable, and duplex receptacles. Dielectric withstand voltage test requirements in current standards for residential wiring and wiring devices vary over a wide range. In some cases, the standard test voltage values for both wiring and wiring devices are less than surge voltages recorded on wiring in residences. Also, field-recorded voltage wave forms and rates of their application are different from those used in standard withstand voltage tests.

NBSIR 78-1541. Techniques for the measurement of acoustic impedance of asphalt. P. A. Mansbach and C. I. Holmer, 95 pages (Oct. 1978). Order from NTIS as PB287936.

Key words: acoustic impedance of asphalt; acoustics; correlation used to measure acoustic impedance; Fermat's principle in acoustics; impedance, acoustic, measurement of; impedance, acoustic, of asphalt; noise measurement, truck passby; sound propagation, in wind gradients; sound propagation over impedance surface; wind gradients, effect on sound propagation.

Five techniques were used in an attempt to measure the very high acoustic impedance of an asphalt surface. These techniques are: Impedance Tube, Pure-Tone Traverse, Pulse-Echo, Broad-Band Cross-Correlation, and Direct Accelerometer Measurement. These techniques are described and evaluated in some detail, and the results of the measurements are presented. Of the five techniques, the broad-band cross-correlation proved to be the most effective, and also is capable of even further improvement. The value of the specific acoustic admittance of the sealed asphalt surface obtained with this technique is .007.

The effects of wind and temperature gradients on ray propagation are derived theoretically, as well as spherical wavefront corrections to plane-wave reflection. These refinements are necessary to realize the full potential of the broad-band measurement technique.

Effects of the finite test surface impedance on source emission measurements are discussed. Measurement uncertainties of the order of 1-2 dB due to surface impedance are considered likely.

NBSIR 78-1542. State-of-the-art study of heat exchangers used with solar assisted domestic hot water systems (Potential contamination of potable water supply). F. E. Metz and M. J. Orloski, 82 pages (July 1978). Order from NTIS as PB287410.

Key words: contamination; corrosion; heat exchanger; heat transfer fluids; potable water; solar energy; standards; toxicity.

This report presents the results of a nonquantitative state-of-the-art study of heat exchangers used with solar assisted domestic hot water systems where a heat exchanger interface exists between the potable water supply and a heat transfer fluid. Emphasis is placed on the potential for contaminating the potable water supply if failures should occur. The study considers (1) characteristics of various heat exchanger types and their relative safety; (2) characteristics of heat exchanger fluids (toxicity, corrosivity, thermal properties, etc.); (3) regulatory considerations; and (4) designs of similar systems with potential for contamination.

NBSIR 78-1543. **Recommended testing and calculation procedures for determining the seasonal performance of residential central furnaces and boilers**, G. E. Kelly, J. Chi, and M. E. Kuklewicz, 110 pages (Oct. 1978). Order from NTIS as PB289484.

Key words: annual operating cost; boilers; fossil fuel heating systems; furnaces; part load performance; rating procedures; seasonal efficiency.

As part of the requirements of the Energy Policy and Conservation Act (PL 94-163) passed by Congress in December 1975, the Department of Energy (formerly Federal Energy Administration) directed the National Bureau of Standards to develop test procedures for certain covered consumer products, including residential central furnaces and boilers. This report summarizes NBS recommendations on how these central heating appliances may be tested in the laboratory and the resulting data used to calculate their annual fuel utilization efficiencies and annual operating costs.

NBSIR 78-1544. **Low velocity performance of a compact impact-deflection anemometer**, L. P. Purtell, 29 pages (Sept. 1978). Order from NTIS as PB287496.

Key words: airflow; anemometer; laser velocimeter; low velocity; performance; wind tunnel.

Performance of a compact impact-deflection anemometer is evaluated over the speed range of 50.8 to 716 feet per minute. The tests were performed in the NBS Low Velocity Airflow Facility which provides a uniform flow of low turbulence and utilizes a laser velocimeter as the velocity standard.

NBSIR 78-1548. **An evaluation of ASHRAE Standard 94-77 for testing water tanks for thermal storage**, B. J. Hunt, T. E. Richtmyer, and J. E. Hill, 75 pages (Oct. 1978). Order from NTIS as PB288793.

Key words: ASHRAE Standards; evaluation of test procedure; solar heating components; standard test procedure; thermal storage tests; water tank thermal storage.

The National Bureau of Standards proposed a standard test procedure for rating thermal storage devices, in mid-1975. Early in 1977, the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) adopted ASHRAE Standard 94-77 Method of Testing Thermal Storage Devices Based on Thermal Performance, which is based substantially on the NBS procedure. In order to evaluate the Standard, NBS has conducted an experiment in which a 1.9 m³ (500 gal) water tank, built as part of a residential solar heating and cooling system, was tested in accordance with this Standard. A description of the test apparatus, test procedure, and detailed test results are given. It was found that there were no major problems encountered in using the Standard for this kind of thermal storage device. In addition, suggestions are made for minor modifications in the Standard.

NBSIR 78-1549. **Plan for the assessment and implementation of seismic design provisions for buildings**, C. G. Culver, R. E. Chapman, P. W. Cooke, B. R. Ellingwood, S. G. Fattal, J. R. Harris, and E. V. Leyendecker, 31 pages (Nov. 1978). Order from NTIS as PB288762.

Key words: assessment; building codes; building design; disaster mitigation; earthquakes; engineering; implementation; standards.

This plan deals with the assessment and implementation of tentative seismic design provisions developed by the Applied Technology Council as part of the Cooperative Federal Pro-

gram in Building Practices for Disaster Mitigation of the National Science Foundation and the National Bureau of Standards. The plan was prepared based on comments received from a broad spectrum of representatives of the building community. The National Bureau of Standards invited participation from a broad spectrum of interests to help develop the plan. Trade associations, industry group, professional organizations, the model code organizations, standards organizations and Federal agencies were included; groups with national representation rather than regional or local interest were selected.

The plan includes four phases (1) Review and Refine Tentative Provisions, (2) Trial Designs and Impact Assessment, (3) Consideration and Adoption of Provisions, and (4) Assistance to Facilitate implementation. It can form the basis for the assessment and implementation of the tentative seismic design provisions. As the effort proceeds, it may be necessary to refine the plan. Additional details will need to be specified for the individual tasks. These will be influenced by the procedure adopted to carry out the activities.

NBSIR 78-1552. **The influence of scattering foils on absorbed dose distributions from electron beams**, M. J. Berger and S. M. Seltzer, 36 pages (Nov. 1978). Order from NTIS as PB288804.

Key words: absorbed dose; central axis depth dose; collimation; electrons; radial dose profile; scattering foil.

This paper presents results of transport calculations pertaining to the distribution of absorbed dose in a water phantom irradiated with high-energy electrons. The electron beam, initially monoenergetic and monodirectional, was assumed to pass through a lead scattering foil and 100 cm of air before reaching the phantom. The principal aim of the calculation was to determine the energy spread and angular divergence of the electron beam due to its passage through the lead foil and air, and to estimate the resulting modification of the absorbed-dose distribution in the phantom. Also included in the calculation were the effects of beam collimation to finite field size, and the contribution to the absorbed dose from secondary bremsstrahlung generated in the scattering foil as well as in the phantom.

NBSIR 78-1553. **Theory and application of a two-layer Hall technique**, R. D. Larrabee and W. R. Thurber, 29 pages (Oct. 1978). Order from NTIS as PB288763.

Key words: epitaxial growth; Hall measurements; indium-doped silicon; p-n junction isolation; two-layer structures.

The electrical characterization of epitaxial layers of silicon on substrates of the opposite conductivity type presents serious problems if the p-n junction at the interface has significant leakage current such that it cannot be used to effectively isolate the two regions. In order to meet the need for nondestructively characterizing such structures, a modification of the conventional Hall technique was developed in which the Hall measurements are made simultaneously on both the epitaxial layer and its substrate; the interface impedance is measured; and the interaction between the two regions is modeled and taken into account. This technique can be used not only to measure the unperturbed resistivity and Hall coefficient of each layer separately, but also to verify those cases in which the perturbing effects of a high resistivity substrate are negligible, thus justifying conventional measurements on the epitaxial layer.

This technique was used to measure the parameters of an n-type indium-doped silicon epitaxial layer on a bulk-grown p-type indium-doped substrate. The results suggest that the major n-type dopant in this specimen has a density of about 1×10^{17} cm⁻³ and an apparent activation energy of about 45 meV. Similar data were obtained on a second epitaxial layer grown on a high resistivity undoped substrate. These results argue

strongly for the presence of one or more undesired sources of shallow donor contamination in the epitaxial growth system used to produce these specimens.

NBSIR 78-1554. An analysis of the behavior of stair users, J. A. Templer, G. M. Mullet, J. Archea, and S. T. Margulis, 75 pages (Nov. 1978). Order from NTIS as PB291797.

Key words: architectural design; design considerations; dimensional relationships; environmental design; safety; stairs; user needs.

The National Bureau of Standards has conducted research for the Consumer Product Safety Commission the objective of which is to recommend ways to reduce the frequency and severity of stair and landing accidents. One of the several approaches to identifying stair hazards is to videotape stair use in a variety of public settings. About 50 hours of videotape of stair use have been collected and it has been processed in various ways to provide information on typical human responses to stairs and landings. This report of an analysis of videotape of stair use focuses on the relationship between the occurrence of incidents, including falls, and the stair users' characteristics, user behavior, and environmental conditions. The analysis relies, in part, on a comparison of matched samples of incident and nonincident user groups. Based on the findings of the analysis, a literature review, and other research on stair use by the authors, 44 performance statements are proposed which, if applied to stair design, should substantially reduce the frequency and severity of stair accidents.

NBSIR 78-1557. NDE publications: 1972-1977, L. Mordfin, Ed., 35 pages (Nov. 1978). Order from NTIS as PB289755.

Key words: acoustic emission; bibliography; eddy currents; index; National Bureau of Standards; nondestructive evaluation; publications; radiography; ultrasonics.

This report is a bibliography of 211 National Bureau of Standards (NBS) publications on nondestructive evaluation (NDE) and related technologies for the years 1972 through 1977. A detailed subject index is included, as well as information on how copies of many of the publications may be obtained. A preface by Harold Berger, Chief of the NBS Office of Nondestructive Evaluation, cites several early and significant NBS contributions to NDE, some of them dating back fifty years or more.

NBSIR 78-1559. An assessment of high-power thyristor technology, R. I. Scace, 42 pages (Oct. 1978). Order from NTIS as PB288730.

Key words: high current switches; high voltage switches; SCR; semiconductor devices; semiconductor measurements; silicon controlled rectifiers; silicon devices; solid-state switches; technology assessment; thyristors.

The current state of the technology for designing and making high-power thyristors is reviewed. The discussion is confined primarily to thyristors having voltage ratings of 2000 V or greater, and current ratings above a few hundred amperes. Particular attention is given to describing the factors which limit the performance of such devices and to discussing recent work aimed at solving these problems.

NBSIR 78-1562. Interim performance criteria for solar heating and cooling systems in residential buildings, J. K. Holton, 114 pages (Nov. 1978). Order from NTIS as PB289967.

Key words: buildings; cooling; heating; hot water; performance criteria; solar energy; standards.

The interim performance criteria, developed for the Department of Housing and Urban Development, is a baseline docu-

ment for criteria and standards for the design, development, technical evaluation and procurement of the solar heating and cooling systems to be used in residential buildings during the solar heating and cooling demonstration program authorized by Public Law 93-409, the "Solar Heating and Cooling demonstration Act of 1974."

This second edition of the "residential criteria" document, represents the first revision to the "Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings" published in January 1975. Its revision draws upon comments received and experience gained in the use of two companion documents, the "Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings," NBSIR 76-1187, and the "HUD Intermediate Minimum Property Standards Supplement, 1977 Edition, Solar Heating and Domestic Hot Water Systems," 4930.2.

These interim criteria are intended primarily for use in the solar residential demonstration program and as a basis for the preparation of definitive performance criteria in accordance with the requirements of Section 8 of PL 93-409.

NBSIR 78-1563. Guidelines for evaluation of a MIUS demonstration, R. A. Grot, D. J. Mitchell, J. R. Schaeffgen, A. C. Chao, M. E. Kuklewicz, and S. F. Weber, 46 pages (Dec. 1978). Order from NTIS as PB291441.

Key words: co-generation; integrated utility systems; solid waste management; thermal systems; total energy; wastewater treatment.

In order to obtain maximum benefits from a MIUS demonstration facility, a carefully planned evaluation should: assess the technical performance of the MIUS demonstration plant, determine the public benefits of a Modular Integrated Utility System (MIUS); show the viability of private ownership and operation of a MIUS plant, and provide a data base to support future analysis. This document is a guideline for the development of a detailed evaluation plant for a MIUS facility which was planned for demonstration at St. Charles, Maryland. The generic types of technical, institutional, and economic issues are discussed. General performance measures for the total system and each subsystem are indicated. The classes of data that will be required and the types of data analyses to be employed are outlined.

NBSIR 78-1568. Economic analysis of the Norris Cotton Federal Office Building, P. T. Chen, 61 pages (Nov. 1978). Order from NTIS as PB289813.

Key words: building; construction cost estimation; discounted payback period; economic analysis; economic evaluation; energy conservation; life-cycle costing; present value analysis.

The Norris Cotton Federal Office Building in Manchester, New Hampshire, has been constructed and occupied by the General Services Administration to demonstrate energy conservation techniques in the design and operations of a contemporary office building. This post-occupancy economic evaluation conducted by the National Bureau of Standards shows that additional construction costs incurred in order to reduce the energy consumption of the building are adequately offset by the present value of the resulting annual energy savings. In the economic model, the actual construction cost and energy consumption of the constructed building are compared with the estimated construction cost and energy consumption of a hypothetical equivalent conventional building. The present value costs of the two buildings are calculated for each year during a 40-year study period.

3.15. GRANTEE/CONTRACTOR REPORTS AND NBS PATENTS

Grantee/contractor reports are prepared by non-NBS persons or organizations working under grant or contract from the National Bureau of Standards. Those contract reports not incorporated into the formal NBS publication series are available directly from the National Technical Information Service (NTIS, Springfield, VA 22161) in paper copy or microfiche form unless otherwise stated. When ordering a report from NTIS you must order it by the "COM, PB, AD, or N" number as indicated.

Patents are legal documents which fully describe inventions in return for the right for 17 years to exclude others from making, using, or selling the inventions. They are obtained on NBS inventions of high commercial potential in order to establish Government ownership of the patent rights. The patents are then made available for the grant of nonexclusive licenses to all qualified applicants. A limited exclusive license may be granted under a particular patent, however, if it appears that some period of exclusivity is necessary as an incentive for the investment of risk capital. For information on licensing any of the following patents, write to the Office of the Legal Adviser, National Bureau of Standards, Washington, DC 20234. Copies of patents may be obtained from the U.S. Patent and Trademark Office, Washington, DC 20231 for 50 cents each.

NBS-GCR-77-98. An experimental investigation of the heat transfer from a buoyant gas plume to a horizontal ceiling—Part 2. Effects of ceiling layer, E. E. Zukoski and T. Kubota, 78 pages (May 1978). Order from NTIS as PB280746.

Key words: buoyant plumes; ceilings; compartment fires; fire plumes; heat transfer; room fires; scale models.

This report contains the results of experiments carried out as part of a study of heat transfer to room ceilings under conditions similar to those encountered in the early stages of a room fire before the room becomes completely involved in flames. Part 1 of this study was concerned with heat transfer to a bare ceiling and scaling procedures were developed there which gave complete modeling rules for this example. The work reported here differs from this previous effort because side walls are used in the present experiments and they trap a thick layer of hot gas under the ceiling. This hot gas layer (the ceiling layer) will affect the temperature and momentum flux in the fire plume and hence the initial conditions for the ceiling jet formed by the impingement of the plume on the ceiling. It will also affect the temperature level in the ceiling jet since hot gas rather than cool air will be entrained.

This report presents data obtained with two configurations of side walls, on axisymmetric Curtain Wall and a Model Room with a single (door) opening. Temperature and heat transfer data are presented and certain elements of a scaling model are discussed. A complete scaling model is still being developed and will be the subject of a later report.

NBS-GCR-77-100. A numerical procedure for calculating temperature in hollow structures exposed to fire, U. Wickstrom, 62 pages (Aug. 1977). Order from NTIS as PB284517.

Key words: ASTM E-119; building fires; ceilings; computer programs; concrete slabs; construction materials; convection; heat transfer; radiation; slabs (members); steel beams; structural members.

An approximate theory for two-dimensional heat transfer in hollow structural elements exposed to fire is described. Radia-

tion as well as convection heat transfer are accounted for. The theory is coded in a set of FORTRAN subroutines that can easily be adapted to most programs for analysis of solid state conduction using finite element or finite difference approximations. For voids with piecewise straight boundaries and all angles between surfaces less than or equal to 180 degrees, a set of equations has been programmed to calculate view factors. In calculating convection heat exchange, it is assumed that the heat capacity of enclosed air is negligible, and that a uniform effective air temperature can be calculated as a function of surrounding surface temperature only. To illustrate the method, the finite element program FIRES-T is employed. Four hollow structures exposed to ASTM E-119 fire are analyzed. For two of the examples where experimental data are available excellent agreement between measured and calculated temperature is achieved.

NBS-GCR-77-101. Experimental and modeling studies of smoldering in flexible polyurethanes, T. J. Ohlemiller, F. E. Rogers, A. Kurtz, J. Bellan, and M. Summerfield, 125 pages (July 1977). Order from NTIS as PB284500.

Key words: chairs; char; combustion; fabric flammability; fire safety; flexible foams; furniture; polyurethanes; small scale fire tests; smoldering; upholstery.

The fire safety hazard posed by smoldering combustion of polyurethane-based cushioning materials is the subject of a continuing study, now underway for two years. The focus is on the smolder process in open cell, flexible polyurethanes. The goal is a sufficient understanding of the thermophysics and chemistry of this process to permit construction of a predictive mathematical description of it; this model should help indicate what steps are needed to eliminate the smolder hazard. This report summarizes results of the two-year study in four sections. (1) The phenomenology of the smolder process have been derived from two sources: detailed studies of a particular self-smoldering foam and smolder tendency studies of a large variety of systematically varied foam formulations. (2) The smoldering of a cellulosic fabric is important because in a hazard situation it frequently is a large part of the driving force in foam smolder. (3) The complex degradation chemistry occurring in a polyurethane during smolder can, with the help of thermal analysis (TGA and DSC) be reduced to a simple scheme of overall reactions. (4) Model development has proceeded in stages beginning with the transient heating of 1-D inert foam. The second state of modeling, 1-D reactive foam with one step char oxidation, was based on a program seeking an artificial steady state and the extinction limits for it. Experimental data on the results of computer simulations are presented and discussed.

NBS-GCR-77-104. Exhaust emission evaluation of three caterpillar tractor D-398 diesel-electric sets, C. E. Kitson and R. S. Egdall, 73 pages (Nov. 1977). Order from NTIS as PB276102.

Key words: diesel engines; exhaust emissions; MIUS; total energy systems.

Gaseous and particulate emissions testing was conducted on three Caterpillar D-398 600 kW-rated generator sets at varying operating loads which included 0, 20, 40, 59, 79, 100, and 110 percent. These engines were designed to provide the dual functions of electric generation, and heat supply through exhaust heat exchangers. Water jacket cooling water temperatures were

maintained at two levels depending on engine load; i.e., ≤ 200 °F at loads of 100 and 110 percent, and ≤ 228 °F at 79 percent and below.

Measured parameters included carbon monoxide, nitrogen oxides, hydrocarbons, and particulate matter. The measurement techniques and resulting emission data are presented herein.

NBS-GCR-77-105. Effect of selected variables on the distribution of water from automatic sprinklers, C. L. Beyler, 70 pages (June 1977). Order from NTIS as PB275083.

Key words: collection arrays; density; distribution patterns; flow rate; mapping; spray patterns; sprinkler heads; sprinkler systems; superposition.

The effects of flow rates, supply pipe size, direction of supply, deflector to ceiling clearance, orientation of sprinkler arms, angles of the sprinkler head, and sprinkler guards on the distribution of water from upright and pendant sprinkler heads have been studied. Three collection arrays were used to measure densities from one or two sprinklers. To evaluate the effects of the above variables data from tests were used in conjunction with a Synagraphic Mapping System (SYMAP) computer program to produce isodensity mappings of sprinkler discharges.

NBS-GCR-77-106. People in fires: A manual for mapping, L. Lerup, 47 pages (1977). Order from NTIS as PB275155.

Key words: building fires; case histories; critical incidents; decision making; escape; fire behavior; human factors; mapping; methodology; performance (human); reaction (psychology); stress (psychology).

Manual provides step by step instructions for the investigation, data gathering and organization, and graphic mapping procedures involved in graphically presenting the behavior patterns of fire development and persons exposed to fire in a building. The manual is intended to be used in conjunction with NBS-GCR-76-73, "Mapping of Recurrent Behavior Patterns in Institutional Buildings under Fire: Ten Case Studies of Nursing Facilities," also prepared by Lars Lerup. The use of the mapping approach to fire reporting can provide better identification of an insight into both the development of fire and the reactions of persons to it.

NBS-GCR-77-107. Beyond the performance concept, E. D. Ehrenkrantz, 191 pages (Dec. 1977). Order from NTIS as PB275524.

Key words: building; center for building technology; design; performance concept.

This report of a brief study attempts to identify the knowledge-based problems of those responsible for building design, and to suggest areas in which the Institute for Applied Technology should focus its present and future efforts in order to improve building.

NBS-GCR-77-108. Fire development in a room—A bibliography, T. Waterman, 293 pages (Aug. 1976). Order from NTIS as PB278634.

Key words: bibliographies; fire dynamics; fire tests; gases; room fires flashover; smoke; standards; test procedures.

The bibliography presented in this report represents references collected by IIT Research Institute in preparation of a methodology to evaluate preflashover fire development in a room. Data on the generation of smoke and fire gases, material properties and performance in standard tests are included.

NBS-GCR-77-109. Analysis of data and results for the round-robin flat-plate collector test program, W. C. Thomas and A.

G. Dawson, 86 pages (Aug. 31, 1977). Order from NTIS as PB275576.

Key words: flat-plate collectors; measurement; modeling; solar; standards; testing.

A roundrobin test program was conducted in order to determine the inter-comparability of thermal performance experimental data on two liquid-heating solar collectors from 21 test facilities across the United States, using a common test procedure. Data from approximately half the facilities were selected for detailed analysis. A collector analytical model was used to show that less than one third of the spread could be attributed in the measured values of collector efficiency to different environmental conditions from facility to facility. The data for the second collector showed less scatter than data for the first collector. In general, the data from a single facility were consistent, and the majority of scatter was attributed to systematic uncertainties from facility to facility. When the data from six participants reportedly adhering to the requirements of ASHRAE Standard 93-77 were analyzed, the scatter was found to be within normal limits expected for the test procedure.

NBS-GCR-77-110. A study of the development of room fires, T. E. Waterman and R. Pape, 92 pages (Sept. 1976). Order from NTIS as PB278648.

Key words: computer program; flashover; furniture; ignition; room fires; thermodynamics; ventilation.

This report summarizes the research performed under the NBS Grant No. 5-9018. Separate reports were released on the literature surveyed and categorized, the computer code and methodology developed, and a case study conducted. The report addresses the state-of-the-art of fire buildup to flashover in a room assuming an ignition has occurred. The authors suggest that the model for the development of a fire in a room from ignition to flashover should be considered a research tool and not a design tool. Several recommendations for model improvement are included.

NBS-GCR-77-111. Semistochastic approach to predicting the development of a fire in a room from ignition to flashover. Program documentation and users guide, T. Waterman, 86 pages (June 1976). Order from NTIS as PB278643.

Key words: computer programs; fire plume; flashover; ignition; room fires; rooms; thermodynamics; ventilation.

A computer program and a methodology which embodies the computer program is presented. The methodology is for evaluating the development of a room fire from ignition to flashover. The purpose of the methodology is to express fire characteristics probabilistically. The code is exercised for a series of possible room arrangements and furniture item burning actions, each case with an estimated probability of occurrence. The computercode computes the heat exchanges and performs the heat and mass balances for an enclosure (room) exposed to internal fire in a series of finite time steps.

NBS-GCR-77-112. Semistochastic approach to predicting the development of a fire in a room from ignition to flashover. Program documentation and users guide (Addendum), R. Pape and T. Waterman, 20 pages (Aug. 1976). Order from NTIS as PB278644.

Key words: computer programs; fire tests; flashover; ignition; probabilities; room fires.

The basic report (Semistochastics Approach to Predicting the Development of a Fire in a Room From Ignition to Flashover, August 1976, IITRI-J6367) describes the computer program used in this study. This addendum provides a demonstration of

the total methodology using the NBS "Nike Fire Test Facility" test data as a test case.

NBS-GCR-77-116. Investigation of the properties of the combustion products generated by building fires. B. T. Zinn, R. A. Cassanova, C. P. Bankston, R. F. Browner, E. A. Powell, J. U. Rhee, K. Kailasanath, 101 pages (Jan. 1978). Order from NTIS as PB276549.

Key words: building fires; combustion products; optical density; particle size; polypropylene; polyvinyl chloride; smoke.

This report describes the research conducted under a National Bureau of Standards grant entitled "Investigation of the Properties of the Combustion Products Generated by Building Fires." Eleven polyvinyl chloride and seven polypropylene samples of different compositions have been burned under non-flaming conditions and measurements made of smoke particle size distributions, total smoke particulate mass generated, smoke mean particle diameter, smoke optical density and sample weight loss. Measurements have also been taken for the polypropylene samples burned in a heated ventilation gas. Results show that the characteristics of the smoke particulates and sample weight loss behavior are affected by the presence or absence of different chemical additives for both PVC and polypropylene. Also, the burning and smoke characteristics of the polypropylene samples are influenced by the ventilation gas temperature.

NBS-GCR-78-114. Fire response of reinforced concrete slabs. Z. Nizamuddin and B. Bresler, 42 pages (Mar. 1977). Order from NTIS as PB284502.

Key words: building fires; computer programs; concretes; creep; fire models; slabs (members); steels; stresses; structural materials; thermal analysis.

A mathematical procedure is described for predicting displacement and stress histories of reinforced concrete slabs in fire environments using a computer program, FIRES-SL (*FIRe REsponse of Structures-SLabs*). The temperature distribution histories used in FIRES-SL are obtained either from experimental results or from a one-, two-, or three-dimensional thermal analysis based on selected fire models. In a fire environment, thermal gradients and dilatation are sources of internal stress from local restraints within the slab and global restraint from the overall structural system. Structural response is determined in terms of displacements, internal forces, stresses and strains in concrete and steel reinforcement, and current states of concrete (cracking and crushing) and steel reinforcement (yielding). FIRES-SL uses a nonlinear finite element approach coupled with time step integration. Within time steps, an iterative approach is used to find a deformed shape which results in equilibrium between forces associated with external loads and internal stresses. The solution method is general and can be used for any specified slab shape, specified boundary conditions, and placement of reinforcement. Numerical solutions are compared to available experimental results. Comparisons between solutions from computer program FIRES-SL and experimental results show that predicted response is accurate to within 5 to 15 percent of observed behavior.

NBS-GCR-78-115. FIRES-RC II. A computer program for the fire response of structures—Reinforced concrete frames (Revised version). R. H. Iding, B. Bresler, and Z. Nizamuddin, 249 pages (July 1977). Order from NTIS as PB278661.

Key words: building fires; computer programs; concretes; creeps; failure analysis; fire models; steels; structural failure; structural materials; thermal degradation.

FIRES-RC II is a computer program used to evaluate the structural response of reinforced concrete frames in fire environments. The report describes the analytical and material behavior models upon which FIRES-RC II is based. The thermal response associated with fire environments used for the analysis of reinforced concrete frames in FIRES-RC II is predicted by a companion computer program, FIRES-T. A nonlinear, direct stiffness formulation couples with time step integration is the analytical technique used in FIRES-RC II. Within a given time step, an iterative approach is used to find a deformed shape which results in equilibrium between internal stresses and external forces. The material behavior models for concrete and steel account for dimensional changes caused by temperature differentials, changes in mechanical properties of materials with changes in temperature, degradation of sections by cracking and/or crushing, and increased rates of shrinkage and creep with an increase in temperature. Nonlinear stress-strain laws, in which inelastic deformation associated with unloading is accounted for, are used in FIRES-RC II to model concrete and steel behavior. The report includes a user's manual for FIRES-RC II, a sample problem, and a listing of the program.

NBS-GCR-78-117. An experimental investigation of flame spread over condensed combustibles: Gas phase interactions. A. C. Fernandez-Pello, 28 pages (Dec. 1977). Order from NTIS as PB275999.

Key words: combustible materials; convection; flame spread; flame velocity; gaseous phase; heat transfer; Laser Doppler Velocimeter; liquid fuels.

The present study of flame spreading over combustible materials is intended to elucidate the role of gas phase heat transfer on flame spread over solid materials. Particularly, the major objective is to ascertain the importance of gas phase convective effects in the energy transfer mechanisms. The importance of convective gas phase effects on flame spread has been a controversial point for some time. Due to instrumentation problems, measurements of gas phase velocities which could resolve the question have not been determined unambiguously. Qualitative measurements of velocities of the order of magnitude of those encountered in the flame spread environment are simply difficult to make using conventional techniques such as pitot tubes or hot wire anemometers. With the additional complication that the flow may also be reversing in direction, little real progress has been possible. With the advent of LDV techniques however the possibility of determining the role of gas phase convective effects has become realizable. A sophisticated Laser Doppler Velocimeter facility has been constructed to undertake this project. We feel that the present fire research facility at Princeton University represents a unique capability in the fire research field for the study of gas phase phenomena.

NBS-GCR-78-118. Toward a performance approach to life safety from fire in building codes and regulations. D. S. Haviland, 191 pages (Jan. 1978). Order from NTIS as PB276926.

Key words: building codes; building design; buildings; construction methods; fire prevention; fire protection; fire safety; life safety; standards.

Building codes in use throughout the U.S. contain mostly prescriptive provisions which specify how a proposed building must be designed and constructed. Prescriptive provisions tend to leave little latitude for the building's designer to exercise expert judgment or use modern materials and methods even though these might improve the finished building or reduce its cost. A solution to this dilemma is the use of performance provisions for building codes. Performance provisions state how

the building is to function or operate to satisfy the needs of its occupants, and leaves much discretion to the building's designer as to how the specified performance is to be achieved. This report discusses the performance provisions which should be considered by building researchers, code authorities, and by those who enforce the Nation's building regulatory system. Hopefully, future building codes might be couched in performance terminology as recommended in this report.

NBS-GCR-78-119. Development of engineering models and design aids to predict flame movement and fire severity within a room, R. W. Fitzgerald, 98 pages (Dec. 1977). Order from NTIS as PB276865.

Key words: barrier analysis; fire severity; fire spread; fuel load; models; probabilistic analysis; room fires; systems analysis; ventilation.

This report presents a logical framework and engineering models for the determination of the probabilities of flame movement and fire severity within a room. The fire researcher is the intended audience for this report. The report describes the engineering application of the Goals Oriented Systems Approach. It identifies the data requirements needed to quantify engineering predictions of flame movement within a room. A model is presented that will translate results into a useable engineering form. A format for the display of results for use in engineering practice is suggested in Appendices B and C. A systems logic for barrier analysis and a philosophy for engineering design was a necessary prerequisite to the establishment of fire severity levels. The logic presented in the report forms the basis of the conclusion that if the predictability of field performance of barriers is the objective of barrier analysis, refinement of the fire severity component alone will do little to accomplish the objective. A procedure for barrier analysis somewhat similar in concept to the structural design of floors is proposed. In this context, a method for establishing the energy impact (fire severity) component is suggested in Appendix D. An overview of the states-transition method of the Goals Oriented System Approach is presented in Appendix A. It is suggested that Appendix A be studied by those unfamiliar with this method before reading the body of the report.

NBS-GCR-78-120. A model of human behavior in a fire emergency, L. Bickman, P. Edelman, and M. A. McDaniel, 33 pages (Dec. 1977). Order from NTIS as PB277773.

Key words: decision making; egress; emergencies; fires; human behavior; human performance; life safety; panic.

This paper describes a conceptual model which describes some of the significant factors thought to influence human behavior in a fire emergency. The model attempts to integrate previous research on fire and human behavior with relevant findings from the field of social psychology. The model involves three stages: 1) detection of cues; 2) definition of the situation; and 3) coping behavior. These stages describe the logical flow of behavior during a fire. Six categories of variables are presented which are hypothesized to affect behavior at each stage in the model: 1) physiological/physical; 2) intrapersonal; 3) education/preparation; 4) social; 5) fire characteristics; and 6) physical environment. The potential value of the model in explaining behavior in actual fires and in formulating future research is demonstrated with specific examples.

NBS-GCR-78-121. The interaction of fire and sprinklers, C. L. Beyler, 80 pages (Sept. 1977). Order from NTIS as PB278605.

Key words: distribution patterns; drops (liquid); drop size; fire models; fire plumes; sensitivity analysis; spray; sprinkler heads; vaporizing.

Models of the actuation of sprinklers, drop dynamics in a nonfire situation, and drop dynamics in a fire situation are developed. Sensitivity analysis is performed with the models.

The actuation model makes use of empirical curve fit relations for the temperature and velocity fields of the ceiling-jet. The relations are the result of curve fits to the exact solutions given by Alpert's model. The model also makes use of "Plunge Test" data as developed by Heskestad and Smith.

The model of nonfire drop dynamics developed is found to be unable to predict the distribution pattern from sprinklers. The model utilizes a single constant initial velocity for all drops. Results indicate that a distribution of initial velocities exists.

The model of drop dynamics in a fire indicates that evaporation need not be considered when studying drop penetration through the fire plume. The fire plume is found to effect similarly all drops which exceed a critical diameter. Below the critical diameter the drop is carried away by the plume. The critical diameter is a function of the heat output.

NBS-GCR-78-123. Detailed application of a technology for the formulation and expression of standards, Applied to ANSI A58.1-1972, L. K. Cunningham, J. W. Melin, and R. L. Tavis, 262 pages (Jan. 1978). Order from NTIS as PB279091.

Key words: building codes; computer model; decision table; decision theory; network, specifications; standards; systems engineering.

This investigation applies decision-table and information-network technology in the analysis of the American National Standard Building Code Requirements for Minimum Design Loads in Building and Other Structures (NASI A58.1-1972).

Part I summarizes the logic and technology available for decision-table and information-network analysis. It also sets down a rationale for the attempt to apply this logic at the requisite level of detail and develops the concepts, policies, and procedures that enable such application.

Part II applies the available technology to the ANSI Standard, and in a detailed commentary on each decision table and on the information network, sets down the questions raised by the analysis of each. General questions about the ANSI Standard, classification of data, and potential application of these methods in the expression of standards follow. The analysis concludes by testing the validity of its proposition in the overall findings of the work.

NBS-GCR-78-125. Report on organization of certification program for solar collectors, G. R. Munger, R. J. Evans, 99 pages (Nov.30, 1977). Order from NTIS as PB280025.

Key words: certification program; operational manual; rating standard; solar collectors.

Proposed documentation is presented for the operation of a solar collector certification program. The documents included are an Equipment Rating Standard, a Certification Program Operational Manual, a Certification Laboratory Contract, and a Manufacturer's License Agreement. Also provided is a typical calendar for the initiation of a program and an estimate of the first annual budget for a certification program.

NBS-GCR-78-126. Effects of ignition sources and fire retardants on material ignition, P. Durbetaki, W. C. Tincher, H. Chang, C. C. Ndubizu, M. L. Teague, and V. L. Wolfe, Jr., 230 pages (Mar. 31, 1978). Order from NTIS as PB281451.

Key words: cellulosic materials; cotton fabrics; fabrics; fire retardant materials; flame resistant fabrics; flame retardants; heat sources; ignition; ignition time; polyesters; pyrolysis; textiles.

The fire loss probability is composed of all sub-probabilities which are associated with the events and processes leading to the occurrence of the fire loss. The events and processes generally fall into two categories, the selection processes and the physico-chemical processes. The first important event of the physico-chemical processes is ignition after given exposure to heat source.

Measurements have been carried out to provide required data on thermophysical properties, constitutive description of processes, and ignition times. Description of the preignition processes and the prediction of ignition time was formulated and the results compared with measurements.

Thermal radiative properties have been measured. Thermal conductance measurements were carried out.

Ignition time and ignition frequency measurements under convective heating have been carried out with a microburner ignition source on fire retarded and untreated fabrics.

Ignition time measurements on vertical fabric samples under radiative heating were conducted using large samples of fire retardant and untreated fabrics.

NBS-GCR-78-130. An annotated compilation of the sources of information related to the usage of electricity in nonindustrial application, B. Reznick, 684 pages (July 1978). Order from NTIS as PB285260.

Key words: abstracts; annotated compilation; electrical usage; government contractor's report; information sources; nonindustrial.

This government contractor's report is a thorough compilation of the sources of information related to the usage of electricity in nonindustrial applications, as available in the open literature and from the U.S. electrical power industry. The report's scope encompasses all aspects of: electric load management; end-use; and the various methods of acquisition, analysis and implementation of electricity usage data. There are over 400 abstracts: 156 from LRC/AEIC reports and 264 from the open literature. The abstracts cover references containing over 12,000 pages plus about 2,500 references and 6,200 graphs and tables pertinent to electricity usage in nonindustrial applications. In addition to the LRC/AEIC abstracts, this document identifies over 100 sources of directly relevant information (in contrast to general interest sources and material of secondary relevance).

NBS-GCR-78-139. An investigation of regulatory barriers to the re-use of existing buildings, N. J. Habraken and A. M. Beha, 117 pages (Oct. 1978). Order from NTIS as PB287801.

Key words: building codes; building research; code enforcement; construction; existing buildings; rehabilitation; renovation.

This team investigation focuses on provisions of the regulatory systems which adversely impact re-use of existing buildings. The findings are separated into experientially based team analyses of regulatory systems and data gathered from several Massachusetts sources. A series of recommendations for resolution of specific code problems are made, and a research agenda is presented to identify areas for future study towards the resolution of code-rehab conflicts.

NBS-GCR-ETIP 76-07. Analysis of federally funded demonstration projects: Vol. 3: Supporting case studies, W. Baer, et al., 792 pages (Aug. 1976). Order from NTIS as PB262123.

Key words: demonstration projects; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; technology.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to RAND, Santa Monica, CA, to conduct a study whose purpose was "To develop cost benefit and market/industrial/institutional criteria and guidelines for the use of federally procured demonstration projects as catalysts for technological change."

The analysis indicated that projects successful in diffusion tend to have the following attributes: (1) A technology well in hand, (2) Cost and risk sharing with local participants, (3) Project initiative from non-Federal sources, (4) The existence of a strong industrial system for commercialization, (5) Inclusion of all elements needed for commercialization, and (6) Absence of tight time constraints.

The study developed guidelines for demonstration projects. These are grouped under the headings of (1) Strategies for Demonstrations, (2) Initial Exploratory Study, (3) Project Planning and Implementation, (4) Management, Monitoring, and Evaluation, and (5) Dissemination of Results.

This volume provides details of the individual supporting case studies.

U.S. Patent 4,067,015. System and method for tracking a signal source, L. N. Mogavero, E. G. Johnsen, J. M. Evans, Jr., and J. S. Albus, 7 pages (Jan. 3, 1978).

Key words: automated spotlight; performer tracking; transmitter tracking.

A system for tracking moving signal sources is disclosed which is particularly adaptable for use in tracking stage performers, although a wide range of other uses is possible. A miniature transmitter is attached to the person or object to be tracked and emits a detectable signal of a predetermined frequency. A plurality of detectors positioned in a preset pattern sense the signal and supply output information to a phase detector which applies signals representing the angular orientation of the transmitter to a computer. The computer provides command signals to a servo network which drives a device such as a motor driven mirror reflecting the beam of a spotlight, to track the moving transmitter.

U.S. Patent 4,068,381. Scanning electron microscope micrometer scale and method for fabricating same, D. B. Ballard, F. Ogburn, and J. P. Young, 6 pages (Jan. 17, 1978).

Key words: electrodeposited metal layers; gold-nickel layers; micrometer scale; scanning electron microscope scale.

A microscopic length scale typically about 50 μm long and graduated in several intervals ranging from 1 μm to 20 μm . The scale is useful in calibrating the magnification of scanning electron microscopes (SEMs) and other electron imaging instruments. The scale comprises alternating layers of two metals deposited on a substrate. The two metals have substantially different electron emission coefficients to provide contrasting emission signals when scanned by an electron beam. One of the metals, preferably gold, is deposited in uniform layers about 40-80 nm thick. The other metal, preferably nickel, is deposited in several layers ranging from 1 μm or so thick near the substrate to 20 μm thick in the outermost layer. The resultant multilayer composite is cut into one or more samples and each sample is mounted on edge. The exposed edge is ground and metallographically polished and a microscopic indentation is made in the substrate near the first gold layer. The indentation defines a reference region, and the distances between the first gold layer and the subsequent gold layers in the reference region are measured. The measurement is made using a similar sample which was previously calibrated with the aid of a polarizing laser interferometer.

U.S. Patent 4,069,479. **High speed, wide dynamic range analog-to-digital conversion**, R. J. Carpenter and K. W. Yee, 9 pages (Jan. 17, 1978).

Key words: analog-to-digital converter; expanded range analog-to-digital conversion; overlapping analog-to-digital converters; priority encoder; sample and hold; scaling amplifiers.

A wide dynamic range, wide bandwidth, analog-to-digital conversion system and method. A plurality of overlapped analog-to-digital converters are utilized in conjunction with scaling amplifiers to provide a plurality of output ranges. Means for selecting the set of output bits which provides a magnitude representation of the input signal are provided along with means for outputting a digital representation of the appropriate range.

U.S. Patent 4,087,738. **Magnetic resonance detection method and apparatus**, C. T. Van Degrieff and D. B. Utton, 7 pages (May 2, 1978).

Key words: frequency measurement; nuclear magnetic resonance; reentrant cavity resonator; static magnetic susceptibility measurements; tunnel diode oscillator.

A method and apparatus for detecting magnetic resonance of a sample. The apparatus utilizes an exceptionally stable tunnel diode rf oscillator incorporating a LC reentrant cavity resonator. The method entails measuring a magnetic resonance of the sample through the frequency of the oscillator. The resulting dispersion curve can be utilized to obtain the static magnetic susceptibility of the sample. From the value of the static magnetic susceptibility additional parameters may be determined such as material density, temperature or particle spin. The method and apparatus has applications in NMR, NQR and ESR measurements.

U.S. Patent 4,091,327. **Broadband isotropic antenna with fiber-optic link to a conventional receiver**, E. B. Larsen, J. R. Andrews, and E. E. Baldwin, 8 pages (May 23, 1978).

Key words: electromagnetic field strength measurement; fiber optics; light-coupled antenna-receiver; light emitting diodes.

A broadband active isotropic receiving antenna for use with a conventional electromagnetic interference receiver to measure weak near-zone electric fields of unknown polarization. The antenna consists of three mutually orthogonal active dipoles, including RF amplifier circuitry and light emitting diode means, located therein coupled to fiber optic waveguide means. The frequency range of each of the three field components is amplified and used to modulate respective light emitting diodes whose modulated infrared or visible signals are guided through the fiber optic waveguide means to photo-detectors at the far end of the fiber optic guides. These photo-detectors recover the RF modulation from the IR carrier which is then time multiplexed for input to the electromagnetic interference receiver. The DC output from the receiver is processed to provide an output voltage proportional to the square root of the sum of the squares, i.e. the Hermitian magnitude of the three mutually orthogonal electric field components.

U.S. Patent 4,104,583. **Six-port measuring circuit**, G. F. Engen, 20 pages (Aug. 1, 1978).

Key words: automatic network analyzer; microwave measurements; six-port.

A six-port measuring circuit includes only four hybrids coupling two input ports to four power measuring ports. A first hybrid is connected to one input port and to second and third

hybrids; a second input port is connected to the second hybrid; the second and third hybrids are connected to a fourth hybrid; first and second measuring ports are connected respectively to the second and third hybrids; and third and fourth measuring ports are connected to the fourth hybrid. In one embodiment, the first hybrid is a 180° hybrid; and the second, third and fourth hybrids are quadrature hybrids. In a second embodiment, the first three hybrids are 180° hybrids and the fourth a quadrature hybrid. Another embodiment includes three quadrature hybrids as the first three hybrids and a 180° hybrid as the fourth hybrid. A fourth embodiment employs four quadrature hybrids. The basic six-port circuit is useful as a vector voltmeter and may be coupled to a transmission line by means of a directional coupler. Net power and the complex reflection coefficient Γ_1 may be computed from the power readings at the measuring ports.

U.S. Patent 4,122,408. **Frequency stabilization utilizing multiple modulation**, F. L. Walls, 14 pages (Oct. 24, 1978).

Key words: frequency stabilization; hydrogen frequency standard; multiple modulation.

A system and method is disclosed for achieving frequency stabilization. A tunable element, such as a cavity structure, is stabilized through the use of multiple modulation to stabilize both the resonant frequency of the cavity structure and the probe signal coupled to an atomic, molecular or other reference resonance line. Said reference resonance line can be internal or external to the cavity structure. A local oscillator provides a carrier signal, which typically can be at a frequency of 5 MHz, with the carrier signal being phase or frequency modulated by multiple modulating signals, such as, for example, by modulating signals with frequencies of 12.2 KHz and 0.4 Hz, and the multiple modulated carrier signal then processed and the resulting probe signal coupled to the cavity structure substantially at a preselected frequency, which frequency can be approximately 1420 MHz for a hydrogen frequency standard useful for atomic clocks. The output signal coupled from the cavity structure is amplitude modulated with the modulation at the fundamental and odd harmonics of the first modulation frequency having a level proportional to any frequency offset between the probe signal and the atomic, molecular or other reference resonance line, and the modulation at the fundamental and odd harmonics of the second modulation frequency having a level proportional to any frequency offset between the cavity frequency and the frequency of the probe signal. The output signal from the cavity is processed and ultimately rectified so that various amplitude modulations on the output signal can be recovered. The error signal resulting from synchronous detection of the amplitude modulation signal of the second frequency, 12.2 KHz in this example, or odd harmonics thereof, is coupled to the tuning element of the cavity tuning control circuitry to precisely tune the resonant frequency of the cavity to the frequency of the probe signal and the error signal resulting from synchronous detection of the amplitude modulation signal of first frequency, 0.4 Hz in this example, or odd harmonics thereof, is coupled to the local oscillator to adjust the frequency so that the probe signal is maintained at the center of the resonance of the atomic, molecular or other reference resonance and to thereby stabilize the resonant frequency of the cavity and the output frequency of the device over a long term.

U.S. Patent 4,129,864. **High speed, wide dynamic range analog-to-digital conversion**, R. J. Carpenter and K. W. Yee, 9 pages (Dec. 12, 1978).

Key words: analog-to-digital converter; two's complement analog-to-digital converters.

A wide dynamic range, wide bandwidth, analog-to-digital conversion system and method. A plurality of overlapped analog-to-digital converters are utilized in conjunction with scaling amplifiers to provide a plurality of output ranges. Means for selecting the set of output bits which provides a magnitude representation of the input signal are provided along with means for outputting a digital representation of the appropriate range.

4. TITLES AND ABSTRACTS OF PAPERS PUBLISHED IN NON-NBS MEDIA, 1978

Reprints from the journals listed in this section may often be obtained from the authors. See page 3 for additional information.

17351. Coxon, B., Fatiadi, A. J., Sniegowski, L. T., Hertz, H. S., Schaffer, R., **A novel acylative degradation of uric acid. Carbon-13 nuclear magnetic resonance studies of uric acid and its degradation products.** *J. Organ. Chem.* **42**, 3132-3140 (1977).

Key words: acylation; isobutyric anhydride; mass spectrometry; nuclear magnetic resonance; uric acid; ^{13}C chemical shifts; ^{13}C and ^{15}N coupling constants; ^{14}C and ^{15}N labeled derivatives.

Treatment of uric acid (1) with boiling isobutyric anhydride causes cleavage and rearrangement of the pyrimidine and imidazole rings to give a new heterocyclic derivative, 2-(1-methylethyl)-4-(1-hydroxy-2-methylpropylidene)aminoimidazole-5-carboxylic acid 5,1'-lactone (2). The structures of the lactone and related derivatives have been elucidated by infrared spectroscopy, ^1H and ^{13}C NMR, and mass spectrometry. Experiments with uric acids labeled with carbon-14 at either C-2, C-6, or C-8 confirmed that C-2 and C-8 were eliminated during the cleavage process. Uric acid, its 1,3- $^{15}\text{N}_2$ labeled derivative, and a series of degradation products and related model compounds have been studied by ^{13}C NMR spectroscopy, and the carbon-13 chemical shifts and coupling constants correlated with molecular structure.

17352. Birmingham, B. W., **Foreword, Book: Stabilization of Superconducting Magnetic Systems**, pp. v-vi (Plenum Press, New York, NY, Oct. 1977).

Key words: composite superconductor; stabilizing; superconducting magnetic systems; superconductivity.

The material prepared is to be used as a Foreword to a book translated from the Russian language entitled "Stabilization of Superconducting Magnetic Systems."

This Foreword sets the stage with a brief history of superconductivity, the attempts at commercialization and the stability problems encountered in developing superconducting magnetic systems.

17353. Montgomery, G. F., **Product technology and the consumer**, *Sci. Am.* **237**, No. 6, 47-54 (Dec. 1977).

Key words: appliances; consumer behavior; consumer information; consumer products; energy conservation; government regulation; product design; product performance; product standards; safety.

Performance of consumer products is the concern of buyer, manufacturer and government alike. There is new emphasis on product safety, energy use, and lifetime cost, and in providing the buyer with information that will help him to make rational product choices. Product designs that eliminate danger from surface burns and electric shock, for example, are well understood, as are many of the details of home appliance operation that affect energy use and operating costs. But knowledge concerning the safety and energy efficiency of many products is incomplete, as is the detailed understanding of the effects of user habits on safety and energy economy. New research is uncovering both questions and answers.

17354. Feldman, A., Horowitz, D., Waxler, R. M., **Photoelastic constants of potassium chloride at 10.6 μm** , *Appl. Opt.* **16**, No. 11, 2925-2930 (Nov. 1977).

Key words: dispersion; elasto-optic constants; electronic absorption; interferometry; lattice absorption; photoelastic constants; photoelasticity; piezo-birefringence; piezo-optic constants; polarimetry; potassium chloride; refractive index; stress-birefringence; stress-optical constants.

The piezo-optic constants of pure KCl and KCl doped with KI have been measured in the visible and at 10.6 μm by interferometric and polarimetric techniques. The dispersion of the elasto-optic constants, computed from the piezo-optic constants, differs from the dispersion calculated from a theory based on a two-oscillator model of the refractive index.

17355. Mathew, M., Schroeder, L. W., **The crystal structure of calcium ammonium hydrogen-pyrophosphate $\text{CaNH}_4\text{HP}_2\text{O}_7$** , *Acta Cryst.* **B33**, 3025-3028 (1977).

Key words: calcium phosphate; crystal structure; hydrogen bonding; pyrophosphate.

$\text{CaNH}_4\text{HP}_2\text{O}_7$ is monoclinic, space group $P2_1/n$, with $a = 10.523$ (2), $b = 17.672$ (6), $c = 7.266$ (3) \AA , $\beta = 90.47$ (2)°, $Z = 8$ (25 °C). The structure was refined to $R_w(F) = 0.044$, $R(F) = 0.039$ for 2895 observed reflections. The structure consists of layers of Ca^{2+} and $\text{HP}_2\text{O}_7^{3-}$ ions alternating with layers of NH_4^+ and $\text{HP}_2\text{O}_7^{3-}$ ions. The two independent Ca^{2+} ions are each coordinated to seven O atoms whose arrangement forms a distorted pentagonal bipyramid. A short, probably symmetric [O...O = 2.473 (4) \AA], hydrogen bond links $\text{HP}_2\text{O}_7^{3-}$ ions as dimers. Two additional $\text{HP}_2\text{O}_7^{3-}$ ions act as donors to form two hydrogen bonds with the $\text{HP}_2\text{O}_7^{3-}$ dimers. The NH_4^+ ions participate in strong hydrogen bonds.

17356. Adams, J. W., Kanda, M., Shafer, J., Wu, Y., **Near-field electric field strength levels of EM environments applicable to automotive systems**, *Proc. IEEE Int. Symp. on Electromagnetic Compatibility, Seattle, WA, Aug. 2-4, 1977, 77CH 1231-0 EMC*, pp. 336-343 (Institute of Electrical and Electronics Engineers, New York, NY, 1977).

Key words: biological hazard; electromagnetic compatibility; field strength measurements; mobile communication systems; vehicular electronic systems.

As the number of electronic systems used on vehicles increases, the need to know the electromagnetics environment in and around these vehicles increases. This knowledge becomes basic information needed by system designers to avoid electronic system failures. Results of electric field strength measurements are reported for the near-field inside and outside of a passenger vehicle and of a tractor-trailer vehicle. These measurements were made with all common combinations of mobile transmitters and antennas. The rf transmitting sources used the maximum legal output power (110 W) at 40, 162, and 416 MHz, and nominal 100 watt power levels in the HF band (3 to 30 MHz). Illegal power levels (~100 watts) of CB transmissions at 27 MHz were used through a special authorization by the Interagency Radio Advisory Committee (IRAC).

Fields in and around vehicles with on-board transmitters range mostly between 10 and 300 volts per meter, with some exceptions. Field strengths in and around vehicles adjacent to vehicles with transmitters range mostly between 5 and 100 volts

per meter. Data is reported for fields on vehicles on normally conducting surfaces such as concrete and asphalt as well as on metal ground screens.

The results of the electric field strength measurements in the near-field regions of fixed, high power transmitters are also reported. These sites include AM, FM, TV broadcast stations, high-power military and FAA fixed transmitters. The electric field strengths in the near-field region of the AM broadcast station in the frequency range between 550 kHz and 1.6 MHz are found to be much higher than those at other fixed, high-power transmitters.

17357. Misra, D. N., Bowen, R. L., **Sorption of water by filled-resin composites**, *J. Dental Res.* **56**, No. 6, 603-612 (June 1977).

Key words: interphase bonding; metal-resin composites; organo-functional coupling agents; parabolic rate law; water sorption.

Water-sorption studies discriminate between passive (those containing Sn, Nb, and Ti) and reactive (those containing Zn and an alloy of CoCrMo) metal-resin composites. The reactive ones form hydrated oxides or hydroxides or both, in accord with a parabolic rate law. The nature of the chemical reaction is elucidated in two instances by analysis of the resultant gases.

17358. Truhlar, D. G., Wyatt, R. E., **H + H₂: Potential-energy surfaces and elastic and inelastic scattering**, Chapter in *Advances in Chemical Physics* **36**, 141-204 (John Wiley and Sons, New York, NY, 1977).

Key words: ab initio quantum chemistry; elastic scattering; energy transfer; excited states; hydrogen atoms; hydrogen molecules; H₃; inelastic collisions; long-range forces; potential energy surfaces; semiempirical valence-bond theory; transport properties.

The H + H₂ reaction has long been considered an important prototype for chemical reactions with activation barriers. We have recently reviewed the history of H₃ kinetics, with emphasis on experimental and theoretical studies of the reactive dynamics in the ground electronic state. The first step in all such calculations is the Born-Oppenheimer approximation, i.e., the assumption of a potential energy hypersurface (called the potential, the potential surface, or the surface for short). Thus there has been considerable work attempting to obtain this potential surface more accurately, especially by calculating the electronic energy of H₃ but also in some cases by attempting to fit analytic expressions to results of collision experiments. In particular such work has emphasized the region around the saddle point because this region is thought to be the most important for determining the rate of reaction at low and medium temperatures (less than about 1000°K). This work on the potential surface is reviewed here. We also review theoretical and experimental information about other parts of the ground-state potential surface, about potential surfaces for excited electronic states, about nonreactive dynamics on the ground-state surface, and about the dynamics of processes involving excited electronic states. This review and our previous one, taken together, constitute a review of all work concerned with gas-phase collisions of H with H₂. (Includes 250 entry bibliography).

17359. Hanson, D. W., Cateora, J. V., Davis, D. D., **A time code from NOAA's geostationary operational environmental satellites**, *Proc. Eighth Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Greenbelt, MD, Nov. 30-Dec. 2, 1977*, pp. 105-124 (Goddard Space Flight Center, Greenbelt, MD, 1976).

Key words: clocks; GOES; satellites; time; time code.

In support of the environmental data collection on NOAA's GOES satellites, a time code has been incorporated by NBS into an interrogation message from these satellites. This message is directed to data-collection platforms engaged in seismic, tsunami, hydromet and other related monitoring activities. The NBS has developed this time-code system to serve environmental data users who require only a few tenths of a second accuracy as well as those who need a more accurate time reference.

The time code is available continuously from two geostationary satellites and provides a coverage of the Atlantic and Pacific Ocean Basins as well as the North and South American Continents. The time code includes the necessary information to compensate for free-space propagation delays between the master clock located at Wallops Island, VA, and the user. Preliminary results indicate a timing resolution of 10 μs. The accuracy is very much dependent upon the quality of orbital information supplied to NBS by NOAA. This is presently being evaluated.

The time-code system is supported by atomic clocks maintained at Wallops Island, VA, the point of origin for all signals to be sent through the satellites. A data-logging system monitors three television networks and Loran-C to provide a comparison link between the Wallops Island clocks and reference standards at the NBS.

A microprocessor "smart" clock has been developed for the user that automatically corrects for path and equipment delays and places its recovered time in synchronism with UTC generated by (NBS). This clock and associated recovery equipment will also be discussed in the presentation.

17360. Cotton, I. W., **Cost-benefit analysis of interactive systems**, *Comput. Networks* **1**, No. 6, 311-324 (Nov. 1977).

Key words: analysis; cost-benefit; cost-effectiveness; economics; interactive systems; performance evaluation.

This paper assesses the state-of-the-art in cost-benefit analyses of interactive systems and suggests an approach for developing improved methodology. Cost-benefit analyses are distinguished from analyses of system performance in that the latter are directed at optimizing system performance at a given level of investment, while the former are directed at justifying the investment itself.

Methods of analyzing the performance and costs of computer systems in general and interactive systems in particular are discussed. With this information it is shown how cost-effectiveness analyses may be performed. The next crucial step is to conduct benefit analysis, an ill-defined art. The results of benefit analysis must be combined with cost-effectiveness analysis in order to perform the desired cost-benefit analysis.

An experimental methodology is suggested for better performing benefit analyses of interactive systems. A more rigorous formulation of the cost-benefit procedure is then outlined. Two examples of the application of this concept are reported.

17361. Crawford, M. L., Thomas, C. L., **Converting a rectangular shielded enclosure into a TEM transmission cell for EMI measurements**, *Proc. EMC Conf., Seattle, WA, July 31-Aug. 2, 1977*, pp. 1-6 (1977).

Key words: electromagnetic interference measurements; shielded enclosure; transverse electromagnetic transmission cell.

This paper describes the modifications needed to convert a rectangular shielded enclosure into a TEM moded EMI test chamber. The resulting chamber resembles existing TEM cells (i.e., is a 50-ohm transmission line) with the exception that the rf transmission line characteristics are achieved without the

common tapering schemes used to facilitate a transition from coaxial cable to shielded stripline. The modified shielded enclosure or cell, discussed in this paper, is a scaled model of a screen room and is evaluated by showing measurement results such as VSWR and test field uniformity as a function of frequency. The enclosure was modified in two ways: The first way uses type N input and output connectors attached at opposite ends of the enclosure. The connector's center pins are connected to a flat center conductor or septum mounted longitudinally inside the enclosure. This converts the enclosure into a double-ended 50-ohm impedance matched transmission line system. The second way is to modify the enclosure with its center plate connected to a single input/output connector at one end of the enclosure with the other end terminated internally into a 50-ohm matched impedance. The modifications described allow use of a conventional shielded enclosure as a broadband transducer for either establishing susceptibility test fields or for measuring radiated emission from equipment under test.

17362. Crawford, M. L., Workman, J. L., Thomas, C. L., **Generation of EM susceptibility test fields using a large absorber-loaded TEM cell**, *IEEE Trans. Instrum. Meas.* **IM-26**, No. 3, 225-230 (Sept. 1977).

Key words: EM compatibility; EM interference; EM susceptibility; metrology; TEM cells.

This paper discusses the development of an electromagnetic simulator for accurate generation of broad-band susceptibility test fields within a shielded environment. The simulator consists of a large, $3\text{ m} \times 3\text{ m} \times 6\text{ m}$, rectangular transverse electromagnetic (TEM) transmission cell that is loaded with RF absorber to suppress multimoding at frequencies above the cell's waveguide cutoff or resonant frequencies. The paper describes the measurement facility and technique, and the experimental verification of pertinent test parameters such as system VSWR, insertion loss, and test field uniformity. The measurement system is anticipated to provide swept, automated susceptibility measurements of electronic equipment to CW, pulsed, and EMP fields within the frequency band, 10 kHz to 1 GHz.

17363. Davis, D. D., **A microprocessor data logging system for utilizing TV as a time-frequency transfer standard**, *Proc. Eighth Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Greenbelt, MD, Nov. 30-Dec. 2, 1976*, pp. 167-181 (Goddard Space Flight Center, Greenbelt, MD, 1976).

Key words: frequency calibration; frequency transfer standard; microprocessor; television; time transfer standard.

The TV network color subcarriers have been used for several years as frequency transfer standards. Additionally, a time transfer method using TV line-10 is presently used for maintaining clock synchronization at the microsecond level. This paper describes an NBS-developed microprocessor data logging system that automates both functions in a relatively inexpensive package.

Three of these systems are in routine use to collect the color subcarrier and line-10 data published in the NBS Time and Frequency Services Bulletin. Two additional systems are used to monitor the station clocks of WWV/WWVB and the GOES satellite clock at Wallops Island, Virginia.

17364. Djadoun, S., Goldberg, R. N., Morawetz, H., **Ternary systems containing an acidic copolymer, a basic copolymer, and a solvent. I. Phase equilibria**, *Macromolecules* **10**, No. 5, 1015-1020 (Oct. 1977).

Key words: acidic copolymer; basic copolymer; copolymer, solvent; phase equilibria; ternary systems.

Ternary phase diagrams were determined for systems consisting of polystyrene or a styrene-4-vinylpyridine copolymer, poly(methyl methacrylate) or a methyl methacrylate-methacrylic acid copolymer, and a solvent (dioxane, butanone, or chloroform). While the polystyrene-poly(methyl methacrylate) solvent systems all exhibit two coexisting dilute phases, each containing predominantly one of the polymeric species, introduction of a small concentration of the acidic and basic comonomer leads to solutions containing both polymers. At higher concentrations of strongly interacting comonomers, a different type of phase separation is observed where a concentrated phase containing both copolymers is in equilibrium with a highly dilute solution. The solvent dependence of the phase diagrams is discussed in relation to polymer-solvent interaction parameters (derived from intrinsic viscosities) and in the light of calorimetric data of the enthalpy of mixing of low molecular weight analogues of the monomer residues in the copolymers.

17365. Simiu, E., Marshall, R. D., Haber, S., **Estimation of alongwind building response**, *J. Structural Div. ASCE* **103**, ST7, 1325-1338 (July 1977).

Key words: building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind loads.

The differences between the dynamic alongwind response, the gust factors, and the total alongwind response obtained using various current procedures may in certain cases be as high as 200, 100, and 60 percent, respectively. The purpose of this paper is to investigate the causes of such differences. To provide a framework for this investigation, the paper presents an overview of the questions involved in determining alongwind structural response, and a critical description of the basic features of procedures currently in use. A comparison is made between alongwind deflections of typical buildings selected as case studies, calculated by both new and traditional procedures, some of which are described in various building codes. The reasons for the differences between the respective results are pointed out. The procedures were evaluated on the basis of a recently developed method which utilizes a logarithmic variation of wind speed with height above ground, a height-dependent expression for the spectrum of the longitudinal wind speed fluctuations. The method also allows for realistic cross-correlations between pressures on the windward and leeward building faces.

17366. Taylor, P. O., Gregory, D., Dunn, G. H., **Absolute cross sections for $2s-2p$ excitation of C^{3+} by electron impact**, *Phys. Rev. Lett.* **39**, No. 20, 1256-1259 (Nov. 14, 1977).

Key words: absolute cross sections; C^{3+} ; crossed beams; electron impact; excitation ($2s-2p$).

Absolute cross sections have been measured for excitation of the $2s\ ^2S_{1/2}-2p\ ^2P_{1/2,3/2}$ resonance doublet in Li-like C^{3+} by electron impact for energies ranging from below threshold (8.0 eV) to 530 eV. The measurements agree with recent unpublished Coulomb-Born and close-coupling calculations over the entire range of electron energies.

17367. Parker, R. L., **Space processing program of the National Bureau of Standards**, Paper in *Materials Sciences in Space with Application to Space Processing. Vol. 52. Progress in Astronautics and Aeronautics*, L. Steg, Ed., pp. 423-435 (American Institute of Aeronautics and Astronautics, New York, NY, 1977).

Key words: convection; crystal growth; crystal perfection microgravity; purification; space processing.

The work of the National Bureau of Standards (NBS) for NASA's space processing program is described. The general emphasis of the NBS work has been on ground-based studies

of those aspects of space which possibly could provide a unique environment for making materials more perfect or more pure. Individual projects on crystal perfection in melt growth, evaporative purification, composites, melt shape, vapor transport, and surface traction are described.

17368. Massa, N. E., Mitra, S. S., Prask, H., Singh, R. S., Trevino, S. F., **Infrared-active lattice vibrations in alkali azides**, *J. Chem. Phys.* **67**, No. 1, 173-179 (July 1, 1977).

Key words: alkali azides; external vibrations; far infrared; lattice dynamics; optical constants; reststrahlen spectra.

The far infrared reststrahlen spectra of lithium, sodium, potassium, rubidium, and cesium azides have been measured. The reflection spectra of monocrystalline and polycrystalline samples were analyzed by Kramers-Krönig and damped Lorentz oscillator methods to obtain long wavelength optical mode frequencies and optical constants. It has been determined that the substances are quasicubic, which results in small anisotropy splittings. The similarity of the alkali azides with corresponding halides is pointed out.

17369. Berger, H., **The nondestructive evaluation program at the National Bureau of Standards**, *NDT Int. J. Non-Destructive Testing* **10**, No. 5, 277-279 (Oct. 1977).

Key words: acoustic emission; calibrations; nondestructive evaluation; radiography; reference blocks; standards; transducers.

The Nondestructive Evaluation Program at NBS is briefly reviewed for the readers of an international NDE journal. The aims of the program are outlined. The methods under study in the NDE Program are reviewed, emphasis being placed on the acoustic-ultrasonic and radiographic methods.

17370. Touloukian, Y. S., Kirby, R. K., Taylor, R. E., Lee, T. Y., **Thermophysical properties of matter—The TPRC data series. Volume 13. Thermal expansion—Nonmetallic solids**, *Book: 1787 pages* (IFI/Plenum, New York, NY, 1977).

Key words: coefficients of thermal expansion; compilation; compounds; critical data evaluation; nonmetallic elements; thermal expansion.

This volume of Thermophysical Properties of Matter comprises two major sections: the front text on theory and measurement, together with its bibliography, and the main body of numerical data and its references. The main body of numerical data is the result of a comprehensive survey of the literature. The scope of coverage includes data on the thermal expansion of the nonmetallic elements and compounds. All data were extracted directly from their original sources and have been critically evaluated and analyzed and recommended reference values, provisional values, or typical values, are presented.

17371. Brown, D. W., Lowry, R. E., **Henry's law and diffusion constants of vinyl chloride in poly(vinyl chloride) at high temperature**, *J. Polymer Sci.: Polymer Chem. Ed.* **15**, 2623-2639 (1977).

Key words: desorption; diffusion constants; Henry's law constants; poly(vinyl chloride); sorption; vinyl chloride.

The Henry's law and diffusion constants of vinyl chloride in poly(vinyl chloride) were determined at temperatures of 24, 90, 120, 150, and 170 °C for weight fractions of vinyl chloride between 0.2×10^{-3} and 0.8×10^{-3} . Above 90 °C, Henry's law applies; values of the constant increase with temperature from 1.8×10^2 to 5.5×10^2 atm per unit weight fraction of dissolved vinyl chloride. The heat of desorption is about 15 kJ/mole. At 24 °C, the nominal Henry's law constant was smaller than would have been obtained by extrapolating the values found at

higher temperature. The diffusion constants increase with temperature from about 2×10^{-13} to 3×10^{-7} cm²/sec. The activation energy for diffusion is about 110 kJ/mole between 90 and 170 °C. Although all values were determined in the absence of air, it is likely that they apply to polymer in air. They may, therefore, be used to calculate the vinyl chloride content in the gas above poly(vinyl chloride) under specific processing conditions.

17372. Wlodawer, A., Roberts, J., Holcenberg, J. S., **Characterization of crystals of L-glutaminase-asparaginase from *Acinetobacter glutaminasificans* and *Pseudomonas 7A***, *J. Mol. Biol.* **112**, 515-519 (1977).

Key words: crystal packing; glutaminase-asparaginase; preliminary crystal data; protein crystallization; tumor regulatory proteins; unit cell data.

Single crystals of glutaminase-asparaginase from two sources have been grown. A new crystal form (III) of *Acinetobacter* enzyme belongs to the space group *I222*, $a = 96.7$ Å, $b = 112.4$ Å and $c = 70.9$ Å, with one subunit in the asymmetric unit. Crystals of *Pseudomonas 7A* enzyme belong to the space group *P2₁2₁2₁*, $a = 118.0$ Å, $b = 131.2$ Å and $c = 85.1$ Å, with a tetrameric molecule in the asymmetric unit. Both types of crystals are suitable for high resolution structure determination.

17373. Cascaval, C. N., Straus, S., Brown, D. W., Florin, R. E., **Thermal degradation of polystyrene: Effect of end groups derived from azobisisobutyronitrile**, *J. Polymer Sci.: Symp.* **No. 57**, 81-88 (1976).

Key words: azobisisobutyronitrile end groups; polystyrene; pyrolysis gas chromatography; thermal degradation; weak bonds.

Polystyrenes containing end groups derived from azobisisobutyronitrile (AIBN) were subjected to thermal degradation at 280-350 °C and the rates of volatilization compared with those of thermally and anionically prepared polystyrene. At 330-350 °C the degradation of the AIBN polymer resembled that of the thermal polymer and differed from that of the anionic one. At 280-320 °C its behavior was complex infrared analysis of the degraded polymer and pyrolysis gas chromatography results suggest weak bond involvement in some cases.

17374. Evans, J. P., **Note on the relation between resistance thermometer, thermocouple, and radiation temperature scales: 630-1064 °C**, *Metrologia* **13**, 171-172 (1977).

Key words: interpolation equation; IPTS-68; radiation temperature; resistance thermometer; standard thermocouple; temperature scale; thermodynamic temperature.

This note points out that values of temperature derived from a quadratic interpolation equation for high temperature platinum resistance thermometers and from a fifth degree polynomial interpolation equation for standard (Pt-10% Rh/Pt) thermocouples are in close agreement with reported values of thermodynamic temperature determined by radiation measurements in the region 630-1064 °C.

17375. Burkhalter, P. G., Reader, J., Cowan, R. D., **Spectra of Mo xxx, xxxi, and xxxii from a laser-produced plasma**, *J. Opt. Soc. Am.* **67**, No. 11, 1521-1525 (Nov. 1977).

Key words: ions; molybdenum; spectra; structure; ultraviolet.

Spectra of highly charged Mo ions generated in a laser-produced plasma were observed from 10 to 190 Å with a 3 m grazing-incidence spectrograph. Line identifications in Mo xxx-xxxii were made with the help of relativistic Hartree-Fock calculations. In Mo xxxi (Mg-like) the $3s^2 1S_g-3s3p 1P_1$ resonance

line was found to be at 115.944 Å. In Mo xxxii (Na-like) the $3s^2S_{1/2}-3p^2P_{3/2,1/2}$ resonance lines are at 127.814 and 176.62 Å. These values support the recent identifications of these lines in the Princeton ST tokamak by Hinnov. The density-sensitive $3p^2P_{3/2}-3d^2D_{5/2}$ transition in Mo xxxii is at 126.937 Å. At shorter wavelengths, the $3s-4p$ transitions of Mo xxxii are at 14.384 and 14.565 Å.

17376. Manka, M. J., Pierce, H., Huggett, C., **Studies of the flash fire potential of aircraft cabin interior materials**, *DOT Report No. FAA-RD-77-47*, 33 pages (U.S. Department of Transportation, Federal Aviation Administration, Systems Research & Development Service, Washington, DC, Dec. 1977).

Key words: aircraft cabin materials; aircraft impact accidents; flash fires; pyrolysis products.

A flash fire cell was developed to provide a method of evaluating the relative flash fire potential of aircraft cabin interior materials. Twenty-four typical cabin materials were examined by this method. The method is convenient and provides good discrimination between materials. The results suggest that quantities as small as 150 lb. of some materials, if completely pyrolyzed, could produce flash fire conditions in a cabin of 10³ cu. ft. volume. Much larger quantities of some other materials could be used without danger of a flash fire.

A minimum energy principle was proposed to characterize the flash fire behavior of the complex mixture of fuels derived from the pyrolysis of organic materials. This principle states that a flash fire is possible when the potential combustion energy content of the pyrolyzate-air mixture exceeds approximately 425 cal L⁻¹. A variety of experiments were performed to provide support for the minimum energy principle. The results were in general agreement with predictions, but the precision of the measurements was not good enough to permit detailed conclusions. Oxidative pyrolysis appears to play a significant role in the formation of the fuel-air mixture in the flash fire cell. Particulates contribute to the creation of flash fire conditions, but they present a difficult measurement problem.

17377. Tassej, G., **The effectiveness of venture capital markets in the U.S. economy**, *Public Policy* 25, No. 4, 479-497 (Fall 1977).

Key words: barriers; imperfections; policy; resource allocation; technology; venture capital.

Two separate policy questions must be addressed in evaluating the role of the U.S. venture capital market in economic growth. One concerns the compatibility of society's allocation of funds to this sector of the capital market with a set of social goals that requires continual injections of new technology to attain acceptable rates of growth. Many contend that society has made decisions affecting the allocation of resources without regard for their longer term implications, with the result that these decisions are not consistent with its own goals. The net effect of these decisions is under investment in new technology due in part to direct restrictions on the flow of funds in venture capital markets.

The second and distinctly different question concerns the efficiency with which venture capital markets operate. Given the potential of new technological ventures to contribute to increases in productivity and growth, and the possible allocation of capital to these new ventures, are the relevant markets efficiently supporting appropriate levels of technological change? In other words, are there imperfections in the internal operations of the venture capital market?

Earlier works have discussed the issue of sufficiency in venture capital markets by addressing both questions at once, without clarifying which is considered troublesome. This paper

attempts to identify each policy question as a separate issue in a framework for technology policy, and concludes that, while there are no significant internal imperfections in these markets, there are external forces, in particular regulation, that are having a negative impact.

17378. Lovas, F. J., Suenram, R. D., **Identification of dioxirane (H₂COO) in ozone-olefin reactions via microwave spectroscopy**, *Chem. Phys. Lett.* 51, No. 3, 453-456 (Nov. 1, 1977).

Key words: chemistry; dioxirane; microwave spectra; olefins; ozone reactions; rotational constants; spectra.

Dioxirane (H₂COO) has been identified as a reaction product in the low temperature reaction of ozone with ethylene. The identification comes as the result of a microwave experiment in which the ozonolysis reaction is carried out at -196 °C in a waveguide reactor.

17379. Cohen, E. R., Birnbaum, G., **Influence of the potential function on the determination of multipole moments from pressure-induced far-infrared spectra**, *J. Chem. Phys.* 66, No. 6, 2443-2447 (Mar. 15, 1977).

Key words: collision induced absorption; far-infrared spectra; multipole moments; potential functions.

The effect of the choice of the potential function on the evaluation of molecular multipole moments from pressure-induced far-infrared spectra is investigated. The analysis is restricted to low densities where collisions are predominantly bimolecular. The quadrupole and hexadecapole moments of N₂ and O₂, and the octupole and hexadecapole moments of CH₄ and CF₄ are evaluated from far-infrared data using potential models consisting of a spherically symmetric part represented by the Lennard-Jones, Kihara, and *m*-6-8 potentials and an anisotropic part representing the electrostatic interactions of the permanent multipole moments. In general, although different values of the multipole moments are obtained with different potentials, for similar molecular diameters the variation is not great.

17380. Wineland, D. J., Hellwig, H., **Comment on "The Millman effect in cesium beam atomic frequency standards"**, *Metrologia* 13, 173-174 (1977).

Key words: atomic clock; cesium beam frequency standard; Millman effect; molecular and atomic beam magnetic resonance.

In a recent paper entitled "The Millman Effect in Cesium Beam Atomic Frequency Standards" (Mungall, A. G.: *Metrologia* 12, 151 (1976) a systematic frequency shift was observed and explained in terms of the Millman effect. The purpose of this note is to suggest that an alternative explanation be sought for the observed results.

17381. Heimbach, C. R., Lehman, D. R., O'Connell, J. S., **Three-body calculation of two-body threshold electrodisintegration of ³He and ³H**, *Phys. Rev. C* 16, No. 6, 2135-2150 (Dec. 1977).

Key words: Coulomb; electron scattering; helium; magnetic; three-body; tritium.

Threshold two-body electrodisintegration of ³He and ³H is investigated within the context of exact three-body theory. The calculations performed are based on the formalism of Gibson and Lehman. Careful consideration is given to the singularities of the disintegration Born amplitude for this case, since the momentum transfer is not zero, to assure validity of the numerical methods. Calculated results are compared with all the latest threshold ³He electrodisintegration data which sample a range of scattered-electron angles, 92.6° ≤ θ_e ≤ 180°, and incident

electron energies, $40 \text{ MeV} \leq E_0 \leq 120 \text{ MeV}$. Predictions are made for ^3H electrodisintegration for some of the same kinematics. The mechanism for the sharp rise as a function of excitation energy in the (e, e') cross section for $\theta_e \sim 90^\circ$ due to the $^2S \rightarrow ^2S$ monopole transition from Coulomb scattering is singled out by examination of the contributions to the Coulomb doublet amplitude. A similar analysis is carried out for the doublet and quartet transverse amplitudes where the $^2S \rightarrow ^4P$ magnetic quadrupole transition dominates for excitation energies less than 20 MeV.

17382. Birnbaum, G., **Far-infrared absorption in H_2 and $\text{H}_2\text{-He}$ mixtures**, *J. Quant. Spectrosc. Radiat. Transfer* **19**, 51-62 (1978).

Key words: collision induced absorption; far-infrared absorption; H_2 and $\text{H}_2\text{-He}$ mixtures.

Collision induced absorption in the translation rotation band of H_2 and $\text{H}_2\text{-He}$ mixtures is measured from 20 to 900 cm^{-1} at 77.4, 195 and 292K. To establish the accuracy of the results various sources of error are investigated. The zeroth and first spectral moments are evaluated from experiment and theory for H_2 at the various temperatures. To obtain theoretical moments consistent with the experimental values, the quantum pair distribution function must be used. The major portion of the experimental moments can be accounted for by quadrupole induced dipoles in H_2 pairs. The remaining portion is attributable to an anisotropic overlap interaction, although its magnitude depends on the value of the molecular parameters required to calculate the quadrupole contribution.

17383. Rabolt, J. F., Fanconi, B., **Longitudinal acoustic modes of polytetrafluoroethylene copolymers and oligomers**, *Polymer* **18**, 1258-1264 (Dec. 1977).

Key words: conformation in melt; elastic moduli; longitudinal acoustic modes; normal mode calculation; perfluoro n-alkanes; polytetrafluoroethylene-hexafluoropropylene copolymer; Raman spectroscopy.

Raman active longitudinal acoustic modes (*LAM*) have been observed in the perfluoro n-alkanes and in a random copolymer of tetrafluoroethylene and hexafluoropropylene (TFE-HFP). Low frequency bands were found in both the melt and solid phases of the oligomers, and their comparison indicates that regular extended helical conformations exist in the melt phase of perfluoro n-alkanes below $n\text{-C}_{12}\text{F}_{26}$. Good agreement is found between the lamellar long spacings of the copolymer and that calculated from the *LAM* frequencies. Normal mode calculations, using available force fields, have been performed on the infinite homopolymer (PTFE) and $n\text{-C}_{16}\text{F}_{34}$. It was found that the helix reversal type of chain defect does not affect *LAM* frequencies and intensities.

17384. Melmed, A. J., Carroll, J. J., Smit, J., **FEM-FIM study of Fowler-Nordheim slope variation with crystal plane size**, (Proc. First Seminar on Surface Physics, Łagow, Poland, June 7-11, 1976), *Acta Univ. Wratislav. Mat. Fiz. Astronom. No. 380*, pp. 29-35 (Wyda WNICTwa Uniwersytetu, Wrocławskiego, Wrocław, Poland, 1977).

Key words: electron work function; field-electron emission; field-ion emission; ruthenium; surface characterization; tungsten.

Field-electron microscope determinations of Fowler-Nordheim slope variations with plane size are reported for crystal planes characterized by field-ion microscopy. Experimental results are compared to theoretical computations.

17385. Moody, J. R., Lindstrom, R. M., **Selection and cleaning of plastic containers for storage of trace element samples**, *Anal. Chem.* **49**, No. 14, 2264-2267 (Dec. 1977).

Key words: cleaning; containers; contamination; storage; trace elements.

Since the sample container represents one of the earliest and potentially one of the largest sources of sample contamination, much of the analytical accuracy will depend upon the choice of container materials and the method of cleaning containers. Twelve different plastics have been examined by gravimetry, isotope dilution mass spectrometry, and neutron activation analysis. The present study examines the levels of impurities present in the various plastics as well as the quantities of impurities leached from the plastics by acid cleaning. A suggested method of cleaning containers is presented.

17386. Gallagher, A., Holstein, T., **Collision-induced absorption in atomic electronic transitions**, *Phys. Rev. A* **16**, No. 6, 2413-2431 (Dec. 1977).

Key words: atomic line shapes; collision induced radiation; radiation.

The collision-induced absorption and emission coefficients for electric-dipole forbidden atomic transitions are calculated for weak radiation fields. The approximations used are valid for $\hbar\omega$ near $\hbar\omega_0$, the atomic energy differences. The example case of *S-D* transitions induced by a spherically symmetric perturber (e.g., a noble-gas atom) is treated in detail and compared to measurements. The case of "radiative collisions," in which both colliding atoms change their state, is included in the theory and is also compared to experiment.

17387. Hunter, C., **The collapse of unstable isothermal spheres**, *Astrophys. J.* **218**, 834-845 (Dec. 15, 1977).

Key words: hydrodynamics; instabilities; star formation.

Similarity solutions provide simple analytical descriptions of modes of collapse of gravitationally unstable isothermal spheres, both before and after a collapsed core has formed. A new class of similarity solutions has been found, to add to the solutions obtained earlier by Larson, Penston, and Shu. Numerical integrations of collapses were performed to study their resemblance to the similarity solutions. None of the collapses studied showed any strong tendency to a similarity solution. Computed behaviors were generally intermediate between those described by similarity solutions, with the Larson-Penston solution giving the best description of the flow in the immediate neighborhood of the point of core formation. It was also found that perturbed gravitationally unstable spheres do not necessarily collapse; they may instead perform periodic oscillations of large amplitude.

17388. Taylor, P. O., Gregory, D., Dunn, G. H., Phaneuf, R. A., Crandall, D. H., **Absolute cross sections for 2s-2p excitation of C^{3+} by electron impact**, *Phys. Rev. Lett.* **39**, No. 20, 1256-1259 (Nov. 14, 1977).

Key words: absolute cross sections; crossed beams; C^{3+} ; electron impact; excitation (2s-2p).

Absolute cross sections have been measured for excitation of the $2s \ ^2S_{1/2} - 2p \ ^2P_{1/2,3/2}$ resonance doublet in Li-like C^{3+} by electron impact for energies ranging from below threshold (8.0 eV) to 530 eV. The measurements agree with recent unpublished Coulomb-Born and close-coupling calculations over the entire range of electron energies.

17389. Sugar, J., **Resonance lines in the Ag I and Pd I isoelectronic sequences: Cs IX through Sm XVI and Cs X through Nd XV**, *J. Opt. Soc. Am.* **67**, No. 11, 1518-1521 (Nov. 1977).

Key words: barium; cerium; cesium; lanthanum; praseodymium; samarium; spectra.

Spectra of Cs, Ba, La, Ce, Pr, Nd, and Sm ions were obtained with a low-temperature triggered spark produced with a 14.2 μF capacitor charged to voltages of 3-15 KV. They were photographed with a 10.7 m grazing incidence spectrograph in the range of 60-600 \AA . Resonance lines in the Pd I isoelectronic sequences $4d^{10}\text{-}4d\ 9s$, and $4d^{10}\text{-}4d\ 9d$ were identified. In the Ag I sequences, spectral lines arising from $5s\text{-}5p$, $5p\text{-}5d$, $4f\text{-}5d$, and $4f\text{-}5g$ transitions were identified.

17390. Rowe, J. M., Rush, J. J., Prince, E., Chesser, N. J., **Neutron scattering studies of crystal dynamics and order-disorder phase transitions in alkali cyanides**, *Ferroelectrics* 16, 107-109 (1977).

Key words: antiferroelectric; cyanides; diffraction; neutron scattering; phase transition; soft mode.

The structure, phase transitions and crystal dynamics of KCN and NaCN have been studied by a series of neutron diffraction and inelastic scattering measurements. High resolution powder diffraction results on the three phases of both salts show that the ordered low temperature phase has an "antiferroelectric" orthorhombic structure, based on a primitive orthorhombic unit cell with essentially the same dimensions as the body-centered orthorhombic cell of the intermediate phase. The characteristic superlattice diffraction peak vanishes as the phase transition temperature is approached from below in the manner expected for a continuous order-disorder phase transition. In accord with other workers, we find no evidence of second-order behavior below the orthorhombic-cubic phase transition. Neutron inelastic scattering results are presented for the cubic phase of KCN, including a careful study of the behavior of a soft shear mode down to the cubic-orthorhombic phase transition.

17391. Zelkowitz, M. V., Larsen, H. J., **Implementation of a capability-based data abstraction**, *IEEE Trans. Software Eng.* SE-4, No. 1, 56-64 (Jan. 1978).

Key words: data abstraction; information hiding; Pascal; PL/I; pointer variables.

One important feature in programming language design is an appropriate data definitional facility. Criteria now recognized as important are the concepts of information hiding and data abstraction. The problem, however, is to embed these ideas into languages. Although including these ideas has often led to the design of a new language, that is not always necessary. Such facilities may be added to languages like PL/I or Pascal. This report discusses the inclusion of such facilities within one such PL/I compiler. While the resulting system does not have the optimal set of protection features, it does have several advantages: the base language is known to a large class of programmers, there are many such compilers already written, and the system achieves almost as much protection as is needed.

17392. Treado, M. J., Taggart, H. E., Nelson, R. E., Workman, J. L., Project Staff, **Fixed and base station antennas**, *NILECJ-STD-0204.00*, 16 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Nov. 1977).

Key words: antenna; base station antenna; fixed antenna; law enforcement; performance standard.

This document is a voluntary performance standard for antennas used at fixed sites and base stations. It is intended for use by law enforcement agencies as an aid in the selection and procurement of this type of antenna. The standard includes the minimum performance requirements and methods of test to determine the effectiveness and suitability of these antennas for law enforcement use.

17393. Jickling, R. M., Shafer, J. F., Project Staff, **FM repeater systems**, *NILECJ-STD-0213.00*, 16 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Nov. 1977).

Key words: FM repeater; law enforcement; mobile communications equipment; NILECJ standard; relay station; repeater station.

The document is a voluntary performance standard that establishes minimum performance requirements and methods of test for FM repeaters used by law enforcement agencies. This standard specifies the test conditions, the test equipment needed, the test methods, and the minimum performance requirements necessary for satisfactory performance.

17394. Antonucci, J. M., Bowen, R. L., **Adhesive bonding of various materials to hard tooth tissues: XIII. Synthesis of a polyfunctional surface-active amine accelerator**, *J. Dent. Res.* 56, No. 8, 937-942 (Aug. 1977).

Key words: accelerator; adhesion; amines; anionic catalyst; chelation; composite resins; cyanoacrylates; epoxy resin; *N*-methyl-*p*-toluidine; *N*-phenylglycine; pit and fissure sealants; polymerization.

Surface-active amine polymerization accelerators can be prepared by the reaction of poly-epoxy resins with the sodium salt of *N*-phenylglycine and *N*-methyl-*p*-toluidine. These materials are expected to promote adhesion through complexation with surface calcium (or other metal ions), utilizing several chelating groups per molecule, and by functioning as polymerization accelerators for dental resins; they can also function as catalysts for the anionic polymerization of cyanoacrylate monomers.

17395. Douglas, T. B., **Thermodynamic properties of molybdenum pentafluoride vapor**, *J. Chem. Thermodyn.* 9, 1165-1179 (1977).

Key words: enthalpy; entropy; gas oligomers; Gibbs energy; ion fragmentation; molybdenum pentafluoride; saturated vapor; thermodynamic properties; vapor association.

There are calculated for 298 K and higher temperatures the standard entropies of the liquid and the important gas species (monomer, dimer, and trimer) of MoF_5 , and their differences in enthalpy and Gibbs energy. Besides estimated mean heat capacities, the input data are: the vapor pressure at one temperature and the saturated-vapor density at two temperatures (based on measurements in this laboratory); the standard entropies of the three gas species (estimated from published spectroscopic data on the crystal and monomer); and an ion-abundance proportion (from a published mass-spectral study). This ion proportion is corrected for fragmentation after demonstrating that changes in the ion proportions for a similar fluoride, RhF_5 , can be explained by assuming that the rates of fragmentation of the dimer and trimer are equal. For those input data considered most uncertain (the vapor pressure, the entropies of dimer and trimer, and the ratios of mass-spectral ionization efficiencies) several sets of values covering their respective estimated ranges of uncertainty are used alternatively in the calculations. Results at 298.15 K—expressed in the form "preferred value (probable range due to uncertainty)," with H° and G° relative to the liquid, and S° —are as follows: liquid, $S^\circ = 46$ (44.5 to 49) $\text{cal}_h\ \text{K}^{-1}\ \text{mol}^{-1}$; monomer, $H^\circ = 19$ (17 to 22) $\text{kcal}_h\ \text{mol}^{-1}$, $G^\circ = 8.5$ (7.5 to 11.5) $\text{kcal}_h\ \text{mol}^{-1}$, $S^\circ = 80.6$ $\text{cal}_h\ \text{K}^{-1}\ \text{mol}^{-1}$; dimer, $H^\circ = 15.7$ (15 to 16) $\text{kcal}_h\ \text{mol}^{-1}$, $G^\circ = 6.48$ (6.45 to 6.51) $\text{kcal}_h\ \text{mol}^{-1}$, $S^\circ = 123$ (121 to 127) $\text{cal}_h\ \text{K}^{-1}\ \text{mol}^{-1}$; trimer, $H^\circ = 17.7$ (16 to 21) $\text{kcal}_h\ \text{mol}^{-1}$, $G^\circ = 8.4$ (8.1 to 8.7) $\text{kcal}_h\ \text{mol}^{-1}$, $S^\circ = 169$ (161 to 185) $\text{cal}_h\ \text{K}^{-1}$

mol⁻¹. The calculated mole fractions of monomer, dimer, and trimer in the saturated vapor at 298.15 K average 0.027, 0.94, and 0.035, respectively.

17396. Julienne, P. S., Theory of rare gas-group VI ¹S-¹D collision-induced transitions, *J. Chem. Phys.* **68**, No. 1, 32-41 (Jan. 1, 1978).

Key words: collision-induced emission; interatomic interactions; long range perturbation theory; rare gas oxides; rare gas selenides; rare gas sulfides.

The collision-induced ¹S-¹D emission of a Group VI metastable ¹S atom in the presence of a rare gas background is investigated theoretically. Approximate model potentials are constructed for the Group VI ¹S-rare gas interaction based on the mixed rare gas ground state potentials. The model is supplemented by *ab initio* calculations for ArO and by the RKR potential for XeO. Long range perturbation theory is used for the induced dipole transition moment, supplemented at short range by the available *ab initio* calculations on Ar, Kr, and Xe oxides. The model gives a satisfactory account of the measured emission coefficients for the rare gas oxides and sulfides and predicts emission coefficients for the rare gas selenides.

17397. Krause, R. F., Jr., Douglas, T. B., The melting temperature, vapor density, and vapor pressure of molybdenum pentafluoride, *J. Chem. Thermodyn.* **9**, 1149-1163 (1977).

Key words: melting point; molybdenum pentafluoride; static technique; transpiration; vapor density; vapor pressure.

A sample of MoF₅ was prepared by reaction of MoF₆(g) and Mo(c). Melting curves of temperature against time established the melting temperature at zero impurity to be 318.85 K, the enthalpy of fusion to be 6.1 kJ mol⁻¹ (±5 percent), and the cryoscopic impurity of the sample to be 0.15 mole percent. In the presence of MoF₆(g), which was added to suppress disproportionation, the vapor density of MoF₅ over the liquid was measured by the transpiration method at 343, 363, and 383 K, the total MoF₅ that evaporated being determined by permanganate titration. The total vapor pressure of MoF₅ oligomers over the liquid was measured by a simple static method at 373 and 392 K, while melting temperatures were taken alternately to monitor possible contamination of the sample. Although the vapor pressures were adjusted for disproportionation, solution of MoF₆ in MoF₅(l), and wall adsorption of MoF₆, their percentage uncertainty is probably several times that of the vapor densities. A combination of the two properties indicates the average extent of association of the saturated vapor to be near 2, which is the value for the dimer species (MoF₅)₂.

17398. Filliben, J. J., DATAPAC: A data analysis package, *Proc. Ninth Interface Symp. on Computer Science and Statistics, Boston, MA, Apr. 1-2, 1976*, pp. 212-217 (1976).

Key words: computer package; data analysis; data analysis package; DATAPAC; Fortran; Fortran subroutine set; package; portable; software; stand-alone subroutine; statistics; subroutine set.

DATAPAC is a homogeneous and systematic set of FORTRAN subroutines for statistical data analysis. DATAPAC subroutines are portable (ANSI FORTRAN) and stand-alone (self-contained) with simple, systematic, and consistent subroutine names, simple argument structure, and modularized internal coding. The 174 DATAPAC subroutines are grouped into 14 categories: cumulative distribution functions, probability density functions, percent point functions, sparsity functions, random number generators, probability plots, individual statistics, general analyses, time series analyses, polynomial regression, printer plots, terminal plots, I/O, and data manipula-

tion. The DATAPAC package is unique in the completeness of its cdf/pdf/ppf/sf categories, its probability plot category (18 distributions), and its tail length analyses (3 distributions).

17399. Rowe, J. M., Low-temperature lattice properties of PdD alloys, *J. Phys. F: Metal Phys. Lett.* **8**, No. 1, L7-L8 (1978).

Key words: alloy; Debye temperature; elastic constant; hydrogen; lattice modes; PdD_{0.63}.

The measured phonon dispersion relations for PdD_{0.63} at 150 K are used to estimate the elastic constants and low-temperature Debye θ for this compound. The results explain the observations that the low-temperature lattice properties (e.g. specific heat, thermal expansion) of PdH_x alloys for $x \approx 0.6$ are very similar to those for pure Pd.

17400. Gait, J., A new nonlinear pseudorandom number generator, *IEEE Trans. Software Eng.* **SE-3**, No. 5, 359-363 (Sept. 1977).

Key words: cycle testing; encryption; key generation; nonlinear generator; power spectrum test; pseudorandom numbers.

During the next few years a new pseudorandom number generator will become available on many computer systems. A concern for the security of computer data has led to the adoption of a Data Encryption Standard (DES) by the National Bureau of Standards. This standard specifies a nonlinear cryptographic algorithm which can be used *inter alia* as a source of pseudorandom numbers in software applications, such as those involving order statistics, where the usual linear congruential and generalized feedback shift register generators seem to be inadequate. Results of testing the DES as a pseudorandom number generator indicate that the algorithm is more than satisfactory for this purpose.

17401. Page, C. H., Classes of units in the SI, *Am. J. Phys.* **46**, No. 1, 78-79 (Jan. 1978).

Key words: base; decibel; derived; dimension; logarithm; neper; radian; SI; supplementary; units.

The mathematical nature of the categories of *base*, *supplementary*, and *derived* units in the SI is explained, and the usual definition of "supplementary" modified to be more precise. An argument is presented for adding "neper" to the SI as a supplementary unit.

17402. Raveché, H. J., Stuart, C. A., Uniqueness for the BBGKY hierarchy for hard spheres in one dimension, *J. Stat. Phys.* **17**, No. 5, 311-321 (1977).

Key words: correlation functions; one-dimensional hard spheres; solution of BBGKY hierarchy; uniqueness.

We prove that the stationary BBGKY hierarchy for an infinite system of hard spheres in one dimension has a unique solution for all densities, within a symmetry class that pertains to either a fluid array or to a perfect crystalline array. The solution is shown to correspond to the uniform fluid, which is the only equilibrium state of the infinite system. The proof is subject to the recursion relation for the correlation functions found by Salsburg, Zwanzig, and Kirkwood, which we show exactly reduces the infinite hierarchy to a pair of coupled equations. A brief discussion is given of the existence of multiple solutions of an approximate BBGKY equation.

17403. Paffenbarger, G. C., The disciples of Eugene W. Skinner: Philander B. Taylor and George M. Hollenback, *Operative Dentistry* **2**, No. 4, 148-153 (Autumn 1977).

Key words: biography (dental); history (dental); Hollenback, G. M.; lecture (memorial); Skinner, E. W.; Taylor, Philander, B.

Eugene W. Skinner, Ph.D. (Physics) was pre-eminent in the science of dental materials having taught at Western Reserve and at Northwestern Universities for several decades. His textbook, "The Science of Dental Materials" first published in 1934, has sold in excess of 100,000 copies. Two of his prominent disciples as well as students were Philander B. Taylor, A. M. (Physics) and George M. Hollenback, D.D.S., M.S.D. Taylor's researches involved denture bases, direct filling resins and the lost wax casting process. Hollenback designed a host of instruments for measuring pertinent physical properties of dental materials primarily used in restorative dentistry. The researches of all three men contributed substantially to the advancement of dental health service.

17404. Chabay, I., Rosasco, G. J., Etz, E. S., **Alternative techniques for fiber characterization: Particulate size distribution measurement by Doppler shift spectroscopy and chemical identification by microRaman spectroscopy**, (Proc. Symp. on Electron Microscopy of Microfibers, Pennsylvania State Univ., University Park, PA, Aug. 23-25, 1976), *Section V. Alternate Techniques in First FDA Office of Science Summer Symposium on Electron Microscopy of Microfibers*, I. M. Asher and P. P. McGrath, Eds., pp. 181-188 (U.S. Department of Health, Education, and Welfare, Bethesda, MD, 1977).

Key words: aerosol size distribution; Doppler shift spectroscopy; microfibers; microRaman spectrometer; Mie scattering; Raman spectroscopy; sulfate in particulates.

Descriptions of two new techniques for measurement of particle properties are presented. Raman spectroscopy to characterize chemically individual micrometer-size particles can be routinely performed with an instrument designed and constructed at NBS. Data obtained by Drs. Rosasco and Etz on their microRaman instrument is discussed. The spectra of individual micrometer-sized particles of anhydrite in urban dust, cholesterol and a comparison of the spectra of ammonium, sodium, and calcium sulfate are included.

A Doppler shift spectrometer has been developed which can measure the size distribution of liquid or solid aerosols from 0.5 to 50 μm radius. The Stokes Law settling velocity and the scattered light intensity are used together to determine the size distribution of an aerosol with a minimum of perturbation of the sample. This technique is rapid, inherently calibrated without external standards, and independent of assumptions regarding the width or shape of the size distribution.

Both techniques discussed can in principle be applied readily to microfibers. As yet, this has not been attempted. The Doppler shift light scattering technique could also provide information on the axial ratios of microfibers.

17405. Hill, J. E., Streed, E. R., **Testing and rating of solar collectors**, Paper X in *Applications of Solar Energy for Heating and Cooling of Buildings, Section 2: System Components and Performance*, R. C. Jordan and B. Y. H. Liu, Eds., ASHRAE GRP 170, pp. X-1—X-18 (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., New York, NY, 1977).

Key words: rating solar collectors; solar collector; testing solar collectors.

The use of solar energy for space heating, cooling, and supplying domestic hot water to buildings is receiving serious attention at present due to the mounting public awareness of the shortage of conventional fuels. It is clear that this trend is creating an on-rush of solar collectors of various designs, all

claiming a specific efficiency and potentially significant fuel savings if used. It is imperative that standard methods of testing and rating solar collectors be adopted so that the collectors can be evaluated in a meaningful and consistent way.

The purpose of this chapter is to describe the fundamental approach to testing solar collectors, give a brief description of testing activities that have been and are being conducted around the world, and to give the status as of 1975 of efforts being directed toward the adoption of a standard test method for testing and rating collectors. Attention is focused on the flat-plate collector because of its predominant use for space heating, cooling, and domestic water heating. However, it is felt that the basic approach described here is valid for concentrating collectors having a low concentration ratio, that are being considered for solar cooling applications.

17406. Durst, R. A., **Continuous determination of free cyanide by means of membrane diffusion of gaseous HCN and an electrode indicator technique**, *Analytical Lett.* **10**, No. 12, 961-978 (1977).

Key words: cyanide; cyanide analyzer; gas dialysis; ion-selective electrode; silver cyanide indicator; silver electrode.

A continuous measurement system for free cyanide has been developed based on the principle of diffusion across a gas-permeable membrane to affect the separation of hydrogen cyanide from the acidified sample solution. The cyanide absorbed in the alkaline indicator solution is subsequently analyzed by an indirect technique using a silver ion-selective electrode. In the concentration range of 30 to 400 $\mu\text{g CN}^-/\text{L}$, the accuracy and precision of this method is approximately two percent. The detection limit of this system is approximately 0.5 $\mu\text{g CN}^-/\text{L}$.

17407. Harrje, D. T., Hunt, C. M., Treado, S. J., Malik, N. J., **Automated instrumentation for air infiltration measurements in buildings**, *Princeton University Center for Environmental Studies Report No. 13*, 33 pages (Princeton University, Princeton, NJ, Apr. 1975).

Key words: air infiltration instrumentation; air infiltration measurement; building ventilation rates; sulfur hexafluoride tracer.

Automated instrumentation using sulfur hexafluoride as a tracer gas in residential housing to determine rates of air infiltration in housing is described. The principles of operation, the necessary calibration procedures and the early field data are discussed in detail. Concentration levels of SF_6 are maintained at the parts per billion level in the buildings and are measured by sensitive electron capture detectors in conjunction with a gas chromatograph.

17408. Furukawa, G. T., Bigge, W. R., Riddle, J. L., Reilly, M. L., **The freezing point of aluminum as a fixed point for platinum resistance thermometry**, (Proc. 11th Session Comité Consultatif de Thermométrie, Comité Int. des Poids et Mesures, Sèvres, France, June 15-16, 1976), Paper T 19 in *Comite Consultatif de Thermometrie*, pp. T 163-T 166 (Bureau International des Poids et Mesures, Sèvres, France, 1976).

Key words: aluminum freezing point; aluminum point; thermometric standard.

The range of the freezing points for five aluminum specimens was found to be 0.51 mK. The equation $W(t') = 1 + At' + Bt'^2$ was extrapolated to the aluminum point. The range of the values of t' (Al) computed for five platinum resistance thermometers (SPRT) was 3.3 mK. The enhancement of the reproducibility of SPRT temperature scales by applying the aluminum point is described. An equation suitable for a SPRT

scale that includes the aluminum point is: $W(t^*) = 1 + At^* + Bt^{*2} + Dt^{*3}$ ($t^* = 231.9292$ °C) ($t^* = 419.58$ °C).

17409. Thornton, D. D., Mangum, B. W., **Clinical fixed points—The melting point of gallium**, (Proc. 11th Session Comité Consultatif de Thermométrie, Comité Int. des Poids et Mesures, Sèvres, France, June 15-16, 1976), Paper T 17 in *Comité Consultatif de Thermométrie*, pp. T 157-T 160 (Bureau International des Poids et Mesures, Sèvres, France, 1976).

Key words: clinical laboratories; clinical thermometers; precision thermometers; temperature; temperature reference points.

There is a special need for a reliable, simple, and economical system of temperature reference points between 0 °C and 100 °C. This need arises from an increasingly wide usage of electronic thermometers, which use thermistor sensors. The complete temperature characteristics of thermistors and the possibility of calibration drift make it important to be able to quickly calibrate them at several points in the temperature range of interest. The need for high accuracy in temperature measurement is particularly acute in clinical laboratories where thermistors are used as temperature sensors in automated enzyme analyzers. We propose to document a set of liquid-solid phase transitions to be used as fixed points. In this paper we demonstrate that the melting point of 7 N's pure gallium, at 29.772 °C, is reproducible to a millikelvin and that small (20 grams) samples can be used to calibrate thermistors to this accuracy and any thermometer to an accuracy of 10 mK or better in a temperature controlled bath.

17410. Furukawa, G. T., Bigge, W. R., **The triple point of mercury as a thermometric standard**, (Proc. 11th Session Comité Consultatif de Thermométrie, Comité Int. des Poids et Mesures, Sèvres, France, June 15-16, 1976), Paper T 14 in *Comité Consultatif de Thermométrie*, pp. T 138-T 144 (Bureau International des Poids et Mesures, Sèvres, France, 1976).

Key words: freezing point; mercury triple point; thermometric standard; triple point.

Mercury can readily be made purer than 99.9999 percent by chemical washing followed by multiple distillation. The range of the freezing points of mercury from three sources was found to be 0.1 mK. The total impurity of one of the samples, SRM-743, is estimated to be less than 20 parts per billion. The second sample was a part of the NBS "density standard" mercury. The third sample was a part of a large lot purified for manometry at the NBS. The triple point of mercury was found to be close to 234.308 3₂ K (-38.841 6₈ °C). The triple point of mercury is expected to be as reproducible as the triple point of water.

17411. Guildner, L. A., Kostkowski, H. J., Evans, J. P., **Appraisal of interpolation instruments for a practical temperature scale from 630.74 °C to 1064.43 °C**, (Proc. 11th Session Comité Consultatif de Thermométrie, Comité Int. des Poids et Mesures, Sèvres, France, June 15-16, 1976), Paper T 21 in *Comité Consultatif de Thermométrie*, pp. T 173-T 185 (Bureau International des Poids et Mesures, Sèvres, France, 1976).

Key words: International Practical Temperature Scale; photoelectric spectral pyrometer; platinum resistance thermometer; temperature; thermocouple; thermodynamic temperature; thermometry.

The uncertainties of realizing the IPTS-68 between 630.74 and 1064.43 °C are large (from 100 to 300 mK) because of limitations of the Pt-10 percent Rh/Pt thermocouple as an interpolating instrument.

There is sufficient experimental evidence to conclude that an important reduction of uncertainty can be attained by replacing the thermocouple as the standard instrument with a platinum resistance thermometer. It has already been demonstrated that resistance thermometers, immediately after calibration, can determine value of temperature in this range with a total uncertainty (3σ + systematics) of about 10 mK, and after exposure to high temperatures for 125 h, with a total uncertainty of about 70 mK.

A proposed alternative, a scale based on blackbody radiation using a photoelectric spectral pyrometer as the interpolating instrument, is estimated to be more precise and accurate than the present scale realized by using thermocouples. However, the experimental demonstration to date has been very limited. The smallest reported uncertainty at the temperature of the gold point on such a scale when starting at the silver point is 40 mK and when starting at the antimony point is 160 mK. There are other serious problems and limitations in adopting a photoelectric pyrometer scale below the gold point. Among these are the unavailability of suitable commercial photoelectric pyrometers, the high level of technical proficiency required for making such measurements and the scarcity of adequately trained people, and the difficulties of transferring and applying such a radiation temperature scale.

Thus from the standpoint of reproducibility, ease and economy of use, and the extent to which such a scale would be used broadly by technical workers, the platinum resistance thermometer has significant advantages over the photoelectric spectral pyrometer. If it were used now in the range 630.74 to 1064.43 °C, the platinum resistance thermometer could yield values of temperature that would not differ significantly from the realization of the present scale when these values are derived from an already established equation. We recommend that the CCT encourage such use as a means of broadening the acceptance of this instrument. If its use becomes broad enough by the time that a new scale is formulated, as we estimate, the high temperature platinum resistance thermometer should replace the thermocouple for the new IPTS up to the temperature of the gold point.

17412. Evans, J. P., **Present efforts in high temperature resistance thermometry at the National Bureau of Standards**, (Proc. 11th Session Comité Consultatif de Thermométrie, Comité Int. des Poids et Mesures, Sèvres, France, June 15-16, 1976), Paper T 20 in *Comité Consultatif de Thermométrie*, pp. T 167-T 172 (Bureau International des Poids et Mesures, Sèvres, France, 1976).

Key words: high temperature; laser machining; platinum; resistance thermometry; temperature scale; thermometer.

Work now in progress or planned for the near future at the National Bureau of Standards is aimed at developing superior platinum resistance thermometers for use at high temperatures and at encouraging their commercial production. Present efforts are concentrated on the design and construction of thermometers having a resistance at 0 °C of 2.5 ohm and intended for use up to at least 700 °C. This report describes some of the features of the thermometer construction, including the use of laser machining to make silica glass supporting parts.

17413. Mangum, B. W., Bowers, W. J., **Magnetic thermometry between 1K and 20K using neodymium ethylsulfate**, (Proc. 11th Session Comité Consultatif de Thermométrie, Comité Int. des Poids et Mesures, Sèvres, France, June 15-16, 1976), Paper T 10 in *Comité Consultatif de Thermométrie*, pp. T 89-T 91 (Bureau International des Poids et Mesures, Sèvres, France, 1976).

Key words: low temperatures; low temperature thermometry; magnetic thermometry; neodymium ethylsulfate; rare earths at low temperatures.

We have measured the ac magnetic susceptibility of neodymium ethylsulfate (NES) in the temperature range 2-20K. We find that it is a good magnetic thermometer for this range and that its susceptibility is rather well described by the equation

$$N = N_{\infty} + A \left[(1/T) + (0.0133/T^2) - (0.000224/T^3) \right]$$

in which the coefficients were calculated assuming dipolar interactions and hyperfine effects only. In using the NES results to smooth the acoustic scale, some apparently systematic errors appear in the later.

17414. White, H. J., *The NSRDS and data banks*, (Proc. Asilomar Conf., Pacific Grove, CA, Jan. 16-21, 1977), Paper No. 27 in *Phase Equilibria and Fluid Properties in the Chemical Industry*, T. S. Storvick and S. I. Sandler, Eds., ACS Symposium Series No. 60, pp. 468-473 (American Chemical Society, Washington, DC, 1977).

Key words: data banks for the chemical industry; National Standard Reference Data System.

The National Standard Reference Data System (NSRDS) is described, and it is pointed out that the output of the NSRDS is in itself a data bank (unautomated). The relationship of this data bank to various mission-oriented data banks including a data bank of thermophysical properties for fluids for the chemical industry is discussed. Recent initiatives of the NSRDS to meet the data needs of the chemical industry including "Project Evergreen" are discussed.

17415. Swyt, D. A., *Design of a pattern on a photomask-like physical standard for evaluation and calibration of linewidth-measuring systems*, *Solid State Technol.*, pp. 35-42 (Jan. 1978).

Key words: accuracy; dimensional measurement; electron microscope; integrated circuit; linespacing; linewidth; metrology; microelectronics; optical microscope; photomask; precision; principles of measurement.

A pattern for a photomask-like physical standard, having among its elements lines of widths and spacings in the 1-to-10 micrometer (μm) range, has been developed to be used by the integrated circuit industry to calibrate linewidth-measuring optical microscopes. In order to meet the special requirements of a National Bureau of Standards (NBS) measurement transfer program, the pattern has been designed with some essential metrological and statistical principles in mind. The resulting unusual and functionally important features are intended first, to test the ability of an optical system to perform proper linewidth measurements; second, to expose or counteract instrument and operator biases in the measurement process; and third, to allow a transfer of linewidth calibration values with a built-in test of the accuracy and precision of the transfer. The basic pattern can be scaled to micrometer and submicrometer sizes, formed on transmitting photomasks and opaque substrates, and used with linewidth-measuring devices of imaging or nonimaging, reflecting or transmitting, optical or electron types.

17416. Timmerhaus, K. D., Reed, R. P., Clark, A. F., Eds., *Advances in cryogenic engineering*, (Proc. First Int. Cryogenic Materials Conf., Kingston, Ontario, Canada, July 22-25, 1975), *Book: 22*, 570 pages (Plenum Publ. Corp., New York, NY, 1977).

Key words: applied superconductivity; cryogenic engineering; cryogenic materials research; cryogenic systems; LNG, storage and transportation; low-temperature materials research.

This volume presents the latest advances in low-temperature materials research, consolidating the most recent findings of materials investigators with current reports from the designers of cryogenic systems. Responding to the two greatest stimuli for cryogenic materials research—applied superconductivity and the storage and transportation of LNG—eminent international investigators offer discussions on the properties of a wide variety of low-temperature materials, including: fatigue and fracture behavior of structural alloys used in superconducting machinery LNG ships; thermal properties of epoxies used in composites; critical current and AC losses in new developmental superconductors.

Numerous applications of low-temperature materials research in controlled thermonuclear fusion, in energy transmission, generation, and storage, and in the oxygen and liquefied gas industries are described. The use of low-temperature materials for insulators, seals, and structural supports for low-temperature areas such as storage tanks, power lines, bubble chambers, and magnets is discussed as well. The book includes discussions of efficient alloy selection, alternate materials choices, and degradation properties, all leading to a safer design of cryogenics systems.

17417. Logan, K. W., Trevino, S. F., Casella, R. C., Shaw, W. M., Muhlestein, L. D., Mical, R. D., *The lattice dynamics of NaNO_3* , (Proc. Int. Conf. on Phonons, University of Rennes, Rennes, France, July 26-29, 1971), Paper in *Phonons*, M. A. Nusimovici, Ed., pp. 104-108 (Flammarion Sciences, Paris, France, 1971).

Key words: ionic crystals; neutron scattering; phonons.

The lattice dynamics of NaNO_3 have been studied by inelastic neutron scattering. The dispersion relations of phonons along the high symmetry C direction and along two directions of lower symmetry have been measured. The identification of the modes to appropriate irreducible representation has been accomplished with the aid of a new group theoretical procedure. Most of the previously measured optically active modes have been detected and the three inactive modes have now been identified.

17418. Caswell, R. S., Coyne, J. J., Randolph, M. L., *Kerma factors for tissue compositions, compounds and mixtures*, (Proc. Workshop on Physical Data for Neutron Dosimetry, Rijswijk, The Netherlands, May 19-21, 1976), Paper in *Monograph on Basic Physical Data for Neutron Dosimetry*, EUR5629e, pp. 69-76, 287-309 (Radiation Protection Research Commission of the European Communities, Munich, Germany, 1976).

Key words: energy absorption coefficients; kerma factors; neutron dosimetry; neutron radiation therapy; radiobiology; tissue composition.

The basis for the calculation of new tables of kerma factors (kerma per unit neutron fluence) for neutrons of energy below 30 MeV is discussed. Kerma factors are given for 19 elements or nuclides: H, ^6Li , ^7Li , B, C, N, O, F, Na, Mg, Al, Si, P, S, Cl, Ar, K, Ca, and Fe. Kerma factors are given for 15 tissue, compositions, compounds and mixtures of interest for neutron dosimetry, neutron radiation therapy, and radiobiology. Nuclear data from the Evaluated Nuclear Data File ENDF/B-4 are used when available.

17419. Reed, R. P., Ledbetter, H. M., van Reuth, E. C., Eds., *Semi-annual technical reports on materials research in support of superconducting machinery—VI*, Mar. 1, 1976 to Sept. 1, 1976, 567 pages (Advanced Research Projects Agency, Arlington, VA, 1976).

Key words: elastic; electrical and magnetic; fatigue and fracture; low-temperature; specific heat; superconducting machinery; tensile; thermal and magnetothermal conductivity; thermal expansion.

The sixth semi-annual technical reports are collected from three subcontractors of an ARPA-sponsored program to study the very low-temperature properties of structural materials in support of the development of superconducting machinery. The program is outlined and new research results are reported. Low-temperature results are given for the following properties: elastic, tensile, fatigue and fracture, thermal expansion, specific heat, thermal and magnetothermal conductivity, electrical and magnetic. Effects of processing and fabrication are also considered for some properties; weld and braze-joint properties are included. Tensile and compressive properties at 4 K of selected composite materials are presented.

17420. Kotter, F. R., Misakian, M., **AC transmission line field measurements**, *Energy Technol. HCP/T-6010/EI*, 82 pages (U.S. Department of Energy, Division of Electric Energy Systems, Washington, DC, Nov. 1977).

Key words: calibration; calibrators; electric fields; electric field strength; electric power transmission; field strength; magnetic fields.

The influence of temperature, relative humidity, frequency, waveform, proximity of the observer, as well as other parameters, on the accuracy of a small number of two commercially available ac electric field meters is documented. Procedures for the calibration of these instruments are reviewed and guidance is given for the construction of a calibration facility suitable for use in achieving calibrations to an accuracy of 1 percent. Measurement errors which develop when these meters are used in a highly nonuniform single-phase field are investigated theoretically and experimentally. The performance of a magnetic field probe provided as an accessory with one of the field meters is described, and an analysis of the accuracy to be expected from the use of simple multi-turn rectangular loops for the calibration of such magnetic field meters is given.

17421. Rockar, E. M., Pletka, B. J., **Fracture mechanics of alumina in a simulated biological environment**, (Proc. 2d Intl. Symp. on Fracture Mechanics, State College, PA, July 26-29, 1977), Paper in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., 4, 725-735 (Plenum Publ. Corp., New York, NY, 1978).

Key words: alumina; biaxial tension; bioceramics; bovine serum; dynamic; fatigue; fracture; grain-size; Krebs-Ringer solution; microstructure.

Dense, polycrystalline alumina, because of its high compressive strength and excellent biocompatibility, will soon be used in human prosthetic devices. However, the environmental effects of the biological system on the long term strength and wear of alumina have not been evaluated. As a preliminary investigation of this problem, crack propagation data on nine types of highly dense alumina were obtained in environments of distilled water, and Krebs-Ringer solution. The data were obtained primarily by strength measurements using a biaxial tension test. Variations in crack propagation data were observed among the different materials. The causes of these variations are discussed in terms of microstructure and environment.

17422. Roth, R. S., Negas, T., Parker, H. S., Minor, D. B., Jones, C., **Crystal chemistry of cerium titanates, tantalates and niobates**, *Mater. Res. Bull.* 12, 1173-1182 (1977).

Key words: cerium titanates; crystal chemistry; niobates; oxide reactions; tantalates.

Cerium dioxide has been found to react with other oxides at high temperatures in an open air environment with the formation of Ce^{+3} , Ce^{+4} or mixed valence phases. The compound $Ce^{+4}Ti_2O_6$ forms with the brannerite structure $a = 9.804$, $b = 3.758$, $c = 6.914$, $\beta = 119^\circ 8.7'$, however, with the addition of sodium, the black pseudocubic perovskite compound $NaCe^{+3}Ti_{2a}$ is formed, $a = 3.864A$. Single crystals of $Ce^{+3}Ta_7O_{19}$ reveal that this compound is hexagonal, $P6_3/mcm$, $a = 6.232$, $c = 19.985A$. Single crystals of the compound $Ce^{+3}TaO_4$ are light green of the $LaTaO_4$ -type, $P2_1/c$ with $a = 7.618$, $b = 5.531$, $c = 7.767A$, $\beta = 100^\circ 56.3'$. On oxidizing at low temperature, $\sim 600^\circ C$, the crystals turn black and change to monoclinic, $P2/m$, $a = 7.617$, $b = 5.491$, $c = 3.851A$, $\beta = 102^\circ 30.5'$, with a corresponding change to $\sim CeTaO_{4.174}$. Another phase which is also light yellow is formed by oxidizing at $350^\circ C$ for long periods of time and corresponds to $CeTaO_{4.50}$. The compound $CeNb_5O_{14}$ is orthorhombic $Pmnb$, $a = 20.12$, $b = 12.474$, $c = 7.744A$. $Ce^{+3}NbO_4$ has a fergusonite unit cell when quenched to room temperature $a = 5.544$, $b = 11.434$, $c = 5.177A$, $\beta = 94^\circ 41.8'$. On oxidation in air the cell size is $a = 5.364$, $b = 11.424$, $c = 5.129A$, $\beta = 93^\circ 22.7'$ at room temperature and corresponds to $\sim CeNbO_{4.25}$.

17423. Pletka, B. J., Wiederhorn, S. M., **Subcritical crack growth in glass-ceramics**, (Proc. 2d Intl. Symp. on Fracture Mechanics, State College, PA, July 26-29, 1977), Paper in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., 4, 745-759 (Plenum Publ. Corp., New York, NY, 1978).

Key words: crack growth; fracture; fracture mechanics; glass-ceramics; strength; stress corrosion cracking.

As part of a program to evaluate failure prediction theories for ceramic materials, the crack propagation parameter, n , was determined by fracture mechanics and strength techniques for a lithium aluminosilicate and a magnesium aluminosilicate glass-ceramic. In the magnesium aluminosilicate glass-ceramic, n was influenced by the crack morphology, which probably resulted from an interaction of the crack with particles present in the microstructure. For both glass-ceramics, values of n determined from four-point bending and biaxial tension strength data were smaller than values determined from crack velocity data. This result raises doubts as to the direct applicability of fracture mechanics data to failure prediction methods. It is recommended that for any material, the equivalence of strength and fracture mechanics data be proven before the latter are used for failure prediction purposes.

17424. Fong, J. T., Penn, R. W., **Multi-axial fatigue and creep at elevated temperatures and mathematical modeling**, (Proc. Intl. Conf., Hong Kong, Mar. 21-25, 1977), Paper in *Fracture Mechanics and Technology*, G. C. Sih and C. L. Chow, Eds., I, 145-159 (Sijthoff & Noordhoff Int. Publ., Alphen aan den Rijn, The Netherlands, 1977).

Key words: creep-fatigue interaction; dissipation; energy approach; fatigue; hysteresis loop; irreversible thermodynamics; low-cycle fatigue; mathematical modeling; multi-axial fatigue; polymethyl-methacrylate; stainless steel; viscoplasticity.

An operational decomposition of the total mechanical energy that goes into a specimen undergoing low-cycle fatigue testing is reviewed and discussed with respect to multi-axial and elevated temperature design environment. This energy approach, when first applied by Fong (1975) to the analysis of uniaxial fatigue data for reannealed AISi type 304 stainless steel with and without hold time at $593^\circ C$ ($1100^\circ F$), contained an operational definition of a total latent heat for structural change. It is the exhaustion of that latent heat which Fong

postulated as the cause for fatigue failure. To check this postulate which involves energy quantities hitherto defined only for uniaxial or torsional mode of deformation, tension-torsion fatigue data with variable hold times for polymethyl-methacrylate which simulates steel at elevated temperatures are analyzed. To the accuracy of the biaxial mechanical testing of PMMA tubes at the National Bureau of Standards, it was found that the postulate for the exhaustion of a total latent heat for structural change is reasonable for either uniaxial, torsional, or tension-torsion mode of deformation. The concept of an experimental correspondence principle between a class of metals at elevated temperatures and a class of polymeric materials at room temperatures is explored.

17425. Negas, T., Roth, R. S., McDaniel, C. L., Parker, H. S., Olson, C. D., **Oxidation-reduction reactions of CeMO_{4+x} ($\text{M} = \text{Ta}$ or Nb) phases**, *Mater. Res. Bull.* **12**, 1161-1171 (1977).

Key words: CeMO_{4+x} ; cerium oxide; oxidation-reduction reactions; phase equilibrium methods; powder x-ray diffraction.

Phase equilibrium methods, single crystal and powder x-ray diffraction analyses, thermogravimetric analysis and magnetic susceptibility measurements were utilized to define subsolidus phase relations in air for the systems cerium oxide- Ta_2O_5 and cerium oxide- Nb_2O_5 . Stoichiometric CeTaO_4 is stable in air ($P_{\text{O}_2} = 0.21$ atm) only above 1265 °C. At 1265 °C, the reversible reaction, $3\text{CeTaO}_4 + 1/2 \text{O}_2 \leftrightarrow \text{CeTa}_3\text{O}_9 + 2\text{CeO}_2$ is established. If CeTaO_4 is quenched to room temperature and reheated below 1000 °C, or, if the material is rapidly cooled from above 1265 °C to below 1000 °C it absorbs oxygen according to, $\text{CeTaO}_4 + 1/2 \text{O}_2 \rightarrow \text{Ce}_{1-2x}^{3+}\text{Ce}_{2x}^{4+}\text{TaO}_{4+x}$. The x parameter is variable and temperature dependent. Using a thermal microbalance, three distinct complex reaction series involving a homogeneity range in x were established, (a) $0.50 \geq x \geq 0.48$ (<350–600 °C), (b) $0.17 \geq x \geq 0.06$ (600–950 °C), and (c) $0.40 \geq x \geq 0.34$ (950°-room temperature). CeNbO_4 (not isostructural with CeTaO_4) also absorbs oxygen below ~700 °C in air to yield CeNbO_{4+x} materials.

17426. Siedle, A. R., Candela, G. A., Finnegan, T. F., Van Duyn, R. P., Cape, T., Kokoszka, G. F., Woyciesjes, P. M., **Copper derivatives of tetrathiafulvalene**, *J. Chem. Soc. Chem. Commun.*, No. 2, 69-70 (Jan. 18, 1978).

Key words: chlorocuprates; copper; electron spin resonance; low dimensional materials; magnetic susceptibility; tetrathiafulvalene.

The donor-acceptor complex $(\text{TTF})_2(\text{CuCl}_2)_3$ is formed from tetrathiafulvalene and cupric chloride in ethanol. It is converted to $(\text{TTF})_2\text{CuCl}_4$ by recrystallization from acetonitrile. Oxidation in acetonitrile produces $(\text{TTF})\text{CuCl}_4$. Resonance Raman spectroscopy was used to determine the oxidation state(s) of TTF in these materials. The TTF chlorocuprates exhibit three-dimensional magnetic exchange fields.

17427. Read, D. T., Reed, R. P., **Effects of specimen thickness on fracture toughness of an aluminum alloy**, *Int. J. Fract.* **13**, No. 2, 201-213 (Apr. 1977).

Key words: aluminum alloys; critical stress intensity; cryogenic temperature; fracture toughness; J-integral; sub-critical crack extension.

J-integral resistance curves for three specimen thicknesses and valid (according to ASTM Method E 399) K_{Ic} values at 76 K are reported for aluminum alloy 2219. The J-integral values were independent of thickness at small crack extensions, but at substantial crack extensions the values for the thin specimens were larger than those for the thick specimens. The measured J_{Ic} values were less than those calculated from the measured

K_{Ic} values. The reason for this discrepancy was that crack extension occurred before the K_{Ic} measurement point was reached.

17428. Ledbetter, H. M., Read, D. T., **Low-temperature elastic properties of a 300-grade maraging steel**, *Metall. Trans.* **8A**, No. 11, 1805-1808 (Nov. 1977).

Key words: bulk modulus; compressibility; iron alloy; maraging steel; nickel alloy; Poisson ratio; shear modulus; sound velocity; Young's modulus.

Elastic properties of an annealed 300-grade maraging steel (18 Ni, 9 Co, 5 Mo pct by weight) were studied between room temperature and liquid-helium temperature. Longitudinal and transverse ultrasonic velocities were determined by a pulse method. The reported elastic constants are: longitudinal modulus, shear modulus, Young's modulus, bulk modulus, and Poisson's ratio. Except for the bulk modulus, the room-temperature elastic constants are all lower than those of iron; and their temperature dependencies are regular in the studied temperature region.

17429. Schramm, R. E., Kasen, M. B., **Cryogenic mechanical properties of boron-, graphite-, and glass-reinforced composites**, *Mater. Sci. Eng.* **30**, No. 3, 197-204 (1977).

Key words: aluminum matrix; boron fiber; composites; cryogenics; epoxy matrix; expansivity; glass fiber; graphite fibers; mechanical properties.

This paper presents key static tensile, compressive, and shear properties for uniaxial laminates of boron-epoxy, boron-aluminum, graphite-epoxy, and glass-epoxy composites at temperatures of 295, 76 and 4 K. The data also include tensile properties of $\pm 45^\circ$ crossply layups and uniaxial thermal expansivity.

17430. Tobler, R. L., Reed, R. P., **Fracture mechanics parameters for a 5083-0 aluminum alloy at low temperatures**, *J. Eng. Mater. Technol.* **99**, No. 4, 306-312 (Oct. 1977).

Key words: aluminum alloys; crack propagation; cryogenics; fatigue; fracture; low temperature tests; mechanical properties.

The fatigue crack growth and fracture resistance of a 5083-0 aluminum alloy plate were investigated at four temperatures in the ambient-to-cryogenic range—295, 111, 76, and 4 K. J-integral test methods were applied using compact specimens 3.17 cm thick, and the value of J required to initiate crack extension (J_{Ic}) is reported as an index of fracture toughness. The fracture toughness was orientation dependent, with anisotropy accounting for J_{Ic} variations of up to a factor of 2. For specimens having fracture planes parallel to the rolling direction, J_{Ic} increases progressively from 9 to 25 kJm^{-2} as temperature decreases between 295 and 4 K. In contrast, the fatigue crack growth rates (da/dN) are insensitive to specimen orientation. The fatigue crack growth rates at cryogenic temperatures are up to 10 times lower than in air at room temperature, but are virtually constant between 111 and 4 K.

17431. Diller, D. E., **LNG density determination**, *Hydroc. Proc.* **56**, No. 4, 142-144 (Apr. 1977).

Key words: custody transfer; densimeter; density; liquefied natural gas; mathematical model.

Accurate LNG densities are required for equitable custody transfer contracts and operations. Mathematical models and direct reading densimeters for use on LNG type mixtures are being evaluated at the National Bureau of Standards. Accurate (0.1%) orthobaric liquid density data have been obtained for LNG components and their mixtures and are being used to optimize and evaluate four published mathematical models. A

density reference system has been constructed and is being used to evaluate commercially available densimeters. Recent progress on these tasks is summarized and discussed.

17432. Mann, D. B., **What's new in LNG measurement methods and instrumentation**, *Intl. Pipe Line Ind.* **45**, No. 6, 21-24 (Dec. 1976).

Key words: cryogenic; density; flowmetering; instrumentation; liquids; measurement; natural gas.

The progress of the past and current research programs at the National Bureau of Standards is presented. A review of cryogenic flowmetering and the applications to liquefied natural gas (LNG) are described with particular emphasis on current moderate scale LNG flowmetering gas industry supported projects.

Measurements of density, both inferred and direct, are reviewed and the results of a gas industry supported density reference system are previewed by indicating performance of dielectric, vibrating element and displacement densimeters.

The role of accurate and precise property data is pivotal to the instrumentation and measurements of LNG in respect to flow, density, temperature, pressure, and liquid level.

17433. Choi, C. S., Prince, E., Garrett, W. L., **Refinement of α -lead azide by neutron diffraction**, *Acta Cryst.* **B33**, 3536-3537 (1977).

Key words: bond length; covalent azide; crystal structure; explosives; lead azide; neutron diffraction.

$\text{Pb}(\text{N}_3)_2$, orthorhombic, *Pnma*; $a = 6.63$, $b = 16.25$, $c = 11.31$ Å, $Z = 12$ [Azaroff (1956), *Z. Kristallogr.* **107**, 362-369]. The four independent azide groups in the structure are all asymmetric, with N—N bond distances, corrected by the riding model, ranging from 1.164 to 1.196 Å, and N—N—N bond angles as small as 177.9°.

17434. Yee, K. W., **Development of the test procedure for television set energy consumption**, *Appliance* **35**, No. 2, 58-61 (Feb. 1978).

Key words: energy consumption; television set; test method; test procedure.

Television sets are one of the consumer products which will soon be labeled to show the estimated annual operating cost for energy. This cost will be the product of an average cost per kilowatt hour times the average annual energy consumed as measured by a standard test procedure.

A final test procedure for television sets was promulgated by the Federal Energy Administration (FEA) on September 14, 1977 in the Federal Register. This procedure is based on a test procedure recommended to FEA by the National Bureau of Standards (NBS). Energy consumption measured by this test procedure will also be used to monitor an efficiency program and will be the basis of measurement if efficiency standards are imposed. The State of California has already proposed maximum power consumption standards for televisions. This test procedure supersedes any state test procedure which is not the same.

17435. Kossecka, E., de Wit, R., **Disclination kinematics**, *Arch. Mech.* **29**, No. 5, 633-651 (1977).

Key words: Burgers vector; compatibility; continuum mechanics; defect; disclination; dislocation; distortion; dynamics; elasticity; Green's tensor; incompatibility; loop; plasticity; strain; Volterra.

A mathematical theory of moving disclinations is developed. Kinematics is derived for a continuous distribution of disclinations and dislocations as well as for moving discrete disclination

and dislocation lines. The concept of the plastic velocity is used to give the theory a symmetrical form. The new concepts of disclination and dislocation loop currents are introduced. The relation between the disclination theory and the incompatibility theory is given.

17436. Maki, A. G., **Further assignments for the far-infrared laser transitions of HCN and HC^{15}N** , *J. Appl. Phys.* **49**, No. 1, 7-11 (Jan. 1978).

Key words: energy transfer; HCN far-infrared; infrared lasers; laser; molecular lasers; spectra.

Assignments are given for the 13 $\text{H}^{12}\text{C}^{14}\text{N}$ and 4 $\text{H}^{12}\text{C}^{15}\text{N}$ laser transitions that have not yet been identified. Although 10 different vibrational systems give rise to 27 laser transitions for $\text{H}^{12}\text{C}^{14}\text{N}$ and $\text{H}^{12}\text{C}^{15}\text{N}$ combined, all follow the same basic pattern involving a particular Coriolis interaction and a population inversion between stretching and bending vibrational manifolds. The laser transitions involve rotational states up to $J = 48$, which is higher than has been observed in room-temperature spectra.

17437. Motz, J. W., Danos, M., **Image information content and patient exposure**, *Med. Phys.* **5**, No. 1, 8-22 (Jan.-Feb. 1978).

Key words: antiscatter grid; image contrast; image information content; image processing; patient exposures; signal-to-noise ratio; statistical noise.

Presently, patient exposure and x-ray tube kilovoltage are determined by image visibility requirements on x-ray film. With the employment of image-processing techniques, image visibility may be manipulated and the exposure may be determined only by the desired information content, i.e., by the required degree of tissue-density discrimination and spatial resolution. This work gives quantitative relationships between the image information content and the patient exposure, give estimates of the minimum exposures required for the detection of image signals associated with particular radiological exams. Also, for subject thickness larger than approximately 5 cm, the results show that the maximum information content may be obtained at a single kilovoltage and filtration with the simultaneous employment of image-enhancement and antiscatter techniques. This optimization may be used either to reduce the patient exposure or to increase the retrieved information.

17438. Rybicki, G. B., Hummer, D. G., **A generalization of the Sobolev method for flows with nonlocal radiative coupling**, *Astrophys. J.* **219**, No. 2, 654-675 (Jan. 15, 1978).

Key words: escape-probability method; radiative transfer; Sobolev approximation; spectral line formation; stellar atmosphere.

The Sobolev, or escape-probability, method for solving radiative transfer problems in moving atmospheres is generalized to treat flows in which the line-of-sight component of the flow velocity is not monotonic; for these cases the purely local nature of the approximation is lost, and radiative coupling between distant parts of the atmosphere must be taken into account. The method is formulated for a general three-dimensional flow. For spherically symmetric cases in which the relative projected flow velocity on a line of sight goes through zero 2, 3, ..., N times, an integral equation for the source function is obtained. In the simplest nontrivial case when $N = 2$, it is shown that the normalization of the kernel is such that an iterative solution of the integral equation always converges rapidly. For spherically symmetric flows with $N = 2$, the kernel of the integral equation is expressed in closed form. Extensive numerical results for inverse power-law velocity fields are presented to illustrate the magnitude of the coupling between different parts of the atmosphere. Errors in the magnitude of the flux

peak of 50 percent or larger are readily made if this coupling is neglected.

17439. Hiza, M. J., Haynes, W. M., Parrish, W. R., **Orthobaric liquid densities and excess volumes for binary mixtures of low molar-mass alkanes and nitrogen between 105 and 140 K.** *J. Chem. Thermodyn.* 9, No. 9, 873-896 (1977).

Key words: binary systems; densities; excess volumes; liquid mixtures; LNG components; orthobaric.

A magnetic suspension densimeter has been used to determine orthobaric liquid densities of gravimetrically prepared binary mixtures of the major components of liquefied natural gas (LNG) i.e., nitrogen, methane, ethane, propane, *i*-butane, and *n*-butane, generally between 105 and 140 K. All binary combinations were included in this study, with the exception of nitrogen + *i*-butane and nitrogen + *n*-butane. Uncertainties in the reported liquid-mixture densities are discussed in detail. Comparisons are made between excess volumes computed from the present results and comparable values from the literature. It was found that the volumetric properties of binary liquid mixtures of the heavy hydrocarbons (those mixtures not containing nitrogen or methane) are closely approximated by ideal mixing. Some observations are included on the use of excess volumes of the heavy hydrocarbon systems to determine effective molar volumes of *n*-butane in liquid mixtures below its triple-point temperature. For mixtures containing nitrogen or methane, approximate total vapor pressures are given.

17440. Loevinger, R., **Dissemination of the unit of absorbed dose by calorimetric and ionometric methods.** (Proc. Int. Course at Varenna, Italy, Sept.-Oct. 1974), Paper D-3 in *Ionizing Radiation Metrology*, pp. 141-162 (Editrice Compositori Bologna, Italy, 1977).

Key words: absorbed dose; absorbed-dose calibration; calorimeter; dissemination; exposure calibration; ionization chamber; primary standard; unit.

Absorbed dose to water or to tissue can be determined by an ionization chamber of known volume, or can be derived from an ionization chamber calibrated in terms of exposure (against cavity chambers as standards), or in terms of absorbed dose (against calorimeters as standards). Formulae for relating absorbed dose to water to instrument response and calibration factor are developed and discussed, and the associated uncertainties are estimated. Portable absorbed-dose calorimeters are expected to play an important role in comparing national standards of absorbed dose, and in verifying the accuracy of any system for disseminating the unit of absorbed dose.

17441. Garber, A. R., Bodner, G. M., Todd, L. J., Siedle, A. R., **High-resolution ¹H and ¹¹B NMR studies of 1,2- and 1,7-B₁₀C₂H₁₂.** *J. Magn. Res.* 28, 383-390 (1977).

Key words: boron hydride; carborane; nuclear magnetic resonance; 1,2-Dicarba-closo-dodecarborane; 1,7-Dicarba-closo-dodecarborane.

The 70.6-MHz ¹¹B NMR spectrum of 1,2-B₁₀C₂H₁₂ has been assigned by use of labeled derivatives. The assignments are, in order of increasing field, B(9,12), B(8,10), B(4,5,7,11) and B(3,6). Resonances in 1,7-B₁₀C₂H₁₂ are due, in order of increasing field, to B(5,12), B(9,10), B(4,6,8,11) and B(2,3). The ¹H NMR spectrum of 1,2-D₂-1,2-B₁₀C₂H₁₀ in C₆D₆ contains four quartets at -2.7, -2.5, -2.1, and -1.7 ppm due to H(8,10), H(9,12), H(4,5,7,11) and H(3,6), respectively. Confirmation of the assignment was achieved by double-resonance experiments.

17442. Zelkowitz, M. V., **Effects of structured programming on PL/I programmers.** *Software-Pract. Exper. Short Commun.* 7, No. 6, 793-795 (1977).

Key words: PL/I; program measurement; structured programming.

A PL/I system has been implemented which automatically collects and saves information on every program compiled and executed. This note describes some of the analysis that has been performed on approximately 9,000 of these collected programs.

17443. Loevinger, R., **Realization of the unit of exposure: Cavity chambers.** (Proc. Int. Course at Varenna, Italy, Sept.-Oct. 1974), Paper C-5 in *Ionizing Radiation Metrology*, pp. 103-110 (Editrice Compositori Bologna, Italy, 1977).

Key words: cavity chambers; cobalt-60; exposure; gamma radiation; measurement standards; national standards; units.

The relationship between the quantity exposure and the response of a cavity ionization chamber is derived from the Bragg-Gray equation and the definition of exposure. The gas in the cavity chamber used to realize the unit of exposure need not be air, but can be any gas whose properties are suitable and known. A comparison in a cobalt-60 gamma-ray beam of the national cavity chamber standards of exposure of the National Bureau of Standards (USA) and the Physikalisch-Technische Bundesanstalt (F.R.G.) with the standard of the Bureau International des Poids et Mesures (in Paris) has been published (*Metrologia* 11, 17-23, 1975). This comparison is summarized and discussed. It is concluded that existing cavity chamber standards are adequately accurate for present needs, but several challenging physical problems in cavity chamber theory remain unsolved.

17444. Cook, L. P., Roth, R. S., Parker, H. S., Negas, T., **The system K₂O-Al₂O₃-SiO₂. Part 1. Phases on the KAISiO₄-KAlO₂ join.** *Am. Mineralogist* 62, 1180-1190 (1977).

Key words: kalsilite; KAISiO₄; nonstoichiometric phases; phase transition; single crystal; system K₂O-Al₂O₃-SiO₂.

High-temperature experiments have yielded information about the part of the tectosilicate join between KAISiO₄ and KAlO₂. Orthorhombic KAISiO₄ synthesized at 950 °C [*a* = 9.057(2), *b* = 15.642(2), *c* = 8.582(2)Å], space group *P*2₁2₁2 transforms upon heating above 1450-1485 °C to another orthorhombic phase having a larger unit cell [*a* = 18.110(3), *b* = 15.600(3), *c* = 8.560(2)Å]. The space group of the latter is shown from single-crystal precession photographs to be one of three possibilities: *P*2₁*am*, *P*ma2, or *P*mm.

A body-centered tetragonal phase, K_{1+x}Al_{1+x}Si_{1-x}O₄ (*x* ≈ 0.1), with unit-cell dimensions *a* = 8.943(1), *c* = 5.221(1)Å is stable at the expense of orthorhombic KAISiO₄ and silica-saturated KAlO₂ solid solution in the range 1400-1600 °C. Five space groups within Laue group 4/*mmm* are possibilities.

The compound previously reported to be K₂Al₂SiO₆ is most likely a member of the f.c.c. solid solution K_{1-x}Al_{1-x}Si_xO₂. The SiO₂-rich end-member of this solid solution has a composition with *x* ≈ 0.25 at 1600 °C, and apparently belongs to Laue group *m*3m.

17445. Fong, J. T., **Some recent applications of matrices and isotropic tensors to continuum physics at U.S. National Bureau of Standards.** (Proc. 14th Annual Meeting of the Society of Engineering Science, Inc., Bethlehem, PA, Nov. 14-16, 1977), Paper in *Recent Advances in Engineering Science*, G. C. Sih, Ed., pp. 655-666 (Lehigh University Publ., Bethlehem, PA, 1977).

Key words: bead-spring model; BKZ fluid; Capelli's identity; continuum physics; isotropic tensor; matrix method; nonlinear viscoelasticity; piezoelectricity; polymer physics; Schur's lemma; symmetric matrix.

Three recent applications of matrix and tensorial methods to the modeling of mechanical and piezoelectric properties of polymeric materials are described. The first problem deals with a three-term decomposition of a nonlinear potential function which characterizes the mechanical properties of a class of compressible viscoelastic fluids. The problem was solved by applying a mathematical result known as Schur's lemma (1909) on irreducible sets of matrices. The second application resulted in an upgrading of the well-known Zimm's eigenvalue problem (1956) which models a polymer molecule in a solvent as a necklace with a large number of beads and springs. The new solution was obtained by applying some elementary properties of symmetric matrices traceable to Kelvin-Tait (1867) and Cayley (1872). The final example in this expository paper is taken from the nonlinear theory of piezoelectricity where the coupling between large strains and electric field can no longer be neglected. The solution to this problem was made possible by applying some earlier work of Capelli (1887) and Cisotti (1930) on isotropic tensors.

17446. Loevinger, R., Loftus, T. P., **Uncertainty in the delivery of absorbed dose**, (Proc. Int. Course at Varenna, Italy, Sept.-Oct. 1974), Paper G-6 in *Ionizing Radiation Metrology*, pp. 459-473 (Editrice Compositori Bologna, Italy, 1977).

Key words: absorbed dose; cobalt-60; radiation therapy; random uncertainty; systematic uncertainty; uncertainty.

The magnitude of the absorbed dose delivered to a patient can in principle be traced back to a national primary measurement standard. Each step in the measurement chain contributes to the uncertainty in the magnitude of the final delivered dose. A method is described of taking into account estimated values of the many random and systematic uncertainties so as to arrive at a quasi-quantitative estimate of overall uncertainty. The method is applied to a simplified model, starting with the national primary standard for cobalt-60 gamma rays, and continuing to administration of absorbed dose to a soft-tissue phantom. This leads to an estimate for the overall uncertainty in the delivery of absorbed dose to a tissue phantom, of about 2 1/2 percent for optimum conditions, and about 5 percent for minimally acceptable conditions of measurement and instrumentation.

17447. Chen, S. T., Gallagher, A. C., **Electron excitation of the resonance lines of the alkali-metal atoms**, *Phys. Rev. A* **17**, No. 2, 551-560 (Feb. 1978).

Key words: alkalis; cesium; electron collisions; potassium; rubidium.

We have measured the relative optical-excitation functions and polarizations of the K, Rb, and Cs resonance lines, using crossed electron and atom beams, for electron energies from threshold to 1500 eV. The electron energy resolution was ~0.25 eV for energies below 13 eV, and the atom beam was optically thin. The atomic resonance-level (n^2P) excitation functions have been normalized to the Born theory in the high-energy limit. Comparisons are made with other measurements and calculations. The polarizations and total cross sections for H, Li, Na, K, Rb, and Cs are also compared with each other in reduced units to investigate systematic behavior.

17448. Kessler, E. G., Jr., Deslattes, R. D., Henins, A., Sauder, W. C., **Redetermination of ^{198}Au and ^{192}Ir γ -ray standards between 0.1 and 1.0 MeV**, *Phys. Rev. Lett.* **40**, No. 3, 171-174 (Jan. 16, 1978).

Key words: angle interferometers; crystal lattice spacing; gamma rays; muonic x rays; standard wavelengths; x rays.

Prominent γ -ray reference lines including ^{198}Au 411 and 675 keV and ^{192}Ir 205, 295, 308, 316, 468, 484, 588, 604, and 612

keV have been measured with respect to an I_2 -stabilized He-Ne laser. The ^{198}Au 411-keV line, a *de facto* γ -ray standard, is reported at 3.010 7788 pm (0.37 ppm) or 411 804.41 eV, which is 25 ppm higher in energy and forty times more accurate than previous values.

17449. Greer, S. C., **Coexistence curve of D_2O + deuterated isobutyric acid**, *Ber. Bunsengesllh. Physkh. Chem.* **81**, No. 10, 1079-1081 (1977).

Key words: coexistence curve; consolute point; critical exponent; critical phenomena; deuterated isobutyric acid + heavy water; isobutyric acid + water; liquid density; liquid-liquid critical point; magnetic densimeter.

We report precise data on the densities of the coexisting liquid phases near the liquid-liquid critical point in D_2O + deuterated isobutyric acid. The result for the critical exponent $\beta(0.315 \pm 0.008)$ is consistent with our earlier work on H_2O + isobutyric acid, with other work on critical points in fluids, and with current theoretical predictions. The effect of deuteration is to increase the miscibility gap.

17450. Cezairliyan, A., Miiller, A. P., **Heat capacity and electric resistivity of titanium in the range 1500 to 1900 K by a pulse heating method**, *High Temp.-High Pressures* **9**, 319-324 (1977).

Key words: electrical resistivity; emittance; heat capacity; high-speed measurements; high temperature; titanium.

The measurements of the heat capacity and electric resistivity of 99.9+% pure titanium in the temperature range 1500 to 1900 K by a subsecond duration pulse heating method are described. The results are expressed by the relations:

$$C_p = 43.14 - 2.337 \times 10^{-2}T + 1.069 \times 10^{-5}T^2,$$

$$\rho = 126.5 + 1.810 \times 10^{-2}T,$$

where C_p is in $\text{J mol}^{-1} \text{K}^{-1}$, ρ is in $\mu\Omega \text{ cm}$, and T is in K. The hemispherical total emittance is 0.37 for the temperature range 1700 to 1900 K. Estimated maximum inaccuracies of the measured properties are: 3 percent for heat capacity, 2 percent for electric resistivity and 5 percent for hemispherical total emittance.

17451. McLaughlin, W. L., Miller, A., Pejtersen, K., Pedersen, W. B., **Distribution of energy deposited in plastic tubing and copper-wire insulation by electron beam irradiation**, *Radiat. Phys. Chem.* **11**, 39-52 (1978).

Key words: absorbed dose; cross linking; dose distributions; dosimetry; electron beams; nylon; plastic tubing; polyethylene; polymer improvement; polyvinylchloride; radiation processing; wire insulation.

Scanned electron beam treatment is used to improve the physical properties of certain polymers, such as shrinkable plastic tubing and insulated wire and cable. Tubing or wires are passed at high speed under the beam scanner, and the material is irradiated to absorbed doses of several Mrad as uniformly as possible, usually by means of a multipass arrangement. In the present study, using irradiation by a scanned 0.4 MeV electron beam, measurements were made of high-resolution distributions of absorbed dose in polyethylene tubing and copper wire coated with polyethylene, nylon, or polyvinyl chloride insulation. Radiochromic dye films equivalent to the insulating materials were used as accurate dosimeters having a response independent of dose rate. Irradiations were in various geometries, wire and plastic thicknesses, positions along the beam scan, and with different backing materials near the wire as it passed through the electron beam.

17452. Glinka, C. J., Rowe, J. M., Rush, J. J., Rahman, A., Sinha, S. K., Flotow, H. E., **Inelastic-neutron-scattering line shapes in PdD_{0.63}**, *Phys. Rev. B* 17, No. 2, 488-493 (Jan. 15, 1978).

Key words: defect crystal structures; inelastic neutron scattering; lattice dynamics; metal-hydrogen systems; palladium-deuteride (PdD_{0.63}); phonon lineshapes.

Previous measurements of the phonon-dispersion curves in a single crystal of PdD_{0.63} have been augmented by detailed inelastic-neutron-scattering measurements of the optical-phonon line shapes at 80 K. The line shapes observed at this temperature show substantial broadening and subsidiary structure. The data have been compared to line shapes calculated from a Born-von Kármán type model in which the nonstoichiometric structure of the crystal is explicitly taken into account. Although the model results cannot reproduce all details of the observed line shapes, the observed and calculated linewidths agree reasonably well, which demonstrates that the broadening is primarily an effect of nonstoichiometry and not, for example, due to anharmonicity. The Pd-D force constants derived from the nonstoichiometric model agree closely with those obtained from an earlier analysis of the dispersion curves based on a conventional Born-von Kármán approach in which the crystal was treated as stoichiometric PdD. The near-neighbor D-D force constants obtained in the present analysis, however, are some 50 percent larger than those deduced with a stoichiometric model.

17453. Barnes, J. A., **The current state of primary standards at the National Bureau of Standards**, *Proc. 7th Session Comité Consultatif pour la Définition de la Seconde, Sèvres, France, July 9-11, 1974, Annexe S 9*, pp. 66-70 (Bureau International des Poids et Mesures, Sèvres, France, 1974).

Key words: Consultative Committee for the Definition of the Second (CCDS); Coordinated Universal Time; Ephemeris Time; International Atomic Time (TAI); legal time; standard time; time.

Three questions of current interest to CCDS are considered and a recommended position is presented. The recommended positions are: (1) It is reasonable to have legal time in the Meter Convention countries be tied to UTC; however, this does not seem to imply any changes in U.S. laws; (2) TAI could be reset by 32 seconds to bring it into agreement with ET but there is a need to investigate more completely the implications of such a change; and (3) the name change from "Coordinated Universal Time" to "International Time" is desirable and CCDS should recommend such an action to the CCIR.

17454. Kruger, J., **Application of ellipsometry to the study of corrosion processes**, (Proc. Intl. Colloq. on the Optical Properties of Solid-Liquid Interfaces, La Colle sur Loup, France, May 23-28, 1977), *J. Phys.*, No. C5, C5-129—C5-138 (1978).

Key words: corrosion; crevice corrosion; ellipsometry; optical measurements; pitting; stress corrosion.

Because corrosion processes involve localized effects in thin passive layers and because these processes lead to surface roughening, it is virtually impossible to do quantitative ellipsometry at today's theoretical and experimental state of the art. This paper, therefore, describes qualitative apparatus that provide valuable insights into corrosion processes without attempting to determine optical constants or exact measures of film thickness. A description is given of measurements of the repassivation kinetics of bare surfaces, changes in the passive film prior to breakdown and changes in crevices that lead to crevice corrosion.

17455. Hudson, R. P., **A century of cryogenics**, *J. Wash. Acad. Sci.* 67, No. 4, 119-130 (1977).

Key words: cryogenics; history of science; low temperature physics.

In the 100-year period since the first liquefaction of oxygen and nitrogen, cryogenics has developed into a broad area of scientific research—with many exciting discoveries along the way—and also a substantial industrial activity in most of the advanced nations. A superficial, historically-framed survey is presented of the major topics of scientific interest, supplemented by a few remarks on recent technological developments.

17456. Swing, R. E., **Microdensitometer optical performance: Scalar theory and experiment**, *Opt. Eng.* 15, No. 6, 559-577 (Nov.-Dec. 1976).

Key words: coherence theory; effective incoherence; image scanning; microdensitometry; optical linearity; overfilled optics; sample scanning; underfilled optics.

The scalar theory of microdensitometer performance developed in previous papers is revised and expanded to include coherent illumination. The central ideas of scalar microdensitometry are combined from several basic sources and summarized; this paper serves as a convenient single source of microdensitometer theory. Eight distinct variations of instrument configuration and operation are identified, and the image characteristics and conditions for linear microdensitometry are developed for each. The concept of effective incoherence is summarized and discussed. Further consideration of the problems associated with aperture sizes, determination of the sampling aperture size and image vs. sample scanning are presented. An experimental test program, carried out with the Mann-Data Microanalyzer, by experienced operators, under closely controlled conditions to test the theory, is reported. Among the conclusions is that the instrument manifests its best performance with overfilled optics and sample scanning, and that an increased reduction factor on the influx side would be useful with image scanning. Several fundamental problems surface during the course of the investigation. These are discussed and the need for further study in certain areas is emphasized.

17457. Swing, R. E., **The theoretical basis of a new optical method for the accurate measurement of small linewidths**, (Proc. SPIE Conf. on Developments in Semiconductor Microlithography, San Jose, CA, June 1-3, 1976), *Semicond. Microlithography* 80, 65-77 (1976).

Key words: coherent illumination; line-width measurement; microscope objective; optical microscope; spatial filtering.

As part of the effort conducted at NBS to solve some of the fundamental problems associated with width measurement of very small (1.5- μm) lines and spaces, the performance of an optical microscope with coherent illumination is investigated. From these studies, the theoretical basis for a new method of accurate width measurements is developed and explored. The new method, in effect, produces an optical transformation in which the image no longer resembles the original line but in which the location of the line-edges is marked by two narrow, dark lines within a bright surround. The correct line-width is then given by the distance between these two lines, a measurement that eliminates the orientation problems normally associated with filar eyepieces and sidesteps the coherence problem that affects shearing eyepieces. Suggestions are made about implementing the technique. Available microscope objectives are not suitable for such a system, and a redesign is recommended.

17458. Goodwin, R. D., **An equation of state for thermodynamic properties of pure fluids**, *Proc. 5th Biennial Intl. Conf. on CODATA, Boulder, CO, June 28-July 1, 1976*, B. Dreyfus, Ed., pp. 441-444 (Pergamon Press, New York, NY, 1977).

Key words: coexistence boundary; critical point; equation of state; ethane; fluids; orthobaric densities; specific heats; vapor pressures.

This equation originates on a given, liquid-vapor coexistence envelope, thus eliminating the long-standing problem of continuity at this boundary of the $P(\rho, T)$ surface. Curvatures of this surface vs. T are consistent with the known behavior of specific heats via the relation:

$$\Delta C_v = -T \cdot \int (\partial^2 P / \partial T^2) \cdot d\rho / \rho^2.$$

The present nonanalytic equation of state yields a maximum in the isochoric specific heats, $C_v(\rho, T)$, at the critical point. It has only five coefficients to be found by least squares from experimental P - ρ - T data. The consistency obtained by constraint to the liquid-vapor coexistence boundary does not alleviate difficulties arising from inaccurate orthobaric densities and P - ρ - T data in the all-important critical region.

17459. Powell, C. J., **Auger electron spectroscopy**, *ASTM Stand. News* 6, No. 2, 15-17 (Feb. 1978).

Key words: ASTM; Auger electron spectroscopy; standards; surface analysis.

A description is given of Auger-electron spectroscopy, its industrial applications, and of the development of standards by subcommittee E-42.03 on Auger Electron Spectroscopy.

17460. Mosburg, E. R., Jr., Wilke, M. D., **Some new transition probabilities for mercury I**, *J. Quant. Spectrosc. Radiat. Transfer* 19, No. 1-F, 69-81 (1978).

Key words: dimers; discharge; f-values; mercury; oscillator strengths; radiation probabilities; spectra; transition probabilities.

Detailed studies of a pure mercury positive column have allowed us to determine the densities and effective temperatures which characterize the discharge. From this knowledge of the discharge conditions, a series of transition probabilities is derived for 70 lines in the neutral mercury spectrum in the wavelength range 238-1530 nm, including many lines for which transition probabilities have not previously been published.

17461. Sengers, A. L., Hocken, R., Sengers, J. V., **Critical-point universality and fluids**, *Phys. Today* 30, No. 12, 42-51 (Dec. 1977).

Key words: critical exponents; critical points; fixed points; gravity effects; homogeneity; magnetic densimeter; optical interference; power laws; relevant fields; Renormalization Group; scaling; scattering; universality.

Critical-point physical and model systems are introduced. The concepts of power laws, critical exponents, homogeneity and scaling are discussed. Critical-point universality is defined in the framework of the Renormalization Group approach. A persistent difficulty, namely fluid critical exponents not obeying universality, has been recently resolved by three new experiments: optical interferometry in pure fluids, by Hocken and Moldover; magnetic densimetry in binaries, by Greer; and light scattering in binaries by Chang et al.

17462. Wong, N. C., Eberly, J. H., **Multiphoton absorption in the presence of two finite-bandwidth lasers**, *Opt. Lett.* 1, No. 6, 211-213 (Dec. 1977).

Key words: Bloch equations; coherence; coherent multiphoton effects; density matrix equations; Heisenberg equations; laser bandwidth; multiphoton absorption; multiphoton ionization; partially coherent lasers; power broadening; two laser absorption.

Interactions between a three-level atom and two amplitude-fluctuating lasers are studied theoretically. One interesting feature of the interactions is the influence of the finite laser bandwidth and the two-laser cross-bandwidth on the absorption rate into the third level. As an example, it is shown how the partially saturated absorption process depends on both the autocorrelated and cross-correlated laser bandwidths.

17463. Spencer, F. E., Jr., Phelps, A. V., **Momentum transfer cross-sections and conductivity integrals for gases of MHD interest**, (Proc. 15th Symp. on Engineering Aspects of Magnetohydrodynamics, The University of Pennsylvania, Philadelphia, PA, May 24-26, 1976), Paper in *Proceedings of the 15th Symposium on Engineering Aspects of Magnetohydrodynamics, Session IX, IX.9.1-IX.9.12* (Dept. of Mechanical Engineering, University of Mississippi, University, MS, 1976).

Key words: conductivity; cross sections; electron; gases; magnetohydrodynamics.

We give our present best estimates for the electron momentum-transfer collision cross-sections for the principal gases occurring in present laboratory and demonstration scale MHD generators of the closed cycle type and of those open cycle generators running on ash-free combustion plasmas. Also, we give the integrals of these cross-section functions for direct incorporation into the algorithm of Demetriades for calculating electrical properties of gas mixtures.

17464. Jackson, W. D., Schneider, S. J., Young, W. E., Sheindlin, A. E., Telegin, G. P., Burenkov, D. K., **Joint test of an U.S. electrode system in the U.S.S.R. U-02 facility**, (Proc. 15th Symp. on Engineering Aspects of Magnetohydrodynamics, The University of Pennsylvania, Philadelphia, PA, May 24-26, 1976), Paper in *Proceedings of the 15th Symposium on Engineering Aspects of Magnetohydrodynamics, Session I, I.1.1-I.1.12* (Dept. of Mechanical Engineering, University of Mississippi, University, MS, 1976).

Key words: electrode materials; materials characterization; MHD (magnetohydrodynamics); U.S.-U.S.S.R. program; 100 endurance test.

The first (Phase 1) joint U.S.-U.S.S.R. test of U.S. electrode materials was carried out in Moscow between September 25 and October 1, 1975 in the U.S.S.R. U-02 MHD facility. The test procedure followed closely a predetermined work plan designed to test five different zirconia based materials in cathode and anode electrode wall modules under MHD operating conditions. The electrode materials were: (in Mol %) 88ZrO₂:12Y₂O₃, 82ZrO₂:18CeO₂, 50ZrO₂:50CeO₂, 25ZrO₂:75CeO₂ and 20ZrO₂:78CeO₂:2Ta₂O₅. Each of the five electrode materials had four different current densities established between the anode and cathode during the experiment which lasted a total of 127 hours; 100 hours under MHD power operational conditions.

Fourteen electrode pairs performed satisfactorily during the entire test. Five pairs failed early in the life test and the sixth pair failed in the last several hours. Failure was not due to the electrode materials, however, but due to lead-out melting caused by Joule heating in the platinum wires.

Extensive pre- and post-test materials characterizations were made to determine the effect of the MHD environment on the electrodes and insulators. Measurements included: thermal dif-

fusivity, thermal expansion, chemical composition, microstructure, electrical conductivity, phase composition, closed and open porosity, pore size distribution, and radiography. Results indicate that there was extensive attack by the seed on the cathode wall causing chemical reactions and phase changes of the electrode materials. There was also seed penetration through cracks and pores in both insulator and electrode.

17465. Ruff, A. W., **Measurements of plastic strain in copper due to sliding wear**, (Proc. Intl. Conf. on Wear of Materials, St. Louis, MO, Apr. 26-28, 1977), *Wear* **46**, 251-261 (1978).

Key words: copper; electron channelling; metals; plastic deformation; surfaces; wear.

Wear experiments have been conducted to determine the plastic strains that are introduced in the surface material near sliding wear tracks. Both oil lubricated and dry sliding experiments have been carried out at different sliding distances on surfaces of copper. The strain values were determined from selected area electron channelling patterns obtained using a scanning electron microscope from regions as small as 10 μm in size and 0.05 μm deep around the wear track. A deformed calibration specimen was used to relate electron channelling band contrast to deformation strain. Strain maps were obtained on the wear surface lateral to the wear track and also below the surface using electropolishing metal removal techniques. Particular attention was placed on the near-surface strain values. In all cases, the maximum strain was found at the wear surface located at the track center and the strains decreased uniformly with depth. Significant, large strains were also found outside the wear tracks. The results are compared with those previously reported for iron and with recent theoretical models.

17466. Ruff, A. W., **Quantitative methods in wear debris analysis**, (Proc. Intl. Conf. on Wear of Materials, St. Louis, MO, Apr. 26-28, 1977), *Wear* **46**, 263-272 (1978).

Key words: electron microscope; particle analysis; wear; wear debris; x-ray analysis.

Wear debris has been recovered from a number of test systems and analyzed using different methods. Those methods produced specific information concerning the particulate size and composition. A magnetic debris recovery method was quantitatively evaluated using actual debris samples and also using collections of manufactured particulates having known sizes and compositions. Small 5 μm diameter SiO_2 spheres, some containing nickel, were used to simulate debris. Other particulates of iron and nickel in different size ranges were also used in order to investigate such matters as size resolution, lubricant dilution techniques, particle overlap difficulties, and the general problem of calibration of debris recovery system. A comparison between chemical analysis and particulate analysis findings is presented. The application of optical and electron microscope methods and x-ray microanalysis in characterizing the wear particulates was carried out directly on the recovery substrate; those techniques are described.

17467. Ives, L. K., Ruff, A. W., **Transmission and scanning electron microscopy studies of deformation at erosion impact sites**, (Proc. Intl. Conf. on Wear of Materials, St. Louis, MO, Apr. 26-28, 1977), *Wear* **46**, 149-162 (1978).

Key words: electron channelling; erosive wear; scanning electron microscopy; solid particle impact; transmission electron microscopy; 310 stainless steel.

Scanning and transmission electron microscopy methods have been employed to study topographic features and subsurface damage associated with erosive particle impact craters in annealed 310 stainless steel surfaces. Angular Al_2O_3 and spherical glass particles approximately 50 μm in diameter were projected

at a velocity of 59 m/s to impact at attack angles of 90° and 20°. Under these conditions, material was found to be displaced but not removed from the surface at isolated impact sites. A comparison was made with damage produced at diamond pyramid hardness indentations. Substantial differences were not observed. In general, a high dislocation density zone a few micrometers wide was found to surround both impact craters and hardness indentations. The width of this zone varied according to the size and shape of the crater and the direction of particle motion. Deformation twinning occurred at some impact sites. An electron channelling pattern analysis of the strain field around impact craters in 310 stainless steel and copper was compared to the dislocation distribution observed directly by transmission electron microscopy.

17468. Wiederhorn, S. M., **Mechanisms of subcritical crack growth in glass**, (Proc. 2d Intl. Symp. on Fracture Mechanics, State College, PA, July 26-29, 1977), Paper in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., **4**, 549-580 (Plenum Publ. Corp., New York, NY, 1978).

Key words: diffusion in glass; fracture; glass; lattice trapping; mechanisms of fracture; plastic deformation of glass; reaction rate theory; subcritical crack growth; tunnelling.

Mechanisms of subcritical crack growth are divided into two groups: those that occur near the crack tip; and those that occur some distance from the crack tip. In the first group are diffusion mechanisms, plastic flow mechanisms, and chemical mechanisms of crack growth. In the second group are physical processes that control the transport of active agents to the crack tip, and chemical processes that control the composition of the crack tip environment. Other factors that influence subcritical crack growth are the structure of the crack tip and the type of rate limiting reaction that occurs during crack growth. In this paper, the above phenomena are discussed with regard to data on crack growth in glass. It is noted that although water is the main cause of subcritical crack growth in glass, there is still considerable controversy as to the dominant mechanism of fracture in glass.

17469. Fuller, E. R., Jr., Thomson, R. M., **Lattice theories of fracture**, (Proc. 2d Intl. Symp. on Fracture Mechanics, State College, PA, July 26-29, 1977), Paper in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., **4**, 507-548 (Plenum Publ. Corp., New York, NY, 1978).

Key words: activated processes; cohesive bond; fracture; Griffith criteria; lattice models; lattice trapping; quantum tunneling; stress activation; subcritical crack growth; surface energy.

This paper briefly reviews our current understanding of the role of physics in elementary crack-tip processes. Particular attention is given to the influence of atomic discreteness on brittle fracture and crack propagation. One-dimensional lattice models are used to illustrate the phenomenon of "lattice trapping," whereby a crack is stably trapped by the atomic structure. These models are also used to discuss the role of thermodynamic surface energy in the brittle fracture process and in a microscopic Griffith criterion for fracture. Finally, two atomic mechanisms of subcritical crack growth are discussed with reference to a crack that is trapped by a lattice. One mechanism of crack growth results from thermal activation over the lattice-trapping energy barriers; and the other mechanism results from quantum tunneling through the barrier.

17470. Roder, H. M., **The PVT surface of simple liquids at densities near melting**, *Proc. 5th Biennial Intl. Conf. on CODATA*,

Key words: density dependence of the *PVT* surface; liquids; melting; *PVT* data, range of densities; *PVT*, simple liquids.

Experimental data establish the temperature and density dependence of the *PVT* surface for this range of densities. A general feature is that the pressure along an isotherm increases as the density increases. A number of equations of state are examined in light of the behavior expected. Several widely used equations are shown to exhibit incorrect curvature along isotherms at densities near melting. The direct result, namely systematic deviations from experimental *PVT* data, is often obscured by the uncertainty inherent in the *PVT* data. That the curvatures are incorrect can be seen by the failure of the equations to correctly predict the specific heats. Extrapolation of incorrect behavior to densities beyond the melting line is shown to be the cause of a very vexing problem, nonunique solutions in density. It is recommended that a check near the melting line be included as part of the procedure in correlating a *PVT* surface.

17471. Howell, B. F., McCune, S., Schaffer, R., **Influence of salts on Michaelis-constant values for NADH**, *Clin. Chem.* **23**, No. 12, 2231-2237 (1977).

Key words: inhibitors of lactate dehydrogenase; Michaelis constant for NADH.

Values of the Michaelis constant for NADH for the conversion of pyruvate to lactate with lactate dehydrogenase (E.C. 1.1.1.27) in the presence of 0.1 mol/liter buffers at 25 °C were found to show first order dependence on enzyme concentration. This effect, previously unexplained, is now recognized to be due to an inhibitory influence exerted by buffers, e.g., NH_4HCO_3 , tris(hydroxymethyl)aminomethane (tris), and phosphate, or salts, e.g. $(\text{NH}_4)_2\text{SO}_4$ and NaCl, present in the reaction mixtures. Inhibition constants for the enzyme inhibitor complexes formed with these substances are approximately 0.3 mol/liter for competition of NH_4HCO_3 with NADH, 0.4 mol/liter for competition of NH_4HCO_3 with pyruvate; and 0.6 mol/liter for NaCl, 1.0 mol/liter for sodium phosphate, 0.3 mol/liter for $(\text{NH}_4)_2\text{SO}_4$, and 0.08 mol/liter for tris when these substances compete with NADH. Because of the large molar ratio of buffer to substrate (ca 10³:1) in enzymatic assays, the buffer concentration significantly influences the Michaelis constant, despite the large value for the inhibition constant.

17472. Post, M. A., Godette, M., Campbell, P. G., **Anti-graffiti coatings**, *Mod. Paint Coat.* **68**, No. 2, 28-35 (Feb. 1978).

Key words: graffiti; graffiti-resistant coating; performance characteristics.

Commercially available graffiti-resistant coatings were screened using a graffiti cleanability test. The most easily cleaned coatings were then subjected to additional graffiti removal tests and to other tests designed to measure performance characteristics. Differences in performance characteristics were tabulated. The test results formed the basis for proposed performance criteria for graffiti-resistant coatings. The results show that organic coatings are available which can be used to protect building substrates against defacement by graffiti.

17473. Han, C. C., **Full-photon-counting Rayleigh spectrometer: A correlation and/or fast Fourier transform instrument**, *Rev. Sci. Instrum.* **49**, No. 1, 31-38 (Jan. 1978).

Key words: correlator; FFT spectrum analyzer; photon counting; quasielastic light scattering; Rayleigh spectrometer.

A fast, flexible, and relatively inexpensive minicomputer based Rayleigh spectrometer has been constructed. This spectrometer can utilize photon pulses in a most efficient way by performing autocorrelation and/or FFT with any desired number of channels. Its capability has been demonstrated by measuring large latex particles, small sodium dodecyl sulfate micelles, and a polydisperse latex- γ -globulin system. Detailed timing diagrams and circuit schematics are also included.

17474. Moulder, J. C., Clark, A. F., **Time-resolved spectroscopy of laser-initiated metal combustion**, *Opt. Eng.* **16**, No. 4, 393-398 (July-Aug. 1977).

Key words: laser effects; luminescence; metal combustion; spectroscopy; titanium alloys.

A rapid-scan spectrometer employing a silicon-target vidicon detector was used to study the time-resolved emission spectra of laser-ignited metals. Bulk specimens of Ca, Mg, Zr, Ti and several Ti alloys were ignited with a 90 W cw CO₂ laser in air or under a gentle flow of oxygen. Line and band emissions observed between 300 and 1100 nm during combustion help to identify vapor phase reactants and products and their locations in the flame. Disappearance of discrete spectra during the transient combustion of Ti and Zr gives information on the accumulation of molten oxide products. Observations of the continuum radiation emitted by laser-irradiated flames indicate a laser-stimulated luminescence from condensed metal oxide particles.

17475. Richmond, J. C., **Optical measurements of selective solar absorber coatings**, *Proc. D.O.E./D.S.T. Thermal Power Systems Workshop on Selective Absorber Coatings*, Golden, CO, Dec. 6-8, 1977, pp. 143-156 (Solar Energy Research Institute, Golden, CO, 1977).

Key words: coatings; emittance; optical efficiency; reflectance; reflection losses; reradiation losses; selective solar absorbers; solar absorptance; solar reflectance.

It is shown that the optical efficiency, α_m , of a selective solar absorber coating may be expressed by the equation

$$\alpha_m = 1 - \rho_s - \epsilon\theta^4$$

where ρ_s is the directional-hemispherical solar reflectance and ϵ is the total hemispherical emittance of the coating and θ is a dimensionless temperature, $\theta = T_o/T_e$, where T_o is the operating temperature of the coating and T_e is computed as $T_e = (S/\sigma)^{1/4}$, where S is the incident solar irradiance, in $\text{W}\cdot\text{m}^{-2}$, and σ is the Stefan-Boltzmann constant.

Methods of evaluating solar absorptance, solar reflectance and total hemispherical emittance are briefly described.

17476. Albus, J. S., **Hierarchical interaction between behavior generation and pattern recognition**, *Proc. Seventh Annual Automation Imagery Pattern Recognition Symp.*, College Park, MD, May 23-24, 1977, pp. 343-383 (Electronic Industries Assoc., Washington, DC, 1977).

Key words: adaptive; control hierarchical; goal-directed behavior; learning; multivariant table look-up; robot control; sensory-interactive.

CMAC (Cerebellar Model Automatic Computer) is a computing device which accepts up to 12 input variables and produces an output which is some function of those variables. It is based on a model of the cerebellum, which is a portion of the motor control system in the brain. CMAC can be implemented with inexpensive microprocessor technology. CMAC modules can be interconnected in a hierarchical structure to generate sensory-interactive goal-directed behavior in adaption, autonomous systems. It provides an entirely new approach to

many significant problems in robot control, artificial intelligence, data base management, and large scale distributed computing systems.

17477. Abouaf-Marguin, L., Jacox, M. E., Milligan, D. E., **The rotation and inversion of normal and deuterated ammonia in inert matrices**, *J. Mol. Spectrosc.* **67**, No. 1, 34-61 (Sept. 1977).

Key words: ammonia infrared spectrum; inversion; matrix isolation; rotation.

Infrared spectra have been recorded for all of the vibrational fundamental regions of NH_3 in argon, krypton, and xenon matrices, for the ν_2 fundamental region of NH_3 in neon and nitrogen matrices, and for the ν_2 , ν_4' , and ν_4'' fundamental regions of the deuterated ammonias in an argon matrix. Detailed studies of the temperature and time dependence of absorptions attributed to rotational structure in the vibrational transitions have led to an assignment consistent with almost free rotation of the ammonia molecule in rare gas matrices. The theory of Devonshire has been used to evaluate a barrier to rotation of NH_3 in these matrices. The inversion splittings observed for the ν_2 fundamentals of NH_3 , NH_2D , and NHD_2 are somewhat smaller than for the gas-phase molecules, but the calculated inversion potential barrier is increased by only about 10 percent in the rare gases. No structure in the ν_2 spectral region can be attributed to the rotation or inversion of $\text{NH}_3\text{-d}_n$ in a nitrogen matrix. However, rotation of the molecule about its C_3 axis may occur in the nitrogen matrix.

17478. Armstrong, G. T., Goldberg, R. N., **Chemical thermodynamics in biology: Applications and compiled sources of evaluated data**, *Proc. 5th Biennial Intl. Conf. on CODATA, Boulder, CO, June 28-July 1, 1976*, B. Dreyfus, Ed., pp. 339-348 (Pergamon Press, New York, NY, 1977).

Key words: aqueous electrolytes, thermochemistry of; biothermodynamics; data compilations for biological thermodynamics; electrolyte thermodynamics; thermochemistry of biochemicals.

Thermodynamic data needs for biological applications in many cases are similar to the general needs for data on organic substances and aqueous electrolyte systems. The literature in the field is rapidly growing. Much thermodynamic data specifically determined on systems of biological interest is determined under special conditions of ionic strength, pH, and metal ion concentrations, and is difficult to relate directly to the well known thermodynamic standard states. Because of the variety of conditions necessary for study of individual substances, much existing data on similar systems is not easily correlated. The thermodynamic significance of some equilibrium data is partially obscured by the common practice of using concentrations rather than activities, which is done because it is difficult to visualize obtaining activities in many cases. Recommendations for standard practices have recently been made by a joint IUPAC-IUB-IUPAB Commission on Biothermodynamics.

17479. Baird, G. N., Oliver, P., Rountree, R., **The payoff in COBOL compiler validation—What has been gained?**, *Courr. Norm.* **257**, 413-416 (Sept.-Oct. 1977).

Key words: COBOL; Federal ADP standards; programming languages; software testing; validation.

The paper gives the background and history of validating COBOL compilers to assure compliance with the U.S. Federal Government Standard COBOL, and current status of the testing program.

17480. Balfour, F. W., Sengers, J. V., Moldover, M. R., Sengers, J. M. H. L., **Universality, revisions of and corrections to**

scaling in fluids, *Phys. Lett.* **65A**, No. 3, 223-225 (Mar. 6, 1978).

Key words: critical phenomena; critical-point universality; equation of state; internal energy; steam; thermodynamic potential.

PVT and internal energy data in the critical region of steam are accurately described by a thermodynamic potential based on renormalization-group calculations for Ising-like spin systems. The potential includes both "corrections-to-scaling" and "mixing-of-variables" terms.

17481. Becker, J. D., Ordman, E. T., **On functions defined by iterations of each other**, *Aequationes Math.* **8**, No. 3, 238-241 (1972).

Key words: functional equation; iteration of functions; modular arithmetic.

Let f and g be functions from and into the nonnegative integers, and denote iteration by superscripting (so $f^2(n) = f(f(n))$). We find all solutions of the functional equation

$$f^{n+1}(m) = g^{m+1}(n) \quad 0 \leq m, n < \infty$$

and show in particular $f(n) = g(n)$ for all n , for all solutions. The solution involves elementary modular arithmetic.

17482. Bennett, H. S., Kayser, R., Jr., **Transient heat flow to a liquid fuel droplet in combustion gases**, *Ind. Eng. Chem. Fundam.* **17**, No. 1, 8-10 (Feb. 1978).

Key words: combustion; emulsified fuel droplet; fuel droplet; heat flow; micro-explosion; preheat.

Two models for the preheat stage of conventional liquid fuel droplets and of emulsified fuel droplets in combustion gases are analyzed theoretically. These models contain the effects of transient heat conduction to the droplets. In the first model, the droplet and gas temperatures vary temporally but only the gas temperature varies spatially; i.e., the droplet temperature is spatially uniform. Numerical examples, computed from this model, for both the droplet and gas temperatures are given. In the second model, both the droplet and gas temperatures vary spatially and temporally. Numerical examples computed from this second model for the surface and average temperature of the droplet are given. These analyses show that the temperature gradients inside droplets of oil and water are small compared to those in the combustion gases near the droplet and that temperature profiles given by both models are very similar. In particular, the predicted times at which micro-explosions are expected to occur agree within 10 percent of each other.

17483. Bennett, H. S., Rosasco, G. J., **Heating microscopic particles with laser beams**, *J. Appl. Phys.* **49**, No. 2, 640-647 (Feb. 1978).

Key words: change of index of refraction with temperature; heat conduction; laser beam, microscopic particle; Mie scattering; optical path length change; Raman; thermal diffusion.

A number of recently developed techniques for fine particle and aerosol measurement employ focused high-irradiance (power per unit area) laser beams. A knowledge of the temperature profiles in the media surrounding microsamples and the temperature of the microsample is essential for the design and operation of these instruments. In this paper, we develop theoretical models to estimate the final temperature and temperature profiles associated with microscopic particles heated by intense laser beams. We conclude that a heat-sinking medium, such as sapphire, can be effective in maintaining sample temperatures at acceptable levels for nondestructive analysis.

This paper also examines the time required for particle temperatures to reach a steady-state time-independent value. These results are useful for assessing the effectiveness of laser power modulation techniques in these instruments. And finally, the above results are used to calculate the optical path-length changes near the heated microparticle due to temperature rises in the host medium.

17484. Bennett, L. H., Carter, G. C., Kahan, D. J., **Alloy phase diagram activities of the alloy data center**, *Proc. 5th Biennial Intl. Conf. on CODATA, Boulder, CO, June 28-July 1, 1976*, B. Dreyfus, Ed., pp. 51-56 (Pergamon Press, New York, NY, 1977).

Key words: alloys; compilations; phase diagrams.

The NBS Alloy Data Center has proposed a program concerned with coordination of alloy phase diagram data evaluation projects, centralization of bibliographic data, and distribution of this information to the scientific and technical community. Our proposed program has been endorsed by a National Academy of Sciences—National Research Council ad hoc Advisory Panel on Phase Diagrams for Alloys which recommended, among other things, that the Alloy Data Center establish priorities on the basis of specific needs expressed by users, and that the Center maintain an indexed bibliographic file.

On the basis of the Panel's recommendations, the Alloy Data Center plans to provide evaluated phase diagrams in a coordinated and systematic manner. We plan 1) to evaluate small subsets of phase diagrams, on a continuing basis and as appropriate to our research interests, 2) to coordinate and organize the compilation and evaluation of phase diagrams from sources both within the USA and internationally, to participate in and direct such activities as needed and to encourage funding sources to provide financial support to other groups for appropriate phase diagram evaluation projects, and 3) to become a center of bibliographic information for all alloy phase diagrams, both evaluated and unevaluated.

17485. Berke, J. G., **Experimental incentives for national procurement policies**, *Stand. News* 4, No. 10, 13-17 (Oct. 1976).

Key words: ETIP; Federal Supply Service; innovation; life cycle costing; local government; performance specifications; procurement policy; state government; test methods; value incentive clauses; Veterans Administration.

An overview of the Experimental Technology Incentives Program (ETIP) at NBS. More specific description of the procurement policy area, the objectives and philosophy of operation. Details about specific product and systems experiment with major Federal, state and local procurement agencies such as Federal Supply Service of GSA, Veterans Administration, National Institute of Governmental Purchasing, National Association of State Purchasing Officials. Examples are given of purchases of appliances using LCC and on product suggestions supplied under Value Incentive clauses in procurement documents.

17486. Bowman, C. D., Lamaze, G. P., Duvall, K. C., Schrack, R. A., **Structure limitation on accuracy of ^{235}U fission cross section measurements**, *Proc. NEANDC/NEACRP Specialists Meeting on Fast Neutron Fission Cross Sections of U-233, U-235, U-238, and Pu-239, Argonne National Laboratory, June 28-30, 1976*, W. P. Poenitz and A. B. Smith, Eds., Nos. ANL-76-90, ERDA-NDC-5/L, NEANDC(US)-199/L, pp. 270-277 (Argonne National Laboratory, Argonne, IL, 1976).

Key words: averages; cross section; fission; high resolution; keV energies; structure; ^{235}U .

High resolution measurements of the ^{235}U fission cross section carried out at LLL in 1970 have been averaged using Gaussian averaging functions with a FWHM = 1 percent, 2.5 percent, and 10 percent. Deviations from the 10 percent average are calculated and the results expressed in a table which permits an estimate of uncertainties introduced by the cross section fine structure for monoenergetic measurements of known resolution.

17487. Bowman, C. D., Schrack, R. A., **Effects of phonon transfer on near-thermal neutron fission cross sections**, *Phys. Rev. C* 17, No. 2, 654-663 (Feb. 1978).

Key words: capture; Doppler effect; phonon exchange; temperature dependence.

For low energy neutron-induced fission in the thermal and epithermal range, the momentum transferred in forming the compound nucleus is small enough that the compound nucleus may remain bound in the lattice until it decays. Phonons, therefore, may be emitted or absorbed in the neutron absorption process changing the energy of the compound nucleus from that which would be derived simply from measuring the incoming neutron energy. The probability and influence of phonon transfer to and from the lattice is calculated at energies below 1 eV and is shown to have a small but significant effect on the observed cross section. The magnitude of the effect is temperature dependent and ranges in size from a few tenths of 1 percent for ^{235}U fission at thermal to 5 percent for ^{239}Pu fission at the 0.3 eV resonance. Some of the effect can be accounted for by applying the usual Doppler broadening approximation in the thermal range.

17488. Braithwaite, M., Leone, S. R., **Pulsed kinetic studies of laser excited molecular states**, *Proc. Electro-Optics/Laser 77 Conf. and Exposition, Anaheim, CA, Oct. 25-27, 1977*, pp. 582-588 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1977).

Key words: chemical kinetics; chemical laser; chemiluminescence; energy partitioning; energy transfer; vibrational excitation.

A tunable pulsed dye laser is used to study reactions of atoms and molecules in their ground and electronically excited states. Infrared detection of vibrational fluorescence serves to monitor reaction rates and branching ratios of reaction exothermicity. Studies of the reaction $\text{Cl} + \text{H}_2\text{S}$ have been carried out using Cl_2 and S_2Cl_2 as photodissociation sources of Cl atoms. The reaction with Cl_2 as a source of Cl is shown to proceed via a further chain reaction. The HCl product of the $\text{Cl} + \text{H}_2\text{S}$ reaction is vibrationally excited ($v=1$), while the HS product is not. The analogous reaction of $\text{Br}^*(^2\text{P}_{1/2}) + \text{H}_2\text{S}$ is found to produce $\text{HBr}(v=1)$ predominantly. Studies of this kind provide a wealth of new information about the dynamics of the reactive collisions in simple systems.

17489. Brown, W. E., **Solubility product variability at constant pressure and temperature**, *J. Phys. Chem.* 80, 2708 (1976).

Key words: calcium fluoride; equilibrium; free energy; Gibbs-Duhem equation; nonstoichiometry; point defects; solubility product.

The conclusion of Stearns and Berndt that the solubility product constant of CaF_2 varies with solution composition is refuted on the basis that it could lead to a process involving a spontaneous increase in free energy. The Gibbs-Duhem equation is used to show that the equilibrium free energy of calcium fluoride should be invariant as long as the composition is nearly stoichiometric.

17490. Brauer, G. M., Termini, D. J., Levy, S. M., **Surface chemical modification of hard tissues: I. Bone**, *J. Dent. Res.* 56, No. 6, 646-659 (June 1977).

Key words: bone; chemical grafting; copolymerization; hard tissue; surface modification; wettability.

Surfaces of bone were modified in a controlled manner by grafting or by adding interpenetrating polymeric side chains to the bone substrate. The properties of the hard tissue surface attained varied widely. The surface alteration may improve the ability of hard tissues such as bone or dentin to adhere to restorative materials.

17491. Brinckman, F. E., Johannesen, R. B., Hammerschmidt, R. F., Handy, L. B., **Bonding information from fluorine NMR for alkoxy tungsten pentafluorides**, *J. Fluorine Chem.* 6, 427-436 (1975).

Key words: alkoxy; bonding; chemical shifts; fluorides; nuclear magnetic resonance; tungsten.

The ^{19}F chemical shifts have been measured for the fluorines bound to tungsten in the compounds ROWF_5 , where R is CH_3 , ClCH_2CH_2 , Cl_2CHCH_2 , Br_3CCH_2 , Cl_3CCH_2 , F_3CCH_2 , $\text{F}_2\text{CH}(\text{CF}_2)_3\text{CH}_2$, $\text{F}_3\text{CCF}_2\text{CH}_2$, and $(\text{CF}_3)_2\text{CH}$. For the series as written, both the axial and equatorial fluorines resonate at progressively lower field, and the change in resonant position from one compound to another is twice as great for the axial as for the equatorial fluorines. These results are interpreted in terms of σ - and π -bonding contributions.

17492. Brown, W. E., Gregory, T. M., **Calcium pyrophosphate crystal chemistry**, (Proc. Conf. on Pseudogout and Pyrophosphate Metabolism, Santa Ynez, CA, Oct. 19-22, 1975), Paper in *Arthritis and Rheumatism* 19, No. 3, 446-462 (Arthritis Foundation, New York, NY, and The Kroc Foundation, Santa Ynez, CA, May-June 1976).

Key words: calcium diphosphate; calcium pyrophosphate; chondrocalcinosis; pseudogout; solubility; solubility product; synovial fluid.

Theoretical considerations governing the solubilities of calcium pyrophosphates are presented in terms of phase diagrams and calculations based on an ionic model, and the reliability of reported solubility data is examined in terms of the model. The solubility product constant, $(\text{Ca}^{2+})^2(\text{P}_2\text{O}_7^{4-})$, of $\text{Ca}_2\text{P}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ appears to be in the vicinity of 3×10^{-18} , but some of the data indicate that it may be as high as 10^{-14} to 10^{-13} . Recommendations are given for the future experimental measurements.

17493. Butrymowicz, D. B., Manning, J. R., Read, M. E., **Diffusion rate data and mass transport phenomena for copper systems**, *Book: INCRA Monograph V. The Metallurgy of Copper*, 333 pages (International Copper Research Assoc., Inc., New York, NY, July 1977).

Key words: alloys; copper; critical analyses; data; diffusion; electromigration; grain boundaries; molten metals; monograph; review; surfaces; thermomigration.

A survey, comparison, and critical analysis is presented of data compiled from the scientific literature concerning diffusion in copper alloy systems involving elements in Group IA, IIA, IIIA, IVB, VB, VIB, VIIB, VIII, IB, and VA as well as self-diffusion of the pure metal Cu. Here the term "copper alloy system" is interpreted in the broadest sense. For example, the review of diffusion in the Cu-M system reports all diffusion situations which involve both copper and element M, including diffusion of Cu in M or in any binary, ternary or multicomponent alloy containing M; diffusion of M in Cu or in any alloy containing both Cu and M. Topics include volume diffusion,

surface diffusion, grain boundary diffusion, tracer diffusion, alloy interdiffusion, electromigration, thermomigration, dislocation-pipe diffusion, and diffusion in molten metals. An extensive bibliography is presented along with figures, tabular presentation of data and discussion of results.

17494. Carpenter, R. J., **On-site data communication in security systems**, *Proc. Seminar on Sensor Technology for Battlefield and Physical Security Applications, Fort Belvoir, VA, July 13-15, 1977*, pp. 266-280 (MERADCOM, U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, VA, 1977).

Key words: digital communication; electrical communication; local digital communication; multidrop; optical communication; packet communication.

Security systems for a single site, be it an office building or a weapons storage facility, require substantial communication from sensors to a central station and from that central station back to actuators. Even the simplest burglar alarm system has solved many of the same problems which face the designer of modern site security systems; just the level of performance is very different.

17495. Carter, R. S., **Utilization of the NBS reactor**, *Trans. of the American Nuclear Society 1977 Winter Meeting, San Francisco, CA, Nov. 27-Dec. 2, 1977*, Vol. 27, 828 (American Nuclear Society, Inc., La Grange Park, IL, 1977).

Key words: materials characterization, neutron; neutron radiography; neutron scattering; neutron standards; reactor; trace analysis.

17496. Casella, R. C., **Neutrino scattering in a modified GIM model**, *Nuovo Cimento* 42 A, No. 3, 377-396 (Dec. 1, 1977).

Key words: GIM model; neutrinos; partons; quarks; reconciliation; scattering; (V-A)-currents.

The high y anomaly in antineutrino-nucleon scattering is explained in terms of scaling violations utilizing a simple cut-off procedure expressing diminution of free-parton scattering in the wee-x region. The rise in $\sigma^{\bar{\nu}}/\sigma^{\nu}$ with increasing energy E results from an increasing number of the sea quark-partons being freed as the wee-x domain recedes towards $x = 0$. (x and y are the usual Bjorken scaling variables.) Parton distribution functions are described in the lepton-nucleon center-of-mass frame which approaches the infinite-momentum nucleon frame as $E \rightarrow \infty$. The cross-section ratio $\sigma^{\bar{\nu}N}/\sigma^{\nu N}$, $\langle y \rangle^{\bar{\nu}}$, inclusive $d\sigma/dy$ distributions for neutrinos and antineutrinos (with various x cuts), and the absolute magnitude of $\sigma^{\nu N}$ are calculated within the model, leading to good overall agreement with experiment from 10 GeV to 150 GeV. Some discrepancy in $\langle y \rangle^{\bar{\nu}}$ remains near 40 GeV. Ingredients are the standard four (fractionally charged) quarks, (V-A)-coupled to neutrinos (at least in the charged-current sector), and data on the electromagnetic scattering of muons on deuterium at 150 GeV. We are led to a 33 percent sea contribution, of which 64 percent is strange. We suggest that this may be the origin of the high strangeness multiplicity observed in the recent ν and $\bar{\nu}$ induced μe events. The requirement that the valence quark-parton distribution $v(x)$ integrate to 3 is met to within ~ 10 percent by extrapolating the electromagnetic form factor $F_2^d(x)$ to $x = 0$ using a simple empirical observation rather than employing existent theoretically motivated fits.

17497. Caswell, R. S., **Interactions of charged particles with matter: Ions and electrons**, (Proc. Intl. Course at Varenna, Italy, Sept.-Oct. 1974), Paper F-1 in *Ionizing Radiation Metrology*, pp. 329-354 (Editrice Compositori Bologna, Italy, 1977).

Key words: charged-particle tracks; collision cross section; delta rays; electrons; heavy charged particles; range-energy relations; stopping power; straggling.

This paper is a didactic review of the subject of the interactions of charged particles with matter, specifically ions and electrons. Topics discussed include the fundamental collision cross section, stopping power for heavy charged particles, range-energy relations, straggling, delta-ray production, dose distribution and delta-ray flux around charged particle tracks, electron stopping power, and penetration.

17498. Caswell, R. S., **Neutron measurement intercomparisons**, (Proc. Intl. Course at Varenna, Italy, Sept.-Oct. 1974), Paper D-1 in *Ionizing Radiation Metrology*, pp. 113-132 (Editrice Compositori Bologna, Italy, 1977).

Key words: fast neutron flux density; intercomparisons; neutron absorbed dose; neutron-induced reaction rates; neutron kerma; neutron source emission rate; statistical analysis; thermal neutron flux density.

Neutron measurement intercomparisons are discussed from the standpoint of philosophy (reasons for carrying out intercomparisons), methods for making intercomparisons, and a method for carrying out the statistical analysis of intercomparisons is carried through. Examples of measurement intercomparisons are given for neutron source emission rate, thermal neutron flux density, fast neutron flux density, neutron-induced reaction rates, and for fast neutron kerma and absorbed dose.

17499. Chabay, I., Bright, D. S., **Measurement of the size distribution of liquid and solid aerosols by Doppler shift spectroscopy**, *J. Colloid Interface Sci.* **63**, No. 2, 304-309 (Feb. 1978).

Key words: aerosols; calibration of instruments; dioctylphthalate aerosol; Doppler shift spectrometer; heterodyne laser light scattering; light scattering; Mie scattering; particle size; size distribution of particles; Stokes law velocity.

Particle Doppler shift spectroscopy (PDSS) is being used at NBS for measuring the size distribution of particles produced by aerosol generators, calibrating other types of particle sizing instruments, and studying the agglomeration, coalescence, evaporation, and condensation of liquid and solid aerosols. Size distributions of particles in the size range 0.5-50 μm can be measured in minutes or seconds. Number densities in the scattering volume from single particle to $10^9/\text{cm}^3$ can be handled. The technique at present has a precision of 0.05 μm . Measured sizes are accurate to 0.08 μm . Calculations of the Mie scattering function for materials of known refractive index serve to normalize the size distributions and provide instrument calibration from first principles. Light scattered out of a horizontally propagating laser beam by falling particles is collected at one angle in the vertical scattering plane. Beat frequencies in the photocurrent of the detector due to the Doppler shift of the radiation scattered by the settling aerosol are analyzed to determine particle velocities. The slip-corrected Stokes Law settling velocity gives the particle's size for a known particle density, while the amplitude of the beat frequency component contains information on the number of particles of that size. Dioctylphthalate (DOP) aerosol produced by a Berglund-Liu vibrating orifice generator, polystyrene latex spheres, and powder samples have been studied thus far by the PDSS technique at NBS.

17500. Chapman, R. E., **Lead paint poisoning: A closer look at the costs**, *J. Housing* **33**, No. 10, 489-492 (Nov. 1976).

Key words: abatement; building materials; cost; economics; housing; lead-based paint; lead poisoning.

Indecision about how to deal with the lead paint poisoning problem in residential dwellings stems in part from a lack of knowledge about the costs of various abatement methods. This research, sponsored by HUD's Office of Policy Development and Research, provides a procedure for estimating the costs of the alternative abatement methods. Federal and local housing officials can use this procedure and cost information derived from its application to achieve more lead paint abatement per public dollar invested.

17501. Chow, L. C., **Fluoride penetration and retention (Discussion)**, *Caries Res.* **11**, Suppl. 1, 191-198 (1977).

Key words: acidulated phosphate fluoride; calcium fluoride; dicalcium phosphate dihydrate; fluorapatite; topical fluoride.

The penetration of fluoride into enamel produced by topical treatments may occur at three levels: (1) F^- penetration accompanied by histological changes in enamel, (2) F^- penetration into the inner zones of enamel via intercrystalline pores, and (3) F^- penetration into the interior of the apatite crystals. Although CaF_2 may be a more potent source of fluoride, the poor retention in the oral environment greatly limits the effectiveness of CaF_2 as a cariostatic agent. Fluorapatite is believed to be the most desirable form of fluoride incorporation both because it is stable in normal oral environments and because its dissolution under cariogenic conditions would give rise to kinetic behavior that would tend to diminish caries activity. The formation of fluorapatite in teeth by a recrystallization process is described.

17502. Clarke, R. M., Kilmer, R. D., Blomquist, D. S., **Locomotive in-cab noise—Towards a standardized measurement methodology**, *Proc. NOISE-CON 77 Conf. on Noise Control Engineering, NASA Langley Research Center, Hampton, VA, Oct. 17-19, 1977*, pp. 431-442 (Noise Control Foundation, Poughkeepsie, NY, Oct. 1977).

Key words: acoustics; hearing conservation; in-cab locomotive noise; noise measurement; noise (sound); transportation noise.

The U.S. Federal Railroad Administration, in cooperation with the Association of American Railroads, is currently sponsoring efforts by the National Bureau of Standards to collect locomotive in-cab noise level data. The purpose of the program is to develop a simplified stationary test procedure which will correlate with operational duty cycle, crew exposure, and noise level data, and which is based on current OSHA hearing conservation regulations. This paper describes the measurement methodology and instrumentation system developed for this program. The data and conclusions presented are preliminary in nature. The program is scheduled for completion in early 1978.

17503. Cohen, P. I., Abramowitz, S., Broida, H. P., **Chemisorptive luminescence from Ba and Mg films**, *Surface Sci.* **69**, 601-604 (1977).

Key words: Ba and Mg films; chemisorptive luminescence; films, Ba and Mg; luminescence, chemisorptive.

Chemiluminescence has been used to study the mechanisms and kinetics of gas and liquid phase reactions for many years. Recently, several workers trying to extend such studies to surfaces have reported luminescence during the chemisorption of O_2 onto W, Si, Mg, Al, and ThO_2 ; O_2 , CO, and acetone onto NiO, Cr_2O_3 , and ZnO; and Br_2 , Cl_2 , and I_2 onto Na. This luminescence is not well understood but since it occurs in such diverse systems there is probably more than one mechanism involved. The light intensity is quite weak with only 10^{-5} to 10^{-9} photons produced per molecule adsorbed. Only crude spectral information is available because of low light intensity.

Our purpose was to survey several possible surface reactions, guided by gas phase reactions known to produce strong chemiluminescence to find surface reactions with more efficient photon yields and therefore more amenable to spectral analysis.

17504. Corley, D. M., **Empirical model for predicting in-service truck tire noise levels**, *Proc. SAE Highway Tire Noise Symp., San Francisco, CA, Nov. 10-12, 1976*, pp. 303-309 (Society of Automotive Engineers, Inc., Warrendale, PA, 1977).

Key words: acoustics; noise measurement; noise (sound); tire noise; transportation noise; truck.

SAE Recommended Practice J57a—Sound Level of Highway Truck Tires—specifies a simple, practical noise certification test procedure for tires which results in a single-number rating—maximum A-weighted sound level—of the coastby sound level measured according to prescribed procedures. Such a rating by itself, however, does not allow prediction of in-service noise levels. This report discusses the basic assumptions and necessary input data for a DOT/NBS developed empirical model which utilizes the certification test results to predict in-service noise levels. The usefulness and expected accuracy of the predictive model are shown through a comparison of measured versus predicted maximum A-weighted sound levels for a variety of truck/tire combinations.

17505. Culver, C., **A model for formulating seismic design provisions**, *Proc. CENTO Seminar on Recent Advances in Earthquake Hazard Minimization, Tehran, Iran, Nov. 14-16, 1976*, pp. 536-545 (Technical Research and Standard Bureau, Tehran, Iran, June 1977).

Key words: building codes; earthquakes; structural engineering.

The paper describes a program currently underway in the United States to develop improved seismic design provisions for buildings. Organization of the activity, the form of the provisions and the technical areas included are discussed. Important aspects of the provisions dealing with: (1) design ground motion, (2) structural design, (3) architectural and mechanical-electrical design, and (4) existing buildings are summarized.

17506. Culver, C. G., **Characteristics of fire loads in office buildings**, *Fire Technol.* **14**, No. 1, 51-60 (Feb. 1978).

Key words: buildings; fire loads; load surveys.

A study was made to determine the effects of various parameters on the fire load characteristics of office buildings. This and future studies are expected to form the basis for improving fire resistant design requirements.

17507. Currie, L. A., **Detection and quantitation in x-ray fluorescence spectrometry**, Chapter 25 in *X-Ray Fluorescence Analysis of Environmental Samples*, T. G. Dzubay, Ed., pp. 289-306 (Ann Arbor Science Publishers Inc., Ann Arbor, MI, 1977).

Key words: atmospheric pollutants; counting statistics; detection limits; energy vs. wavelength dispersion; imprecision; merit; quantitation limits; reporting of data; systematic error; x-ray fluorescence analysis.

Detection and quantitation limits may be computed for x-ray fluorescence (XRF) measurements given the assumption of normal, random errors, an estimate of the standard deviation of the blank, and the sensitivity (calibration) function. Comparison of XRF techniques may be made numerically or by a graphical approach in which reduced concentration (signal/background) is plotted vs. background counts; this results in a single family of curves which are independent of time, sensitivity or background rate. Both approaches have

been illustrated for four XRF methods for potassium. Background equivalent concentration (BEC) and signal/background at the detection limit (r_D) have proved helpful in considering sensitivity to non-Poisson variations. Factors such as sampling errors, chemical recovery, interference and contamination, matrix absorption and scattering and data reduction models all pose limitations to the above assumptions. Assessment of imprecision via replication, and assessment of bias via intercomparison yields information concerning the range over which the Poisson assumption may be safely applied. The above criteria were applied to the evaluation of measurement adequacy for nine trace elements appearing in typical urban particles.

17508. Currie, L. A., DeVoe, J. R., **Systematic error in chemical analysis**, (Proc. Symp. Division of Analytical Chemistry 171st Meeting of the American Chemical Society, New York, NY, Apr. 5-6, 1976), Paper 3 in *ACS Symposium Series 63, Validation of the Measurement Process*, J. R. DeVoe, Ed., pp. 114-139 (American Chemical Society, Washington, DC, 1977).

Key words: chemical analysis; chemical measurement process; detectability; diagnosis of bias; reporting of results; systematic.

Inaccurate analytical results, which sometimes lead to damaging societal decisions, are invariably the product of systematic error. This review focuses on four key aspects of systematic error in chemical analysis: (a) the serious consequences of inaccuracy in the external use of analytical results, (b) the essential requirement of systematic error detection or accuracy verification via laboratory or method intercomparison, (c) the systems analytic approach to the CMP as the only reliable, organized way to anticipate the origin, magnitude and flow of systematic error, (d) the power of numerical and graphical diagnostic techniques, which are rapid and relatively immune to assumptions and blunders, for exposing the particular nature of systematic errors following their detection.

17509. Currie, L. A., **Model uncertainty and bias in the evaluation of nuclear spectra. I. The smoothest consistent baseline**, *J. Radioanal. Chem.* **39**, 223-237 (1977).

Key words: baseline estimation; counting statistics; gamma-ray spectrometry; Lagrange multiplier; numerical analysis; spectrum analysis; x-ray fluorescence spectrometry.

Unbiased analysis of γ -ray and x-ray spectra is impossible in the absence of a complete physical or mathematical model. Partial model knowledge may be supplemented by simple assumptions or by various heuristic schemes in order to effect a solution. Assessment of limits for bias, based upon the properties of the surrogate model and physical-chemical knowledge of the measurement system, is the principal target of this work. The Smoothest Consistent Baseline (SCB) approach has been introduced in an attempt to weaken assumptions and minimize bias in the extraction of a spectral peak from a baseline of uncertain shape. The bias matrix, which results directly from the numerical analysis, permits limiting baseline profiles to be simply converted into bounds for systematic model error.

17510. Currie, L. A., **Accuracy and merit in liquid scintillation counting**, (Proc. Symp. on Liquid Scintillation Counting, Bath, England, Sept. 16-19, 1975), Chapter 18 in *Liquid Scintillation Counting*, M. A. Crook and P. Johnson, Eds., **4**, 219-242 (Heyden, New York, NY, 1976).

Key words: accuracy; blank; Cerenkov counting; figure of merit; liquid scintillation counting; Poisson errors; precision; quenching; random error; reduced activity; systematic error; ^3H ; ^{32}P .

Modern liquid scintillation spectrometry, while extremely convenient and broad in its applicability, presents the user with numerous opportunities for systematic and random error. Following a survey of the current state of the art with respect to accuracy, a detailed inquiry is made into the magnitude and nature of error sources. Special attention is paid to sampling errors, recovery errors (chemical and isotopic), quenching errors and blank (contamination errors). Control of blunders via monitoring techniques and redundancy is recommended.

Figure of Merit (F) as a measure of method performance is examined in depth. Inconsistent and equivocal measures for F are exposed, and a rational approach is developed. The resulting graphical technique permits immediate evaluation of relative merit among several alternative procedures as well as optimization of controllable variables for a given procedure. Illustrations are given for high and low-energy β -emitters (^{32}P , ^3H) for liquid scintillation, Cerenkov and gas counting.

17511. Davis, G. T., Broadhurst, M. G., **Piezoelectricity and pyroelectricity in polar polymers**, *Proc. Intl. Symp. on Electrets and Dielectrics, Sao Carlos, Brazil, Sept. 1-6, 1975*, pp. 299-319 (Instituto de Fisica e Quimica de Sao Carlos, Universidade de Sao Paulo, 13560 Sao Carlos, SP, Brazil, 1977).

Key words: aligned dipoles; piezoelectricity; polarization; polyvinylchloride; polyvinylidene fluoride; pyroelectricity; transducers; vinylidene-fluoride-tetrafluoroethylene copolymer.

The piezoelectric and pyroelectric response in polymer electrets is explained using a model of frozen-in molecular dipoles aligned during the poling procedure. The piezoelectric coefficient d_p for a change in hydrostatic pressure has been shown to be equal to $P\beta\epsilon_\infty/3$ where P is the polarization, β is the isothermal volume compressibility and ϵ_∞ is the relative permittivity for immobilized dipoles. The pyroelectric coefficient p has been shown to be approximately equal to $P[\alpha\epsilon_\infty/3 + (\Delta\phi)^2/2T]$ where α is the volume thermal expansion coefficient, T is absolute temperature, and $\Delta\phi$ is the RMS angular fluctuation of dipoles about a mean position.

These expressions are compared with experimental results for a glassy polymer, polyvinylchloride, in which P is a linear function of the polarizing electric field and found to account well for the data. The above expressions are also compared with data obtained for poled samples of a copolymer of vinylidene fluoride containing 27 percent tetrafluoroethylene in which P is not a linear function of the field. When it is assumed that the oriented dipoles lie within the crystalline regions of the polymer, the results obtained so far can be accounted for by invoking less than the predicted maximum polarization.

17512. Davis, G. T., Broadhurst, M. G., **Pyroelectricity in a vinylidene fluoride-tetrafluoroethylene copolymer (Extended Abstract)**, *Proc. 148th Meeting of the Electrochemical Society, Dallas, TX, Oct. 5-10, 1975, 75-2*, Abstract No. 116, 297-299 (1978).

Key words: compressibility; piezoelectric; polarization; polyvinylidene fluoride-tetrafluoroethylene copolymer; pyroelectricity; thermal expansion.

The pyroelectric (p) and piezoelectric (d_p) coefficients of poled films of a vinylidene fluoride-tetrafluoroethylene copolymer have been investigated. Using a model of aligned dipoles within the crystalline regions of the polymer, it is shown that pyroelectricity can arise from a change in polarization due to thermal volume change as well as a change in amplitude of thermal oscillations of the dipole about a fixed mean orientation. The maximum experimental values of the coefficients obtained so far ($p = 2.7 \text{ nC/cm}^2\text{K}$ and $d_p = 12.1 \text{ pC/N}$) can be accounted for by this model.

17513. DiMarzio, E. A., **Comments on a paper entitled "Prigogine-Defay ratio for systems with more than one order parameter"**, *J. Chem. Phys.* **67**, No. 5, 2393-2394 (Sept. 1, 1977).

Key words: glasses; glass transition; order parameter theory; thermodynamics of glasses.

A recent paper by Gupta and Moynihan claims to show that order-parameter theory (OPT) can be used to prove that the Prigogine-Defay ratio $\gamma = \Delta C_p \Delta \kappa / TV(\Delta \alpha)^2$ is greater than 1. They also claim to show that a previous paper in which the relation $\gamma = 1$ is derived is in error. This comment is a response to the Gupta-Moynihan paper.

17514. DiMarzio, E. A., **Configurational packing statistics of polymers near a surface. I. The generalization of the rigid rod case to include both orientation dependence and spatial variation**, *J. Chem. Phys.* **66**, No. 3, 1160-1169 (Feb. 1, 1977).

Key words: liquid crystals; polymer adsorption; position dependent thermodynamics; rigid molecule statistics; surface adsorption.

The following problem is solved. What is the total number of ways to pack rigid rod molecules together given that the number density $f(\Omega, r)$ at each point r and each orientation Ω are specified. This constitutes a generalization of previous work which allowed for only Ω dependence. The problem is first solved for a cubic lattice and then generalized to a continuous variation of both position and orientation. The problem of minimizing the associated free energy is solved. The results are applicable to determination of the adsorption properties of rigid rod molecules near a surface as well as liquid crystal behavior.

17515. DiMarzio, E. A., **Some insights into the order parameter theory of glasses. A response to a comment by Goldstein**, *Macromol. Notes* **10**, 1407-1408 (Nov.-Dec. 1977).

Key words: entropy theory of glasses; glasses; kinetics of glasses; order parameters.

The implications of the Davies-Jones assumption of a freezing in of order parameters are ascertained. It is found that certain sets of frozen in parameters are incompatible with the time dependent equations. It is observed that it is in general impossible for two different intersecting histories to result in the same set $z_i(t)$ at the intersection. Finally, an example of the Prigogine-Defay ratio r being less than 1 is given.

17516. DiMarzio, E. A., Rubin, R. J., **Dynamics of a polymer attached to a surface: Bead and spring model**, *J. Polym. Sci., Polym. Phys. Ed.* **16**, 457-466 (1978).

Key words: bead and spring; polymer dynamics; polymer on surface; surface dynamics.

The Smoluchowski formalism is used to solve the problem of a bead of frictional resistance β attached to a surface with a spring of force constant κ over which a linear shear field of strength α flows. The power dissipation is given by $\beta \alpha^2 k T / \kappa$. k and T have their usual meanings. The result is generalized to a Rouse model polymer attached to a surface at one end is twice that of an identical polymer flowing freely in solution. If the force constant κ arises from an entropy force, then, because of the effect of the surface on the number of polymer configurations, there is an additional factor of two. The same relationship is expected to also hold for the frequency-dependent power dissipation. It is argued that a net circulation exists in the beads above the surface and that the magnitude of the circulation is roughly comparable to that which exists in a polymer freely rotating in solution under a shear field of the same magnitude.

17517. Domingues, L. P., Negas, T., Armstrong, A. J., Hosler, W. R., **Development of a potential electrode material for MHD: Yttrium orthoferrite**, *Proc. 17th Symp. Engineering Aspects of Magnetohydrodynamics*, C. H. Kruger, Ed., Stanford, CA, Mar. 27-29, 1978, pp. G.6.1-G.6.5 (Stanford University, Stanford, CA, Mar. 1978).

Key words: ceramics; electrical conductivity; microchemical; microstructural; yttria.

Yttria-based ceramics have not been developed fully for MHD applications. As part of an expanded program, this paper presents some exploratory data related to $YFeO_3$ -type materials. Preparation and microchemical/microstructural details together with relevant electrical conductivity and thermal expansion data are given. Emphasis is on $YFeO_3$ - $CaFeO_{2.5}$ - $CaZrO_3$ solid solutions and composites.

17518. Fahey, D. W., Schearer, L. D., **Non-statistical excitation of the magnetic substates of the 1P_1 level of group II metal atoms in collision with 800 eV helium atoms**, *Phys. Lett.* **65A**, No. 3, 215-216 (Mar. 6, 1978).

Key words: group II metal atoms; neutral helium beam; optical polarization.

A large polarization has been observed for the emission lines of strontium and calcium excited by a beam of neutral helium atoms with 800 eV lab energy. The measured value of 15 percent indicates a preferential population of the magnetic substates of the target species. Depolarization of the emission in a magnetic field has been observed demonstrating the feasibility of Hanle-type lifetime measurements.

17519. Fechter, J. V., Van Cott, H. P., **The house that NBS built**, *J. Consumer Stud. Home Econ.* **1**, 101-108 (1977).

Key words: appliance research; behavioral laboratory; consumer product studies; human behavior research; human factors laboratory; range energy consumption.

In a suburban house in Maryland researchers at the National Bureau of Standards (NBS) are studying the behaviour of people in a residential setting. This house, on the NBS campus outside Washington, has been turned into a laboratory equipped with 12 T.V. cameras, three observation booths, two kitchens, a computer and several miles of communications wiring.

17520. Feldman, A., **Optical properties of infrared laser windows**, *Proc. Electro-Optical Systems Design Conf. 76 and International Laser Exposition*, New York, NY, Sept. 14-16, 1976, pp. 499-506 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1976).

Key words: interferometry; laser materials; photoelasticity; piezo-optic constants; refractive index; stress birefringence; thermal coefficient of refractive index; thermal expansion.

The refractive index, n , the change of index with temperature, dn/dT , the piezo-optic constants, q_{ij} , and the thermal expansion coefficient, α , of infrared laser window materials are being measured. These parameters are needed for determining the performance of these materials as windows in high-power laser systems as well as in other optical systems. Precision spectrometers are used to measure n from $0.2 \mu\text{m}$ in the ultraviolet to $50 \mu\text{m}$ in the infrared. Measurements of n at two temperatures, 20°C and 30°C , permit us to calculate dn/dT over a wide wavelength range. More precise values of dn/dT are obtained at discrete wavelengths and over a much wider temperature range, -190°C to 800°C , by Fizeau interferometry. We measure α similarly by Fizeau interferometry. The piezo-optic constants, which determine the effect of stress on refractive index, are measured by several interferometric techniques. Measure-

ments are made at the wavelengths of the helium-neon laser, $0.6328 \mu\text{m}$, $1.15 \mu\text{m}$ and $3.39 \mu\text{m}$, and at the wavelength of the carbon-dioxide laser, $10.6 \mu\text{m}$.

17521. Fife, D. W., **Software management standards**, (Working Papers of the Software Life Cycle Management Workshop, Airlie House, Warrenton, VA, Aug. 21-23, 1977), Paper in *Software Phenomenology*, pp. 63-80 (U.S. Army Institute for Research in Management Information and Computer Science, Department of the Army, Fort Belvoir, VA, 1977).

Key words: computer management; computer programming; computer project control; computer software; software engineering; software quality; software reliability.

Software management consists of all the technical and management activities, decisions, and controls that are directly required to purchase, produce, or maintain software throughout the useful life of a computer system or service. This paper discusses the scope of software management from the viewpoint of life cycle phases. Needs are described for standards of practice in the areas of quality assurance, software design and software production tools.

17522. Fine, J., Gorden, R., Jr., **On producing visual two-dimensional images of ion beams**, Paper in *Proceedings of the Seventh International Vacuum Congress and the Third International Conference on Solid Surfaces*, Vienna, Austria, Sept. 12-16, 1977, R. Dobrozemsky, F. Rüdener, F. P. Viehböck, and A. Breth, Eds., III, 2561-2564 (F. Berger and Söhne, Vienna, Austria, Sept. 1977).

Key words: charge storage; electron beams; insulators; ion beams; phosphors; surface conductivity; surfaces; visual images.

Two-dimensional images of 1-5 keV argon ion beams incident on solid surfaces have been obtained by the coincident interaction of a rastered electron beam. Various target materials have been examined but only insulators were found effective in producing ion beam images. Those processes that seem basic to understanding this imaging effect are enhanced surface conductivity and charge storage and neutralization. The use of coincident ion and electron beams presents a new technique that is potentially useful for studying surface interactions.

17523. Finn, J. M., Crannell, H., Hallowell, P. L., O'Brien, J. T., Penner, S., **Inelastic electron scattering from low-lying states in the nuclei ^{36}Ar and ^{40}Ar** , *Nucl. Phys. A.* **290**, 99-108 (1977).

Key words: enriched ^{36}Ar target; measured $\sigma(E, \theta)$; nuclear reactions $^{36,40}\text{Ar}(e, e')$, $E = 65$ to 115 MeV ; $^{36,40}\text{Ar}$ deduced levels J, π, Γ .

The low-lying level structure of ^{36}Ar and ^{40}Ar has been investigated using the technique of inelastic electron scattering. Data were collected at the National Bureau of Standards Linear Accelerator with incident electron energies between 65 and 115 MeV and scattering angles of 92.5° and 110° . The data span a range of momentum transfer squared between 0.29 and 0.92 fm^{-2} . Tassie model and Helm model analyses have been applied to data for levels at 1.97 and 4.18 MeV in ^{36}Ar and at 1.46, 2.52, 3.21 and 3.68 MeV in ^{40}Ar . A 2^+ assignment to the 3.21 MeV state in ^{40}Ar is suggested. Transition strengths, transition radii, and mean lifetimes for these states are computed and compared with results of previous experiments.

17524. Fisher, G. B., Madey, T. E., Waclawski, B. J., Yates, J. T., Jr., **Ultraviolet photoemission studies of methanol adsorbed on Ru(110)**, Paper in *Proceedings of the Seventh International Vacuum Congress and the Third International Conference on Solid Surfaces*, Vienna, Austria, Sept. 12-16, 1977,

R. Dobrozemsky, F. Rüdener, F. P. Viehböck, and A. Breth, Eds., **II**, 1071-1074 (F. Berger and Söhne, Vienna, Austria, Sept. 1977).

Key words: adsorption; methanol; photoelectron spectroscopy; ruthenium; surfaces; thermal desorption; ultraviolet photoemission.

Methanol (CH_3OH) adsorbed on Ru(110) has been studied under UHV conditions by angle-integrated ultraviolet photoemission (UPS) as part of a search for surface complexes related to intermediates present during the methanation reaction on Ru. For low exposures at 80 K, the UPS spectra indicate that the methanol chemisorbs nondissociatively. In the initial layer, the work function drops linearly with exposure while the orbitals of adsorbed methanol remain fixed in binding energy relative to the Ru Fermi level. The relative spacings of the orbitals suggest that bonding to the substrate occurs via oxygen-derived orbitals. Of the two major desorption products, H_2 and CO, hydrogen leaves the surface at lower temperatures. Upon heating the adsorbed methanol, the UPS spectra indicate that methanol decomposes on the surface before significant desorption occurs.

17525. Flynn, J. H., **Thermogravimetric analysis and differential thermal analysis**, Chapter 12 in *Aspects of Degradation and Stabilization of Polymers*, H. H. G. Jellinek, Ed., pp. 573-603 (Elsevier Scientific Publ. Co., Amsterdam, The Netherlands, 1978).

Key words: aging; degradation; differential scanning calorimetry; differential thermal analysis; nonisothermal kinetics; polymers; review; stability; thermogravimetry.

This chapter is a description and a critical review, including sixty-six references, on the fundamentals and experimental techniques of thermogravimetry differential scanning calorimetry and differential thermal analysis as they may be applied to the study of the degradation of polymeric materials. Problems related to temperature measurement, instrumental lags and heat flow are defined and analyzed. The discussion of techniques deals with quantitative aspects, especially kinetic analysis of degradation reactions. Most of the present techniques of applied nonisothermal kinetic analysis are found to be insufficient to cope with these complex systems. It is predicted that quantitative equipment, automated and interfaced with computers and combined with other analytical techniques, will be exploited to develop new methods of programming and data analysis. Some new directions of kinetic analysis—jump methods, isokinetic techniques, and relaxation methods—are presented.

17526. Flynn, J. H., Plummer, W. J., Smith, L. E., **Initial weight-loss kinetics for the thermal degradation of polyurethanes**, (Proc. American Chemical Society New Orleans Meeting, New Orleans, LA, Mar. 20-25, 1977), Paper in *Polym. Prepr.* **18**, No. 1, 757-760 (Division of Polymer Chemistry, Inc., American Chemical Society, Washington, DC, Mar. 1977).

Key words: activation energy; aging; initial kinetics; polyurethane; reversion; thermal degradation; thermogravimetry.

Rates of degradation obtained from the initial stages of decomposition of a polymer are the most useful in relating the observed kinetics to a mechanistic scheme as well as in predicting a useful service lifetime for the material. Unfortunately, the determination of such initial rates is complicated by a number of experimental factors. Using techniques to minimize these factors, initial rates of weight-loss for an MDI and TDI polyether urethane have been determined by a differential method at a constant heating rate of two degrees per minute

in nitrogen and vacuum. The activation energy determined under these conditions was ~ 38 kcal/mole in the 0.5 percent to 4.0 percent weight-loss range for both cases. There was no evidence for an early acceleration of the rate.

17527. Fowler, J., **The electronic aspects of the NBS detector response and intercomparison package and laser stabilization facility**, *Proc. Electro-Optics/Laser 77 Conf. and Exposition*, Anaheim, CA, Oct. 25-27, 1977, pp. 689-695 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1977).

Key words: detector responsivity; electro-optic modulator; high accuracy radiometer; silicon detector; temperature controlled silicon cell.

The paper describes two silicon detector based instruments designed to fill the needs of the NBS program of calibration and transfer of detector responsivity. The first instrument to be described is a self-contained high accuracy radiometer employing a temperature controlled silicon cell, amplifier, filter and digital readout. The second instrument is a device employing an electro-optic modulator which stabilizes the power in a laser beam to 0.05 percent from DC to 100 KHZ in the 350 to 1200 nm range.

17528. Fong, J. T., **Some mathematical aspects of engineering research at selected universities in Hong Kong and Japan**, *Sci. Bull.* **2**, No. 4, 15-18 (Oct.-Dec. 1977).

Key words: computer simulation; distributed cracks; distributed dislocations; fatigue; fracture; microstructural analysis; multi-axial analysis; nondestructive evaluation; reliability analysis; safety factors; statistical modeling; stochastic theory of fracture.

Recent progress on the mathematical aspects of two research problems in engineering at several academic centers in Hong Kong and Japan is reported. The two engineering research problems are: (a) How to quantify the engineering judgment in the use of safety factors, and (b) how to quantify the mathematical judgment in the use of lower-dimensional solutions as approximations to higher-dimensional problems in engineering design. Significance of selected works at University of Hong Kong, two research institutes of University of Tokyo, and Tohoku University at Sendai, Japan, is discussed in conjunction with recent works on similar subjects at U.S. National Bureau of Standards.

17529. Frederikse, H. P. R., **Data requirements in properties of solids—Past, present and future**, *Proc. 5th Biennial Intl. Conf. on CODATA*, Boulder, CO, June 28-July 1, 1976, B. Dreyfus, Ed., pp. 607-613 (Pergamon Press, New York, NY, 1977).

Key words: chemical and physical properties; existing data compilations; materials science and engineering; new data needs; solid state.

The need for numerical data and information concerning the properties of solids depends to a great extent on the point-of-view from which solids (or materials) are being considered. During the last 10-20 years this viewpoint has changed notably from a disciplinary, research-oriented approach to one in which the application (energy, environment, communication, defense, etc.) and the supply of materials are playing the dominant roles. Among the three groups of solid state properties—structural, chemical and physical—the emphasis is shifting from the latter to the first two categories. This paper briefly reviews existing data compilations and data centers and suggests a few areas of materials properties where new and expanded data collections are urgently needed.

17530. Fuller, E. R., Jr., Thomson, R., **Nonlinear lattice theory of fracture**, (Proc. Fourth Intl. Conf. on Fracture, Waterloo,

Canada, June 19-24, 1977), *Fract.* 3, No. ICF4, 387-394 (University of Waterloo Press, Waterloo, Ontario, Canada, 1977).

Key words: brittle fracture; crack healing; lattice trapping; nonlinear lattice theory; subcritical crack growth; surface energy.

A nonlinear lattice theory of fracture is developed for a quasi-one-dimensional lattice model of a crack, where nonlinear cohesive force laws are introduced for the interaction of the "crack-tip" atoms. Similar to previous developments, the crack is found to be stable over a range of applied forces, or "lattice trapped." Within this lattice trapping regime, conditions of stability give not only equilibrium configurations, but also a saddle point configuration, thus enabling the calculation of forward and backward energy barriers for thermally activated subcritical crack propagation, or crack healing. As in the three-dimensional development by Esterling, the microscopic surface energy density, as defined by one-half the area under the cohesive force versus displacement curve, is found to lie outside the lattice trapping regime for certain cohesive force laws. However, the present model is not self-consistent for these atomic forces laws, and requires the consideration of additional nonlinear "crack-tip" interactions to reduce this inconsistency.

17531. Gadzuk, J. W., **X-ray photoemission spectra from adsorbed layers on metal substrates**, Paper in *Proceedings of the Seventh International Vacuum Congress and the Third International Conference on Solid Surfaces, Vienna, Austria, Sept. 12-16, 1977*, R. Dobrozemsky, F. Rüdener, F. P. Viehböck, and A. Breth, Eds., I, 715-718 (F. Berger and Söhne, Vienna, Austria, Sept. 1977).

Key words: chemisorption; many-body effects; photoemission; relaxation.

Photoelectron spectra from atoms adsorbed onto surfaces are modified in several important ways compared to gas phase spectra. In this work, the focus is on those changes falling under the generic heading of extra-atomic relaxation effects. For adsorbed atoms, the x-ray photoelectron spectrum from core states is characterized by an upward "image potential shift," balanced by surface plasmon shake-up satellites. Theories exist in which the spectrum has been obtained for a single adsorbed atom. In this paper, core state photoelectron spectra for adsorbates forming a uniform film are calculated. The modifications to the substrate response function and the surface plasmon dispersion relations due to the presence of the adsorbed film are included as is intra-adsorbate polarization (approximately). The consequent effects on the relaxation shifts and satellite line shapes are calculated.

17532. Galloway, K. F., Roitman, P., **Important considerations for SEM total dose testing**, *IEEE Trans. Nucl. Sci.* NS-24, No. 6, 2066-2070 (Dec. 1977).

Key words: hardness assurance; ionizing radiation effects; radiation dose; radiation testing; scanning electron microscopy; semiconductor devices; total dose screening.

The kilovolt electron beam utilized in a scanning electron microscope has been of interest as a tool for total dose screening of semiconductor devices for hardness assurance because of its convenience and because devices can be selectively irradiated directly at the wafer level. A number of factors such as the depth-dose distribution of kilovolt electrons, the dose-rate, uniformity of exposure, and device biasing must be considered when applying this technique. This paper is devoted to these and other aspects of SEM total dose testing.

17533. Garvin, D., Parker, V. B., Wagman, D. D., Evans, W. H., **A combined least sums and least squares approach to the solution of thermodynamic data networks**, *Proc. 5th Biennial Intl. Conf. on CODATA, Boulder, CO, June 28-July 1, 1976*, B. Dreyfus, Ed., pp. 567-575 (Pergamon Press, New York, NY, 1977).

Key words: chemical thermodynamics; computer techniques; data evaluation; least squares (L2); least sums (L1).

A description is given of a system for computer-based evaluation of interrelated thermodynamic measurements of enthalpies of reaction, equilibria and entropies. This system is an extension of the CATCH program developed by J. B. Pedley, University of Sussex. In the new system linear least sums and least squares techniques are used to solve networks of thermodynamic equations to obtain the enthalpies and free energies of formation and the entropies of chemical substances. The least sums technique is shown to be useful in assessing the consistency of the data. A method has been developed for combining least sums and least squares solutions. It provides a weighted solution that reproduces closely the solutions that are obtained by a detailed analysis of the data using the customary sequential procedure. The results from tests on four large networks are discussed. These networks are the thermodynamic data for compounds of B, U, Th and Rb. It is anticipated that the methods described here will be useful in the development of an international cooperative program for the evaluation of thermodynamic data. Such a program will require development of a computer-based data bank of experimental measurements contributed and evaluated by many scientists throughout the world.

17534. Geist, J., **Frontiers in optical radiation measurements**, *Proc. Electro-Optical Systems Design Conf. 76 and International Laser Exposition, New York, NY, Sept. 14-16, 1976*, pp. 281-284 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1976).

Key words: electrically calibrated detector; optical radiation measurements; primary standards; standard source.

Recent progress in optical radiation measurements is reviewed with emphasis on very recent progress in areas currently undergoing significant development. By its nature the paper must rely to some extent on unpublished material.

17535. Geist, J., Lind, M. A., Schaefer, A. R., Zalewski, E. F., **A laser based characterization facility for silicon photocell studies**, *Proc. Terrestrial Photovoltaic Measurement Workshop, Baton Rouge, LA, Nov. 10-12, 1976*, pp. 223-231 (Available from the National Technical Information Service, Springfield, VA, 1976).

Key words: absolute radiometry; detector; electrically calibrated detectors; laser power measurements; pyroelectric detectors; radiometry; silicon cell; silicon detector; silicon photodetector.

A laser-based facility for characterization of photocells, and some studies performed on it are described with emphasis towards results of the greatest interest to the silicon solar cell community.

17536. Gerstenberg, H. M., **Computer-assisted data evaluation in a small data center**, *Proc. 5th Biennial Intl. Conf. on CODATA, Boulder, CO, June 28-July 1, 1976*, B. Dreyfus, Ed., pp. 515-518 (Pergamon Press, New York, NY, 1977).

Key words: central computer; chaining programs; data evaluation; demand terminal; digital data; NIRA programs; Photonuclear Data Center.

The Photonic Data Center of the National Bureau of Standards (NBS) is a relatively small group presently engaged in the evaluation of cross section (graphical) data. These data exist in digital form in a library maintained by the Center. Extensive use is made of the NBS central computer and its facilities to process data for entry into the digital library, to manipulate the data in various ways during evaluation, and finally, to prepare camera-ready copy in tabular as well as graphical form for publication. Maximum use is made of the computer's executive control language to handle data flow in the evaluation process. For instance, the "chaining" together of programs (the concept where the output of one program is used as input in another program) is used to maximize the efficiency of data flow from the initial stage to the final result desired. A brief description is given of the computer programs used to obtain an evaluated data set. An example of the data flow from the published literature to the final evaluated data is also shown.

17537. Gills, T. E., McClendon, L. T., **Role of neutron activation analysis in the evaluation of sampling, storage, and analysis of samples for the National Environmental Banking System**, *J. Radioanal. Chem.* **39**, 285-291 (1977).

Key words: National Environmental Banking System; neutron activation analysis; organs and tissue biopsies; radiochemical separation; sampling and storage; subsampling.

Some problems inherent to the sampling, storage and analysis of whole organs or tissue biopsies were studied. The method used to evaluate the proper conditions of these, was neutron activation analysis.

17538. Grabner, L., **Spectroscopic technique for the measurement of residual stress in sintered Al_2O_3** , *J. Appl. Phys.* **49**, No. 2, 580-583 (Feb. 1978).

Key words: piezospectroscopic effect; residual stress.

Using the R-line fluorescence of trace Cr^{3+} in sintered Al_2O_3 as an example, a method of analysis is outlined for determining the residual microstress and macrostress in a polycrystalline aggregate. It uses the shift and broadening, induced by residual stress, of a line due to a transition in an atomic system dissolved in the aggregate. For sintered Al_2O_3 from three different manufacturers, but made for the same purpose, the isotropic and shearing components of the residual microstress and macrostress are listed in tabular form. For the isotropic component of the microstress a distribution is found, with a mean value of ~ 2 kbar, in which tension and compression are equally probable.

17539. Green, R. B., Keller, R. A., Luther, G. G., Schenck, P. K., Travis, J. C., **Use of an opto-galvanic effect to frequency-lock a continuous wave dye laser**, *IEEE J. Quantum Electron* **QE-13**, No. 2, 63-64 (Feb. 1977).

Key words: laser stabilization; opto-galvanic effect; opto-galvanic spectroscopy.

An electrical signal, derived from a gas discharge irradiated by a CW dye laser, is used to lock the laser to characteristic transition frequencies of species in the discharge. The technique may be used with commercial hollow cathode lamps to lock to both resonance and excited state transitions in a wide variety of elements.

17540. Grot, R. A., Galowin, L. S., **Integrated household appliances and utility services for energy conservation in dwellings**, *Proc. ERDA Conf. Div. of Bldgs. and Comm. Services on Technical Opportunities for Energy Conservation in Appliances*, Boston, MA, May 11, 1976, CONF ERDA 7605139, pp. 109-121 (Arthur D. Little, Inc., Cambridge, MA, Mar. 1978).

Key words: appliance combinations; energy conservation in dwellings; ERDA; heat recovery; hot water distribution systems; integrated appliances; utility systems.

The technical feasibility of combining various appliances now constructed separately into integral assemblies which permit more efficient energy design, utilizing waste heat and minimizing the impact of appliance operation on heating and cooling systems is considered. Alternative strategies are suggested to the ways in which energy-consuming services are supplied and utilized in residences. Particular attention is given to the combination of the refrigerator-water heater, air conditioner-water heater and the construction of appliances such as clothes washers and dishwashers which heat only the quantity of water required for their operation from a warm-water house system.

17541. Gubser, D. U., Hein, R. A., Waterstrat, R. M., Junod, A., **Electronic and superconducting properties of the Ti_3P -type compounds Nb_3As and Nb_3Si** , *Phys. Rev. B* **14**, No. 9, 3856-3861 (Nov. 1, 1976).

Key words: arsenic compounds; electronic properties; niobium compounds; silicon compounds; superconductivity; Ti_3P -type compounds.

Superconductivity has been observed below temperatures of about 0.3 K in the tetragonal Ti_3P -type compounds Nb_3Si and Nb_3As . Measurements of the electrical resistivity, heat capacity, superconducting transition temperature, and the critical magnetic field curve are reported. From these measurements, values of the electronic specific-heat coefficient γ , the Debye temperature θ , the electron-phonon coupling constant λ , and the Ginzburg-Landau parameter κ , are deduced. Both compounds have low γ values ($\gamma_{Nb_3Si} \approx 2.15$ mJ/K² g-atom and $\gamma_{Nb_3As} \approx 0.9$ mJ/K² g-atom) which probably accounts for the low transition temperatures. A comparison of their electronic and superconducting properties with those of A_3B compounds of the $A15$ type suggests that the electron-phonon interaction is quite large in these Ti_3P -type materials.

17542. Hampson, R. F., Jr., Garvin, D., **Evaluation of reaction rate data**, *J. Phys. Chem.* **81**, No. 25, 2317-2319 (1977).

Key words: atmospheric chemistry; chemical kinetics; compilation; data base; data evaluation; models; ozone; rate constant.

Recently chemists have been attempting to analyze very complex chemically reacting systems in terms of the individual elementary chemical reactions. There is an attempt to reproduce the observed behavior of the complex system by mathematical simulations, that is, models. The validity of the analysis is limited by the reliability of the input data including rate constant values for the large number of elementary reactions. Recent activities in the areas of compilation and critical evaluation of rate data have produced extensive tables of preferred values of rate parameters. This paper provides a guide to these sources of evaluated rate data. The importance of the use of evaluated data in models is discussed along with factors that must be considered in the evaluation of published rate data. Current gaps in the kinetic data base for one particular system, namely the chlorine-catalyzed destruction of stratospheric ozone, are indicated.

17543. Handy, L. B., Benham, C., Brinckman, F. E., Johansen, R. B., **Bonding information in tungsten (VI) compounds from directly bonded fluorine and fluorophenoxy substituents**, *J. Fluorine Chem.* **8**, 55-67 (1976).

Key words: alkoxy; aryloxy; bonding; chemical shifts; fluorides; nuclear magnetic resonance; stereochemistry; tungsten.

The series of compounds $(\text{FC}_6\text{H}_4\text{O})_n\text{WF}_{6-n}$, where $n = 1-6$ and F is *meta* or *para* to oxygen, has been prepared and all fluorine nmr chemical shifts determined. The *W-F*, *para-F*, and *meta-F* resonances all shift upfield as a function of n with approximate relative sensitivities of 1, 1/20, and 1/30, respectively. All chemical shifts are also found to be sensitive to molecular stereochemistry, with substituents *trans* to oxygen shifted to higher field than those *trans* to fluorine. ^{19}F data is also reported for the complete series $(\text{C}_6\text{H}_5\text{O})_n\text{WF}_{6-n}$.

17544. Harrije, D. T., Grot, R. A., **Automated air infiltration measurements and implications for energy conservation**, *Proc. Intl. Conf. on Energy Use Management, Tucson, AZ, Oct. 24-28, 1977*, R. A. Fazzolare and C. B. Smith, Eds., pp. 457-464 (Pergamon Press, New York, NY, 1977).

Key words: air infiltration; automated instrumentation; energy conservation; gas chromatograph; sulphur hexafluoride; tracer gas.

In the average home approximately one third of the energy for space heating is lost through air infiltration. The driving forces for air infiltration often become more severe in larger buildings. Correlation of air infiltration with parameters that are building-related (cracks, seals, porosity, etc.), occupant-related (door, vent, window openings, etc.) weather-related (wind direction, and intensity, outside temperature, etc.) and terrain-related (nearby structures, trees, fences, etc.) has required the development of specialized monitoring equipment. Using sulphur hexafluoride as a tracer gas, using automated procedures for seeding the gas into the building, and measuring the subsequent concentration decay, air infiltration has been measured for a wide range of circumstances. The details of the instrumentation presented here include: injection procedures, sampling methods, detection of the appropriate gas chromatograph concentration peak, and recording the data on magnetic tape for easy retrieval for computer calculations. The data resulting from such air infiltration instrumentation uses are providing the basis for improved energy modeling in buildings, evaluation of energy conserving retrofits, new and old building inspection, and a better evaluation of other air infiltration measurement techniques.

17545. Heinrich, K. F. J., Yakowitz, H., **Electron probe microanalyzers**, Chapter 7 in *X-Ray Spectrometry*, H. K. Herglotz and L. S. Birkes, Eds., pp. 163-204 (M. Dekker, Inc., New York, NY, 1978).

Key words: applied analysis; electron probe microanalysis; energy-dispersive analysis; lithium-drifted silicon detector; scanning electron microscope; x-ray spectrometry.

Within the framework of a book on x-ray spectrometric analysis, this chapter describes the principles, instrumentation, quantitation theory and application of electron probe microanalysis. The common features and specific characteristics of both the electron probe microanalyzer and the scanning electron microscope are discussed, as are the advantages and limitations of energy-dispersive x-ray spectrometric analysis with the lithium-drifted silicon detector. A large selection of general and specific literature references is given.

17546. Herbst, J. F., **Angle-resolved photoemission from crystal-field-split adatom levels**, *Phys. Rev. B* **15**, No. 8, 3720-3730 (Apr. 15, 1977).

Key words: adatom; crystal field; photoemission.

We investigate the angular distribution of photoelectrons emitted from atoms physisorbed on the surface of a metal. The crystalline electric field of the surface is represented by a small number of point charges in the vicinity of the adatom, and the splittings of p and d adatom levels in the crystal field are calcu-

lated. The spin-orbit splitting of the adatom states is assumed to be large in comparison with the crystal-field effects. For adatom p levels we consider both fourfold and bridge sites on a (100) surface of an fcc or bcc metal, and we include results for d states in the fourfold configuration. Within the dipole approximation photoelectron distributions are calculated for these cases assuming normally incident, unpolarized light. The results demonstrate that the angular distributions are sensitive to substrate geometry. Implications of this work for recent ultraviolet photoemission experiments involving xenon and mercury adsorbed on a tungsten surface are discussed.

17547. Heydemann, P. L. M., **Pressure measurements and services at NBS**, *Proc. 1976 Fluid Power Testing Symp., Milwaukee School of Engineering, Milwaukee, WI, Aug. 16-18, 1976*, pp. 2.4.1-2.4.17 (1976).

Key words: calibrations; instrumentation; national measurement system; pressure measurements.

Pressure is one of the most important thermodynamic variables. Numerous industrial manufacturing processes and the operation of many different types of machines depend on its measurement. The very large number of pressure measurements made in industry requires an elaborate national measurement system to ensure that measurements at the point of use can be performed with sufficient accuracy. The Pressure and Vacuum Section of the National Bureau of Standards maintains the primary standards to which most pressure measurements in the U.S.A. are referred. These standards cover a range from 10^{-4} Pa (10^{-2} torr) to 5×10^9 Pa (50 kbar). This report describes the physical principles used in these standards, the calibration services available to industry, the training facilities, reports and papers, the extensive consultation services, as well as research and development programs in the field of pressure measurements.

17548. Heydemann, P. L. M., **The exact fractions interferometer**, *Proc. 1976 Ultrasonics Symp., Annapolis, MD, Sept. 29-Oct. 1, 1976*, pp. 649-652 (Institute of Electrical and Electronics Engineers Group on Sonics and Ultrasonics, New York, NY, 1976).

Key words: exact fractions; fractions; interferometer, fractions.

A mathematical algorithm is described which provides an algebraic solution to the problem of measuring distance or signal velocity with the exact fractions method using phase information from several reflected waves with different wave lengths. This algorithm makes the exact fractions method attractive for length and velocity measurements with ultrasonic interferometers. These measurements are virtually instantaneous, nonaccumulating and they retain the resolution of the best conventional interferometer methods. The method is illustrated with numerical examples, and the necessary electronic circuitry is indicated.

17549. Hilpert, L. R., May, W. E., Wise, S. A., Chesler, S. N., Hertz, H. S., **Interlaboratory comparison of determinations of trace level petroleum hydrocarbons in marine sediments**, *Anal. Chem.* **50**, No. 3, 458-463 (Mar. 1978).

Key words: gas chromatography; gas chromatography-mass spectrometry; hydrocarbons; intercalibration; liquid chromatography; marine sediment; polynuclear aromatic hydrocarbons.

Results of analyses for petroleum hydrocarbons at the $\mu\text{g}/\text{kg}$ (ppb) level in marine sediments have been compared among eight laboratories. Values for concentrations of total extractable hydrocarbons scattered between 9 to 500 $\mu\text{g}/\text{kg}$ and 49 to 6625 $\mu\text{g}/\text{kg}$ for the two sites examined. Scatter of results for

hydrocarbons in the gas chromatographic elution range, for the most abundant aliphatic and aromatic hydrocarbons and for total polynuclear aromatic hydrocarbons (four rings and larger) were similar. Results for percent water and pristane/phytane ratio were somewhat more consistent. Sample inhomogeneity and analysis uncertainty contributed to an observed intralaboratory precision (1σ) of ± 25 percent for nine replicate analyses of one sediment sample. The data are discussed with regard to the reliability and comparability of current methods for environmental baseline measurements.

17550. Hobbs, T. G., **The use of graphite as a health physics monitor for high energy neutrons**, *Proc. 4th Conf. on Scientific and Industrial Applications of Small Accelerators, North Texas State University, Denton, TX, Oct. 27-29, 1976, No. 76CH 1175-9 NPS*, pp. 357-362 (Institute of Electrical and Electronics Engineers, New York, NY, 1976).

Key words: activation; carbon-11; health physics; high energy neutrons; monitoring; neutrons; radiation safety.

Solid, nuclear-purity graphite, machined into cup shapes, is activated by neutrons with energies greater than 20.2 MeV by $^{12}\text{C}(n,2n)^{11}\text{C}$. The resulting 20.3 minute half-life, positron-emitting ^{11}C is measured with NaI(Tl) detectors. Comparison of the results of the solid monitor with results from simultaneously irradiated powder results, coupled with an efficiency for powder doped with a positron emitter, shows that neutron flux densities below $1 \text{ n/cm}^2\text{-s}$ can be detected.

17551. Hocken, R., Simpson, J. A., Borchardt, B., Lazar, J., Reeve, C., Stein, P., **Three dimensional metrology**, (*Proc. CIRP Conf., New Delhi, India, Aug. 25-30, 1977*), *Ann. Int. Inst. Prod. Eng. Res.* 26, No. 2, 403-408 (1977).

Key words: algorithm metrology; measuring machines; multiple redundancy; three dimensional.

We present the results of research into the three dimensional measurement process using a classically designed measuring machine. This machine has been retrofitted with laser interferometers to provide a stable metric and is controlled by a minicomputer. Machine motions are programmable in a high level interactive language. Data links are provided to a larger computer for sophisticated data processing.

We have pursued the objective of creating, with the lasers, a machine independent coordinate system based at a point. Measurements made in this reference frame are transformed into the coordinate system of the measured object using the techniques of rigid body kinematics. The error terms inherent to the mechanical design (yaw, pitch, straightness, etc.) are measured over the machine volume, $48 \times 24 \times 10$ inches, on a cubic lattice of spacing two (2) inches. These error terms are stored as matrices and used to correct the data during a measurement. A measurement history on these error terms is being compiled. Real time instrumental drifts due to temperature and other external effects are removed using cross referenced measurement algorithms. Errors that cannot be accessed by calibration, such as axis nonorthogonality, are obtained by measuring the object in different angular positions within the measurement volume. This technique, which we call multiple redundancy, allows the assessment of all metric errors which do commute with the finite rotation matrix.

17552. Holton, J. K., **Establishing technical standards for solar installations**, (*Proc. on Overcoming Legal Barriers to the Utilization of Solar Energy, Manchester, NH, Apr. 14, 1977*), Paper in *IDEA—J. Law Technol.* 19, No. 1, 25-34 (Capital Offset Co., Inc., Concord, NH, 1977).

Key words: buildings; cooling; heating; performance criteria; solar collectors; solar energy; standards.

The Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409) and the National Program for Solar Heating and Cooling (Residential and Commercial Applications), October 1975, recognizes the importance of developing performance criteria and standards to help stimulate the creation of a viable industrial and commercial capability to produce and distribute solar heating and cooling systems. Program activities relating to the development of performance criteria and standards for solar heating and cooling systems, components and materials which are being carried out by the National Bureau of Standards for the Energy Research and Development Administration (ERDA) and the Department of Housing and Urban Development (HUD) are described. Specific activities include the preparation of a standards development plan, establishment of an American National Standards Institute steering committee, the preparation of draft standards for determining the thermal performance of solar components and the performance of various materials used in solar components, and the development of performance criteria to be used in ERDA and HUD solar heating and cooling demonstration programs.

17553. Hulick, C., **Expanded areas of contracting: A case study on the use of performance incentives to achieve technological innovation**, *Proc. Sixth Annual Dept. of Defense Procurement Research Symp., U.S. Military Academy, West Point, NY, June 22-24, 1977*, pp. 273-277 (Army Procurement Research Office, U.S. Army Logistics Management Center, Fort Lee, VA, June 1977).

Key words: contracting, expanded areas; incentives, performance; innovation, technological; technological innovation.

The purpose of this paper is to document a procurement experiment jointly sponsored by the Experimental Technology Incentives Program and the Federal Supply Service, wherein performance incentives were employed in an attempt to achieve technological innovation. The paper will first briefly describe the Experimental Technology Incentives Program, in particular the procurement portion, and then document the experiment design and implementation phases. Finally, issues to be resolved in the evaluation phase will be highlighted.

17554. Hulick, C., Berke, J. G., **Using procurement incentives for technological innovation**, *Proc. 1977 Annual Reliability and Maintainability Symp., Philadelphia, PA, Jan. 18-20, 1977*, pp. 78-80 (Annual Reliability and Maintainability Symp., 6411 Chillum Place, N.W., Washington, DC, Jan. 1977).

Key words: life cycle cost; performance specifications; procurement incentives; technological innovation.

The Experimental Technology Incentives Program is engaged in conducting procurement experiments with participating agencies to test the hypothesis that government procurement can through the use of procurement incentives induce private sector technological innovation. Experiments are currently underway at the Federal, State and local levels with participating agencies. The result of the ETIP work will be a summation showing which combination of individual agency characteristics and procurement incentives are most effective in bringing forth technological innovation.

17555. Unassigned.

17556. Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the reaction of H atoms with NO. The infrared spectrum of HNO**, *J. Mol. Spectrosc.* 48, No. 3, 536-559 (Dec. 1973).

Key words: DNO; force constants; HNO; infrared spectrum; matrix isolation; NOCl; reaction of H with NO; vacuum-ultraviolet photolysis.

Studies of the reaction with NO in an argon or a nitrogen matrix at 4° or 14°K of H and D atoms produced either photolytically or in a microwave discharge have confirmed the previous identification of the ground-state NO stretching fundamental of HNO and of DNO but have dictated a reassignment of the deformation fundamental of these two species. An absorption at 1153 cm⁻¹ has been assigned as the deformation fundamental of DNO, and evidence is presented suggesting that the deformation fundamental of HNO lies very close to 1500 cm⁻¹. The assignment of an absorption at 2717 cm⁻¹ as the NH stretching fundamental of HNO and of an absorption at 2043 cm⁻¹ as the corresponding fundamental of DNO is consistent with the previous report of an exceptionally long NH bond for ground-state HNO. Detailed isotopic studies support this revised vibrational assignment, which is shown to be consistent with previous gas-phase studies. The force constants and thermodynamic properties of ground-state HNO derived from the matrix data are presented.

17557. Kasen, M. B., Schramm, R. E., Read, D. T., **Fatigue of composites at cryogenic temperatures**, (Proc. American Society for Testing and Materials Symp. on Fatigue of Filamentary Composite Materials, Denver, CO, Nov. 15-16, 1976), *Am. Soc. Test. Mater. Spec. Tech. Publ. 636*, pp. 141-151 (1977).

Key words: aluminum; boron; composite materials; cryogenics; fatigue tests; modulus of elasticity; structural composites; tensile strength.

A comparison has been made between the wearout rates of (0±45/0)_n boron/epoxy and boron/aluminum composites in low-cycle fatigue at 295 and 76 K. Using degradation of modulus as the wearout criterion, these preliminary data indicate that cryogenic temperatures have a negligible effect on either tensile or compressive fatigue performance of boron/epoxy. A similar indication was obtained for boron-aluminum in tensile fatigue. These conclusions are substantiated by high-cycle fatigue results on boron/epoxy.

17558. Kilmer, R. D., **Status report on an experimental study of environmental effects on truck noise measurements**, *Proc. Third SAE Sound Measurement Workshop, St. Charles, IL, Mar. 31-Apr. 1, 1977*, pp. 22-24 (Society of Automotive Engineers, Inc., Warrendale, PA, 1977).

Key words: acoustics; environmental conditions; noise measurement; noise (sound); transportation noise; truck.

The National Bureau of Standards in conjunction with the Motor Vehicle Manufacturers Association, the Engine Manufacturers Association and the U.S. Department of Transportation is conducting a study on the effect of environmental variables on truck noise measurements. This paper briefly summarizes the objectives of this study and describes the test program that was developed. Following the description of the test program, the expected results of this study are outlined, and the current status of the program is discussed.

17559. Kilmer, R. D., **Test procedures for future tire noise regulations**, *Proc. SAE Highway Tire Noise Symp., San Francisco, CA, Nov. 10-12, 1976*, pp. 281-286 (Society of Automotive Engineers, Inc., Warrendale, PA, 1977).

Key words: acoustics; noise measurement; noise (sound); tire noise; transportation noise; truck.

Based on the actions of the U.S. Environmental Protection Agency and the State of California, it appears that Federal and/or state regulations on tire noise are imminent. Basic questions involving the measurement procedure and other technical problems are likely to arise in the development of such tire noise regulations. This paper treats two specific

questions, the first dealing with the load/tire inflation pressure adjustments recommended in SAE J57a and the second with the effect of tire size on tire noise. Based on the limited set of data presented, it appears that testing using either the load/tire inflation pressure recommendations of SAE J57a or the more convenient alternative of maintaining the tire inflation pressure constant at the maximum rated value with reduced loading can be used provided the loads are greater than 70 to 75 percent of the maximum rated tire load. It also appears that compliance testing using a single tire size is feasible since sound level variations with size for tires with similar carcass construction and tread design are small.

17560. Kintner, E. C., **An analytic recurrence procedure for computing the cross-multiplication coefficients in an analytic OTF method**, *Opt. Acta* **24**, No. 12, 1237-1246 (1977).

Key words: Bessel functions; generalized hypergeometric series; optical imaging; Optical Transfer Function; orthogonal series expansions; recurrence relations.

The cross-multiplication coefficients required in an analytic method for calculating the Optical Transfer Function may be computed analytically through the use of a recurrence relation. The new recurrence procedure is both faster and more accurate than numerical integration, and the results obtained from it suggest that the analytic OTF method will be more accurate and more versatile than suggested earlier.

17561. Kirchhoff, W. H., **Determination of force fields by analysis of centrifugal distortion in microwave spectra**, *Proc. Conf. Critical Evaluation of Chemical and Physical Structural Information, Dartmouth College, Hanover, NH, June 24-29, 1973*, D. R. Lide, Jr. and M. A. Paul, Eds., pp. 312-322 (National Academy of Sciences, Washington, DC, 1974).

Key words: centrifugal distortion; force field; microwave spectra.

This paper describes the accuracy of molecular force fields derived from centrifugal distortion constants. Only bent, symmetric, triatomic molecules are discussed. The discussion deals primarily with the discrimination between the effects of measurement and model errors. The accuracy of the force field is judged by calculating from the force constants of the harmonic, fundamental vibrational frequencies and comparing these with the harmonic frequencies obtained from the infrared spectrum. This comparison, in turn, is measured against measurement errors arising from a statistical analysis of the microwave spectra. The particular molecular species for which such an analysis has been performed are SO₂, OF₂, SiF₂, O₃, OCl₂, CF₂, and SF₂.

17562. Kistenmacher, T. J., Rossi, M., Chiang, C. C., Van Duyne, R. P., Cape, T., Siedle, A. R., **Synthesis, structure, and spectral properties of (TFF)(HgCl₃), an unusual metal-tetraphthalene**, *J. Am. Chem. Soc.* **100**, No. 6, 1958-1959 (Mar. 15, 1978).

Key words: low-dimensional materials; mercury; Raman spectroscopy; tetrathiafulvalene; x-ray crystallography.

The x-ray crystal structure of (TFF)HgCl₃ demonstrates the presence of two chloromercurate species, (HgCl₃)₂²⁻ and a polymeric (HgCl₃)_nⁿ⁻ and of two types of TFF species. The thiocarbon is present as ring-over-bond columns and eclipsed dimers. The resonance Raman spectrum shows two bands in the ν₃ region, in agreement with the x-ray data.

17563. Knözinger, E., Jacox, M. E., **Matrix isolation spectroscopy of stable organic molecules in the far infrared region**, *Ber. Bunsengesllh. Physkh. Chem.* **82**, 57-60 (1978).

Key words: acetonitrile dimers; far infrared spectrum; intermolecular interactions; matrix isolations; methyl formate; torsion vibrations.

The potential of the matrix isolation technique for providing heretofore inaccessible information on the torsional vibrations of organic compounds and on the structures of dimers of polar molecules is illustrated by far infrared studies of methyl formate and of acetonitrile isolated in argon and nitrogen matrices.

17564. Blackburn, D. L., Rubin, S., **A nondestructive method for the determination of forward-biased safe-operating-area limits for power transistors**, *Proc. 1977 Power Electronics Specialists Conf., Palo Alto, CA, June 14-16, 1977*, pp. 17-22 (Oct. 1977).

Key words: hot spots; nondestructive testing; safe-operating-area; second-breakdown; thermal instability; thermal resistance; transistor, power.

It is proposed that the limit of thermal instability replace the traditional limit of second-breakdown for the safe-operating-area limits of power transistors. A nondestructive method for measuring the limit of thermal instability is described. The relationships between thermal instability, stable hot spots and second-breakdown are reviewed and it is shown that stable hot spots operating conditions can exist within the traditional SOA based upon second-breakdown. The proposed safe-operating-area limit is shown to exclude these hot-spot operating conditions. The effect of thermal resistance on the thermal instability limit is briefly discussed.

17565. Meissner, P., **Personal identification devices help to keep networks safe**, *Data Commun.* 6, No. 4, 67-71 (Apr. 1977).

Key words: ADP security; computer networks; controlled accessibility; encryption; evaluation criteria; key; password; personal identification; terminals; verification.

Computers are becoming increasingly accessible through the use of data communications, remote terminals, and computer networks. In order to prevent the misuse of these facilities by unauthorized persons, provisions must be included for automatically verifying the identity of authorized users. Several techniques for this purpose are presently being perfected. A person's identity may be verified by the possession of unique information (such as a password), a unique artifact (such as a key), or a unique attribute (such as his signature). This article discusses the factors involved in determining the effectiveness of various identity verification techniques and provides a set of evaluation criteria for use in assessing their suitability for intended applications.

17566. Menis, O., Mackey, J. A., Garn, P. D., **Differential thermoanalysis (DTA) survey method for traces of chrysotile asbestos**, *Proc. 4th Joint Conf. on Sensing of Environmental Pollutants, New Orleans, LA, Nov. 7-10, 1977*, pp. 899-903 (American Chemical Society, Washington, DC, 1978).

Key words: chrysotile asbestos; differential thermoanalysis; survey method for traces of chrysotile.

A practical survey method was developed for chrysotile asbestos by an improved design of the differential thermoanalytical instrument and a modified procedure. Under the new condition the measurement of the endothermic peak area of the hydroxylation of chrysotile at 640 °C region provides a selective and sensitive method for traces of this asbestos form. This resulted from improved instrumental components such as a more sensitive ΔT sensor, and a better sensor-sample thermal contact. In addition, a self-generated controlled atmosphere provided higher resolution and sensitivity. The incorporation of

quartz as an internal standard provides the means of improving the precision and accuracy of the measurement. The addition of clay material provides a "buffer" to eliminate the effects of variation in type or quantity of matrix. This study demonstrated the feasibility of measuring microgram quantities of chrysotile in the presence of at least a ten thousand fold excess of foreign substance. Empirically, the extrapolated sensitivity expressed as the area under the recorded endothermic curve was nearly 2 cm² per microgram of chrysotile. Data in the range of 3 μ g of chrysotile in individual samples confirms this estimate. The method distinguishes between chrysotile and amphiboles. The proposed approach should provide an efficient, objective, and inexpensive survey method.

17567. Milton, H. J., **Metrication—A concrete opportunity**, *J. Am. Concr. Inst. No. 11*, pp. N13-N21 (Nov. 1977).

Key words: construction industry metrication; metrication benefits; rationalization; technical issues in metrication.

This paper presents the impending change to metric (SI) measurement in the construction community as an "opportunity" and a once-only chance for review, technical improvement and cost reduction. It deals with the analysis of precedent in the change to SI; defines some new terms, such as "hard conversion" to preferred sizes and descriptions; discusses metrication for benefit; and focuses on the opportunities for rationalization associated with the change.

Four principal opportunities are identified: simplification, rationalization, harmonization and standardization, and each one is illustrated by a number of examples.

The paper recommends that metrication should be regarded as a "worthwhile challenge," rather than as a "problem," so that the approach to change is a vigorous and positive one instead of a defensive and negative one.

The benefits from opportunities realized should easily pay for the once only cost of the change.

17568. Moore, R. T., Park, J. R., **The Graphic Pen. An economical semiautomatic fingerprint reader**, *Proc. 1977 Carnahan Conf. on Crime Countermeasures, Carnahan House, Lexington, KY, Apr. 6-8, 1977*, pp. 59-62 (ORES Publications, College of Engineering, University of Kentucky, Lexington, KY, Apr. 1977).

Key words: computerized fingerprint matching; fingerprint readers, semiautomatic; fingerprints; latents; minutiae; pattern recognition.

Progress in the development of minutiae-based systems for automatic fingerprint identification has highlighted the need for an economical semiautomatic device for reading data from low quality impressions such as latents or scene-of-crime prints. With a semiautomatic reader, the superior pattern recognition capabilities of the human can be supported by the accuracy and fidelity of machine recording to yield minutiae data of a quality that is unattainable by a fully automatic fingerprint reader.

Several semiautomatic fingerprint readers have been implemented using a variety of technical approaches. Of these, the Graphic Pen is novel chiefly because of its simplicity and economy. It can function in conjunction with a local or remote terminal on any general-purpose computer system and it requires little or no changes to existing teleprocessing software. Minutiae position and orientation data are read with eight bits resolution and with an accuracy and repeatability of + or -1/2 lsb. This paper provides a description of the Graphic Pen together with examples of its performance capabilities.

17569. Morrissey, B. W., **The adsorption and conformation of plasma proteins: A physical approach**, *Ann. NY Acad. Sci.* 283, 50-64 (Feb. 10, 1977).

Key words: adsorption plasma proteins; conformation adsorbed plasma proteins; review, plasma protein adsorption.

The adsorption of clotting factors and proteins on the surface of artificial materials placed in the cardio-vascular system can modify both their biological activity and the subsequent interaction of formed cellular elements with the surface. The important concepts and techniques describing protein adsorption, protein desorption and exchange, and the conformation and conformational changes of adsorbed proteins at the solid/solution interface will be reviewed. In particular, recent *in situ* ellipsometric, infrared bound fraction, and radiotracer rate studies carried out in our laboratories have shown that plasma proteins exhibit different conformational stabilities upon adsorption, and have different dependences upon such parameters as surface concentration, applied potential, surface free energy, pH, and ionic strength. Serum albumin and prothrombin change little in conformation upon adsorption with no effect of surface concentration, while the conformation of γ -globulin is markedly dependent on surface concentration. All proteins studied show a dependence of the adsorbed conformation on surface free energy of the substrate, and on an impressed potential.

17570. Norton, P. R., Tapping, R. L., Broida, H. P., Gadzuk, J. W., Waclawski, B. J., **High resolution photoemission study of condensed layers of nitrogen and carbon monoxide**, *Chem. Phys. Lett.* **53**, No. 3, 465-470 (Feb. 1, 1978).

Key words: CO; condensed gases; nitrogen; photoemission.

High resolution (0.09 eV) UPS spectra have been obtained of condensed films of N_2 and CO. All spectral features are broadened by ≥ 0.6 eV upon condensation. The origin of this broadening is discussed. The difference in linewidths for all equivalent levels, $\Delta\epsilon_{CO-N_2} \approx 0.1$ to 0.2 eV can be understood in terms of a hole-dipole multiphonon excitation mechanism. Photoemission from what is believed to be the $a^1\Pi$ excited neutral state of CO has been detected in the solid phase for the first time.

17571. Oman, R. C., **Automatic typewriter studies**, *J. Syst. Manage.* **29**, No. 4, 18-23 (Apr. 1978).

Key words: automatic typewriters; cost-effective; economic; research designs; surveys; typewriters.

This report discusses four alternative methods for gathering information about typing workload when considering the replacement of conventional typewriters with automated typing equipment. Some of the advantages and disadvantages of the four methods are presented. The cost of conducting one such study is compared to automated equipment cost.

17572. Pallett, D. S., Cadoff, M. A., **The National Measurement System for Acoustics**, *Sound and Vibration* **11**, No. 10, 20-25, 27-31 (Oct. 1977).

Key words: acoustical measurements; acoustics; national measurement system; noise; noise control; sound.

Many recent acoustical measurement processes have been motivated by societal concern over noise and have broad relevance to our contemporary technological society. The emphasis of the study of the National Measurement System for Acoustics has been to determine the adequacy of these important physical measurements and to promote improvements within the measurement system. The relevant physical quantities are indicated, and the interactions occurring between participants as well as the roles of acoustical standardization institutions are specified. Finally, the status and trends of the System and the NBS role in adapting to changing technology are discussed.

17573. Peterlin, A., **Intrinsic viscosity according to elastic necklace model with hydrodynamic interaction**, *Macromolecules* **10**, No. 5, 975-977 (Sept.-Oct. 1977).

Key words: free draining coil; hydrodynamic interaction; impenetrable coil; intrinsic viscosity; necklace model.

The exact calculation of intrinsic viscosity for the necklace model with up to 300 elastic links and hydrodynamic interaction parameter h^* between 0 and 0.4 shows how slowly with increasing M one reaches the limiting case of impenetrable coil where $[\eta]$ is proportional to $M^{1/2}$. Hence according to the model, a finite $a > 0.5$ can be interpreted as a sign of good solvent only if the measurements are extended over so large a molecular weight range that one is certain that one has already reached the limit of impenetrable coil. The limitation of $h^* = (3/\pi)^{1/2} a_h/b_0$ to values below 0.25 caused most likely by the inadequacy of the linear approximation of Oseen's tensor of hydrodynamic interaction interferes with molecular interpretation of the a_h/b_0 ratio derived from $[\eta]$ as soon as h^* is close to 0.25.

17574. Petersen, S. R., **Economic optimization in the energy conservation design of single-family housing**, *ASHRAE Trans.* **82**, Pt. 1, 446-458 (1976).

Key words: building economics; economic analysis; energy conservation; engineering economics; housing; insulation; life-cycle cost analysis.

Energy conservation measures appropriate to the design of single-family housing must be utilized to reflect both climatic and economic considerations if life-cycle HVAC costs in housing are to be minimized. This paper examines the economic criteria for minimizing life-cycle costs for both independent and interdependent energy conservation techniques. An index number format with cost data is presented with which the economically optimal use of attic insulation, wall insulation, and storm windows can be estimated for various climatic and economic assumptions, including heating and cooling factors, energy costs, energy conservation costs, discount rates, fuel price increases, and building lifetimes. In general it is shown that the economically optimal use of energy conservation techniques is often considerably greater than currently being observed in most new housing construction.

17575. Pierce, D. T., Celotta, R. J., Unertl, W. N., **Surface studies using spin polarized electrons**, Paper in *Proceedings of the Seventh International Vacuum Congress and the Third International Conference on Solid Surfaces, Vienna, Austria, Sept. 12-16, 1977*, R. Dobrozemsky, F. Rüdener, F. P. Viehböck, and A. Breth, Eds., II, 1297-1300 (F. Berger and Söhne, Vienna, Austria, Sept. 1977).

Key words: electron scattering; polarized LEED; spin polarization; surface physics.

Photoemission from negative electron affinity GaAs irradiated with circularly polarized light provides an electron beam with a spin polarization which can be modulated from -50 percent to +50 percent. The spin dependence in electron scattering can be measured simply by monitoring the modulated component of the scattered intensity. The experimental requirements on the electron source for polarized low energy electron diffraction (PLEED) are discussed. We also discuss applications of PLEED to the development of a low energy high efficiency polarization detector, to the determination of surface parameters, and to the determination of the effects of multiple scattering and phonon scattering on spin polarization.

17576. Pierce, S., **Multiplicative maps of matrix semigroups over Dedekind rings**, *Arch. Math.* **XXIV**, No. 1, 25-29 (1973).

Key words: Dedekind rings; integral domains; matrix; matrix semigroups; multiplicative maps.

Let R be an integral domain, K its quotient field, and $M_n(R)$ the set of all $n \times n$ matrices over R . A multiplicative map $f: M_n(R) \rightarrow M_n(R)$ is called nondegenerate ([1]) if there exists a matrix X with zero determinant such that $f(X) \neq 0$. Jodeit and Lam determined all nondegenerate maps of $M_n(R)$ into itself when R is a principal ideal domain.

17577. Placious, R. C., Moser, E. S., Holland, R. S., Masi, F., **Status report. A standard method for determining the efficiency of optical x-ray intensifying screens**, *Proc. Application of Optical Instrumentation in Medicine VI, Boston, MA, Sept. 25-27, 1977*, pp. 110-113 (Society of Photo-Optical Instrumentation Engineers, Palos Verdes Estates, CA, 1977).

Key words: fluorescent screens; intensifier screen standards; radiographic intensifier screen efficiency; screen evaluations; sensitivity of screens; spectro-radiometry of screens; x-radiation of intensifier screens.

A proposed ANSI standard for classifying radiographic intensifier screens has been under test at the National Bureau of Standards. This standard establishes procedures for characterizing, on an absolute basis, the optical spectral output of fluorescent screens per unit of incident x-ray exposure. The testing procedure has undergone revision since an earlier status report was given. Calcium tungstate screens, however, still form the basis of comparison in this procedure because of the long acceptability and stable output qualities of this screen. The nature of the revisions and current output data on the screens will be described.

17578. Powell, C. J., **Relative yields of KLL and LVV Auger electrons from aluminum**, Paper in *Proceedings of the Seventh International Vacuum Congress and the Third International Conference on Solid Surfaces, Vienna, Austria, Sept. 12-16, 1977*, R. Dobrozemsky, F. Rüdener, F. P. Viehböck, and A. Breth, Eds., III, 2319-2322 (F. Berger and Söhne, Vienna, Austria, Sept. 1977).

Key words: aluminum; Auger-electron spectroscopy; Auger-electron yields; surface analysis.

Measurements have been made of the relative yields of KLL and LVV Auger electrons from aluminum to check the validity of a simple model for surface analysis by Auger-electron spectroscopy and of data for the several parameters. Data were obtained for incident electron energies of 2, 3, 4, and 5 keV and with evaporated aluminum films. The secondary-electron energy distributions were measured with a cylindrical-mirror analyzer operated in the dc mode (i.e., without applied modulation) so that the current for each Auger transition could be easily determined. Excellent agreement has been obtained between experiment and the predictions of the model.

17579. Powell, C. J., **Surface characterization: Present status and the need for standards**, *Appl. Surface Sci.* 1, No. 2, 143-169 (1978).

Key words: applications of surface-characterization measurements; atomic motions on surfaces; status of surface-characterization methods; surface analysis; surface atomic structure; surface characterization; surface composition; surface electronic structure; surface properties; surface standards.

A summary is given of the present status and use of surface-characterization measurements in the United States. Attention is primarily devoted to those properties needed to characterize a solid surface, specifically the determination of surface composition, surface atomic structure, surface electronic structure,

and atomic motions on surfaces; these characteristics directly affect many important surface properties or processes that occur on surfaces (e.g., electrical and optical properties, adhesion, bonding, catalytic activity, plating, durability, corrosion, decoration, segregation, lubrication, and reactivity). The above four forms of surface characterization are widely utilized in surface-science experiments while measurements of surface composition are routinely made to solve a wide variety of problems in the semiconductor, chemical, petroleum, and metals industries for applications ranging from process and device development, process control, process evaluation, to failure analysis. Surface-characterization measurements in government laboratories support a variety of agency missions. Surface science and surface technology have both grown rapidly in the past ten years, and further growth is expected. At this time, there is an almost complete lack of standards, standard procedures, and standard materials to support surface-characterization measurements. A new Committee on Surface Analysis has been recently formed by the American Society for Testing and Materials to develop standards for all methods of surface analysis in common use. Examples are given of the standards that need to be developed.

17580. Powell, C. J., Larson, P. E., **Quantitative surface analysis by x-ray photoelectron spectroscopy**, *Appl. Surface Sci.* 1, No. 2, 186-201 (1978).

Key words: aluminum oxide; indium; lead; surface analysis; x-ray photoelectron spectroscopy.

Measurements have been made of the relative intensities of the principal features in x-ray photoelectron spectra of indium, lead, and aluminum oxide and compared with those expected from a simple model for the photoemission process. Systematic effects in the determination of line intensities are discussed and a suitable procedure for determining intensities is described. The satisfactory agreement between computed and measured intensities confirms the validity and utility of the photoemission model and associated data and indicates that quantitative analyses of homogeneous single-phase surfaces can be obtained by x-ray photoelectron spectroscopy.

17581. Quigley, D. F., Kelly, G. E., **Oilburner modification cuts costs**, *Fuel Oil and Oil Heat*, pp. 50, 52 (Sept. 1977).

Key words: heating efficiency; oil-fired furnaces; overfiring of oil-burners.

This paper discusses the results of a field study of residential oil heating systems. The study showed that most oil burners are overfired for the heating load. This overfiring causes low seasonal efficiencies. The article presents a method for optimizing firing rates for improved efficiency.

17582. Quintiere, J., McCaffrey, B. J., Kashiwagi, T., **A scaling study of a corridor subject to a room fire**, *Am. Soc. Mech. Eng. Publ. 77-HT-72*, pp. 1-13 (Apr. 1978).

Key words: corridor; heat transfer; room fire; scaling; temperature; velocity.

A study was made of the thermal and flow environment within a corridor subject to a room fire of intensities of 300 to 1500 kW approximately. A corresponding model study was done under 1/7th geometric scale. Dimensionless groups were derived from the conservation equations governing the gas and solid phases. A subset of dimensionless groups was identified as significant to establish criteria to maintain partial dynamic scaling between the model and prototype experiments. Good results were achieved between the model and prototype for the convective process, i.e., gas temperature, velocity, and convective heat transfer. Radiant heat transfer did not scale, but an analysis of the data explains the lack of agreement in terms of

dimensionless groups that were not preserved in scaling. A secondary result yielded corridor convective heat transfer coefficients which could be correlated by a general relationship.

17583. Quintiere, J. G., McCaffrey, B. J., Rinkinen, W., **Visualization of room fire induced smoke movement and flow in a corridor**, *Fire Mater.* 2, No. 1, 18-24 (1978).

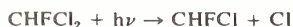
Key words: corridor; experimental; fire induced flow; flow rate; flow visualization; prediction; smoke layer.

A study was conducted of the smoke and flow field in a corridor subject to a room fire. The study was conducted using a scale model of roughly 0.35 m in height. The effect of corridor-exit doorway width was recorded while the room doorway and fire-room temperature were maintained constant. Smoke was generated from cotton wads soaked with titanium tetrachloride which produces white particles of titanium dioxide. By this means, the smoke layer resulting from the room fire and the corridor flow characteristics were visualized. The results show the lowering interface of the corridor smoke layer with decreasing corridor-exit door width. Also a four-layer horizontal counter-current flow pattern was displayed and shown to result from a restriction (e.g. soffit) at the corridor exit. The mixing of the incoming cold flow and exiting hot flow at the corridor exit was observed to be shedding vortices swept into the cold floor jet. Results based on velocity measurements and smoke observations are presented for the corridor smoke layer height and doorway neutral-plane heights. The limitations of current predictive models are demonstrated for layer-heights and flow rates for the room and corridor experiments.

17584. Rebbert, R. E., Lias, S. G., Ausloos, P., **The gas phase photolysis of CHFCl_2** , *J. Photochem.* 8, 17-27 (1978).

Key words: carbenes; chloromethane; free radical reactions; lasers; photochemistry; quantum yields.

The 300 K photolysis of CHFCl_2 has been investigated at 213.9, 163.3, and 147 nm. Methane, Br_2 , HBr , and HCl were added as free radical interceptors in order to unravel the primary photodecomposition processes. Analysis of the data shows that at 213.9 and 163.3 nm, the photodissociative process:



occurs with a quantum yield of 0.9-1.0, giving stable CHFCl radicals. At shorter wavelengths, the quantum yield of CHFCl shows a drastic decrease with concurrent appearances of species such as CFCl , CHF , and CF . The laboratory experiments indicate that CF is mainly formed via the dissociative process:



The CF radicals react with CH_3 to yield $\text{C}_2\text{H}_2(\text{CF} + \text{CH}_3 \rightarrow \text{C}_2\text{H}_2 + \text{HF})$ while the CHF species insert readily into HCl to yield CH_2FCl . In the presence of Br_2 , CF and CHF undergo reactions which result in the formation of CFBr_3 and CHFBr_2 , respectively.

17585. Linsky, J. L., Ayres, T. R., **Stellar model chromospheres.**

VI. Empirical estimates of the chromospheric radiative losses of late-type stars, *Astrophys. J.* 220, No. 2, 619-628 (Mar. 1, 1978).

Key words: Ca II emission; stars, chromospheres; stars, emission line; stars, late-type.

We develop a method for estimating the nonradiative heating of stellar chromospheres by measuring the net radiative losses in strong Fraunhofer line cores. This method is then applied to observations of the Mg II resonance lines in a sample of 32 stars including the Sun. We find at most a small dependence of chromospheric nonradiative heating on stellar surface gravi-

ty, contrary to the large effect predicted by recent calculations based on acoustic heating theories.

17586. McCaffrey, B. J., Heskestad, G., **A robust bidirectional low-velocity probe for flame and fire application**, *Combust. Flame Brief Commun.* 26, 125-127 (1976).

Key words: angular insensitivity; fluidic device; hot wire anemometer; ion deflection device; laser Doppler anemometer; Reynolds number.

A robust bidirectional flow measuring device has been evaluated and appears to have significant advantages over a pitot-static tube for use in fire research studies. Three different diameter probes were used to secure a low Reynolds number calibration needed for accurate assessment at very low velocities. The bidirectional capability is illustrated by an example of the use of the probe in a scale model corridor-burn room facility.

17587. McCarter, R. J., **Smoldering combustion of cotton and rayon**, *J. Consum. Prod. Flammability* 4, 346-358 (Dec. 1977).

Key words: catalysis; char; combustion; flame; free radical; heterogeneous reaction; oxidation; promotion; retardant; smolder; thermal analysis.

Smolder of cottons and rayons was found to be induced by adsorbed inorganic impurities, which may be largely removed by a water rinse. Compounds identified as promoting smolder included salts and hydroxides of monovalent metals, and salts of iron, chromium, and lead. These compounds were found to effect an increase in the yield and reactivity of char formed during the pyrolysis of celluloses.

The actions of smolder inhibitors were investigated. Conventional inhibitors appeared to intervene chemically in oxidation reactions on char surfaces. Various compounds in powder form were found to suppress smolder, and may indicate innovative possibilities. Data were obtained indicating that free radicals may influence smolder kinetics and have a key role in the smolder process.

17588. McCarter, R. J., **Smoldering combustion of wood fibers: Cause and prevention**, *J. Fire Flammability* 9, 119-126 (Jan. 1978).

Key words: cellulose; combustion; fiberboard; glow; inhibitor; nonflaming; pulp; smolder; test method; wood.

Means were sought to reduce the smolder tendency of porous wood fiberboard, which has been the ignition source in serious fires.

Vulnerability to smolder was found to result from inclusion of carboxylic metal salts, principally those of calcium and magnesium, in the alpha-cellulose content of wood fibers. Displacement of detrimental metal cations by hydrogen, ammonium, or aluminum cations depleted the smolder tendency of the fibers. Process modifications to effect this displacement are suggested.

Methods to test smolder tendency are discussed.

17589. McKinney, J. E., Davis, G. T., **Piezo- and pyroelectricity of poly(vinylidene fluoride) from plasma poling**, (Proc. 175th Meeting of the American Chemical Society, Anaheim, CA, Mar. 12-17, 1978), Paper in *Organic Coatings and Plastics Chemistry* 38, 271-277 (American Chemical Society, Washington, DC, 1978).

Key words: dielectric; piezoelectric; plasma; polarization; poling; poly(vinylidene fluoride); pyroelectric.

A plasma poling device is described which allows essentially instantaneous poling of polymeric films at room temperature at very high fields. Using poly(vinylidene fluoride) both undrawn

(comprising essentially pure α conformation) and biaxially drawn (both α and β conformation) were polarized in this manner. The polarization of the sample was determined from current integration measurements. The piezoelectric and pyroelectric coefficients were then measured and compared with those estimated from the polarization theory of Mopsik and Broadhurst, which expresses these coefficients as linear functions of polarization. The theory gives an accurate representation of the piezoelectric coefficients, but underestimates the pyroelectric coefficients considerably.

In addition, x-ray measurements from various techniques were made on both drawn and undrawn PVDF samples. For the unpoled samples the results are in good agreement with those in the literature. Some changes in spacings and intensities were observed with poling for both the drawn and undrawn samples. As yet we do not have a clear interpretation of these results in terms of crystal structure changes resulting from polarization.

17590. Madey, T. E., Yates, J. T., Jr., **Evidence for the structures of adsorbed NH_3 and H_2O on Ru(001)**, Paper in *Proceedings of the Seventh International Vacuum Congress and the Third International Conference on Solid Surfaces, Vienna, Austria, Sept. 12-16, 1977*, R. Dobrozemsky, F. Rüdener, F. P. Viehböck, and A. Breth, Eds., II, 1183-1186 (F. Berger and Söhne, Vienna, Austria, Sept. 1977).

Key words: ammonia; bonding; chemisorption; electron stimulated desorption; ion angular distribution; water.

The adsorption of NH_3 and H_2O on Ru(001) have been studied using the Electron Stimulated Desorption Ion Angular Distribution (ESDIAD) method, in conjunction with thermal desorption spectroscopy and LEED. The results suggest that chemisorbed NH_3 and H_2O are bonded to Ru via the N and O atoms, respectively, with H atoms pointed away from the surface. The utility of ESDIAD for determination of structures of adsorbed molecules is indicated.

17591. Mandel, J., Nanni, L. F., **Measurement evaluation**, Chapter 4 in *Quality Assurance Practices for Health Laboratories*, S. L. Inhorn, Ed., pp. 209-272 (American Public Health Association, Washington, DC, 1978).

Key words: accuracy; confidence intervals; control chart; diagnostic tests; experimental error; linear regression; precision; tolerance intervals.

A chapter written for inclusion in a book on "Quality Assurance Practices for Health Laboratories," to be published by the American Health Association. This chapter deals with basic statistical concepts and their application to the evaluation of measurements. It covers, among other topics, the evaluation of precision and accuracy, using point and interval estimates, statistical distribution functions, straight line fitting, the evaluation of diagnostic tests, and control chart techniques.

17592. Masters, L. W., **An approach to the development of predictive service life tests for building components and materials**, *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977*, II, 176-188 (RILEM, Paris, France, 1977).

Key words: accelerated aging tests; building components and materials; degradation; methodology; predictive service life tests; service life.

A systematic approach to the development of predictive service life tests and the improvement of existing service life tests for building components and materials is outlined. The approach consists of four parts: Problem Definition, Pre-Testing, Testing and Interpretation and Reporting of DATA. It can be

applied to all components and materials comprising a building system. For example, the approach can be applied at the component level to foundations, walls, floors and roofs. It can also be applied to materials comprising components, e.g. coatings, roofing, concrete, sealants, adhesives, metals, wood and others.

Application of the approach to many components and materials is limited, at present, because of the lack of knowledge regarding exposure conditions and mechanisms of failure. Despite these limitations, however, the approach will help in 1) identifying the data needed to develop more definitive tests, 2) ensuring the best possible test is developed and 3) providing a uniform approach to service life prediction and the reporting of results.

17593. Unassigned.

17594. Mayo, S., Evans, W. H., **Thermodynamic considerations in the use of polysilicon oxidation tubes for clean SiO_2 film preparation**, *J. Electrochem. Soc.* **125**, No. 1, 106-110 (Jan. 1978).

Key words: alkali contamination; clean SiO_2 -film; microelectronic device preparation; MOS-structures; oxidation atmosphere; silicon dioxide; silicon oxidation tube; sodium impurity.

The thermodynamic equilibria established in oxidation atmospheres in polycrystalline silicon tubes operated at 1000 °C are analyzed. Silicon oxidation tubes made by chemical vapor deposition through hydrogen reduction of pure trichlorosilane have very low sodium content (about 10 ppb or 1000 times less sodium than in transparent fused silica oxidation tubes). Due to the low sodium content in new oxidation tubes, clean (low alkali content) thermal oxide films can be grown on silicon wafers. However, tube contamination developed during semiconductor processing operations imposes the need for appropriate periodic tube cleaning to maintain sodium contamination in the oxidation atmosphere within acceptable levels. Tube cleaning reactions taking place at oxidation temperature are discussed showing that the quality of thermal oxide films is influenced by tube cleaning efficiency.

17595. Meinke, W. W., **Characterization of solids—Chemical composition**, Chapter 7 in *Treatise on Solid State Chemistry*, Vol. 1, N. B. Hannay, Ed., pp. 387-435 (Plenum Publ. Corp., New York, NY, 1973).

Key words: activation analysis; characterization; chemical composition; chromatographic analysis; coulometry; electron probe microanalysis; ion-selective electrodes; mass spectrometry; polarography; spectrochemical analysis; thermal analysis; wet chemistry; x-ray fluorescence.

Determination of the chemical composition of solids, i.e., information on the identity and location of the atoms in a particular material, is essential if one is to have confidence that the material can be reproduced. In this chapter an integrated summary of pertinent information on many different analytical techniques is presented. Summaries of sensitivities and precisions to be expected using these techniques are given. Applications to specific characterization problems are discussed and examples are given from the literature, of detailed studies of a number of high purity materials which illustrate the present state-of-the-art for the characterization of practical samples.

17596. Reneker, D. H., Edelman, S., DeReggi, A. S., Vanderhart, D. L., **An ndt method using piezoelectric polymer transducers and computerized vibrational spectroscopy**, *NDT Intl.*, pp. 15-16 (Feb. 1978).

Key words: mechanical integrity; nondestructive evaluation; normal modes; orthopedic implants; piezoelectric polymer; plastics; vibrations.

The normal mode vibrational spectrum of a particular object contains a wealth of information about the mechanical integrity of the object. The nondestructive evaluation of objects by observation of their vibrational spectra is facilitated by the combination of recently developed low mass, high compliance piezoelectric polymer transducers; a synchronized method for exciting the sample; and a small mini-computer capable of making digital Fourier transforms which convert the complicated, oscillatory, decaying signal from the transducer into the intensities and frequencies of normal modes.

17597. Reneker, D. H., Fanconi, B. M., Mazur, J., **Energetics of defect motion which transports polyethylene molecules along their axis**, *J. Appl. Phys.* **48**, No. 10, 4032-4042 (Oct. 1977).

Key words: annealing; computer modeling; point defects; polyethylene; polyethylene crystals; self-diffusion.

Defect energy was calculated as a function of dihedral angles of the bonds in a point dislocation for sequences of conformations that resulted in motion of the dislocation along the polyethylene chain. Paths that presented low barriers to diffusive motion of the defect were found by incrementing, in a particular sequence, selected dihedral angles around two separated bonds near the opposite ends of the defect as the computer searched for the lowest energy conformation of all the other parts of the defect. Thus, the diffusion of a point dislocation provides a plausible mechanism for diffusion of the chain along its axis.

17598. Rosasco, G. J., Parker, H. S., Roth, R. S., Forman, R. A., Brower, W. S., **Study of the low-temperature phase transition in Hg_2Cl_2** , *J. Phys. C: Solid State Phys.* **11**, 35-44 (1978).

Key words: Calomel; crystal structure; mercurous chloride; phase transition; Raman spectroscopy; x-ray powder diffraction.

Studies of the temperature dependence of the x-ray powder diffraction and single-crystal Raman spectra of Hg_2Cl_2 are reported for temperatures from 300 K to below the phase transition at ~ 180 K. From the x-ray data it is established that the crystal class changes from tetragonal in the high-temperature phase to monoclinic in the low-temperature phase. The Raman spectra at low temperatures are explained by a primitive monoclinic cell of doubled content and the space group identified as C_{2h}^2 . The temperature dependence of the Raman spectrum of a "soft" acoustic branch is observed above the phase transition and used to suggest a mechanism for the transition.

17599. Rubin, R. J., Weiss, G. H., **Span of a random-flight model of a star-branched polymer chain**, *Macromolecules* **10**, No. 2, 332-334 (Mar.-Apr. 1977).

Key words: polymer chain; random flight; span; star-branched molecule.

An expression is derived for the probability distribution function of the span of a random-flight model of a star-branched polymer molecule. The model consists of f random flight chains, each containing N steps, which emanate from a common point. Numerical results showing the form of the distribution function as a function of the number of branches are presented.

17600. Rubin, S., Blackburn, D. L., **A test unit for the non-destructive determination of forward-biased safe-operating-area limits for power transistors**, *Proc. Conf. Industrial Applications Society Annual Meeting, Los Angeles, CA, Oct. 3-6, 1977*, Paper 27-F, pp. 666-673 (Oct. 1977).

Key words: hot spots; measurement technique; nondestructive testing; safe-operating-area limits; second breakdown; thermal instability; transistors, power.

A measurement technique is described and a detailed circuit description given for using the onset of thermal instability to generate the safe-operating-area (SOA) limits of power transistors. The technique is nondestructive. The safe operating area generated using this method excludes operating conditions for which current nonuniformities and excessive junction temperatures (hot spots) occur. Comparisons are given between safe operating areas based upon the limit of thermal instability, the manufacturer's specified SOA, and the measured limit of second breakdown.

17601. Rosenthal, R., **Network access techniques—A review**, *Proc. 1976 National Computer Conf., New York, NY, June 8, 1976*, pp. 495-500 (American Federation of Information Processing Societies, Montvale, NJ, June 1976).

Key words: access procedures; computer networks; network access assistance; network resource acquisition; network service selection; protocols.

The computer industry's ability to serve a diverse and expanding user community is evidenced by the rapid growth of computer network services. Computer service providers design and market their own offerings as they deem best, given their own market and their own set of resources. This has led to a proliferation of similar resources requiring different user access procedures. With emphasis on currently operating and planned systems that assist users in accessing available network services, this paper identifies the techniques used in network access devices. By examining these devices, the trend toward improving the interface between the user and the computer is brought more clearly into focus and up to date.

17602. Rubin, R. J., Mazur, J., **Spans of polymer chains measured with respect to chain-fixed axes**, *Macromolecules* **10**, No. 1, 139-149 (Jan.-Feb. 1977).

Key words: asymmetric step distributions; ordered spans; polymer segment density; self-avoiding polymer chains; unrestricted random walks.

An N -step random walk on a cubic lattice is adopted as a model of a polymer chain. The span or extent of a random walk in a direction e is defined as the maximum distance between parallel planes normal to e which contain lattice points visited by that walk. The spans of each random walk configuration are measured with respect to two different sets of orthogonal axes determined by the configuration. The first set of orthogonal axes is based on the direction of the maximum span of the configuration. The second set is based on the directions of the principal components of the radius of gyration tensor of the chain configuration. For each set of axes, a smallest right prism is determined whose edges are parallel to the chain-fixed axes and which contain all the steps of the random walk. A Monte Carlo procedure is used to estimate the average largest, intermediate, and smallest spans, or prism dimensions. Both the simple unrestricted random walk with $N = 50, 100, 200$ and the self-avoiding random walk with $N = 50, 75, 100, 150$ are treated. In the case of the orthogonal axes based on the maximum span, the ratio of the average maximum span to the average smallest span is approximately independent of N and equal to 2.42 for the unrestricted walk and 2.73 for the self-avoiding walk. The distribution of steps inside the spanning right prisms is investigated by dissecting them in two different ways. First, the prism is cut in ten equal sections by a set of parallel, equally spaced planes which are normal to an edge of the prism. The fraction of steps contained in pairs of sections which are equidistant from the central cutting plane is deter-

mined. This procedure is repeated in turn for each of the different edges of the prism. Second, a symmetric oval (the ellipsoid is a special case) is inscribed in the prism with its axes parallel to those of the prism. Four similar and successively smaller nested ovals are also introduced. For each random walk configuration, the fraction of steps contained in each oval shell is determined.

17603. Sanders, A. A., Cook, A. R., **An NBS laser Measurement Assurance Program (MAP)**, *Proc. Electro-Optical Systems Design Conf. 76 and International Laser Exposition, New York, NY, Sept. 14-16, 1976*, pp. 277-280 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1976).

Key words: laser MAP; laser Measurement Assurance Program; laser power and energy measurement; laser power and energy standards; MAP; measurement assurance program; 1 mW HeNe MAP.

A review is given of the NBS laser MAP for the measurement of 1 mW, HeNe (632.8 nm) laser radiation. Included in the discussion are: (1) The detailed structure and plan for the NBS-MAP service; (2) The range and accuracies associated with the National standards and peripheral measurement systems; (3) Documentations pertinent to the transfer standards utilized in the MAP.

The review describes pertinent qualities necessary for an NBS transfer standard including the measurement accuracies and precision assigned by NBS. Moreover, typical accuracies and precision that a MAP participant can expect to achieve in his laboratory by intercomparison with a transfer standard are explored. Important considerations for making laser measurements are presented. The information presented should be of interest to those individuals and organizations who want to establish a documented laser measurements capability for the purpose of regulatory compliance.

17604. Sansing, R. C., **The t -statistic for a double exponential distribution**, *SIAM J. Appl. Math.* **31**, No. 4, 634-645 (Dec. 1976).

Key words: double exponential population; joint density of sample mean and variance; nonnormality; robustness; t -statistic density.

Questions of robustness of the "Student's" t -statistic have been given attention for many years. The qualitative results produced thus far have led to consideration of new tests for routine use that depend less heavily on the model assumptions. In order to properly evaluate these new procedures, more quantitative results on the t -test are required. To this end the t -test with samples from a population with a double exponential density function are considered here in some detail. The joint density of the sample mean and variance is derived exactly in the region where the ratio is sufficiently large and the exact density of the t -statistic for $|t| > n-1$ is given for samples from this population. Upper and lower bounds are given for these density functions in the remaining regions. These bounding functions have the property that they coincide with the exact densities in the regions where the exact densities have been derived. Particular emphasis is placed on the evaluation of approximations of the t -density, and attention is given to possible improvements in one of these approximations.

17605. Saunders, R. D., Jr., Kostowski, H. J., **Accurate spectroradiometry of solar simulators in the UV-B spectral region**, *Proc. Electro-Optics/Laser 77 Conf. and Exposition, Anaheim, CA, Oct. 25-27, 1977*, p. 458 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1977).

Key words: solar simulators; spectroradiometry of solar simulators; UV-B spectral region.

Discussion on methodology and equipment needed to make accurate solar measurements.

17606. Saunders, R. D., Ott, W. R., Bridges, J. M., **Spectral irradiance standard for the ultraviolet: The deuterium lamp**, *Appl. Opt.* **17**, No. 4, 593-600 (Feb. 15, 1978).

Key words: calibration; deuterium; irradiance; lamp; radiance; radiometry; source; spectroscopy; standard; ultraviolet.

A set of deuterium lamps is calibrated as spectral irradiance standards in the 200-350-nm spectral region utilizing both a high accuracy tungsten spectral irradiance standard and a newly developed argon mini-arc spectral radiance standard. The method which enables a transfer from a spectral radiance to a spectral irradiance standard is described. The following characteristics of the deuterium lamp irradiance standard are determined: sensitivity to alignment; dependence on input power and solid angle; reproducibility; and stability. The absolute spectral radiance is also measured in the 167-330-nm region. Based upon these measurements, values of the spectral irradiance below 200 nm are obtained through extrapolation.

17607. Saylor, C. P., **Optical microscopy as used in unorthodox ways**, *SPIE J., Vol. 108, Optics in Security and Law Enforcement*, 60-66, 1977.

Key words: fabrics as screening gunshot burns; negative/positive superposition; powder burns; scorching of fabrics by gunfire; typescript identification; wood, identification of boards.

In the nineteen thirties, before the great Government crime laboratories were established, individual scientific workers in the Federal agencies were sometimes called upon to settle important questions that the detectives could not handle. For this purpose, it was often necessary to invent new techniques to tackle problems by new approaches. The laboratory man needed to develop imaginative ways of looking at fragmentary material that became available. This presentation will deal with three episodes involving original procedures. The procedures proved their point in the issues at hand, but the findings were never used in court so far as the author is aware. They have not been published or publicly disclosed.

If a board has been sawed into three pieces of which the middle one is missing, how do you establish that the end pieces were once joined? If a method of recognizing typescript is developed that provides quick and convincing evidence of identity, what are the chances that a sophisticated forger, knowing the technique of recognition, could successfully imitate the identity? What do you do if the exhibits in a murder case are effective and relevant evidence so far as the facts are concerned, but indicate that another and critical piece of evidence is missing? Suppose that without the missing piece, nothing else has firm meaning! These three examples are chosen for presentation because, although the microscopical techniques that were used are interesting, they appear to have lain dormant for over forty years.

17608. Schaefer, A. R., **Effect of silicon detector physics on radiometric applications**, *Proc. Electro-Optical Systems Design Conf. 76 and International Laser Exposition, New York, NY, Sept. 14-16, 1976*, pp. 75-79 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1976).

Key words: detector physics; radiometric applications; silicon detector physics.

Recent radiometric applications of silicon photodetectors are placing stringent demands on them. Several factors have been reported which severely degrade their performance, such as spatial nonuniformity of spectral responsivity in the ultraviolet

and infrared, changes in detector responsivity due to exposure to ultraviolet radiation, thermal effects, etc. These effects, and approaches to alleviate the resulting problems will be discussed in some detail.

17609. Schaefer, A. R., **Ultraviolet enhanced responsivity of silicon photodiodes: An investigation**, *Appl. Opt.* **16**, No. 6, 1539-1542 (June 1977).

Key words: silicon photodiodes; ultraviolet, silicon photodiodes.

An enhancement of the responsivity of certain types of silicon photodetectors after exposure to uv radiation has been recently reported. Several possible mechanisms were investigated experimentally and ruled out on the basis of the results.

17610. Schaefer, A. R., Zalewski, E. F., Lind, M. A., Geist, J., **Linearity studies on silicon photodiodes**, *Proc. Electro-Optics/Laser 77 Conf. and Exposition, Anaheim, CA, Oct. 25-27, 1977*, pp. 459-463, 463-A (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1977).

Key words: krypton-ion laser; linearity; silicon photodiodes; spectral response.

A technique described earlier by Lind has been used to study extensively the linearity of spectral response of the silicon photodiodes contained in the NBS Detector Response Transfer and Intercomparison Package. An amplitude stabilized CW krypton-ion laser was used to provide both the AC and DC light beams necessary for the application of this technique. This study was performed at a number of the available krypton lines from the near ultraviolet to the near infrared, in order to look for wavelength dependence of the onset of nonlinearities. This provides more insight into the physics of the detector.

17611. Schooley, J. F., **State-of-the-art of instrumentation for high temperature thermometry**, *Proc. 1977 Symp. on Instrumentation and Process Control for Fossil Demonstration Plants, Chicago, IL, July 13-15, 1977*, pp. 323-347 (U.S. Department of Energy, Washington, DC, 1978).

Key words: coal conversion; high temperatures; Johnson noise; process instrumentation; thermocouples; thermometry.

Current pilot-plant coal conversion operations have exposed several deficiencies in the present practice of industrial temperature measurement. Among these are the limited high-temperature performance (both ultimate temperature limit and rate of failure or of decalibration) of thermocouples which are presently in common use, response time of thermowell-protected temperature sensors, and measurement errors associated with radiation pyrometry. Some of these problems will be discussed in other talks, particularly that of N. Pitcher.

Recent innovations in high-temperature thermometry may help to improve both the quality and efficiency of coal conversion processes.

In this talk, I will discuss the use of specially-prepared tungsten-rhenium alloy thermocouples and platinum-rhodium alloy thermocouples for extended-term temperature measurements above 1200 °C, and the use of a new nickel-based (Nicrosil-Nisil) thermocouple for similar measurements below 1200 °C. I will also discuss both the use of velocity-of-sound thermometry, and temperature measurement employing the detection of Johnson noise in resistors. Finally, I will present some general remarks on radiation pyrometry as a preface to the discussion by R. F. Leftwich.

17612. Schwarz, F. P., Wasik, S. P., **Fluorescence measurements of carcinogenic and polycyclic aromatic hydrocarbons in**

water, *Proc. Intl. Conf. on Environmental Sensing and Assessment, University of Nevada, Las Vegas, NV, Sept. 14-19, 1975*, pp. (30-2) 1-5 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: carcinogenic compounds; partition coefficient; photon counting; polycyclic aromatics; spectrofluorimetry; water.

The application of spectrofluorimetry to the measurement and identification of polycyclic aromatic hydrocarbons (PAH) in aqueous solutions was investigated. At naperian absorbances ≤ 0.05 , the fluorescence intensities of solutions containing naphthalene, anthracene, pyrene, and fluoranthene in water are a superposition of the component fluorescence spectra. At the higher PAH optical densities of the mg/l level and when viewed perpendicular to the excitation light, the fluorescence spectra vary unpredictably with the concentration. The PAH fluorescence intensity is unaffected by the presence of sodium chloride at sea water concentrations and by the presence of mg/l concentrations of iron, zinc, cobalt, or nickel cations in the water.

17613. Shold, D. M., **Effect of methyl and halogen substituents on the decay of singlet excited benzenes**, *Chem. Phys. Lett.* **49**, No. 2, 243-246 (July 15, 1977).

Key words: chlorotoluenes; fluorescence; fluorobenzenes; fluorotoluenes; liquid; nonradiative; quantum yields; radiative; substituent effect.

Radiative and nonradiative decay for singlet excited states of halogen- and methyl-substituted benzenes were determined in solution. The effect of halogen substitution on the nonradiative decay is much greater than that of methyl substitution, which is obscured by effects of the solvent.

17614. Shold, D. M., **Formation of singlet oxygen from aromatic excimers and monomers**, *J. Photochem.* **8**, 39-48 (1978).

Key words: excimer; naphthalene; pyrene; singlet oxygen; upper triplet.

Singlet oxygen ($^1\Delta_g$) formation is sensitized by excimers of aromatic hydrocarbons as well as by monomers. In methanol the pyrene excimer is a somewhat less efficient sensitizer than is pyrene itself, while the excimer of naphthalene is more efficient than the monomer. An explanation invoking involvement of upper triplet states in oxygen-enhanced intersystem crossing is suggested.

17615. Simmons, J. H., **Refractive index and density changes in a phase-separated borosilicate glass**, *J. Non-Cryst. Solids* **24**, 77-88 (1977).

Key words: borosilicate glass; density; glass; phase separation; refractive index; relaxation processes.

The refractive index and density of a soda-borosilicate glass are measured at successive stages of phase separation. Two effects are observed which consist of a structural rearrangement of the homogeneous glass reflecting changes in the heat-treatment temperature, followed by a volume increase as phase separation progresses. The structural rearrangement is analyzed by a volume relaxation model originated by O. S. Narayanaswamy, and the observed increase in volume resulting from the phase separation is discussed.

17616. Slattery, W. J., **Information center profile. Standards information service**, *Inf. Hotline* **8**, No. 9, 30-31 (Oct. 1976).

Key words: engineering standards; information center; scientific and technical information; standardization.

This article describes the background leading to the establishment of the NBS Standards Information Services (NBS-SIS). It also discusses the purpose and scope of NBS-SIS activities, services and programs, and lists the publications compiled and their availability.

17617. Slattery, W. J., **NBS-SIS. Everything you wanted to know about standards...and more**, *Metric News* 4, No. 3, 18-20 (May/June 1977).

Key words: index of standards; National Bureau of Standards; standards information.

The National Bureau of Standards maintains a reference collection of more than 240,000 U.S., foreign national and international standards, specifications, test methods, codes and recommended practices. This article describes the services available in retrieving information on standards and standardization activities.

17618. Slattery, W. J., **Standards information service of the National Bureau of Standards**, *J. Quality Technol.* 8, No. 4, 232-234 (Oct. 1976).

Key words: index of standards; National Bureau of Standards; standards information.

The National Bureau of Standards maintains a collection of over 240,000 documents relating to standards, specifications, test methods, codes, and recommended practices. This note describes the services available in retrieving information on standards and standardization activities.

17619. Stiehler, R. D., Decker, G. E., Bullman, G. W., **Determination of hardness and modulus of rubber with spherical indentors**, *Proc. Intl. Rubber Conf., Kuala Lumpur, Malaysia, Oct. 20-25, 1974, Vol. 5, 277-287* (Rubber Research Inst. of Malaysia, Kuala Lumpur, Malaysia, 1976).

Key words: hardness; modulus; rubber; spherical indentors; standard ISO 48; vulcanizate.

The determination of the hardness of rubber in International Standard ISO 48 and related national standards is based on the modulus (E) calculated from the equation: $F = 1.9 E r^2 (d/r)^{1.35}$, where F is the force applied to a spherical indenter of radius r that indents the rubber to a distance d ; all values being expressed in SI units. This equation differs from the classical equation of Hertz in two respects: (1) the constant is 1.9 instead of 16/9 and (2) the exponent is 1.35 instead of 1.5. The empirical equation in ISO 48 is essentially correct for indentors about 2.5 mm in diameter, but it is not valid for other radii. Studies reported in this paper show that the exponent in the equation is related to the radius of the indenter. The Hertz equation is approached as the radius of the indenter increases. Other factors that affect the measurement are discussed. It is concluded that more reliable measurements of modulus and hardness could be made by measuring the force at a fixed indentation of a specified indenter.

17620. Stein, R. J., Powell, C. J., **Abstract: Electron-energy-loss spectra of condensed hydrocarbons**, *J. Vac. Sci. Technol.* 14, No. 1, 481 (Jan./Feb. 1977).

Key words: acetylene; butane; electron; energy-loss spectra; ethane; ethylene; isobutane; isobutylene; propane; propylene; 1-butene; 1,3-butadiene.

An abstract of a talk presented at the 1976 symposium of the American Vacuum Society is presented which describes measurement of the energy loss spectra of 100 eV electrons striking condensed hydrocarbons. The samples investigated were films of ethane, propane, butane, isobutane, acetylene, ethylene, propylene, isobutylene, 1-butene and 1,3-butadiene.

17621. Suenram, R. D., Johnson, D. R., **Microwave spectrum of chlorine nitrate (ClNO₂)**, *J. Mol. Spectrosc.* 65, 239-248 (1977).

Key words: atmospheric pollution; chemistry of the atmosphere; chlorine nitrate; electric dipole moment; fluorocarbon destruction of stratospheric ozone; microwave spectrum; structure.

Microwave spectra of chlorine nitrate (³⁵ClNO₂ and ³⁷ClNO₂) in the ground and first excited vibrational states have been analyzed in detail. Rotational constants and centrifugal distortion parameters are reported for each species. The permanent electric dipole moment in ClNO₂ was found to have two components, $\mu_a = 0.72 \pm 0.07$ D and $\mu_b = 0.28 \pm 0.02$ D.

17622. Suenram, R. D., Lovas, F. J., Johnson, D. R., **Microwave spectrum of ethyl hypochlorite**, *J. Mol. Spectrosc.* 69, 458-472 (1978).

Key words: dipole moment; ethyl hypochlorite; hyperfine structure; microwave spectrum; molecules; rotational spectra.

The microwave spectrum of ethyl hypochlorite has been analyzed in detail in the region of 20-60 GHz. Observed transitions for C₂H₅O³⁵Cl in the ground state have been fit to a Hamiltonian model which includes p⁴ centrifugal distortion terms. The lowest vibrationally excited state of C₂H₅O³⁵Cl and the ground and vibrationally excited state of C₂H₅O³⁷Cl were analyzed with a rigid rotor model. This lowest vibrational mode lies at 125 ± 23 cm⁻¹ and is most likely the torsional motion about the C-O bond. The dipole moment has been measured and found to have two nonzero components; $\mu_a = 1.623 \pm 0.010$ D, $\mu_b = 1.097 \pm 0.005$ D. No A-E torsional splittings were observed in either the ground state or the $v = 1$ state implying a lower limit for the barrier to internal rotation of ~ 3.0 kcal/mole. Ethyl hypochlorite was synthesized in the waveguide by the reaction of chlorine nitrate with ethanol.

17623. Szalata, Z. M., Finn, J. M., Flanz, J., Kline, F. J., Peterson, G. A., Lightbody, J. W., Jr., Maruyama, X. K., Penner, S., **Low-momentum-transfer elastic electron scattering from ³He**, *Phys. Rev. C* 15, No. 4, 1200-1203 (Apr. 1977).

Key words: deduced rms charge radius; measured $\sigma(E)$ at $\theta = 75^\circ$; nuclear reactions; ³He(e,e'), E = 28.8-95.0 MeV.

Elastic electron scattering cross sections for ³He were measured relative to those of ¹²C in the range of momentum transfer squared between 0.032 and 0.34 fm⁻². The ³He rms charge radius was determined from the data to be 1.89 ± 0.05 fm.

17624. Szalata, Z. M., Itoh, K., Peterson, G. A., Flanz, J., Fivozinsky, S. P., Kline, F. J., Lightbody, J. W., Jr., Maruyama, X. K., Penner, S., **Electroexcitation of ²⁰Ne giant electric-dipole and -quadrupole resonances**, *Phys. Rev. C* 17, No. 2, 435-442 (Feb. 1978).

Key words: dipole resonance; electron scattering; energy weighted sum rule; enriched gas target; giant resonance; Neon 20; quadrupole resonance.

Electrons at five energies between 60 and 120 MeV were used to study the giant electric-dipole and -quadrupole resonances in ²⁰Ne. Prominent electric-dipole peaks were found at 17.7, 19.1, 20.2, and 23 MeV in good agreement with photoreaction results. In addition our analysis reveals weaker fragmented electric-dipole strength in the region between 12.5 and 15 MeV. Prominent electric-quadrupole peaks were found at 13.0, 13.7, and 16.2 MeV, and broad peak was found from 14.2 to 15.9 MeV. Two different analyses reveal a broad

quadrupole excitation between 16 and 25 MeV. The dipole and quadrupole resonances deplete about 65 percent and 100 percent of the energy-weighted sum rule, respectively.

17625. Teague, E. C., **Uncertainties in calibrating a stylus type surface texture measuring instrument with an interferometrically measured step**, *Metrologia* **14**, 39-44 (1978).

Key words: imperfect geometry; interferometry; methods divergence; step-height measurement; stylus instrument; surface texture; uncertainties.

This paper presents discussion and experimental data to demonstrate that: (1) proper measurement of a step-height with interferometry must include a determination of the geometry of the surfaces on both sides of the step in the neighborhood of the measured area, (2) uncertainty of a step-height measurement with the use of interferometry is determined both by uncertainty in the measurement of fringe displacement and uncertainty produced by the variation of step-height measurements with fringe dispersion when specimen geometry is imperfect, (3) when specimen geometry is imperfect, uncertainty in calibrating the stylus instrument is produced by methods divergence between the height values measured with interferometry and with stylus instruments, and (4) uncertainty in assigning a height value to a stylus profile of a step is ultimately limited by and is approximately equal to the root mean square roughness, or the arithmetical average roughness value of the surface texture on both sides of the step.

17626. Tighe, N. J., **Microstructural aspects of deformation and oxidation of magnesia-doped silicon nitride**, (NATO Advanced Study Institute on Nitrogen Ceramics, Canterbury, England, Aug. 16-27, 1976), Paper in *Nitrogen Ceramics*, F. L. Riley, Ed., pp. 441-448 (Noordhoff Intl. Publ., Leyden, The Netherlands, 1977).

Key words: electron microscopy; fracture interfaces; microstructure; nitrogen ceramics; oxidation; silicon nitride; slow crack growth.

The microstructural changes that occurred in magnesia-doped silicon nitride as a result of slow crack growth, plastic deformation and oxidation were studied by transmission electron microscopy. Specimens which exhibited slow crack growth showed extensive crack branching along the fracture path and ahead of the primary crack tip. These primary and secondary cracks followed intragranular paths. In samples which were deformed by bending at 1400 °C, dislocation arrays were found as well as intergranular cracks and voids. Silicon nitride oxidized during heating in air at 1400 °C and enstatite and crostobalite were present in the oxide layer. At lower oxidation temperatures, crystalline and amorphous silica formed a semiprotective layer on the silicon nitride surfaces.

17627. Tomusiak, E. L., Dressler, E. T., **Pion electroproduction from ${}^6\text{Li}$** , *Phys. Lett.* **72B**, No. 1, 1-3 (Dec. 5, 1977).

Key words: electroproduction; nuclear structure; pions; virtual photons; ${}^6\text{He}$; ${}^6\text{Li}$.

The pion electroproduction cross section from ${}^6\text{Li}$ is calculated assuming the ${}^6\text{He}$ nucleus is detected. The wavefunctions used in this calculation are those which gave the best agreement with the ${}^6\text{Li}(\gamma, \pi^+){}^6\text{He}$ data. The electroproduction experiment will provide a useful check of these wave functions.

17628. Trevino, S. F., Prask, H., Casella, R. C., **Group-theoretical selection rules and experimental determination of lattice modes in NaNO_3 via inelastic neutron scattering**, *Phys. Rev. B* **10**, No. 2, 739-744 (July 15, 1974).

Key words: group theory; lattice modes; neutron; scattering; selection rules; sodium nitrate.

The general group-theoretical selection rules of Casella and Trevino for characterizing the harmonic vibrations of molecular crystals within the rigid-molecule model via inelastic neutron scattering are applied to NaNO_3 . For a given reciprocal-lattice vector the experimental resonances are classified not only according to the irreducible representation to which the eigenmode belongs, but also as to whether the interaction proceeds via the translational or rotational character of the mode (or both). The structure functions (i.e., sums of structure factors) belonging to each representation at Γ and Z and along Λ in the Brillouin zone are calculated explicitly. The results of experimental measurements at Γ are presented and compared with theory. In particular, we conclude that the resonances at 120 and 175 cm^{-1} are both to be associated with A_{2g} modes of mixed translational-rotational character. At the (0, 0, 15) reciprocal-lattice point both are observed via their translational component and at (0, 2, 1) via their rotational part. These assignments differ from earlier ones made prior to development of the selection rules and moreover contradict the assignment of the 22- cm^{-1} mode to A_{2g} by Rao *et al.*, based upon their Raman measurements. A search was made for the 22- cm^{-1} mode at the (0, 2, 1) point but none was found.

17629. Verdier, P. H., Kranbuehl, D. E., **Monte Carlo studies of the motion of random-coil polymer chains: Studies of model dependence**, *Polym. Prepr.* **17**, 148-150 (1976).

Key words: excluded volume; Monte Carlo; polymer chain dynamics; random coil; random flight chain; relaxation time.

Dynamical Monte Carlo studies of the motion of lattice-model polymer chains have been carried out for move rules which include a crankshaft-like local motion of two adjacent beads. Simulations have been carried out for chains of 15 and 63 beads, with and without excluded volume interactions. The results obtained with the crankshaft rules are essentially identical with previously reported work employing single-bead chain movement rules. In particular, the additional chain-length dependence of the relaxation time of end-to-end length which appears in the earlier work when excluded volume is introduced also appears with the crankshaft model. The similarity of the results obtained with both sets of bead movement rules, although not demonstrating the correctness of either model, supports the view that the excluded volume result is not an artifact of the bead movement rules and the lattice geometry.

17630. Wampler, R. H., **Test problems and test procedures for least squares algorithms**, *Proc. Computer Science and Statistics Eleventh Annual Symp. on the Interface, North Carolina State University, Raleigh, NC, Mar. 6-7, 1978*, A. R. Gallant and T. M. Gerig, Eds., pp. 84-90 (Institute of Statistics, North Carolina State University, Raleigh, NC, 1978).

Key words: algorithms; computer programs; least squares; regression; statistics; test problems.

Numerous test problems have been introduced in the past twenty years for the purpose of studying and comparing least squares algorithms and computer programs. This paper discusses and classifies some of the useful test problems which have appeared in the literature. A recent large-scale test procedure is briefly summarized. Several neat, mathematical examples are displayed. A new example is presented, and results from several computer programs in solving this problem are given.

17631. Wang, T. J., Stiefel, S. W., **Service lives of major appliances**, *Proc. 23d Annual Conf. of American Council on Consumer Interests, Denver, CO, Apr. 20-23, 1977*, pp. 14-17 (American Council on Consumer Interests, Executive Director, University of Missouri, Columbia, MO, 1977).

Key words: appliances; appliances, household; household appliance cost considerations; household appliances; life-cycle costing; purchase of household appliances; service lives of household appliances.

Information on retention and on disposal of major household appliances will assist in determining both the demands of consumers and the requirements of manufacturers for product durability. Preliminary results of studies in progress indicate that almost all managers of rental properties tend to retain the original appliances in their properties as long as possible, whereas a significant number of individual home owners dispose of appliances after only relatively short periods. Efforts are under way to develop data on several-year operating costs of appliances so that consumers might be able to use life-cycle considerations in the purchase of new appliances.

17632. Wassermann, I., Samuel, D., Yuwiler, A., Carpenter, B. S., **Location of catecholamines in the brain using the $^{17}\text{O}(n,\alpha)$ ^{14}C reaction**, (Transactions American Nuclear Society 1974 Annual Meeting, Philadelphia, PA, June 23-27, 1974), *TANSAO* 18, 18 1-401, 85 (American Nuclear Society, Inc., Hinsdale, IL, 1974).

Key words: alpha tracking; micromapping; neurotransmitting compounds; nuclear track technique; oxygen-17; stable isotopes.

A Study was made to map the distribution and turnover of biogenic amines (catecholamines), the neurotransmitting compounds, by the Nuclear Track Technique. The location of catecholamines that formed in the hypothalamus and pons regions of rat brains by inhaling air which was enriched in the stabled $^{17}\text{O}_2$ isotope were examined. The effect of inhibiting the formation of the catecholamines in the brain by the injection of α -methyl-*p*-tyrosine in the rat was also included in this study.

17633. Waterstrat, R. M., Haenssler, F., Müller, J., Dahlgren, S. D., Willis, J. O., **New high-pressure phases of Nb_3Si produced by recrystallization of metastable sputter deposits**, *J. Appl. Phys.* 49, No. 3, 1143-1148 (Mar. 1978).

Key words: high-pressure phases; metastable structure; niobium-silicon alloys; recrystallization; sputtered films; superconductivity.

Three new phases of the alloy Nb_3Si have been produced by a relatively low-temperature ($\sim 800^\circ\text{C}$) recrystallization anneal under pressures of up to 100 kbars. The new phases are apparently formed only when the Nb_3Si starting material has a metastable body-centered-cubic structure which is prepared by sputtering. They are not formed when the Nb_3Si starting material has the Ti_3P -type structure. One of the new high-pressure phases has a superconducting transition temperature T_c of 5.45 K, but its crystal structure has not yet been identified. The phase formed at 60 and 100 kbars has a tetragonal Ni_3P -type structure, but the structure of the 80-kbar phase is not known.

17634. Watkins, S. W., Abrams, M. D., **Remote terminal emulation in the procurement of teleprocessing systems**, *Proc. 1977 National Computer Conf., Dallas, TX, June 13-16, 1977*, 46, 723-727 (American Federation of Information Processing Societies, Montvale, NJ, 1977).

Key words: evaluation; interactive; measurement; performance evaluation; performance measurement; remote terminal emulation; remote terminal emulator; teleprocessing.

This paper addresses some of the problems which exist when benchmarking interactive computing. The teleprocessing workload may be emulated by a program running internal to the System Under Test (SUT), known as an internal driver or inter-

nal stimulator. The limitations of internal drivers are discussed, especially with respect to procurement testing. The use of live operators and tape loops are also discussed, but these are also limited techniques. The most attractive alternative is to employ another, external, computer system to emulate the teleprocessing workload; this approach is called remote terminal emulation. The emulation constraints are delineated; terms applicable to the process are defined, including: Remote Terminal Emulator (RTE), scenario, script, and scene. Ten RTE's, representative of current capabilities, are briefly described.

17635. Watson, R. E., Bennett, L. H., **Volume-corrected isomer shifts of transition metal atoms: Charge flow and electronegativity scales in alloys**, *Hyperfine Interact.* 4, 806-810 (1978).

Key words: alloy theory; electronegativity; Mössbauer effect; transition metal.

It is shown that, once volume effects are accounted for, a universal curve describes the Mössbauer isomer shifts of ^{57}Fe , ^{99}Ru , ^{181}Ta , ^{193}Ir , ^{195}Pt , and ^{197}Au impurity nuclei in a variety of hosts. The curve defines an "orbital" electronegativity associated with non-d electron charge flow on or off these transition metal atoms in alloys. The shape of the curve is remarkable in the extent to which it agrees with the "total" electronegativity scales of Pauling, Gordy-Thomas and others. This agreement suggests that d and non-d charge flow are simply proportional to one another to an extent we find surprising.

17636. Wiederhorn, S. M., **Dependence of lifetime predictions on the form of the crack propagation equation**, (Proc. Fourth Intl. Conf. on Fracture, Waterloo, Canada, June 19-24, 1977), *Fract.* 3, No. ICF4, 893-901 (University of Waterloo Press, Waterloo, Ontario, Canada, 1977).

Key words: failure predictions; fracture; fracture mechanics; glass; static fatigue; strength.

The importance of crack propagation equations to failure predictions is discussed. It is noted that for failure predictions purposes the most conservative predictions should be used.

17637. Zalewski, E. F., **Coupling to the detector measurement base at NBS**, *Proc. Electro-Optical Systems Design Conf. 76 and International Laser Exposition, New York, NY, Sept. 14-16, 1976*, pp. 285-289 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1976).

Key words: base, detector measurement; coupling, detector; measurement base, detector.

The structure of the measurement chain for the determination of the absolute response of photodetectors and other radiometric instrumentation will be described. There are three possible modes of coupling to this chain. These will be discussed along with the various advantages and limitations.

17638. Zalewski, E. F., Lind, M. A., **Improving the accuracy of radiant power measurements based on photodetector instrumentation**, (Proc. Symp. on Biological Effects and Measurement of Light Sources, Rockville, MD, Mar. 25-26, 1976), *HEW Publ. (FDA) 77-8002*, D. G. Hazzard, Ed., pp. 117-127 (U.S. Department of Health, Education and Welfare, Rockville, MD, 1977).

Key words: detector responsivity measurement; interlaboratory photodetector measurement comparison; laser power measurement; photodetectors; radiant power measurement; radiometric instrument characterization; radiometric measurement accuracy.

A model of the radiometric measurement system for detector based instrumentation is described. Four areas of research at NBS affecting this measurement system are briefly discussed. They are: (1) evaluation of the absolute (electrical) base measurements of radiant power; (2) instrumentation for detector characterization and absolute spectral response measurements; (3) ultraviolet radiation effects on silicon photodetectors; and (4) an interlaboratory comparison to test the state-of-the-art in detector responsivity transfer measurement.

17639. Zalubas, R., Hagan, L., **Atomic energy levels of rare earth elements**, *Proc. 11th Rare Earth Research Conf., Traverse City, MI, Oct. 1-10, 1974*, pp. 411-416 (U.S. Atomic Energy Commission, Technical Information Center, Oak Ridge, TN, 1974).

Key words: atomic energy levels; elements, rare earth; rare earth elements.

At the National Bureau of Standards members of the Spectroscopy Section are investigating rare earth spectra and are working on a critical compilation of rare earth energy levels. Also a number of people in other laboratories are working on these spectra. The compilation will include experimentally known levels of free atoms and ions of lanthanum through lutetium ($Z = 57-71$).

17640. Cook, R. K., **The history of American acoustics: Introductory comments**, *J. Acoust. Soc. Am.* **61**, No. 2, 249 (Feb. 1977).

Key words: acoustics; history; history of American acoustics.

This paper introduces six papers on the history of American acoustics. All of the papers were presented at the 91st Meeting of the Acoustical Society of America, held in Washington, DC, in April 1976. Publication is planned for the *Journal of the Acoustical Society of America*.

17641. Hertz, H. S., May, W. E., Wise, S. A., Chesler, S. N., **Trace organic analysis**, *Anal. Chem.* **50**, No. 4, 428A-433A (Apr. 1978).

Key words: accuracy; chromatography; fluorescence detection; mass spectrometry; trace organic analysis.

Until recently the major emphasis in trace analysis has been in the analysis of inorganic substances. However, we are now coming to realize that many of our most pressing problems require competence in trace *organic* analysis. This report contains a discussion of the present state-of-the-art of trace organic analysis. Included are a discussion of the achievement of accuracy in trace organic measurements and current methodologies being used in performing these measurements.

17642. Smith, J. C., Graminski, E. L., **Characterizing the inter-fiber bond strengths of paper pulps in terms of a breaking energy**, *Proc. 1977 Annual MAPPI Meeting, Atlanta, GA, Feb. 14-16, 1977*, pp. 169-175 (Technical Assoc. of Paper and Pulp Industry, Atlanta, GA, Feb. 1977).

Key words: adhesion of paper; bonding; bonding of paper fibers; characterization; paper; paper fibers; paper pulps; paper tensile tests.

If a very thin open web of pulp fibers is elongated to break in a sensitive tensile tester, a force-elongation curve containing numerous jags is obtained. Each jag is caused by the breakage of a bond between fibers comprising the paper network. From a plot of work of extension as a function of the number of bond breaks, the average energy stored in the fibers previously connected by a broken bond can be estimated. This energy parameter can be used as a means of characterizing the adhesion between two paper fibers.

Paper samples of basis weight 2.5 g/m² were made from Northern and Southern softwood kraft pulps subjected to various amounts of beating. The energy parameters for these papers were measured in order to characterize the bonding.

17643. Clark, F. O., Brown, R. D., Godfrey, P. D., Storey, J. W. V., Johnson, D. R., **Detection of interstellar vibrationally excited cyanoacetylene**, *Astrophys. J.* **210**, No. 3, L139-L140 (Dec. 15, 1976).

Key words: cyanoacetylene; interstellar molecules; millimeter wave; orion; radio astronomy; vibrational states.

Two transitions of the ν_7 vibrationally excited state of cyanoacetylene have been detected in the Orion molecular cloud. They are observed with LSR velocities of approximately 4 and 6 km s⁻¹. An unidentified line at 92.353 GHz was also observed.

17644. Mahajan, B. M., **Applications of experimental skin injury research to product safety** (Abstract only as C3b.7), *Proc. 28th Annual Conf. on Engineering in Medicine and Biology, New Orleans, LA, Sept. 20-24, 1975*, **17**, 182 (Alliance for Engineering in Medicine and Biology, Chevy Chase, MD, 1975).

Key words: Consumer Product Safety Commission; mechanical factors; skin injury research; threshold values.

17645. Yates, J. T., Jr., Goodman, D. W., Madey, T. E., **Decomposition of H₂CO and CH₃OH on Ru(110) and Ni(100)**, Paper in *Proceedings of the Seventh Int. Vacuum Congress and the Third Int. Conference on Solid Surfaces, Vienna, Austria, Sept. 12-16, 1977*, R. Dobrozemsky, F. Rüdener, F. P. Viehböck, and A. Breth, Eds., **II**, 1133-1136 (F. Berger and Söhne, Vienna, Austria, Sept. 1977).

Key words: adsorption; CH₃OH; decomposition; H₂CO; oxygenated hydrocarbon complexes; Ru surfaces.

The coadsorption of H₂ + CO as well as the adsorption and decomposition of H₂CO and CH₃OH on Ru(110) and Ni(100) have been studied using temperature programmed description methods. CH₄ is observed as a minor product in the thermal decomposition of H₂CO on Ru(110), but is not detected as a desorption product from the other adsorbate-substrate combinations. The results suggest that oxygenated hydrocarbon complexes may be of importance in the catalytic methanation reaction on Ru surfaces, but not on Ni surfaces.

17646. Besley, L. M., Plumb, H. H., **Stability of germanium resistance thermometers at 20 K**, *Rev. Sci. Instrum.* **49**, No. 1, 68-73 (Jan. 1978).

Key words: germanium resistors; low temperature thermometers; stability of germanium resistors; thermal cycling to 20.275 K; thermometers reproducibility.

Thirty germanium resistance thermometers have been thermally cycled 100 times between 20 K and 300 K, and their stability at 20 K has been evaluated. The results reveal a wide range of stabilities, ranging from 0.1 to 20 mK. Five different modes of behavior have been provisionally classified as stable, drifting, jumping, bimodal, and irregular.

17647. Fisher, T. R., Becker, J. A., Watson, B. A., Marshak, H., Burleson, G. R., Cooper, M. D., Hagerman, D. C., Halpern, I., Jakobson, M. J., Jeppeson, R. H., Johnson, K. F., Knutson, L. D., Marrs, R. E., Meyer, H. O., Redwine, R. P., **Pion cross section measurements on aligned ¹⁶⁵Ho in the (3,3) resonance region**, *Phys. Rev. C* **16**, No. 6, 2367-2375 (Dec. 1977).

Key words: nuclear alignment; nuclear reformation; pion cross sections; proton and neutron form factors; ¹⁶⁵Ho.

The removal cross section $\sigma(\Omega)$ for the interaction of π^+ and π^- with aligned ^{165}Ho has been measured at $E\pi = 115, 165,$ and 240 MeV employing a single crystal holmium target with a nuclear alignment $B_2 = -0.44$. The range of Ω was from 0.05 to 0.55 sr. The data on $\sigma(\Omega)$ and $\Delta\sigma(\Omega)$, the difference between the aligned and unaligned cross sections, are compared with the predictions of a coupled-channels optical model calculation employing parameters from recent muonic x-ray data.

17648. Dick, C. E., Motz, J. W., **New method for the experimental evaluation of x-ray grids**, *Med. Phys.* **5**, No. 2, 133-140 (Mar.-Apr. 1978).

Key words: anti-scatter grids; contrast improvement; experimental method; exposure reduction; grid performance; radiography; x-ray grids.

This work describes a new method for the experimental evaluation of antiscatter x-ray grids in radiography. Five commercial grids are evaluated in terms of two parameters which are determined only by the construction of the grid and the x-ray energy. A comparison of the grid performances was made for the x-ray energies and scatter conditions that usually apply to chest radiography and mammography. The results show that for maximum scatter conditions the grid enhances the subject contrast by factors of approximately 6 and 2 in chest radiography and mammography, respectively, and that the contrast increases as the grid ratio increases. Also, in these examinations, the results show that, with improved grids, it is possible to reduce the patient exposures required for the no-grid case by approximately one-half without loss of the image-information content (signal-to-noise ratio).

17649. DeReggi, A. S., Guttman, C. M., Mopsik, F. I., Davis, G. T., Broadhurst, M. G., **Determination of charge or polarization distribution across polymer electrets by the thermal pulse method and Fourier analysis**, *Phys. Rev. Lett.* **40**, No. 6, 413-416 (Feb. 6, 1978).

Key words: charge distribution; copolymer; piezoelectric polymers; polarization distribution; poly(vinylidene fluoride); thermal pulse method.

Fourier analysis, applied to the recently introduced thermal pulse method, yields new and unique relations between the time-dependent pyroelectric response of a thin specimen and the Fourier coefficients of the charge or polarization distribution across its thickness. The new analysis is applied illustratively to thermal pulse data for a vinylidene fluoride copolymer electret.

17650. Flannery, M. R., Yang, T. P., **Ionic recombination of rare-gas atomic ions X^+ with F^- in a dense-gas X** , *Appl. Phys. Lett.* **32**, No. 5, 327-329 (Mar. 1, 1978).

Key words: charge transfer; ionic recombination; rare-gas fluorine lasers.

Rates for the recombination processes $X^+ + F^- + X \rightarrow XF^* + X$, ($X \equiv \text{He, Ne, Ar, Kr, Xe}$) at 300 K are calculated for pressures of the background gas X in the range ~ 0.1 – 50 atm. Rates as high as $(2-7) \times 10^{-6}$ $\text{cm}^3 \text{sec}^{-1}$ are obtained for pressures 1–5 atm of $\text{Xe} \rightarrow \text{He}$, and in general decrease with increasing ionic mass, except at low gas densities.

17651. Harter, W. G., dos Santos, N., **Double-group theory on the half-shell and the two-level system. I. Rotation and half-integral spin states**, *Am. J. Phys.* **46**, No. 3, 251-263 (Mar. 1978).

Key words: double groups; group theory; Hamilton's rotations; icosahedral group; octahedral group; rotation algebra; spinors; two-level system.

A geometrical construction by Hamilton is used to simplify the quantum mechanics of half-integral spin. A slide rule is described which can be used to (a) compute products of half-integral or integral spin rotation operators, (b) convert between the Euler-angle and "axis-angle" rotation operator parameters, and (c) calculate the time evolution of a spin-1/2 state for a constant Hamiltonian operator. A type of nomogram is developed which suggests ways to simplify the "double-group" theory of half-integral spin in molecular point symmetry, as well as the "ordinary" group theory for integral spin systems. Cubic and icosahedral symmetry group characters are derived for half-integral spin operators.

17652. Flannery, M. R., Yang, T. P., **Ionic recombination of rare-gas molecular ions X_2^+ with F^- in a dense gas X** , *Appl. Phys. Lett.* **32**, No. 6, 356-357 (Mar. 15, 1978).

Key words: charge transfer; ionic recombination; rare-gas fluorine lasers.

Rates for the recombination processes $X_2^+ + F^- + X \rightarrow [X_2F]^* + X$, ($X \equiv \text{He, Ne, Ar, Kr, Xe}$) are calculated at 300 K for pressures of the background gas X up to 50 atm. We find rates as high as $(2-6 \times 10^{-6}) \text{cm}^3 \text{sec}^{-1}$ for pressures of 1–8 atm, as the gas is varied from Xe to He. The rates are somewhat smaller than those for the corresponding cases involving atomic ions.

17653. Hertz, H. S., Chesler, S. N., May, W. E., Wise, S. A., Hilpert, L. R., Brown, J., Fatiadi, A., Guenther, F., **The NBS program for standards for trace organic analysis in the marine environment**, *Proc. Environmental Effects of Energy Related Activities on Marine/Estuarine Ecosystems, Newport, RI, Mar. 1977*, pp. 227-242 (U.S. Environmental Protection Agency; Washington, DC, Oct. 1977).

Key words: intercalibration; internal standard; marker compounds; petroleum; reference materials; SRM; trace organic analysis.

The National Bureau of Standards (NBS) is currently conducting a research program to develop standards for trace organic analysis in the marine environment. In this paper, we summarize the results of these analyses for petroleum-in-sediment and petroleum-in-biota reference materials, marker compounds, and concentration techniques for polar organic materials.

17654. Unassigned.

17655. Shier, D. R., **A min-max theorem for p -center problems on a tree**, *Transp. Sci.* **11**, No. 3, 243-252 (Aug. 1977).

Key words: center; graph; location problems; min-max; network; tree.

This paper considers the problem of locating p facilities on a tree network in order to minimize the maximum distance from a point on the network to its nearest facility. Such a problem might arise, for example, in optimally locating a fixed number of fire hydrants along a street network. The present paper identifies an underlying min-max theorem that governs such a p -center problem. More specifically, this p -center problem is shown to be equivalent to the "dual" problem of locating $p+1$ points on the network so as to maximize the minimum distance between pairs of points.

17656. Bass, A. M., Ledford, A. E., Jr., Whittaker, J. K., **Ultraviolet photometer for ozone calibration**, *Proc. Int. Conf. on Photochemical Oxidant Pollution and Its Control, Research Triangle Park, NC, Sept. 12-17, 1976, EPA-600/3-77-001a, Ecological Research Series, 1*, 13-17 (Environmental Sciences Research Laboratory, Research Triangle Park, NC, Jan. 1977).

Key words: air pollution; atmospheric monitoring; calibration, ozone; UV photometry.

In order to provide a facility for photometric ozone measurements, we have designed and constructed a double-beam photometer for ozone concentrations in the range 0.025–1.0 ppm. The sample path length in this instrument is approximately 300 cm. The instrument measures changes in ozonized-air sample transmissions of mercury radiation at 253.7 nanometers where the photo-absorption cross-section of ozone has been well determined.

Radiation at wavelengths other than 253.7 nanometers from the mercury lamp is removed by passing the light through a narrow-band interference filter. The light is collimated and passed through a beam splitter which directs approximately equal intensity beams through the two cells. Clean air flows through one cell into the ozone generator and then the ozonized air flows through the second cell. The light beams are recombined on the face of a photomultiplier tube used in the photon counting mode. A rotating chopper allows the two beams to be detected sequentially so that the transmissions of the two cells may be directly observed.

Tests indicate that measurements may be made at the 0.05 ppm level with a precision of 10 percent or better.

17657. Harman, G. G., Albers, J., **The ultrasonic welding mechanism as applied to aluminum- and gold-wire bonding in microelectronics**, *IEEE Trans. Parts, Hybrids, Packag. PHP-13*, No. 4, 406-412 (Dec. 1977).

Key words: adhesion; bonding; mechanism; thermocompression; ultrasonic; welding; wire.

This paper represents a review as well as an extension of previous work concerned with the mechanism of microelectronic ultrasonic welding for both aluminum and gold wires. A series of experiments was carried out to determine the mechanism of gold-to-gold ultrasonic bonding. These experiments, including lift-off pattern studies, clamped-wire studies, and bond deformation versus ultrasonic vibration amplitude studies, indicate that gold ultrasonic bonding takes place primarily by means of a deformation mechanism as opposed to a heating or sliding mechanism. This is substantially the same result previously obtained from studies on the aluminum ultrasonic bonding mechanism. Further, it is shown that a deformation mechanism also holds for other forms of solid phase microelectronic bonding. Specific examples are taken from electric discharge "tweezer welds" and from thermocompression bonds. The role of contaminant removal and certain reliability aspects of ultrasonic bonding are also discussed.

17658. Free, G., Morrow, J., **Transportable 1000 pF capacitance standard**, (Proc. Conf. on Precision Electromagnetic Measurements, Boulder, CO, June 28-July 1, 1976), *CPEM 1976, IEEE CAT. NO. 76CH1099-1 IM*, pp. 6-8 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: capacitance; measurement assurance program; mechanical stability; thermal stability.

A capacitance transport standard has been constructed for use in the NBS MAP's program. The transport was designed so that variations in ambient temperature, and mechanical shock would have a minimal effect on the value of the capacitors. A significant improvement in stability of 1000 pF capacitors during shipment and while in the laboratory has been achieved through this design.

17659. Snyder, J. J., **Fizeau wavelength meter**, *Proc. Third Int. Conf. on Laser Spectroscopy, Jackson, WY, July 4-8, 1977*, pp. 419-420 (Springer-Verlag, New York, NY, Aug. 1977).

Key words: interferometer; laser; laser interferometer; laser meter; laser wavelength; wavelength.

Our Wavelength Meter is a self-contained instrument that measures the wavelength of radiation produced by lasers or other pulsed or cw sources of monochromatic light. The instrument is based on a Fizeau or "optical wedge" interferometer. The fringe pattern produced by the interferometer is digitized and stored in a small computer which converts the fringe pattern into the wavelength (in the desired units) of the interfering light.

17660. Loebenstein, W. V., Kumpula, J. W., **New method evaluates coupling agents bonding polymer to tooth mineral**, *J. Dent. Res.* **56**, No. 10, 1219-1226 (Oct. 1977).

Key words: adhesion; adhesive test; bonding agent comparison; coupling agent; dental materials; test method for adhesion.

Polymerized test specimens consist of a Bis-GMA matrix and a filler of synthetic hydroxy-apatite previously coated with the coupling agent under investigation. As the concentration of filler increases for a given coupling agent, the specimen's tensile strength decreases. The more effective the coupling agent, the less pronounced is the decrease. Application of the method is proposed for classifying coupling agents as well as providing a means for assessing the weakening effects of environmental exposure.

17661. Bur, A. J., Fetters, L. J., **The chain structure, polymerization, and conformation of polyisocyanates**, *Chem. Rev.* **76**, No. 6, 727-746 (Dec. 1976).

Key words: conformational energy calculations; degradation; dielectric constant; dielectric relaxation time; electric birefringence; electric dichroism; intrinsic viscosity; light scattering; polymerization; poly(n-alkyl isocyanate); rodlike molecule.

The chemical and physical properties of the poly(n-alkyl isocyanate) (PAIC) are reviewed. The review of the chemical properties includes a description of the anionic polymerization of the monomer, a determination that the main chain grows via the C-N bond rather than the C-O bond, and a qualitative description of the degradation of the polymer as an unzipping process which yields mostly monomer and trimer products. Synthesis and properties of other polyisocyanates, e.g., phenyl isocyanate, diisocyanates, optically active *d*- β phenylpropyl isocyanate, and copolymerization of monoisocyanates, are discussed. The review of the physical properties concentrates on the solution measurements of the PAIC's because the molecule displays extraordinary rigidity in solution. Quantitative analysis of the solution measurements is limited to experiments carried out with well-characterized polymer fractions. The measurements on PAIC solution include dielectric relaxation time, static dielectric constant, intrinsic viscosity, light scattering, electric birefringence, and electric dichroism. The picture of the PAIC molecule in solution is that of a rigid helix with a large dipole moment parallel to the main chain and with a persistence length in the range 500 Å to 1000 Å depending on the polarity of the solvent. Dilatometer measurements on bulk poly(n-butyl isocyanate) showed that decomposition occurs at 140 °C.

17662. Hauser, W., Cavallo, L., **Measurement and quality assurance of the amount of administered tracer**, (Proc. Symp. on Standardization, Performance and Quality Control in Nuclear Medicine, Gaithersburg, MD, June 12-14, 1975), Chapter 17 in *Quality Control in Nuclear Medicine, Radiopharmaceuticals, Instrumentation, and in Vitro Assays*, B. A. Rhodes, Ed., pp. 154-163 (The C. V. Mosby Company, St. Louis, MO, 1977).

Key words: administered tracer; dose calibrator measurement errors; quality control of radioactive material; radioactive tracer; radioactivity, tracer.

Problems encountered in the measurement of radioactivity by the producer and/or user of radioactive materials are many. This paper is concerned with terminology, techniques for minimizing dose-calibrator measurement errors, within-laboratory quality control and interlaboratory comparisons, and the importance of accuracy in the quantification of radioactive material to be administered to patients.

17663. Rhyne, J. J., **Curie temperatures of amorphous RFe₂ alloys**, (Proc. 21st Annual AIP Conf. on Magnetism and Magnetic Materials, Philadelphia, PA, Dec. 9-12, 1975), Paper in *Magnetism and Magnetic Materials—1975*, J. J. Becker, G. H. Lander, and J. J. Rhyne, Eds., No. 29, pp. 182-183 (American Institute of Physics, New York, NY, 1975).

Key words: amorphous; Curie temperature; magnetism; molecular field; phase transition; rare earth.

Curie temperatures of the series of amorphous rare earth-iron alloys RFe₂ (where R = Gd, Tb, Dy, Ho, Er, and Y) have been determined from Belov-Goryaga plots of the magnetization isotherms. The Curie Temperature of GdFe₂ is 500 K, and drops sharply (e.g., ErFe₂T_c = 105 K) as one proceeds to the right in the above series (decreasing R spin). The observed Curie temperatures exhibit a smooth variation with the DeGennes factor of the rare earth ion, with the zero spin limit YFe₂ exhibiting no long-range order. This is in marked contrast to the analogous crystalline Laves phase compounds for which YFe₂ has a 535 K Curie temperature and which show a much weaker dependence on the rare earth spin. These results imply a more significant effect of the structural disorder on the direct Fe-Fe exchange versus the RKKY Fe-R and R-R couplings. A molecular field model describing these interactions has been used to calculate the expected Curie temperature for both the amorphous and crystalline series. Overall agreement with the observed T_c's was less satisfactory for the amorphous than for the crystalline materials.

17664. Sengers, J. V., Sengers, J. M. H. L., **Critical phenomena in classical fluids**, Chapter 4 in *Progress in Liquid Physics*, C. A. Croxton, Ed., pp. 103-174 (John Wiley & Sons, New York, NY, 1978).

Key words: correlation function; correlation length; critical phenomena; equation of state; fluid mixtures; fluids; lattice gas; scaling laws; universality.

A status report is presented on current concepts and methods for describing equilibrium critical phenomena in fluids. We review the predictions of three theoretical models for a critical-point phase transition in fluids, namely the classical equations with third-degree, that with fifth-degree isotherm, and the lattice gas. We also discuss the nature of the gravity effects and how they affect critical-region experimentation in fluids. The behavior of the thermodynamic properties and the correlation function is formulated in terms of scaling laws. The predictions of these scaling laws and of the hypothesis of universality of critical behavior are compared with experimental data for one-component fluids and it is indicated how the methods can be extended to describe critical phenomena in fluid mixtures. For one-component fluids, we relate the scale factor of the correlation length to the two scale factors of the thermodynamic functions. The report concludes with a discussion of the relationship between correlation length and equation of state of one-component fluids near the critical point.

17665. Sauder, W. C., Huddle, J. R., Wilson, J. D., **Detection of multiplet structure in Cu K $\alpha_{1,2}$ by means of a monolithic**

double crystal spectrometer, *Phys. Lett.* **63A**, No. 3, 313-315 (Nov. 14, 1977).

Key words: Cu K $\alpha_{1,2}$; double vacancy states; Hartree-Fock calculation; monolithic double crystal spectrometer; relative strengths; x-ray emission.

A monolithic double crystal spectrometer has been employed to produce a highly dispersed, well-resolved Cu K $\alpha_{1,2}$ spectrum. The observed spectrum contains structure that can be attributed to spectator vacancies accompanying the single vacancy transition.

17666. Kurylo, M. J., Manning, R. G., **Flash photolysis resonance fluorescence investigation of the reaction of Cl(²P) atoms with ClONO₂**, *Chem. Phys. Lett.* **48**, No. 2, 279-283 (June 1, 1977).

Key words: chlorine atoms; chlorine nitrate; chlorofluorocarbons; rate constant; resonance fluorescence; stratosphere.

Rate constants for the removal of Cl(²P) atoms by homogeneous gas phase reaction with ClONO₂ were measured using the flash photolysis resonance fluorescence technique at 224, 250, and 273 K. The values obtained have been used to derive the Arrhenius equation $k_6 = (1.68_{-1.33}^{+6.44}) \times 10^{-12} \exp[-(607 \pm 388)/T] \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$. The uncertainties expressed are 95 percent confidence limits obtained using the statistical standard deviation of the individual rate constants plus a 15 percent additional estimated uncertainty attributed to difficulties in chlorine nitrate concentration measurements. The results indicate that destruction of chlorine nitrate by reaction with chlorine atoms is perhaps the least important of the atmospheric reactive channels and at least three orders of magnitude slower than calculated photodissociation rates at all stratospheric altitudes.

17667. Etz, E. S., Cunningham, W. C., Rosasco, G. J., **The chemical identification of airborne particulates by laser Raman spectroscopy** (Abstract only), (Proc. 1976 Federation of Analytical Chemistry and Spectroscopy Societies, Philadelphia, PA, Nov. 15-19, 1976), *1976 FACSS Abstracts*, Paper No. 246, 2 pages (Nov. 1976).

Key words: air pollution; analytical spectroscopy; environmental samples; microanalysis; particles; Raman.

A recently developed micro-Raman spectrometer has been applied to the study of individual micro-particles of environmental significance. Detection and identification via the Raman spectrum is demonstrated for a variety of inorganic sulfate, phosphate, nitrate and carbonate micro-particles derived from laboratory quality materials. Preliminary results on the analysis of individual particles from urban dusts and power plant emissions are also discussed.

17668. Etz, E. S., Rosasco, G. J., Cunningham, W. C., **The chemical identification of airborne particles by laser Raman spectroscopy**, Paper in *Environmental Analysis*, G. W. Ewing, Ed., pp. 295-340 (Academic Press, Inc., New York, NY, 1977).

Key words: airborne particles; atmospheric pollution; microprobe analysis; molecular composition; Raman spectroscopy; vibrational spectrum.

Single, micrometer-size particles are routinely analyzed for molecular constituents in a recently developed Raman microprobe. Identification as to the principal molecular species present in such samples is made on the basis of the recorded Raman spectrum. Considerations important to successful analysis of microparticles by Raman spectroscopy and the unique

aspects of the design of the new microprobe are described. Present capabilities for the detection and identification of various types of environmentally significant species are demonstrated. Raman spectra are discussed for single particles, down to 1 μm in size, of common inorganic compounds, minerals and selected organic compounds. Emphasis is placed on the speciation of sulfur (e.g., HSO_4^- , SO_4^{2-} , SO_3^{2-}) in microparticles. Preliminary results on liquid sulfate particles generated from sulfuric acid aerosol are presented. Other species of interest, such as NH_4^+ , NO_3^- , CO_3^{2-} , and PO_4^{3-} are shown to be readily identifiable as major components of airborne particles. The method is applied to the chemical identification of particles in the primary size fraction ($\pm 2 \mu\text{m}$) of ambient air particulate samples. Specific results of analyses which are discussed highlight the general utility of the technique and the important types of analytical information obtained in its application. The importance of unambiguous sampling and the application of the probe to the study of the sampling process are described.

17669. Swyt, D. A., **An NBS physical standard for the calibration of photomask linewidth measuring systems**, *Soc. Photo-Opt. Instrum. Eng.* **129**, 98-105 (1977).

Key words: calibration standards; closed-circuit TV systems; dimensional metrology; electron microscope; filar eyepiece; image shearing eyepiece; integrated circuits; linewidths; microelectronics; optical microscopes.

In the final stages of development at the National Bureau of Standards (NBS) is a photomask-like physical standard for the evaluation and calibration of linewidth-measuring optical microscopes, including those of the automatic, closed-circuit TV types. The standard bears clear and opaque lines in the 1 to 10 micrometer (40 to 400 microinch) range and is applicable to microscopes used to measure the opaque-type, as opposed to "see-through," photomasks in transmitted light. Primary calibrations of the standard are done on an electron microscope/laser interferometer system with secondary calibrations done on a high-performance photometric optical microscope. The NBS linewidth standard, having linewidths and line spacings distributed in a special way over the range where serious problems in industrial linewidth measurements occur, can be used to detect systematic errors and the biases within measuring systems which cause them. Given in this paper is a constructed numerical example, based on observed effects, of how use of the standard can reveal a number of different types of systematic errors within a single system and can point to likely sources of biases which cause these errors.

17670. Brinckman, F. E., Iverson, W. P., **Chemical and bacterial cycling of heavy metals in the estuarine system**, (Proc. Symp. Middle Atlantic Region 169th Meeting of the American Chemical Society, Philadelphia, PA, Apr. 8-10, 1975), *ACS Symp. Series 18, Marine Chemistry in the Coastal Environment*, T. M. Church, Ed., Paper 18, 319-342 (American Chemical Society, Washington, DC, 1975).

Key words: bacterial transformations; bimetallic pathways; chemical transformations; Chesapeake Bay; estuarine system; heavy metals; metal transport; methylation; petroleum; pollution; sediment; sulfur cycle.

Anthropogenic inputs of heavy metals into an estuary such as the Chesapeake Bay result in substantial partitioning between sediments, waters, and primary trophic levels. Many metals, including Hg, are concentrated in oil fractions isolated from some sediments. Although low concentrations of metals exist in the aqueous phase, significant transport by aquated metal species is believed to occur via combinations of both abiotic and biological transformations. The case for Hg pollutants is most developed, where it is shown that benthic

microorganisms can be responsible for volatilization and resolubilization of Hg(II) via Metabolic gaseous Hg or methylmercurials. Previous views held that most, if not all, Hg is sediment-bound as the sulfide under oxygen-depleted conditions. Nonetheless, in petroleum-contaminated sediments where active sulfur occurs with biogenic formation of ca. 1 percent elemental S, significant portions (3-45%) of total Hg are recoverable as ligated metal soluble in organic extractants. Since both chemical and biological factors may be involved in such transport, evaluation of the intermediacy of other organometallic species has been conducted, with the recent finding of a bimetallic pathway involving transmethylation between tin and Hg. Here, aerobic marine bacteria directly methylate Sn(IV) (while reducing Hg(II)) to abiotically form subsequently methylmercury from available Hg(II). This is a case essentially similar to the known methylcobalamin involvement in environmental CH_3Hg formation. These bacteria are likewise highly tolerant towards other pollutant metals. Results of a survey concerned with other similar bimetallic biotic-abiotic transport routes in saline media will be discussed.

17671. Faller, J. E., **Large multi-lensed telescope: A receiver for point sources in the sky**, *Proc. Conf. on Optical Telescopes of the Future, Geneva, Switzerland, Dec. 1977*, pp. 301-311 (European Southern Observatory, CERN, M. Carealho, Geneva, Switzerland, 1978).

Key words: astronomy; light buckets; optical arrays; optics; telescopes.

A large 80" (2-meter) multi-lensed, computer-controlled and encoder-pointed telescope will be described. It is being used as the receiver in the new high-performance lunar laser ranging station on Mt. Haleakala on the island of Maui, Hawaii: however it could also be used for other astronomical applications when the moon is not up. This telescope, which was designed for applications requiring aperture but not field, could impact the design of future very large astronomical instruments intended mainly for point-source spectroscopy and similar applications. The telescope and its performance to date will be discussed.

17672. Rowen, J. W., Lyons, J. W., **The importance of externally imposed heat flux on the burning behavior of materials**, *J. Cell. Plast.*, pp. 25-32 (Jan.-Feb. 1978).

Key words: fire research; fire retardants; fire tests; flammable materials; heat flux; heat transfer.

This study develops further understanding of behavior of materials at increasing heat fluxes and seeks to explain differences in rank ordering within a set of materials. The study involves four sets of materials—Plywood, Hardboard, Polyurethane, and Polystyrene—modified with four levels of fire retardants. Two types of measurements, rate of burning (m) and rate of heat release (q) were carried out over the heat flux range of 2-6 watts/cm² to obtain the needed understanding. It was found that there were 164 crossovers or reversals in a total of 342 m and q flux curves. The majority of the 50 percent of crossovers were in the rate of burning series but an appreciable number of the crossovers were in the heat release series. This work shows the importance of knowing the heat flux applied to a material in a fire test and how this heat flux compares to that anticipated in the most probable scenarios. Finally, this study shows why rank ordering will produce different results at different heat fluxes.

17673. Ausloos, P., Lias, S. G., **Charge transfer equilibria involving aromatic compounds**, *Proc. 7th Int. Mass Spectrometry Conf., Florence, Italy, Aug. 30-Sept. 3, 1976*, pp. 321-325 (Elsevier Publ. Co., London, England, 1978).

Key words: aromatic cations; charge transfer; equilibrium constants; ion cyclotron resonance spectrometry; ionization potentials; ion-molecule reactions.

Equilibria involving charge transfer between aromatic molecules and the parent ions of aromatic compounds have been examined in a pulsed ion cyclotron resonance mass spectrometer. Thermochemical information has been inferred from the observed equilibrium constants, and a self-consistent thermodynamic network which can be related to the corresponding ionization potentials of the various molecules is derived. A discussion is presented about the assumptions which are made in such a derivation. The ionization potential scale determined in this way is compared with a corresponding scale based on well-established ionization potentials from the literature.

17674. VanderHart, D. L., **Observation of natural-abundance, ^{13}C - ^{13}C dipolar satellites in ultraoriented polyethylene**, *J. Magn. Reson. Commun.* **24**, 467-470 (1976).

Key words: dipolar; NMR; polyethylene; structure; ^{13}C .

It is shown that very weak ^{13}C - ^{13}C dipolar satellites may be observed in an oriented organic solid such as highly drawn polyethylene. In polyethylene, one can observe three different satellites corresponding to ^{13}C pairs which are one, two, or three bonds separated. Since the dipolar interaction depends on orientation as well as internuclear distance, structural information may be deduced from these satellites. The satellite splittings are not totally consistent with the assumed polyethylene structure. This discrepancy is discussed.

17675. Kirchhoff, W. H., **Measurement standards for air pollution monitoring and control associated with energy production**, *Proc. Second National Conf. on Interagency Energy/Environment Research and Development, Washington, DC, June 6-7, 1977*, pp. 425-426 (Environmental Protection Agency, Washington, DC, Nov. 1977).

Key words: air pollution; energy; measurement; monitoring; particulates; SRM's.

In accord with the overall mission of the National Bureau of Standards to provide standards of measurement and means for making measurements consistent with those standards, NBS scientists are participating in the EPA administered program on environmental aspects of energy production and use by developing measurement methods and Standard Reference Materials (SRM's) for air pollution monitoring. A new instrument for monitoring atmospheric particulates containing sulfur has been developed which combines electrostatic precipitation with flame photometric detection as its principle of operation. Standard Reference Materials (SRM's) applicable to the measurement of stack concentrations of SO_2 have been developed and progress has been made on similar standards for NO_2 . SRM's for CO in air in the concentration range of 10 to 50 ppm are also near completion. Methods are being investigated to develop SRM's for the x-ray fluorescence analysis of particulates on filter papers. To this end, techniques for fabricating glass microspheres of known composition have been developed and sputtering techniques for producing thin films of known composition have been investigated.

17676. Kirchhoff, W. H., **Measurement standards for water monitoring associated with energy production and use**, *Proc. Second National Conf. on Interagency Energy/Environment Research and Development, Washington, DC, June 6-7, 1977*, pp. 449-451 (Environmental Protection Agency, Washington, DC, Nov. 1977).

Key words: effluents; measurement; monitoring; SRM's; water pollution.

In accord with the overall mission of the National Bureau of Standards to provide standards of measurement and means for making measurements consistent with those standards, NBS scientists are participating in the EPA administered program on environmental aspects of energy production and use by developing measurement methods and Standard Reference Materials (SRM's) for water pollution monitoring. Projects currently underway include the development of an SRM consisting of eighteen trace elements in water, the development of methods for the measurement of trace elements in sea water, the development of SRM's for the measurement of organic compounds in water and sediment and the development of methods for measuring polar organic compounds in water and for coupling liquid chromatography with mass spectroscopy for the identification of organic compounds in water. Methods for determining the chemical form (speciation) of trace elements in water are being investigated as are methods for determining the depth profile of trace elements in individual sediment particles using ion microprobe analysis.

17677. VanderHart, D. L., Retcofsky, H. L., **Analysis of the aromatic content of whole coals by high-power proton decoupled C-13 NMR**, *Proc. 1976 Coal Chemistry Workshop, Menlo Park, CA, Aug. 26-27, 1976*, pp. 202-218 (Stanford Research Institute, Menlo Park, CA, 1976).

Key words: aromaticity; coal; cross polarization; NMR; solid; ^{13}C .

The H-C 13 cross polarization experiment is described and its applicability to solid coals is discussed. Results indicate that the aromatic content of bituminous and anthracitic coals may be determined to an accuracy ± 4 percent using this cross polarization technique. Results also show that coal does not contain any significant concentration of large, unprotonated-carbon domains. Limitations of the method are also discussed.

17678. Coxon, B., **Fourier transform NMR spectroscopy nitrogen-15 studies of amino sugars**, *Pure Appl. Chem.* **49**, 1151-1168 (1977).

Key words: amino sugars; carbon-13 NMR; coupling constants; Fourier transform NMR; nitrogen-15 NMR; proton NMR; quantitative analysis; spin-lattice relaxation times; stereochemistry.

The synthesis and nuclear magnetic resonance (n.m.r.) spectroscopy of ^{15}N -labeled derivatives of 6-amino-6-deoxy-D-glucose, 6-amino-6-deoxy-D-galactose, and 5-amino-5-deoxy-D-ribose are reviewed. The use of these derivatives in the measurement of ^{15}N coupling constants, ^{15}N nuclear Overhauser effects, and ^{15}N spin-lattice relaxation times is described. Integration of the natural abundance ^{15}N n.m.r. spectra of aqueous solutions of the common 2-amino sugar hydrochlorides and their N-acetyl derivatives has given ratios of α and β anomers for the equilibrated solutions that are in good agreement with published data from proton n.m.r., with the exception of 2-amino-2-deoxy-D-galactose hydrochloride, for which a discrepancy was noted. The equilibria of this amino sugar in aqueous solution have been reinvestigated by proton n.m.r. spectroscopy at 60 and 220 MHz, and by ^{13}C n.m.r., and the α -pyranose anomer found to be predominant. Correlations of the ^{15}N chemical shifts with molecular structure and stereochemistry have been made.

17679. Haus, J. W., Tanaka, T., **Model for the ice VII-ice VIII transition**, *Phys. Rev. B* **16**, No. 5, 2148-2153 (Sept. 1, 1977).

Key words: cluster variation technique; cumulant expansion; dielectric constant; mean field approximation; proton ordered state; pseudo spin; sublattice.

A lattice model is proposed to describe the transition between the proton-disordered ice VII phase and the proton-ordered ice VIII phase. The model includes a ferroelectric four-proton interaction which prefers to satisfy the ice rule. This model is solved in the mean-field approximation; the change in the Kirkwood correlation factor, which is related to the change in the dielectric constant, the change in entropy, and the specific heat are presented. Generalizations of the model and higher-order approximations are discussed.

17680. Harter, W. G., dos Santos, N., **Double-group theory on the half-shell and the two-level system. II. Optical polarization**, *Am. J. Phys.* **46**, No. 3, 264-273 (Mar. 1978).

Key words: birefringence; circular dichroism; Faraday rotation; Jones calculus; Mueller calculus; optical activity; optics; polarization; Stokes parameters.

Relations are derived between several different descriptions of optical polarization by analogy to the theory of spin 1/2. The rotational slide rule developed in the preceding article (1) is used to (a) compute the final polarization state and phase of an optical beam given the optical wave matrix, initial state, and phase, (b) make conversions between various types of polarization parameters, and (c) find the output intensity for perfect polarizers. Other polarization problems and methods are discussed briefly.

17681. Garner, E. L., Dunstan, L. P., **Determination of nanogram per gram concentrations of iron by isotope dilution mass spectrometry**, (Proc. 7th Int. Mass Spectrometry Conf., Florence, Italy, Aug. 30-Sept. 3, 1976), Paper in *Advances in Mass Spectrometry*, N. R. Daly, Ed., **7A**, 481-485 (Heyden & Son Ltd., London, England, 1978).

Key words: iron concentrations; isotope dilution; nanogram per gram; thermal ionization mass spectrometry.

Iron concentrations have been determined in blood serum, rhenium filament ribbons, high-purity reagents and high-purity molybdenum, rhenium and silver ingots by thermal ionization isotope dilution mass spectrometry. The concentration of iron in these materials has ranged from 0.1/ng for sub-boiling distilled reagents to approximately 1 $\mu\text{g/g}$ for blood serum and high-purity metals. Known sources of error in the concentration determination are the calibration of the spike solution, the variability of the analytical blank, the isotopic ratio determination, and the natural iron contribution from the ionizing filament.

The magnitude and variability of the analytical blank were found to be the limiting factors in the measurement of nanogram quantities of iron. Although the blank has been controlled at less than 50 ng, there are still random factors which produce magnitudes and variabilities greater than 100 ng. Measures utilized to control the analytical blank include the chemical preparation of all samples in a Class 100 clean air environment, rigorous cleaning of apparatus, exclusive use of sub-boiling distilled reagents, thorough cleaning of ion exchange resin, and acid leaching of rhenium filament ribbons.

17682. Linden, T. A., **Specifying abstract data types by restriction**, *ACM SIGSOFT, Software Eng. Notes* **3**, No. 2, 7-13 (Apr. 1978).

Key words: abstract data types; hidden functions; program specification; restricted specification; semantic specification; syntactic specification; type; type restriction.

Restrictions are one instance of mathematically-based relationships between types that can be used to simplify program specifications. Restriction of an abstract data type provides a theoretical justification for the concept of a hidden function that appears in some current specification methodologies. The

use of type restrictions to simplify formal specifications is illustrated by the example of traversible stacks.

17683. LaVilla, R. E., **Unusually broad x-ray emission lines: $L\gamma_{2,3}$ ($L_1N_{2,3}$) spectra of $_{50}\text{Sn}$, $_{52}\text{Te}$, and $_{53}\text{I}$** , *Phys. Rev. A* **17**, No. 3, 1018-1020 (Mar. 1978).

Key words: iodine; $L\gamma_{2,3}$ spectra; tellurium; tin; x-ray emission.

The $L\gamma_{2,3}$ ($L_1N_{2,3}$) x-ray emission spectra from $_{50}\text{Sn}$, $_{52}\text{Te}$, and $_{53}\text{I}$, excited by direct electron bombardment, were measured with a double-crystal monochromator. The spectral profiles are similar to their 4p energy-level-region x-ray photoelectron spectra (XPS), with base widths of about 50 eV. The origin of these unusual line profiles is attributed to many-body effects in their final states which are comparable to their respective XPS final states.

17684. Kearsley, E. A., Zapas, L. J., **Experimental tests of some integral rheological relations**, *Trans. Soc. Rheol.* **20**, No. 4, 623-637 (1976).

Key words: BKZ fluid; first normal stress difference; polyisobutylene solution; rheological relations; shear flow.

Some new rheological relations are derived for the BKZ fluid in shear. These relations all involve integrals rather than derivatives of stress measurements. For suddenly applied constant rate of shear, several relations are found connecting (a) time-dependent normal-stress at one shear rate to integrals of time-dependent shear-stress over shear-rate and time, (b) time-dependent shear-stress to integrals of time-dependent normal-stress over shear-rate and time, (c) an integral over time of normal-stress to an integral over shear rate of steady-state shear-stress, and (d) an integral over time of shear-stress to an integral over shear-rate of steady-state normal-stress. For sudden cessation of steady shear a rheological relation is found connecting an integral over time of shear-stress to an integral over shear-rate of normal-stress.

These relations are tested with data from measurements on PIB solutions. The results suggest that time-dependent normal-stress data are not reliable. Within this limitation, the results are consistent with the requirements of a BKZ fluid.

A rheological relation appropriate to single-integral rate-type constitutive equations is examined also and found to be inconsistent with the data, as is the van Es and Christensen test.

17685. Kearsley, E. A., **Some new integral rheological relations**, *Proc. VII Int. Congress on Rheology, Gothenburg, Sweden, Aug. 23-27, 1976*, pp. 576-577 (Tages-Anzeiger/Regina-Druck, Zurich, Switzerland, 1976).

Key words: BKZ fluid; first normal stress difference; polymer solutions; rheological relations; shear flow.

Some new relations are derived for the BKZ fluid in shear. These relations all involve integrals rather than derivatives of stress measurements. For suddenly applied constant rate of shear, relations are found connecting a) normal-stress to integrals of shear-stress over shear-rate and time, b) shear-stress to integrals of normal-stress over shear-rate and time, c) an integral over time of normal-stress to an integral over shear-rate of steady-state shear-stress and d) an integral over time of shear-stress to an integral over shear-rate of normal-stress. For sudden cessation of steady shear a rheological relation is found connecting an integral over time of shear-stress to an integral over shear-rate of normal-stress.

17686. Hoppes, D. D., **Radionuclidic purity**, (Proc. Symp. on Standardization, Performance and Quality Control in Nuclear Medicine, Gaithersburg, MD, June 12-14, 1975), Chapter 18 in *Quality Control in Nuclear Medicine. Radiopharmaceuticals*,

Instrumentation, and in Vitro Assays, B. A. Rhodes, Ed., pp. 164-172 (The C. V. Mosby Company, St. Louis, MO, 1977).

Key words: gamma-ray spectroscopy; germanium detector characteristics; pulse-height analysis; radionuclidic impurities; spectral data analysis by computer.

Radionuclidic impurity determinations are described, with the selection and use of germanium detectors for measuring gamma rays discussed in detail. Spectral artifacts and analysis methods are illustrated, and an example of an impurity determination is given.

17687. Hofmann, H., Leone, S. R., **Collisional deactivation of laser-excited $\text{Br}^*(^2\text{P}_{1/2})$ atoms with halogen and interhalogen molecules**, *Chem. Phys. Lett.* **54**, No. 2, 314-319 (Mar. 1, 1978).

Key words: $\text{Br}^*(^2\text{P}_{1/2})$; collisional deactivation; halogens; interhalogens; laser excitation; quenching.

Deactivation rates of spin-orbit excited $\text{Br}^*(^2\text{P}_{1/2})$ atoms by halogens I_2 , Br_2 , and Cl_2 and interhalogens IBr , ICl and BrCl have been measured by laser-excited, time-resolved infrared emission techniques. The results are effectively explained in terms of a collision complex formation model.

17688. Santoro, A., Roth, R. S., Minor, D., **Neutron powder diffraction study of the intermediate-temperature form of lithium tantalate**, *Acta Crystallogr.* **B33**, 3945-3947 (1977).

Key words: diffraction; lithium location; lithium tantalate; neutron; powder sample; profile analysis.

$\text{M-LiTa}_3\text{O}_8$, monoclinic, $C2/c$, $a = 9.410$ (1), $b = 11.521$ (1), $c = 5.0506$ (5) Å, $\beta = 91.108$ (5)°, $Z = 4$. The location of the lithium ion in the structure has been determined by profile analysis of powder diffraction data.

17689. Moore-Sitterly, C., **Collaboration with Henry Norris Russell over the years**, *IAU Symp. No. 80, The HR Diagram: 100th Anniversary of Henry Norris Russell, Washington, DC, Nov. 2-5, 1977*, pp. 27-42 (1977).

Key words: atomic spectroscopy; double stars; dynamical parallax; Hertzsprung-Russell Diagram; historical review; H. N. Russell; masses of stars; moon's position; solar composition; solar spectra.

The brilliant achievements of Henry Norris Russell have left a lasting imprint on science in many fields, but to this audience his contributions to astrophysics appear to be the most significant. My collaboration with him started in 1920. For some twenty years I was suddenly plunged into large and varied research programs. The subjects depended on his rapid overall perception of gaps in our knowledge of astrophysical problems and on his intelligent grasp of how they should be handled. The assignments given to me without warning ranged from the first—the laborious photographic determination of the moon's position, to the unraveling of the intricacies of complex atomic spectra, such as those of the alkaline earths, Ti I, Fe I, etc. Interspersed with these was the fascinating work on identifying, as to chemical origin, lines in solar and sun-spot spectra. His keen conception of calibrating the Rowland Intensity Scale by a detailed study of solar multiplets led, in turn, to his classical paper on "The Composition of the Sun." This pioneer work in solar physics laid a solid foundation for our present interpretation of XUV solar spectra and for abundance determinations in stellar spectra of many types. He instituted a comprehensive study of the motions of some 2500 double stars which provided not only dynamical parallaxes; but, also, a critical insight into the properties of these stars as described in the treatise on "The Masses of the Stars" (1940). This survey does not do

justice to the many facets of activity in which we were engaged intermittently until 1955. Perhaps it does not signify the breadth of thinking and knowledge that led to his almost superhuman contributions.

17690. Mann, W. B., Cali, J. P., **Traceability and standard reference materials**, (Proc. Symp. on Standardization, Performance and Quality Control in Nuclear Medicine, Gaithersburg, MD, June 12-14, 1975), Chapter 16 in *Quality Control in Nuclear Medicine. Radiopharmaceuticals, Instrumentation, and in Vitro Assays*, B. A. Rhodes, Ed., pp. 147-153 (The C. V. Mosby Company, St. Louis, MO, 1977).

Key words: quality control; radioactivity measurements; radiopharmaceuticals; traceability.

A brief history of the National Bureau of Standards involvement in the quality control of radioactivity measurements in all of its varied applications (medicine, the environment, nuclear power and in industry) is given. The genealogical relationships (both domestic and international) implicit in the concept of traceability are discussed. A brief summary is also given of the NBS involvement in quality control programs carried out in cooperation with other laboratories, both private and government. The research associate program, a cooperative endeavor of eight industrial procedures of radiopharmaceuticals, under the aegis of the Atomic Industrial Forum, and the Radioactivity Section, NBS, is defined.

17691. Margolis, S. A., Howell, B. F., Schaffer, R., **Lactate dehydrogenase inhibitors in NADH preparations**, *Clin. Chem.* **23**, No. 9, 1581-1584 (1977).

Key words: chromatography on DEAE-cellulose; high-performance liquid chromatography; lactate dehydrogenase inhibitor.

The presence of a new lactate dehydrogenase inhibitor on the trailing edge of the NADH peak from chromatography on diethylaminoethyl-cellulose [Loshon *et al.*, *Clin. Chem.*, this issue] was verified. It was resolved from the NADH by high-performance liquid chromatography on μ Bondapak C_{18} . When the new inhibitor was present in a reaction mixture to the extent that, of the initial 260-nm absorbance, about 5 percent was contributed by the inhibitor, the rate of NADH oxidation by lactate dehydrogenase decreased by 65 percent. The inhibitor absorbs at 260 and 340 nm, and is different from the Strandjord-Clayson inhibitor [*J. Lab. Clin. Med.* **67**, 144 (1966)] by both types of chromatography. Because this new inhibitor has ultraviolet properties similar to those of NADH and chromatographs with the NADH on DEAE-cellulose, the high-performance liquid chromatographic method must be used to ensure its absence in preparations of NADH used for clinical assay.

17692. Alperin, H. A., Flotow, H., Rush, J. J., Rhyne, J. J., **Deuterium-site occupancy in the α and β phases of TiD_x** , *Proc. Conf. on Neutron Scattering, Gatlinburg, TN, June 6-10, 1976*, pp. 517-521 (Oak Ridge National Laboratory, Oak Ridge, TN, Sept. 1, 1976).

Key words: deuteride; hydride; neutron diffraction; octahedral sites; tetrahedral sites; titanium.

Neutron diffraction patterns were taken of $\text{TiD}_{0.075}$ at 375C and $\text{TiD}_{0.87}$ at 400C in the α (hcp) and β (bcc) phases respectively. A mixed octahedral (y)—tetrahedral (1-y) site occupancy was found. The results are for the α -phase: $y = 0.68 \pm .02$, while for the β -phase: $0.15 < y < 0.30$.

17693. Ausloos, P., Lias, S. G., **Comments concerning the structures and reactions of C_7H_n^+ ions**, *Chem. Phys. Lett.* **47**, No. 3, 495-498 (May 1, 1978).

Key words: charge transfer; ion-molecule reactions; ion structures; nitronium ion; toluene ions.

Toluene ions do not abstract NO_2 from alkyl nitrates, as has been reported. Rather, solvated NO_2^+ ions formed in alkyl nitrates transfer NO_2^+ to aromatic compounds, accounting for the formation of the $\text{C}_7\text{H}_8\text{NO}_2^+$ product ions in toluene-alkyl nitrate mixtures. Information about the structures of fragment C_7H_8^+ ions in butyl benzenes has been derived from the rates of their charge transfer reactions.

17694. Ausloos, P., Lias, S. G., **Equilibrium isotope effects on the proton transfer reactions of methylbenzenes**, *J. Am. Chem. Soc.* **99**, 4198-4199 (1977).

Key words: ion-molecule equilibria; isotope effects; proton affinity; proton transfer; p-xylene; toluene.

A recent paper (J. F. Wolf, J. L. Devlin, III, D. J. DeFrees, R. W. Taft, and W. J. Hehre, *J. Am. Chem. Soc.*, **98**, 5097 (1976)) reported large deuterium isotope effects ($\Delta G = 0.2$ to 0.3 kcal/mole) on proton transfer equilibria in mixtures of alkylbenzenes with their partially deuterated analogues. This was interpreted as evidence for hyperconjugative stabilization of the protonated species. This note reports a careful redetermination and evaluation of such equilibrium measurements, showing that the reported isotope effects are nonexistent within experimental error (± 0.05 kcal/mole).

17695. Ausloos, P., Lias, S. G., **Entropy changes for the protonation of alkenes**, *J. Am. Chem. Soc.* **100**, No. 6, 1953-1954 (Mar. 15, 1978).

Key words: alkene; entropy; equilibrium constant; heat of formation; ion cyclotron resonance; proton transfer; t-alkyl ions; t-butyl ion.

Equilibrium constants have been determined as a function of temperature for several proton transfer equilibria involving branched C_4 - C_8 olefins. From the measured entropy changes for the reactions it has been deduced that there is an entropy change associated with the loss of an internal rotation of a methyl group in going from a t-alkyl ion to the corresponding olefin. Relative values for the heats of formation of the $\text{t-C}_4\text{H}_9^+$, $\text{t-C}_5\text{H}_{11}^+$, and $\text{t-C}_8\text{H}_{13}^+$ ions deduced from these results agree with those derived from hydride transfer equilibria.

17696. Ausloos, P., Lias, S. G., **The proton affinity of ketene and the heat of formation of CH_3CO^+** , *Chem. Phys. Lett.* **51**, No. 1, 53-56 (Oct. 1, 1977).

Key words: acetone; acetyl ion; heat of formation; ketene; proton affinity; proton transfer.

The equilibrium for proton transfer involving acetone and ketene ($\text{CH}_3\text{COCH}_3\text{H}^+ + \text{CH}_2\text{CO} \rightleftharpoons \text{CH}_3\text{CO}^+ + \text{CH}_3\text{COCH}_3$) has been studied in a pulsed ion cyclotron resonance spectrometer. Values of 193.6 ± 1 and 194.1 ± 1 kcal/mole (1 kcal/mole = 4.18 kJoules) are obtained for the proton affinities of acetone and ketene, respectively (based on a proton affinity of 193.5 ± 1 kcal/mole for isobutene). A value of 161.5 ± 1 kcal/mole for $\Delta H_f(\text{CH}_3\text{CO}^+)$ is derived from these results.

17697. Bennett, H. S., Rosasco, G. J., **Resonances in the efficiency factors for absorption: Mie scattering theory**, *Appl. Opt.* **17**, No. 4, 491-493 (Feb. 15, 1978).

Key words: change of index of refraction with temperature; heat conduction; laser beam; microscopic particle; Mie scattering; optical path length change; Raman; thermal diffusion.

The nature and implications of the very sharp resonances which exist in the efficiency factors for absorption by weakly

absorbing spheres are discussed in this letter. Numerical examples are given for thoria microparticles in air.

17698. Bowman, C. D., Schröder, I. G., Duvall, K. C., Dick, C. E., **Subthreshold photofission of ^{235}U and ^{232}Th** , *Phys. Rev. C* **17**, No. 3, 1086-1088 (Mar. 1978).

Key words: barrier shape; fission; nuclear reactions; photofission bremsstrahlung; threshold; track counting.

Photofission cross sections for ^{232}Th , and ^{236}U have been measured in the energy range from 3.25 to 5.75 MeV and for ^{234}U and ^{236}U at 3.5 MeV. The cross sections change by over seven orders of magnitude for this energy range. Cross section shapes are significantly different for different isotopes indicating a strong sensitivity to fission barrier parameters.

17699. Choi, C. S., Santoro, A., Abel, J. E., **The crystal structure of 3,7-diacetyl-1,3,5,7-tetraazabicyclo[3,3,1]nonane (DAPT)**, *Acta Crystallogr.* **B32**, 354-358 (1976).

Key words: bicyclononane system; diffraction; direct-methods; explosives; single-crystal; x rays.

The crystal structure of 3,7-diacetyl-1,3,5,7-tetraazabicyclo[3,3,1]nonane (DAPT), $\text{C}_9\text{H}_{16}\text{N}_4\text{O}_2$, has been determined by single-crystal x-ray diffraction techniques. The compound crystallizes in the monoclinic system with $a = 6.183$ (2), $b = 10.101$ (2), $c = 17.037$ (4) Å, $\beta = 101.78$ (4)°, space group $P2_1/c$, $D_x = 1.353$, $D_m = 1.34$ g cm^{-3} and $Z = 4$. The structure has been solved by direct methods and has been refined by least-squares analysis to a conventional R value of 0.052 ($R_w = 0.04$) based on 1708 observed reflections. The molecule of DAPT has a twin-chair conformation similar to that of the molecule of 3,7-dinitro-1,3,5,7-tetraazabicyclo[3,3,1]nonane (DPT). The heavy atoms of the acetamide groups are essentially coplanar with the ring carbon atoms adjacent to each group. The bicyclononane ring of the DAPT molecule possesses two pseudo-symmetry planes almost perpendicular to one another. Short intermolecular contacts of 3.28, 3.39 and 3.47 Å have been observed. The molecules having these contacts are stacked along the unique b axis to form a linear chain. The lateral links between chains are weak with contacts between heavy atoms longer than 3.5 Å.

17700. Clark, F. O., Johnson, D. R., **Rotation and velocity structure in the core of the optical condensation B213 NW and its relation to the parent gas**, *Astrophys. J.* **220**, No. 2, 500-509 (Mar. 1, 1978).

Key words: B213 NW; cloud dynamics; contour maps; formaldehyde; interstellar gas; radio astronomy.

A small region around the high-density core of the optical condensation referred to as B213 NW has been studied in some detail. The 2 cm formaldehyde spectral line was used as a probe for the study. The gas in this region is observed to consist of several fragments, the most massive of which appears to be rotating. The other fragment observed with the 2 cm line appears to be unbound and will escape from B213 NW. The relationship between the gas in this dense core and the parent cloud is discussed. A new method of determining distance to dense gas clouds which exhibit rotation is outlined.

17701. Cooper, T., Bertozzi, W., Heisenberg, J., Kowalski, S., Turchinets, W., Williamson, C., Cardman, L., Fivozinsky, S., Lightbody, J., Jr., Penner, S., **Shapes of deformed nuclei as determined by electron scattering: ^{152}Sm , ^{154}Sm , ^{166}Er , ^{176}Yb , ^{232}Th , and ^{238}U** , *Phys. Rev. C* **13**, No. 3, 1083-1094 (Mar. 1976).

Key words: first excited states for $0.5 < q_{eff} < 1.2$ fm $^{-1}$; measured-cross sections for ground state; nuclear reactions

¹⁵²Sm(e,e'), ¹⁵⁴Sm(e,e'), ¹⁶⁶Er(e,e'), ¹⁷⁶Yb(e,e'), ²³²Th(e,e'), ²³⁸U(e,e').

Electron scattering experiments have been performed on the deformed nuclei, ¹⁵²Sm, ¹⁵⁴Sm, ¹⁶⁶Er, ¹⁷⁶Yb, ²³²Th, and ²³⁸U at momentum transfers between 0.5 fm⁻¹ and 1.3 fm⁻¹. The cross sections for 0⁺, 2⁺, and 4⁺ rotational states of these nuclei have been obtained and, together with other information on the electromagnetic properties of these nuclei, these data lead to information about the deformed shapes. The shapes of ¹⁶⁶Er and ¹⁷⁶Yb are quite different from the shapes of ¹⁵²Sm and ¹⁵⁴Sm and require a varying skin thickness. The Sm isotopes require a constant skin thickness. Results are presented for $\rho_0(r)$, $\rho_2(r)$, and $\rho_4(r)$.

17702. Czyzewski, J. J., Madey, T. E., Yates, J. T., Jr., **Angular distributions of electron-stimulated-desorption ions: Oxygen on W(100)**, *Phys. Rev. Lett.* **32**, No. 14, 777-780 (Apr. 8, 1974).

Key words: angular distribution; desorption; electron stimulated desorption; oxygen; single crystal; tungsten.

Ions liberated from an adsorbed layer by electron-stimulated desorption are shown to have sharply peaked, symmetric angular distributions which are in registry with the substrate. We propose a new method for investigation of the symmetry of binding sites for adsorbed species.

17703. Dragoo, A. L., Spain, I. L., **The elastic moduli and their pressure and temperature derivatives for calcium oxide**, *J. Phys. Chem. Solids* **38**, 705-710 (1977).

Key words: Born model; calcium oxide; elastic moduli; pressure derivatives; pulse superposition technique; temperature derivatives.

The room temperature adiabatic elastic moduli of CaO were obtained using a pulse superposition technique to measure the ultrasonic velocities. The elastic moduli were found to be (in GPa) at 298 K.

$$c_{11} = 226.2 \pm 0.9$$

$$c_{12} = 62.4 \pm 0.9$$

$$c_{44} = 80.6 \pm 0.3$$

The pressure derivatives of the elastic moduli, which were measured at below room temperature, decrease with decreasing temperature. The temperature derivatives of the elastic moduli were also obtained for several temperatures below room temperature.

17704. Fahey, D. W., Schearer, L. D., Parks, W. F., **High-flux beam source of fast neutral helium**, *Rev. Sci. Instrum.* **49**, No. 4, 503-506 (Apr. 1978).

Key words: high flux source; neutral helium atoms.

A high-flux beam source of fast neutral helium has been constructed by extending the designs of previous authors. The source is a dc or pulsed electric discharge in an expanding gas nozzle. The beam produced has a flux on the order of 10¹⁵ atoms/ssr and a mean velocity on the order of 10⁷ cm/s. The composition of the beam has been determined by the use of particle detectors and by the observation of the excitation of certain target gases. An upper bound of 3.7 × 10⁻⁵ has been estimated for the He(2³S₁)/He(1¹S₀) beam density ratio and a value of 0.2 found for the He⁺/He(1¹S₀) beam density ratio.

17705. Faller, J. E., **Laser ranging to the moon: Eight years of scientific progress**, *Proc. Laser 77 Opto-Electronics Conf., Munich, Germany, June 20-24, 1977*, pp. 1-11 (IPC Science and Technology Press, Ltd., Surrey, England, Apr. 1978).

Key words: Apollo, geophysics; history; lasers; lunar ranging relativity.

This paper is based on the highlights address given by Dr. Faller at LASER 77 in Munich. It describes what is involved in lunar laser ranging, discusses some of the experiments and scientific accomplishments during the past eight years and gives some history of the experiment.

17706. Feldman, A., Waxler, R. M., Horowitz, D., **Photoelastic constants of germanium**, *J. Appl. Phys. Commun.* **49**, No. 4, 2589-2590 (Apr. 1978).

Key words: acoustic-optic; birefringence; elasto-optic; figure of merit; germanium; photoelasticity; piezo-birefringence; piezo-optic; pressure; refractive index; stress.

The photoelastic constants of Ge have been measured at 3.39 and at 10.6 μm. Our stress-birefringence data join smoothly to earlier stress-birefringence data at other wavelengths. The acousto-optic figure of merit M_2 , computed from our data, agrees well with M_2 determined for commercial acousto-optic devices. However, our data disagree with some earlier measurements of M_2 , the elasto-optic constants p_{ij} , and the change of refractive index with hydrostatic pressure dn/dP .

17707. Fine, J., Gorden, R., Jr., **Visual ion-beam images produced by electron and ion-beam interaction on surfaces**, *J. Appl. Phys.* **49**, No. 3, 1236-1240 (Mar. 1978).

Key words: electron beams; insulators; ion beams; phosphors; surfaces; visual images.

Two-dimensional images of 1–5-keV ion beams incident on solid surfaces have been obtained by a method similar to that used in a scanning electron microscope. This easily applied technique produces visual real-time images, whose size correlates well with beam-current profile measurements; actual photographs of two such images obtained for different width ion beams are presented. Various target materials have been examined, but only insulators were found effective in producing ion-beam images by this method. Some mechanisms that may relate to the interaction of ion and electron beams on surfaces are discussed. Those processes that seem to be basic to understanding the surface interactions responsible for this imaging effect are enhanced surface conductivity and charge neutralization. The technique itself has direct application to ion-beam alignment and diagnostics. The use of coincident ion and electron beams presents a new technique that is potentially useful for the investigation of surface interactions.

17708. Fisher, G. B., Erikson, N. E., Madey, T. E., Yates, J. T., Jr., **X-ray photoemission study of physically adsorbed SF₆**, *Surf. Sci.* **65**, 210-228 (1977).

Key words: adsorption; ESCA; physical adsorption; rutherfordium; sulphur hexafluoride; x-ray photoelectron spectroscopy.

The physical adsorption of octahedral SF₆ on Ru(001) has been studied with x-ray photoelectron spectroscopy (XPS) in an attempt to see effects on the energy levels resulting from the conformation of the molecule on the surface. Near 80 K surface coverages up to a monolayer have been studied at various steady state pressures of SF₆. Kinetic studies, core level binding energies, and peak areas indicate that the surface species studied was a physically adsorbed monolayer of SF₆. The sticking coefficient of SF₆ at ≈80 K is approximately unity. Also, a multilayer structure was observed at the highest pressures of SF₆. The binding energy of the F(1s) peak for monolayer coverage is centered at 688.2 ± 0.2 eV relative to the Ru Fermi level, while the multilayer F(1s) peak is shifted more than 3.5 eV to higher binding energy. The F(1s) linewidth for one

monolayer has a full width at half maximum of 1.75 ± 0.1 eV. The F(1s) linewidth of the multilayer peak narrows with increasing coverage. Its narrowest observed linewidth was 1.35 eV ± 0.1 eV or approximately the same as that found in the gas phase. One of the mechanisms which may account for the F(1s) linewidth with monolayer coverage is a difference in F(1s) binding energy between those F atoms in contact with the substrate and those further away. This may be due to the variation in chemical environment and relaxation effects as a function of distance from the substrate. A classical image force calculation including finite screening effects of the substrate indicates that there is a differential binding energy, ΔW , between the F ligands; $\Delta W = 0.85 \pm 0.25$ eV, for realistic ranges of adsorption distances from the substrate and screening lengths in the substrate. The observed broadening of the monolayer F(1s) level is consistent with a ΔW of 0.7 ± 0.1 eV, indicating the possible existence of such a mechanism. Adsorption of a monolayer of SF₆ onto the Ru covered with a monolayer of oxygen shifts the F(1s) peak to lower binding energy by 0.8 eV. Similar effects due to oxygen have been observed previously in the physical adsorption of Xe on W(111).

17709. Freund, S. M., Stephenson, J. C., **Laser enhanced chemical reaction between O₃ (001) and NO**, *Chem. Phys. Lett.* **41**, No. 1, 157-159 (July 1, 1976).

Key words: chemical reaction; laser; laser enhanced chemical reactions; nitric oxide reactions; ozone reactions; reaction kinetics.

A CO₂ TE laser excited fluorescence experiment demonstrated that ozone in the (001) vibrational state causes the enhancement in the rate constant recently observed for the reaction $O_3^+ + NO \rightarrow NO_2^* (^2B_1) + O_2$. Rate constants for vibrational deactivation of O₃⁺ by NO₂ and O₂ at $T = 298$ K were measured by observing the 10 μm fluorescence from O₃, with the results $k_{O_3-NO_2} = 5900 \pm 660$ s⁻¹ torr⁻¹ and $k_{O_3-O_2} = 605 \pm 50$ s⁻¹ torr⁻¹. The total rate of removal of O₃⁺ by NO was determined from NO₂^{*} fluorescence measurements and agrees with the value currently in the literature.

17710. Garrett, D. A., Berger, H., **The technological development of neutron radiography**, *At. Energy Rev.* **15**, No. 2, 125-142 (1977).

Key words: inspection; neutron interrogation; neutron radiograph; nondestructive evaluation; nondestructive inspection; radiography.

Neutron radiography is a relatively recent technological development in the annals of nondestructive evaluation. It promises to play a role of increasing importance as the technology is further developed. The technique is placed in perspective with regard to other nondestructive evaluation methods in this paper. The history of the development of neutron radiography is traced to the early work of Becker, Bothe and the Joliot-Curies in Europe, and to the work of Chadwick in Great Britain. Details of the experiments which led to the discovery of the neutron by Chadwick in 1932, nuclear properties and energy classifications of neutrons, and the various interactions of neutrons with matter are discussed in detail. A history of neutron radiography is presented which outlines the early experiments by Kallmann and Kuhn; these experiments led to the production of the first neutron radiograph in Germany in 1938. The paper continues with a description of the general techniques that are characteristic of the neutron radiographic process. The breadth and extent of present neutron radiographic technology is discussed as a conclusion of the paper.

17711. Garrity, S. D., **A review of an administrative experiment in organization design: Some lessons**, *Proc. 9th Annual Conf.*

American Institute for Decision Sciences, Chicago, IL, Oct. 19-21, 1977, pp. 398-400 (American Institute for Decision Sciences, Atlanta, GA, Oct. 1977).

Key words: administrative experimentation; evaluation; evaluation research; organizational design; policy analysis; program evaluation.

An Administrative experiment in organization design was recently conducted by the Experimental Technology Incentives Program (ETIP) with a regulatory commission and a related organization. The experiment consisted of two phases: one which involved changing the design of an organization used to develop regulatory standards, and another to evaluate the effects of these changes. The purpose of this paper is to review this experience for some lessons learned about the conduct of administrative experiments. Different phases of the experiment will be discussed and some major problems identified. A final section will present some conclusions and recommendations for future experiments.

17712. Glasser, M. L., Olver, F. W. J., **Asymptotic behaviour of integrals of Bessel functions of high order**, *Utilitas Math.* **12**, 225-239 (1977).

Key words: Airy functions; asymptotic approximation; Barnes integral; Bessel functions; Legendre functions; Meijer G-function.

Two methods are developed for the approximate evaluation of infinite integrals of products of Bessel functions when the order of these functions is large. The first method is to transform the integral into a contour integral of Barnes' type, and then approximate the resulting Gamma functions by Stirling's formula. The second method is to approximate the Bessel functions by their uniform asymptotic approximations in terms of elementary or Airy functions.

17713. Goodman, D. W., Madey, T. E., Ono, M., Yates, J. T., Jr., **Interaction of hydrogen, carbon monoxide, and formaldehyde with ruthenium**, *J. Catal.* **50**, 279-290 (1977).

Key words: carbon monoxide; chemisorption; formaldehyde; hydrogen; ruthenium.

The interaction of H₂, CO, and H₂CO with a clean (110) ruthenium surface has been studied using temperature-programmed desorption methods. Although Ru is known to be an excellent catalyst for methane production via hydrogenation of CO, no observable CH₄ was produced over Ru(110) at H₂ ± CO pressures up to ~10⁻³ Torr, due to kinetic limitations. Also, no CH₄ was observed to desorb from coadsorbed H₂ + CO. Formaldehyde dissociates upon adsorption on Ru(110) and yields H₂ and CO as the dominant desorption products. In addition, a small (~0.1% of a monolayer) amount of CH₄ was also seen following H₂CO adsorption. This CH₄ presumably originates from the thermal decomposition of a low-concentration oxygenated hydrocarbon complex. The relationship between this complex and the catalytic intermediate in the methanation reaction is explored.

17714. Goodman, D. W., Yates, J. T., Jr., Madey, T. E., **Interaction of methanol with ruthenium**, *Chem. Phys. Lett.* **53**, No. 3, 479-482 (Feb. 1, 1978).

Key words: catalytic methanation; chemisorption; methanol; ruthenium.

The interaction of methanol with a clean (110) ruthenium surface has been studied using temperature programmed desorption methods. Methanol dissociates upon adsorption at 300 K and yields H₂(g) and chemisorbed CO as the dominant products. Randomization of evolved hydrogen was shown to

occur during methanol adsorption and also upon subsequent thermal desorption using isotopically labeled methanol, CH_3OD . In addition to hydrogen and CO, small amounts of H_2CO , CH_3OH , CO_2 , and H_2O , are also observed upon thermal desorption. In contrast with a previous study of formaldehyde on Ru(110), no detectable CH_4 product is found upon methanol desorption.

17715. Hastie, J. W., McBee, C. L., **Mechanistic studies of halogenated flame retardants: The Antimony-Halogen System**, (Proc. Symp. Southwest Research Institute, San Antonio, TX, Apr. 23-24, 1975), *ACS Symp. Series 16, Halogenated Fire Suppressants*, R. G. Gann, Ed., Paper 4, 118-146 (American Chemical Society, Washington, DC, 1975).

Key words: antimony chlorides; fire retardants; flame inhibition; flame radicals; mass spectrometry.

A fundamental study of the chemical interactions leading to flame inhibition is described for systems containing antimony oxide and a chlorine containing component.

17716. Herron, J. T., Huie, R. E., **Stopped-flow studies of the mechanisms of ozone-alkene reactions in the gas phase. Ethylene**, *J. Am. Chem. Soc.* **99**, No. 16, 5430-5435 (Aug. 3, 1977).

Key words: alkene reactions; ethylene; gas-phase; ozone-alkene reactions in the gas-phase.

The reaction of ozone with ethylene has been studied in the gas phase at 298 K and 1.1 kPa (8 Torr), using a stopped-flow reactor coupled to a beam-sampling mass spectrometer. The concentrations of C_2H_4 and the products CO_2 , H_2O , CH_2O , HCOOH , CH_3OH , and an unidentified product at mass 43 were measured as a function of reaction time. Using a computer model, the role of free radicals in the reaction was quantitatively assessed, and a complex free-radical mechanism proposed. The initial reactions occurring are postulated to be: $\text{C}_2\text{H}_4 + \text{O}_3 \rightarrow \text{CH}_2\text{O} + \text{CH}_2\text{O}_2$; $\text{CH}_2\text{O}_2 \rightarrow [\text{HCOOH}] \rightarrow \text{H}_2\text{O} + \text{CO}$ (67%); $\text{CH}_2\text{O}_2 \rightarrow [\text{HCOOH}] \rightarrow \text{H}_2 + \text{CO}_2$ (18%); $\text{CH}_2\text{O}_2 \rightarrow [\text{HCOOH}] \rightarrow 2\text{H} + \text{CO}_2$ (9%); $\text{CH}_2\text{O}_2 \rightarrow [\text{HCOOH}] \rightarrow (\text{M?}, \text{ wall?}) \text{HCOOH}$ (6%). If these results hold under atmospheric conditions, they imply that considerably fewer free radicals are produced in the reactions of ozone with terminal alkenes than previously assumed.

17717. Heydemann, P., Tilford, C., Angel, W., **Ultrasonic interferometer manometers: 10^{-5} torr resolution**, *Proc. 22d Int. Instrumentation Symp., San Diego, CA, May 25-27, 1976*, pp. 69-75 (Instrument Society of America, Pittsburgh, PA, 1976).

Key words: manometer; mercury; pressure; ultrasonic interferometer; vacuum.

The principal tasks in operating a manometer are to locate the positions of the liquid menisci, to transfer the positions to a scale and to measure the distance between these positions and a common reference line. In the ultrasonic manometer the positions of the liquid menisci are sensed by ultrasonic wave trains and the distances are measured in terms of the known wavelength of sound in the liquid. This measurement is performed automatically, rapidly, and without operator interference. A prototype instrument with a full scale range of 13 kPa (100 torr) and a resolution of 0.05 Pa (5×10^{-5} torr) has been constructed and will be described.

17718. Hirshfeld, A. T., Hoppes, D. D., Schima, F. J., **Germanium detector efficiency calibration with NBS standards**, *Proc. ERDA X- and Gamma-Ray Symp., Ann Arbor, MI, May 19-21, 1976*, pp. 90-93 (Available as ERDA Conf. 760539 from the National Technical Information Service, Springfield, VA, 1976).

Key words: data analysis; detector efficiency calibration; gamma-ray measurement.

The efficiency calibration of two complementary germanium detectors has provided a means of comparing the gamma-ray emission rates of all suitable radioactivity standards currently available at the National Bureau of Standards. This procedure has not only checked the activity calibrations and the accepted gamma-ray probability per decay for each gamma ray, but has served to illustrate precautions necessary for the use of the standards in accurate detector calibrations. Our approach has been initially to use rather idealized conditions (low rates, geometrical efficiencies of about 0.1 percent of 4π , well-separated peaks) to establish the characteristics of the detector systems, then to observe discrepancies as these conditions are relaxed. A constant-dead-time pulse-height-analysis system allows monitoring of the operating parameters during data collection and statistical evaluation from repeated measurements. An expansion of the logarithm of a detector efficiency in powers of the energy fits extensive energy regions with only small systematic deviations and provides an interpolation function. The calibration curve for a 30-cm³ coaxial Ge(Li) detector contains 24 points between 88 and 2754 keV, with an average deviation from a fitted function of about 1/2 percent. The detector systems have been used to measure directly a probability per decay for many gamma rays from standards of ^{75}Se , ^{110m}Ag , and ^{152}Eu whose activities had been determined by methods essentially independent of decay-scheme parameters.

17719. Hollis, J. M., Snyder, L. E., Lovas, F. J., Buhl, D., **Radio detection of interstellar DCO^+** , *Astrophys. J.* **209**, L83-L85 (Oct. 15, 1976).

Key words: chemical fractionation; deuterium; dust clouds; emission lines; formyl ion; radio astronomy.

The $J = 1-0$ transition of the deuterated formyl ion, DCO^+ , has been detected in emission from NGC 2264 and DR 21(OH) and from the cool dust cloud L134. Estimates for the column density ratios of H^{13}CO^+ to DCO^+ are given for NGC 2264 and DR 21(OH); lower limits for the ratios are given for five other clouds. The DCO^+ detection in L134 provides unique observational evidence in support of chemical fractionation. The L134 results also suggest that the dust clouds may act as repositories for primordial deuterium.

17720. Hollis, J. M., Ulich, B. L., Snyder, L. E., Buhl, D., Lovas, F. J., **A radio search for interstellar CO^+ , HCN^+ , HNC^+ , and CN^+ ions**, *Astrophys. J.* **219**, No. 1, 74-76 (Jan. 1, 1978).

Key words: interstellar sources; ions; microwave spectra; molecular lines; radio astronomy; rotational spectra.

The $N = 1-0$ transition of CO^+ , with components $J = 1/2-1/2$ at 117.692 GHz and $J = 3/2-1/2$ at 118.102 GHz, has been searched for but not found in molecular clouds showing strong emission from the $J = 1-0$ transition of carbon monoxide. Rotational transition rest frequency calculations were made for HCN^+ , HNC^+ , and CN^+ ; subsequent interstellar searches were conducted for these ions, but none was detected.

17721. Holmer, C. I., Lubman, D., **Comparison of microphone traverse and microphone array for determining space average sound pressure level in a reverberation room**, *Noise Control Eng.* **7**, No. 2, 64-70 (Sept./Oct. 1976).

Key words: error of sound power measurement; microphone array; noise; noise measure; reverberation room; sound power measurement; standard test procedures for sound power measurement.

A feasibility study of a particular reverberation room design is described in which the effectiveness of different systems for finding the space average sound level of the sound field in that reverberation room is studied. The specific systems include a fixed microphone array, a single circular microphone traverse, and a single linear microphone traverse.

The relative effectiveness of each system is evaluated using the limited measurement volume which is permitted when measurements are performed in accordance with American National Standard S1.21, "Methods for the determination of sound power output of small sources in reverberation rooms." Comparisons with the objectives for measurement precision established in this standard are made. It is concluded that none of the systems meets the precision objectives without additional reduction of the spatial variations of a pure tone sound field such as is provided by a rotating diffuser. Alternatively, with an "effective" rotating diffuser, it is found that the circular traverse and array systems are nearly adequate for the precision objectives. The choice between the systems may thus be based on other factors such as cost, ease of implementation or operational flexibility.

17722. Jackson, J. A., Lias, S. G., Ausloos, P., **An ion cyclotron resonance study of the structures of $C_7H_7^+$ ions**, *J. Am. Chem. Soc.* **99**, No. 23, 7515-7521 (Nov. 9, 1977).

Key words: benzyl ions; hydride ion transfer; ion cyclotron resonance; ion molecule rate constants; ion structures; isomerization; tropylium ions.

The $C_7H_7^+$ fragment ions formed in toluene, and the chlorinated, brominated, and iodinated toluenes, as well as the $C_7H_8F^+$ fragment ions in fluorinated toluenes have been studied in an ion cyclotron resonance spectrometer. In all these systems, it is seen that there are two populations of $C_7H_7^+$ ions, one of which reacts with the parent compound and other compounds, and one of which is totally unreactive. Because the reactive $C_7H_7^+$ ions from the different precursors all undergo the same reactions and at the same rate as the $C_7H_7^+$ ions in toluene and benzyl chloride, which have previously been shown to have the benzyl structure, this structure is assigned to the reactive $C_7H_7^+$ populations; the unreactive $C_7H_7^+$ ions are assigned the tropylium structure. The relative abundance of the unreactive tropylium ion is low (< 15%) in the chloro-, bromo-, and iodotoluenes, and decreases with decreasing energy of the ionizing electrons. This is interpreted to mean that the rearrangement to the seven-membered ring structure occurs after the fragment ion is formed. In toluene and fluorotoluenes, the unreactive component comprises 30-60 percent of the $C_7H_8X^+$ ($X = H, F$) ions, and decreases with increasing energy of the ionizing electrons, indicating that rearrangement occurs prior to the fragmentation of the parent ion. Rate constants for the hydride transfer to the benzyl ion from cyclopentane, cyclohexane, 3-methylpentane, and 3-methylhexane are reported. An estimate that $\Delta H_f(C_6H_5CH_2^+) = 219 \pm 4$ kcal/mol is based on the assumption that the maximum endothermicity of reaction is given by $-RT \ln k_{RN}/k_{collision}$, as well as on determinations of equilibrium constants for the reactions $C_6H_5CH_2^+ + (CH_3)_3CX \rightleftharpoons (CH_3)_3C^+ + C_6H_5CH_2X$ where $X = Br$ or Cl . The relative abundances of benzyl and tropylium ions determined by this technique in various compounds are compared with analogous results from collisional activation spectra. Tolly ions, if formed, rearrange to the more stable benzyl ion structure within 10^{-8} s.

17723. Jacox, M. E., **Matrix isolation study of the infrared spectrum and structure of the CH_3 free radical**, *J. Mol. Spectrosc.* **66**, 272-287 (1977).

Key words: CH_3 - d_n ; infrared spectrum; matrix isolation; molecular structure; quartic anharmonicity; rotational energy levels; vibrational band centers.

A reproducibly good yield of CH_3 has been obtained in matrix isolation studies of the products of the interaction of CH_4 with electronically excited argon atoms produced in a microwave discharge. Detailed observations have been conducted in the ν_2 vibrational fundamental region of all of the CH_3 - d_n species isolated in an argon matrix at temperatures between 11 and 20 K. The temperature dependence of the CH_3 - d_n band structures is in good agreement with that calculated for the superposition of low- J rotational transitions on the ν_2 vibrational absorption of the planar molecule; the rotational energy levels do not undergo major perturbation in the argon matrix environment, and there is no evidence for the occurrence of inversion splitting. Rotational structure has also been observed in the ν_4 absorption of CH_3 . The argon matrix observations have confirmed that the previously reported quartic anharmonicity of CH_3 is a molecular property rather than a result of matrix interactions.

17724. Jacox, M. E., **Matrix isolation study of the interaction of excited argon atoms with CF_2Cl_2 , CF_2ClBr , and CF_2Br_2 . Infrared spectra of the CF_2Cl^+ and CF_2Br^+ molecular ions**, *Chem. Phys. Lett.* **54**, No. 1, 176-180 (Feb. 15, 1978).

Key words: CF_2Br^+ ; CF_2Cl^+ ; CF_2Br_2 ; CF_2Cl_2 ; CF_2ClBr ; excited argon atom reactions; infrared spectrum; matrix isolation.

The infrared absorptions associated with the two C—F stretching fundamentals of CF_2Cl^+ and CF_2Br^+ have been identified in studies of the matrix-isolated products of the interaction of excited argon atoms with CF_2Cl_2 , CF_2ClBr , and CF_2Br_2 . The exceptionally high values of the C—F stretching frequencies obtained in these experiments are consistent with the implications of previous experimental and theoretical studies.

17725. Jacox, M. E., Milligan, D. E., **Matrix isolation study of the infrared spectrum of thioformaldehyde**, *J. Mol. Spectrosc.* **58**, 142-157 (1975).

Key words: CH_3SH ; CH_3S ; dimethyldisulfide; infrared spectrum; matrix isolation; pyrolysis; *s*-trithiane; thioformaldehyde; ultraviolet photolysis; vacuum ultraviolet photolysis.

H_2CS has been trapped in argon and nitrogen matrices at 14 K as a product of the pyrolysis of *s*-trithiane or $(CH_3)_2S_2$ and of the ultraviolet or vacuum ultraviolet photolysis of CH_3SH . A small concentration of H_2CS has also been observed upon vacuum ultraviolet photolysis of a mixture of CH_4 and H_2S in an argon matrix. The isotopic data support the assignment of absorptions at 993 and at 1063 cm^{-1} to the out-of-plane deformation and the C = S stretching fundamentals of H_2CS . Absorptions in the CH stretching region which were assigned to H_2CS in an earlier gas-phase study were confirmed in the matrix experiments. Studies of the vacuum ultraviolet photolysis of CD_3SH have provided information on the mechanism of the photolysis process.

17726. Jacox, M. E., Milligan, D. E., **Matrix isolation study of the products of the interaction of electrons and of argon atoms in excited Rydberg states with $HCClF_2$** , *Chem. Phys.* **16**, 381-392 (1976).

Key words: chemiionization; electron capture; excited argon atom reactions; exciton diffusion; $HCClF_2$; $HCClF_2^-$; HCF_2^- ; infrared spectrum; matrix isolation; molecular structure; ultraviolet spectrum; vacuum ultraviolet photolysis.

Infrared absorptions of the $(ClCF)_2 \cdots H-F^-$ and HCF_2^- anions have been identified in the spectrum of the products of the photolysis of $HCClF_2$ isolated in an argon matrix at 14 K

using radiation in the 147-105 nm spectral range. These anions are also produced in matrix experiments in which the Ar:HCClF₂ sample is codeposited with an atomic beam of sodium and charge transfer processes are induced by mercury arc radiation, as well as in experiments in which the sample is codeposited with a beam of argon that has been passed through a microwave discharge. Both the spectral data and molecular orbital calculations for HCF₂⁻ indicate that this molecule has an exceptionally weak C-H bond and that its apex angle is considerably more acute than that of the uncharged HCF₂ radical. The high threshold for ion production from HCClF₂ dictates consideration of the role played by highly excited Rydberg states of argon in the discharge experiments. It appears probable that the charge transfer occurs between these excited argon atoms and HCClF₂. The high ion yield typical of the discharge experiments is also consistent with product formation resulting from collision of matrix-isolated HCClF₂ with free excitons formed by the impact of highly excited argon atoms at the surface of the solid deposit.

17727. Jacox, M. E., Milligan, D. E., **Matrix isolation study of the products of the interaction of electrons and metastable argon atoms with HCCl₂F**, *Chem. Phys.* **16**, 195-208 (1976).

Key words: argon metastables; CCl₂; (CCl₂)HF anion; electron capture; HCClF anion; HCCl₂F; hydrogen bonding; infrared spectrum; matrix isolation; ultraviolet spectrum; vacuum ultraviolet photolysis.

Two groups of infrared absorptions common to experiments in which samples of HCCl₂F isolated in an argon matrix at 14 K are exposed to vacuum ultraviolet radiation or to electrons produced by ultraviolet irradiation of an alkali metal, as well as to experiments in which the Ar:HCCl₂F sample is codeposited with a beam of argon atoms excited in a microwave discharge, have been assigned to anions produced upon associative and dissociative electron capture by HCCl₂F. Detailed isotopic substitution studies suggest that these anions are (Cl₂C)···H-F⁻, representing a unique type of hydrogen bonding, and HCClF⁻. The HCClF⁻ anion photodecomposes in the 345-250 nm spectral region, but the products of its photodecomposition have not been identified. Both CCl₂ and Cl₂CF are also produced in the discharge experiments, but there is no evidence for the production of HCF. Mechanisms for the formation of ion products by electron capture and by exposure of HCCl₂F to radiation or to excited argon atoms of energy equal to or less than 11.8 eV are considered.

17728. Jerke, J. M., Hartman, A. W., Nyyssonen, D., Rosberry, F. W., Swing, R. E., Swyt, D. A., Young, R. D., **Accurate line-width measurements at the National Bureau of Standards**, (Proc. Kodak Microelectronics Seminar, Monterey, CA, Oct. 3-5, 1976), *Kodak Publ. No. G-47*, pp. 51-59 (Eastman Kodak Co., Rochester, NY, 1977).

Key words: linewidth measurements; microelectronics; micrometrology; optical microscopes; photomasks; semiconductor technology.

The current progress of the NBS program to develop primary measurement calibration of 1 to 10 μm line widths on integrated-circuit photomasks, to develop improved theory for accurate line-width measurements with optical microscopes, and to provide calibrated measurement artifacts and measurement procedures are discussed. Calculated line-width image profiles for known conditions of partial coherence, defocus, and spherical aberration in an optical microscope are given. These calculated image profiles are compared with photometric image profiles obtained from an optical-microscope measurement system. The effects of image polarity (clear or opaque) and edge-location criteria on line-width measurements made

with filar and image-shearing eyepieces are discussed. A polarization interferometer located in a scanning electron microscope has been developed to make the primary line-width calibrations. The measurement assurance program used to transfer line-width measurements from NBS to the microelectronics industry is described.

17729. Kelley, R. D., Madey, T. E., Revesz, K., Yates, J. T., Jr., **Kinetics of carbon monoxide hydrogenation on a polycrystalline nickel ribbon catalyst**, *Appl. Surf. Sci.* **1**, 266-277 (1978).

Key words: catalysis; kinetics; methanation; nickel; surface chemistry.

Ultrahigh vacuum procedures have been employed to highly purify reactant gases and to prepare a clean Ni ribbon for use as a methanation catalyst in a static reactor. The kinetics of CO-hydrogenation to produce CH₄ have been studied over a Ni catalyst temperature range of 600-740 K using 4 H₂:1 CO at a total pressure of 120 Torr. Under these conditions, the reaction was found to be highly selective (less than 1% higher hydrocarbons produced). Small amounts of CO₂ were also produced continuously during methanation. The initial rate of CH₄ production was used to estimate the activation energy (66 kJ mole⁻¹) in this temperature range. Satisfactory agreement was observed between our rate measurements (turnover numbers) made on a 10 cm² Ni ribbon and other kinetics studies made on supported Ni catalysts of much larger surface area. A comparison of data from different laboratories suggests that the methanation activation energy falls as the Ni temperature is raised, and that raising the reaction temperature also produces enhanced selectivity towards CH₄ production.

17730. Klein, R., Shih, A., **Chemisorption and decomposition of nitric oxide on ruthenium**, *Surf. Sci.* **69**, No. 2, 403-427 (Dec. 2, 1977).

Key words: catalysis; chemisorption; field emission; nitric oxide; nitrogen; oxygen; ruthenium; work function.

Nitric oxide, strongly chemisorbed on ruthenium, is desorbed almost completely as oxygen and nitrogen. Oxygen, nitrogen, and nitric oxide were observed singly on ruthenium with field emission microscopy. Thermal desorption spectroscopy from Ru(10 $\bar{1}$ 0) showed that molecular nitrogen is only physisorbed but nitrogen from NO decomposition is strongly chemisorbed. Nitrogen from NO shows three binding states, the most strongly bound being present to only a small extent. NO shows three and two binding states when adsorbed at 120 K and 295 K respectively. Work function measurements gave $\Delta\phi = 1.3$ eV for a monolayer of NO. NO is dissociatively adsorbed above 250 K but a lower temperature limit was not established. The decomposition of NO on Ru(10 $\bar{1}$ 0) under high vacuum conditions is catalytic in that no oxides of ruthenium were observed to form in the process.

17731. Konopelski, J. P., Reimann, C. W., Hubbard, C. R., Mighell, A. D., Santoro, A., **Hexakis(imidazole)nickel(II) chloride tetrahydrate**, *Acta Cryst.* **B32**, Pt. 10, 2911-2913 (Oct. 1976).

Key words: hexakis(imidazole)nickel(II) chloride tetrahydrate; hydrate; hydrogen bonding; imidazole; transition metal complex; x-ray structure determination.

Ni(C₃H₄N₂)₆(Cl)₂·4H₂O, *M* = 610.1; triclinic, $P\bar{1}$; *a* = 9.084 (2), *b* = 8.808 (2), *c* = 10.566 (2) Å, α = 83.16 (2), β = 104.89 (2), γ = 118.28 (2)°, *V* = 719.5 Å³; *Z* = 1, *D_m* = 1.41 (2), *D_c* = 1.408 g cm⁻³. Final *R* = 0.043. The crystal structure consists of six planar imidazole rings coordinated to Ni with an extensive network of hydrogen bonding.

17732. Kuriyama, M., Boettinger, W. J., Burdette, H. E., **Crystal perfection in Czochralski grown nickel single crystals**, *J. Cryst. Growth* **43**, 287-300 (1978).

Key words: anomalous transmission; asymmetric crystal topography; crystal growth; crystal perfection; Czochralski growth; dislocation density; magnetic domains; x-ray dynamical diffraction.

To study the relationship between crystal growth conditions and resultant crystalline perfection, large nickel single crystals more than 12 cm long and 2 to 3 cm in diameter have been grown from the melt by the Czochralski method. The crystal perfection of as-grown nickel single crystals has been assessed by x-ray dynamical diffraction topography with an asymmetrical (double) crystal topographic (ACT) camera. Transmission topographs were obtained from crystals of thickness ranging from 0.37 mm ($\mu L = 18$) to 1.03 mm ($\mu L = 52$) using {111}, (002) and (220) diffraction. The 0-diffracted (transmitted) and the *H*-diffracted (Bragg-diffracted) beams display almost identical *disruption* images of crystal imperfections in the interior of the crystals. The types of imperfection and the degree of crystal perfection have been sorted by a set of crystal growth parameters, such as seed orientation and rotation rate. In addition to the images of crystal imperfections, there are disruption images of 71° and 109° magnetic domain walls in the topographs. In this work it has been found that nickel single crystals with perfections between 400 and 1000 dislocation lines/cm² can be produced by controlling practical process parameters, such as the rotations of the seed and the melt, and the growth directions. However, more crucial factors influencing the ultimate level of crystal perfection are governed by some crystallographic effects closely related to the behavior of dislocations in grown crystals.

17733. Levin, E. M., McMurdie, H. F., **Phase diagrams for ceramists**, *Book: 1975 Supplement*, 513 pages (American Ceramic Society, Inc., 1975).

Key words: ceramists; melting points; phase diagrams; polymorphism.

This volume is a supplement to previous publications. It contains phase diagrams on 749 systems from the literature, references to original work and commentaries outlining the method of study, accuracy, and relation to other studies in the area.

17734. Lias, S. G., **Adiabatic ionization energies from charge transfer equilibrium constants; experimental determinations of entropy changes for charge transfer equilibria**, *Chem. Phys. Lett.* **54**, No. 1, 147-153 (Feb. 15, 1978).

Key words: aromatic compounds; charge transfer equilibria; entropy; ion cyclotron resonance; ionization potentials.

Equilibrium constants have been measured as a function of temperature for the charge transfer equilibria in mixtures of NO with aromatic compounds, and mixtures of aromatic compounds. The experimentally determined entropy changes are in good agreement with entropy changes calculated from statistical mechanical considerations provided an intermolecular component is included. The enthalpy changes for the charge transfer reactions correspond to the differences in the adiabatic ionization potentials of the compounds.

17735. Lias, S. G., **Ion-molecule reactions involving fluorine-containing organic compounds**, (Proc. Symp. Division of Physical Chemistry 169th Meeting of the American Chemical Society, Philadelphia, PA, Apr. 7-11, 1975), Paper 6 in *ACS Symposium Series 66, Fluorine-Containing Free Radicals Kinetics and Dynamics of Reactions*, J. W. Root, Ed., pp. 152-187 (American Chemical Society, Washington, DC, 1978).

Key words: fluorinated ions; fluorocarbons; ion-molecule reactions; mass spectrometry; rate constants; thermochemistry.

This chapter presents a review of ion-molecule reactions occurring in fluorinated or partially-fluorinated systems. Also included is a brief discussion of the information about the heats of formation of fluorinated ions derived from studies of ion-molecule reactions.

17736. Lias, S. G., Ausloos, P., **Ion-molecule reactions involving halomethyl ions; heats of formation of halomethyl ions**, *Int. J. Mass. Spectrom. Ion Phys.* **23**, 273-292 (1977).

Key words: chloride transfer; fluoride transfer; halogenated methyl ions; halomethanes; heats of formation; ion cyclotron resonance; ion-molecule reaction; proton transfer.

This study examines the reactions of $\text{CH}_5^+(\text{CD}_5^+)$ and $\text{C}_2\text{H}_5^+(\text{C}_2\text{D}_5^+)$ ions generated in CH_4 or CD_4 , and of C_3H_7^+ ions generated in neopentane or propane with CH_3Cl , CH_2Cl_2 , CHCl_3 , CCl_4 , CH_3F , CH_2F_2 , CHF_3 , CF_4 , CH_2FCl , CHF_2Cl , CHFCl_2 , CFCl_3 , CF_2Cl_2 , and CF_3Cl . In addition, the reactions of the various halomethyl ions with the halomethanes are investigated. Rate constants were determined for all reactions observed using a pulsed ion cyclotron resonance mass spectrometer.

The $\text{CH}_5^+(\text{CD}_5^+)$ ion transfers a proton to all of these molecules. The protonated halomethanes (except CH_3ClH^+ , $\text{CH}_2\text{F}_2\text{H}$, CHF_3H^+ , and CF_4H^+) dissociate by losing HX .

The ethyl, sec-propyl ions, and halomethyl ions, abstract chloride or fluoride from the halomethanes. Chloride transfer always predominates over fluoride transfer when both channels are exothermic. Ethyl and sec-propyl ions do not undergo hydride transfer reactions with any of these molecules.

The results indicate that the heat of formation of CF_3^+ is 4.07 ± 0.09 eV (93.8 ± 2 kcal/mole). The heat of formation of CCl_3^+ lies between the limits, 8.34–8.82 eV (192–203.5 kcal/mole), and therefore is lower than previously reported values by at least 0.25 eV. The value obtained for $\Delta H_f(\text{CFCl}_2^+)$ is 6.72 ± 0.22 eV (155 ± 5 kcal/mole), and that for $\Delta H_f(\text{CHFCl}^+)$ is 7.76 ± 0.22 eV (179 ± 5 kcal/mole).

17737. Lindstrom, R. M., **Radial efficiency gradients in Ge(Li) gamma detectors**, *J. Radioanal. Chem.* **39**, 153-161 (1977).

Key words: accuracy and precision; efficiency of detectors; gamma-ray detectors; Ge(Li) detectors; geometry of counting; semiconductor detectors.

Counting of radioactive sources in contact with the vacuum container of a Ge(Li) detector may lead to errors because of large efficiency gradients. In order to explore the radial dimension of this problem, several point sources were stepped across in contact with the cap of several detectors, and curves of absolute efficiency against radius were measured. The insensitive core of an open-end coaxial detector reduced the central point-source efficiency at 122 keV at the cap to 20 percent less than a comparable closed-end detector. In compensation, however, there was a reduction in the radial efficiency gradient. The radial efficiency gradient was approximately proportional to the radius, with the central flattening for the open-end detector superimposed on the trend.

17738. MacDonald, R. A., Tsai, D. H., **Energy transport in a crystalline solid subjected to intense excitation**, *Proc. Int. Conf. on Lattice Dynamics, Paris, France, Sept. 5-9, 1977*, pp. 156-159 (Flammarion Science, Paris, France, 1978).

Key words: crystals; heat pulse; high pressure; high temperature; molecular dynamics; second sound; shockwave; thermal diffusion; thermal relaxation.

We have used the method of molecular dynamics to study thermal relaxation processes in a solid at high pressures and high temperatures. We have studied thermal diffusion, heat pulse propagation and shock wave propagation in a perfect, monatomic bcc lattice. The details we obtain are helpful to our understanding of the phenomenon of second sound, and in the interpretation of shock wave data. The importance of thermal relaxation processes in a strongly coupled system is clearly demonstrated.

17739. Madey, T. E., Czyzewski, J. J., Yates, J. T., Jr., **Ion angular distributions in electron stimulated desorption: Adsorption of O₂ and H₂ on W(100)**, *Surf. Sci.* **49**, 465-496 (1975).

Key words: adsorption; angular distribution; chemisorption; desorption; electron stimulated desorption; hydrogen; ion desorption; oxygen; tungsten.

The angular distributions of ions liberated by electron stimulated desorption (ESD) of H⁺ and O⁺ from adsorbed layers of oxygen and hydrogen on the (100) surface of tungsten have been examined. The resultant patterns of ion emission are observed visually in a display-type apparatus. Two types of ESD angular distribution patterns are observed: (1) hazy patterns with ill-defined boundaries, and (2) patterns in which the ions are liberated in well-defined cones of emission whose directions are correlated with the symmetry of the underlying substrate. These latter patterns are postulated to arise from ESD from a directionally-bonded adsorbate in which the direction of the ground state adsorbate-substrate bond may be preserved in ion desorption.

17740. Madey, T. E., Yates, J. T., Jr., Sandstrom, D. R., Voorhoeve, R. J. H., **Catalysis by solid surfaces**, Chapter 1 in *Treatise on Solid State Chemistry*, N. B. Hannay, Ed., 6B, 1-124 (Plenum Publishing Corp., New York, NY, 1976).

Key words: catalysis; chemisorption; heterogeneous catalysis.

This chapter gives an overview of current concepts in catalysis of predominantly simple reactions. Catalysts covered are metals, semi-conducting oxides, and sulfides. The emphasis is on the connections between solid-state chemistry/physics, spectroscopy, and surface physics in ultrahigh vacuum on the one hand and catalysis on the other hand. For physicists and materials scientists of various plumage, the chapter is expected to serve as a concise (but not oversimplified) primer.

17741. Mandel, J., **Statistics and standard reference materials**, *ASTM Stand. News* **5**, No. 10, 10-15 (Oct. 1977).

Key words: evaluation of testing methods; measurement methods; standard reference materials; statistical model for measuring processes; statistical techniques; testing methods.

The purpose of this paper is to place the use of standard reference materials in proper perspective within the larger framework of the evaluation of measuring and testing methods. According to the dictionary, the term *measurement* has a dual

meaning: "the act or process of measuring," and a "figure, extent, or amount obtained by measuring." The distinction is not pedantic for while we are often interested in the quality of an *individual* measurement result, we cannot, in general evaluate this quality except through a study of the *method* by which the result was obtained. The situation is presented schematically in figure 1.

17742. Mangum, B. W., Thornton, D. D., **The importance of temperature standardization in medicine**, *Lab. Manage.*, pp. 32-37 (Jan. 1978).

Key words: biomedical; clinical laboratory; gallium; medicine; melting point; thermometry.

After a brief discussion of the requirements and problems of thermometry in medicine, we describe how, in a program to develop temperature fixed points in the range of biomedical interest, we have developed a point in the clinically important region near 30 °C. This fixed-point is a consequence of and is realized by the latent heat involved in the first-order phase transition exhibited by gallium metal at its liquid-solid equilibrium point. A general discussion is given of the melting and freezing behavior of pure metals. To check the suitability of the gallium system for use by the biomedical community, we have investigated the melting behavior of a few grams of pure gallium contained in a small Teflon container under an inert gas having a nominal pressure at one atmosphere. The melting point of gallium in such an environment is highly reproducible, easily realized, and has the value 29.7723 ± 0.0007 on the International Practical Temperature Scale of 1968. It has been proposed that the melting-point of gallium, as realized in SRM 1968, provides a convenient fixed-point temperature suitable for use as the *the* temperature for enzyme reference methods in clinical enzymology, as well as for use in accurate calibrations in general applications.

17743. Mann, W. B., **Reliability and traceability in radioactivity measurements**, *Proc. Southeastern Workshop on the Utilization and Interpretation of Environmental Radiation Data, Orlando, FL, Mar. 1-3, 1976*, pp. 199-207 (1976).

Key words: activity; intercomparative measurements; measurements; radioactivity standards; traceability.

The use of radioactivity standards as they relate to data documentation will be discussed—specifically in the utilization and interpretation of environmental radiation data. The reliability and traceability in radioactivity measurements will be dealt with in some detail and the role that the Radioactivity Section performs in this area.

17744. Unassigned.

17745. Martin, D. J., Rhyne, J. J., **Re-analysis of dysprosium magnetostriction**, *J. Phys. C* **10**, 4123-4126 (1977).

Key words: anisotropy; domain effects; dysprosium; magnetism; magnetostriction; rare earths.

A re-analysis of earlier magnetostriction measurements on dysprosium is presented. Domain effects have been corrected for using the phase theory. The re-analysed results for the tem-

perature dependence of the magnetostriction constants and of the magnetocrystalline anisotropy energy are in reasonable agreement with theoretical predictions and the results of other experimental workers. For $T \rightarrow 0$ K it is found that $\lambda^{v,2} = (10.6 \pm 0.2) \times 10^{-3}$ and $K_6^6 = (-1.4 \pm 0.2) \times 10^6 \text{ Jm}^{-3}$.

17746. May, W. E., Wasik, S. P., Freeman, D. H., **Determination of the aqueous solubility of polynuclear aromatic hydrocarbons by a coupled column liquid chromatographic technique**, *Anal. Chem.* **50**, No. 1, 175-179 (Jan. 1978).

Key words: aqueous solubility of polynuclear aromatic hydrocarbons; coupled columns liquid chromatography; heat of solution; polynuclear aromatic hydrocarbons; salt-out effect.

A coupled column liquid chromatographic method for determining the aqueous solubility and related parameters of polynuclear aromatic hydrocarbons (PAHs) is discussed. The method is designed to avoid problems with adsorption onto container walls and offers the potential of generating known concentrations of slightly soluble organic compounds in water. The method is based on pumping water through a column containing glass beads coated with the compound being studied and has been used to measure solubilities and the temperature dependencies of the solubility of some PAHs. The precision of replicate measurements and day to day reproducibility are better than ± 3 percent.

17747. McIlrath, T. J., Lucatoro, T. B., **Laser excitation and ionization in a dense Li vapor: Observation of the even-parity, core-excited autoionizing states**, *Phys. Rev. Lett.* **38**, No. 24, 1390-1393 (June 13, 1977).

Key words: atomic-spectroscopy; autoionization; laser-excited; laser-ionization; lithium; photoabsorption.

The first optical absorption from excited states to autoionizing core-excited levels has been observed in lithium. A 1-MW dye laser tuned to the $1s^2 2s \rightarrow 1s^2 2p$ resonance produced $\sim 10^{18}$ excited atoms/cm² in a heat-pipe oven. Far-uv absorption spectra of $\text{Li}^*(2p)$ and Li^+ were obtained. A curve of the evolution from excited neutrals to ~ 95 percent ions is presented, and the significance of the Li observations for understanding the ionization mechanism is discussed.

17748. Meijer, P. H. E., Stamm, W. C., **Phase diagram and critical points for a metamagnetic Ising model using constant coupling approximation**, *Physica* **90A**, 77-96 (1978).

Key words: bicritical end point; constant coupling approximation; Curie point; FeBr_2 ; hessian; internal fields; Ising model; meta magnet; molecular field theory; random phase approximation.

We compute the isotherms and phase diagram in the constant coupling approximation for an Ising metamagnet with various values for the ratio of the ferromagnetic to the antiferromagnetic coupling parameters. The constant coupling method is set up entirely with the internal fields as the variation parameter. The search for the tricritical point, both directly and indirectly via the hessian of the internal fields led to the conclusion that this model has no tricritical point, but a critical end point. Comparing our computation with the experimental result for FeBr_2 , we find that the value for the critical end point lies closer to the experiment than either the molecular field theory or the random phase approximation.

17749. Mighell, A. D., **The reduced cell: Its use in the identification of crystalline materials**, *J. Appl. Cryst.* **9**, Pt. 6, 491-498 (Dec. 1976).

Key words: classification; crystal data; crystalline material; evaluation; identification; reduced cell.

A rapid-identification file for crystalline materials is being prepared from the Crystal Data file. In this new file, each cell is represented in its reduced form, which is unique, primitive, and based on the three shortest noncoplanar vectors of the lattice. Unknown materials can be rapidly matched with the same or related crystals in the file. To identify an unknown crystalline material, a primitive cell is first determined experimentally, then it is reduced and checked against the file for a match. Even if the cell of the unknown lattice is not primitive, identification is still possible by calculating appropriate derivative lattices, reducing them, and then checking the file.

17750. Milonni, P. W., Eberly, J. H., **Temporal coherence in multiphoton absorption. Far off-resonance intermediate states**, *J. Chem. Phys.* **68**, No. 4, 1602-1613 (Feb. 15, 1978).

Key words: ac Stark shift; adiabatic approximation; dissociation; harmonic generation; ionization; laser bandwidth; multiphoton absorption; multiphoton dynamics; non-resonant processes; n-photon Bloch equations; pole approximation; 3-photon Bloch equations.

We develop a consistent formalism for the treatment of temporal atomic or molecular coherence in multiphoton absorption. The formalism is fully quantum mechanical under the assumption that the exciting laser fields are well described by coherent states. We make use of the language and methodology of resonance physics to the extent possible, but deliberately avoid the rotating-wave approximation, and do not restrict the allowed atomic states to be finite in number or the electric field strengths to be small in magnitude. For compactness in the presentation only electric dipole transitions are considered. As all of the transitions, both stimulated and spontaneous, are due to the activation of quantum mechanical dipoles, it is most efficient to construct the formalism so that it emphasizes the role of dipole operators, and we do this. The one strong restriction imposed here, but avoided in a following paper, is to consider only multiphoton transitions that have one resonance between initial and final states and no intermediate resonance. We describe, in effect, the time dependences associated with the early multiphoton absorption calculations of Bebb and Gold.

17751. Moldover, M. R., Gallagher, J. S., **Critical points of mixtures: An analogy with pure fluids**, *AIChE J.* **24**, No. 2, 267-278 (Mar. 1978).

Key words: $\text{CO}_2\text{-C}_2\text{H}_6$; critical locus; critical point; $\text{C}_6\text{H}_{18}\text{-C}_3\text{H}_8$; equation-of-state; mixtures; $PVTx$; $\text{SF}_6\text{-C}_3\text{H}_8$; thermodynamic potential.

The thermodynamic properties of vapor-liquid equilibrium (VLE) states near the critical locus of mixtures are correlated in very close analogy with the techniques used to correlate the properties of pure fluids near a critical point. The only mixture parameters used in the correlation are the values of pressure, volume, temperature, and mole fraction ($PVTx$) along the physical critical locus. We illustrate the power of the present approach by correlating the rather extensive $PVTx$ data that exist near the critical loci of the binary mixtures: $\text{CO}_2\text{-C}_2\text{H}_6$, $\text{SF}_6\text{-C}_3\text{H}_8$, and $\text{C}_6\text{H}_{18}\text{-C}_3\text{H}_8$. Nearly all the data within 10 percent of the critical temperature may be described within their accuracy despite the occurrence of critical azeotropy or large regions of retrograde condensation.

17752. Mountain, R. D., **Collective modes in classical monoatomic liquids**, Chapter 6 in *Topics in Current Physics, Vol. 3, Dynamics of Solids and Liquids by Neutron Scattering*, S. W. Lovesey and T. Springer, Eds., pp. 301-329 (Springer-Verlag, Berlin, Germany, 1977).

Key words: collective modes in liquids; density fluctuations; fluctuations; generalized hydrodynamics; kinetic theory; liquids; neutron scattering.

Recent developments in the study of collective motions in monoatomic liquids by neutron spectroscopy are discussed within the framework of generalized hydrodynamics. The formal representation of the scattering law is discussed and specific experimental results for argon, neon, helium, rubidium, and sodium as well as molecular dynamics studies are examined. From these studies it is possible to gain new insight into the physical process in liquids at the molecular level. The theoretical efforts to calculate the generalized transport coefficients are examined and the most promising techniques are identified.

17753. Mountain, R. D., Ruijgrok, T. W., **Monte-Carlo study of the Maier-Saupe model on square and triangle lattices**, *Physica* **89A**, 522-538 (1977).

Key words: fluctuations; lattice model; Maier-Saupe model; Monte Carlo; order parameter; phase transition.

The Monte Carlo method is used to investigate the statistical physics of the Maier-Saupe model on square and triangle lattices. These systems are found to exhibit higher than first order phase transitions except for the negative coupling square lattice case. The transition is signaled by a pronounced maximum in the specific heat as a function of temperature. The mechanism of the transition is shown to be associated with the onset of partial ordering of the vectors in individual members of the ensemble. A temperature dependent internal order parameter is introduced to characterize the degree of internal order in the system since the ordering process does not break the rotational symmetry of the Hamiltonian and no macroscopic order parameter exists.

17754. Newman, M., **A note on an equation related to the Pell equation**, *Am. Math. Mon.* **84**, No. 5, 365-366 (May 1977).

Key words: diophantine equation; Dirichlet; Pell equation.

It is shown that the diophantine equation $x^2 - dy^2 = -1$ has solutions, provided that $d = p_1 p_2 \dots p_r$ where r is 2 or odd and p_1, p_2, \dots, p_r are distinct primes congruent to 1 modulo 4 such that $(p_i/p_j) = -1, i \neq j$.

17755. Nyyssonen, D., **Linewidth measurement with an optical microscope: The effect of operating conditions on the image profile**, *Appl. Opt.* **16**, No. 8, 2223-2230 (Aug. 1977).

Key words: linewidth measurement; microscopic; optical imaging; partially coherent imaging; photomask linewidth measurement; photometric image scanning.

A theoretical model of the optical microscope based on the theory of partial coherence is used to predict the image profiles of lines on IC photomasks and assess factors contributing to measurement errors for different conditions of microscope operation. A comparison of experimental and theoretical image profiles is given, showing good agreement with theory for a 0.9 N.A. and linewidths as small as 0.5 μm . The primary sources of differences appear to be edge quality and accuracy of focus. The theory indicates that for well-corrected microscope optical systems, spectrally filtered to eliminate longitudinal chromatic aberration and chromatic difference of magnification, accurate determinations of linewidth may be made from the image profile using a threshold of 25 percent of maximum intensity (corrected for finite background transmittance in the opaque region). The correspondence between the edge location and the 25 percent threshold appears to be nearly invariant with small amounts of defocus and spherical aberration as well as variation in the numerical aperture of the condenser.

17756. Odom, J. V., **Weights & measures play vital roles in metrication**, *Metric News* **4**, No. 3, 5, 11, 29 (May/June 1977).

Key words: education for metric; laws and regulations; metrication; metric system; National Conference on Weights and Measures; weights and measures.

This paper discusses the role weights and measures officials will play during the changeover to the metric system in the United States. Goals and objectives for the weights and measures community are outlined, and specific projects relating to the metric revision of Model Laws and Regulations and metric education for weights and measures officials is discussed.

17757. Oser, H. J., **An average distance, problem 75-12**, *SIAM Rev.* **18**, No. 3, 497-501 (July 1976).

Key words: adjacent squares; average distance; mathematical analysis; transportation models.

To determine the average distance between points in two adjacent unit squares, the following 4-fold integral has to be evaluated:

$$F = \int \int \int \int \{(x_1 - x_2)^2 + (y_1 - y_2)^2\}^{1/2} dx_1 dx_2 dy_1 dy_2$$

where the (x_1, y_1) and (x_2, y_2) domains are adjacent unit squares. This paper shows how the four integrations can be carried out explicitly. The value is 1.08814. This result should be of interest to workers in transportation modelling and similar fields. The problem was suggested by Charles R. Johnson.

17758. Peterlin, A., **Models of internal viscosity of polymers**, *Croat. Chem. Acta* **50**, 253-269 (1977).

Key words: hydrodynamic interaction; internal viscosity; intrinsic birefringence; intrinsic viscosity; necklace model.

One introduces the tensor $\tilde{\Phi}$ of internal viscosity as a diagonal tensor in normal coordinate space of the necklace model with Z ideally elastic links and $Z + 1$ beads. One has a substantial freedom in the choice of diagonal values. Four models are presented. If the diagonal terms are proportional to those of diagonalized link force tensor (model M2) the resistance to deformation rate of the necklace model is confined to resistance to single link deformation. A model of this kind represents a necklace, in which each link consists of an ideal spring and ideal dashpot in parallel. Any other choice of diagonal elements introduces resistance forces against deformation rate of distance between any two beads. If the relative coefficients ϕ_p/ϕ_z are smaller than those of model M2, one obtains the unrealistic situation of deformation rate enhancement by the negative values of internal viscosity coefficients between nonadjacent beads. Hence, the majority of ϕ_p/ϕ_z must be larger than, or equal to, the corresponding values of model M2. For Z between 3 and 300 $h^* = .25$ (impermeable coil), $\phi/f = 2$ the frequency dependence of intrinsic viscosity and birefringence is shown for models M1 and M2.

17759. Phillips, J. C., Mattamal, G. J., **Effect of number of carboxyl groups on liquid density of esters of alkylcarboxylic acids**, *J. Chem. Eng. Data* **23**, No. 1, 1-6 (Jan. 1978).

Key words: alkane; carboxylic esters; density; empirical; liquid; oligomer; polymer.

Liquid-density data for esters covering a molecular weight range of 88-939 (monocarboxylics; dialkyl esters series; triglyceride esters series; and oligomeric ester series) and a temperature range of 0-242.8 $^{\circ}\text{C}$ have been empirically fitted to about 1 percent to an equation of the form $\rho = \lambda + K\lambda^2 + f'(T)$, where λ is a function of the absolute temperature, T , number of carboxyl groups, N_{coo} , and the molecular weight, M ; K is a function of T , N_{coo} , and N_2 (number of methylene groups). The equation in its limiting form may be used to estimate densities of poly(carboxylic esters) from a knowledge of the structure of the repeating unit. Data for the monocarboxyl-

ics were obtained from published values, those of the sebaccate series and triglyceride series were measured dilatometrically and that of the oligomeric ester series was measured by a capillary method. The results show a rather strong dependence of the density on N_{COO} .

17760. Pickart, S. J., Alperin, H. A., Rhyne, J. J., **Small-angle magnetic scattering from a dilute amorphous Fe(Tb) alloy**, *Phys. Lett.* **64A**, No. 3, 337-339 (Dec. 26, 1977).

Key words: amorphous alloys; amorphous magnetism; magnetic clusters; rare earth materials; small angle scattering.

Low temperature neutron scattering measurements on an amorphous alloy of composition $\text{Tb}_{0.018}\text{Fe}_{0.982}$ reveal anomalous small-angle magnetic scattering similar to that observed in the more rare-earth-rich compounds TbFe_2 and HoFe_2 . Interferences are drawn from the angular dependence of the scattering concerning cluster size and magnetic structure.

17761. Pontius, P. E., Doher, L. W., **The joint ANSI-INMM 8.1—Nuclear Regulatory Commission study of uranium hexafluoride cylinder material accountability bulk measurements**, (Proc. 18th Annual Meeting of the Institute of Nuclear Materials Management, Inc., Washington, DC, June 29-July 1, 1977), *Nucl. Mater. Manage.* **VI**, No. III, 480-487 (Fall 1977).

Key words: accountability bulk measurements; nuclear material control; Nuclear Regulatory Commission; reference mass standards; uranium hexafluoride.

This paper reports the progress to date in a demonstration of the procedures in ANSI N15.18-1975, "Mass Calibration Techniques for Nuclear Material Control," sponsored and funded by the Nuclear Regulatory Commission (NRC).

The philosophy of mass measurement as a production process, as promulgated in ANSI N15.18-1975, is reviewed. Special emphasis is placed on the use of artifact Reference Mass Standards (RMS) as references for uranium hexafluoride (UF_6) calibration and bulk measurement processes. The history of the creation of the artifact concept and its adoption by ANSI N15.18-1975 and the Nuclear Regulatory Commission is narrated.

The program now under way is specifically described; including descriptions of the RMS, their calibration, and the assignment of uncertainties to them by the National Bureau of Standards (NBS). Instrument tests, in-house standards (IHS), and assignment of values relative to the RMS-NBS values at nuclear facilities which measure UF_6 cylinders are described. Comparisons and the data base are detailed to provide realistic measurement process parameters associated with accountable transfer of UF_6 .

The as yet uncompleted part of the demonstration is described, that is, to further close the measurement loop by verification both between and within facilities.

17762. Rhyne, J. J., Koon, N. C., Milstein, J. B., Alperin, H. A., **Spin waves in ErFe_2** , *Phys.* **86-88B**, 149-151 (1977).

Key words: crystal fields; exchange coupling; magnetic excitations; neutron scattering; rare earth compounds; spin waves.

Spin excitations in a single crystal of the rare earth Laves phase compound ErFe_2 have been studied using inelastic neutron scattering at room temperature and at 4 K ($T_c = 574$ K). A nearest neighbor spin wave model was used to derive the three exchange parameters from the observed dispersion relations.

17763. Ritter, J. J., **Isotopically selective CO_2 transverse excitation laser induced chemical reactions of Cl_2CF_2 and Br_2CF_2**

with olefins, *J. Am. Chem. Soc.* **100**, No. 8, 2441-2444 (Apr. 12, 1978).

Key words: difluorocarbene; direct isotope specific synthesis; isotope enrichment; laser induced chemical reactions; olefins; TE laser.

The CO_2 transverse excitation laser induced chemical reactions of Cl_2CF_2 and Br_2CF_2 with isobutylene, propylene, and ethylene have been investigated. In the $(\text{H}_3\text{C})_2\text{C} = \text{CH}_2/\text{Br}_2\text{CF}_2$ system, evidence for the initial presence of laser-produced difluorocarbene was provided by the isolation of the $:\text{CF}_2$ -olefin addition compound 1,1-difluoro-2,2-dimethylcyclopropane in the product array. The yield of this product from the $(\text{H}_3\text{C})_2\text{C} = \text{CH}_2/\text{Cl}_2\text{CF}_2$ system was dependent upon the laser irradiation frequency. No analogous *gem*-difluorocyclopropanes were detected in the $\text{Br}_2\text{CF}_2/\text{H}_3\text{CCH} = \text{CH}_2$ and $\text{Br}_2\text{CF}_2/\text{C}_2\text{H}_4$ systems. Carbon isotopic segregation was noted in all experiments. The complex nature of these reaction systems is examined in some detail. The concept of utilizing a laser-produced, isotopically specific reactive intermediate such as $:\text{CF}_2$ for the direct synthesis of labeled compounds is presented.

17764. Rook, H. L., Wolf, W., **The quantitative determination of volatile trace elements in NBS biological Standard Reference Material 1569, Brewers Yeast**, (Proc. Univ. of Missouri's 11th Annual Conf. on Trace Substances in Environmental Health, Univ. of Missouri, Columbia, MO, June 7-9, 1977), Paper in *Trace Substances in Environmental Health-XI*, D. D. Hemphill, Ed., pp. 324-333 (University of Missouri, Columbia, MO, Dec. 1977).

Key words: activation analysis; brewers yeast; chromium; volatile trace elements.

In the past few years, a large body of analytical data has been reported on trace levels of chromium in biological samples. From data on materials such as NBS Standard Reference Material 1577, Bovine Liver, and IAEA standard materials, it is now apparent that much of the reported Cr data are in error.

It has been suggested that some of the analytical problems may be due to the presence of a volatile organic complex of Cr in many biological matrices.

In an effort to resolve the question of Cr volatility, a series of experiments have been conducted on a new NBS Standard Reference Material—Brewers Yeast SRM 1569, which has been certified for Cr content. The experimental design allowed for the quantitative collection of volatile species in a thermally-heated vacuum distillation system over a temperature range of 150-325 °C. A small fraction of the total Cu (<1%), about 25 percent of the total Hg and about 50 percent of the total Se were trapped and determined quantitatively. Arsenic, Ag and Au were also observed in the trapped fraction.

17765. Rowe, J. M., Rush, J. J., Chesser, N. J., Michel, K. H., Naudts, J., **Nature of the phase transition in KCN at 168 K**, *Phys. Rev. Lett.* **40**, No. 7, 455-458 (Feb. 13, 1978).

Key words: elastic constant; KCN; lattice dynamics; neutron scattering; phase transition; reorientation.

Neutron inelastic scattering line shapes for [100] TA phonons in KCN have been measured for temperatures between 169 and 300 K. The results are compared to the predictions of a model incorporating a strong *indirect* (CN)⁻(CN)⁻ ion interaction mediated by elastic strains. The present experiments confirm the essential features of the model and elucidate the nature of the mode softening which leads to the phase transition at 168 K. In particular, the softening is shown to exist even for wave vectors one-half the distance to the Brillouin zone boundary.

17766. Schwarz, W. H. E., Butscher, W., Ederer, D. L., Luca-torto, T. B., Ziegenbein, B., Mehlhorn, W., Prömpeler, H., **Core-excited molecular states: Theoretical and experimental investigation of the Li_2 molecule**, *J. Phys. B* **11**, No. 4, 591-602 (1978).

Key words: autoionization; configuration interaction calculations; core-excited molecular states; diatomic lithium; ejected-electron spectroscopy; photoabsorption spectroscopy.

The excitation and decay of core-excited molecular lithium has been investigated by experimental and theoretical methods. The associated far-UV photoabsorption spectrum, which was observed with partly resolved vibrational structure, was interpreted on the basis of configuration-interaction (CI) calculations. In addition, the autoionisation of these states was investigated by ejected-electron spectroscopy and explained through the use of a stationary Born-Oppenheimer model. A theoretical determination of the related potential curves and the 1s ionisation potential is presented along with a discussion of the electronic structure of the core-excited states.

17767. Simiu, E., Biétry, J., Filliben, J. J., **Sampling errors in estimation of extreme winds**, *J. Struct. Div. Am. Soc. Civ. Eng.* **104**, No. ST3, 491-501 (Mar. 1978).

Key words: buildings (codes); dynamic response; gust loads; structural engineering; tall buildings; wind forces; wind pressure.

The closure to the paper "Equivalent Static Wind Loads for Tall Building Design" published in April 1976 is presented following four discussions of the paper published in the February 1977, April 1977, June 1977, and October 1977 issues of the ASCE Journal of the Structural Division.

17768. Simmons, J. A., Clough, R. B., **Theoretical aspects of acoustic emission spectral measurements**, *Proc. Eighth World Conf. on Nondestructive Testing, Cannes, France, Sept. 6-10, 1976*, pp. 1-8 (Imprimans, Paris, France, 1976).

Key words: acoustic emission; dislocations; nondestructive evaluation; spectra.

Frequency spectrum analysis of acoustic emission signals from moving defects such as cracks and dislocations shows great promise as a nondestructive evaluation technique provided that there is a satisfactory theoretical understanding of the process and adequate instrumentation for spectrum measurement. The authors have attempted to set down a conceptual framework for some of the essential principles needed to make quantitative defect characterizations using acoustic emission spectral analysis. The simplest possible system was therefore selected—an infinite isotropic body with an essentially one-dimensional moving dislocation segment. Its transfer function is formulated and some of the characteristics of the signal and its measurement are discussed.

17769. Soulen, R. J., Jr., **The primary temperature scale and how to use it at low temperatures**, *Proc. ISA-76 Int. Conf. and Exhibit, Houston, TX, Oct. 11-14, 1976*, pp. 1-8 (Instrument Society of America, Pittsburgh, PA, 1976).

Key words: cryogenics; temperature; temperature scale; thermometry.

Three international practical temperature scales have evolved since 1927. The latest version (IPTS-68), established in 1968, extends upwards from 13.8 K. This scale is maintained by the National Bureau of Standards as the legal basis for all temperature measurements within the United States. This article will describe how the scale is made available to a user by means

of thermometers calibrated by NBS. It will also outline the process by which the temperature scale is continually revised and improved. Efforts to extend the scale deeper into the cryogenic region as well as to develop suitable fixed points over the full range will be reviewed.

17770. Soulen, R. J., Jr., Utton, D. B., **Electrical resistance of epitaxially-grown films of $(\text{SN})_x$** , *Solid State Commun.* **21**, No. 1, 105-108 (1977).

Key words: granular films; superconductivity; tunneling; 1-D conductivity.

The d.c. electrical resistance of three epitaxially-grown thin films of $(\text{SN})_x$ was measured from 0.030 to 8.9 K in a low ambient magnetic field. Above 0.25 K the data for all samples are best fit by an equation representing transport of electrons by tunneling between metallic particles of $(\text{SN})_x$.

A change in the temperature dependence of resistance below 0.25 K is interpreted as suggestive, but not conclusive evidence of superconductivity.

17771. Sparrow, J. H., Dick, C. E., **Pulsed high intensity monoenergetic low energy x-ray source and absolute x-ray monitor**, *Nucl. Instrum. Methods* **141**, 283-292 (1977).

Key words: absolute x-ray detector; electron excitations; monoenergetic x rays; pulsed x-ray source; x-ray detector calibration; 1.5-8 keV x rays.

An x-ray source of 1.5, 4.5, or 8.0 keV with 10 ns durations has been produced utilizing a pulsed electron source to excite the characteristic K-line radiation of elemental targets. A parallel plate ionization chamber was calibrated in the NBS standard monoenergetic K x-ray beams and used with Ross filters to measure the pulsed source K x-ray fluence. Typical measured peak x-ray flux intensities are 10^{18} - 10^{19} K x-rays per sr per s. The pulsed source contains four identical ports for simultaneous measurement of the K x-ray intensity by the ionization chamber and detectors being calibrated. The pulsed K x-ray source and the NBS standard steady state K x-ray source, which differ in intensity by 10 orders of magnitude, have been utilized to determine the responses of a photoelectric diode, a scintillator-vacuum photodiode combination, and a silicon PIN diode.

17772. Staples, B. R., **Correspondence on "Ionic equilibrium constants of aqueous alkaline earth salts"**, *Environ. Sci. Technol.* **12**, No. 3, 339-342 (Mar. 1978).

Key words: activities; alkaline earth salts; aqueous; critical evaluation; electrolytes; equilibrium constants; free energy; Gibbs energy; ionic; solutions; thermodynamic properties.

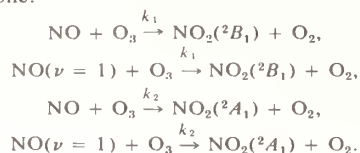
The calculation of ionic equilibrium constants for aqueous electrolytes from available tables of critically evaluated data is discussed with reference to needs in water quality applications. Sample calculations are given and tables of selected equilibrium constants and Gibbs energies of formation of aqueous ionic species at 298.15 K are presented. A table of equilibrium constants for aqueous solutions of the alkaline earth salts, along with tables of Gibbs energies of formation for selected common cations and anions are provided.

17773. Stephenson, J. C., Freund, S. M., **Infrared laser-enhanced reactions: Chemistry of $\text{NO}(v=1)$ with O_3** , *J. Chem. Phys.* **65**, No. 10, 4303-4310 (Nov. 15, 1976).

Key words: infrared laser excitation; laser chemistry; laser enhanced reactions; nitric oxide; nitric oxide, ozone reaction; ozone.

Vibrationally excited nitric oxide, produced by absorption of carbon monoxide laser radiation, was found to react signifi-

cantly faster at $T = 298^\circ\text{K}$ than does thermal NO in the reaction with ozone:



The modulation in visible fluorescence from the $\text{NO}_2(^2B_1)$ product, following laser excitation of NO, was measured. The exponential decay time of $\text{NO}(\nu = 1)$ infrared fluorescence following the laser excitation was also monitored and related to the vibrational deactivation process.



The results obtained are

$$k_1'/k_1 = 5.7 \pm 1.4^{2.6}, (k_2' + k_{\text{NO}-\text{O}_3})/k_2 \leq 22,$$

and

$$k_{\text{NO}-\text{O}_2} = 920 \pm 80 \text{ sec}^{-1} \cdot \text{torr}^{-1}.$$

This rate enhancement occurs even though the excited NO bond does not break during the reaction.

17774. Stockbauer, R., **Kinetic energy release in the fragmentation methane and ketene ions**, *Int. J. Mass Spectrom. Ion Phys.* **25**, 401-410 (1977).

Key words: coincidence; fragmentation; ions; ketene; mass spectrometry; methane; methane- d_4 ; photoionization; threshold photoelectron spectroscopy; time of flight mass spectrometry.

A threshold photoelectron-photoion coincidence mass spectrometric technique has been developed to measure the kinetic energy of ions formed by photoionization. The kinetic energy released upon fragmentation of a molecular ion can be measured. The coincidence technique allows the measurement to be made as a function of parent ion internal energy. Results are presented for CH_3^+ and CH_2^+ from methane, CD_3^+ and CD_2^+ from methane- d_4 and CH_2^+ from ketene. The results show a near zero (< 30 meV) kinetic energy release for these fragments at threshold. Above threshold, the slope of the kinetic energy release vs. internal energy curve for CH_2^+ (CD_2^+) is a factor of 2 greater than the slope for the CH_3^+ (CD_3^+) curve. This does not agree with theoretical calculations which predict that the slopes should be nearly equal.

17775. Tsang, T., Utton, D. B., **Proton magnetic relaxation and internal rotations in tetramethylammonium cadmium chloride**, *J. Chem. Phys.* **64**, No. 9, 3780-3783 (May 1, 1976).

Key words: crystallographic phase transformations; internal rotations; nuclear magnetic resonance; proton second moments; proton spin-lattice relaxation times; tetramethylammonium cadmium chloride.

Proton spin-lattice relaxation times (T_1) and second moments (M_2), at 14.7 MHz, have been investigated for tetramethylammonium cadmium chloride. Discontinuities in T_1 at 104 and 119 K indicate the occurrence of crystallographic transformations. It is proposed that, in the low temperature phase below 104 K, the correlation time for hindered motion of one of the methyl groups is somewhat different from that of the other three. Using this model, the calculated T_1 and M_2 values are in satisfactory agreement with the experimental data. For the low temperature phase, the activation energies of the tetramethylammonium ion, 2.0 ± 0.3 and 1.6 ± 0.3 kcal/mole (8.4 ± 1.3 and 6.7 ± 1.3 kJ/mole), are considerably lower than the values 5.5–11 kcal/mole observed for the tetramethylam-

monium halides. In the high temperature phase, the activation energy decreases even further to 0.7 ± 0.2 kcal/mole (2.9 ± 0.8 kJ/mole). This decrease is in accordance with other order-disorder phase transitions involving tetrahedral ions.

17776. Utton, D. B., Vanier, J., **Thermometry by nuclear quadrupole resonance**, *Instrum. Technol.* **23**, No. 12, 47-52 (Dec. 1976).

Key words: accuracy; nuclear quadrupole resonance; precision; thermometry; 50 K-473 K.

Although temperature measurement based on nuclear quadrupole resonance involves more sophisticated hardware than conventional techniques, it offers several advantages: universal calibration, ultrahigh precision and insensitivity to mechanical handling. The authors explain the principles of NQR thermometry, describe the temperature sensor and its associated control equipment, and then present some of the potential applications of this new method to industrial and scientific measurements.

17777. Van Degrift, C. T., **Ultra-stable LC oscillators and their applications in metrology**, *Proc. 31st Annual Symp. on Frequency Control, Fort Monmouth, NJ, June 1-3, 1977*, pp. 375-384 (Electronic Industries Association, Washington, DC, 1977).

Key words: acceleration; humidity; LC oscillators; linear motion; nuclear magnetic resonance; pressure; temperature; transducer; tunnel diode oscillators.

A review of the use of extremely stable tunnel diode LC oscillators in a wide variety of transducer applications is presented. A general discussion of the circuit design is first given followed by a listing of its three inherent frequency noise sources.

Two types of low frequency circuits are described—one used for the measurement of the dielectric constant of liquid ^4He at 4 MHz and one used to study electrical resistivity of a single crystal of copper. A detailed digital computer modeling of this latter circuit is then presented.

Tunnel diode oscillators which have LC circuits in the form of reentrant resonators are then discussed. They are particularly well-suited for sensing pressure, temperature, acceleration, linear motion, and humidity with the capacitive region of their resonators. Furthermore, they also can be used to make absolute nuclear susceptibility measurements with the inductive region.

Finally, we list projects currently under way in our laboratory which test the extent to which these circuits can be further improved and to determine their ultimate practically attainable performance in transducer applications.

17778. VanderHart, D. L., Retcofsky, H. L., **Estimation of coal aromaticities by proton-decoupled carbon-13 magnetic resonance spectra of whole coals**, *Fuel* **55**, 202-204 (1976).

Key words: aromaticity; coal; NMR; ^{13}C .

A recently developed nuclear magnetic resonance (n.m.r.) cross-polarization technique has been applied to obtain high-resolution carbon-13 spectra of vitrains from two coals. The method, which overcomes the problem of dipolar line broadening by protons, permits estimates of the carbon aromaticities of solid coals. Preliminary results support the classical views that coals are highly aromatic materials and that the aromaticity of coal increases with increasing rank. Limitations of the technique, the accuracy of representation of the distribution of carbons in the sample, and consequently the reliability of the resulting f_a values are discussed.

17779. Wachtman, J. B., Jr., Johnson, J. R., **Ceramics in the future**, Paper in *Science, Technology, and the Modern Navy, Thirtieth Anniversary 1946-1976*, ONR-37, pp. 388-414 (Office of Naval Research, Arlington, VA, 1976).

Key words: ceramics; electromagnetic properties; future needs; glass; molecular engineering; processing strength; research opportunities.

Ceramics in the broad sense of inorganic, nonmetallic materials already play many vital roles in military and civilian technology. The first 30 years of the Office of Naval Research's existence coincided with great progress in the development of advanced ceramics for special applications such as computers, optics, electronics, etc. Important developments in ceramics for bulk uses have also occurred, e.g., refractories for the basic oxygen process and glass reinforcing fibers.

Prospects for future development are discussed in terms of a matrix structure that considers promising scientific opportunities as one dimension and promising technologies as another. The discussion is developed in an overall context of concern with energy, declining supplies of some high-grade ores, general pollution effects, and specific concern for toxic substances.

It is concluded that further advances in high-technology ceramics with important practical payoffs should occur. In addition, high volume use of advanced bulk ceramics seems possible. The extent of such use may be determined as much by public attitudes as by strict technical advantage.

17780. Wells, P. I., Tryon, P. V., **The attenuation of UHF radio signals by houses**, *OT Report No. 76-98*, 87 pages (Available as PB258447 from the National Technical Information Service, Springfield, VA 22161, Aug. 1976).

Key words: building attenuation; direct satellite communication; disaster warning; statistical analysis; statistics; ultra-high frequency.

This paper presents the results of a measurement program which was conducted to determine the attenuation of UHF radio signals penetrating to the inside of a typical house. This program is part of a study to determine the feasibility of using direct satellite communication to disseminate disaster warning messages. The measurements were made in a manner to determine the building attenuation as a function of frequency, construction type, climate, and the elevation angle to the signal source.

Attenuation measurements were made in five cities, Boulder, CO; Duluth, MN; Kansas City, MO; Little Rock, AR; and Houston, TX. The measurements were made at three frequencies, 860 MHz, 1550 MHz, and 2569 MHz, using the ATS-6 geosynchronous satellite as a signal source. Most measurements were made on two principal house types, wood frame with a wood outside surface and a wood frame brick veneer outside surface.

A brief description of the measurement program and an analysis of the measurement results are presented.

17781. Wiese, W. L., **Atomic data compilation and evaluation programs at NBS pertinent of fusion research**, (Proc. of an Adv. Group Meeting, Abingdon, UK, Nov. 1-5, 1976), Paper in *Atomic and Molecular Data for Fusion*, pp. 535-540 (International Atomic Energy Agency, Vienna, Austria, 1977).

Key words: atomic data; data center; National Standard Reference Data System; numerical data; rearrangement of data; thermonuclear fusion.

The U.S. National Bureau of Standards operates, under the National Standard Reference Data System (NSRDS), a number of data centers in various fields of the physical sciences.

Among them three centers compile atomic data of interest to Thermonuclear Fusion Research. These centers are the Atomic Energy Levels Data Center at NBS, the Data Center on Atomic Transition Probabilities and Line Shapes at Washington, DC, and the Joint Institute for Laboratory Astrophysics (JILA) Atomic Collision Information Center, at Boulder, CO.

17782. Willis, J. O., Hein, R. A., Waterstrat, R. M., **Superconductivity in Ti_3P -type compounds**, *Phys. Rev. B* 17, No. 1, 184-190 (Jan. 1, 1978).

Key words: electrical resistivity; electron-phonon interaction; low temperature properties; specific heat; superconductivity; Ti_3P compounds.

A study of 12 intermetallic A_3B compounds which crystallize in the tetragonal Ti_3P -type structure has revealed five new superconductors with transition temperatures below 1 K: Zr_3Si , Zr_3Ge , Zr_3P , V_3P , and Nb_3Ge (extrapolated from the alloy series Nb-Ge-As). In addition, two compounds, Zr_3Sb and Ta_3Ge , having the Ni_3P structure type were found to be superconducting below 1 K. Within the Ti_3P -type compounds, those with the lighter "B" elements in a given column of the Periodic Table have the higher transition temperatures. Critical-magnetic-field and electrical-resistivity data are reported for the superconducting Ti_3P -type compound Nb_3P which permit one to estimate the Ginzburg-Landau κ parameter and the electronic-specific-heat coefficient γ . The κ value of 8.4 indicates that this material is type II, and the γ value of 1.3 mJ/mole K^2 for Nb_3P is probably related to its low transition temperature relative to many A15 compounds.

17783. Worley, S. D., Erickson, N. E., Madey, T. E., Yates, J. T., Jr., **An XPS study of formaldehyde and related molecules adsorbed on the surface of a tungsten (100) single crystal**, *J. Electron Spectrosc. Relat. Phenom.* 9, 355-370 (1976).

Key words: adsorption; carbon dioxide; carbon monoxide; chemisorption; decomposition; formaldehyde; oxygen; x-ray photoelectron spectroscopy.

X-ray photoelectron spectroscopy has been used to study the adsorption and catalytic decomposition of formaldehyde on a W(100) single crystal. Comparison with the O(1s) spectra of CO(ads), CO₂(ads) and O(ads) has been carried out in an attempt to understand the surface complexes formed from H₂CO. It has been shown that H₂CO dissociates at 100 K upon adsorption up to ca. 1/2 monolayer. Above this coverage, condensation of undissociated H₂CO occurs. A surface complex leading to the liberation of CO₂ from the formaldehyde layer has been detected by XPS. However, no complex uniquely related to an intermediate which yields a small quantity of CH₄ has been detected by XPS.

17784. Zapas, L. J., **Non-linear behavior of polyethylene in torsion**, *Proc. VII Int. Congress on Rheology, Gothenburg, Sweden, Aug. 23-27, 1976*, pp. 662-663 (Tages-Anzeiger/Regina-Druck, Zurich, Switzerland, 1976).

Key words: BKZ theory; constant rate of strain; multistep stress-relaxation; nonlinear behavior; polyethylene; torsion of a rod.

The nonlinear mechanical behavior in torsion of a polyethylene rod was studied at various strain histories. A modified BKZ theory was used to correlate successfully the stress response on single and multistep stress relaxation experiments. Constant rate of strain experiments were performed in the form of triangular strain history and the calculated results were in very good agreement with the experimental values. This modified BKZ theory is a fluid theory with a memory, which depends on the previous strain history.

17785. Hutchinson, J. M. R., Mann, W. B., Mullen, P. A., **Development of the National Bureau of Standards low-energy-photon-emission-rate radioactivity standards**, *Proc. ERDA X- and Gamma-Ray Symp., Ann Arbor, MI, May 19-21, 1976*, pp. 25-28 (Available as ERDA CONF. 760539 from the National Technical Information Service, Springfield, VA, 1976).

Key words: defined solid angle spectrometer; standardization; ^{55}Fe , ^{85}Sr , ^{109}Cd , ^{125}I .

The National Bureau of Standards has recently developed point source low-energy-photon-emission-rate standards of ^{55}Fe , ^{85}Sr , ^{109}Cd and ^{125}I . The standardizations were performed using a defined solid angle, NaI(Tl) spectrometer that can be operated with gas fillings at atmospheric and reduced pressure. The corrections applicable to such a spectrometer have been discussed by W. B. Bambynek.

17786. Snyder, J. J., **Paraxial ray analysis of a cat's-eye retroreflector: Author's reply to comments**, *Appl. Opt.* **15**, No. 7, 1691 (July 1976).

Key words: cat's-eye reflector; paraxial ray analysis; retroreflector, cat's-eye.

17787. Ruff, A. W., **Discussion on the Paper, "Ferrographic analysis of wear debris from boundary lubrication experiments with a five ring polyphenyl ether"**, *ASLE Trans.* **18**, No. 3, 162 (1975).

Key words: boundary lubrication; ferrographic analysis; wear debris.

17788. Braun, E., Cobble, V. B., Krasny, J. F., Peacock, R., **Development of a proposed flammability standard for commercial transport flight attendant uniforms**, *FAA Report No. FAA-RD-75-176*, 193 pages (Available as ADA 033740 from National Technical Information Service, Springfield, VA 22161, Aug. 1976).

Key words: aircraft; fabrics; fire; flame resistant materials; flight attendants; garments; heat flux; protection; standards; tests.

17789. Geist, J., Lind, M. A., **The application of electro-optical modulators in optical radiation measurements**, *Proc. Electro-Optics/Laser 77 Conf. and Exposition, Anaheim, CA, Oct. 25-27, 1977*, p. 696 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1977).

Key words: electro-optical modulating; measurement, optical radiation; optical radiation measurements; radiation measurements, optical.

17790. Gerhold, W. F., **Comments on the Paper "Corrosion Behavior of Ductile Cast-Iron Pipe in Soil Environments"** (Journal AWWA, Feb. 1977), *J. Am. Water Works Assoc.* **69**, No. 7, 404 (July 1977).

Key words: carbon steel; corrosion; ductile cast-iron; statistical analysis; underground.

17791. Peterlin, A., **Individual bead contribution to intrinsic viscosity of polymers**, *Polym. Lett.* **18**, 747-749 (July 1977).

Key words: average gradient; intrinsic viscosity; nonrotating bead; single bead contribution to I.V.; torque on the bead.

17792. Edelman, S., **Piezoelectric and pyroelectric polymer sensors**, *Proc. Conf. on Sensor Technology for Battlefield and Physical Security Applications, Fort Belvoir, VA, July 13-15, 1977*, pp. 204-212 (U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, VA, July 1977).

Key words: dynamic measurement; noise spectrum; piezoelectric polymers; pyroelectric polymers; sensors; sound measurement; transducers.

The polymer poly(vinylidene fluoride) (PVDF) can be used as the active element of piezoelectric and pyroelectric sensors and has properties which make it useful in military applications.

The purpose of this talk is to summarize a number of applications of piezoelectric and pyroelectric polymer sensors. This compilation is meant to give a feeling for the versatility of the material and some idea of the kind of application for which a polymer sensor can be used with advantage over a conventional sensor.

As a piezoelectric material it has good response to dynamic stress or strain over a wide range of frequencies, is not likely to be harmed by the usual ambient conditions, salt water, soaps, common organic solvents, nearby explosions, or other mechanical shocks. It is readily available in relatively cheap, thin, light, flexible sheets of large area and is easily shaped for a particular application.

Many of the same characteristics hold for its use as a pyroelectric material. It has good sensitivity to temperature changes caused by radiation of a wide range of wavelengths from infrared to ultraviolet.

Piezoelectric polymer instruments can be used as microphones and sound sources in air, as hydrophones in water over the frequency range from a few hertz to many megahertz, as detectors of stress or strain in the soil, for a number of biomedical applications, as detectors of acoustic emission on a wide variety of materials and structures, as vibration detectors, to monitor the acoustic signature of components of machinery as a means of detecting incipient failure, and for intrusion detection.

Pyroelectric polymer instruments can be used for intrusion detection, for infrared imaging, to detect incipient fires, and to monitor temperature changes in operating machinery from a distance.

17793. Fine, J., Gorden, R., Jr., **Ion and electron beam interaction on surfaces—A detection mechanism for obtaining visual ion beam images**, (Proc. Third Int. Conf. on Ion Beam Analysis, Georgetown Univ., Washington, DC, June 27-July 1, 1977, Session 6B.6), *Nucl. Instrum. Methods* **149**, 679-683 (1978).

Key words: beam profile measurement; insulator surfaces; ion and electron beam interaction; ion beams; surface conductivity; surfaces.

Two-dimensional images have been obtained of ion beam impact cross sections on solid surfaces by the coincident interaction of a rastered electron beam. This detection method is effective in producing images in real time on various insulator surfaces. The size of these images correlates well with ion beam current density profile measurements (at full width) and, therefore, can be very useful for ion beam diagnostics and alignment.

17794. Jeffery, S., Linden, T. A., **Software engineering is engineering**, *Proc. 10th Hawaii Int. Conf. on System Sciences, University of Hawaii, Honolulu, HI, Jan. 6-7, 1977*, pp. 204-207 (Western Periodicals Co., North Hollywood, CA, 1977).

Key words: education; engineering; programming methods; software engineering; software reliability; software requirements.

Software engineering implies an orderliness to the design and implementation of computer software. It also implies that the results will meet certain quality, performance, and cost objectives analogous to those traditionally set in the more classical engineering disciplines. A considerable body of knowledge and

methods common to the traditional areas of engineering is also applicable to software engineering. General engineering methods will be more readily applied in the development of software when software engineering is recognized as a legitimate engineering discipline with its own educational curriculum.

17795. Nyyssonen, D., **Optical linewidth measurements on silicon and iron-oxide photomasks**, (Proc. SPIE Conf. on Developments in Semiconductor Microlithography II, San Jose, CA, Apr. 4-5, 1977), *SPIE J.* **100**, 127-134 (1977).

Key words: integrated circuits; micrometrology; microscopy; optical imaging; partial coherence; photolithography.

Measurement of linewidths on silicon and iron-oxide photomasks is hampered by the dark banding which occurs along the edges. It is shown that this banding arises from the combination of low contrast and optical path difference introduced by the silicon or iron-oxide in conjunction with the partial coherence of the illumination. As previously shown in work with chromium-oxide photomasks, when the condenser numerical aperture is sufficiently less than that of the objective, an expression can be derived for the proper transmittance threshold for determining edge location. An expression is also derived for the linewidth error which would result from locating the edge at the center of the dark band. Theoretical and experimental results are compared.

17796. Benjamin, I. A., **Development of a room fire test**, *Am. Soc. Testing Mater. Spec. Tech. Publ.* **614**, pp. 300-311 (1977).

Key words: fire test design; fire test variables; large scale fire tests; room fire tests.

This paper has attempted to indicate the need for full-scale room and compartment tests at this time, indicating two possible uses of the compartment test (for approval, or for validating small-scale tests) and has discussed a few of the factors which affect the design of the tests, using the choice of ignition source as an example of the problems involved in the test design. Reference is made to the recommended practice developed by the task group of American Society for Testing and Materials Committee E-39.10.01.

17797. Block, S., Forman, R. A., Piermarini, G. J., **Pressure and electrical resistance measurements in the diamond cell**, *Book: High-Pressure Research Applications in Geophysics*, M. H. Manghni and S. Akimoto, Eds., pp. 503-508 (Academic Press, Inc., New York, NY, 1977).

Key words: diamond cell; electrical resistance measurements; fixed points; high pressure; ruby pressure scale; semiconductor.

A method for measuring electrical resistance in the diamond anvil high pressure cell that employs gasketed samples and a fluid pressure transmitting medium has been developed. Measurements on the semiconductors, ZnS and GaP, both of which exhibit pressure-induced transitions to opaque phases have been made. A decrease in electrical resistance of several orders of magnitude has been measured with the appearance of the high pressure phase, thus indicating the formation of a metallic or semi-metallic state. These results are in agreement with our earlier work which indicated the need for downward revision of the fixed-point pressure scale.

17798. Brennan, J. A., **Better LNG flow measurement sought**, (Proc. ASME Energy Technology Conf., Houston, TX, Sept. 18-23, 1977), *Oil Gas J.* **76**, No. 5, 168, 173-174, 177 (Jan. 30, 1978).

Key words: comparison; density; experimental; gas; glow; liquid; LNG; measurement.

A method of testing flowmeters for use in large diameter LNG pipelines is described and some experimental data presented. Densitometers for use in conjunction with volumetric flowmeters to give mass flow information are discussed and some performance data listed.

17799. Buehler, M. G., **Microelectronic test patterns for use in procuring custom and highly reproducible integrated circuits**, *Proc. Symp. on Utilization of Large Scale Integrated Circuits in Military Systems, Arlington, VA, Aug. 9-11, 1977*, G. W. Preston, Ed., IDA Paper P-1296, Pt. II, pp. III-105—III-117 (Institute for Defense Analyses, Science and Technology Division, 400 Army-Navy Drive, Arlington, VA, Oct. 1977).

Key words: integrated circuit; line width; sheet resistance; silicon; test patterns; TTL.

A different approach is under development for use in the procurement of custom integrated circuits. It involves the process validation wafer (PVW) which is used to evaluate a fabrication technology in terms of the uniformity of various process and device parameters across a silicon wafer. Improved uniformity is a key to built-in reliability and predictable system performance. The PVW concept is illustrated by the NBS-7 test pattern designed to assess a TTL fabrication process. Wafer maps of various parameters are presented and their use in pinpointing fabrication problems is demonstrated. In addition, random fault test structures for evaluating various fault densities are discussed. Finally, the use of the PVW in procuring integrated circuits is mentioned.

17800. Buehler, M. G., Grant, S. D., Thurber, W. R., **Bridge and van der Pauw sheet resistors for characterizing the line width of conducting layers**, *J. Electrochem. Soc.* **125**, No. 4, 650-654 (Apr. 1978).

Key words: bridge structure; cross-bridge structure; cross structure; diffused layer; line width; process control; sheet resistance; sheet resistor; silicon; test pattern; test structure; van der Pauw structure.

It is shown that the line width of conducting layers can be computed from simple d-c electrical measurements made on bridge and van der Pauw shaped test structures. A compact six-contact, cross-bridge sheet resistor test structure was developed to make this measurement directly. Line widths measured on boron nitride diffused layers indicate that the method is sensitive to width variations of the order of $\pm 0.1 \mu\text{m}$ ($\pm 4 \mu\text{in.}$).

17801. Buehler, M. G., Thurber, W. R., **An experimental study of various cross sheet resistor test structures**, *J. Electrochem. Soc.* **125**, No. 4, 645-650 (Apr. 1978).

Key words: cross structure; diffused layer; process control; sheet resistance; sheet resistor; silicon; test pattern; test structure; van der Pauw structure.

Newly designed cross sheet resistors are shown to give the same (within 0.5%) measured sheet resistance as conventional van der Pauw structures. Diffused boron and phosphorus layers with sheet resistances near $200 \Omega/\square$ were studied with the sampled areas varying from a square $6.4 \mu\text{m}$ (0.25 mil) on a side to a circle $762 \mu\text{m}$ (30.0 mils) in diameter. An increase in measured sheet resistance values was observed due to surface leakage currents, and an equivalent circuit model was developed to explain the results. The effect of joule heating on measured sheet resistance values was observed in both large and small cross structures.

17802. Bullis, W. M., **The NBS Semiconductor Technology Program**, *Proc. Symp. on Utilization of Large Scale Integrated Circuits in Military Systems*, Arlington, VA, Aug. 9-11, 1977, G. W. Preston, Ed., IDA Paper P-1296, Pt. II, pp. III-89—III-94 (Institute for Defense Analyses, Science and Technology Division, 400 Army-Navy Drive, Arlington, VA, Oct. 1977).

Key words: electronics; large scale integrated circuits; measurement methods; semiconducting materials; semiconductor devices; semiconductor processing.

The NBS Semiconductor Technology Program is a laboratory-based research effort directed toward development of practical, well documented measurement methods and associated data and instrumentation for use by the semiconductor electronics community. Use of improved measurement technology enables the integrated circuit (IC) manufacturer to exert more effective control over his manufacturing processes. The user benefits because his ICs have greater uniformity, improved quality and reliability, and more predictable performance. Examples are given in which the results of the work have led to cost savings and reliability improvements. Various current technical activities of importance to production of large scale integrated circuits (LSICs) are described briefly, and ways in which the results of the work are transferred to the industry are discussed.

17803. Bur, A. J., **Piezoelectric effect in bone (Abstract only as C4.10)**, *Proc. 28th Annual Conf. on Engineering in Medicine and Biology*, New Orleans, LA, Sept. 20-24, 1975, 17, 192 (Alliance for Engineering in Medicine and Biology, Chevy Chase, MD, 1975).

Key words: bone; characterization data; Maxwell-Wagner polarization; piezoelectric coefficients; piezoelectric effects.

The piezoelectric properties of bovine bone have been measured as a function of temperature, relative humidity, and frequency of applied stress. Measurements were made in compression and shear. The data show dispersion effects in shear which are sensitive to changes in relative humidity or water content of the sample. At low frequencies, less than 10 Hz, a large interfacial or Maxwell-Wagner polarization was observed.

17804. Chesler, S. N., Gump, B. H., Hertz, H. S., May, W. E., Wise, S. A., **Determination of trace level hydrocarbons in marine biota**, *Anal. Chem.* 50, No. 6, 805-810 (May 1978).

Key words: gas chromatography; headspace analysis; hydrocarbon analysis; liquid chromatography; marine biota; petroleum analysis; trace analysis.

A method is described for the determination of petroleum hydrocarbons in marine biota. This procedure utilizes dynamic headspace sampling of an aqueous caustic tissue homogenate to extract and collect volatile organic components. Interfering polar biogenic (nonanthropogenic) components are removed by normal-phase high-performance liquid chromatography. Quantitation and identification of the individual compounds are accomplished using gas chromatography and gas chromatography-mass spectrometry. The nonvolatile polynuclear aromatic hydrocarbons which remain in the homogenate after headspace sampling are solvent-extracted and then analyzed by reversed-phase liquid chromatography.

17805. de Meijere, J. L. F., Eberly, J. H., **Rate of resonant two-photon ionization in the presence of a partially coherent radiation field**, *Phys. Rev. A* 17, No. 4, 1416-1430 (Apr. 1978).

Key words: Bloch equations; density matrix equations; Heisenberg equations; laser bandwidth; multiphoton ionization; multiphoton saturation effects; partially coherent

laser; power broadening; rate approximation; two photon absorption; two photon ionization.

A treatment is given of two-photon ionization in which particular attention is paid to the influence of the bandwidth of the ionizing light on the ionization rate. The model adopted for the atom is a common one, including two bound levels and a continuum. The model of the laser is general enough to allow short-term temporal fluctuations of amplitude or phase, and these fluctuations give rise to the laser bandwidth. It is found that the fluctuations have the most interesting effects on the ionization rate when the laser coherence time is shorter than the atomic memory time, as could be expected. In addition to laser bandwidth, we consider the influence on the ionization rate of the detuning of the laser from the intermediate-state resonance, the laser power, and the finite lifetime of the intermediate state. Comparisons with related earlier calculations are made and similarities and differences are pointed out.

17806. DuBois, R. D., Jeffries, J. B., Dunn, G. H., **Dissociative recombination cross sections for NH_4^+ ions and electrons**, *Phys. Rev. A* 17, No. 4, 1314-1320 (Apr. 1978).

Key words: cross sections; dissociation; electron impact; NH_4^+ -ammonium; recombination; trapped ions.

Cross sections for electron- NH_4^+ recombination have been measured for an electron energy range of $0.065 \leq E \leq 2.00$ eV using a trapped-ion technique with an ion temperature of ~ 340 K. The cross section σ deduced from these measurements can be represented by $4.30 \times 10^{-16} E^{1.40}$ for $0.050 \leq E \leq 0.3$ eV and by $3.73 \times 10^{-17} E^{-3.43}$ for $E > 0.3$ eV. There is a total uncertainty in the measurements of ± 60 percent. Using a Maxwellian electron-velocity distribution, recombination-rate coefficients were calculated and compared with measurements of Huang, Biondi, and Johnsen.

17807. Ginter, M. L., Tilford, S. G., Bass, A. M., **Electronic spectra and structure of the hydrogen halides. States associated with the $(\sigma^2\pi^3)c\sigma$ and $(\sigma^2\pi^3)c\pi$ configurations of HI and DI**, *J. Mol. Spectrosc.* 57, 271-283 (1975).

Key words: electronic states; electronic structure; hydrogen halides; molecular spectra; vacuum ultraviolet.

The high resolution absorption spectra of HI and DI have been investigated in the ~ 1425 Å to 1570 Å region. The majority of the bands observed in the region are assigned to transitions from $X^1\Sigma^+$ to states associated with the excited configurations $(\sigma^2\pi^3)c\sigma$ and $(\sigma^2\pi^3)c\pi$. This region also contains bands assigned to transitions from $X^1\Sigma^+$ to states associated with more highly excited configurations and to excited vibrational levels of the $V^1\Sigma^+$, $b^3\Pi$, and $C^1\Pi$ states. The states associated with the $(\sigma^2\pi^3)c\sigma$ and $c\pi$ configurations exhibit Ω , ω coupling. Effective molecular constants are presented for the bands observed within the above wavelength region.

17808. Gross, D., **Measurements of fire loads and calculations of fire severity**, (Proc. Symp. Society of Wood Science and Technology, Trends in Fire Protection, Session II—Technology and Research, Madison, WI, Apr. 19-21, 1977), *Wood Fiber* 9, No. 1, 72-85 (Spring 1977).

Key words: building fire; combustible contents; fire endurance; fire load; fire protection; fire severity; fire test.

Types of furnishings, interior finish, and occupancy trends have changed considerably over the last several decades, so new fire load surveys for various occupancies are being conducted in various countries, using modern surveying techniques. These new data can be used to calculate fire growth curves, considering modern lightweight methods of construction using large window areas and mechanical ventilation. Computer

models are designed to evaluate fire growth as a dynamic process, using such factors as heats of combustion, changing temperature levels, combustion enthalpy per unit mass of air, thermal conductivities and radiation, furniture arrangements and collapse during fires, etc. As these computational methods become more refined, changes in fire endurance testing can be made to produce more realistic results, which may represent fire exposures and potential fire severities different than those we are familiar with.

17809. Heaton, H. T. II, Gilliam, D. M., Spiegel, V., Eisenhauer, C., Grundl, J. A., **Fission cross sections of ^{235}U , ^{238}U , and ^{239}Pu averaged over the ^{252}Cf neutron spectrum**, *Proc. NEANDC/NEACRP Specialists Meeting on Fast Neutron Fission Cross Sections of U-233, U-235, U-238, and Pu-239, Argonne National Laboratory, Argonne, IL, June 28-30, 1976*, W. P. Poenitz and A. G. Smith, Eds., Nos. ANL-76-90, ERDA-NDC-5/L, NEANDC(US)-199/L, pp. 333-352 (Argonne National Laboratory, Argonne, IL, 1976).

Key words: absolute; fission cross section; integral fission measurement; spontaneous fission spectrum; $^{235}\text{U}(n,f)$; $^{238}\text{U}(n,f)$; ^{239}Pu .

A measurement was made in a ^{252}Cf spontaneous fission neutron field to determine the absolute fission cross section of ^{235}U (1205 ± 27 mb), and at the same time to determine the fission cross section ratio of $^{238}\text{U}/^{235}\text{U}$ (0.2644 ± 0.0035) and $^{239}\text{Pu}/^{235}\text{U}$ (1.500 ± 0.024). Two NBS double fission chambers were mounted 5 cm on either side of a singly encapsulated ^{252}Cf source (4×10^9 n/sec, 1.4 mm³ emission volume) in compensated beam geometry. The Cf neutron source strength was calibrated in a Manganous Sulfate Bath relative to the NBS-1, the internationally compared Ra-Be photoneutron source. Corrections were made for geometrical effects (1.0085 ± 0.0064), for undetected fission fragments (typically 1.0222 ± 0.0030), for neutron elastic scattering (typically 0.9587 ± 0.0109) and for inelastic scattering to subthreshold energy for ^{238}U (0.986 ± 0.007). Integral results are compared with various differential data sets using an evaluated ^{252}Cf fission spectrum.

17810. Howe, R. E., Phillips, T. W., Bowman, C. D., **Prompt fission neutrons from eV resonances in ^{235}U : Measurement and correlation with other fission properties**, *Phys. Rev. C* **13**, No. 1, 195-205 (Jan. 1976).

Key words: fission; neutron detection; neutron multiplicity; resonance; time-of-flight; ν ; ^{235}U .

The energy dependence of the fission neutron multiplicity $\bar{\nu}$ for neutron-induced fission of ^{235}U in the energy region 0.5 to 125 eV has been measured using a continuous spectrum of neutrons from a 100 MeV electron Linac. A new neutron detection technique was used to search for variations in resonance $\bar{\nu}$ values and possible correlations with other fission properties. Evidence was obtained for a nonstatistical fluctuation in the value of $\bar{\nu}$ as a function of energy. However, no correlation with resonant spin, Γ_f , fission-fragment asymmetry, or the angular distribution of fission fragments was observed. A comparison of these data with previous $\bar{\nu}$ measurements also has been included.

17811. Jerke, J. M., Hartman, A. W., Nyssonen, D., Swing, R. E., Young, R. D., Keery, W. J., **Comparison of linewidth measurements of an SEM/interferometer system and an optical linewidth-measuring microscope**, (Proc. Conf. on Developments in Semiconductor Microlithography II, San Jose, CA, Apr. 4-5, 1977), *SPIE J.* **100**, 37-45 (1977).

Key words: integrated circuits; linewidth measurements; microelectronics; micrometrology; optical microscope; photomask; scanning electron microscope; semiconductor technology.

In the current linewidth-measurement program at the National Bureau of Standards, the primary measurement of micrometer-wide lines on black-chromium artifacts is made with an interferometer located in a scanning electron microscope (SEM). The data output consists of a line-image profile from the electron detector and a fringe pattern from the interferometer. A correlation between edge location and fringe location is made for both line edges to give the linewidth in units of the wavelength of a He-Ne laser. A model has been developed to describe the interaction of the electrons with the material line and thereby relate a threshold value on the SEM image profile to a selected point on the material line. An optical linewidth-measuring microscope is used to transfer the primary measurements to secondary measurement artifacts; these artifacts will be used to transfer the linewidth measurements to the integrated-circuit industry. Linewidth measurements from the SEM/interferometer system and the optical linewidth-measuring microscope are compared, and the level of measurement uncertainty for each system is discussed.

17812. Kelch, W. L., Linsky, J. L., Basri, G. S., Chiu, H. Y., Chang, S. H., Maran, S. P., Furenli, I., **Stellar model chromospheres. VII. Capella (G5 III+), Pollux (K0 III), and Aldebaran (K5 III)**, *Astrophys. J.* **220**, No. 3, 962-979 (Mar. 15, 1978).

Key words: Ca II emission, stars; chromospheres, stars; emission-line, stars; late-type, ultraviolet; spectra.

Data from high-resolution SEC vidicon spectroscopy with a ground-based telescope (for the Ca II K line) and from spectral scans made with the BUSS ultraviolet balloon spectrograph (for the Mg II *h* and *k* lines) are used to derive models of the chromospheres and upper photospheres of three G-K giants. The models are based on partial redistribution analyses of the Ca II K line wings and cores and on the fluxes in the Mg II lines. The photospheres thus computed are hotter than predicted by radiative equilibrium models. $T_{\text{min}}/T_{\text{eff}}$ is found to decrease with decreasing T_{eff} , while m_0 (the mass column density at the top of the chromosphere) increases with decreasing stellar surface gravity. The computed pressure at the chromosphere top in the primary member of the Capella spectroscopic binary system is 70 times smaller than the transition-region pressure derived by Haisch and Linsky, which suggests that additional terms must be included in the transition-region energy equations for giant stars. Estimates of the Ca II and hydrogen column densities are made for the circumstellar envelope of Aldebaran.

17813. Larsen, E. B., Shafer, J. F., **Surveys of electromagnetic field intensities near representative higher-power FAA transmitting antennas**, *FAA Report No. FAA-RD-77-179*, 115 pages (National Technical Information Service, Springfield, VA, 22161, Dec. 1977).

Key words: antenna; calibration; electromagnetic field intensity; field strength measurement; radar; rf probe.

The National Bureau of Standards has completed surveys of electromagnetic field intensities near the antennas of typical FAA transmitters. These include aircraft radars, ground surveillance radars, instrument landing systems, navigation equipment and communication antennas. The surveys were made with rf radiation monitors having isotropic response patterns. Commercial monitors with thermocouple sensors were used to measure electric fields between 0.5 and 24 GHz and magnetic fields between 10 and 300 MHz. Probes designed at NBS with diode detectors were used for electric field between 100 kHz and 10 GHz. These radiation monitors cannot measure (accurately) the pulse-peak field of a radar nor the field of a scanning antenna; therefore, most of the radar surveys involved fixed antennas.

The intensity in the direct beam of air route surveillance radars was greater than 10 mW/cm^2 at distances within about 14 meters from the antennas. The intensity of airport surveillance radars was above 10 mW/cm^2 at distances within 15 meters, except for the newer ASR-8 model. The direct beam of aircraft radars exceeded 10 mW/cm^2 at distances ranging from 2 to 7 meters. If the time-averaging effect for antenna scanning is taken into consideration, these field values would be greatly reduced. Also, the near-zone beams of FAA antennas are not normally accessible to personnel. In accessible areas the measured fields were generally less than 1 mW/cm^2 .

17814. Levy, J., **Efficient equipment maintenance: A tool for energy conservation**, *AACE Bull.* **20**, No. 2, 49-51 (Mar./Apr. 1978).

Key words: dynamic programming; economic analysis; energy conservation; equipment maintenance; Markov decision process; policy improvement algorithm.

A general model of equipment performance as a function of maintenance is developed that permits quantification of the optimal level of maintenance in terms of performance attainment and relative factor costs. The model formulation is that of a finite state, finite action Markov decision process. The model will help persons responsible for making decisions concerning maintenance policies in selecting economically efficient levels of maintenance for elements of building service equipment.

17815. Olver, F. W. J., **A new approach to error arithmetic**, *SIAM J. Numer. Anal.* **15**, No. 2, 368-393 (Apr. 1978).

Key words: chopping; disc analysis; error analysis; floating-point arithmetic; inner products; interval analysis; polynomial evaluation; relative error; rounding error; software.

By modification of the standard definition of relative error, a form of error arithmetic is developed that is well suited to floating-point computations. Rules are given for conversion from interval analysis to the new approach, and vice versa, both for real and complex variables. Illustrative applications include accumulation of products, quotients, sums and inner products, and the evaluation of polynomials. The paper also includes some new error bounds for basic operations in floating-point arithmetic.

17816. Olver, F. W. J., **Sufficient conditions for Ackerberg-O'Malley resonance**, *SIAM J.* **9**, No. 2, 328-355 (Apr. 1978).

Key words: boundary-value problem; eigenvalues; parabolic cylinder functions; resonance; rotating disks; singular perturbations; turning-point; viscous flow; Weber's equation.

An investigation is made of the asymptotic nature of the solution of the boundary-value problem

$$\epsilon y'' + 2\chi A(\epsilon, \chi) y' - A(\epsilon, \chi) B(\epsilon, \chi) y = 0; y(a) = l, y(b) = m,$$

as $\epsilon \rightarrow 0$, where $A(\epsilon, \chi)$ and $B(\epsilon, \chi)$ are continuous real functions of ϵ and χ , $a < 0$, $b > 0$, and $A(\epsilon, \chi)$ is nonzero in $[a, b]$. Particular attention is paid to the problem of resonance, which arises when the limiting form of the solution exhibits an unusual lack of decay (in the case $A(\epsilon, \chi) < 0$), or an unusual rate of growth (in the case $A(\epsilon, \chi) > 0$). By application of a recent theory of differential equations with coalescing turning points sufficient conditions for resonance are established, both with and without the assumption that $A(\epsilon, \chi)$ and $B(\epsilon, \chi)$ are analytic functions of ϵ and χ . Illustrative examples are also included.

17817. Pearl, M. H., Goldman, A. J., **Policing the market place**, *Math. Mag.* **50**, No. 4, 179-185 (Sept. 1977).

Key words: inspection; theory of games.

This paper, of an expository nature, presents a simple mathematical model dealing with an inspector-inspectee relationship. This model takes the form of a zero-sum two-person game. The inspectee always tries to maximize his net gain which is the amount he obtains by "cheating" less the amount he is penalized when caught. Several simple examples are presented to show the relation between the level of cheating and the levels of inspection resources and penalty.

17818. Plante, E. R., **Interaction of seed with slag in open cycle MHD**, *Proc. National Science Foundation-Office of Coal Research Engineering Workshop on MHD Materials*, Cambridge, MA, Nov. 20-22, 1974, pp. 301-311 (The Energy Laboratory, Massachusetts Institute of Technology, Cambridge, MA, 1974).

Key words: K_2O -silica solutions; MHD; open-cycle MHD; potassium silicates; seed recovery; seed-slag interaction.

A discussion of the factors involved in absorption of seed by slag in coal-fired open cycle MHD systems is given. Previous measurements and methods based on thermodynamics used to assess the extent and importance of this problem are reviewed. Some preliminary measurements on the evaporation of $\text{K}(\text{g})$ and $\text{O}_2(\text{g})$ from silica melts are presented and used to estimate the amount of seed loss to slag. Predictions based on current data are limited to conditions for which the amount of seed absorbed by the slag is greater than 20 wt percent. Directions for future studies of seed slag interaction are indicated.

17819. Powell, R. L., Clark, A. F., **Definitions of terms for practical superconductors. 2. Critical parameters**, *Cryogenics* **18**, No. 3, 137-141 (Mar. 1978).

Key words: critical parameters; definitions; flux phenomena; Josephson phenomena; stabilization; superconductors; terminology.

The definitions of terms used in describing the phenomenology and measurement practices of practical superconductive materials are proposed. The definitions cover the subject categories of: 1. fundamental states and flux phenomena, 2. critical parameters, 3. fabrication, stabilization, and transient losses, and 4. Josephson phenomena. It is intended that these terms will become the basis for the development of standard measurement practices and responses are invited.

17820. Radebaugh, R., **Behavior of the pyroelectric coefficient at low temperatures**, *Phys. Rev. Lett.* **40**, No. 9, 572-574 (Feb. 27, 1978).

Key words: cryogenics; entropy; ferroelectrics; pyroelectrics; thermodynamics.

The third law of thermodynamics is used to show that the primary pyroelectric coefficient as $T \rightarrow 0 \text{ K}$ cannot have a linear temperature dependence when the coefficient is negative and when the specific heat is proportional to T^3 . The argument is consistent with previous microscopic theories that predict a cubic temperature dependence for the pyroelectric coefficient but not with those that predict a linear temperature dependence. Electrocaloric cooling effects in lithium sulfate monohydrate below 1 K must then be smaller than predicted earlier.

17821. Rosenblum, S. S., Steyert, W. A., Fickett, F. R., **A simple method for producing high conductivity copper for low temperature applications**, *Cryogenics* **17**, No. 11, 645-647 (Nov. 1977).

Key words: copper; electrical property; impurity; oxidation; resistance ratio; resistivity.

We report here the details and results of a simple technique for treating polycrystalline copper which significantly reduces its low temperature electrical resistivity (and concomitantly the thermal resistivity). For polycrystalline copper, in the best cases one can obtain residual resistance ratios, rrr , defined as

$$rrr = R(295 \text{ K})/R(4 \text{ K}) \approx \rho(295 \text{ K})/\rho(4 \text{ K})$$

of over 10 000. For copper of electrical quality or better, the room temperature resistivity is completely dominated by the phonon contribution and is independent of the usually small amounts of impurities (less than 30 ppm), thus, the larger the rrr , the better is the copper as a low temperature conductor.

17822. Sengers, J. V., Moldover, M. R., **Two-scale-factor universality near the critical point of fluids**, *Phys. Lett.* **66A**, No. 1, 44-46 (Apr. 17, 1978).

Key words: correlation of fluids; critical point of fluids; fluids, critical point; two-scale factor, critical point of fluids.

Experimental evidence is presented in support of the validity of two-scale-factor universality for the correlation function of fluids near the gas-liquid critical point. For Xe, SF₆, and CO₂, the dimensionless quantity $R = \xi_0(B^2 P_c / \Gamma k_B T_c)^{1/3}$ is universal within the experimental accuracy of 10 percent and agrees with the value predicted by theory.

17823. Streed, E. R., **The results of a roundrobin flat-plate collector test program**, *Proc. 1977 Flat-Plate Solar Collector Conf., Orlando, FL, Feb. 28-Mar. 2, 1977*, D. B. Ward, Ed., pp. 267-279 (Florida Solar Energy Center, Publications Auxiliary, 300 State Road 401, Cape Canaveral, FL, Sept. 1977).

Key words: flat-plate collectors; roundrobin test; solar collector; thermal performance testing.

A roundrobin solar energy collector test program has been conducted to evaluate a proposed test method to rate collectors on the basis of thermal performance. Two liquid-type collectors were distributed to 21 organizations in the United States to obtain data in various climatic regions using the prescribed apparatus under allowable ranges of environmental conditions. Plots of the efficiency as a function of the difference in average fluid temperature and ambient temperature divided by the insulation were used to obtain performance curves for each collector. The overall transmittance-absorptance product ($F'\alpha_T$) and the overall heat loss coefficient ($F'U_L$) were determined by each participant using a least-squares analysis of the data. The mean and standard deviation for each of these parameters is calculated and the significance with respect to the testing and rating of collectors is discussed.

17824. Thomson, R., **Brittle fracture in a ductile material with application to hydrogen embrittlement**, *J. Mater. Sci.* **13**, 128-142 (1978).

Key words: ductile and brittle fracture; fracture; hydrogen embrittlement; plastic zone of fracture.

A physical model of fracture in materials is developed which features a brittle crack imbedded in a plastically deformed medium. This model is presented as an alternative to fully ductile failure by hole growth, and general criteria for the two alternatives are discussed. One of these criteria for the existence of an atomically sharp crack is that the dislocation content near the crack tip be limited by the inhomogeneous character of dislocation slip in the crystal. With the dislocation distribution characteristic of Mode III fracture, we derive expressions for the fracture toughness as a function of material parameters. We have extended the theory to the case of hydrogen embrittlement in steels and compare our theoretical predictions with experimental work by others.

17825. Thurber, W. R., Carpenter, B. S., **Boron determination in silicon by the nuclear track technique**, *J. Electrochem. Soc.* **125**, No. 4, 654-657 (Apr. 1978).

Key words: alpha track; boron; dopant density; nuclear track technique; resistivity; silicon.

The nuclear track technique was used for the determination of the boron dopant density in silicon. It was found that boron in the range of 10^{15} - 10^{20} atoms/cm³ could be detected. The resistivity of the silicon specimens as a function of the boron density determined by the nuclear track technique compares well with the work of Wagner relating resistivity to boron density. The results obtained by the nuclear track technique show some scatter, but in general agree with those determined by the junction capacitance-voltage method.

17826. Van Blerkom, D., **Mass loss from P Cygni: The evidence of the Balmer lines**, *Astrophys. J.* **221**, No. 1, 186-192 (Apr. 1, 1978).

Key words: Balmer lines; mass loss; P Cygni; radiation transfer.

Envelopes of stars which are losing mass are divided into two groups according to their velocity distribution. "Rapid accelerators" are driven to nearly terminal velocity near the photosphere and then coast outward at nearly constant speed. "Gradual accelerators" experience a steady increase in velocity over a sizable fraction of the envelope. The Balmer-line profiles from P Cygni are shown to be consistent with the latter class of envelope model. Very good agreement between theory and observation is shown by a model with $v(r) \propto r$ throughout and with $\dot{M} = 3 \times 10^{-5} \dot{M}_{\odot} \text{ yr}^{-1}$. A model in which the envelope decelerates is not required to account for the Balmer spectrum. This brings into accord the various indicators of envelope velocity: the line-width-excitation-energy correlation, the Balmer progression, and the free-free continuum.

17827. Van Brunt, R. J., Gallagher, A., **Electron scattering with 1 meV resolution**, (Invited Papers and Progress Reports from the 10th Int. Conf. on the Physics of Electronic and Atomic Collisions, Orsay, France, July 1977), Paper in *Electronic and Atomic Collisions*, G. Watel, Ed., pp. 129-142 (North-Holland, Amsterdam, The Netherlands, 1978).

Key words: electron monochrometer; electron scattering; helium.

The advantages of higher energy resolution in resonant electron scattering measurements are examined with regard to possible improvements in accuracy of determining resonance profiles and natural widths. A technique is described that employs a photoionization electron source together with scattering from a supersonic atomic beam which is capable of achieving a net energy resolution approaching 1 meV. Results obtained by this method for sharp Feshbach resonances observed in differential elastic scattering of electrons from N₂, O₂, Ar, Ne and He are reported. A careful examination of the well-known 19.3 eV He ²S resonance in forward angle scattering ($\theta = 22^\circ$) with a net energy resolution (including residual Doppler broadening) of 7 to 12 meV has revealed possible serious difficulties with the simple partial wave description used in previous analyses of the resonance profile.

17828. Wasson, O. A., **The ²³⁵U neutron fission cross section measurement at the NBS linac**, *Proc. NEANDC/NEACRP Specialists Meeting on Fast Neutron Fission Cross Sections of U-233, U-235, U-238, and Pu-239*, Argonne National Laboratory, Argonne, IL, June 28-30, 1976, W. P. Poenitz and A. B. Smith, Eds., Nos. ANL-76-90, ERDA-NCD-5/L, NEANDC(US)-199/L, pp. 183-207 (Argonne National Laboratory, Argonne, IL, 1976).

Key words: cross section; fission; neutron; uranium-235.

The ^{235}U neutron fission cross section was measured relative to neutron-proton scattering from 5 to 800 keV neutron energy. The experiment was performed on the 200 m flight path at the NBS electron linac using a hydrogen gas proportional counter as a neutron flux monitor. This relative measurement was normalized by means of a second experiment on the 23 m flight path. This experiment, which used a 0.5 mm ^6Li glass for a flux monitor, covered the energy region from 6 eV to 30 keV, and, normalized to an integrated cross section of 238.4 eV b in the 7.8 to 11.0 eV region, yields an average cross section of 2.48 ± 0.05 b for the 10 to 20 keV interval. The resultant cross section in the 200-800 keV interval is approximately 5 percent less than the ENDF/B-IV evaluation.

17829. West, W. P., Gallagher, A., **Pressure dependence of Na resonance line broadening by Kr and Xe**, *Phys. Rev. A* **17**, No. 4, 1431-1438 (Apr. 1978).

Key words: line broadening; sodium.

The fluorescent spectrum of the Na D lines, pressure broadened by Xe and Kr, has been measured for noble-gas densities of 2×10^{19} – 3×10^{20} cm^{-3} ; at the lower density, the lines are isolated while, at the higher, they are severely blended. The spectra are obtained in normalized intensity units allowing the nonbinary behavior of the line wing intensity to be clearly observed. At the lower density the broadening is well characterized by isolated binary interactions; at the higher density multiple-perturber interactions dominate. Nonlinearities in the pressure dependence of shifts, widths, and satellite shape are reported.

17830. Myklebust, R. L., Fiori, C. E., Heinrich, K. F. J., **FRAME C: A compact procedure for quantitative energy-dispersive electron probe x-ray analysis (Abstract)**, *Proc. 8th Int. Conf. X-ray Optics Microanalysis and 12th Annu. Conf. Microbeam Analysis Society, Boston, MA, Aug. 18-24, 1977*, pp. 96A-96D (Aug. 1977).

Key words: computer program; energy dispersive detector; multichannel analyzer; peak overlap; quantitative electron probe microanalysis; x-ray continuum; x-ray spectrum.

A correction procedure (FRAME C) for quantitative electron probe microanalysis with a lithium-drifted silicon detector was developed for use with a small computer. The procedure consists of a background correction calculated from two selected background regions of interest, a simple method of resolving overlapping peaks, and the ZAF matrix corrections. To save computation time, FRAME C uses small groups of adjacent channels (regions of interest) in the multi-channel analyzer rather than individual channels for the calculations. The method used for computing the overlap factors is also described. Examples of several different types of analyses are presented.

17831. Marvin, R. S., **A brief history of the International Committee on Rheology**, *Proc. VIIth Int. Congress on Rheology, Gothenburg, Sweden, Aug. 23-27, 1976*, pp. 31-36 (Swedish Society of Rheology, Dept. of Polymeric Materials, Chalmers University of Technology, S-402-20, Gothenburg, Sweden, 1976).

Key words: history; International Committee on Rheology; national societies of rheology; rheology.

The formal recognition of rheology as a separate branch of science occurred in 1929 with the formation of the Society of Rheology in the United States. During the next eleven years rheological activities continued to grow, and new organizations were formed in Holland and in Great Britain. Immediately after

the Second World War the International Council of Scientific Unions formed a Joint Committee on Rheology which evolved in 1953 into our present International Committee on Rheology. At the same time rheologists in Holland and Great Britain initiated the series of International Congresses which has continued to the present. The International Committee has now grown to include eleven member organizations and has been granted affiliate status by the International Unions of Pure and Applied Chemistry and of Theoretical and Applied Mechanics.

17832. Martinez, R. I., Herron, J. T., **Stopped-flow study of the gas-phase reaction of ozone with organic sulfides: Dimethyl sulfide**, *Int. J. Chem. Kinet.* **X**, 433-452 (1978).

Key words: air pollution; chemical kinetics; dimethyl sulfide; ozone; rate constant.

The autoinhibiting reaction of ozone with dimethyl sulfide (DMS), $\text{DMS} + \text{O}_3 \rightarrow \text{products}$ has been studied at 296°K and 1.1 kPa (8 torr) as a function of the concentrations of both reactants. The major products of the reaction are H_2CO , H_2O , CO , and SO_2 . The specific rate of primary attack of O_3 on DMS is immeasurably slow. It is suggested that the rapid overall rate observed for this reaction is due to a chain reaction initiated by the very slow primary reaction. It is concluded that reaction (1) cannot be important under atmospheric conditions and that the major loss process for DMS in the atmosphere is probably reaction with photochemically generated free radicals.

17833. Laufer, A. H., Bass, A. M., **A new channel for the formation of hydrogen cyanide in $\text{CH}_2\text{-N}_2$ systems**, *Combust. Flame* **32**, 215-218 (1978).

Key words: combustion; hydrogen cyanide; methylene; nitrogen; photolysis; rate constant.

Hydrogen cyanide has been observed as a product from the photolysis of the $\text{CH}_2\text{CO-N}_2$ and $\text{CH}_2\text{N}_2\text{-N}_2$ systems. The rate constant for the reaction of $\text{CH}_2(\text{X}^3\text{B}_1)$ with N_2 has been determined to be $\leq 10^{-16}$ $\text{cm}^3 \text{molecule}^{-1} \text{s}^{-1}$. A time history of the HCN production has been obtained and a hypothesis advanced to explain its production.

17834. Parker, W. L., Berger, H., Lapinski, N. P., Reimann, K. J., **Three-dimensional thermal neutron radiography**, *Proc. 8th World Conf. on Nondestructive Testing, Cannes, France, Sept. 6-11, 1976*, Section 3L4, pp. 1-6 (1977).

Key words: complex objects; laminagraphy; multiple-film; rotational movement; thermal neutrons; three-dimensional radiography.

Three-dimensional radiography with thermal neutrons is described. The laminagraphic method is shown to provide a spatial resolution better than 1 mm for complex objects as thick as 50 mm.

17835. Newbury, D. E., Myklebust, R. L., Heinrich, K. F. J., **A Monte Carlo procedure employing single and multiple scattering (Abstract)**, *Proc. 8th Int. Conf. X-ray Optical Microanalysis and 12th Annu. Conf. Microbeam Analysis Society, Boston, MA, Aug. 18-24, 1977*, pp. 27A-27G (Aug. 1977).

Key words: backscattered electrons; electron-specimen interaction; energy distribution; Monte Carlo electron trajectory calculation; multiple-scattering; single-scattering.

A Monte Carlo procedure for the calculation of electron trajectories in solid specimens with incident beam energies in the range 1-50 keV is described. The procedure employs a detailed single-scattering description of elastic scattering for the initial five percent of the energy loss and then calculates the remainder of the trajectory with a multiple-scattering approxi-

mation. This hybrid model realizes a savings of a factor of ten in time spent per trajectory calculation while achieving a good description of the electron interaction. The energy distribution of the backscattered electrons calculated by the hybrid model is more accurate than the distribution determined when the multiple-scattering model is employed exclusively.

17836. Newbury, D. E., **The utility of specimen current imaging in the SEM, Proc. 9th Annu. Scanning Electron Microsc. Symp., Chicago, IL, Apr. 1976**, pp. 111-120 (IIT Research Institute, Chicago, IL, 1976).

Key words: contrast mechanisms; depth sensitivity; image formation; resolution; scanning electron microscopy; specimen current.

Specimen current is one of the least used signals for image formation in the scanning electron microscope. Specimen current does, however, offer certain unique characteristics which can be of considerable value to the microscopist. Specimen current is sensitive only to the number of electrons which exit the specimen due to backscattering and secondary electron emission. Specimen current is not sensitive to the trajectories of the emitted electrons or to the resistivity differences of composite specimens composed of conductors and/or semiconductors. The insensitivity to trajectory effects has a marked influence on the contrast of specimen current images, particularly when topographic contrast is involved. The specimen current signal can be obtained in circumstances where the emitted electrons are difficult to collect, e.g., specimen proximity to the polepiece. Provided that image quality is not limited by the amplification instrumentation, the resolution observed in the specimen current image is identical to the emissive mode image if all emitted electrons were collected. Similarly, the depth sensitivity of the specimen current image is identical to the total emissive signal image.

17837. Newbury, D. E., **Quantitative analysis of glasses by secondary ion mass spectrometry (Abstract), Proc. 8th Int. Conf. X-ray Optical Microanalysis and 12th Annu. Conf. Microbeam Analysis Society, Boston, MA, Aug. 18-24, 1977**, pp. 140A-140F (Aug. 1977).

Key words: ion microprobe mass analysis; local thermal equilibrium model; microanalysis; quantitative analysis; secondary ion mass spectrometry; surface analysis.

Quantitative analysis by secondary ion mass spectrometry has been tested by analyzing a series of NBS research material glasses. Spectral intensities have been converted to compositional values by use of a physical model of the secondary ion emission process, the local thermal equilibrium (LTE) model, and by use of experimentally derived elemental sensitivity factors. The analyses with the local thermal equilibrium model show an error distribution such that 50 percent of the analyses fall within a factor of two of known values and 80 percent within a factor of five. Analysis with average sensitivity factors derived from several different glasses yields compositional values within a factor of two in 83 percent of the cases and within a factor of five in 99 percent of the cases.

17838. Newbury, D. E., **Quantitative analysis by secondary ion mass spectrometry**, (Proc. American Society for Testing and Materials Symp. on Quantitative Surface Analysis of Materials, Cleveland, OH, Mar. 2-3, 1977), *Am. Soc. Test. Mater. Spec. Tech. Publ. 643*, pp. 127-149 (Feb. 1978).

Key words: elemental sensitivity factors; local thermal equilibrium model; microanalysis; quantitative analysis; secondary ion mass spectrometry; surface analysis.

Quantitative analysis by secondary ion mass spectrometry (SIMS) involves reduction of spectral intensities to composi-

tional values by the use of either empirical sensitivity factors or a physical model of ion emission. Of the several physical models available, the local thermal equilibrium (LTE) model is the one most easily applied to the analysis of an arbitrary multielement specimen. The accuracy of SIMS analysis by both the LTE model and by sensitivity factors has been compared on a series of well-characterized glass samples.

Error factor histograms have been prepared for several hundred elemental determinations. For the LTE analysis, approximately 50 percent of the analyses fall within a factor of two of the accepted value, and 80 percent fall within a factor of five. For analysis with elemental sensitivity factors derived from the glasses, approximately 80 percent of the analyses lie within a factor of two and over 95 percent within a factor of five of known values.

17839. Wiederhorn, S. M., Lawn, B. R., **Strength degradation of glass resulting from impact with spheres, J. Am. Ceram. Soc. 60**, No. 9-10, 451-458 (Sept.-Oct. 1977).

Key words: erosion; fracture; fracture mechanics; glass; mechanics strength.

The nature and extent of degradation incurred by glass surfaces impacted with spheres of steel and tungsten carbide were studied. The residual strength after impact depends on the velocity, radius, and density of the projectile; on the toughness and (indirectly) the hardness of the target; and, to a lesser degree, on the preexisting mechanical condition of the surface. The damage morphology involves modification of the basic Hertzian cone crack pattern by median (radial) cracks and crushed glass at the impact site. The essential features of the degradation may be predicted by a theoretical analysis of residual strength as a function of impact velocity as derived from indentation fracture mechanics. This study accounts, in particular, for a threshold velocity for significant strength loss, above which further strength decrease is relatively slight. Small, but significant, discrepancies between observed and predicted degradation characteristics are attributed to the departure from ideal Hertzian fracture geometry and to the dynamic nature of the contact. However, it is suggested that quasi-statically based theory may be used for estimating the strength of structural ceramics in small-particle impact situations.

17840. Kornblith, R., Eberly, J. H., **Polarisation dependence in three-level atom resonance fluorescence, J. Phys. B 11**, No. 9, 1545-1556 (1978).

Key words: dressed atom; fluorescence spectrum; Heisenberg equations; laser excitation; Liouvillian; multiphoton; polarization; resonance fluorescence; spontaneous emission; strong field.

The resonance fluorescence from a three-level atom irradiated by a monochromatic laser is studied. Detailed spectra are calculated by using the Heisenberg source-field approach, and introducing Liouvillian space techniques. It is predicted that in the steady-state limit the fluorescence from an atom having two closely spaced excited states will have an anisotropically polarised seven-line spectrum. Graphs are shown of the predicted spectra in the case of on-resonance excitation and of far off-resonance excitation.

17841. Hummer, D. G., **Atmospheres of central stars**, (Proc. Planetary Nebulae, Observations and Theory, Cornell Univ., NY, June 13-15, 1977, Y. Terzian, Ed.), *IAU Symp. No. 76*, pp. 171-183 (Apr. 1978).

Key words: planetary nebulae central stars; stellar atmospheres.

This review begins with a brief summary of atmospheric models that are of possible relevance to the central stars of

planetary nebulae, and then discusses the extent to which these models accord with the observations of both nebulae and central stars. Particular attention is given to the significance of the very high Zanstra temperature implied by the nebular He II $\lambda 4686 \text{ \AA}$ line, and to the discrepancy between the Zanstra He II temperature and the considerably lower temperatures suggested by the appearance of the visual stellar spectrum for some of these objects.

For a wider discussion of the central stars, the reader is referred to the very comprehensive review of Aller (1976).

17842. Berger, H., Bracher, D. A., **Real-time thermal neutron radiographic detection systems**, *Proc. 8th World Conf. on Non-destructive Testing, Cannes, France, Sept. 6-11, 1976*, Section 3L6, pp. 1-7 (1977).

Key words: fluoroscopy; image system; motion-response; neutron radiography; nondestructive evaluation; real-time; television.

Systems for real-time detection of thermal neutron images are reviewed. Characteristics of one system are presented; the data include contrast, resolution and speed of response over the thermal neutron intensity range $2.5 \times 10^3 \text{ n/cm}^2\text{-sec}$ to $10^7 \text{ n/cm}^2\text{-sec}$.

17843. Unassigned.

17844. Tsai, D. H., MacDonald, R. A., **Shock wave profile in a crystalline solid**, *J. Phys. C: Solid State Phys.* 11, L365-L371 (1978).

Key words: crystalline solid; energy relaxation; Hugoniot relations; molecular dynamics; pressure calculation; shock wave profile; temperature calculation.

We analyze the results of Paskin, Gohar and Dienes obtained from their molecular dynamical simulation of shock wave propagation in a solid. We find that their kinetic 'temperature' profiles T_1 and T_3 behind the shock front are in error, because these are defined with respect to a reference frame that experiences acceleration, instead of one that moves at a uniform velocity with the compressed lattice as a whole. The basic difficulty with their definition is that with respect to non-Galilean transformation the Newtonian equations of motion are not in-

variant and the kinetic energy is not conserved. The error incurred is precisely equal to the kinetic energy associated with the oscillatory motion of the atomic planes relative to the compressed lattice. This error is very large in the region immediately behind the shock front, and it is not zero even in the tail region of the shock profile, where the interplanar oscillations are expected to disappear. When this kinetic energy is properly accounted for, as in their temperature profile T_2 , their results are in qualitative agreement with those which we obtained previously.

17845. Unassigned.

17846. Ballantine, C. S., Johnson, C. R., **Accretive matrix products**, *Linear and Multilinear Algebra* 3, 169-185 (1975).

Key words: accretive; eigenvalues; positive definite; set product.

Let $\Sigma(F)$ be the class of hermitian positive definite elements of $M_n(F)$, where F is either R , the real or C , the complex field, and let

$$\Pi(F) = \{A \in M_n(F) : \text{Re}(A) \in \Sigma(F)\}.$$

For $j \geq 0$ and $k \geq 1$, all set products of the form:

$$\Sigma(F)^j \Pi(F)^k$$

are determined for integers j, k . This completes earlier work of Ballantine and Tausky which determined

$$\Sigma(F)^j$$

for integers $j \geq 0$. Also inequalities for the eigenvalues of

$$A = ST \in \Pi(C)^2$$

are given in terms of conjunctive invariants of $S, T \in \Pi(C)$. Finally some conditions are presented which insure for certain pairs $A, B \in M_n(C)$ that the product AB is in $\Pi(C)$.

17847. Barbera, A. J., Albus, J. S., Evans, J. M., Jr., **Control strategies for industrial robots systems**, (Proc. 1st Ind. Robot Conf. and Exposition, Chicago, IL, Oct. 26-28, 1976), *SME Tech. Paper MR76-616*, pp. 1-10 (Society of Manufacturing Engineers, Dearborn, MI, 1976).

Key words: automation systems; computer control; hierarchical control; microcomputer control; proximity sensors; sensory feedback control.

The efficient control of complex automation systems requires that the control problem be partitioned into a hierarchy of sub-problems. The National Bureau of Standards has developed a hierarchical control system of three levels that could be implemented on a microprocessor for any industrial robot system. This paper describes the various levels of the control hierarchy, evaluates their effectiveness, and discusses the use of sensory feedback to allow the robot to cope with uncertainties in its environment in real time.

17848. Bauer, R. W., **Survey of the use of casting alloys in commercial dental laboratories. Part II. Ceramic alloys**, (Proc. National Association of Dental Laboratories Annual Meeting, Seattle, WA, Aug. 1977), *J. Nat. Assoc. Dent. Labs. Spec. Issue*, pp. 8-15 (Sept. 1977).

Key words: ceramic casting alloys; fabrication problems; nonprecious alloys; porcelain fused to metal restorations.

The current usage of various types of ceramic casting alloys in commercial dental laboratories was assessed by a comprehensive survey of 3,044 member laboratories of the National Association of Dental Laboratories. It was found that high, noble, medium noble, low noble and nonprecious alloys ac-

counted for 33.3, 36.5, 5.2 and 25.0 percent respectively of the total production of ceramic units in 1975 and 1976. Data provided by NADL member laboratories indicates that there is a strong negative correlation between the total noble metal content and the degree of difficulties experienced during fabrication of porcelain fused to metal restorations.

17849. Beaty, E. C., Hesselbacher, K. H., Hong, S. P., Moore, J. H., **Measurements of the triple-differential cross section for low-energy electron-impact ionization of helium**, *Phys. Rev. A* **17**, No. 5, 1592-1599 (May 1978).

Key words: helium; ionization; triple-differential cross section.

The triple-differential cross section for ionization of helium by low-energy electron impact is investigated over the energy and angular variables. Measurements have been made for primary electron energies near 100 eV, ejected electron energies of 5, 10, and 20 eV, and scattering angles 15°, 20°, and 30°. The forward lobe of the triple-differential cross section is found to be approximately cylindrically symmetric.

17850. Berger, H., **Inspection by neutron radiography**, Paper in *Metals Handbook Eighth Edition, Vol. 11, Nondestructive Inspection and Quality Control*, 156-160 (American Society for Metals, Metals Park, OH, Aug. 1976).

Key words: inspection by neutron radiography; neutron radiography; nondestructive evaluation by neutron radiography; nondestructive testing by neutron radiography; radiography-neutron.

Neutron radiography is a form of nondestructive inspection that employs a neutron beam to form a radiographic image of an object. The principles of the process and the role that it plays in the nondestructive evaluation of materials and components are the subjects of this article. The characteristics that differentiate neutron radiography from other radiographic methods and the complementary role that it plays in relation to other techniques are emphasized. Details of neutron beams and their interactions with matter, sources, the attenuation of neutron beams, neutron collimation and neutron beam imaging are included in this presentation. The applications of neutron radiography are presented in terms of its advantages for improved contrast on low-atomic-number material, discrimination between isotopes and elements, and the inspection of highly radioactive materials.

17851. Swyt, D. A., Rosberry, F. W., Nyyssonen, D., **Calibration of optical microscopes for photomask linewidth measurements**, (Proc. 1977 Kodak Microelectronics Seminar, Monterey, CA, Oct. 5-7, 1977), *Kodak Publ. No. G-48*, pp. 131-144 (1978).

Key words: calibration standards; closed-circuit TV systems; dimensional metrology; electron microscope; filar eyepiece; image shearing eyepiece; integrated circuits; linewidths; microelectronics; optical microscopes.

An on-going program at the National Bureau of Standards has produced a method for the use of optical microscopes for photomask linewidth measurements in the general 1- to 10 μm range which can significantly reduce certain types of troublesome systematic errors. Proposed as a means to improve accuracy of industrial photomask linewidth measurements made with optical microscopes, the method involves the use of an NBS-calibrated linewidth artifact and a recommended measurement procedure. To be discussed are relevant aspects of: laboratory and field testing of the overall method; a comparison of measurements made with filar, TV and image-shearing eyepiece microscopes; the NBS proto-type linewidth artifact and the manner of calibration of such artifacts at NBS.

17852. Sleater, G., **Development of performance criteria for the selection of stone preservatives**, (Proc. American Geological Society, Symp., Miami Beach, FL, Nov. 1974), *Engineering Geology Case Histories No. 11*, pp. 65-71 (1978).

Key words: accelerated laboratory testing; performance criteria; stone decay; stone preservatives.

This paper describes how test methods and performance criteria for the selection of stone preservatives are being developed. Accelerated aging of stone and of preservative treated stone followed by tests of the aged specimens is used to evaluate both test methods and stone preservatives. The laboratory aging procedure incorporates important causes of stone decay—Chemical Attack, Salt Action, Water Action, Thermal Effects—in a special test chamber (CAD) and test cycle. The effects of the accelerated aging on the weight, appearance, absorption of liquid water, permeability to water vapor, abrasion resistance, and surface hardness of the treated test specimens are used as measures of preservative performance. It is explained how this test data and the test methods employed can be used to set limits of acceptable performance to be used as preliminary performance criteria for the selection of stone preservatives.

17853. Rush, J. J., Rowe, J. M., **Comment on "High temperature thermodynamics of palladium-hydrogen. II. Temperature dependence of partial molar properties of dilute solutions of hydrogen in the range 500-700 K"**, *J. Chem. Phys.* **68**, No. 8, 3954 (Apr. 15, 1978).

Key words: acoustic modes; entropy; hydride; PdD_{0.63}; site occupation; thermodynamics.

17854. Rook, H. L., **The determination of iodine in biological and environmental standard reference materials**, *J. Radioanal. Chem.* **39**, 351-358 (1977).

Key words: biological standard reference materials; gas phase separation; iodine; irradiation; SRM's; standard reference materials.

Iodine is an element with excellent intrinsic sensitivity when determined by thermal neutron activation. However, in most real samples, the preponderance of chlorine and bromine, relative to iodine, makes the direct determination of iodine virtually impossible. Over the past 20 years, there probably have been as many publications on the separation of iodine as there have been for any other radionuclide. Upon review, however, the methods are essentially the same. After irradiation, the samples are subjected to a rapid destructive process to free the iodine from the matrix and then the iodine is separated from the other halides either by liquid-liquid extraction or by liquid ion exchange. Both of these procedures are, however, rather complex and do not effect a complete separation of the halides in one pass. In the work presented here, a simple procedure is described for the quantitative separation of iodine from chlorine. The procedure utilizes a gas phase separation on hydrated manganese dioxide with iodine collected on silvered quartz wool. The described procedure has been used for the determination of iodine in numerous new and old SRM's at the NBS.

17855. Reeder, D. J., Sniegowski, L. T., Schaffer, R., ***o*-phthalaldehyde for the fluorometric assay of nonprotein amino compounds**, *Anal. Biochem.* **86**, 490-497 (1978).

Key words: bovine serum albumin; fluorogenic assay of free amino acids in plasma; Standard Reference Materials.

We describe a manual fluorometric method for the quantitation in protein solutions of total free amino compounds, expressed as norleucine. A trichloroacetic acid deproteinization

step is employed, and *o*-phthalaldehyde, buffered with phosphate at pH 9.2, is used as the fluorogenic reagent. The method is linear, reproducible, and rapid. Recoveries of amino acids added to serum are quantitative. Sensitivity is in the picomole range. Results on unselected patient sera are discussed.

17856. Powell, C. J., **The physical basis for quantitative surface analysis by Auger electron spectroscopy and x-ray photoelectron spectroscopy**, (Proc. American Society for Testing and Materials Symp. on Quantitative Surface Analysis of Materials, Cleveland, OH, Mar. 2-3, 1977), *Am. Soc. Test. Mater. Spec. Tech. Publ.* 643, pp. 5-30 (Feb. 1978).

Key words: analytical methods; Auger-electron spectroscopy; ESCA; quantitative surface analysis; reference materials; x-ray photoelectron spectroscopy.

A review is given of the physical basis for quantitative surface analysis by Auger electron spectroscopy (AES) and by x-ray photoelectron spectroscopy (XPS) or electron spectroscopy for chemical analysis (ESCA). The principal topics discussed are: the feasibility of surface analysis, approaches to surface analysis, description of models and data for surface analysis by AES and XPS, analytical methods, intensity measurements, practical considerations, applications, and reference materials.

17857. Pommersheim, J. M., Mathey, R. G., **Prediction of bitumen slip and sag in roofing systems**, (Proc. First Int. Conf. Math. Modeling, St. Louis, MO, Aug. 29-Sept. 1, 1977), *Eng. Sci.* III, 1347-1359 (1977).

Key words: asphalt; bitumen; built-up roofing; coal-tar pitch; roofing; sag; slip.

Mathematical models for slippage of built-up roofing membranes and sag of roofing bitumens were formulated, solved and tested against previously developed experimental data. Bitumens used were coal tar pitch and ASTM Types I, II and III asphalts. Model predictions confirmed the increased slip and sag observed with increased membrane loading, roof slope, interply bitumen film thickness and bitumen temperature. Viscosities were calculated from the models for slip and sag and compared to ones measured independently using a plastometer. Agreement was good for Types II and III asphalts but only fair for coal tar pitch and Type I asphalt. The calculated bitumen viscosities for the slip and sag tests agreed well with one another except for coal tar pitch. Separate calculations showed either Newtonian or pseudoplastic behavior. Design predictions were made for the amount of slip in a built-up roofing membrane subjected to typical summer temperatures and solar radiation intensities. The methods presented in this paper help to quantify the separate and combined effects of the factors influencing roofing performance when slippage and sag occur.

17858. Christensen, R. G., May, W. E., **Detectors for liquid chromatographic analysis for polynuclear aromatic hydrocarbons**, *J. Liq. Chromatogr.* 1, No. 3, 385-399 (1978).

Key words: detector; fluorimeter; liquid chromatography; photometer; polynuclear aromatic hydrocarbon; selectivity; sensitivity; spectrofluorimeter.

A number of liquid chromatographic detectors of various types have been evaluated for both selectivity and sensitivity for the detection of polynuclear aromatic hydrocarbons (PAH). Detection limits for fixed and variable wavelength UV photometers, filter fluorimeters, and spectrofluorimeters have been determined. The utility of each of these types of detectors for use in the reversed-phase HPLC analysis of environmental extracts containing trace levels of PHA's is discussed.

17859. Collins, B. L., **Human response to windows**, *Proc. RILEM/ASTM/CIB Symp. Evaluation Performance External Vertical Surfaces of Buildings*, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, 1, 327-338 (1977).

Key words: energy conservation; glare; human factors; psychology; thermal discomfort; window management; windows.

Research into human reaction to windows must consider several different types of response. Windows provide important psychological benefits, including a view out, and dynamic change within a space through continuous variations in external lighting. In addition, another response involves comfort in such areas as temperature, glare, and noise. Finally, it is important to consider the actual use of windows. The way in which people actually use windows and window accessories can be critical to the acceptable performance of glazed areas. Pertinent information from different researchers on human response is reviewed.

17860. de Wit, R., **The modified Westergaard equations**, (Proc. 4th Int. Conf. on Fracture, Waterloo, Canada, June 19-24, 1977), *Fracture* 3, Pt. V, 185-189 (1977).

Key words: Airy stress function; crack; fracture mechanics; plane elasticity; stress; Westergaard method.

A restriction of Westergaard's equations for plane problems in linear elasticity, previously discussed and corrected by Sih and Eftis and Liebowitz, is briefly discussed anew. It is shown that the correction can be made very simply by adding the real part of a term in z^2 to the Airy stress function of Westergaard. The result is illustrated by the classical example of a single line crack in an infinite plate under constant remote stress.

17861. Hulick, C., Berke, J., **An experimental approach to procurement policy research**, *Proc. 5th Annual DOD Procurement Research Conf., Monterey, CA, Nov. 17-19, 1976*, pp. 148-157 (Naval Postgraduate School, Monterey, CA, Nov. 1976).

Key words: ETIP; Federal Supply Service; innovation; life cycle costing; National Association of State Purchasing Officials; National Institute of Government Purchasing; policy research; procurement; technological change.

The ETIP Procurement Program through procurement experiments with participating government agencies is testing the hypothesis that government procurement can stimulate private sector technological innovation by the use of procurement incentives such as life cycle costing, performance specifications and value incentive provisions. The products involved in these experiments are commercial in nature. Examples of participating agencies are, at the Federal level, GSA and VA, and at the state and local level respectively, the National Association of State Purchasing Officials (NASPO) and the National Institute of Government Purchasing (NIGP).

Procurement experiments to date have used life cycle costing in the purchase of home appliances (window air conditioners, hot water heaters, refrigerators), printer ribbons, and performance specifications in the purchase of lawnmowers, oxygen producers, and reflective sheeting.

Results thus far indicate that government's use of procurement incentives is an effective method of increasing competition and obtaining product innovation for the government market. The short term goal of the participating agencies, buying the most current technology available, has been met, and in doing so, the necessary climate for the long term ETIP goal, private sector technological innovation, has been created.

17862. Hulick, C., Berke, J., **Procurement incentives and the innovation process**, *Proc. 1976 Int. Conf. on Procurement and*

Grants Management, Charlottesville, VA, Apr. 28-30, 1976, pp. 165a168 (School of Continuing Education, Univ. of VA, Charlottesville, VA, 1976).

Key words: ETIP; Federal Supply Service; innovation; life cycle costing; local government; procurement policy; state government; test methods; value incentive clauses.

The paper discusses the process of information interchange and industry-government interaction and its effects on new product innovation and technological change. Specifically, it reviews the philosophy and objectives of ETIP and how these are carried out through actual procurement experiments. Policies addressed include performance spec. purchasing, life cycle costing, value incentive clauses, plus such new incentives as warranties, innovative unsolicited proposals, and cost plus contracting for product improvement. References include studies on specific products as air conditioners, hot water heaters, gas and refrigerator-freezers.

17863. Fatiadi, A. J., *New applications of malononitrile in organic chemistry—Part I and Part II, Synthesis: Int. J. Methods Synth. Org. Chem.* **3**, pp. 165-282 (Mar. 1978).

Key words: application; chemistry; industry; malononitrile; mechanism; methods; organic; review; synthetic.

Recent applications of malononitrile in organic chemistry are reviewed; an overview of the chemistry of substituted malononitriles is also included. New trends, mechanisms and synthetic methods employing malononitriles are discussed. Among other topics, this survey includes new information on malononitrile dimers and trimers, new Knoevenagel and Michael condensation reactions, reactions with cyclic polyketones, quinones, sulfur and organometallic compounds, and the synthesis of new heterocycles, pesticides, charge-transfer complexes, and solvatochromic dyes.

17864. Fatiadi, A. J., *Synthesis of 1,3-(dicyanomethylene)croconate salts. New bond-delocalized dianion, "Croconate Violet", J. Am. Chem. Soc.* **100**, No. 8, 2586-2587 (Apr. 12, 1978).

Key words: bond-delocalized; croconates; derivatives; dianions; dicyanomethylene; esters; planar; salts; structure.

A new croconate dianion analog was prepared whose physical and chemical behavior are reported. The preparation of new electron-acceptors from croconic esters is also described. The new dipotassium salt of 1,3-(dicyanomethylene)-2-oxo-5-cyclopentene-4,5-diol is assigned a symmetrical, bond-delocalized structure.

17865. French, J. C., *Where we stand and where we need to go: Electronic technology, Proc. 1976 Symp. of the National Conference of Standards Laboratories, National Bureau of Standards, Gaithersburg, MD, Oct. 6-8, 1976 (Complete transcript in the form of 8 cassettes of the Conference available for \$20.00 from the NCSL, Secretariat, National Bureau of Standards, Room 4101 Radio Building, Boulder, CO 80303, 1976).*

Key words: electronic technology; equipment; manufacturing; materials; measurements; practical measurements; semiconductor technology.

The growth of electronics and its spread as a valuable tool throughout society's endeavors have been remarkable. Its growth and pervasiveness are expected to continue as the technology advances in the future. These advances, however, will enlarge a problem to which standards laboratories should increasingly direct their attention: the inadequacy of measurement methods needed to control the properties of materials and equipment as they enter into and are used on a manufacturing

line, and those needed to characterize the manufactured product. These inadequacies are inhibiting productivity and the uniformity and reliability of products to a degree that concerns both the manufacturers and users of these products.

17866. Harris, R. E., *Numerical evaluation of the response of a Josephson tunnel junction in an arbitrary circuit, J. Appl. Phys.* **48**, No. 12, 5188-5190 (Dec. 1977).

Key words: Josephson junctions; simulation; superconducting devices; superconductivity theory; tunneling.

A numerical technique is presented for calculating the response of a Josephson tunnel junction when connected to an arbitrary circuit. The approach includes all of the details of the microscopic theory including sine and cosine terms as well as the quasiparticle current together with its reactive part. An example is given, and techniques for reducing computation time are discussed.

17867. Haynes, W. M., Hiza, M. J., McCarty, R. D., *Densities of LNG for custody transfer, Proc. 5th Int. Conf. on Liquefied Natural Gas, Dusseldorf, Germany, Aug. 29-Sept. 1, 1977, LNG 5, 2, Session III, Paper 11, 34 pages (1977).*

Key words: cell model; corresponding states model; custody transfer; density; equation of state; hard spheres model; liquefied natural gas; magnetic suspension densimeter; measurements; mixture data; pure fluid data; saturated liquid.

An accurate knowledge of the density of LNG is required to provide a basis for equitable custody transfer. A project has been carried out to provide experimental density data for liquefied natural gas components and their mixtures with a total uncertainty of less than 0.1 percent. The apparatus, data, experimental procedures, etc. are described. The assessment of the accuracy of the data has been propagated into estimates of financial inequities (bias) in the custody transfer of LNG.

Several mathematical models for the calculation of LNG densities for custody transfer have been optimized, tested and compared. An assessment of the accuracy of the resulting models is given. The models optimized and tested include an extended corresponding states method, a hard sphere model, a cell model and an empirical model due to Klosek and McKinley. The extent to which the objective of predicting LNG densities within 0.1 percent of the true value from an input of pressure, temperature and composition has been achieved is discussed.

17868. Hebner, R. E., Jr., Malewski, R. A., Cassidy, E. C., *Optical methods of electrical measurement at high voltage levels, Proc. IEEE* **65**, No. 11, 1524-1548 (Nov. 1977).

Key words: current measurement; electric fields; electric power transmission; electro-optics; Faraday effect; high voltage measurement; impulse measurement; Kerr effect; magnetic fields; magneto-optics; Pockels effect; waveform measurements.

Optical methods to measure electric parameters and transmit the information from high voltage circuits to ground potential are described and evaluated in the light of the specific requirements of high-voltage measurement applications. The history and physics of a variety of optoelectrical methods found suitable for electrical measurement applications are introduced. Existing optical devices for measuring alternating, direct, and impulse currents and voltages in high-voltage circuits are reviewed with emphasis on the operation and features of several selected methods. The use of these techniques in industrial systems, in research laboratory apparatus, and in reference standards laboratories is discussed.

17869. Heinrich, K. F. J., Marinenko, R. B., Ruegg, F. C., **Electron probe testing for homogeneity of standards (Abstract)**, *Proc. 8th Int. Conf. on X-ray Optics and Microanalysis and 12th Ann. Conf. of the Microbeam Analysis Soc., Boston, MA, Aug. 18-24, 1977*, pp. 148A-148D (Aug. 1977).

Key words: digital periodic integrator; electron microscope; homogeneity; standard reference materials; standards.

Standard Reference Materials (SRM's) certified for composition by the National Bureau of Standards have occasionally been used to test the accuracy of microprobe techniques. Such use is justified only if these materials have been previously tested for homogeneity on a micrometer scale, as were the materials cited in Table 1. Two research materials which were also tested for homogeneity on a micrometer scale, are also listed in this table.

17870. Evans, J. M., Jr., **Standards for the NC user**, (Proc. 13th Ann. Meeting and Tech. Conf. of the Numerical Control Society, Cincinnati, OH, Mar. 28-31, 1976), Paper in *NC/CAM—The New Industrial Revolution*, pp. 33-37 (Numerical Control Society, Inc., Glenview, IL, 1976).

Key words: computer aided manufacturing; numerical control; standards.

The Numerical Control Society is predominately composed of users of numerically controlled machine tools. The user of NC equipment finds that a numerically controlled machine tool is not as simple as a manual tool in that it combines electronics and computer systems which may be alien to the new user. This requires an education process and a reorganization of an existing management structure to be able to cope with the changes in productivity and the implicit requirements for changes in scheduling, personnel training, and maintenance and support facilities and personnel.

The user of numerically controlled machine tools also finds that he must deal not with a single supplier of the machine tool, but with the machine tool company, the control system manufacturer, a computer service system, a paper tape dealer, and potentially, independent software houses for software programs for specific applications. The number of people getting into the act already seems bewildering.

One is immediately led to the speculation that there must be standards that control compatibility and quality in procurement of all these various system components, and indeed there are. However, the standards for those various components are created by organizations that are almost as bewildering and diverse as the marketplace itself.

17871. Johnson, C. R., **Price stability in unions of markets**, (Proc. National Science Foundation-Conf. Board of Mathematical Sciences on the Stability of Dynamical Systems: Theory & Applications, Mississippi State, MS, July 1976), Chapter 10 in *Stability of Dynamical Systems: Theory and Applications*, J. R. Graef, Ed., pp. 127-135 (Marcel Dekker, Inc., New York, NY, 1977).

Key words: Gersgorin's theorem; Lyapunov's theorem; multiple market; stable equilibrium.

When two separate markets in the same set of commodities are joined into one, resulting equilibria are not necessarily locally stable even if all equilibria were stable in the predecessor markets. Considered are conditions under which a resulting equilibrium is stable.

17872. Greer, W. L., Haus, J. W., **Electronic Green's function for a linear crystal in a thermal gradient**, *J. Chem. Phys.* **68**, No. 9, 4238-4243 (May 1, 1978).

Key words: electronic properties; Green's function; line shapes; nonequilibrium; solid state; spectral density; statistical mechanics.

By employing a modification to Lloyd's exactly solvable model, we have evaluated exactly the configuration-averaged Green's function for an electron (or exciton) in a one-dimensional crystal subjected to a thermal gradient. Our formalism is applied both to a continuous lattice in which the otherwise free electron experiences a randomly fluctuating potential at all points in the crystal, and to the discrete lattice in which the thermal fluctuations are confined to specified sites. The thermal gradient is incorporated by requiring that the root mean square potential fluctuation varies linearly with position. We compare the spectral density $A(k, \omega)$ so obtained with that appropriate to thermal equilibrium. Comments on transport properties are also included.

17873. Fisher, G. B., Shalvoy, R. B., **X-ray photoemission studies and bonding in amorphous chalcogens**, *AIP Conf. Proc. No. 31 on Structure and Excitations of Amorphous Solids*, Williamsburg, VA, Mar. 25-27, 1976, G. Lucovsky and F. L. Galeener, Eds., pp. 48-52 (American Institute of Physics, New York, NY, 1976).

Key words: amorphous materials; bonding; selenium; sulfur; tellurium; x-ray photoelectron spectroscopy.

Trends in x-ray photoelectron (XPS) spectra of chalcogens which relate to their bonding are discussed. Valence band spectra of disordered S are reported along with measurements in the same apparatus of amorphous Se and Te. Each chalcogen's spectrum has a minimum about 7 eV below E_F , between the largely p-derived states nearer E_F and the s-derived states. The p states are split into a largely nonbonding level near E_F and a bonding peak an energy ΔE_p below it. The splitting ΔE_p (S, 3.5 eV; Se, 2.9 eV; Te, 2.2 eV) grows with decreasing atomic number, Z, and is found to scale with Pauling's bond energies. The s states exhibit an apparent bonding-antibonding splitting which also grows with decreasing Z and scales with the increasing overlap of the s orbitals. Although the s states overlap, comparisons with calculated valence levels in the free atom suggest that most of the cohesive energy in the chalcogens is gained by the bonding of the p electrons, with no major contribution from the s electrons.

17874. Kamper, R. A., **Review of electromagnetic measurements using the Josephson effect**, *Proc. ISA Int. Instrumentation-Automation Conf., New York, NY, Oct. 28-31, 1974*, pp. 1-8 (Instrument Society of America, Pittsburgh, PA, 1974).

Key words: electronics; Josephson effect; precise measurements; superconductivity.

Practical systems are now at various stages of development to measure voltage, current, rf power and attenuation, sub-millimeter wave frequency, noise temperature, magnetic susceptibility, and the magnetic activities of the earth and the human body. All these systems employ the Josephson effect in superconductors. Their widespread adoption will take liquid helium cryostats to places where they have never been seen before.

17875. Sengers, J. V., Moldover, M. R., **Critical phenomena in a low gravity environment**, Paper in *COSPAR: Space Research XVIII*, M. J. Rycroft and A. C. Stickland, Eds., 495-506 (Pergamon Press, New York, NY, 1978).

Key words: critical phenomena; fluids; gravity effects; materials science; phase transitions; spacelab experiments.

The study of critical phenomena in fluids is related to some very general issues in materials science. Earth-bound experiments near the critical point of fluids are severely affected by

the presence of the earth's gravitational field. If critical phenomena experiments in fluids were conducted in a low gravity environment, the results might be of interest to materials science in general.

17876. Hertz, H. S., May, W. E., Chesler, S. N., Gump, B. H., **Petroleum analysis: Methodology for quantitative and qualitative assessment of oil spill**, *Environ. Sci. Technol.* **10**, No. 9, 900-903 (Sept. 1976).

Key words: dynamic headspace sampling; gas chromatography; liquid chromatography; mass spectrometry; petroleum analysis; weathering factor.

An integrated chromatographic technique for petroleum analysis compatible with long-term studies of oil spills is presented. Dynamic headspace sampling and the complementary analytical techniques of gas chromatography and coupled-column liquid chromatography are utilized for quantitation of petroleum containing samples. Gas chromatography-mass spectrometry is employed for identification of individual components in these samples. Analytical data obtained from a major oil spill are presented and discussed.

17877. Doyle, W. M., McIntosh, B. C., Geist, J., **Characterization of the electrically calibrated pyroelectric radiometer**, (Proc. 19th Annu. SPIE Symp., San Diego, CA, Aug. 19-20, 1975), *SPIE* **62**, Modern Utilization of Infrared Technology, I. J. Spiro, Ed., pp. 166-170 (1977).

Key words: electrically calibrated radiometer; gold-black, pyroelectric detector.

This paper is a discussion of the experimental techniques presently being used to characterize the Electrically Calibrated Pyroelectric Radiometer (ECPR) and of the degree of accuracy attained, to date, with these techniques. The results reported are an indication of the extent to which an ECPR can be regarded as an absolute radiometer for use as an optical calibration standard in place of a standard source.

17878. Etz, E. S., Rosasco, G. J., Blaha, J. J., **Observation of the Raman effect from small, single particles: Its use in the chemical identification of airborne particulates**, (Proc. 10th Rochester Int. Conf. on Environmental Toxicity, Rochester, NY, May 23-25, 1977), Paper in *Environmental Pollutants*, T. Y. Toribara, J. R. Coleman, B. E. Dahneke, and I. Feldman, Eds., pp. 413-456 (Plenum Publ. Corp., New York, NY, Apr. 1978).

Key words: air particulates; asbestos particles; chemical microanalysis; micro-mineralogy; microparticles; micro-Raman spectroscopy; pollution analysis; Raman microprobe; Raman spectra; stack particulates.

A Raman microprobe developed at the NBS is used to observe the normal Raman effect from single microparticles of size 1 μm and larger. The resulting spectra of the Raman-scattered light are characteristic of molecular and crystal vibrations in the solid and are the basis for the qualitative identification of major molecular constituents. Particles composed of a broad range of compounds exhibit vibrational Raman spectra and thus can be identified spectroscopically by comparison with spectra obtained from known particles or by reference to Raman data available for bulk samples. The application of Raman spectroscopy to the analysis of small, single particles thereby offers the opportunity for the determination of the chemical states of major elements. This capability for the speciation of principal molecular components is not available from other microprobe techniques which furnish elemental composition data only.

17879. Wiederhorn, S. M., **Mechanical properties of glass**, *Proc. ERDA Workshop on Ceramic & Glass Radioactive Waste*

Forms, Germantown, MD, Jan. 4-5, 1977, D. W. Readey and C. R. Cooley, Eds., pp. 215-231 (Available as ERDA CONF-770102 from National Technical Information Service, Springfield, VA 22161, 1977).

Key words: brittle fracture; fracture; glass; radioactive waste disposal; static fatigue; strength; stress corrosion cracking.

The fracture of glass is reviewed and related to problems of nuclear waste disposal. Although there is a dearth of information on glasses intended for radioactive waste disposal, many of the techniques that have been developed to characterize the strength of glass and to improve the reliability of structural glasses will be applicable to problems of waste disposal. Suggested areas for research include: characterization of the mechanical behavior of glasses for waste disposal; characterization of the effect of radiation damage on mechanical properties; evaluation of the effect of recrystallization and phase separation on the strength of glass.

17880. Wiederhorn, S. M., Tighe, N. J., **Application of proof testing to silicon nitride**, *Proc. ERDA Workshop on Ceramics for Advanced Heat Engines, Orlando, FL, Jan. 24-26, 1977*, pp. 247-258 (Available as ERDA CONF-770110 from National Technical Information Service, Springfield, VA 22161, 1977).

Key words: fracture; nondestructive evaluation; proof testing; silicon nitride; strength; turbine materials.

Proof testing is being investigated as a method of insuring the reliability of silicon nitride in high temperature structural applications. In principle, proof testing ensures that the test survivors have a probability of failure that is acceptable for design purposes. A model program is being conducted at both room temperature and at 1200 °C to determine if the mechanical performance of hot-pressed silicon nitride can be enhanced by proof testing. It is observed that proof testing is useful for hot-pressed silicon nitride at service temperatures provided the effect of exposure time on strength is taken into account. Results are discussed with regard to flaw generation and oxidation in oxygen rich environments.

17881. Ackerson, B. J., Hanley, H. J. M., **The thermal diffusivity of methane in the critical region**, *Chem. Phys. Lett.* **53**, No. 3, 596-598 (Feb. 1, 1978).

Key words: critical point; methane; Rayleigh light scattering; thermal conductivity; thermal diffusivity.

Rayleigh light scattering results for the thermal diffusivity of methane along the critical isochore at temperatures to within 0.001 K of the critical temperature are reported. The results, corrected to zero wave vector, are compared with values from an expression introduced previously. Agreement is within 10 percent. Some possible reasons for this discrepancy are given.

17882. Albus, J., Barbera, A. J., Evans, J. M., Jr., VanderBrug, G. J., **Control concepts for industrial robots in an automatic factory**, *SME Tech. Paper MS77-745*, pp. 1-14 (Society of Manufacturing Engineers, Dearborn, MI, 1977).

Key words: computer-aided manufacturing; goal-directed systems; hierarchical control; robots; sensory feedback; task decomposition.

The NBS program in automation technology carries out research in sensors and computer control systems relevant to industrial robots. In particular, NBS has pursued the concept of industrial robots coupled with machine tools as the basis module of an automatic factory. Basic concepts of sensing and hierarchical control for machine tool loading and unloading will

be examined, and data from NBS experience in using a robot for tool loading will be presented. In addition, the integration of robot/machine tool modules into integrated computer aided manufacturing systems will be discussed, with emphasis on the question of interfaces.

17883. Andrews, J. R., **Automatic network measurements in the time domain**, *Proc. IEEE* 66, No. 4, 414-423 (Apr. 1978).

Key words: automated measurements; fast Fourier transform; pulse generator; pulse measurements; sampling oscilloscope; scattering parameters; spectrum amplitude.

The Time Domain Automatic Network Analyzer (TDANA) is described. It utilizes time domain measurements and the fast Fourier transform to obtain frequency domain scattering parameters. A TDANA consists of a pulse generator, sampling oscilloscope and a minicomputer. The present state of the art for TDANAs includes frequency coverage from dc to 18 GHz in a single instrument and a complex scattering parameter measurement uncertainties of the order of 1 percent.

17884. Bagozzi, R. P., Ives, W. R., Nahman, N. S., **Determination of the dielectric relaxation time in a Debye binary liquid by pulse measurements**, (Proc. XVI General Assembly of the International Union of Radio Science (URSI), Ottawa, Canada, Aug. 1969), Paper in *Progress in Radio Science 1966-1969*, J. A. Lane, J. W. Findlay, and C. E. White, Eds., 2, 257-265 (International Union of Radio Science, Brussels, Belgium, 1971).

Key words: dielectric measurements; dielectric relaxation time; time-domain; transmission lines.

The dispersive properties of a lossy coaxial transmission line were used to deduce the Debye relaxation time for dilute solutions of (polar) 2-heptanone in (nonpolar) normal heptane. The step responses of a liquid filled coaxial line were measured and compared with the Debye model in order to deduce the relaxation time τ . Over the concentration range of 0.1 to 1.1 molal, 1 kHz capacitance measurements showed that the static dielectric constant varied linearly with increasing concentration from 1.98 to 2.54; also, the deduced relaxation time varied from 1.36 to 5.4 picoseconds.

17885. Barbera, A. J., Albus, J. S., Evans, J. M., Jr., **Control strategies for industrial robot systems**, *SME Tech. Paper MR76-616*, pp. 1-10 (Society of Manufacturing Engineers, Dearborn, MI, 1976).

Key words: control systems; industrial robots; interface standards; performance evaluation; programming languages; robot classification.

The efficient control of complex automation systems requires that the control problem be partitioned into a hierarchy of sub-problems. The National Bureau of Standards has developed a hierarchical control system of three levels that could be implemented on a microprocessor for any industrial robot system. This paper describes the various levels of the control hierarchy, evaluates their effectiveness, and discusses the use of sensory feedback to allow the robot to cope with uncertainties in its environment in real time.

17886. Barger, R. L., West, J. B., English, T. C., **Fast frequency stabilization of a cw dye laser**, *Appl. Phys. Lett.* 27, No. 1, 31-33 (July 1, 1975).

Key words: calcium atomic beam; optical frequency/wavelength standard; Rydberg constant; stabilized dye laser.

A system is described for stabilizing a cw dye laser frequency to a high-finesse optical cavity. The length of this optical cavity

is locked to a CH₄-stabilized He-Ne laser with a tunable frequency-offset technique. A very fast servo system (using an intracavity KD*P crystal), a long dye laser cavity, and the stabilized optical cavity result in an absolute frequency stability of 1 kHz for an integration time of 10⁻⁴ sec and 300 Hz for 300 sec. Intensity is stabilized to one part in 10⁴.

17887. Bohlander, R. A., Gebbie, H. A., Pardoe, G. W. F., **Absorption spectrum of water vapour in the region of 23 cm⁻¹ at low temperatures**, *Nature* 228, 156-157 (Oct. 10, 1970).

Key words: atmosphere; far infrared; low temperature; water dimer.

New atmospheric and laboratory measurements have given further evidence for the existence of water dimers in the atmosphere.

17888. Bradley, C. C., Gebbie, H. A., **Refractive index of nitrogen, water vapor and their mixtures at submillimeter wavelengths**, *Appl. Opt.* 10, No. 4, 755-758 (Apr. 1971).

Key words: index; interferometer; maser; nitrogen; refractive; submillimeter; water vapor.

Molecular masers have been used to measure the refractive index of nitrogen, water vapor, and their mixtures at wavelengths of 337 μ , 311 μ , and 28 μ . A discrepancy between the new measurement and microwave values for pure nitrogen is at present unexplained.

17889. Brennan, J. A., **Operation and measurement in base load LNG terminals: Measurement methods**, *Proc. 52d Int. School of Hydrocarbon Measurement Symp.*, Oklahoma Univ., Norman, OK, Apr. 12-14, 1977, pp. 501-504 (Oklahoma Univ., Norman, OK, 1977).

Key words: flow; instrumentation; liquefied natural gas; measurement; tank gauging.

Presently there are no base load LNG terminals operating in the United States. Two facilities are nearing completion, however, and should start operation during late 1977 or early 1978. Some of the measurement systems included in these terminals for measuring the LNG as it moves from the ship to the transmission line are presented.

17890. Broadhurst, M. G., Harris, W. P., **Precision in dielectric measurements**, (Proc. Conf. on Electrical Insulation and Dielectric Phenomena, Gaithersburg, MD, Nov. 3-6, 1975), *1975 Annual Report*, pp. 143-150 (National Academy of Sciences, Washington, DC, 1978).

Key words: dielectric measurements; electrical measurements; electrical properties of materials; precise measurements; 2-terminal; 3-terminal.

The dielectric properties of a material are a measure of how that material responds to an electric stress. Generally the response is observed as an electric current and the stress as an electric potential difference (voltage). Measurements of current and voltage are usually done with an electric circuit associated with a specimen of the material and the current and voltage in the material are inferred from geometric considerations. Errors may occur in the electrical measurements but more often the assumed connection between circuit response and material response is the major source of error. If one can optimize conditions such as the material's physical state, size and shape, measurement frequency and voltage level and ambient pressure and temperature, one can determine a material's dielectric constant to better than ± 0.01 percent. Usually conditions are not optimum and one finds that techniques required for extreme measurement frequencies or for difficult specimen shapes and sizes may yield errors comparable in magnitude to the quanti-

ties being measured. Even worse than for a well defined quantity such as dielectric constant, high-field dielectric properties (e.g., breakdown) have the added uncertainty that the quantity being measured is not clearly defined and at best represents a statistical average of measured values. Thus, the degree to which a particular dielectric measurement is precise depends on the existing state-of-the-art for that measurement. In this paper we will survey some of these measurements of dielectric properties for optimum and extreme conditions, and try to indicate the source and magnitude of errors.

17891. Chamberlain, G. E., Simpson, P. A., Smith, R. L., **Improvements in a calorimeter for high-power CW lasers**, *IEEE Trans. Instrum. Meas.* **IM-27**, No. 1, 81-86 (Mar. 1978).

Key words: CW high energy laser; electrically calibrated laser meter; intercomparison of laser meters; laser beam calorimeter; laser beam overspill monitor; laser beam power and energy measurement; laser calorimeter backscatter monitor; water-stirred calorimeter.

Measurement certainty with the BB series of electrically calibrated calorimeters for high-energy lasers has been enhanced by the addition of monitors for energy backscattered from the meter and for energy missing the entrance aperture (overspill). The performance and design features of the recently constructed BB2 meter are compared with the previously described BB1 meter. Direct intercomparison shows the agreement between meters to be 1 percent.

17892. Daney, D. E., **A cryogenic pressure regulator**, *Cryogenics* **18**, No. 4, 234-235 (Apr. 1978).

Key words: cryogenic flow control; flow control; liquid helium pressure regulator; pressure regulator.

A simple, dome-loaded pressure regulating valve suitable for use in a low temperature, high vacuum environment is described. Design principles and operating characteristics are given as well.

17893. Davis, G. T., Broadhurst, M. G., **Piezoelectricity and pyroelectricity in a polyvinylidene fluoride copolymer**, (Proc. Conf. on Electrical Insulation and Dielectric Phenomena, Gaithersburg, MD, Nov. 3-6, 1975), *1975 Annual Report*, pp. 37-44 (National Academy of Sciences, Washington, DC, 1978).

Key words: electret; piezoelectric; polarization; polymer; polyvinylidene fluoride; pyroelectric.

Piezoelectric (d_p) and pyroelectric (p) coefficients of films of copolymer of vinylidene fluoride with 27 percent tetrafluoroethylene have been measured as a function of poling conditions and the results interpreted in terms of a model of aligned dipoles within the crystalline regions of the polymer. The experimental results are compared with the predictions of a dipole model and are shown to be easily accounted for by the model.

17894. Daywitt, W. C., **A precision earth-terminal system for accurate C/kT, G/T, and EIRP measurements with a calibrated radio star**, *Proc. URSI Int. Symp. on Measurements in Telecommunications, Lannion, France, Oct. 3-7, 1977*, pp. 1-4 (1977).

Key words: C/kT; EIRP; error analysis; G/T; precision measurements; radio star; satellite communications.

The National Bureau of Standards (USA) has constructed a system designed to accurately measure the downlink C/kT, earth-terminal G/T, and satellite EIRP. It operates off the i-f patch panel of the downlink earth terminal and automatically controls the steps of the several measurement sequences.

The procedure employed in the system is a modified version of the "radio star" method of measuring the above parameters. The modification allows earth terminal receiver gain fluctuations to be removed from the measurement, significantly reducing the measurement error.

In addition to a digital voltmeter, programmable i-f attenuators, and well characterized bandpass filters, the system features an extremely accurate power bridge and an improved rf solid state noise source of high stability. Combined, the components can routinely measure power ratios to a few hundredths of a decibel.

A thorough measurement and error analysis appropriate to the 1 GHz to 10 GHz frequency range has been incorporated into the systems' computer software. The analysis reveals additional errors, a higher atmospheric correction factor than previously calculated, and adds some interesting insight into the usual star shape correction factor.

17895. Epstein, M. S., Rains, T. C., Brady, T. J., Moody, J. R., Barnes, I. L., **Determination of several trace metals in simulated fresh water by graphite furnace atomic emission spectrometry**, *Anal. Chem.* **50**, No. 7, 874-880 (June 1978).

Key words: aluminum; atomic emission; barium; beryllium; copper; graphite furnace; manganese; molybdenum; nickel.

Copper, manganese, barium, aluminum, molybdenum, nickel, and beryllium are determined in the part-per-billion concentration range in Standard Reference Material (SRM) 1643 (Trace Elements in Water) using graphite furnace atomic emission spectrometry. The precision and accuracy of results are compared to analysis by graphite furnace atomic absorption spectrometry. The effect of chemical, physical, and spectral interferences on analytical results using both techniques is evaluated.

17896. Fickett, F. R., Reed, R. P., **A review of the NBS-ERDA workshop on materials at low temperatures**, *Proc. 7th Symp. on Engineering Problems of Fusion Research, Knoxville, TN, Oct. 25-28, 1977*, M. S. Lubell and C. Whitmire, Jr., Eds., pp. 1506-1509 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1977).

Key words: composite materials; mechanical properties; physical properties; pure metals; review; stainless steel.

A workshop treating problems related to low temperature materials applications in superconducting magnet systems was held at Vail, Colorado, October 12-14. The major topics considered by the participants were: the recently completed NBS survey of low temperature materials needs for MFE applications and the production of an appropriate data handbook; materials choices of recent device designs; nonmetallic materials applications; high strength stainless steels for cryogenic service; thick section welding; and physical properties of magnet materials. A summary of the presentations and the ensuing discussions is given along with our present assessment of the more pressing of the many low temperature materials research problems considered by the workshop participants.

17897. Flynn, J. H., **Degradation kinetics applied to lifetime prediction of polymer**, (Proc. 17th Eastern Analytical Symp., New York, NY, Nov. 1977), Paper in *Thermal Methods in Polymer Analysis*, pp. 163-186 (The Franklin Institute Press, Philadelphia, PA, 1978).

Key words: accelerated aging; complex reactions; decomposition; degradation; heating rates; initial rates; kinetics; life-time prediction; oxidation; polymers; polyurethanes; pyrolysis; stability; thermal analysis; thermogravimetry.

General problems in relating thermal properties of polymers to lifetime prediction are outlined and criteria for the applica-

tion of thermal degradation data to predict failure at service conditions are discussed. Specific problems encountered in the attempt to apply these data to the prediction of aging characteristics of polymers involve the mode of kinetic coupling of the degradation kinetics to the aging process of interest. We are using three techniques of analysis in which the entire kinetic spectra are compared among experiments performed at different rates of heating in the range from 6 deg/min to 3.6 deg/hr. These techniques are: (1) Changes in mechanism are diagnosed from plots of the logarithm of the heating rate vs. reciprocal temperature. (2) The mode of kinetic coupling between competing processes is elucidated by comparison of experimental rates at slow and fast heating rates with calculated cases of model kinetics. (3) The initial degradation process at use conditions is predicted from a detailed analysis of the first five percent reaction kinetics. The latter technique is applied to weight-loss data for polyurethane degradation. It is concluded that only such a detailed analysis of data from a wide range of heat-rates will allow one to judge whether accelerated weight-loss measurements is a viable method for predicting the service behavior of a polymeric material.

17898. Folcher, G., Braun, W., **Pulsed CO₂ laser photolysis of CF₂Cl₂**, *J. Photochem.* **8**, 341-354 (1978).

Key words: infrared; kinetics; lasers; mechanisms; multi-photon; photochemistry.

The pulsed infrared laser photolysis of CF₂Cl₂ yields primarily (more than 85%) the CF₂Cl free radical and atomic chlorine. Somewhat smaller amounts (less than 15%) of CF₂ and molecular chlorine are produced in a competing primary process. Depending on experimental conditions, e.g. pressure and intensity, secondary processes can occur that can obscure the primary chemistry. For example, at low intensity the CF₂Cl radical can thermally dissociate to yield CF₂ plus chlorine atoms while at high intensity the CF₂Cl radical can undergo reaction with chlorine atoms to yield CF₂ and molecular chlorine. Quantitative measurements can be made of the relative importance of the primary atomic or molecular chlorine elimination channels under conditions where secondary removal of CF₂Cl is entirely eliminated. Under these conditions, the relative importance of these two channels does not depend on the intensity of the laser or on the laser wavelength.

The overall chemistry occurring in this complex system is evaluated in the absence as well as in the presence of atomic and free-radical scavengers using conventional end-product analysis techniques.

17899. Franzen, D. L., Schmidt, L. B., **Absolute reference calorimeter for measuring high power laser pulses**, *Appl. Opt.* **15**, No. 12, 3115-3122 (Dec. 1976).

Key words: calorimeter; laser; measurement; Nd-YAG.

A calorimeter for making absolute energy measurements of high power laser pulses is described. The calorimeter, based on volume absorption in a solid, is calibrated electrically and requires no window or vacuum environment. An error analysis is included giving the systematic and random errors of the instrument for a laser measurement. Briefly, the following performance is typical of the 32-mm—32-mm aperture calorimeter: range 0.4—15-J; random error ± 0.2 percent (one standard deviation); systematic error ± 2.3 percent; and an upper operational limit of 3 J/cm². Most of the volume absorber documentation is applicable for 1.06 μ m; however, the calorimeter should be useful from the near ir through the visible. Absorbers for use with CO₂ lasers in the 9—11- μ m range are also discussed.

17900. Hamilton, C. A., **Automatic 300-4 K temperature cycling apparatus**, *Rev. Sci. Instrum. Notes* **49**, No. 5, 674-677 (May 1978).

Key words: Josephson junction; superconductivity; temperature cycle.

The apparatus described here automatically cycles small samples between 300 and 4 K by alternately raising and lowering the sample through the neck of a commercial liquid helium storage Dewar. A bellows, which is pressurized by the helium boil-off gas, provides all of the required mechanical motion. By utilizing the cooling available from the boil-off gas, liquid helium consumption is limited to 0.03 l/cyc for a 12-g sample. Cycle times can be as short as 5 min.

17901. Haynes, W. M., **Measurements of the viscosity of compressed gaseous and liquid oxygen**, *Physica* **89A**, 569-582 (1977).

Key words: compressed gas; compressed liquid; experimental; oxygen; saturated liquid; saturated vapor; tables; torsional crystal viscometer; viscosity.

The coefficient of shear viscosity of fluid oxygen has been determined at temperatures from 75 to 300 K at pressures up to 34 MPa with a torsionally oscillating quartz crystal. The estimated accuracy and precision of these measurements are 2 percent and 0.5 percent respectively. Dilute gas viscosities and first-density coefficients were obtained from a statistical analysis of the gaseous isotherms at temperatures from 110 to 300 K using expansions in density. An empirical equation that represents the complete set of measurements as a function of density and temperature is presented. Comprehensive comparisons are made with previous experimental data and predicted values.

17902. Hillhouse, D. L., Petersons, O., Sze, W. C., **A prototype field calibration system for coupling capacitor voltage transformers (CCVTs)**, *EPRI EL-690*, 203 pages, Electric Power Research Institute, Palo Alto, CA (Apr. 1978).

Key words: CCVT; compact; field calibration; high accuracy; modular capacitive divider; portable system; truck-mounted.

In recent years, the coupling capacitor voltage transformer (CCVT) has come into wide use for 0.3 percent accuracy extra-high voltage (EHV) revenue metering in interties between utilities, a function performed for many years by the inductive potential transformer (PT). Whereas the PT has been thoroughly proven in this application, the CCVT has not. Considerable user experience has raised very reasonable doubts as to its adequacy and suggested the need for periodic calibration. Since the CCVT is permanently installed in the substation, this calibration must be done on-site.

A prototype field calibration system for CCVTs has been developed. The system consists of 1) CCVT capacitor modules; 2) a high voltage (100 kV) capacitor standard; 3) a current comparator bridge; and, 4) a resonant power supply, all of which are transported in a closed truck. At the substation site, the capacitor modules are removed from the truck and stacked up to form a capacitive divider with a rating that matches the system voltage for calibrating purposes. This divider is used as a transfer standard since it is first calibrated against the high accuracy, high voltage capacitor standard (2) located in the truck. Then it is connected to the high voltage bus to calibrate the substation CCVTs.

The mobile unit is compact and comparatively easy to use. Only a two-man crew plus a minimum of support from the local utility are required to assemble and operate the modular system at the test site.

System accuracy is 0.05 percent and 0.3 milliradians. It has successfully undergone two complete field tests in which a total of six CCVTs and six PTs were calibrated. Feasibility of a considerable simpler and less costly system has been demonstrated in a project extension.

17903. Hong, S. P., Beaty, E. C., **Measurements of the triple-differential cross section for low-energy electron-impact ionization of argon**, *Phys. Rev. A* **17**, No. 6, 1829-1836 (June 1978).

Key words: argon; cross sections; ionization; triple-differential cross sections.

The triple-differential cross section for electron-impact ionization of argon has been investigated for the primary electron energies near 100 eV and scattering angle 15° . The in-plane and out-of-plane measurements show that the forward lobe has a true minimum in the full three-dimensional sense when the ejected electron energy is 5 eV. However, such a minimum is not observed when the ejected electron energy is 20 eV. The cross section has much more structure than that of helium. No simple symmetry has been found common to all the cases for argon.

17904 Hockey, B. J., Wiederhorn, S. M., Johnson, H., **Erosion of brittle materials by solid particle impact**, (Proc. 2d Int. Symp. Fract. Mech., State College, PA, July 26-29, 1978), Paper in *Fracture Mechanics of Ceramics* **3**, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., 379-402 (Plenum Publ. Corp., New York, NY, 1978).

Key words: ceramics; erosion; fracture; plastic flow; solid particle impact; transmission electron microscopy.

Results are presented which show, that in addition to fracture, plastic deformation occurs and plays an important role in the erosion of brittle materials by solid particle impact. These conclusions are supported by transmission electron microscopy studies of impact damage produced in a wide variety of brittle materials and by erosive wear studies on silicon nitride and alumina. The erosive wear studies also indicate that while erosion resistance is primarily determined by fracture toughness and hardness, the relative importance of these materials parameters depends on the test conditions (e.g. temperature and angle of particle impingement).

17905. Imam, M. A., Fraker, A. C., Gilmore, C. M., **Microstructural changes in 900 °C heat treated Ti-6Al-4V after deformation**, (Proc. Thirty-fifth Ann. Meeting of the Electron Microscopy Society of America, Boston, MA, Aug. 22-26, 1977), Paper in *Electron Microscopy*, G. W. Bailey, Ed., pp. 254-255 (Claitor's Publishing Division, Baton Rouge, LA, 1977).

Key words: fatigue; microstructures; titanium; transmission electron microscopy.

Transmission electron microscopy (TEM) techniques have been used to show the microstructural relation to the degree of deformation. The martensite (α' -Ti) size and density increase with increasing deformation and the amount of β -Ti present decreases with increasing deformation. This is illustrated with TEM micrographs and associated electron diffraction patterns from Ti-6Al-4V material after fatigue testing to failure.

17906. Kanda, M., **The characteristics of a relatively short broadband linear antenna with tapered resistive loading**, (Proc. Int. Symp. on Antennas and Propagation Society, Stanford, CA, June 20-22, 1977), *IEEE Antennas and Propagation Society Digest*, pp. 230-233 (1977).

Key words: method of moments; near-field extrapolative range; radiation efficiency; radiation pattern; resistively loaded antenna; TEM cell.

The characteristics of a relatively short cylindrical broadband antenna with continuous resistive loading are studied theoretic-

ally and experimentally. The antenna considered is a nonconducting cylinder with continuously deposited, tapered, resistive loading. The current distribution on the resistively loaded antenna is calculated using the method of moments and compared with the Wu-King approximation. Experimental results indicate that the current distribution on the resistively loaded antenna agrees with the results of the method of moments. Using the current distributions obtained both by the method of moments and by the Wu and King approximation, other quantities such as input admittance, near-field and far-field radiation patterns, and radiation efficiency are calculated and compared with experiments. These experimental results agree with the results from the moment method.

The receiving characteristics are examined using a TEM cell and a near-field extrapolation range to cover the frequency range from 5 kHz to 5 GHz. The resistively loaded antenna with a beam lead Schottky diode detector gives the frequency response flat within ± 3 dB from 700 kHz to 2 GHz. With proper response shaping, the resistively loaded antenna has a potential use for the frequency range between 10 kHz and 3 GHz without distorting the antenna field patterns. The slow rolloff of the frequency response at the low end of the frequency range is due to the space-charge resistance and the spreading resistance of the Schottky diode. The very sharp cutoff at the high end of the frequency range is due to its depletion layer capacitance.

17907. Kautz, R. L., **Picosecond pulses on superconducting striplines**, *J. Appl. Phys.* **49**, No. 1, 308-314 (Jan. 1978).

Key words: superconductivity; thin films; transmission lines.

The attenuation and phase velocity of a superconducting thin-film stripline are calculated at high frequencies using the theory of Mattis and Bardeen. These results are used to study the propagation of picosecond pulses which have frequency components approaching the superconducting energy-gap frequency.

17908. Kayser, R. F., Jr., Raveché, H. J., **Bifurcation in Onsager's model of the isotropic-nematic transition**, *Phys. Rev. A* **17**, No. 6, 2067-2072 (June 1978).

Key words: bifurcation; equation of state; free energy; isotropic-nematic transition; Onsager model; orientational distribution function.

In this paper Onsager's theory of the orientational order in a three-dimensional system of hard rods is reanalyzed as a nonlinear eigenvalue problem. Bifurcation is found and the equation of state is calculated from the orientational distribution function for a nematic phase. We also investigate the corresponding two-dimensional system of hard lines. The existence and order of a phase transition are shown to depend on both the direction of bifurcation and on properties of the global solutions. The analysis can be adapted to other nonlinear equations in theories of liquid crystals.

17909. Lam, L. K., Fujimoto, T., Gallagher, A. C., **Collisional excitation transfer between Na and Na₂**, *J. Chem. Phys.* **68**, No. 8, 3553-3561 (Apr. 15, 1978).

Key words: energy transfer; quenching; sodium.

We have excited $\text{Na}(3s) \rightarrow \text{Na}(3p)$ with a pulsed dye laser at Na densities of 10^{14} – 10^{16} cm⁻³ with typically ~2 percent Na₂. From the decay time constants, intensities and spectra of the Na and Na₂ fluorescences we have identified several collisional and radiative processes in the excited sodium atom-dimer system. Comparing the solutions of coupled equations to the density dependence of the decay constants and fluorescence intensities yields a rate coefficient of $(3.4_{-1.1}^{+1.6}) \times 10^{-9}$ cm³ sec⁻¹

for the excitation transfer process: $\text{Na}^*(3p) + \text{Na}_2(X^1\Sigma) \rightarrow \text{Na}(3s) + \text{Na}_2^*(A^1\Sigma \text{ and } a^3\Pi)$. This indicates that some kind of long-range interaction is operative. Other rate coefficients are determined less accurately; e.g., nonradiative $\text{Na}(3p)$ quenching rate coefficients of $10 \pm 5 \times 10^{-10} \text{ cm}^3 \text{ sec}^{-1}$ due to dimer collisions and of $3 \pm 3 \times 10^{-12} \text{ cm}^3 \text{ sec}^{-1}$ due to atom collisions are obtained.

17910. McDonald, D. G., Peterson, R. L., Bender, B. K., **Design of a Josephson-junction picosecond pulser**, *J. Appl. Phys.* **48**, No. 12, 5366-5369 (Dec. 1977).

Key words: electronics; integrated circuits; Josephson junctions; pulses; superconductivity.

Calculations are described which show that a Josephson junction, when driven by a microwave source, will produce a continuous train of picosecond-wide pulses. Detailed circuit designs, incorporating the microscopic theory of the junction, indicate that it is probably practical to build such pulsers. Furthermore, the theory indicates that picosecond pulses can be produced by circuits with submicron linewidth lithography, if desired. Thus, the possibility of both extremely fast and extremely high-density integrated circuits is supported by these calculations.

17911. Mountain, R. D., **Equation of state of liquid sodium and potassium; a nearly 1st principles calculation**, *Proc. Seventh Symp. on Thermophysical Properties, Washington, DC, May 10-12, 1977*, pp. 878-881 (The American Society of Mechanical Engineers, New York, NY, July 1978).

Key words: equation of state; liquid metal; Monte Carlo; potassium; pseudopotential; sodium.

A nearly first principles calculation of the equation of state of liquid sodium and of liquid potassium is presented. The thermodynamic states considered cover that portion of the liquid region characterized by pressures up to 10^3 MPa and by temperatures from melting up to 500 K. The calculations employ the Monte Carlo simulation technique to determine the pressure implied by the pseudopotentials for sodium and potassium developed by Dagens, Rasolt and Taylor. The reliability of the PVT estimates obtained in this way is checked by comparing the theoretical predictions against the recently reported experimental results of Makarenko, et al. The possibility of theoretically determining the high pressure-high temperature properties of the liquid alkali metals is examined.

17912. Mountain, R. D., **Molecular dynamics of liquids-neutrons and computers**, (Proc. XIIIth European Congress on Molecular Spectroscopy, Proctaw, Poland, Sept. 12-16, 1977), *J. Mol. Struct.* **46**, 381-393 (1978).

Key words: coherent neutron scattering; fluctuations in liquids; generalized hydrodynamics; liquid state; molecular dynamics; statistical mechanics.

The dynamics of liquids has been studied by a variety of techniques; the techniques of neutron scattering and of molecular dynamics (computer simulation) are examined here as complementary methods. While emphasis is placed on monatomic fluids, recent developments for molecular liquids are also considered. The discussion is in terms of generalized hydrodynamics, a theory which makes it possible to identify collective dynamical variables in liquids at the molecular level. This theory is used to provide a unified description of dynamical processes in liquids.

Spectroscopic studies of liquid state dynamics can be profitably carried out at the molecular level using the complementary techniques of slow neutron scattering and of molecular dynamics (computer simulation of the motion of the molecules). Both collective effects and single particle motions

can be investigated using these methods; in this talk we shall confine our attention to what can be done with these techniques to study collective, many-body motions in monatomic liquids. Before going into this subject in any detail it should be noted that considerable effort is being devoted currently to molecular liquids. The state of this work will be considered briefly once the monatomic case has been examined.

17913. Munch, J., Kolpin, M. A., Levine, J., **Frequency stability and stabilization of a chemical laser**, *IEEE J. Quantum Electron.* **QE-14**, No. 1, 17-22 (Jan. 1978).

Key words: chemical laser; frequency stability.

We have built a low-power CW HF/DF chemical laser, designed to achieve high-frequency stability. Measurements are reported which characterize the instantaneous spectral width of the laser output to less than one part in 10^{11} ($\Delta\nu < 1$ kHz) and the variations in absolute frequency of this emission with time to four parts in 10^{10} ($\Delta\nu = \pm 20$ kHz) per 0.1 ms. Two experiments to actively stabilize the laser frequency are reported. In one experiment the laser was locked to a high-finesse Fabry-Perot to five parts in 10^9 ($\Delta\nu = \pm 250$ kHz) for many minutes. In the other experiment one laser was locked to another using heterodyne beat spectroscopy to 1.7 parts in 10^9 ($\Delta\nu = \pm 85$ kHz). The stabilization experiments were limited by the feedback loops used.

17914. Nahman, N. S., **Picosecond-domain waveform measurements**, (Proc. Conf. on Precision Electromagnetic Measurements, Ottawa, Canada, June 26-29, 1978), *Proc. IEEE* **66**, No. 4, 441-454 (Apr. 1978).

Key words: electrical; measurements; optical; picosecond techniques; pulse.

A review of the state-of-the-art of picosecond time-domain measurements is presented which draws together techniques from the electrical and optical regions of the electromagnetic spectrum. Measurement methods are listed in categories which exhibit the commonality between electrical and optical methods. State-of-the-art values for temporal resolution are presented with reference citations to specific methods and related technical topics.

17915. Plante, E. R., Cook, L. P., **Compositional modeling of MHD channel slag, with preliminary vapor pressure data**, *Proc. 17th Symp. Engineering Aspects of Magnetohydrodynamics, Stanford, CA, Mar. 27-29, 1978*, pp. C.1.1-C.1.6 (Stanford University, Stanford, CA, 1978).

Key words: channel slag; coal slag; compositional modeling; K pressure; MHD; slag composition.

Bulk compositional models for MHD channel slags are proposed on the basis of a statistical treatment of coal ash analyses and a consideration of available channel slag data. These model compositions reflect the relatively high CaO content of sub-bituminous ("Western") coal ash, the relatively high FeO_2 content of bituminous ("Eastern") coal ash, and the relative depletion of $\text{SiO}_2/(\text{SiO}_2 + \text{Al}_2\text{O}_3)$ in the channel. KAlSiO_4 is the dominant crystalline phase, resulting in high liquidus temperatures (in excess of 1600 °C). Selective partitioning of iron, calcium and magnesium into the liquid phase with falling temperature is predicted.

Vapor pressure measurements on the model Western channel slag were carried out during which the bulk composition of K_2O decreased from 22.7 to 7 wt %. Between 19 and 7 bulk wt % K_2O , the oxygen pressure was controlled by the K_2O evaporation and the K pressure decreased by a factor of 2. During this period the K pressure was comparable to that over a 20 wt % $\text{K}_2\text{O-SiO}_2$ solution. Potassium pressures over the model Eastern channel slag were measured over a range in

which the bulk K_2O composition decreased from 23.6 to 22 wt %. At temperatures above 1350 °C, K pressures are less than, but within a factor of 2 of the Western slag with bulk K_2O content of 7 wt %. Below 1350 °C positive deviation of the K pressures from the linear $\log P$ vs $1/T$ plot was apparent. This was attributed to reoxidation of the FeO_x component by reaction with O_2 produced by evaporation of the K_2O component. Neither slag gave steady pressures until a small percentage of the sample had been vaporized and both showed O_2 pressures comparable to K pressures until some reduction of the FeO_x component was accomplished in the initial vacuum vaporization experiments.

17916. Powell, R. L., Clark, A. F., **Definitions of terms for practical superconductors. 1. Fundamental states and flux phenomena**, *Cryogenics* 17, No. 12, 697-702 (Dec. 1977).

Key words: critical parameters; definitions; flux phenomena; Josephson phenomena; stabilization; superconductors; terminology.

The definitions of terms used in describing the phenomenology and measurement practices of practical superconductive materials are proposed. The definitions cover the subject categories of: 1. fundamental states and flux phenomena, 2. critical parameters, 3. fabrication, stabilization, and transient losses, and 4. Josephson phenomena. It is intended that these terms will become the basis for the development of standard measurement practices and responses are invited.

17917. Radebaugh, R., Siegwarth, J. D., **The effect of heat treatment and impurities on the Kapitza resistance of copper below 0.2 K**, *Proc. Hakone Int. Symp. on Physics at Ultralow Temperatures, Hakone, Japan, Sept. 5-9, 1977*, T. Sugawara, S. Nakajima, T. Ohtsuka, and T. Usui, Eds., pp. 303-305 (Physical Society of Japan, Tokyo, Japan, 1978).

Key words: annealing; copper; cryogenics; dislocations; heat transfer; helium 3; helium 4; impurities; Kapitza resistance.

Measurements by Anderson showed that sandblasting the surface of commercial purity copper significantly reduced the Kapitza resistance to pure He^3 . He and others attribute this to the interaction of phonons with dislocations near the metal surface. We report here extensive Kapitza resistance measurements made on 99.999+ percent copper in He^3 - He^4 solutions with various surface conditions and heat treatments. We found an increase in Kapitza resistance as the sample was annealed at progressively higher temperatures. In addition, we report measurements on OFHC copper, Cu-0.18 wt % Cr, and Cu-1.86 wt % Be. These measurements show that impurities in these samples cause a large reduction in Kapitza resistance which dominates any effect due to hardening.

17918. Raveché, H. J., Kayser, R. F., Jr., **Towards a molecular theory of freezing: The equation of state and free energy from the first BBGKY equation**, *J. Chem. Phys.* 68, No. 8, 3632-3643 (Apr. 15, 1978).

Key words: bifurcation; crystalline symmetry; freezing; local density; phase transition.

We determine crystalline solutions of a closed BBGKY equation for the local density in a classical hard sphere system. The inhomogeneous solutions, which bifurcate from the fluid phase, are applied to calculate the equation of state and free energy. A first order phase change is found in two and three dimensions and its existence is shown to depend on the direction of bifurcation and on global properties of the solutions. The results are discussed in terms of the closure.

17919. Read, D. T., Ledbetter, H. M., **Temperature dependence of the elastic constants of an NbTi/Cu superconducting composite**, *Composites* 9, No. 2, 100-104 (Apr. 1978).

Key words: bulk modulus; composite; compressibility; copper; cryogenic temperatures; elastic constants; niobium-titanium; Poisson's ratio; shear modulus; Young's modulus.

Low-temperature elastic properties are reported for a commercial superconducting composite consisting of niobium-titanium filaments in a copper matrix. Both an ultrasonic (10 MHz) pulse-superposition technique and a composite-oscillator (100 kHz) technique were used. Seven of the composite's nine independent elastic constants were determined between 76 and 300 K; Young's modulus along the filament axis and a shear modulus perpendicular to that axis were determined between 4 and 300 K; all showed irregular temperature behaviour.

17920. Rhyne, J. J., Koon, N. C., **Magnetic excitations in $HoFe_2$** , *J. Appl. Phys.* 49, No. 3, 2133-2135 (Mar. 1978).

Key words: crystal fields; inelastic scattering; Laves phase; magnetism; rare earths; spin waves.

Spin wave and crystal field excitations in single $HoFe_2$ have been studied using inelastic neutron scattering. At 10 K [100] is the easy magnetic direction and at this temperature the acoustic spin wave mode exhibits a 0.60 meV gap due to anisotropy. The acoustic mode is degenerate at the zone boundary with a flat optic mode of energy 8.3 meV. The lack of dispersion in this mode is a consequence of the small ($< .01$ meV) Ho-Ho exchange energy. A third mode is a highly dispersive optic mode which represents excitations of the iron sublattice spins and has a stiffness parameter almost identical to iron metal. A nearest neighbor linear spin wave model has been applied which represents the data of the three lowest modes well. This model predicts the remaining three allowed modes to be at energies above 200 meV. There is no measurable anisotropy in the spin wave modes with varying propagation directions. At room temperature, higher states of the Ho crystal field multiplet become populated and weaker dispersionless excitations between these levels are observed. The observed excitations are broadened beyond instrumental resolution because of contributions from several levels close together in energy. Crystal field calculations including exchange have been performed and are compared to the energies of the observed optic mode transitions.

17921. Rhyne, J., Pickart, S., Alperin, H., **Magnetic neutron scattering from amorphous $TmFe_2$** , *J. Appl. Phys.* 49, No. 3, 1691-1692 (Mar. 1978).

Key words: crystal fields; inelastic scattering; Laves phase; magnetism; rare earths; spin waves.

Elastic and inelastic neutron scattering was observed from the sputtered amorphous composition $TmFe_2$, which on the basis of magnetization measurements exhibits a transition at $T_0 = 45$ K. Total scattering isotherms taken over a range of temperatures bracketing this value show a magnetic component similar to YFe_2 , but not nearly as large as in $TbFe_2$ and $HoFe_2$. Energy scans taken at $q = .05 \text{ \AA}^{-1}$ show very little change between 60 K and 10 K in the intrinsic linewidth (0.30 meV), suggesting that the spin diffusion does not change greatly on going through the transition.

17922. Shideler, R. W., **A high speed non-overloading discriminator for high accuracy pulse counting**, *Int. J. Mass Spectrom. Ion Phys.* 21, 213-219 (1976).

Key words: high speed; non-overloading; tunnel diode discriminator; wide dynamic range.

A high speed preamplifier discriminator for use with electron multiplier particle counters has a pulse-pair resolution of less than 15 ns. The design combines high sensitivity and exceptional overload performance to provide a stable error-free instrument. The device can be utilized in high speed counting applications where high accuracy and wide dynamic range are requirements. Sensitivity may be controlled externally for remote operation.

17923. Smith, R. L., *Laser power and energy, Proc. Symp. on Biological Effects and Measurement of Light Sources, Rockville, MD, Mar. 25-26, 1976*, pp. 81-86 (U.S. Dept. of Health, Education, and Welfare, Public Health Service, Food and Drug Administration, Bureau of Radiological Health, Rockville, MD, Oct. 1976).

Key words: laser measurements; measurement; measurement assurance programs.

The National Bureau of Standards Laser MAP program as it relates to measurements for safety are reviewed. The concept of MAP is reviewed and the results of a 1 mW HeNe round robin are given.

17924. Smith, R. L., Sanders, A. A., *Improving beam measurement, Laser Focus Mag. Circle No. 155*, pp. 70-71 (Apr. 1975).

Key words: laser energy; laser power; measurement assurance program; measurements; quality control.

The National Bureau of Standards is in the early stages of developing a measurement assurance program, MAP, for the measurement of laser power and energy. We will discuss the main features of a MAP and compare it to the more familiar calibration service. Finally we will give a brief status report on the MAP for laser power and energy measurements.

The goal of a MAP is to assure that those who need a given measurement capability have it with proof that they have it. Thus MAP can supply the evidence you need to defend the quality of one of your measurements.

17925. Stock, M., Smith, E. W., Drullinger, R. E., Hessel, M. M., Pourcin, J., *Analysis of the decay of molecular fluorescence in optically excited mercury vapor, J. Chem. Phys.* **68**, No. 4, 1785-1793 (Feb. 15, 1978).

Key words: decay measurements; dimer and trimer formation; fluorescence bands; kinetic rates; mercury vapor; optical pumping.

The decay of the 485 and 335 nm molecular fluorescence bands in optically excited mercury vapor is studied. A 10 nsec laser pulse at 256 nm is used to excite the vapor and the subsequent fluorescence intensity between 1 and 2000 μ sec was recorded for each band. At late times following the laser pulse, both bands decay at the same exponential rate. This exponential decay coefficient was measured as a function of gas density from 10^{17} to 10^{19} cm^{-3} and as a function of temperature from 473 to 1048 $^{\circ}\text{K}$. These decay data, as well as data on the relative intensities of the two bands, are analyzed in terms of a simple kinetic model for the mercury vapor system and various kinetic rates are determined. Some decay rates for the 6^3P atomic manifold are also obtained and compared with previous measurements.

17926. Szöke, A., *Optical collisions in an intense laser field, Opt. Lett.* **2**, No. 2, 36-38 (Feb. 1978).

Key words: cross section decrease; intense laser field; optical collisions; strontium.

The collisionally broadened optical absorption cross section that is constant at low intensities is predicted to decrease at

high intensities. The prediction is based on a nonlinear change of the effective interaction of the atom with the strong incident electromagnetic field and a distortion of the atomic interaction potential by it. An experiment is analyzed here that observes this falloff on the "wing" of the 460.73-nm strontium resonance line, collision broadened by an argon buffer gas. Qualitative agreement is reached between theory and experiment when the degeneracy of the levels is taken into account.

17927. Trevino, S. F., Farr, M. K., Giguère, P. A., Arnau, J. L., *The lattice dynamics of the deuterium peroxide crystal, J. Chem. Phys.* **68**, No. 9, 4260-4265 (May 1, 1978).

Key words: deuterium peroxide; force model; group theory; lattice dynamics; neutron scattering; phonon.

The phonons propagating along the unique fourfold axis in the D_2O_2 crystal have been measured by coherent inelastic neutron scattering. The measurements covered all branches below 250 cm^{-1} (31 meV), which include all the motions of the rigid molecule, except rotation about the minor axis (close to the O-O axis of the molecule). The sample consisted of a single crystal of 99 percent isotopically pure D_2O_2 in the form of a cylinder 1.5 cm diam and 4 cm long. Group-theoretical selection rules for the observation of the phonons were calculated and used extensively as an aid in the classification and measurement of the phonons. Agreement with previously observed Γ point modes in infrared absorption and Raman scattering was fairly good, but necessitated reassignment of one E mode. A covalent force model, developed in an attempt to reproduce the observations, was only partly successful. The model served to describe the character of the phonon as librational or translational. It is reasonably consistent with the observed intensities of the phonons. The limit success of the model indicates the need for longer range forces than those described as stretching and bending of hydrogen bonds.

17928. Uriano, G. A., Cali, J. P., *Role of reference materials and reference methods in the measurement process, (Proc. Symp. Division of Analytical Chemistry 171st Meeting of the American Chemical Society, New York, NY, Apr. 5-6, 1976)*, Paper 4 in *ACS Symposium Series 63, Validation of the Measurement Process*, J. R. DeVoe, Ed., pp. 140-161 (American Chemical Society, Washington, DC, 1977).

Key words: accuracy; calcium; chromium; measurement compatibility; mercury; nitrogen dioxide; precision; reference materials; reference methods.

Reference Materials (called Standard Reference Materials SRM's by the National Bureau of Standards, NBS) are two important mechanisms being utilized to assure the accuracy and compatibility of measurements in large measurement systems. SRM's are materials whose properties (compositional and/or physical) have been well-characterized and certified by NBS. Reference Methods are analytical methods having high accuracy and precision, which have been vigorously demonstrated. A systems approach to establishing accurate measurement systems is presented. Reference materials and reference methods assist in the transfer of accuracy gained in the experimental realization of base measurement units to the performance of measurements in the field. The application of the systems approach to "real world" situations is illustrated through the presentation of four examples: (1) The measurement of calcium in serum; (2) The determination of NO_2 in ambient air; (3) The analysis of trace levels of mercury in water; and (4) The measurement of chromium in biological matrices.

17929. Wang, F. W., *Determination of block-copolymer molecular weight from measurements of frictional properties, J. Polymer Sci.: Polymer Symp.* **60**, 201-207 (1977).

Key words: bead-spring model; block copolymers; dilute polymer solutions; limiting viscosity number; Mandelkern-Flory-Scheraga equation; molecular weight determination; sedimentation coefficient; translational diffusion coefficient; Zimm theory.

The experimental values of the Mandelkern-Flory-Scheraga parameter for several styrene-isoprene block copolymers are compared with those predicted by the bead-spring model theory which has been previously described. In agreement with the theory, the experiments show that the Mandelkern-Flory-Scheraga parameter is insensitive to composition and molecular weight. A procedure for the determination of block-copolymer molecular weight from measurements of sedimentation coefficient (or translational diffusion coefficient) and limiting viscosity number is discussed.

17930. West, W. P., Shuker, P., Gallagher, A., **The effects of multiperturber interactions on the sodium-rare gas excimer bands**, *J. Chem. Phys.* **68**, No. 8, 3864-3877 (Apr. 15, 1978).

Key words: excimer; line broadening; sodium.

The extreme wing ($600 < \lambda < 820$ nm) of the sodium *D* lines perturbed by xenon and krypton has been measured in fluorescence at perturber densities between 2×10^{10} and 3×10^{20} cm⁻³. At these perturber densities the observed fluorescence results mostly from the NaXe*(NaKr*) molecule in the wavelength range of $600 < \lambda < 720$ nm ($600 < \lambda < 680$ nm) and from the NaXe₂*(NaKr₂*) molecule in the range $740 < \lambda < 820$ nm ($700 < \lambda < 820$ nm). The fluorescence emission coefficient is obtained in normalized units, allowing quantitative comparison to theory. The quasistatic line-broadening theory, including multiple-perturber interactions, is used to calculate the density dependence of the spectra which would result from trimer potential surfaces given by scalarly additive pair interactions. This approximation explains some of the observations; discrepancies between this model and the experimental results are discussed.

17931. Wise, S. A., Chesler, S. N., Hertz, H. S., Hilpert, L. R., May, W. E., **Methods for polynuclear aromatic hydrocarbon analysis in the marine environment**, Paper in *Carcinogenesis*. Vol. 3: *Polynuclear Aromatic Hydrocarbons*, P. W. Jones and R. I. Freudenthal, Eds., pp. 175-182 (Raven Press, New York, NY, 1978).

Key words: aromatic hydrocarbons (PAH's); fluorescence emission spectroscopy; gas chromatography; high-performance liquid chromatography (HPLC); standard reference materials.

Procedures employed at the National Bureau of Standards (NBS) for the analysis of polynuclear aromatic hydrocarbons (PAHs) in water, sediment, and marine biota are described in this chapter. The more volatile PAHs (e.g., naphthalenes, phenanthrene, and pyrene) are removed from the sample matrix by dynamic headspace sampling, and the larger PAHs are removed by a coupled-column trace enrichment technique or by solvent extraction procedures. After removal from the matrix, PAHs are separated according to the number of condensed rings by normal-phase HPLC on a chemically bonded aminosilane packing material. Individual PAH fractions are subsequently analyzed by gas chromatography-mass spectrometry (GC-MS) and/or reversed-phase high-performance liquid chromatography (HPLC) with combined UV absorption/fluorescence emission detection.

In addition, a novel procedure for the preparation of aqueous solutions of PAHs is reported. This procedure should lead to the development of the first trace organic standard reference material (SRM).

17932. Young, M., Lawton, R. A., **Saturation of silicon photodiodes at high modulation frequency**, *Appl. Opt.* **17**, 1103-1106 (Apr. 1, 1978).

Key words: detector; frequency response; high modulation frequency; laser modes; photodiode; saturation.

We have used the constant-amplitude, 600-MHz beat note of a 2-mW He-Ne laser to measure the rms current delivered by silicon photodiodes at 600 MHz. We find that this current first rises with increasing radiant power, saturates, and then begins to decrease at average irradiances ≈ 100 W cm⁻², even though the direct (or average) current remains linear with radiant power. We have also scanned across the faces of the diodes; we find that uniform dc responsivity need not imply uniform 600-MHz responsivity and that saturation of rf responsivity takes place first in regions of high dc responsivity. The response of photodiode at 600 MHz may drop an order of magnitude at an average irradiance of ~ 1000 W cm⁻²; we have observed that the impulse response at roughly the same irradiance is accordingly lengthened.

17933. Berger, H., **Nondestructive testing standards—The role of NBS**, *Proc. 1978 Annual Meeting American Nuclear Society on Nondestructive Testing in the Nuclear Power Industries*, San Diego, CA, June 18-22, 1978, **28**, 124-125 (American Nuclear Society, Inc., La Grange Park, IL, 1978).

Key words: acoustic emission; eddy currents; magnetic particles; microwaves; nondestructive testing; penetrants; radiography; standards; thermal; ultrasonics; visual; wear debris.

Reliable, reproducible and meaningful nondestructive inspection has been a goal of the nuclear power industry from the beginning. A new National Bureau of Standards (NBS) program, Nondestructive Evaluation (NDE), is beginning to contribute toward that goal for nuclear power and other quality-conscious industries. A near-term objective of the NBS-NDE program is to provide means to improve nondestructive measurement reliability and reproducibility. The long-term objective of the NBS work is to gain a better understanding of the meaning of NDE measurements in terms of material or system performance. Therefore, there is a strong materials emphasis in the program.

17934. Burroughs, C. B., Magrab, E. B., **Natural frequencies of prolate spheroidal shells of constant thickness**, *J. Sound Vib.* **57**, No. 4, 571-581 (1978).

Key words: natural frequencies; prolate coordinates; shells; transverse shear; vibrations.

The general displacement-equilibrium equations, which include the effects of transverse shear and rotary inertia, have been derived for a prolate spheroidal shell of constant thickness subject to an harmonically time-varying, arbitrary spatially distributed force normal to the shell surface. The approximate solutions for the two nontorsional displacements of the shell middle surface and the nontorsional rotation of the shell cross-section are obtained by using Galerkin's variational method. Numerical results are presented for the seven lowest axisymmetric natural frequencies of the shell. When 15 term solutions are used for both thick and thin shells, which have eccentricities that vary from 0.13 to 0.89, the approximate natural frequencies for the first seven flexural modes are all found to converge to within less than 8 percent of the final values given, with most converging to within less than 2 percent. Good agreement with other published results is obtained for the approximate natural frequencies of a thin prolate spheroidal shell and for the exact natural frequencies of a thick spherical shell. Additional results are presented for the natural frequencies of

moderately thick shells as a function of shell eccentricity, mode number and shell thickness.

17935. Filliben, J. J., **Testing basic assumptions in the measurement process**, (Proc. Symp. Division of Analytical Chemistry 171st Meeting of the American Chemical Society, New York, NY, Apr. 5-6, 1976), Paper 2 in *ACS Symposium Series 63, Validation of the Measurement Process*, J. R. DeVoe, Ed., pp. 30-113 (American Chemical Society, Washington, DC, 1977).

Key words: assumptions; data analysis; distribution analysis; graphical analysis; in control; measurement process; predictability; probability plots; randomness; statistics; testing assumptions; 4-plot analysis.

This paper concerns itself with the important problem of testing the validity of the basic assumptions in a measurement process. The paper covers four principal areas in this regard: 1) what precisely are the assumptions that are typically made in a measurement process; 2) what are the consequences to the conclusions drawn from a measurement process if the assumptions do not hold; 3) what theoretical statistical tests exist for the checking of basic assumptions; and 4) what practical tools currently exist to facilitate the checking of basic assumptions. Examples of assumption-checking on data drawn from the chemical and physical sciences are included.

17936. Fontanella, J., Johnston, R. L., Colwell, J. H., Andeen, C., **Temperature and pressure variation of the refractive index of diamond**, *Appl. Opt.* **16**, 2949-2951 (Nov. 1977).

Key words: diamond; index of diamond; pressure variation; refractive index; refractive index of diamond.

The temperature and pressure variations of the refractive index for a Type IIa diamond have been measured at audio frequencies using capacitance techniques. Measurements have been made at zero pressure over the 5.5—340-K temperature range and at pressures up to 1.4×10^8 Pa (1.4 kbar) at room temperature. At room temperature, $(1/n)(dn/dT)_p = +4.04 \times 10^{-6}/K$ and $(1/n)(dn/dp)_T = -0.36 \times 10^{-12}/Pa$. In addition, the curvature in the refractive index with temperature has been determined. The first-order derivatives are compared with previous experimental data and the recent theoretical calculations of Van Vechten and Yu and Cardona.

17937. Harter, W. G., Patterson, C. W., da Paixao, F. J., **Frame transformation relations and multipole transitions in symmetric polyatomic molecules**, *Rev. Mod. Phys.* **50**, No. 1, Pt. 1, 37-84 (Jan. 1978).

Key words: Born-Oppenheimer Approximations; Coriolis interactions; frame transformations; group theory; inversion symmetry; Lambda (Λ) coupling; level clusters; multipole transitions; quantum rotor; rovibronic transitions; spherical top molecules; symmetry analysis.

The theory of transformation relations between states of Born Oppenheimer and weak coupling approximations is developed for polyatomic molecules. The relations are a generalization of frame transformation relations used by Chang and Fano for symmetric-top molecules, and they lead to a more convenient symmetry labeling system than was previously available. A key internal symmetry label (named "soul") is defined so that it remains a constant label for frame transformation relations, and is conserved during vibronic transitions, ionization, and even dissociation provided the nuclear spin-rotation interaction is relatively small. Various nomograms, graphs, and tableaux associated with the soul label make it easy to predict and visualize the form of many types of complex high-resolution spectra. Simplified procedures are given for obtaining selection rules, statistical weights, and matrix elements

of multipole operators for common molecules having various point symmetries. Simplifications of computational theory using the new level cluster bases for high J are discussed.

17938. Jarvis, S., Jr., Wineland, D. J., Hellwig, H., **Two-frequency excitation for the Ramsey separated oscillatory field method**, *J. Appl. Phys. Commun.* **48**, No. 12, 5336-5337 (Dec. 1977).

Key words: accuracy; beam tuber; cavity phase error; Doppler shift; envelope deflection; frequency standards.

It is suggested that the systematic frequency shift due to rf phase difference between the two interaction regions in Ramsey's separated oscillatory field technique may be eliminated by using different frequencies in the two interaction regions. The technique is briefly described, and the advantages are noted, particularly for frequency standards based on atomic beams.

17939. Lawton, R. A., Young, M., **Laser-mode beating used for detector frequency-response measurements**, *Appl. Opt.* **16**, No. 10, 2703-2705 (Oct. 1977).

Key words: axial modes; detectors; frequency response; helium-neon lasers; lasers; mode beating; spectral modes.

Low-power He—Ne lasers generally oscillate in two spectral cavity modes. We have found that the amplitude of the beat note between the two modes is nearly constant, even though the powers of the two modes may be changing considerably with time. We use this fact to measure the frequency response of an optical detector at the intermode-beat frequency. Many photodetectors have impulse responses that decay approximately exponentially with time. Therefore, we can further show that it is possible to estimate the frequency response of such detectors at all frequencies from the result of a simple measurement at a single frequency.

17940. Moore, L. J., Heald, E. F., Filliben, J. J., **An isotopic fractionation model for the multiple filament thermal ion source**, (Proc. 7th Int. Mass Spectrometry Conf., Florence, Italy, Aug. 30-Sept. 3, 1976), Paper in *Advances in Mass Spectrometry*, N. R. Daly, Ed., **7A**, 448-474 (Heydon & Son, Ltd., London, England, 1978).

Key words: absolute isotope ratios; atomic/molecular vaporization; atomic weights; calcium; fractionation; isotopes; multiple filament; potassium; strontium; thermal ionization.

Particularly within the last decade, the precise and accurate measurement of stable isotope ratios by thermal ionization mass spectrometry has become well established. With the proper analytical system, it is possible to attain a precision of less than one part in 10 000 for selected elements. The technique has therefore become widely used in isotopic geochemistry and geochronology, high-accuracy isotopic dilution analyses, and the analysis of nuclear fuels and their by-products.

It is well known that the isotopic ratio observed in thermal ionization mass spectrometry is "fractionated". That is, it changes during analysis and is not the same as the actual isotopic ratio of the sample on the filament. Corrections for fractionation can be made, and are usually based on the analysis of known mixtures of individual isotopes. However, isotopic fractionation still limits the accuracy of many isotopic analyses.

Much effort at the National Bureau of Standards has gone into the elimination of systematic biases in NBS thermal ionization mass spectrometers. In doing this and in making accurate stable isotope ratio measurements on many elements, we have compiled a large number of empirical observations on how to minimize isotopic fractionation. Many of these involve unexplained phenomena, and some appear to verge on black magic. In some cases our observations agree with reports in the literature, and in other cases they do not.

There have been a few systematic studies of isotopic fractionation, mostly limited to the single filament source. The widely used multiple filament thermal ionization source (MFTIS), which provides efficient ionization of the sample under relatively gentle vaporization conditions, has not received much attention. Also, some investigations of fractionation have been marred by the errors in the isotopic ratio measurements.

This paper concentrates on isotopic fractionation in the MFTIS. A refined theoretical model for fractionation in the MFTIS is developed and tested against some of the most accurate isotopic ratio data available. As well as explaining a variety of seemingly anomalous fractionation effects, the theory indicates a number of ways fractionation can be controlled or minimized.

17941. Reinhold, T. A., Sparks, P. R., Tielman, H. W., Maher, F. J., **The effect of wind direction on the static and dynamic wind loads on a square-section tall building**, (Proc. 3d Colloq. on Industrial Aerodynamics, Aachen, Germany, June 14-16, 1978), Paper in *Building Aerodynamics, Pt. 1*, pp. 263-279 (Fluid Mechanics Laboratory, Department of Aerodynamics Fachhochschule-Aachen, Germany, May 1978).

Key words: aerodynamics; dynamic loads; dynamic response; structural engineering; tall buildings; wind pressure; wind tunnel tests.

This paper presents the results of a wind-tunnel investigation into the effect of wind direction on the wind loads on a square cross-section building model with sharp corners and an aspect ratio of 8.33 to 1. The studies were carried out in a flow which simulated the mean and turbulent properties expected for an urban boundary layer wind. The static and dynamic wind loads were determined at 6 levels throughout the height of the model. From these loads, local and overall force coefficients were determined for forces normal to the model's faces and for torques about the vertical axis through the geometrical center of the model cross-section. These coefficients are presented together with spectra for the modal forces and modal torques associated with the fundamental translational and modes of the corresponding full structure.

Results indicate that the greatest mean forces do occur when the wind is normal to a building's face but that this is not the case for the mean torques. At certain wind directions mean forces are very sensitive to changes in direction. The dynamic loads suggest that the greatest translational response of the full-scale building would occur in the cross-wind direction with the wind blowing in a direction normal to a face. The greatest dynamic torsional response would also be associated with that direction.

17942. Ruegg, R. T., Chapman, R. E., **Economic analysis of alternative window strategies**, *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. 1*, 395-405 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: buildings costs; economic evaluation; energy conservation; exterior walls; life-cycle costing; windows.

The focus of this paper is the energy and economic performance of the glazed portions of external vertical surfaces in residential buildings. A life-cycle costing technique is used to evaluate the dollar costs of energy, acquisition, maintenance and repair, for windows of alternative design, size, and location, with various accessories and modes of use. The method of evaluation is described briefly and is illustrated in a case study. The results of the case study, based on a "typical" single family dwelling in Portland, Maine, U.S.A. (4173 heating degree days and 131 cooling hours), provide some guidelines for window

selection in a moderately cold climate. In general, the economic evaluation of windows indicates that, depending on their design and use, windows can either greatly increase, decrease, or have little impact on energy consumption and total life-time building costs. There is considerable opportunity for the building community to improve both the energy and the economic efficiency of windows while providing for the important psychological benefits which windows often provide.

17943. Sleater, G., **Performance of industrial-type cladding materials**, *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. II*, 302-308 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: abrasion resistance; coatings; color and gloss change; impact resistance; industrial cladding; moisture resistance; salt spray resistance.

The development of performance criteria for the selection of industrial cladding materials is described. These criteria are based upon: 1) laboratory testing of commercial cladding materials, to determine limits of acceptable performance; 2) natural weathering exposure at NBS Exposure Stations, to study weathering effects; 3) field inspection of structures using industrial cladding, to obtain information about cladding durability under use. The performance criteria cover abrasion resistance, impact resistance, color and gloss changes, salt spray resistance, and moisture resistance.

17944. Sleater, G. A., **Preliminary performance criteria for stone preservatives**, *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. II*, 309, 311-321 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: accelerated stone decay; performance criteria; stone preservatives.

As part of a program to develop performance criteria for the selection of stone preservatives, laboratory methods of accelerated stone decay have been used to obtain data on stone preservatives and to suggest criteria for their selection. Causes of stone decay were simulated in two types of testing: (1) a number of causes were combined in one testing operation, using a special test chamber; (2) the effects of single causes of stone decay were studied individually. Methods for measuring the effects of the test exposures are given, as are the preliminary performance criteria for selecting stone preservatives. No one stone preservative studied in the program met all criteria.

17945. Smyth, K. C., Keller, R. A., Crim, F. F., **Photon-induced ionization changes in a neon discharge**, *Chem. Phys. Lett.* **55**, No. 3, 473-477 (May 1, 1978).

Key words: glow discharge; mass spectrometer; metastable states; neon; photon-induced ionization; tunable dye laser.

Photon-induced voltage changes occur upon irradiation of a gaseous discharge with a tunable dye laser whose wavelength corresponds to an electronic transition of an atomic species in the discharge. The important, and likely dominant, role of ionization changes in producing these voltage changes is demonstrated directly for the first time using a hollow cathode lamp with neon fill gas coupled to a mass spectrometer. Changes in the Ne⁺ concentration are found to correlate with the observed changes in voltage across the discharge when a number of excited state absorption transitions of neutral neon are irradiated.

17946. Smyth, K. C., Schenck, P. K., **Opto-galvanic spectroscopy of a neon discharge: Mechanism studies**, *Chem. Phys. Lett.* **55**, No. 3, 466-472 (May 1, 1978).

Key words: collision; discharges; ionization; laser; neon; opto-galvanic.

Irradiation of gaseous discharges with a tunable laser produces easily observed voltage changes at wavelengths which correspond to electronic transitions for species in the discharge. This work reports observations made in the 572-654 nm region on a neon glow discharge, which is operated at 5 torr (670 Pa) pressure and 2-25 mA current. A wide variety of absorption transitions have been detected which originate in the $1s_n(^3P_{2,1,0}, ^1P_1)$ and $2p_n$ excited states. The resulting voltage signals are both positive and negative, and some transitions exhibit sign changes as a function of discharge current. Some of the results can be interpreted in terms of processes which directly affect the neon metastable atom concentration (3P_2 , 3P_0) and thus ionization in the discharge, in agreement with previous suggestions. Transitions which originate in radiating electronic states also produce voltage changes which can be explained in terms of processes which either enhance or decrease ionization.

17947. Trechsel, H. R., **Test methods for windows and walls—The need for a testing program**, *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. II*, 374-382 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: buildings; design; test methods; walls and windows.

Despite an advanced state of the art in the design of building walls and windows, and despite the extensive testing on building envelope elements, some rather spectacular failures of such elements have occurred in recent years. The paper discusses several selected factors affecting the reliability of test results: number of specimens to be tested, process for selecting specimens, and single performance characteristic tests. Based on these factors, it is proposed that testing be considered as an integral part of the design and build process. It is further suggested that the systems approach be used for developing a test program based on the various trade-offs between cost for the testing and the potential risk for failure.

17948. Trombka, J. I., Schmadebeck, R. L., Bielefeld, M. J., Evans, L. G., Metzger, A. E., Haines, E. L., Dyer, C. S., Seltzer, S. M., Reedy, R. C., Arnold, J. R., **Analytical methods in determining elemental composition from the Apollo x-ray and gamma-ray spectrometer data**, *Trans. Am. Nucl. Soc.* **28**, Suppl. 1, 2-3 (May 1978).

Key words: Apollo; data analysis; gamma-ray; lunar; unfolding; x ray.

Analytical methods are described which were used in the analysis of data obtained with the x-ray proportional-counter and gamma-ray NaI spectrometers flown on the Apollo-15 and -16 missions for the purpose of mapping the elemental composition of the lunar surface. One method includes: (1) procedures for subtracting various background radiation components from the data; (2) a least-squares unfolding of the signal, based on knowledge of the detector response; and (3) the determination of elemental abundances from the photon emission characteristics of excited nuclei. Two simpler, more approximate methods for the analysis of the gamma-ray data are also described, which are useful in limited energy regions.

17949. Benjamin, I. A., Fung, F., Roth, L., **Control of smoke movement in buildings: A literature survey**, *Proc. 2d Joint Panel Meeting The U.J.N.R. Panel on Fire Research & Safety*,

Tokyo, Japan, Oct. 19-22, 1976, Part 1. General Report, pp. 265-317 (Building Research Institute, Ministry of Construction, Tokyo, Japan, 1976).

Key words: basic principles; computer calculations; computer modeling; experimental methods; smoke control methods; smoke movement; smoke simulation; state-of-the-art review.

A state-of-the-art review of efforts in smoke movement and smoke control is presented. Basic principles, experimental techniques and results, computer models, and smoke control methods which have been employed are presented. The paper covers all work in the area of smoke movement and smoke control but emphasizes the work of NBS.

17950. Cohen, G. G., Kuriyama, M., **Polarization phenomena in x-ray scattering**, *Phys. Rev. Lett.* **40**, No. 14, 957-960 (Apr. 3, 1978).

Key words: absorption of x-rays; polarization; rotation of polarization; silicon single crystal; x-ray optical activity; x-ray scattering.

Rotation of the plane of polarization of a linearly polarized x-ray beam by simple transmission through a (110) silicon crystal has been observed. Both the amount of rotation and the amount of absorption of x rays depend on the orientation of the crystal in the incident beam. Contemporary scattering-theory calculations are used to explain this effect, including the x-ray analog to optical birefringence, for a suitable crystal sample.

17951. Deslattes, R. D., LaVilla, R. E., Henins, A., **Double monochromator systems for the study of multiple vacancy processes**, *Nucl. Instrum. Methods* **152**, 179-183 (1978).

Key words: multiple vacancy processes; synchrotron radiation; x rays.

In order to study fluorescent x-ray spectra under tunable excitation, we installed two double monochromator systems at the Stanford storage ring. Characteristics of these systems and results obtained during two experimental periods are described.

17952. Engen, G. F., **Advances in microwave measurement science**, *Proc. IEEE* **66**, No. 4, 374-384 (Apr. 1978).

Key words: automatic network analyzer; connector; microwave; microwave measurement; power equations; six-port.

With the recent impact of digital technology, a review of the subject of microwave measurements is timely. Following a brief summary of those features which make this a unique science, the current status of the so-called "basic standards" for microwave measurements is noted. This is followed by a review of the use of digital techniques, power equation concepts, connector problems, and related developments. Finally, certain projections for the future are made.

17953. Evans, J. M., Jr., Albus, J. S., Barbera, A. J., **Robot loading of an NC machine tool**, *Proc. 1977 Joint Automatic Control Conference, San Francisco, CA, June 22-24, 1977, Vol. 2*, No. 77CH 1220-3CS, 720-724 (McGregor & Werner, Washington, DC, 1977).

Key words: batch manufacturing; control systems; industrial robots; numerically controlled machine tools; productivity; sensors.

Robots have been widely used to load and unload parts from a variety of machine tools on an essentially dedicated basis. However, control capabilities of today's industrial robots have been inadequate to solve the machine loading problem for

small lot production (< 100 parts) which composes the bulk of discrete part batch manufacturing. A multi-level hierarchical control system which embodies a higher level robot programming language will be described, and the use of this system in machine loading in a job shop will be discussed.

17954. Flannery, M. R., **Three-body ion-ion recombination in mercury-halide lasers**, *Chem. Phys. Lett.* **56**, No. 1, 143-147 (May 15, 1978).

Key words: ion-ion recombination; mercury-halide lasers.

The role of ion-ion recombination in the formation of excited states in mercury-halide lasers is outlined. A generalization of Natanson's treatment to unequal-mass constituents and general mean free paths is proposed. Rates as high as $(2.6-1.5) \times 10^{-6} \text{ cm}^3 \text{ s}^{-1}$ are hence determined for the recombination of Hg^+ with F^- , Cl^- , Br^- and I^- respectively, in Ar at (1.7-3.5) atm and 300 K. Somewhat higher rates $(3.4-1.9) \times 10^{-6} \text{ cm}^3 \text{ s}^{-1}$ at slightly lower densities are obtained for the corresponding cases involving Ar^+ .

17955. Galloway, K. F., Mayo, S., **On the compatibility of x-ray lithography and SOS device fabrication**, *IEEE Trans. Electron Devices* **ED-25**, No. 5, 549-550 (May 1978).

Key words: radiation damage; semiconductor devices; silicon-on-sapphire; silicon-sapphire interface; x-ray exposure; x-ray lithography.

If x-ray lithography is applied to the fabrication of silicon-on-sapphire devices (SOS), the average radiation absorbed dose in the sapphire at the silicon-sapphire interface is in excess of ten Mrad. Recent experiments indicate that the resulting radiation damage may not be easily annealed. These results suggest that x-ray lithography and SOS may not be compatible technologies.

17956. Galloway, K. F., Mayo, S., **Radiation dose at the silicon-sapphire interface due to electron-beam aluminization**, *J. Appl. Phys.* **49**, No. 4, 2586-2588 (Apr. 1978).

Key words: electron-beam evaporator; metal evaporation; metallization; microelectronic devices; radiation dose; silicon-on-sapphire; silicon-sapphire interface.

Recently, the process of metallization in an electron-beam evaporator has been shown to result in a buildup of trapped positive charge at the silicon-sapphire interface during the fabrication of silicon-on-sapphire devices. This charge buildup can be attributed to radiation damage produced by x rays generated by electron impact on the aluminum to be evaporated. This paper gives the results of calculations of the radiation dose in the sapphire near the silicon-sapphire interface due to the electron-beam-metallization process.

17957. Huggett, C., **Time-dependent fire behavior of aircraft cabin materials**, *FAA Report No. FAA-RD-77-99*, 39 pages (Dec. 1977). (Available from National Technical Information Service, Springfield, VA 22161, 1977).

Key words: aircraft cabin fires; fire growth; fire growth model; fire hazard; fire safety.

In an aircraft cabin or other inhabited compartment, the early stages of fire growth are critical to life safety. During this period the rate of fire growth, as measured by the mass fuel consumption rate \dot{m} , can be represented approximately as a simple exponential function of time, $\dot{m} = \dot{m}_0 e^{kt}$. The rates of development of hazard from temperature rise and smoke and gas accumulation can be related to \dot{m} . The growth constant k can be related to a small number of system parameters and fuel combustion properties. These properties are identified and laboratory methods for their measurement are suggested.

In a fire situation, the criteria hazard (temperature, smoke, or gas) can be considered to be the one which first reaches a limiting human tolerance level. This mode can be identified and the effects of changes in design and materials on the rate of critical hazard development can be estimated. The simple exponential growth model may provide a means of predicting relative hazard with reasonable accuracy.

17958. Hutchinson, J. M. R., **Possible areas of effort by the international committee on radionuclide metrology in the field of low-level radioactivity measurements**, (Proc. Seminar on Metrology Needs in the Measurement of Environmental Radioactivity, Paris, France, Oct. 4-6, 1976), Paper in *Environ. Int.* **1**, No. 1/2, 11-14 (1978).

Key words: low-level; natural matrix; radioactivity; spiking; traceability.

The results of a survey of the metrology needs in the field of low-level radioactivity measurements are reported.

17959. Jacox, M. E., **Assignment of the hydrocarbon flame bands. The C-X transition of HCO**, *Chem. Phys. Lett.* **56**, No. 1, 43-46 (May 15, 1978).

Key words: emission spectrum; HCO; hydrocarbon flame bands; matrix isolation; molecular orbitals; ultraviolet absorption spectrum.

The analysis previously offered for the absorption counterpart of the hydrocarbon flame bands of HCO, observed in an argon matrix at 14 K, has been extended, providing supporting evidence for the identification of the C-X transition of HCO. The absorption bands can be fitted to the relationship $\nu \text{ (cm}^{-1}\text{)} = 41280 + 1200 \nu'_2 + 960 \nu'_3$. Most of the previously unassigned, diffuse B bands of the flame spectrum can also be assigned to this transition, with $\nu'' = 1$ and an extended progression in the ground-state CO stretching vibration.

17960. Jacox, M. E., **Stabilization of reaction intermediates in an argon matrix in discharge sampling experiments**, *Ber. Bunsenges. Phys. Chem.* **82**, 12-13 (1978).

Key words: charge transfer; infrared spectrum; matrix isolation; reactions of excited argon atoms; ultraviolet spectrum.

A discharge configuration suitable for the trapping of free radicals and molecular ions in an argon matrix is described, and processes which occur in these experiments are characterized. Infrared spectral data are reported for CF_2Cl^+ and CF_2Br^+ .

17961. Lam, L. K., Gallagher, A., Drullinger, R., **Measurement of HgXe excimer potentials**, *J. Chem. Phys.* **68**, No. 10, 4411-4416 (May 15, 1978).

Key words: excimer; mercury; xenon.

The HgXe excimer band at 270 nm has been studied in fluorescence following optical excitation of the $\text{Hg } ^3\text{P}_1$ level. From the temperature dependence of the normalized fluorescence band shape, the potential curves of the $^3\text{O}^+$ excimer state and the $^1\text{O}^+$ ground state are inferred. A binding energy of $1400 \pm 100 \text{ cm}^{-1}$ is found for the $^3\text{O}^+$ state.

17962. Levine, R., **Detection and smoke properties**, *Proc. 2d Joint Panel Meeting The U.J.N.R. Panel on Fire Research & Safety, Tokyo, Japan, Oct. 19-22, 1976, Part 1. General Report*, pp. 350-380 (Building Research Institute, Ministry of Construction, Tokyo, Japan, 1976).

Key words: false detectors; fire; fire alarms; Japan-U.S. cooperation; smoke aging; smoke detectors; smoke measurement; smoke properties.

The purpose of this paper is to describe on-going smoke research in the United States that is applicable to the problem of detection of unwanted fires while minimizing false alarms. The characteristics and short comings of several types of fire warning devices are discussed briefly. This is followed by a review of current U.S. basic research on the properties of smokes as affected by aging, the materials burned, smoldering vs. flaming combustion, and other factors.

The paper is prepared for presentation to a Japanese-U.S. Panel to facilitate continued Japanese-U.S. scientific cooperation in this field.

17963. MacDonald, W. M., **Strength functions for isobaric analog resonances**, *Phys. Rev. Lett.* **40**, No. 16, 1066-1070 (Apr. 17, 1978).

Key words: analog resonance; k-matrix; line broadening; line structure; strength function.

A new strength function continuous in energy and a smoothing parameter is constructed which arbitrarily closely approximates the discontinuous strength function for line broadening defined by A. M. Lane. The functional form of the Lane strength function is then derived for a fragmented isobaric analog resonance. Its non-Lorentzian form is explicitly and qualitatively different from that assumed in a recent analysis of isobaric analog resonances.

17964. May, W. E., Chesler, S. N., Gump, B. H., Hertz, H. S., Searl, T. D., **An analysis of petroleum hydrocarbons in the marine environment: Results of an interlaboratory comparison exercise**, *J. Environ. Sci. Health A13*, Nos. 5&6, 403-410 (1978).

Key words: environmental sampling; intercalibration; petroleum hydrocarbons; water pollution.

An interlaboratory comparison exercise, carried out by Exxon Research and Engineering and the National Bureau of Standards, is described. Marine water samples obtained on a joint cruise using both laboratories' water samplers were split and analyzed at both laboratories. Both samplers were found to be acceptable for the determination of hydrocarbons at $\mu\text{g}/\text{kg}$ (ppb) levels. Differences in analyses were traceable to the analytical schemes employed by each laboratory.

17965. Mosburg, E. R., Jr., Wilke, M. D., **Experimental studies of mercury excimers in a constricted positive column**, (Proc. Third Annual Summer Colloq. on Electronic Transition Lasers, Snowmass Village, CO, Sept. 7-10, 1976), Paper in *Electronic Transition Lasers*, L. E. Wilson, S. N. Suchard, and J. I. Steinfeld, Eds., II, 224-229 (The MIT Press, Cambridge, MA, 1977).

Key words: mercury trimers; spatial profiles.

Current efforts to produce a dissociation laser based on excited dimers such as Hg_2 rely heavily on high power, pulsed excitation such as that provided by electron beam machines. It is clear that a better knowledge of the excimer production and loss mechanisms and their rate coefficients is badly needed. In particular, information about the destruction of excimers in electron collisions is lacking. For this reason a high density ($N \sim 10^{18}$ to 10^{19} cm^{-3}) constricted positive column discharge ($I \sim 30$ to 400 mA) in pure mercury vapor has been studied using fractional absorption measurement techniques as well as absolute emission measurements in order to establish the approximate densities and spatial profiles of the major atomic and molecular species.

At certain pressures and currents the spatial profiles of the 335 nm dimer band emission exhibit very distinctive shapes which can provide information about the reactions involved. Using a simple model for the excimer production and loss

mechanisms which includes dimer to trimer conversion and subsequent loss of trimers, these shapes can be semi-quantitatively reproduced by proper adjustment of three parameters which are ratios of the rate coefficients. If the trimers are removed from the model such a fit is not possible. In this manner a new technique emerges in which the observed spatial profiles, independent of any samples or density measurements, can be made to provide information about the excimer production and loss mechanisms and their rates.

17966. Myers, D. R., Phillips, W. E., **Existence of an isotope shift for the sulfur deep level in silicon**, *Appl. Phys. Lett.* **32**, No. 11, 756-758 (June 1, 1978).

Key words: deep level studies; ion implantation; isothermal transient capacitance method; isotope shift; thermally stimulated capacitance measurement; vibronic coupling.

The deep energy level of the isotope ^{34}S in the upper half of the energy gap of silicon is examined by isothermal transient capacitance measurements on ion-implantation-predeposited diode structures. The resulting energy level at $E_c - 0.512 \text{ eV}$ is found to be 0.014 eV closer to the conduction band edge than the corresponding deep level for the isotope ^{32}S in similarly prepared samples. The existence of an isotope shift for the deep sulfur level is interpreted as implying vibronic coupling between the electronic states of the sulfur center and the silicon lattice.

17967. Nelson, H. E., **Directions to improve application of systems approach to fire protection requirements for buildings**, *Proc. 2d joint Panel Meeting The U.J.N.R. Panel on Fire Research & Safety, Tokyo, Japan, Oct. 19-22, 1976, Part 1. General Report*, pp. 119-151 (Building Research Institute, Ministry of Construction, Tokyo, Japan, 1976).

Key words: "and" gate; behavior; critical events; decision; decision tree; dominant factors; episode; event; fire; fire behavior; fire growth; fire safety; human behavior; models; phase; probability; rate constant; realm; sequence; state; state's-transition; system; systems approach.

This paper covers an examination of the recent and ongoing work in the development of systems approaches for design of fire protection in buildings, as carried out in the United States. The scope of coverage includes: (1) A brief review of the development of fire safety systems approaches in the United States, to the degree felt important to understanding the current situation; (2) An overview of the more extensive and pertinent fire growth systems analysis approaches; (3) A discussion of systems for the analysis of building fire safety design directed at establishing building requirements; (4) A review of the directions and activities now underway to integrate the fire growth models and the total building performance models into a combined approach.

This paper proposes a model of fire and its impact based on a state's-transition concept. The fire is viewed as two separate sequences (Fire Behavior and Human Behavior). Each sequence consisting of connected realms of consistent behavior. The concept views these sequences as interrelating, with a distinct rate consistent for each realm. The concept of state's-conditions is also evaluated. A matrix relating the factors, conditions, and development phase of fire is presented. Finally, a plan for the derivation of a viable fire protection engineering technology is presented.

17968. Risley, A. S., Johnson, E. G., Jr., Hamilton, C. A., **Analog computer studies of frequency multiplication and mixing with the Josephson junction**, (Proc. 1976 Applied Superconductivity Conf., Stanford, CA, Aug. 18-20, 1976), *IEEE Trans. Mag. Mag-13*, No. 1, 381-384 (Jan. 1977).

Key words: analog computer; computer analog; frequency multiplication; Josephson junction.

Using a point-contact Josephson junction (JJ), direct frequency measurement of far-IR laser lines can be performed by mixing the N th harmonic of a microwave frequency ν_2 with the laser frequency ν_1 to produce a beat signal ν_{IF} such that $\nu_{IF} = \nu_1 - N\nu_2$. Analog computer simulation of the JJ has revealed an efficient mode of frequency multiplication and mixing. This is a condition wherein the self-oscillation, ν_J , is phase locked to a frequency $\nu_J = \pm l\nu_2 \pm k\nu_1 \pm m\nu_{IF}$ where l , k , and m are integers. The analog studies show that this phase locking can occur at very low as well as at high levels of the external drives. The result of the phase lock is an efficient transfer of energy into the ν_{IF} output signal. At least one experimental result has verified the occurrence of phase locking to difference frequencies. It is also well known that the optimum bias points in mixing experiments lie between the ν_2 steps. The interpretation of these results and the direct role played by ν_J in mixing experiments has not, however, been generally recognized.

17969. Schwarz, F. P., **Quantitative analysis for hydrogen with a microwave plasma detector**, *Anal. Chem.* **50**, No. 7, 1006-1009 (June 1978).

Key words: deuterium; hydrocarbon; hydrogen; isotope dilution; microwave plasma detector.

Effluent hydrocarbons from a chromatographic column have been analyzed spectroscopically for elemental hydrogen composition. A low pressure microwave discharge through the carrier gas, with added trace amounts of molecular oxygen, resulted in fragmentation of the hydrocarbon and generation of intense atomic hydrogen emission in the visible spectrum. The emission intensity exhibits a 1.5 ± 0.1 power dependence on the atomic hydrogen concentration independent of plasma pressure, carrier gas, oxygen concentration, and hydrocarbon composition. At the measurement conditions of 0.5 to 1.5 percent oxygen concentration in helium carrier gas and a plasma pressure of 5 torr, the microwave plasma detector covered a concentration range of almost three orders of magnitude with a minimum detectable level of 10^{-11} gm/sec. An octane vapor in helium mixture was isotopically diluted with perdeuterated octane and analyzed at 6562.8 \AA for hydrogen composition and at 6561.0 \AA for deuterium composition.

17970. Unassigned.

17971. Steward, W. G., Voth, R. O., Hord, J., Sindt, C. F., Arvidson, J. M., **Flow-induced desorption for He-CO, He-N₂O, and He-N₂ systems**, *Proc. Conf. on Two Phase Flow and Cavitation in Power Generation Systems, Grenoble, France, Mar. 30-Apr. 2, 1976*, pp. 255-265 (Societe Hydrotechnique de France, Grenoble, France, 1976).

Key words: absorption; cavitation; choking flow; desorption; phase equilibrium; two phase flow.

The effects on flow of the liquids CO, N₂O and N₂ due to helium absorption and subsequent flow-induced desorption were investigated experimentally. Friction losses attributable to helium desorption in long channels proved to be negligible both in experimental measurements and in calculations based on assumed equilibrium of liquid and gas. The assumption of phase equilibrium led to gross miscalculations of flows in cavitating or near cavitating nozzles or venturis, actual flow rates being fifty times the theoretical equilibrium choking flow rates. However, definite mass flow rate reductions due to helium desorption were measured in venturi flows, ranging from four percent for nitrogen to twelve percent for nitrous oxide.

17972. Sullivan, D. B., Adair, R. T., Frederick, N. V., **RF instrumentation based on superconducting quantum interference**, *Proc. IEEE* **66**, No. 4, 454-463 (Apr. 1978).

Key words: quantum interference; RF attenuation; RF power; RF standards; SQUID; superconductivity.

The application of the superconducting quantum interference device (SQUID) to RF measurements is reviewed. The SQUID can be adapted as a broadband standard of RF current, power and attenuation and may be used as the sensor for an extremely good regulator of RF current. Bandwidths of dc to 100 MHz and dc to 1 GHz have been demonstrated with a power sensitivity of ~ -100 dBm (100-MHz bandwidth, 0.1-dB resolution). In the measurement of attenuation 0.002 dB uncertainty can be achieved with similar bandwidths.

17973. Younger, S. M., Wiese, W. L., **Theoretical simulation of beam-foil decay curves for resonance transitions of heavy ions**, *Phys. Rev. A* **17**, No. 6, 1944-1955 (June 1978).

Key words: atomic lifetimes; atomic transition probabilities; beam foil experiment; cascade analysis; copper isoelectronic sequence; radiative decay simulation.

A systematic study of the influence of cascades on heavy-ion beam-foil decay curves has been made. Using theoretical data for the lifetimes and initial populations of excited states, decay curves simulating beam-foil excitation conditions have been constructed for the resonance transition of three ions in the copper isoelectronic sequence. Various models for the initial population distribution were tested by comparison with a detailed beam-foil decay curve available for Kr VIII. We found that customary exponential-fitting methods were not able to extract the primary lifetimes from the simulated curves used in constructing them, although the replenishment ratios were close to zero. General implications of this subtle masking of the primary lifetime by numerous cascades for the accuracy of experimental beam-foil data are discussed, especially for $\Delta n = 0$ transitions in heavy ions.

17974. Interrante, C. G., **Elevated-temperature embrittlement of a carbon-manganese steel under impact loading**, *Proc. Conf. on Dynamic Fracture Toughness, London, England, July 5-7, 1976*, Paper 21, pp. 327-338 (British Welding Institute, Cambridge, England, 1976).

Key words: carbon-manganese steel; dimpled rupture; ductile failure; embrittlement; impact energy; plastic failure; secondary hardening; strain aging; temper embrittlement.

Dynamic tear impact specimens of two plates of a carbon-manganese tank-car steel tested over a broad range of temperatures from -46° to 690°C indicate that the steel is embrittled moderately at temperatures near 200°C and markedly at those near 580°C . The embrittlement at the lower temperature appears to be caused by strain-ageing effects. That at the higher temperature is not understood, and the results indicate that it is not because of strain ageing, secondary hardening caused by vanadium, or temper embrittlement. Further study, using additional parameters pertinent to the elevated-temperature fracture process, is suggested for clarification of the phenomenon and its significance with respect to service performance.

17975. Misakian, M., Kotter, F. R., Kahler, R. L., **Miniature ELF electric field probe**, *Rev. Sci. Instrum.* **49**, No. 7, 933-935 (July 1978).

Key words: biological experiments; calibrations; electric field measurement; low frequency; miniature electric field probe; nonuniform field.

A miniature ac electric field probe having direct electrical connections with its battery-operated electronics is described. Because its small size introduces little field perturbation, fields generated by relatively small electrode structures in laboratory environments can readily be characterized.

17976. Penn, D. R., **Role of intrinsic plasmons in conduction-band x-ray photoemission from solids**, *Phys. Rev. Lett.* **40**, No. 9, 568-571 (Feb. 27, 1978).

Key words: conduction band; intrinsic plasmons; loss spectra; x-ray photoemission.

I show that intrinsic plasmons are created in x-ray photoemission experiments on the conduction bands of simple metals. Unlike the core case, the plasmons are produced by many-body effects and are a direct consequence of electron correlation. A theory of the intrinsic plasmon production is given and a calculation of the electron energy-loss spectra in conduction-band x-ray photoemission from Mg and Na is presented. The calculation takes into account both intrinsic and extrinsic plasmon production and the agreement with experiment is good.

17977. Powell, C. J., **Solid state and atomic features in the valence-band Auger spectra of copper, silver, and gold (Abstract)**, *J. Vac. Sci. Technol.* **15**, No. 2, 652 (Mar./Apr. 1978).

Key words: Auger-electron spectra; copper; density of states; electronic band structure; gold; silver.

A brief report is given of high-resolution measurements of selected Auger-electron transitions for copper, silver, and gold. These measurements are compared with a recent prediction by Sawatzky which provides a useful means for distinguishing the atomic-like Auger spectrum of copper from the bandlike spectrum of gold.

17978. Powell, C. J., **Surface analysis by electron spectroscopy at high pressures**, *J. Vac. Sci. Technol.* **15**, No. 2, 549-552 (Mar./Apr. 1978).

Key words: appearance-potential spectroscopy; electron spectroscopy; high pressure; surface analysis; x-ray photoelectron spectroscopy.

Surface analyses are now made by techniques such as Auger electron spectroscopy (AES), x-ray photoelectron spectroscopy (XPS), and appearance potential spectroscopy (APS). These techniques utilize low-energy electrons and have high surface sensitivity but cannot be used at high pressures [$\geq 10^{-4}$ Torr ($\geq 10^{-2}$ Pa)]. Optical techniques can be used at high pressures but their surface sensitivity is poor. It is proposed to combine these approaches by using the high-pressure gas as a converter. Two situations are considered. First, variable-energy x-rays are used to produce variable-energy photoelectrons from the gas which impinge on the sample; these electrons constitute a suitable source for APS. Second, the variable-energy x-rays produce photoelectrons from the sample (XPS) of variable energy; these electrons can be detected using the gas for APS. In both cases, the derivative of the x-ray yield from the gas-sample cell is measured as a function of incident x-ray energy; features in the derivative spectrum can be correlated with the core levels of surface atoms of the sample. Design calculations based on x-ray intensities from available sources indicate that the proposed method could be useful for specialized applications.

17979. Reite, M., Zimmerman, J., **Magnetic phenomena of the central nervous system**, *Ann. Rev. Biophys. Bioeng.* **7**, 167-188 (1978).

Key words: biomagnetism; magnetic evoked response; magnetoencephalography; magneto-oculogram.

Several laboratories have contributed significantly to the present state of experimental knowledge of magnetic phenomena of the central nervous system. This includes observations of magnetoencephalograms of normal and pathological subjects, magneto-oculograms, magnetic visual evoked responses, and extensive comparisons between magnetoencephalograms and electroencephalograms. A useful feature of magnetic detection is that sources in the brain can be localized more precisely, and more easily, than by surface electric potential measurements, because of the quite different way in which the skull and other electrical inhomogeneities affect the two types of measurements. Instrumental sensitivity and interference rejection and shielding techniques are currently adequate for measurements down to about 10^{-14} tesla. Considerably better sensitivity is possible in principle, and would be very desirable in order for the full potential of magnetic detection of neurological phenomena to be realized.

17980. Risley, A. S., **The creation of a Delphi Study for forecasting time and frequency technology**, *Proc. 1974 National Telecommunications Conf., San Diego, CA, Dec. 2-4, 1974*, *Publ. No. 74(CH0902-7CSCB)*, pp. 1087-1091 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1974).

Key words: communications; Delphi Study; national measurement system; position location; technological assessment; technological forecasting; time and frequency.

The Delphi Study described here is a part of a general study of the time and frequency needs of U.S. society. The paper describes the needs for the Delphi Study and the four parameters which comprise it. The three sets of questions that form the questionnaire are discussed. The formation of these questions was based, in part, on the general study, which is also described in some detail.

17981. Tobler, R. L., Reed, R. P., Schramm, R. E., **Cryogenic tensile, fatigue, and fracture parameters for a solution-annealed 18 percent nickel maraging steel**, *J. Eng. Mater. Technol.* **100**, 189-194 (Apr. 1978).

Key words: fatigue; fracture; low temperature tests; maraging steels; mechanical properties; nickel alloys.

The mechanical properties of an eighteen percent nickel, solution-annealed 300-grade maraging steel were measured to assist in the evaluation of this material for low-temperature structural applications. Tensile, fatigue-crack growth rate, and fracture toughness tests were performed in ambient air (295 K), liquid nitrogen (76 K), and liquid helium (4 K), with the following results: (1) the yield strength of this material increases from 831 MPa at room temperature to 1596 MPa at 4 K; (2) the tensile ductility is moderate with elongation decreasing from 15.5 to 6.7 percent for this temperature region; (3) the estimated values of fracture toughness (K_{Ic}) decrease from 165 $\text{MPa}\cdot\text{m}^{1/2}$ at room temperature to 83 $\text{MPa}\cdot\text{m}^{1/2}$ at 4 K; and (4) the fatigue-crack propagation resistance at intermediate stress intensity ranges is relatively insensitive to temperature. These results are compared with similar data for other cryogenic alloys.

17982. Unertl, W. N., Celotta, R. J., Pierce, D. T., **Polarised LEED using a GaAs spin polarised electron source**, (*Proc. Conf. to Mark Anniversary of Discovery of Electron Diffraction*, London, England, Sept. 19-22, 1977). *Inst. Phys. Conf. Ser. No. 41*, Chapt. 4, pp. 287-294 (1978).

Key words: GaAs; low energy electron diffraction; polarized electrons; polarized electron sources.

Two years after their discovery of low-energy diffraction, C. J. Davisson and L. H. Germer (1929 *Phys. Rev.* **33** 760-72) re-

ported the absence of electron spin polarisation effects in LEED. However, it is now known that an unpolarised electron beam is polarised by diffraction from a W (100) surface as found by M. R. O'Neill et al (1975 *Phys. Rev. Lett.* **34** 1167-70) using a Mott detector to measure the polarisation of the reflected beam. Polarised LEED (PLEED) measurements can also be made using a polarised incident beam and recording the dependence of the intensity of the diffracted beam on the polarisation of the incident beam. An ideal source of spin polarised electrons for PLEED measurements is provided by photoemission from negative-electron-affinity GaAs (D. T. Pierce and F. Meier 1976 *Phys. Rev.* **B13** 5484-500). The intense, electron-optically bright beam has a spin polarisation which can be modulated from -50 percent to +50 percent. The spin dependence of LEED can then be measured by synchronously detecting the modulation of the diffracted intensity. We describe an apparatus for making PLEED measurements with a GaAs source. The theoretical basis for PLEED measurements is reviewed and the effects of multiple scattering and phonon scattering on the spin dependence are discussed. The application of PLEED to the development of a new low-energy, high-efficiency polarisation detector and to surface structure determination is explored.

17983. Watson, R. E., Bennett, L. H., **Comment on volume-corrected isomer shifts of transition-metal impurities**, *Phys. Rev. B* **17**, No. 9, 3714-3717 (May 1, 1978).

Key words: charge flow; electronegativity; isomer; Mössbauer effect; shift; transition metals; volume corrections.

Using newly available Mössbauer isomer-shift data, it is found that a universal curve still can describe all the results for transition-metal impurities in all hosts for which data are available.

17984. Allan, D. W., Besson, R. J., Busca, G., Garvey, R. M., Hellwig, H., Howe, D. A., Jarvis, S., Risley, A., Stein, S. R., Walls, F. L., Wineland, D. J., **Some recent progress in microwave frequency and time standards at the National Bureau of Standards**, *Proc. Ninth Annual Precise Time and Time Interval (PTTI) Applications and Planning Meetings, NASA Goddard Space Flight Center, Greenbelt, MD, Nov. 29-Dec. 1, 1977*, pp. 343-350 (Goddard Space Flight Center, Greenbelt, MD, Mar. 1978).

Key words: cesium standards; flicker noise; frequency accuracy; frequency instabilities; long-term instability; microwave frequency; passive hydrogen maser; quartz crystal standards; rubidium gas cell; short-term stability; time standards.

Research and advanced development at the National Bureau of Standards (NBS) in the area of microwave frequency and time standards is discussed. New insights into the causes of flicker noise and long-term instability of cesium standards are discussed. A new cesium beam tube configuration is described with a potential accuracy of $\sim 10^{-14}$. Results and design of a passive hydrogen maser system are given showing stabilities of better than 10^{-14} . Causes for frequency instabilities in rubidium gas cell standards and on line-asymmetries are described. New quartz crystal standards and special purpose atomic standards for field use appear possible. Excellent short-term stability can be realized by superconducting cavity and quartz crystal oscillators.

17985. Allan, D. W., Hellwig, H., Jarvis, S., Jr., Howe, D. A., Garvey, R. M., **Some causes and cures of frequency instabilities (drift & noise) in cesium beam frequency standards**, *Proc. 31st Annual Symp. on Frequency Control, 1977, Fort Monmouth, NJ, June 1-3, 1977*, pp. 555-561 (Electronic Industries Assoc., Washington, DC, 1977).

Key words: cavity phase shift; cesium atom; cesium beam velocity distribution; cesium standards; detector; distributed Ramsey cavity phase shift; frequency drift; frequency stability degradation; long-term frequency instabilities; microwave power.

Frequency drift of the order of several parts in 10^{13} per year is often observed in commercial cesium beam frequency standards, and on some occasions significant changes in the white noise frequency modulation level is also observed. Recently at the National Bureau of Standards some standards with these types of problems have been analyzed and their velocity distributions measured. A comparison of the changes in drift and noise performance with measurements of the velocity distribution leads to some interesting interpretations:

Changes in focusing voltage at or in the vicinity of the detector may cause the finite surface area of the detector to act like a velocity selector; i.e., the detection efficiency of cesium atoms mapped across the surface of the detector changes with time as a result of changing electric fields which focus the cesium ion-beam. Changes in the microwave power cause changes in the most probable cesium atom velocity, which transduce via the Ramsey cavity phase shift into frequency changes.

The magnitude of the cavity phase shifts in a cavity was inferred by reversing the current through the C-field inducing mixing of the m_F states.

17986. Berger, R. E., **A model for evaluating the ocular contusion injury potential of propelled objects**, *J. Bioeng.* **2**, pp. 345-358 (1978).

Key words: eye injury; impact; mathematical model; ocular contusion; propelled objects; tolerance.

The existing data on experimental ocular contusion were analyzed in terms of a simple mathematical model which predicts the maximum contact force between the eye and the impacting projectile. It was shown that this force was related to the injury producing mechanism, eyeball expansion, which was widely advocated in the literature. The effect of loading rate was also accounted for in the model. A dimensional analysis allowed previous experimental data to be used to generate tolerance curves for ocular injury. The agreement between the prediction of the model and previous subjective opinions of a panel of ophthalmologists was considered to be satisfactory. When the model was used to predict the hazard potential of projectile toys which presently exist in the market place, it was found that the contusive injury producing capability of these products covered the full range from safe to hazardous.

17987. Greenspan, M., Breckenridge, F. R., Tschiegg, C. E., **Ultrasonic transducer power output by modulated radiation pressure**, *J. Acoust. Soc. Am.* **63**, No. 4, 1031-1038 (Apr. 1978).

Key words: calibration of transducers; medical ultrasonics; modulated radiation pressure; nondestructive evaluation; radiation pressure; transducers; ultrasonic transducers.

We have set up and are using an apparatus for the measurement of total sound power output of a piezoelectric transducer radiating into water. This apparatus combines the better features of previously used methods which depend on radiation pressure. The input is modulated at a low frequency and the output power is intercepted by a target which experiences a force at the modulation frequency. The target is mounted on the armature of an electromagnetic receiver provided with an independent coil through which a current at the modulation frequency is adjusted in amplitude and phase, either manually or automatically by feedback, to arrest the motion of the armature. When the armature is stationary the force depends only on the current, and the apparatus can be calibrated using direct

current and dead weights. It is thus absolute. In practice, the carrier frequency is swept over any part of the range 0.1-15 MHz while a recording of power output versus frequency is made. The results of comparisons made with those of other methods are encouraging. Examples of curves from normal and defective transducers are shown.

17988. Hanley, H. J. M., **Can theory contribute: Transport properties**, (Proc. ACS Symp. Pacific Grove, CA, Jan. 1977), Paper 17 in *ACS Symposium Series*, T. S. Storvick and S. I. Sandler, Eds., pp. 330-343 (American Chemical Society, Washington, DC, 1977).

Key words: corresponding states; fluids; mixtures; review; theory; transport properties.

A very brief outline of theoretical calculations of the transport coefficients is given. A method to predict the viscosity and thermal conductivity coefficients of pure fluids and mixtures is presented.

17989. Hastings, J. R., Sengers, J. M. H. L., **Vapor pressure, critical pressure, and critical isochore of ethylene**, *Proc. of the Seventh Symp. on Thermophysical Properties*, Gaithersburg, MD, May 10-12, 1977, A. Cezairliyan, Ed., pp. 794-806 (The American Society of Mechanical Engineers, New York, NY, 1977).

Key words: corrections to scaling; critical exponent; critical isochore; critical pressure; critical temperature; ethylene; scaling laws; vapor pressure.

Accurate measurements are reported of the vapor pressure of ethylene (C_2H_4) from $-53.5^\circ C$ to $9.2^\circ C$ (T_c) and of the pressure-temperature relation on several near-critical isochores from $9.2^\circ C$ to $30^\circ C$. Values of the critical pressure and temperature are also reported. For two samples of slightly different purity the vapor pressures generally agree to within 10^{-4} MPa (1 millibar). The vapor pressures are in substantial agreement with those recently presented by Douslin and Harrison. The data have been analyzed using various scaled equations including revisions and corrections to scaling. The critical exponent θ characterizing the divergence of d^2P/dT^2 is in the range 0.085-0.125 independent of sample purity, fill density, range of the fit, and scaled equation used. It equals the specific-heat exponent α to within combined error and differs from the much higher values recently reported by several authors.

17990. Lloyd, I., **Don't define the problem**, *Public Admin. Rev.*, 4 pages (May/June 1978).

Key words: equipment management; management analysis; problem definition; problem solving.

The thesis is that management analysis of very complex problems may be facilitated if the effort to formulate a thoroughgoing definition of the problem is delayed or even omitted from the analysis. Attempts to define a very complex and dynamic problem may result in an oversimplified or erroneous definition which, in turn, leads to an irrelevant solution. The approach which this presentation examines is to experiment with tentative solutions and, by observing the results, arrive at an understanding of the problem.

17991. Risley, A. S., **A study of point-contact Josephson junctions for use in frequency synthesis**, *Proc. 31st Annual Symp. on Frequency Control*, 1977, Fort Monmouth, NJ, June 1-3, 1977, pp. 583-589 (Electronic Industries Assoc., Washington, DC, 1977).

Key words: capacitance effects; energy-gap effects; frequency mixing; frequency multiplication; heating effects; high frequency limitations; I-V curve; point-contact Josephson junction; spectrum spreading.

A carefully controlled microwave experiment using point-contact Josephson junctions (PCJJ) is reported. The experiment measures the IF power, P_{IF} , generated in low-order frequency multiplication and mixing. Also measured is the number of induced steps produced by the microwave source. Four characteristics possessed by PCJJ's which gave the largest P_{IF} are described. These criteria are compared to those which were obtained in studies previously reported. There is good agreement with three of these criteria and the discrepancy with the fourth is discussed in detail. An operational procedure for fabricating a good PCJJ is described. The four most important potential high frequency limitations of a PCJJ are discussed with respect to the experimental results. This paper reports the use of a nonsuperconducting whisker plated with a superconductor.

17992. Wineland, D. J., Howe, D. A., Mohler, M. B., **Results with the special-purpose ammonia frequency standard**, *Proc. 31st Annual Symp. on Frequency Control*, 1977, Fort Monmouth, NJ, June 1-3, 1977, pp. 562-573 (Electronic Industries Assoc., Washington, DC, 1977).

Key words: acceleration insensitive oscillator; ammonia microwave absorption; atomic clock; digital demodulator; frequency-lock servo; frequency standard; precision oscillator.

A special-purpose frequency standard and clock has been developed, featuring a novel combination of stability and accuracy performance, shock and temperature insensitivity, instant turn-on characteristics, and the potential for low weight, low power consumption and fabrication costs. This device should be able to fill a metrology need not satisfied by presently available atomic and quartz-crystal standards.

The device is based on the well-known 3-3 transition in ammonia (~ 23 GHz), which provides the frequency reference for a ~ 0.5 GHz oscillator. This oscillator is a novel stripline transistor oscillator of high spectral purity. Its output is multiplied in one step to κ -band and the resulting output is passed through a waveguide cell containing ammonia. The detected absorption feature is used to frequency lock the 0.5 GHz oscillator to line center. To accomplish this, the oscillator is frequency modulated at ~ 10 kHz and is locked by nulling the third harmonic of the detected output. This technique discriminates to a high degree the effects of "background slope" pulling. In addition, pulling from the microwave cavity absorption cell is diminished by locking the cavity to the ammonia transition by nulling the fifth harmonic of the detected output. A fixed output frequency between 5 and 10 MHz is provided by direct division from 0.5 GHz.

The observed stability is 2×10^{-10} from 10 to 6000 sec., and reproducibility is estimated to be $\pm 2 \times 10^{-9}$. The rather broad linewidth of ammonia (~ 100 kHz due to Doppler broadening) reduces overall resolution but allows a short (≥ 0.15 ms) servo attack time, thus reducing the acceleration sensitivity of the primary 0.5 GHz oscillator. In this respect the ammonia absorption device may have a unique advantage. Linewidths of most other precision oscillators are considerably narrower, resulting in longer attack times needed to lock the primary (vibration sensitive) oscillator to the (vibration insensitive) frequency reference. Vibration sensitivities as small as 10^{-11} s²/m (10^{-10} /g) appear feasible. Servo offset problems have been substantially reduced by using digital demodulators in the feedback networks. Working at pressures where collision broadening contributes to the linewidth allows one to easily null out pressure shifts; shifts smaller than 3.8×10^{-9} /Pa (5×10^{-10} / μ m) have been observed. Power consumption should be < 3 W and expected size of a working device $\sim 10^3$ cm³. With further development, improvements in performance can be expected.

17993. Wineland, D. J., Jarvis, S., Jr., Hellwig, H., Garvey, R. M., A new method to eliminate cavity phase shift in cesium beam standards, *Proc. Ninth Annual Precise Time and Time Interval PTTI Applications and Planning Meetings, NASA Goddard Space Flight Center, Greenbelt, MD, Nov. 29-Dec. 1, 1977*, pp. 571-577 (Goddard Space Flight Center, Greenbelt, MD, Mar. 1978).

Key words: cavity phase; cesium beam; cesium beam standards; standards.

In our presently known laboratory and commercial cesium standards, the so-called Ramsey cavity is employed. The envelope of the associated Ramsey pattern is determined by the distribution of atomic velocities in the atomic beam. The wider the velocity distribution, the narrower will be the half-width of the envelope of the Ramsey pattern. The envelope of this Ramsey pattern is invariant against cavity phase shift. In other words, the center of the envelope—in contrast to the center of the main peak of the resonance—does not shift from cesium atomic resonance frequency when the cavity phase shift is varied.

Therefore, it is suggested that the systematic frequency shift due to an rf phase difference between the two interaction regions of a normal Ramsey cavity can be eliminated by using simultaneously two different frequencies around the cesium resonance applied to two separated interaction regions which are not part of the same cavity. To the atom this is equivalent to a time-varying phase shift between the two interaction regions. A modulation of the frequencies ν_1 and ν_2 applied to cavities 1 and 2 will produce signals symmetrically spaced around true line center of the cesium resonance. This technique is briefly described and the advantages are noted.

An improvement in the achievable accuracy with laboratory type primary frequency standards appears possible. Commercially produced small beam tubes may realize accuracies presently achieved only with the much larger and more expensive laboratory units. In addition, long-term stability and clock performance should be enhanced significantly in both laboratory and commercial versions of this new technique. An experimental program aimed at realizing these advantages is presently under way.

17994. Cava, R. J., Negas, T., Roth, R. S., Parker, H. S., Minor, D. B., Olson, C. D., Crystal chemistry and oxidation-reduction of phases in rare earth tantalate-niobate systems, (*Proc. 13th Rare Earth Research Conf., Olgebay, WV, Oct. 16-20, 1977*), Paper in *The Rare Earths in Modern Science and Technology*, G. J. McCarthy and J. J. Rhyne, Eds., pp. 181-187 (Plenum Publ. Corp., New York, NY, 1978).

Key words: cerium niobate; cerium oxide; cerium tantalate; ionic/electronic conductors; phase equilibria; thermogravimetric.

The data on crystal chemistry and oxidation-reduction phenomena of $CeTaO_{4+x}$ and $CeNbO_{4+x}$ have been extended. Phase transition temperatures were determined by high temperature x-ray diffraction for $LaTaO_4$, $CeTaO_4$, and $PrTaO_4$ and for solid solutions of $PrTaO_4-NdTaO_4$. The oxidation/reduction behavior of $CeTaO_{4+x}$ and $CeNbO_{4+x}$ was studied.

17995. Corbin, R. J., Nygaard, K. J., Snow, W. R., Schearer, L. D., Production of Cl^-HCl cluster ions in $HCl-N_2$ mixtures, *J. Chem. Phys.* **68**, No. 10, 4373-4375 (May 15, 1978).

Key words: Cl^-HCl cluster ions; dissociative attachment; drift tube-mass spectrometer.

A drift-tube-mass-spectrometer apparatus has been used to study the production of Cl^-HCl cluster molecules in $HCl-N_2$ mixtures. The concentration of HCl was 730 ppm and the total

pressure ranged from 0.1-5 Torr. The primary ion Cl^- is produced mainly by dissociative attachment of HCl and is converted to a cluster ion in a three-body collision. The rate of formation of the cluster ion is $k_2 = 10^{-25} \text{ cm}^6/\text{sec}$ at $E/N = 12 \text{ Td}$.

17996. Cramp, A. P., Berger, H. W., The development of improved portable x-ray fluorescent lead paint analyzers and lead paint reference standards, *Proc. 4th Joint Conf. on Sensing of Environmental Pollutants, New Orleans, LA, Nov. 6-11, 1977*, pp. 354-359 (American Chemical Society, Washington, DC, 1978).

Key words: accuracy; calibration; evaluation; lead; paint; poisoning; portable; precision; radiation; references; substrates; x-ray fluorescent.

Portable x-ray fluorescent lead analyzers offer the most cost-effective rapid and adaptable means for the nondestructive detection and measurement of lead paint in housing. Commercially available portably lead analyzers have had poor accuracy and precision below lead levels of about 2 milligrams lead per square centimeter of the surface area. They have also performed relatively unsatisfactorily with regard to service-ability and maintenance. Two new portable lead analyzers, based on x-ray fluorescence, have been developed under HUD contracts. The prototypes of one of these devices have shown considerable improvement over previously available instruments in terms of accuracy, portability, and user characteristics.

Lead paint reference materials containing 0.6, 1.5, and 3.0 mg/cm^2 lead have been developed for distribution to users of portable x-ray fluorescent lead analyzers for purposes of calibration and instrument performance assessment.

This paper discusses the performance and operating characteristics of the lead analyzers developed under HUD contracts and the lead paint reference materials developed by the National Bureau of Standards.

17997. Danos, M., Rafelski, J., Higher-order effects in Fermi-type charged current theory of weak interactions: Semi-leptonic neutral currents, *Phys. Lett.* **73B**, No. 3, 313-316 (Feb. 27, 1978).

Key words: atomic parity mixing; charged currents; fermi theory; neutral currents; neutrino scattering; weak interaction.

In a convergent field theory rescattering graphs lead to neutral-current effects of the observed magnitude if the effective cut-off momentum is $\sim G^{-1/2} \approx 300 \text{ GeV}$. A perturbation expansion is justified owing to the value $f = 0.18$ of the resulting expansion parameter.

17998. Fahey, D. W., Schearer, L. D., A xenon ion pumped blue dye laser, *IEEE J. Quant. Electron.* **QE-14**, No. 4, 220-221 (Apr. 1978).

Key words: dye laser; xenon-ion laser.

A pulsed xenon ion laser with an output power of 5 kW at 364.5 nm has been used as a pump source for several blue dyes. Broadband conversion efficiencies exceed 20 percent. The use of a birefringent filter provides tunable output in the blue region of the spectrum with a bandwidth of 0.08 nm and a pulsewidth of 120 ns.

17999. Gadzuk, J. W., Many-body effects in photoemission, Chapter 5 in *Photoemission and the Electronic Properties of Surfaces*, pp. 111-136 (John Wiley & Sons, Ltd., New York, NY, 1978).

Key words: many-body effects; photoemission spectroscopy; plasmons; relaxation effects; surfaces.

The physical basis and current theoretical understanding of observable many-body effects in photoemission spectra from solids and surfaces is surveyed.

18000. Glackin, D. L., Linsky, J. L., Mango, S. A., Bohlin, J. D., **The solar XUV He I and He II emission lines. II. Intensity ratios and distribution functions**, *Astrophys. J.* **222**, No. 2, 707-715 (June 1, 1978).

Key words: chromosphere, sun; corona; spectra, sun; spectra, ultraviolet; sun; transition region, sun.

From high-resolution solar images we show that the He II $\lambda 256$ line intensity is very nearly uncorrelated with He II $\lambda 304$ at the same location on the Sun and that the $\lambda 256$ line is formed mainly by the photoionization-recombination process. We also derive center-to-limb variations of He II $\lambda 304$ and $\lambda 256$ and He I $\lambda 584$ and $\lambda 537$ for network and cell regions separately and find that (1), in both network and cells, $\lambda 304$ and $\lambda 584$ each limb-brighten in the quiet Sun and limb-darken in coronal holes and (2) for both $\lambda 304$ and $\lambda 584$, network and cell regions are each brighter in the quiet Sun than in coronal holes. We conclude that the appearance of dark coronal holes in the helium lines is not a geometrical effect involving the chromospheric network, but is rather an intrinsic property of the atmosphere in both network and cell regions. We suggest that the network and cells can be treated as isolated atmospheres in solution of the transfer equation in the helium lines.

18001. Grundl, J., Eisenhauer, C., **Benchmark neutron fields for reactor dosimetry**, (Proc. Consultants' Meeting on Integral Cross-Section Measurements in Standard Neutron Fields for Reactor Dosimetry, Vienna, Austria, Nov. 15-19, 1976), Paper I.1 in *Neutron Cross Sections for Reactor Dosimetry 1*, No. IAEA-208, 53-104 (International Atomic Energy Agency, Vienna, Austria, 1978).

Key words: fission; neutron reactions; reactor fuels; reactor materials.

The necessity for benchmark neutron fields measurements to achieve reliable reactor dosimetry is widely recognized. An organized response to this recognition is the IAEA Program, "Benchmark Neutron Fields Applications for Reactor Dosimetry." This report presents one step in the IAEA Program: A first compendium of information on benchmark neutron fields employed for dosimetry data generation, detector calibration, and dosimetry methodology referencing. The information presented is based on results of an IAEA worldwide survey of neutron fields suitable as reactor dosimetry benchmarks. Neutron fields included cover the energy range from fission spectrum neutrons to Maxwellian thermal, and a neutron flux range from 10^7 to 10^{11} n/cm² s. The summary includes a physical description of each system, features of the irradiation facility, and assigned spectra based on spectrometry and calculation. Also included are measured and predicted cross section ratios for a set of representative integral detectors: threshold reactions (Np(n,f), ²³⁸U(n,f), ⁵⁸Ni(n,p), Al(n, α)), and full-energy-range reactions (interpreting integral detector responses are introduced and along with them a few principles of neutron field characterization based on benchmark calibrations.

18002. Horwitz, A. B., Leone, S. R., **Isotopic vibration-to-vibration energy transfer**, *Proc. Society of the Photo Optical Instrumentation Engineers, Bellingham, WA, Aug. 14-15, 1977*, pp. 114-120 (Society of Photo Optical Instrumentation Engineers, Bellingham, WA, 1977).

Key words: energy transfer; hydrogen halides; isotopes; TEA laser; vibrational relaxation.

An isotopically specific transverse discharge chemical laser is used to excite single isotopes of HBr (79-81), DBr (79-81), HCl (35-37), or DCl (35-37). Resonant energy transfer rates between the isotopic species are studied by time resolved infrared emission. Such rates are important for isotope separation schemes using lasers. All of the rates are rapid. Direct comparisons can be made to theoretical models for resonant energy transfer processes.

18003. Hunter, C., **Some extensions of the Lax-Wendroff method**, *J. Comput. Phys. Note* **27**, No. 3, 447-452 (June 1978).

Key words: hydrodynamics; numerical methods.

The Taylor series expansion in time that Lax and Wendroff used to derive their algorithm can clearly be applied to equations that are not in conservation law form. This note considers certain specific applications in fluid dynamics, and shows that such expansions can lead to unstable difference schemes. Fortunately, the difference schemes can also be recast in stable forms. The instabilities that may occur are not primarily due to the fact that we deal with equations that are not of conservation form, but can also arise with equations of conservation form when staggered grids are used.

18004. Hutchinson, J. M. R., Mann, W. B., **Needs in the measurement of environmental radioactivity**, (Proc. Seminar on Metrology Needs in the Measurement of Environmental Radioactivity, Paris, France, Oct. 4-6, 1976), *Environ. Int.* **1**, No. 1/2, 101 pages (1978).

Key words: information exchange; International Committee on Radionuclide Metrology; natural matrix standards; radioactivity; standard.

Needs in the measurement of environmental radioactivity are described. Papers divide generally into two groups, those describing the needs for standards, for example, natural matrix standards, and those connected with monitoring and quality assurance programs in low-level radioactivity measurements. The conclusions drawn from the symposium are that there is a need for quality assurance programs, for an information exchange and a need for some particular radioactivity standards.

18005. Lyon, G., **Batch scheduling from short lists**, *Proc. 1978 Conf. on Information Science and Systems, Baltimore, MD, Mar. 29-31, 1978*, pp. 493-495 (Johns Hopkins University, Baltimore, MD, 1978).

Key words: hashing; resource allocation; scatter tables.

Almost all of m appointment slots can be assigned nearly optimally in $O(m)$ steps provided appointment preferences are sufficiently random. And while there may be hundreds of appointments, each client need only indicate a set of five or six preferred times. These results are in sharp contrast to the standard assignment solution that takes $O(m^3)$ steps in the worst-case and demands that each client provide a preference order for all m slots.

18006. Morrison, N. D., Linsky, J. L., **Photospheric models of solar active regions and the network based on the Mg II h and k line wings**, *Astrophys. J.* **222**, No. 2, 723-724 (June 1, 1978).

Key words: sun, active regions; sun, photosphere; sun, spectra; ultraviolet spectra.

From a comparison between observed and computed wings of the Mg II resonance lines, we derive distributions of temperature versus mass column density for solar photospheric layers in plages and in the chromospheric network. The observed profiles were recorded on film by the Naval Research

Laboratory spectrograph on *Skylab*, with spectral resolution 0.12 Å and spatial resolution 2" × 60". We computed the theoretical profiles assuming partial coherent scattering. In the active regions, temperatures exceed those in the quiet Sun by up to 200 K near the temperature minimum and up to 400 K in deeper layers. In the observed network structure, the temperature is enhanced by 200 K at the temperature minimum but is the same as that in the quiet Sun at greater depths. The difference in the slope of the temperature distribution between the network and plages is real, but may refer only to long elements of the network (cell boundaries) rather than to the brightest portions (vertices). Adjacent to the network is a region in which the temperatures are similar to those in the quiet Sun, except immediately below the temperature minimum, where the temperatures are depressed by 150 K. Since the observed temperature differences may arise in structures too small for the *Skylab* instrument to resolve, all differences quoted are lower limits.

18007. Powell, C. J., **Quantitative surface analysis by electron spectroscopy**, *Am. Lab.* 10, No. 4, 17-31 (Apr. 1978).

Key words: analysis; Auger-electron spectroscopy; electron spectroscopy; surface analysis; x-ray photoelectron spectroscopy.

A brief review is given of the current status of quantitative surface analysis by Auger-electron spectroscopy and x-ray photoelectron spectroscopy. Most methods of analysis rely on a three-step model to describe the measurement process and tests are reported that confirm the validity of the model, associated data, and methods for intensity measurement. It is concluded that surface analyses of homogeneous single-phase samples are now possible but further work is needed to extend the procedures to more complex samples and to establish accuracies of measurement.

18008. Rhyne, J. J., Sankar, S. G., Wallace, W. E., **Sublattice magnetization of ErFe₂-H**, Paper in *Rare Earths in Modern Science and Technology*, G. J. McCarthy and J. J. Rhyne, Eds., pp. 63-68 (Plenum Publ. Corp., New York, NY, 1978).

Key words: Curie temperature; hydrides; magnetic neutron scattering; magnetic properties; rare earths; sublattice magnetization.

ErFe₂ has been found to absorb hydrogen readily and to exhibit a stable phase with composition near ErFe₂H₄. In this study we have examined ErFe₂H_{3.5} which exhibits a Curie temperature of 450 K significantly depressed from the 574 K found for pure ErFe₂. At low temperature the magnetization does not saturate even in fields as large as 120 kOe. Neutron scattering results show that at 10 K the Er sublattice moment is 5.5 μ_B which is sharply lower than the free ion value of 9 μ_B found in pure ErFe₂. The Er moment decreases rapidly as the temperature is raised and is essentially zero at 300 K, well below the overall Curie temperature of 450 K.

The iron moment on the other hand is 1.6 μ_B at low temperatures in agreement with that found in pure ErFe₂ and remains essentially constant up to 350 K before dropping rapidly to zero at the bulk Curie temperature. These results suggest a significant reduction in the Er-Er and Er-Fe exchange interactions on hydriding leading to a structure in which the rare earth is very loosely coupled.

18009. Rosenblatt, J. R., **Research in the Federal Government**, *Newslett. Caucus Women Stat.* 8, No. 3, 9-10 (Aug. 1978).

Key words: statistics; women in scientific research.

Scientific research in a nonacademic environment is described from the perspective of a mathematical statistician working as collaborator with physical scientists.

(Contribution to a panel discussion at a Conference on the Participation of Women in Scientific Research, sponsored by the American Association for the Advancement of Science, October 17, 1977).

18010. Shore, B. W., Eberly, J. H., **Analytic approximations in multi-level excitation theory**, *Opt. Commun.* 24, No. 1, 83-84 (Jan. 1978).

Key words: coherent excitation; finite-level atom; finite-level molecule; intense laser; multiphoton absorption; Rabi oscillations; time dependent populations.

We discuss applicability of simple single-term analytic approximation formulas, based upon infinite-level excitation sequences, to the description of time-dependent populations of resonantly excited *N*-level atoms or molecules.

18011. Skarstad, P. M., Parker, H. S., **Crystal growth of the solid electrolyte (C₅H₅NH)₂Cu₃Br₇ from the melt**, *J. Cryst. Growth* 43, No. 5, 613-617 (June 1978).

Key words: Bridgman growth; crystal growth; ionic conductors; single crystals; solid electrolytes.

The solid electrolyte pyridinium cuprous bromide, (C₅H₅NH)₂Cu₃Br₇, has been found to melt incongruently with no appreciable degradation of the organic component. Single crystals in sizes up to 6 mm in diameter and 25 mm long have been grown by the Bridgman technique from a melt containing excess pyridinium bromide. The fastest drop rate at which reasonable quality growth could be maintained was 0.4 mm/h. Two phenomena were observed: (1) the recrystallization into a single crystal of a polycrystalline aggregate layer on the surface of the single crystal; (2) the periodic deposition of small crystals of another phase within a single crystal near the end of the growth field.

18012. Thomson, R., **Some microscopic and atomic aspects of fracture**, (Proc. ASME Winter Annual Meeting, New York, NY, Dec. 5-10, 1976), Paper in *The Mechanics of Fracture*, F. Erdogan, Ed., AMD-19, 1-21 (The American Society of Mechanical Engineers, New York, NY, 1976).

Key words: atomic aspects of fracture; brittle fracture; crack growth; ductile fracture; ductile to brittle fracture; fracture.

This paper addresses some underlying ideas and issues in brittle and ductile fracture, and in the physics and chemistry of processes at a crack tip. The physical bases for ductile vs. brittle fracture are explored and some new ideas regarding brittle fracture in ductile materials are presented. The lack of physical understanding for the ductile-brittle competition is emphasized. The physical consequences of cracks in lattices are discussed, and the underlying processes defining slow crack growth in materials are explored. Recent success in developing a physical basis for chemical interactions between external atmospheres and cracks in brittle materials is presented. The situation in more ductile materials is much more complex and in a more unsatisfactory state.

18013. Bail, W. G., Zelkowitz, M. V., **Program complexity using hierarchical abstract computers**, *Proc. National Computer Conf., Anaheim, CA, June 5-8, 1978*, pp. 605-608 (AFIPS Press, Montvale, NJ, June 1978).

Key words: computational models; data abstraction; hierarchical abstract computers; program complexity; structured programming.

To measure program complexity of programs, certain restrictions are made on the variance of programs to be compared. Hierarchical abstract computers are defined as a model for

computation, and a particular decomposition of the program is defined—the prime program parse. A complexity measure is defined on this decomposition, and it is shown to be useful in comparing two similar programs for structure and complexity.

18014. Barnes, J. A., **A review of methods of analyzing frequency stability**, *Proc. Ninth Annual Precise Time and Time Interval Applications and Planning Meeting, NASA Goddard Space Flight Center, Greenbelt, MD, Nov. 29-Dec. 1, 1977*, pp. 61-84 (Goddard Space Flight Center, Greenbelt, MD, Mar. 1978).

Key words: flicker noise; frequency; frequency stability; measurement; noise; spectrum analysis; two-sample variance.

Extensive research over the past years has provided a model for the description of frequency instabilities of clocks and oscillators. This model consists of the superposition of three distinct parts: (1) random, nondeterministic fluctuations described as noise; (2) long-term, systematic trends or aging; and (3) fluctuations induced by environmental sensitivities of the oscillator or clock. The random part of the model includes noises which have presented certain mathematical problems. These mathematical problems are partly responsible for the creation of numerous techniques of analysis, but these techniques have neither produced substantively new models nor have they added insight into the physical origins of the random fluctuations—some of which remain obscure. The purpose of the measurement process is to estimate the levels and kinds of instabilities present in a given device—that is, to quantify the model. The mathematical analysis used is merely a means toward this end, and it is important to retain this perspective. Fortunately, there are relatively simple means of analysis which are also commonly used—the two-sample variance and the power spectral density.

Crucial to any measurement are the intended uses of the result. This includes the levels of accuracy and precision needed, as well as the intended application. For example, one may wish only a relative comparison between two oscillators; and, thus, absolute accuracy (as opposed to precision) is of no interest. The specific application intended for the measurement will often influence the form in which the final quantified model is reported.

18015. Ekin, J. W., **Current transfer in multifilamentary superconductors. I. Theory**, *J. Appl. Phys.* **49**, No. 6, 3406-3409 (June 1978).

Key words: critical current; current transfer; multifilamentary superconducting wire; superconducting composites; superconductor.

In short-specimen critical current measurements, inadequate separation between current and voltage contacts results in a finite linear slope in the measured voltage-current characteristic at low currents. A simple approximate analytic expression is developed for estimating the magnitude of this slope from wire parameters. Current-transfer lengths are evaluated for multifilamentary NbTi and Nb₃Sn composite superconductors.

18016. Ekin, J. W., Clark, A. F., Ho, J. C., **Current transfer in multifilamentary superconductors. II. Experimental results**, *J. Appl. Phys.* **49**, No. 6, 3410-3412 (June 1978).

Key words: critical current; current sharing; current transfer; multifilamentary superconducting wire; superconducting composites; superconductor.

Measurements are reported of the current-transfer effect in a 0.58 × 0.68-mm NbTi (180 filament) copper-matrix wire, and in a 0.33 × 0.66-mm Nb₃Sn (3553 filament) bronze-matrix wire at magnetic fields from 2 to 8 T. With a voltage sensitivity of

100 nV, the effect of current transfer in the copper:NbTi wire was too small to be measured at a distance 1 cm from the current contact. In the bronze:Nb₃Sn wire, however, the effect was relatively large and resulted in voltage-current characteristics which had an extensive linear region. The slope of the linear region decreased with distance x from the current contact as $x^{-2 \pm 0.3}$ and reached a value of 10^{-12} Ωcm, for example, at a distance of 3 ± 0.5 cm. Both the magnitude and functional dependence of the measured current-transfer effects correspond closely to that predicted by theory.

18017. Drullinger, R. E., Stock, M., **The Cd*₂ excimer: Fluorescence band shape and decay rates**, *J. Chem. Phys.* **68**, No. 11, 5329-5330 (June 1, 1978).

Key words: cadmium; decay rates; excimer; spectra.

Recent interest in HgCd as an excimer laser molecule has created a need for better knowledge of the Cd₂ excimer. In this Note we report the visible fluorescence spectra and discuss its temperature and pressure dependence as well as some preliminary measurements of the decay rate for this fluorescence.

18018. Edrich, J., Cupp, J. D., McDonald, D. G., **Field-usable Sharpless wafers for Josephson effect devices at millimeter waves**, *Rev. Phys. Appl.* **9**, No. 1, 195-197 (Jan. 1974).

Key words: cryogenics; Josephson junction; microwaves; superconductivity.

It is shown how modified Sharpless wafers can be used for point contact Josephson effect detectors, converters, oscillators and parametric amplifiers. First experimental data indicate that this method results in devices that are rugged, can be permanently adjusted at room temperature and can be cycled in temperature.

18019. Engen, G. F., **An improved circuit for implementing the six-port technique of microwave measurements**, *IEEE Trans. Microwave Theory Tech.* **MTT-25**, No. 12, 1080-1083 (Dec. 1977).

Key words: automatic network analyzer; automation; microwave; microwave measurements; reflectometer; six-port.

In a companion paper, circuit design criteria were developed which lead to optimal performance in applying the six-port technique to the measurement of microwave parameters. A circuit which approximately satisfies these new design goals is described. Together with its several variants, it promises to become, in many applications, the "preferred" six-port circuit.

18020. Hastings, S. R., **A comprehensive approach to window design for energy conservation**, *Proc. Second National Conf. on Passive Solar Energy, Philadelphia, PA, Mar. 15-19, 1978*, pp. 321-325 (American Section ICES, University of Delaware, Newark, DE, Aug. 1978).

Key words: building envelope; energy conservation; fenestration; passive solar; windows.

Six categories of design strategies to improve the energy performance of windows are presented. These design strategies are evaluated by their ability to improve one or more of six possible energy control functions windows can perform. An example strategy is selected from each category to illustrate how substantially a window's performance can be improved. In designing and subsequently evaluating a window one should consider the performance of the window in concert with various design strategies and the performance of a given solution should be considered relative to all six possible energy control functions.

18021. Heinrich, K. F. J., Myklebust, R. L., Newbury, D. E., **Progress and testing of Monte Carlo program for electron probe analysis**, *Proc. of VII Intern. Conf. on X-ray Optics and Microanalysis, Moscow, U.S.S.R., July 7-16, 1974*, pp. 169-171 (1976).

Key words: electron interactions; electron probe microanalysis; electron scattering; Monte Carlo calculations; particulate analysis; trajectory calculations.

A Monte Carlo program has been developed for the characterization of electron distribution and x-ray generation in compound targets of varying shapes. The parameters of importance of the method, various applications, and comparisons of results with the theoretical prediction will be discussed.

18022. Heinrich, K. F. J., Myklebust, R. L., Newbury, D. E., **Analysis of layered materials with the ion microprobe**, *Proc. of VII Intern. Conf. on X-ray Optics and Microanalysis, Moscow, U.S.S.R., July 7-16, 1974*, pp. 266-268 (1976).

Key words: calibration procedures; depth profiling; ion microprobe mass analysis; quantitation; secondary; sputtering.

The ion microprobe mass analyzer has unique capabilities for the characterization of compositional changes in depth on a microscopic scale. The technique is particularly useful for the study of elements implanted or diffused into semiconductor materials. Quantitation is achievable with calibration procedures with known standards.

18023. Heinrich, K. F. J., **Methods of microprobe analysis**, (Proc. 10th Intern. Conf. on Environmental Toxicity, Rochester, NY, May 23-25, 1977), Paper in *Environmental Pollutants*, T. Y. Toribara, J. R. Coleman, B. E. Dahneke, and I. Feldman, Eds., 13, 241-253 (Plenum Press, New York, NY, 1977).

Key words: electron beams; ion beams; laser-Raman spectroscopy; microanalysis; microprobes; x-ray spectrometry.

Microprobe techniques are characterized by the interaction of a finely focused beam of particles or photons with a microscopic region of a solid specimen. The techniques may reveal microscopic topography and isotopic, elementary and molecular compositions as well as lattice parameters. Presently available techniques are listed and described, and their characteristics are tabulated.

18024. Heinrich, K. F. J., **State of the art of quantitative electron probe microanalysis**, *Proc. of VII Intern. Conf. on X-ray Optics and Microanalysis, Moscow, U.S.S.R., July 7-16, 1974*, pp. 187-192 (1976).

Key words: background; data evaluation; detectors; errors; microanalysis; standard materials.

The theory of corrections for quantitative electron probe analysis has concerned the investigators for many years. However, the precision of measurement and the availability of reliable standard reference materials are now among the main factors limiting the accuracy of the procedure. Unless stable measurements are performed under controlled conditions of x-ray intensities from materials of known composition, there is little hope that theoretical considerations can provide significant improvement in the accuracy of analysis.

18025. Hiza, M. J., Robinson, R. L., Jr., **Comment on "Intermolecular forces in mixtures of helium with the heavier noble gases"**, *J. Chem. Phys.* 68, No. 10, 4768-4769 (May 15, 1978).

Key words: binary deviation parameters; combining rules; He plus noble gases; intermolecular forces.

This paper is a comment on "Intermolecular Forces in Mixtures of Helium with the Heavier Noble Gases."

18026. Kimbleton, S. R., Wood, H. M., Fitzgerald, M. L., **Network operating systems—An implementation approach**, (Proc. 1978 National Computer Conf., Anaheim, CA, June 5-8, 1978), Paper in *AFIPS Conf. Proc.* 47, 773-782 (AFIPS Press, Montvale, NJ, 1978).

Key words: computer networks; network operating systems; user assistance.

Network Operating Systems are required to afford ease of access to remote computer resources by masking many system differences from the user. To facilitate ease of access and utilization of systems, subnetworks, and services, an NOS must provide capabilities for job execution and data handling. This paper provides a perspective on the issues and implementation constraints implicit in providing a Network Operating System for a heterogeneous collection of host computers. An Experimental Network Operating System (XNOS), implemented at the National Bureau of Standards, is described. XNOS utilizes Network Interface Machines to offload NOS support from the host and to facilitate centralized design, implementation, and support.

18027. Minor, D. B., Roth, R. S., Brower, W. S., McDaniel, C. L., **Alkali ion exchange reactions with RbAlSiO₄: A new metastable polymorph of KAlSiO₄**, *Mat. Res. Bull.* 13, 575-581 (1978).

Key words: crystal chemistry; ion exchange; polymorphism; potassium aluminum silicate; rubidium aluminum silicate; x-ray diffraction.

A new metastable polymorph of KAlSiO₄ has been prepared by K⁺ ion exchange of orthorhombic RbAlSiO₄ ($a = 9.215 \pm .001$, $b = 5.329 \pm .001$, $c = 8.742 \pm .001$ Å). The new phase is pseudo-orthorhombic with $a = 18.151 \pm .003$, $b = 10.551 \pm .002$, $c = 8.490 \pm .001$ Å with apparent Cc** symmetry but may be monoclinic. This new polymorph is metastable at temperatures up to approximately 1100 °C where it transforms to normal "low" orthorhombic KAlSiO₄.

18028. Newbury, D. E., **Secondary ion mass spectrometry for particulate analysis**, (Proc. 10th Intern. Conf. on Environmental Toxicity, Rochester, NY, May 23-25, 1977), Paper in *Environmental Pollutants*, T. Y. Toribara, J. R. Coleman, B. E. Dahneke, and I. Feldman, Eds., 13, 317-348 (Plenum Press, New York, NY, 1977).

Key words: ion microprobe mass analyzer; microanalysis; particulate analysis; quantitative analysis; secondary ion mass spectrometry; surface analysis.

Analysis of individual environmental particulates can be carried out by secondary ion mass spectrometry (SIMS). Information can be gained on all elements in the sample, including hydrogen. The analysis can be confined to a thin surface layer, and the distribution in depth of elements can be determined. In special cases, information on molecular constituents in the sample can be obtained. Through the use of empirical procedures based on the determination of relative elemental sensitivity factors, quantitative analysis can be carried out with relative errors less than a factor of two in most cases. Detection limits for a wide variety of elements in an oxidized matrix range from 0.1-100 ppm when the analyzed volume is of the order of one micrometer diameter and 10 nm deep.

Examples of positive and negative SIMS spectra from urban particulates show a great number of elements present. An elemental depth distribution from an individual particle showed a marked surface predominance of elements such as lead and barium.

18029. Parrish, W. R., Arvidson, J. M., LaBrecque, J. F., System is accurate, precise for LNG sampling, *Hydrocarbon. Proc.* 57, No. 4, 114-116 (Apr. 1978).

Key words: custody transfer; heating value; hydrocarbon; liquefied natural gas; sampling.

This paper describes a system for obtaining representative samples from flowing LNG systems. Laboratory and field tests showed that the total uncertainty in the computed heating value of samples taken with this sampling system could be routinely within ± 0.2 percent; this included the ± 0.1 percent uncertainty due to analysis by gas chromatography.

18030. Robinson, H. A., Multilinear transformations on matrices, *Linear Algebra and Appl.* 20, 205-218 (1978).

Key words: determinant; invariants; matrices; multilinear function; rank; spectrum.

For each of several invariants P defined on M_n , the vector space of n -square matrices over a field, we determine the set of m -linear transformations $\phi: \times^m M_n \rightarrow M_n$ which satisfy $P(\phi(X_1, \dots, X_m)) = P(X_1 \dots X_m)$ for all $X_1, \dots, X_m \in M_n$. Example: every multilinear determinant preserver is a product of linear determinant preservers.

18031. Slater, P. J., R -domination in graphs, *J. Assoc. Comput. Mach.* 23, No. 3, 446-450 (July 1976).

Key words: computational complexity; dominating set; facility location; graph; k -basis; tree.

The problem of finding a minimum k -basis of graph G is that of selecting as small a set B of vertices as possible such that every vertex of G is at distance k or less from some vertex in B . Cockayne, Goodman, and Hedetniemi previously developed a linear algorithm to find a minimum 1-basis (a minimum dominating set) when G is a tree. In this paper the k -basis problem is placed in a more general setting, and a linear algorithm is presented that solves the problem for any forest.

18032. Slater, P. J., Fibonacci numbers in the count of spanning trees, *Fibonacci Quart.* 15, No. 1, 11-14 (Feb. 1977).

Key words: Fibonacci numbers; labelled graph; labelled multigraph; Lucas numbers; spanning tree.

The occurrence of Fibonacci and Lucas numbers in the count of the number of spanning trees of a labelled graph, or multigraph, is examined. Formulas which give this number for several classes of graphs are presented.

18033. Berger, H., Innovative and advanced ndt radiography, *NDT Int.* 10, No. 6, 337, 339-340 (Aug. 1977).

Key words: flash radiography; high energy radiography; image quality; neutron radiography; nondestructive testing; radiography; signal processing.

A review is given of an American Society for Nondestructive Testing topical conference, Innovative and Advanced NDT Radiography. The conference covered a number of topics of interest to radiographers. These included flash, high energy and neutron radiography, computer analysis and image quality evaluation.

18034. Davies, P. B., Evenson, K. M., Laser magnetic resonance (LMR) spectroscopy of gaseous free radicals, *Proc. Second Int. Cong. on Laser Spectroscopy, Megeve, France, June 23-27, 1975*, pp. 132-143 (Springer-Verlag, Berlin, Germany, 1975).

Key words: gaseous free radicals; laser magnetic resonance; spectroscopy.

A short review of laser magnetic resonance (LMR) techniques and a short discussion of some of the free radicals observed by LMR techniques is presented. Also discussed for the first time is the sensitivity of the LMR spectrometer in relation to the experimental parameters.

18035. Deutsch, D. R., Design of a solar heating and cooling data center, (Proc. OECD Specialist Study on the Use of Generalized Data Management Systems for Handling Scientific Information, Paris, France, Jan. 11-13, 1977 and Lawrence Berkeley Laboratory, Berkeley, CA, Oct. 5-7, 1977), Paper in *Generalized Data Management Systems and Scientific Information, CONF 771062*, pp. 257-262 (Director of Information, OECD Nuclear Energy Agency, 38 bd. Suchet, 75016 Paris, France, 1978).

Key words: database management; data center; GDMS; software selection; solar energy; system design.

The National Bureau of Standards designed and operates a Data Center serving the Federal Solar Energy Research, Development and Demonstration Program. The design effort included thorough consideration of the applicability of generalized data base management software. The functional requirements for the Data Center and the factors influencing the data base decision are described. A modified data base approach is presented and reasons for its adoption by the Data Center are discussed.

18036. Deutsch, D., Fong, E., Characteristics of generalized database management systems, (Proc. OECD Specialist Study on the Use of Generalized Data Management Systems for Handling Scientific Information, Paris, France, Jan. 11-13, 1977 and Lawrence Berkeley Laboratory, Berkeley, CA, Oct. 5-7, 1977), Paper in *Generalized Data Management Systems and Scientific Information, CONF 771062*, pp. 27-49 (Director of Information, OECD Nuclear Energy Agency, 38 bd. Suchet, 75016 Paris, France, 1978).

Key words: acquisition sources; feature description; GDMS; generalized database management systems; product characteristics; software.

Generalized database management systems are complex and diverse software products that are used increasingly by organizations of all types. While many applications of database technology are highly successful, others do not meet expectations. An important determinant of success appears to be a close match between application requirements and database management system capabilities. This paper describes characteristics that differentiate database management software packages and presents in an appendix a list of software products and the computer systems on which they are available.

18037. Deutsch, D., Fong, E., Collica, J., Cost considerations for generalized database management systems, (Proc. OECD Specialist Study on the Use of Generalized Data Management Systems for Handling Scientific Information, Paris, France, Jan. 11-13, 1977 and Lawrence Berkeley Laboratory, Berkeley, CA, Oct. 5-7, 1977), Paper in *Generalized Data Management Systems and Scientific Information, CONF 771062*, pp. 50-70 (Director of Information, OECD Nuclear Energy Agency, 38 bd. Suchet, 75016 Paris, France, 1978).

Key words: application; cost; database management; GDMS; life cycle; methodology.

One important factor that must be considered when evaluating whether generalized database management software should be used is cost. A methodology and a framework based on the application life cycle for estimating costs associated with potential applications of these new software tools is proposed. Import-

tant classes of costs are identified and discussed. The problem of comparing costs for database oriented versus traditional software systems is also considered. Finally, budget guidelines for estimating total life cycle costs for generalized database management applications appear in an appendix.

18038. Engen, G. F., **The six-port measurement technique: A status report**, *Microwave J.* **21**, No. 5, 18, 21-22, 24, 84, 87, 89 (May 1978).

Key words: automatic network analyzer; microwave; microwave measurement; six-port.

Following a brief review of microwave measurement problems, the six-port is introduced as an alternative method for implementing the automatic network analyzer. Its advantages are discussed and the application to both one-port and two-port measurements described. This is followed by a description of practical six-port circuits, and the solution to their associated calibration problems. Finally, the status and performance of existing six-port measurement systems is presented.

18039. Etz, E. S., Rosasco, G. J., Blaha, J. J., Heinrich, K. F. J., Cunningham, W. C., **Particle analysis with the laser-Raman microprobe**, *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 66A-66L (June 1978).

Key words: biological tissues; chemical microanalysis; microparticles; microparticulate pollutants; molecular analysis; Raman microprobe; Raman spectroscopy; sulfate aerosol; trace organics.

A review and results of current research are presented on the microanalytical applications of the laser-Raman microprobe developed at NBS. With the new instrument, Raman spectra can be obtained of single particles or sample regions of micrometer dimensions. These provide a molecular fingerprint and are useful in the qualitative analysis of microsamples for constituent molecular compounds. The microprobe is described and its capabilities are illustrated for the detection and spectroscopic characterization of major molecular components in microparticulate matter of mass down to 10 picogram. Examples include the measurement of inorganic species (e.g., sulfate, carbon) and of organic compounds (e.g., polynuclear aromatic hydrocarbons) of interest in environmental pollution studies. Results from the analysis of single particles ($< 10 \mu\text{m}$ in size) in urban airborne dusts and in fly ash from power plants are given. Work on the characterization of submicron air particulates collected at the South Pole shows the presence of atmospheric sulfate. Microanalysis of biological specimens has emphasized the investigation of thin (5-10 μm thickness) sections of tissue. Examples are the study of thin sections of bone and tooth to furnish new results on the process of calcification. In a study of samples of human biopsy tissue, silicone rubber particles have been identified that can be linked to complications from an implanted silicone rubber prosthetic device.

18040. Fiori, C. E., Myklebust, R. L., **Observations on the sequential simplex method and its application to peak fitting in energy-dispersive x-ray spectrometry**, *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 52A-52F (June 1978).

Key words: curve fitting; electron beam microprobe; lithium-drifted silicon detector; scanning electron microscope; simplex; x-ray spectrometry.

A method will be described for the fitting of Gaussian profiles to the pulse-height distributions of overlapping x-ray peaks measured with an energy-dispersive detector. The desired result is the determination of areas under individual x-ray peaks

in a spectrum in which the peaks overlap. A sequential simplex procedure for selection of the parameters in a mathematical expression which describes a spectral peak, as suggested by Spendly, et. al, is employed. Starting and Stopping criteria for the procedure will be discussed, a computer program will be outlined, and examples of the method applied to peaks obtained from a lithium-drifted silicon detector will be provided.

18041. Flannery, M. R., Tai, H., Albritton, D. L., **Cross sections for the photoionization of $\text{H}_2(X^1\Sigma_u^+, v_i = 0-14)$ with the formation of $\text{H}_2^+(X^2\Sigma_g^+, v_f = 0-18)$, and vibrational overlaps and R -centroids for the associated vibrational transitions**, *Atomic Data and Nucl. Data Tables* **20**, No. 6, 563-585 (Dec. 1977).

Key words: excited vibrational initial levels; molecular hydrogen; photoionization.

Cross sections for the photoionization of $\text{H}_2(X^1\Sigma_u^+)$, initially in vibrational levels $v_i = 0-14$, with the production of $\text{H}_2^+(X^2\Sigma_g^+)$ in vibrational levels $v_f = 0-18$ are tabulated for the full vibrational array at 24 photon wavelengths ranging from 912 Å to 450 Å. The associated vibrational overlap integrals $\langle v_i | v_f \rangle$ and R -centroids, $\langle v_i | R^n | v_f \rangle / \langle v_i | v_f \rangle$, $n = 1$ and 2 are also presented together with accurate curve fits of the bound-free ($\text{H}_2\text{-H}_2^+ + e$) electronic matrix elements.

18042. Frederikse, H. P. R., Hosler, W. R., Negas, T., **Rare earth ceramics for MHD-power generators**, (Proc. 13th Rare Earth Research Conf., Oglebay Park, Wheeling, WV, Oct. 13, 1977), Paper in *The Rare Earths in Modern Science and Technology*, G. J. McCarthy & J. J. Rhyne, Eds., pp. 45-53 (Plenum Publ. and Corp., New York, NY, Aug. 1978).

Key words: ceria-based electrodes; hot-wall; LaCrO_3 ; rare-earth.

The hot-wall type of open-cycle MHD power generators requires electrode materials that are able to operate at temperatures up to 1800 °C in a highly corrosive atmosphere and under severe electrical and thermal current conditions. Several compounds containing rare-earth elements, in particular, LaCrO_3 and CeO_2 with additions of other oxides, have shown to be promising candidates for this application. This paper describes the materials requirements including their physical, chemical and structural properties. Results of evaluation experiments performed on LaCrO_3 - and ceria-based electrodes are discussed.

18043. Galejs, A., Kuyatt, C. E., **Focusing and dispersing properties of a stigmatic crossed-field energy analyzer**, (Proc. 14th Symp. on Electron, Ion, and Photon Beam Technology, Palo Alto, CA, May 25-27, 1977), *J. Vac. Sci. Technol.* **15**, No. 3, 865-867 (May/June 1978).

Key words: aberration coefficients; crossed-field energy analyzer; electron optics; Wien filter.

The electron-optical properties of a stigmatic cross-field energy analyzer (double-focusing Wien filter) have been obtained from exact trajectory calculations. The results are given in the form of focusing and dispersing coefficients to the second order. These coefficients enable the device designer or potential user to calculate the total beam transfer and evaluate the resulting beam quality without additional ray tracing. The specific device for which calculations are made employs a uniform electric field and a toroidal magnetic field. This analyzer is of special interest in our laboratory because it can be constructed with a very small stray magnetic field, and in addition to its dispersive properties it also rotates the spin of a polarized electron beam.

18044. Havemann, R. H., **Photolithographic fabrication of thin-film metal-oxide-metal diodes with submicrometer-square**

junction areas, *J. Vac. Sci. Technol.* **15**, No. 2, 389-391 (Mar./Apr. 1978).

Key words: metal-oxide-metal diodes; photolithography; thin films; tunneling junctions.

A technique is described which uses conventional photolithography in fabricating metal-oxide-metal diodes with submicrometer-square junction areas. The junction is formed at the edge of the first thin-film electrode, thereby reducing one dimension of the junction by an order of magnitude or more over linewidths obtainable by standard photolithographic methods. Although the technique is applied specifically to the fabrication of a metal-oxide-metal diode array, it is generally applicable to other thin-film devices requiring submicrometer-square junction areas.

18045. Havemann, R. H., Hamilton, C. A., Harris, R. E., Photolithographic fabrication of lead alloy Josephson junctions, *J. Vac. Sci. Technol.* **15**, No. 2, pp. 392-395 (Mar./Apr. 1978).

Key words: Josephson junctions; lead alloy; photolithographic; superconducting electronics.

Techniques for the photolithographic fabrication of thin-film Josephson junctions are presented in detail, including metal lift-off processes, lead alloy composition, and formation of tunneling junction barriers using plasma oxidation in an rf discharge. A comparison with earlier rf plasma oxidation studies on Pb(In)-oxide-Pb junctions shows the tunneling resistance of Pb(In,Au)-oxide-Pb(Au) junctions to be nearly two decades lower for a given oxygen pressure in the rf discharge; this difference was attributed to the use of different alloys and sputtering parameter measurement techniques in the respective studies. Typically, tunneling resistance decreased by only 2 percent after ten thermal cycles, but decreased at an accelerated rate with subsequent cycling. Room-temperature storage often induced downward resistance changes on the order of 30 percent per month. Junctions stored at -15°C generally showed little change after a period of three months.

18046. Hoer, C. A., A network analyzer incorporating two six-port reflectometers, *IEEE Trans. Microwave Theory Tech.* **MTT-25**, No. 12, 1070-1074 (Dec. 1977).

Key words: impedance; microwaves; network analyzer; reflection coefficient; reflectometer; scattering parameters; self-calibration techniques; six-port junction.

This paper outlines the theory and design of a microwave network analyzer capable of measuring the network parameters of any linear reciprocal or nonreciprocal, active or passive two port. An RF signal from one source is applied at the same time to two six-port reflectometers which measure the incident and reflected waves at the ports of the two port being measured. An experimental dual six-port network analyzer for the 2-18-GHz range has been completed and is described briefly. Some advantages of the proposed design over existing network analyzer designs are 1) only one source is needed, 2) no phase detectors are required, 3) no flexible cables or arms are used between the reflectometers and the two port being measured, and 4) self-calibration techniques are readily applied.

18047. Kanda, M., A broadband antenna with tapered resistive loading for EMI measurements, *Proc. IEEE Int. Symp. on Electromagnetic Compatibility*, Seattle, WA, Aug. 2-4, 1977, pp. 13-18 (The Institute of Electrical & Electronics Engineers, Inc., New York, NY, 1977).

Key words: broadband antenna; EMI measurements; method of moments; resistively loaded antenna; time domain measurements.

The characteristics of a relatively short cylindrical broadband antenna with continuous resistive loading are studied theoretically and experimentally for EMI measurements. The antenna considered is a nonconducting (glass) cylinder with continuously deposited, tapered, resistive loading. The current distribution on the resistively loaded antenna is calculated using the method of moments. Using the current distribution other quantities such as input impedance, near-field and far-field radiation patterns, and radiation efficiency are calculated and compared with experiments. These experimental results agree well with the theoretical results.

Time domain measurements are performed using a time domain automatic network analyzer. The receiving characteristics of the resistively loaded antenna indicate that the impulse shape of 70 ps duration is well preserved. The resistively loaded antenna with a beam lead Schottky diode load is also examined. The frequency response is flat to ± 3 dB from 700 kHz to 2 GHz. With proper response shaping, the resistively loaded antenna has a potential use for the frequency range between 10 kHz and 3 GHz without distorted antenna field patterns.

18048. Kuyatt, C. E., Systematic transformations of the asymptotic aberration coefficients of round electrostatic lenses (I), (Proc. 14th Symp. on Electron, Ion, and Photon Beam Technology, Palo Alto, CA, May 25-27, 1977), *J. Vac. Sci. Technol.* **15**, No. 3, 861-864 (May/June 1978).

Key words: characteristic function; electron optics; electrostatic lenses; third-order aberration coefficients.

In previous work we formulated the third-order asymptotic aberration coefficients of round (axially symmetric) electrostatic lenses in a form independent of object and aperture positions, and expressions for the six quantities which are sufficient to specify completely the aberration properties of the lenses were derived in the form of integrals involving derivatives of the axial potential through the fourth order. Because actual calculations involved numerical differentiation of the axial potentials, integrations by parts were used to transform the integrals to two new forms with axial derivatives of lower degree. Many other forms of the aberration integral can be obtained by further integrations by parts, but the transformations are laborious and it is not easy to predict the forms which are possible nor to determine the sequence of operations which will yield a desired result. However, using a method originally developed by Seman and extended by Hawkes, a completely general formula has been obtained from which all of the possible forms of the asymptotic integrals can be obtained very simply. A few of these possible forms are derived and discussed.

18049. Lamers, H. J. G., Stalio, R., Kondo, Y., A study of mass loss from the mid-ultraviolet spectrum of α Cygni (A2 Ia), β Orionis (B8 Ia), and η Leonis (A0 Ib), *Astrophys. J.* **223**, No. 1, 207-220 (July 1, 1978).

Key words: mass loss; supergiants; ultraviolet spectrum.

The first results on mass loss from high-resolution mid-ultraviolet spectra of α Cyg (A2 Ia), β Ori (B8 Ia), and η Leo (A0 Ib) are given. The spectrum of α Lyr (A0 V) is also included in this study as a comparison spectrum to distinguish photospheric lines from envelope lines. All spectra have been obtained with the echelle spectrograph of the new Balloon-borne Ultraviolet Stellar Spectrometer. The resonance lines of Mg II and Fe II in α Cyg and β Ori show violet-shifted components: The profiles in α Cyg indicate that the material is accelerated to a terminal velocity of 250 km s^{-1} and that two zones of higher density (shells) are present and variable. The Mg II profiles of β Ori show the presence of a shell at -195 km s^{-1} , which was not observed during previous observations.

No shifted components were found in the spectra of η Leo and α Lyr. The presence of shells and the variation of resonance line profiles indicate that mass loss in high-luminosity stars is not a stationary phenomenon: In addition to a more or less stationary wind, the star produces irregular "puffs" which give rise to concentrations of matter. The mass-loss rate of α Cyg derived from the Fe II resonance lines, assuming a blanketed local thermodynamic equilibrium (LTE) model atmosphere with a cool envelope, is $1.1 \times 10^{-8} M_{\odot} \text{yr}^{-1}$, which is two orders of magnitude smaller than the value derived from the infrared excess. Several possible explanations for this discrepancy are discussed. Either the photospheric Lyman continuum is much brighter than predicted for LTE models, or the temperature in the envelope is higher than the effective temperature.

18050. McClintock, W., Moos, H. W., Henry, R. C., Linsky, J. L., Barker, E. S., **Ultraviolet observations of cool stars. VI. $L\alpha$ and Mg II emission line profiles (and a search for flux variability) in Arcturus**, *Astrophys. J. Suppl. Series* 37, No. 2, 223-233 (June 1978).

Key words: chromospheres; cool stars; Copernicus satellite; emission line profiles; flux variability; stars, chromospheres; stars, circumstellar shells; stars, late type; ultraviolet observations; ultraviolet spectra.

High-precision, high-resolution profiles of the $L\alpha$ and Mg II k chromospheric emission lines from Arcturus (α Boo) obtained with the Princeton Experimental Package aboard the Copernicus satellite are presented. Asymmetries seen in the profiles of these lines are probably intrinsic to the star, rather than the result of interstellar absorption. In contrast to previous observations of the Ca II K emission line, we find no evidence during a three-year period for variability in the profiles or in the total fluxes from these lines on time scales ranging from hours to months. We also present a flux profile of the O I λ 1302 line and flux upper limits for $L\beta$, O VI λ 1032, Si III λ 1206, and O V λ 1218.

18051. Myklebust, R. L., Newbury, D. E., Heinrich, K. F. J., Small, J. A., Fiori, C. E., **Monte Carlo electron trajectory simulation—An aid for particle analysis**, *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 61A-61F (June 1978).

Key words: electron probe microanalysis; electron scattering; Monte Carlo calculations; particle analysis; scanning electron microscopy; x-ray microanalysis.

Monte Carlo electron trajectory simulations are applied to the study of electron interactions in particles. Single scattering, multiple scattering, or a hybrid model can be used to describe elastic scattering. The Bethe continuous energy loss approximation is used to describe inelastic scattering. Monte Carlo calculations of x-ray intensities emitted from particles agree well with experiments on known systems. The x-ray emission from particles normalized to emission from bulk targets shows a peak above unity for soft radiation due to the decreased absorption path. Monte Carlo calculations reveal that the typical arrangement of the x-ray spectrometer in a scanning electron microscope, in which the detector axis is set at a right angle to the beam, can lead to anomalous x-ray intensities from particles. The normalized intensity goes through a peak and sharply decreases with increasing particle size due to an increased absorption length.

18052. Newbury, D. E., **On the accuracy of quantitative analysis in secondary ion mass spectrometry—Round robin results**, *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 6A-61 (June 1978).

Key words: ion microprobe mass analysis; microanalysis; quantitative analysis; relative elemental sensitivity factors; round robin analysis; secondary ion mass spectrometry.

Quantitative analysis by secondary ion mass spectrometry can be carried out with relative elemental sensitivity factors. The procedure yields good accuracy in tests on known samples. To evaluate the accuracy which can be expected in the analysis of unknowns, a round robin analysis has been carried out. Four laboratories performed qualitative and quantitative analyses on four multi-element glass samples. Quantitative analyses were performed with sensitivity factors derived from a suite of glasses previously prepared by NBS. The distribution in errors which was observed for all of the analyses was such that 57 percent of the analyses fell within 20 percent relative of the known compositional values, and 91 percent within a factor of two.

18053. Newbury, D. E., **Secondary ion mass spectrometry for particle analysis**, *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 65A-65D (June 1978).

Key words: depth profiling; ion microprobe mass analysis; microanalysis; particle analysis; secondary ion mass spectrometry; sputtering.

Secondary ion mass spectrometry is a powerful tool for particle analysis. Signals can be obtained for all elements and isotopes, including hydrogen. Molecular signals can be used for speciation studies. Compositional determinations with sensitivity in the parts per million range can be made. Microanalysis at the micrometer scale is possible in the ion microprobe and ion microscope. Surface analysis can be carried out since the primary ion range is less than 50 nm and the secondary ion range is less than 5 nm. Studies of elemental distributions in depth can be made by sputtering the sample in a controlled fashion. Both conducting and nonconducting samples can be studied by selection of the proper primary ion species. Compositional analysis can be carried out with relative errors less than a factor of two. Disadvantages of SIMS include the destructive nature of ion erosion, the strong matrix effects on secondary ion signals, the complicated spectra, and the local damage caused by ion bombardment. Limits of detection for a lead-silicate matrix are reported. The existence of a particle size effect on relative elemental sensitivity factors is reported.

18054. Small, J. A., Heinrich, K. F. J., Fiori, C. E., Newbury, D. E., Myklebust, R. L., **Progress in quantitation of single-particle analysis with the electron probe**, *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 56A-56K (June 1978).

Key words: continuous radiation; electron probe; peak-to-background ratios; quantitative analysis; single-particle analysis.

The National Bureau of Standards is currently developing methods for the quantitative analysis of particles which are based on the energy distribution of the continuous x-rays generated as a result of the electron beam interaction within the sample. One method which is currently being developed is the use of the ratios between characteristic and continuous radiation, live-to-background ratios, to account for the difference between the volume of beam interaction within a particle and a bulk standard. The results of the live-to-background ratios are presented for bulk glass and glass microspheres. The results show good agreement between bulk glass and microspheres in the size range of 1.5 to 29 μm in diameter. In addition to the results, an iterative procedure for the quantitative analysis of particles is presented. This procedure makes use of the ratio of the continuum from the particle compared to the

continuum from the standard to scale up the peak intensity of the particle to a value appropriate to bulk material.

18055. Soulen, R. J., Jr., Giffard, R. P., **Josephson-effect absolute noise thermometer: Resolution of unmodeled errors**, *Appl. Phys. Lett.* **32**, No. 11, 770-772 (June 1978).

Key words: absolute thermometry below 10 K; ac Josephson effect; Josephson junctions; noise thermometry.

An absolute cryogenic temperature scale is being defined at the National Bureau of Standards using the linewidth of radiation emitted by a resistively shunted Josephson junction. We report careful measurements of the impedance of this noise thermometer and show that its behavior is in excellent agreement with the predictions of the resistively shunted junction model assuming a sinusoidal current-phase relationship. The implications for absolute noise thermometry are discussed.

18056. Stock, M., Smith, E. W., Drullinger, R. E., Hessel, M. M., **Relaxation of the first excited 1_u state of Hg_2** , *J. Chem. Phys.* **68**, No. 9, 4167-4175 (May 1, 1978).

Key words: A values; collisional relaxation; electronic transition rates; mercury fluorescence; optical excitation.

The decay of the 335 nm Hg_2 fluorescence band was measured with 1 nsec time resolution for the first 200 nsec following optical excitation by a 10 nsec laser pulse. Measurements of the decay rates for various wavelengths in this band were used to analyze the relaxation of the vibrational levels in the 1_u state. It was found that the lower vibrational levels quickly reach a Boltzmann distribution described by an effective temperature T_{eff} . This effective temperature then decreases with time, asymptotically approaching the gas temperature. Comparison of these data with a model calculation by Montroll and Shuler yields a transition rate of $5.2 \times 10^{-11} \text{ cm}^3 \text{ sec}^{-1}$ for the two lowest vibrational states. Analysis of the relaxation for higher vibrational levels gave a value of $2.7 \times 10^{-10} \text{ cm}^3 \text{ sec}^{-1}$ for the $1_u \rightarrow O_g^-$ transition rate. Since no mercury trimers have been formed at these early times, the 485 nm fluorescence band is not present. It was therefore possible to evaluate the repulsive wall of the 1_u potential curve for small internuclear distances corresponding to wavelengths in the red wing of the 335 nm dimer band which are normally overlapped by the 485 nm trimer band.

18057. Weidman, M. P., **A semiautomated six port for measuring millimeter-wave power and complex reflection coefficient**, *IEEE Trans. Microwave Theory Tech.* **MTT-25**, No. 12, 1083-1085 (Dec. 1977).

Key words: automation; millimeter wave; power measurement; reflection measurement; six port.

A six-port system has been developed and applied to the precision measurement of power and complex reflection coefficient in WR-15 (50-75 GHz) waveguide. The system is automated except for frequency and switching control for the signal source. This system provides a time-saving factor of at least five as compared to a tuned reflectometer with little, if any, degradation in accuracy.

18058. Allan, D. W., Barnes, J. A., **Modeling and optimum utilization of high performance clocks**, *Proc. Conf. Precision Electromagnetic Measurements, London, England, July 1-5, 1974*, pp. 277-278 (Institution of Electrical Engineers, London, England, 1974).

Key words: atomic time algorithm; clock behavior modeling; clock behavior simulation; clock error detection; clock noise characterization; frequency control voltage correlation; frequency deviation; optimum time prediction.

Modeling and optimum utilization of high performance clocks is discussed.

18059. Chi, J., **Seasonal operating performance of gas-fired hydronic heating systems with certain energy-saving features**, (Proc. Int. Conf. Centre Heat & Mass Transfer, Dubrovnik, Yugoslavia, Aug. 29-Sept. 2, 1977), Paper in *Energy Conservation in Heating, Cooling, and Ventilating Buildings, New Techniques in Heating and Cooling of Buildings*, **1**, 495-504 (Hemisphere Publ. Corp., Washington, DC, 1978).

Key words: boiler; computer simulation; DEPAB; energy conservation; heating systems; part-load performance; seasonal efficiency.

DEPAB (DEsign and Performance Analysis of Boilers) is an NBS computer program for simulation of fossil-fuel-fired boilers for residential heating systems. It is based upon an analytical model which accounts for cyclic (on-and-off) operation of a boiler fuel burner and water circulating pump. This paper illustrates the use of DEPAB for evaluating quantitatively the effectiveness of several selected energy-saving features for gas-fired hydronic heating systems. Sufficient information is also provided to demonstrate the important factors of the simulation program DEPAB.

18060. Evans, J. M., Jr., **Automation and productivity in discrete part manufacturing**, *Proc. Technical Symp. on Research and Engineering for Automation and Productivity in Shipbuilding, Atlanta, GA, June 15-16, 1976*, pp. 223-235 (IIT Research Institute, Chicago, IL, 1976).

Key words: automation; computer aided manufacturing; discrete part batch manufacturing; integrated manufacturing systems; productivity; shipbuilding.

The introduction of computer aided manufacturing (CAM) systems in discrete part batch manufacturing, which includes shipbuilding, can increase productivity by hundreds or even thousands of percents. The importance of productivity improvements, the use of automation and particularly CAM to increase productivity, current CAM systems and technical strategies, and the NBS program to stimulate the diffusion of CAM technology in Government and industry are discussed.

18061. Evans, J. M., Jr., **Industrial robots in computer aided manufacturing**, *NC/CAM J.*, 6 pages (Numerical Control Society, Inc., Glenview, IL, Jan. 1977).

Key words: applications; computer aided manufacturing; industrial robots; numerically controlled machine tools; sensors.

This paper discusses both industrial robots of today and the future and their relation to numerical control (NC) and computer aided manufacturing (CAM). Today's robots do not have any sensory capability, and this means that they cannot cope with uncertainties in the external environment. Today's robots can, however, be programmed to do a task and they will faithfully repeat that task over and over, without any variation. Robots in the future will have additional sensory capability to be able to cope with some uncertainties in the environment, such as parts slightly out of position, and will have self diagnostic and error recovery routines to prevent predictable problems. In this paper, the various classes of existing industrial robots are identified and discussed. It is pointed out that over the next few years, significant improvements can be expected in the areas of dynamic performance, programming and sensors. With these improvements, new applications of industrial robots will be seen in automobile manufacturing, welding, machine loading, aerospace, and small part mechanical assembly.

18062. Evans, J. M., Jr., **Keynote address**, *Proc. Second Conf. Automatic Inspection and Product Control*, Chicago, IL, Oct. 19-21, 1976, pp. XIII-XXIII (IIT Research Institute, Chicago, IL, 1976).

Key words: automatic inspection; automation; dynamic measurement; inspection; measurement science; quality control.

Automatic inspection and product control in industry today is based on the use of mechanical gadgets and simple sensors to inspect the properties of manufactured goods after they have been processed and assembled. A perspective for examining examples of the state-of-the-art in automation is provided by a review of the history of measurement. This in turn provides a basis for extrapolating important trends for future developments. Three major trends in automatic measurement that are developed are the automation of inspection, the addition of computers to sensors to create "smart" sensors, and the increasing use of in-process inspection.

18063. Evans, J. M., Jr., **Removing barriers to the application of automation in discrete part batch manufacturing**, (Proc. Int. Federation of Automatic Control Symp., Tokyo, Japan, Oct. 17-20, 1977), Paper in *Information Control Problems in Manufacturing Technology*, Y. Oshima, Ed., pp. 293-296 (Pergamon Press, Oxford, England, 1977).

Key words: automation; computer control; discrete part batch manufacturing; dynamic measurement; numerically controlled machine tools; productivity.

The application of computer control systems in discrete part batch manufacturing operations can increase productivity by hundreds or even thousands of percents. Despite this phenomenal potential, we are not adequately using this technology. For example, numerically controlled machine tools typically increase productivity by 300 or 400 percent and yet account for only 1.3 percent of all machine tools in the United States after 25 years.

Industry has identified high costs of NC tools and other automation systems as the primary barrier to increased use of this technology. This fact has been documented by the General Accounting Office (GAO). GAO and others have identified the lack of standards as one reason for this high cost.

The National Bureau of Standards is working to develop interface standards, standards on programming languages, performance measures, and the basic technology of dynamic measurement and computer control for computer based automation systems. All of these products are aimed at reducing costs of computer aided manufacturing systems and hence at stimulating the use of this technology to increase productivity in manufacturing operations in both Government and industry.

The NBS program will be presented and the technical opportunities for a new generation of inexpensive computer controlled machine tools for the 1980's will be considered in this paper.

18064. Grimes, J. W., Mulroy, W., Shomaker, B. L., **Effect of usage conditions on household refrigerator-freezer and freezer energy consumption**, *ASHRAE Trans.* 83, Part 1, 818-828 (1977).

Key words: appliance labeling; energy use; household freezers; household refrigerators; refrigerator.

A study was made of an automatic- and a manual-defrost refrigerator/freezer combination, and an upright and a chest freezer to measure the effect on energy consumption of five variable usage conditions: thermostat setting, ambient temperature, food load, door-opening frequency, and relative humidity. No evaluation was made of the effect of frost build-up.

Ambient temperature and thermostat setting were found to have considerably greater effect on energy consumption than door-opening and relative humidity changes for the specimens tested.

18065. Hanson, D. W., Davis, D. D., Cateora, J. V., **Time from NBS by satellite**, *Proc. Ninth Annual Precise Time and Time Interval Applications and Planning Meeting*, NASA Goddard Space Flight Center, MD, Nov. 29-Dec. 1, 1977, pp. 139-150 (Goddard Space Flight Center, Greenbelt, MD, Mar. 1978).

Key words: GOES; satellite; synchronization; time broadcasts; time code.

As a complement to the present time and frequency services of WWV, WWVH, and WWVB, the National Bureau of Standards (NBS) is now sponsoring a satellite-disseminated time code using the GOES satellites of the National Oceanic and Atmospheric Administration. The time code is referenced to the UTC (NBS) time scale, giving Coordinated Universal Time. It is considered by NOAA to be a permanent feature of the GOES satellites intended to serve the GOES users. It may, however, be used by others requiring a general purpose time reference. The time code is available to the entire Western Hemisphere from two satellites on a near full-time basis.

This paper is basically an update of last year's PTTI paper on the GOES time code. The time-code generation system is being improved to include a continuous update of its ephemeris message in place of the present 30-minute updated message; triple redundancy is being designed into the generation equipment at the Wallops Island, Virginia, ground station; and monthly status reports will be included in the NBS Time and Frequency Services Bulletin; e.g., scheduled outages, solar eclipses, and past performances. This paper includes comments on NBS experience with the reception of the signals, possible sources of interference, and how to obtain best results.

18066. Johnson, P. M., Langhoff, P. W., O'Neil, S. V., Corcoran, C. T., Reinhardt, W. P., **Moment-trace calculations of atomic and molecular photo-absorption cross sections**, *Chem. Phys. Lett.* 52, No. 2, 380-384 (Dec. 1, 1977).

Key words: L^2 discretization; moments; photoabsorption, atomic; photoabsorption, molecular.

Regularization procedures employing positive integer spectral power moments are described for calculation of atomic and molecular photoionization cross sections. Use of positive moments avoids matrix diagonalizations, and thus appears to have substantial computational advantages.

18067. Komarek, E. L., **Performance characteristics of an automated broad-band bolometer unit calibration system**, *IEEE Trans. Microwave Theory MTT-25*, No. 12, 1122-1127 (Dec. 1977).

Key words: automated measurements; bolometer unit calibration; broadband measurement; microwave power measurement; precision microwave measurements; 6-port junction.

The arbitrary six-port reflectometer concept has been applied to the automated broad-band system in the 1-18-GHz frequency range for the calibration of bolometer units. Performance evaluation results show an improvement in precision over other automated and manually operated measurement systems used at the National Bureau of Standards. Initial evaluation results reported here show a single measurement standard deviation of 0.02 to 0.41 percent from 2-18-GHz. The system is currently used for the calibration of coaxial and waveguide bolometer unit effective efficiency.

18068. Linsky, J. L., **Plage models**, (Proc. Orbiting Solar Observatory Workshop, Boulder, CO, Nov. 7-10, 1977), Paper in *Orbiting Solar Observatory* 8, 139-163 (University of Colorado Press, Boulder, CO, 1977).

Key words: sun, active regions; sun, chromosphere; sun, corona; sun, magnetic fields.

This paper reviews some of the outstanding physical problems of solar active regions (plages) and discusses models which have been constructed for plages, including models for the upper photosphere, temperature minimum, and chromosphere regions. There will also be a preliminary discussion of a new grid of plage models being constructed by Kelch, Morrison, and Linsky. These plage models, as well as models for the network and flares, are compared with average quiet Sun models to assess the relative degrees of temperature enhancement and excess radiative loss. In particular, I will discuss the question of whether "chromospheric activity" can be most easily accounted for by means of enhanced temperature gradients at the base of the chromosphere or increased mass column densities at the top of the chromosphere. Some insight into this question can be gained by comparing models of the active chromosphere stars ϵ Eri and 70 Oph A to a model for the similar but quiet chromosphere star α Cen B.

18069. Jones, R. R., **Resource impact factor (RIF) approach to optimal use of energy resources**, *ASHRAE J.* 18, No. 10, 15-18 (Oct. 1976).

Key words: energy sources; fuel selection; institutional factors; social value.

One of the basic objectives of a national energy conservation effort is to optimize use of nonrenewable resources. A careful analysis of the fuel and energy supplied to buildings is especially important since this sector accounts for about 30 percent of energy consumption in the U.S. and since buildings have greater flexibility with regard to energy sources than do motor vehicles and industrial processes. It is the intent of this paper to present the Resource Impact Factor (RIF) concept as a means whereby, in the technical process of developing energy efficient building projects, a quantification could also be given to the social value of our resources in order to obtain wise utilization.

18070. Kusuda, T., **Fundamentals of building heat transfer**, (Proc. Int. Conf. Centre Heat & Mass Transfer, Dubrovnik, Yugoslavia, Aug. 29-Sept. 2, 1977), Paper in *Energy Conservation in Heating, Cooling, and Ventilating Buildings, New Techniques in Heating and Cooling of Buildings*, 1, 321-338 (Hemisphere Publ. Corp., Washington, DC, 1978).

Key words: air leakage; dynamic heat transfer; energy analysis; heating and cooling loads; heat loss and heat gain; multi-room problems.

Basic problems and unique features of building heat transfer are described in relation to the heating and cooling load calculation, which is a starting point for building energy consumption analysis and equipment sizing. Detailed discussion is given of the relationship between heat loss (heat gain) and heating load (cooling load). Also outlined is a discussion of the multi-space heat transfer problem in which the air and heat exchange equations among adjacent spaces in a building are solved simultaneously with the radiant heat exchange equations for the surfaces of each room.

18071. Linden, T. A., **Protection for reliable software**, (Infotech State-of-the-Art Report), Paper in *System Reliability and Integrity* 2, 245-259 (Infotech Int., Marlow, Buckinghamshire, England, 1978).

Key words: abstract data types; access control; operating systems; programming languages; protection; reliable software.

Research on operating systems and programming languages is leading to protection concepts which are flexible enough to detect unanticipated interactions between modules within the same program. In addition to a role in support of computer security, flexible protection can improve the reliability of software by simplifying the problems encountered when modules are integrated into large software systems. This research is opening the way for many new interactions with software engineering methods. Protection is closely linked with recent approaches to data abstraction where users are allowed to create and manipulate objects of user-defined types. Access controls can then be specified and enforced in terms of the problem-oriented operations implemented by an abstract data type.

18072. Misakian, M., Kotter, F. R., Zafanella, L., Baishiki, R., Whitney, B., Task Force, **Measurement of electric and magnetic fields from alternating current power lines**, *IEEE Trans. Power Apparatus Systems*, PAS-97, No. 4, 1104-1114 (July/Aug. 1978).

Key words: calibration procedures; electric field measurements; instrumentation; magnetic field measurements; measurement procedures; power transmission lines.

This paper is a published closure of a paper which was presented at the IEEE Power Engineering Society 1977 Summer Meeting. The closure acknowledges and comments on a discussion of the paper.

18073. Roth, R. S., Negas, T., Parker, H. S., Minor, D. B., Olson, C. D., Skarda, C., **Phase relationships and crystal chemistry of compounds containing cerium oxide**, (Proc. 13th Rare Earth Research Conf., Olgebay, WV, Oct. 16-20, 1977), Paper in *The Rare Earths in Modern Science and Technology*, G. J. McCarthy and J. J. Rhyne, Eds., pp. 163-171 (Plenum Publishing Corp., New York, NY, 1978).

Key words: cerium niobate; cerium oxide; cerium tantalate; ionic/electronic conductors; phase equilibria; thermogravimetric.

The crystal chemistry and oxidation-reduction behavior of CeTaO_{4+x} and CeNbO_{4+x} suggest that ceramics based on these materials could be exploited as electrodes/electrolytes in high temperature applications. However, these systems are so complex that useful materials could be developed only after considerable modification and control of chemical features. Nevertheless, the $\text{Ce}^{+3} \leftrightarrow \text{Ce}^{+4}$ couple offers promise for electronic/ionic conduction in cerium oxide-based phases provided that a suitable host structure can be found. This paper reviews the efforts underway to determine the crystal chemistry of such host materials from systems containing rare earth oxides, niobium and tantalum oxides and Fe_2O_3 .

18074. Slater, J., Read, F. H., Novick, S. E., Lineberger, W. C., **Alkali negative ions. III. Multichannel photodetachment study of Cs^- and K^-** , *Phys. Rev. A* 17, No. 1, 201-213 (Jan. 1978).

Key words: Cs^- ; K^- ; negative ions; photodetachment; threshold behavior.

A crossed ion-laser beam apparatus has been used to obtain Cs^- and K^- cross sections for photodetachment into the ground (2S) and first excited state (2P) of the neutral atom in the photon energy range near the threshold for production of 2P neutrals. A total cross section is determined from the cross section for production of neutral atoms and the partial cross sections are obtained from the cross section for production of

photoelectrons transmitted through a low-pass kinetic-energy filter. The filter characteristics are determined empirically and the discrimination between ground- and excited-state detachment channels is approximately 1000. It is apparent from the data that the detachment channels are strongly coupled in the threshold region, a result attributed to long-range forces between the detached electron and the neutral atom. The data are compared with a semiempirical multichannel photodetachment model developed by Lee; the model is quite successful in its prediction of the energy-dependent cross section for production of $\text{Cs } ^2P_{1/2,3/2}$ from knowledge of the previously measured Cs^- total photodetachment cross section. We have produced an approximate fit to the K^- data with this model. The following electron affinities have been determined: for Cs, 0.4715(3) eV, and for K, 0.50147(10).

18075. Tighe, N. J., **The structure of slow crack interfaces in silicon nitride**, *J. Mater. Sci.* 13, 1455-1463 (1978).

Key words: cracks; electron microscopy; fracture interfaces; plastic deformation; silicon nitride; turbine materials.

Fracture interfaces formed in silicon nitride at high temperatures were studied using light and electron microscopy. The structure of the fracture interface depended on the type of silicon nitride fractured. High-purity, reaction-bonded silicon nitride always formed flat, relatively featureless, fracture surfaces. Fracture occurred by a brittle mode even at the highest temperature (1500 °C) studied. The critical stress intensity factor for reaction-bonded silicon nitride ($\sim 2.2 \text{ MN m}^{-3/2}$) is relatively low and is insensitive to temperature. By contrast, hot-pressed silicon nitride gave evidence of plastic flow during fracture at elevated temperatures. Crack growth in magnesia-doped, hot-pressed silicon nitride occurs by creep, caused by grain boundary sliding and grain separation in the vicinity of the crack tip. As a consequence of this behaviour, extensive crack branching was observed along the fracture path. The primary and secondary cracks followed intergranular paths; sometimes dislocation networks, generated by momentary crack arrest, were found in grains bordering the crack interface. As a result of the high temperature, cracks were usually filled with both amorphous and crystalline oxides that formed during the fracture studies. Electron microscopy studies of the compressive surfaces of four-point bend specimens gave evidence of grain deformation at high temperatures by diffusion and dislocation motion.

18076. Wineland, D. J., Howe, D. A., Hellwig, H., **Special purpose atomic (molecular) standard**; *Proc. 8th Annual Precise Time and Time Interval Applications and Planning Meeting, U.S. Naval Research Laboratory, Washington, DC, Nov. 30-Dec. 2, 1976*, pp. 429-447 (Goddard Space Flight Center, Greenbelt, MD, 1976).

Key words: frequency lock servo; frequency multiplier; frequency standard; microwave absorption cell; strip line oscillator.

A special purpose frequency standard and clock is being developed featuring a novel combination of stability and accuracy performance, shock and temperature insensitivity, instant turn on characteristics and featuring low weight, power consumption, and potentially low fabrication costs.

This new device is based on the well-known 3-3 transition in ammonia ($\sim 23 \text{ GHz}$) which provides the frequency reference for a $\sim 0.5 \text{ GHz}$ oscillator. The oscillator signal is multiplied in one step to K-band and injected into a waveguide cell containing ammonia. The absorption feature is used to frequency lock the 0.5 GHz oscillator to line center. A fixed output frequency between 5 and 10 MHz is provided by direct division from 0.5 GHz. The 0.5 GHz oscillator is a novel strip-line transistor

oscillator of high spectral purity. It may not only be important for our standard but also for other atomic standards where acceleration and irradiation problems are encountered. The absorption device may well be able to fill a metrology need not satisfied by presently available atomic and quartz crystal standards.

Design goals of the present project are 10^{-10} stability from $\sim 10 \text{ sec.}$ to 10^4 sec. , and 10^{-9} absolute accuracy. The rather broad linewidth of ammonia ($\sim 100 \text{ kHz}$) reduces overall resolution but allows a short ($< 1 \text{ ms}$) servo attack time thus reducing the acceleration sensitivity of the primary 0.5 GHz oscillator. Working at low pressure ($< 10^{-4} \text{ Torr} = 1.33 \times 10^{-2} \text{ Newton/m}^2$) reduces temperature sensitivity to an acceptable level. Power consumption should be $< 3 \text{ W}$ and expected size of a working device $\sim 10^3 \text{ cm}^3$.

18077. Allred, C. M., Manney, C. H., **Self-calibration of complex ratio measuring systems**, (Proc. Int. Measurement Conf. on Measurement and Instrumentation, Dresden, Germany, June 17-23, 1973), *ACTA IMEKO* 1, 157-166 (1973).

Key words: complex ratios; magnitude; phase; self-calibration.

A technique, for self-calibrating complex ratio measuring systems is described. No known standards are required, only reproducible, but unknown, insertion devices are needed. A potentially high calibration accuracy exists for systems with stable parameters.

18078. Balfour, F. W., Sengers, J. V., Moldover, M. R., Sengers, J. M. H. L., **A revised and extended scaled equation of state for steam in the critical region**, *Proc. Seventh Symp. Thermophysical Properties, Gaithersburg, MD, May 10-12, 1977*, A. Cezairliyan, Ed., pp. 786-793 (American Society Mechanical Engineers, New York, NY, 1977).

Key words: critical phenomena; critical region parameters; equation of state; scaling laws; steam; universality of critical behavior.

The anomalous thermodynamic behavior of fluids in the vicinity of the critical point can be described in terms of a thermodynamic potential which is analytic everywhere except at the critical point and which incorporates the so-called "scaling laws." An example frequently used is the potential that implies a linear model parametric equation of state.

In this paper we formulate a thermodynamic potential which leads to a "revised" and "extended" linear model equation of state. We then use it to analyze experimental PVT data obtained by Rivkin and co-workers in the critical region of steam. The "revision," in the language of Mermin and Rehr, accounts for an asymmetric behavior of the gas and liquid branches of the coexistence curve. It incorporates a coexistence curve diameter which deviates from the critical isochore and thus enables us to increase the range of empirical validity of the scaled equation of state. The "extension" consists of adding a correction-to-scaling term with a new critical exponent whose presence is predicted by theory. We show that the revised and extended linear model represents the experimental equation of state data for steam in the critical region with universal critical exponent values predicted theoretically from the Landau-Ginzburg-Wilson model for critical phenomena in Ising-like systems.

18079. Bartel, T. W., Magrab, E. B., **Studies on the spatial variation of decaying sound fields**, *J. Acoust. Soc. Am.* 63, No. 6, 1841-1850 (June 1978).

Key words: analysis of variance; decaying sound fields; diffuse sound field; reverberation room; reverberation time; spatial variance.

The spatial variation of the reverberation time was measured in the NBS reverberation room in the 1/3-octave bands from 80 to 10 000 Hz to determine the following: (1) the effects on the precision of the spatially averaged reverberation time due to (i) vane speed and vane orientation, (ii) loudspeaker location, and (iii) the area and location of an absorbing panel and its absorption coefficient; (2) the selection of the parameters in (1) above such that the measurement uncertainty of the reverberation time is minimized; and (3) the overall measurement uncertainty for this optimum configuration as a function of the number of microphone locations and the number of decay curves recorded at each microphone location. For an 11-m² panel with relatively little low frequency absorption and with the vanes oriented at 22.5° from the vertical and rotating at 7.5 rpm, an analysis of variance indicated that the total uncertainty of the measured average reverberation time (one standard deviation from the mean) was less than 0.5 percent from 160 to 4000 Hz and less than 1.5 percent from 80 to 10 000 Hz when 20 decays at each of six microphone locations were used.

18080. Berger, H., **Californium-252 as a source for thermal neutron radiography**, *Proc. Int. Symp. on Californium-252 Utilization, Paris, France, Apr. 26-28, 1976*, pp. V-1—V-14 (E. I. du Pont de Nemours and Co., Aiken, SC, 1978).

Key words: Californium-252; gaging; inspection; neutron radiography; neutron source; nondestructive evaluation.

Thermal neutron radiography is compared to other methods for nondestructive evaluation; it is shown to offer advantages in many aerospace and nuclear inspection areas. One example concerns problems such as detection of nonbonds or cracks open to the surface, where liquid contrast agents can be used to help image defect areas. Descriptions and economics of neutron sources including reactors, subcritical assemblies, accelerators and radioactive sources are given. All the sources can be considered for in-plant inspection use; the higher yield sources offer initial economic advantages. Radioactive sources are well suited for field applications. The inspection effectiveness of ²⁵²Cf has been demonstrated. This source seems particularly useful where a peak thermal flux of $\geq 10^7$ n/cm²·s is needed.

18081. Butrymowicz, D. B., Manning, J. R., **Chemical interdiffusion and Kirkendall shifts in silver-cadmium alloys**, *Met. Trans.* 9A, 947-953 (July 1978).

Key words: alloys; atom flux; cadmium; chemical interdiffusion; experiments; interdiffusion coefficients; intrinsic diffusion coefficients; Kirkendall shift; Matano analysis; silver; single crystals; vacancy wind.

Chemical interdiffusion in α -phase silver-cadmium alloys was investigated in the temperature range 1072 to 1179 K with solid-solid, single-crystal couples. Interdiffusion coefficients and Kirkendall shifts were experimentally determined. Kirkendall shifts were measured directly by traveling microscope measurements and were compared to those shifts calculated from Matano analyses and those predicted by the theories of Manning and Darken. The experimentally-measured Kirkendall shifts were found in all cases to be greater than those predicted by Darken and equivalent to or slightly larger than those predicted by Manning. This difference from the results predicted by Darken is attributed to the vacancy wind effect. The experimentally-determined interdiffusion coefficients are in reasonable agreement with those predicted by theory.

18082. Early, J. G., **Hydrogen diffusion in palladium by galvanostatic charging**, *Acta. Met.* 26, 1215-1223 (1978).

Key words: ambient-temperature; diffusion; galvanostatic charging; hydrogen; mathematical model; palladium; single and multiple charging transients.

The diffusion of hydrogen in α -palladium at ambient temperature has been studied by a galvanostatic technique. Single transient and multiple transient hydrogen charging experiments were conducted on specimens over a range of charging currents and specimen thicknesses. The mathematical description of multiple transient charging is developed for the galvanostatic technique from the general solution for diffusion.

The diffusion coefficient at 23 °C for hydrogen in α -palladium was determined to be $(3.4 \pm 0.2) \times 10^{-7}$ cm²/s in excellent agreement with results from Gorsky-effect measurements. The results demonstrate that bulk hydrogen diffusion is the rate controlling process, and the hydrogen flux boundary conditions assumed in the mathematical analyses were satisfied by the galvanostatic technique.

18083. Mabie, C. P., Menis, D. L., **Microporous glassy fillers for dental composites**, *J. Biomed. Mater. Res.* 12, 435-472 (1978).

Key words: composite; dental; filler; glass; microporous; radiopacity.

A microporous filler giving greatly improved finishability, systemic nontoxic x-ray opacification, low thermal expansion ($27.2 \times 10^{-6}/^{\circ}\text{C}$), and satisfactory translucencies has been developed for dental composite resin restorations. These fillers are prepared from frits obtained by the low-temperature calcination of gelled inorganic sols followed by pulsed high-temperature treatment. Composites prepared from these fillers are within the range of commercial products with regard to strength and setting contraction.

18084. Orloski, M. J., **All's well that vents well. Pre-occupancy performance of field units with reduced-size vents**, *Proc. American Society Sanitary Engineering Annual Meeting, Philadelphia, PA, Oct. 24-27, 1976*, pp. 55-64 (1976).

Key words: performance testing; plumbing system design; reduced-size vents; trap-seal retention; venting.

Reduced-size vents were installed in six one- and two-story houses at Andrews Air Force Base, Maryland. Tests were conducted before occupancy to evaluate the performance of the system, principally by measurements of trap-seal retention, under loads believed representative of service conditions. These field test results are a follow on to those of the National Bureau of Standards laboratory work on reduced-size venting which were reported at the ASSE Convention in 1974. Both the laboratory and field test results show the viability of reduced-size venting. This is expected to contribute to the inclusion of reduced-size venting in plumbing codes.

18085. Piermarini, G. J., Forman, R. A., Block, S., **Viscosity measurements in the diamond anvil pressure cell**, *Rev. Sci. Instrum.* 49, No. 8, 1061-1066 (Aug. 1978).

Key words: diamond cell; glass transition; high pressure; hydrostaticity; liquids; viscosity.

The viscosity of liquids can be measured in the diamond-anvil pressure cell utilizing a falling-solid sphere method and the ruby technique for pressure measurement. The pressure dependence of the viscosity of a 4:1 mixture (by volume) of methanol-ethanol was determined to 70 kilobars. The accuracy of the method is estimated from measurements made on a fluid of known viscosity.

18086. Wiederhorn, S. M., Tighe, N. J., **Proof-testing of hot-pressed silicon nitride**, *J. Mater. Sci.* 13, 1781-1792 (1978).

Key words: ceramic turbines; failure prediction; fracture; oxidation; silicon nitride; strength.

Proof-testing was investigated as a method for insuring the reliability of hot-pressed silicon nitride in high temperature structural applications. The objective of the study was to determine if the strength distribution of a population of test specimens could be truncated by proof-testing. To achieve this objective the strength of silicon nitride was measured at 25 °C and 1200 °C, both with and without proof-testing. At 25 °C, however, the strength distribution was effectively truncated by proof-testing. At 1200 °C, however, the effectiveness of proof-testing as a means of truncating the strength distribution was determined by the resistance of the silicon nitride to oxidation. Although oxidation removes machining flaws that limit the strength of silicon nitride, long-term exposure to high temperature oxidizing conditions resulted in the formation of surface pits that severely degraded the strength. Provided the effects of high temperature exposure are taken into account, proof-testing is shown to be useful for truncating the strength distribution of hot-pressed silicon nitride at elevated temperatures.

18087. Zelkowitz, M. V., **Places—Programming language and construct evaluation system**, (Proc. 17th Annual Technical Symp.—Tools for Improved Computing in the 80's, Gaithersburg, MD, June 15, 1978), *Assoc. for Computing Machinery, Washington, DC*, pp. 79-85 (1978).

Key words: assertions; data abstractions; implementation; modularization; PL/1 and PLUM; testing.

The PLACES project has been organized to study new language features by using an easily modifiable PL/1 compiler called PLUM. This paper describes PLACES and explains two current investigations. One of these is the inclusion of data abstraction facilities to improve reliability and to make data in programs more modular. The second study is in verification systems. In this case by testing at execution time assertions that cannot be proven leads to a useful validation and testing tool.

18088. Chi, J., Kelly, G., Didion, D., **Use of computer model to evaluate energy saving potentials for gas-fired furnaces**, *Proc. 1978 ASME International Heat Transfer Conf., Toronto, Canada, Aug. 7-11, 1978, Paper 4*, No. 78-IHTC-77, 143-148 (Hemisphere Publ. Co., Washington, DC, 1978).

Key words: building heating system; computer simulation; DEPAF; energy conservation; furnaces; operating cost; seasonal performance.

DEPAF (DEsign and Performance Analysis of Furnaces) is an NBS computer program for simulation of fossil-fuel-fired furnaces for residential heating systems. It is based upon an analytical model which accounts for cyclic (on-and-off) operation of the burner and air circulating blower. This paper illustrates the use of DEPAF to evaluate quantitatively the effectiveness of 15 combinations of selected energy-saving features for gas-fired residential heating furnaces. Sufficient information is also provided to demonstrate the important features of the simulation program DEPAF.

18089. Daney, D. E., Ludtke, P. R., **Friction factors for flow of near-critical helium in curved tubes**, *Cryogenics* 18, No. 6, 345-348 (June 1978).

Key words: friction factor; hydraulic resistance; liquid helium; near-critical helium flow; near-critical helium pressure drop; supercritical helium pressure drop.

Friction factors have been measured for turbulent flow, $1.9(10)^4 < Re < 1.1(10)^5$, of near critical helium in a helically wound ($D/d = 194$) circular, 4-mm id tube of high aspect ratio ($L/d = 4.6(10)^4$). These measurements are in close agreement

with the classical results of Ito for curved pipes. Measured pressure drops in a heated test section with large fluid expansion ratios ($\Delta v/v$ up to 13) agreed well with calculated pressure drops. Results are also given for a 1.32 mm diameter sharp edge orifice flow meter operating in near-critical helium.

18090. Ellerbruch, D. A., Little, W. E., Boyne, H. S., Bachman, D. D., **Microwave characteristics of snow**, *Proc. Western Snow Conf., Albuquerque, NM, Apr. 18-21, 1977*, J. N. Washchek, Ed., pp. 68-74 (1977).

Key words: characterization; measurements; microwave; scattering parameters; snow.

A program is underway at NBS to measure the microwave scattering characteristics of snow. Microwave signals non-destructively penetrate snow, but they are modified by the material properties of snow (density, free moisture content, resistance, temperature). There is a distinct possibility of developing miniaturized microwave instrumentation to remotely sense and measure those undisturbed snow properties as a function of time and depth.

A portable FM-CW system was developed to measure electromagnetic profiles of snow packs down to ground level. This system was used to monitor changes in snow stratigraphy as a function of time of day.

An Automated Network Analyzer system was used to measure the electromagnetic scattering properties of snow at discrete frequencies over the range 250 MHz-18 GHz.

The snow was physically analyzed in terms of resistance, temperature, and density profiles, and by visual characterization. Some experiments included measurement of global radiation and liquid water at the snow surface.

18091. Evenson, K. M., **Redefining the meter**, *Lett. to Editor, Laser Focus* 9, No. 11, 8 (Nov. 1973).

Key words: definition of meter; laser.

This letter corrects a statement made in *Laser Focus* pertaining to the possible redefinition of the meter using lasers.

18092. Hogan, P. B., Smith, S. J., Georges, A. T., Lambropoulos, P., **ac Stark splitting in resonant multiphoton ionization with broadband lasers**, *Phys. Rev. Lett.* 41, No. 4, 229-232 (July 24, 1978).

Key words: nonlinear ionization; optical double-resonance; Rabi-splitting experiment; sodium atom laser; theoretical.

An intense laser and a probe laser in near resonance with the sodium $3S_{1/2} \rightarrow 3P_{1/2}$ and $3P_{1/2} \rightarrow 4D_{3/2}$ transitions, respectively, produce a three-photon ionization current used to study the broadening and Rabi splitting of the $3P_{1/2}$ intermediate state as a function of probe-laser tuning. We find a narrow, intense-laser detuning region where the peak-heights ratio of the Rabi-split $3P_{1/2}$ doublet is reversed from that predicted for a monochromatic laser field. This is attributed to the finite (\sim GHz) laser linewidth.

18093. Jones, M. C., Yeroshenko, V. M., Starostin, A., Yaskin, L. A., **Transient behaviour of helium-cooled current leads for superconducting power transmission**, *Cryogenics* 18, No. 6, 337-343 (June 1978).

Key words: helium-cooled current leads; power transmission; superconducting power transmission; transmission power.

Based upon time dependent differential equations, numerical calculations are presented which allow, first, the determination of burn-out conditions for a helium cooled current lead. Secondly, the response of the lead to an overload current may be examined, both during the overload and during subsequent

time when the normal current again persists. Representing the temperature dependent resistivity and thermal conductivity of the copper conductor as a function of its purity (residual resistivity ratio), the results are parameterized by dimensionless mass flow rate, current and residual resistivity ratio. Defining the burn-out temperature as 500 K and an operating current as 85 percent of the burn-out current, it is shown that although all residual resistivity ratios between five and 100 are suitable, there is a limit on the mass flow rate number which can be utilized. This results from secondary temperature surges occurring after the overload, the conditions for which are rather complicated. It is concluded in particular that, within the permissible range of mass flow rates, no damage should result from a 10X current overload for periods up to 0.2 seconds.

18094. Oman, R. C., **Cost/productivity of automatic/conventional typewriters**, *J. Syst. Manage.* 29, No. 7, Issue No. 207, 10-14 (July 1978).

Key words: automatic typewriters; cost; cost effectiveness; productivity; typewriters.

One aspect of the trend to office automation is the increased use of automatic typewriters. An important consideration in the replacement of standard electric typewriters by automatic typewriters is the large difference in cost between the two machines. Automatic typewriters are often marketed on the basis that their increased cost in comparison to conventional typewriters is offset by dramatically increased typing productivity. This article compares the productivity of a sampling of automatic and conventional typewriters. The labor cost per page and the total cost per page (labor cost + equipment cost) are compared for this sample of automatic and conventional typewriters.

18095. Oman, R., **Implementing change in organizations, based on evaluative research: A bibliography**, *Pub. Admin. Series: Bibl. P-59*, 1-24 (Vance Bibliographies, Monticello, IL, Aug. 1978).

Key words: evaluation; evaluative research; implementation; management analysis; management science; organization change; planned change; program evaluation.

The purpose of this bibliography is to bring together sources that are relevant to the practitioner of "evaluative research" interested in the question of implementing organization change. In my view, "evaluative research" includes any one of a number of functions, activities, and, in the Federal government, job series, which evaluate and propose changes to existing programs, organizations, and operations. These evaluative activities usually combine the role of change agent with that of an evaluator who judges an on-going situation against some standard, guideline, or principle and proposes change (or works toward change) in the desired direction. A commonly thought of form of evaluative research implies the application of scientific principles to improve the efficiency or effectiveness of an organization. Some examples of fields that apply scientific principles to organization problems are management science, industrial engineering, and operations research. For the purposes of this bibliography, however, I have included fields which do not necessarily have a scientific base (in the sense of logical positivist science), but which bring a perspective to bear on a particular situation with the hope of impacting decision makers and moving the organization in the desired direction. The perspective is legitimized by expertise in areas such as management, organization theory, organization development or other social and behavioral fields which are arts as well as sciences.

18096. Cottony, H. V., **A note on resolution of radar targets in clutter**, *Air Force Report AFCRL-TR-73-0306*, 58 pages (Available from the National Technical Information Service, Springfield, VA 22161, Sept. 14, 1973).

Key words: frequency spectrum; power spectrum; radar; radar clutter; radio holography; radar resolution; spectral analysis.

A radar target is assumed to consist of M scatterers at different ranges from radar. Backscatter cross section areas of all scatterers are assumed to be frequency independent. It is shown that the backscatter cross section area of the composite target, as a function of frequency, is equal to the sum of the cross section areas of the individual scatterers plus a series of cosine terms.

Given the backscatter cross section area of a composite target as a function of frequency, an inverse-scatter procedure is developed for evaluating the coefficients and the arguments of various terms. From these, the number of scatterers, their cross section areas, and relative positions are determined.

The spectral return of an assumed radar target with arbitrary range separations is computed. With this spectral data as input to the inverse-scatter program the number of scatterers, their magnitudes and relative positions are evaluated and compared with true values.

A modified technique involving a comparison with an injected pulse is described. The analogy with holography is discussed.

Experimental measurements on scaled backscatter models are described. Model targets consisting of two to eight scatterers were constructed. These were illuminated by a 10-ns pulse at 1100 MHz carrier frequency. Photographs of returns, both in frequency and time domains are displayed.

18097. Cottony, H. V., **A note on measurement of multi-component fields**, *Air Force Report AFCRL-TR-73-0306*, 35 pages (Available from the National Technical Information Service, Springfield, VA 22161, Sept. 15, 1973).

Key words: electromagnetic fields; field measurement; multi-component fields; multi-path propagation; radio holography; standing wave patterns.

The paper considers a propagation model where a signal is propagated via M paths with each component arriving on a horizontal plane from different directions. The M components have random phases, but are coherent with each other. An expression, in the form of a polynomial of complex terms, is derived for the total field strength over the site. By multiplying this polynomial by another with identical but conjugate terms, a polynomial of real terms is obtained; it represents the field intensity distribution and consists of a constant term plus a series of sinusoidal periodicities.

A procedure is derived for carrying out an inverse analysis. Given a field intensity distribution, set up by M multi-path components, it is possible to search for the periodicities hidden in that distribution and to identify the number of components and their individual strengths. The procedure will also identify the directions of arrival of components relative to each other. While the absolute directions of arrival are, in general, not determinable, there are bounds on admissible directions. If the direction angles of one component are known, the direction angles of other components are determinable.

The procedure is illustrated by a numerical example.

18098. Didion, D., Maxwell, B., Ward, D., **A laboratory investigation of a Stirling engine-driven heat pump**, (Proc. Int. Conf. Centre Heat & Mass Transfer, Dubrovnik, Yugoslavia, Aug. 29-Sept. 2, 1977), Paper in *Energy Conservation in Heating, Cooling, and Ventilating Buildings, New Techniques in Heating and Cooling of Buildings*, 2, 583-596 (Hemisphere Publ. Corp., Washington, DC, 1978).

Key words: air-to-air heat pump; energy conservation heating; engine-driven heat pump; heat engine; heat pump; re-

sidential heating; Stirling engine; Stirling engine heat pump.

An experimental investigation was conducted on an air-to-air heat pump powered by a single-cylinder, seven-horsepower, water-cooled Stirling engine. The steady-state part-load performance of the engine-driven heat pump system was determined in both the heating and cooling modes of operation. The unit was operated over a broad range of outdoor temperatures and corresponding coefficients of performance (COP), and seasonal performance factors (SPF) were determined. The energy rejected to the engine's cooling water was measured and included in the heating mode calculations.

18099. LaVilla, R. E., **Tellurium valence-band x-ray spectrum $L\gamma_4$ ($L_1O_{2,3}$)**, *Phys. Rev. B* **18**, No. 2, 644-647 (July 15, 1978),

Key words: direct electron bombardment; $L\gamma_4$ valence-band spectrum; tellurium metal; x-ray emission spectrum.

The profile of the Te $L\gamma_4$ ($L_1O_{2,3}$) x-ray emission spectrum has been measured using direct electron bombardment. Comparisons of this valence-band x-ray spectrum with recent band calculations and photoemission spectrum are in general agreement. Certain differences are nevertheless noted between the observed profile and that expected on the basis of symmetry-weighted density of states. This departure is attributed to the quasiautomatic character of the x-ray emission process and illustrates one limitation of the general practice of obtaining density of states from x-ray emission spectra. An emission line was observed also at 4898.9 ± 0.4 eV, which has tentatively been identified as the quadrupole transition $Te(L_1N_{4,5})$.

18100. Pella, P. A., **Effect of gas burner conditions on lithium tetraborate fusion preparations for x-ray fluorescence analysis**, *Anal. Chem.* **50**, No. 9, 1380-1381 (Aug. 1978).

Key words: fusion; gas-burner; lithium tetraborate; spectrometry; x-ray fluorescence.

The effect of gas burner conditions on lithium tetraborate fusion preparations for x-ray fluorescence analysis was studied by varying the propane/air gas mixture fed into the burner. It was observed that in fusing ternary mixtures of $CaCO_3$, Fe_2O_3 , and flux under two different gas burner conditions, the relative differences found in the determination of iron were as large as 20 percent.

18101. Petersen, F. R., McDonald, D. G., Cupp, J. D., Danielson, B. L., **Accurate rotational constants, frequencies, and wavelengths from $^{12}C^{16}O_2$ lasers stabilized by saturated absorption**, *Proc. Laser Spectroscopy Conf., Vail, CO, June 25-29, 1973*, pp. 555-569 (Plenum Press, New York, NY, 1975).

Key words: frequency metrology; Josephson junctions; lasers; molecular spectroscopy.

New experimental measurements of the frequency separations of 30 pairs of $^{12}C^{16}O_2$ laser lines in the $10.4 \mu m$ band and 26 pairs in the $9.4 \mu m$ band have been made with lasers stabilized to Lamb-dip-type resonances observed in the $4.3 \mu m$ fluorescent radiation. The use of a Josephson junction as the frequency mixing element simplified the measurements. Uncertainties in existing rotational constants for the laser vibrational levels were reduced 20 to 30 times and an additional rotational constant, H_n , was determined for the first time. Frequency and wavelength tables with estimated uncertainties are calculated for both bands with the new constants.

18102. Stiehler, R. D., Hockman, A., Embree, E. J., Masters, L. W., **Existing standards inadequate for solar collector use**, *Solar Eng.* **3**, No. 8, 35-37 (Aug. 1978).

Key words: durability; rubber seals; solar energy systems; standards; test methods.

A study was performed to develop standards for rubber seals used in solar energy systems. Thirty-one preformed and liquid applied seals were evaluated in the laboratory using modified ASTM standard test methods to obtain data needed to evaluate those materials and prepare new standards. Also, studies were performed to develop a test method for determining the effects of outgassing on the transmittance of solar collector covers.

This paper is a summary of the findings of NBSIR Solar Energy Systems—Standards for Rubber Seals, in which standards for rubber seals in solar energy systems are proposed.

18103. Cottony, H. V., **A note on radiation patterns of array antennas**, *Air Force Report AFCRL-TR-73-0579*, 21 pages (Available from the National Technical Information Service, Springfield, VA 22161, Sept. 13, 1973).

Key words: antennas; arrays; power gain; radiation pattern.

The radiation patterns of array antennas are usually expressed as an electric field in the form of a polynomial of complex terms with phases presented in exponential form. This form has certain drawbacks from the analytical standpoint and, in practice, results in limiting the analytical study of arrays to symmetric forms.

In this note it is demonstrated that the radiation pattern of an array antenna, whether linear or planar, can be expressed in terms of power as a polynomial of real terms. This form of presentation is shown to have certain advantages; an asymmetry in the array, whether in the positions of the elements or in the current distribution or both, has no effect on the form of the polynomial; each term of the polynomial has a readily recognizable physical significance.

Some of the characteristics of this form of radiation pattern representation suggest that it may be more suitable for beam shaping and illumination synthesis.

18104. Durst, R. A., **Free cyanide analyzer**, *Proc. Conf. on Ion-Selective Electrodes, Budapest, Hungary, Sept. 5-9, 1977*, pp. 359-362 (Elsevier Scientific Publ. Co., New York, NY, 1978).

Key words: cyanide analyzer; cyanide gas diffusion; ion-selective electrode; silver cyanide indicator; silver electrode.

A continuous measurement system for free cyanide has been developed based on the principle of diffusion across a gas-permeable membrane to affect the separation of hydrogen cyanide from the acidified sample solution. The cyanide is subsequently analyzed using a silver ion-selective electrode indicator technique. The detection limit of this system is approximately $0.5 \mu g CN^-/L$. In the concentration range of 30 to $400 \mu g CN^-/L$, the accuracy and precision of this method is approximately two percent.

18105. Ehrich, H., Kelleher, D. E., **Hydrogen fine-structure effects at low electron densities**, *Phys. Rev. A* **17**, No. 5, 1686-1689 (May 1978).

Key words: broadening; fine-structure; hydrogen; plasma; spin; stark.

Measurements of the plasma-broadened H_n line shape in a wall-stabilized arc show considerable differences between experimental and theoretical line profiles at electron densities below $10^{16} cm^{-3}$. The half-width of the experimental profile is up to three times larger than predicted theoretically. At low electron densities ($\leq 10^{15} cm^{-3}$), part of such discrepancies can be attributed to the neglect of fine-structure splitting in current Stark-broadening calculations, especially for $H_{n\sigma}$, $L_{n\sigma}$, and hydrogenic-ion lines.

18106. Hicho, G. E., Gilmore, C. M., **Comparison of the threshold stress intensities and fracture characteristics for temper embrittled and deembrittled 2 1/4 Cr-1Mo steel in a hydrogen charging environment**, *Am. Soc. Test. Mater. Spec. Tech. Publ.* 645, 351-362 (1978).

Key words: fractography; fracture properties; hydrogen embrittlement; steels; temper embrittlement.

Fracture toughness tests and fractographic examinations were conducted on temper embrittled and deembrittled 2 1/4 Cr-1Mo steel using double cantilever-beam specimens. The tests were conducted in an aqueous/acetic acid solution containing hydrogen sulfide (H₂S). The threshold stress intensity of the temper embrittled specimen tested in the H₂S environment was lower than that of the deembrittled specimens tested in a similar environment. For the purpose of comparing fracture appearances, temper embrittled and deembrittled specimens were fractured in air.

The fracture appearances of the temper embrittled and the deembrittled specimens tested in the H₂S environment and the temper embrittled specimen fractured in air were predominantly intergranular. The fracture appearance of the deembrittled specimen fractured in air exhibited a transgranular ductile mode of failure. These results indicate that the embrittling effects due to temper embrittlement and to the H₂S environment act cooperatively in reducing the threshold stress intensity of 2 1/4 Cr-1Mo steel.

18107. Holton, J. K., **Updating solar performance criteria and standards**, *Proc. 1978 Ann. Meeting American Society Int. Solar Energy Society, Inc., Denver, CO, Aug. 28-31, 1978*, pp. 514-521 (Amer. Section ISES, McDowell Hall, U. of Delaware, Newark, DE, Sept. 1978).

Key words: solar performance criteria; updating.

The two solar performance criteria, "HUD Intermediate Minimum Property Standards (S/MPS)" and the "Interim Performance Criteria (IPC)" both residential and commercial, were developed by the National Bureau of Standards (NBS) early in the federal solar demonstration program to be of assistance in promoting the manufacture and wide-spread use of solar energy systems. Considerable experience has been gained from the demonstration program and other sources that has revealed the actual problems that can occur in the manufacture, installation and use of solar energy systems and components. In order to keep the S/MPS and IPC reasonable and useful standards, they are continually being updated based on current experience. Findings are presented from the residential and commercial demonstration program and from a public commentary process that have led to the updating of numerous sections of the criteria and standards. A comparison is presented of the original criteria, the practical problems and the revised criteria. Topics covered include: system performance covering thermal losses, operating energy, system back-up, thermo-syphoning, flow balancing, controls, safety, maintenance and check-out procedures; and component performance covering freeze protection, stratification, stagnation, materials deterioration, and heat transfer fluid quality.

18108. Howell, B. F., Schaffer, R., Sasse, E. A., **Enzyme immunoassay adapted for use with a digital kinetic analyzer**, *Clin. Chem.* 24, No. 7, 1284 (1978).

Key words: antiepileptic drug assays; diphenyl hydantoin assay; enzyme-multiplied immunoassay technique carbamazepine assay; phenobarbital assay; primidone assay.

The use of a digital kinetic analyzer is described for performing enzyme-linked immunoassays of antiepileptic drugs (carbamazepine diphenylhydantoin, ethosuximide, phenobar-

bital, and primidone) in serum. The values obtained are in good agreement with the known concentrations of the drugs in prototype standards and in samples used for the Pippenger drug surveys.

18109. Pella, P. A., Lorber, K. E., Heinrich, K. F. J., **Energy-dispersive x-ray spectrometric analysis of environmental samples after borate fusion**, *Anal. Chem.* 50, No. 9, 1268-1271 (Aug. 1978).

Key words: borate fusion; energy-dispersive x-ray spectrometry; environmental samples; fly ash; urban particulate.

In order to overcome particle-size and sample inhomogeneity effects in the analysis of environmental samples by energy-dispersive x-ray spectrometry, an automated borate fusion procedure was investigated and applied to the analysis of NBS-SRM 1633 Fly Ash and NBS-SRM 1648 Particulate Matter. Twelve elements in each sample were determined and the results are in agreement with NBS certified values and/or those of other workers, usually within ± 5 to 10 percent for most elements over the concentration range from 70 ppm to 15 percent. Fly Ash samples were fused with the heavy absorbers La₂O₃ or WO₃ and analyzed using a linear calibration curve, assuming no matrix effects. The particulate samples, however, were fused with lithium tetraborate only and the data were corrected for x-ray absorption and K x-ray line interferences by a NBS mathematical procedure. The limits of detection of this procedure for most of the elements analyzed in the sample were between 10 to 100 ppm.

18110. Tsang, W., **Evidence for strongly temperature-dependent A factors in alkane decomposition and high heats of formation for alkyl radicals**, *Int. J. Chem. Kinet.* X, 821-837 (1978).

Key words: alkane; bond cleavage; butane; decomposition; ethyl; heats of formation; hexamethylethane; isopropyl; pre-exponential factor; radical buffer; radical combination; rate expressions; shock tube; tert-butyl; very-low-pressure pyrolysis; 2,3-dimethyl-butane.

The experimental data on alkane decomposition from shock-tube and radical buffer studies and radical combination from very-low-pressure pyrolysis and modulation spectroscopy are shown to be consistent. They lead to experimental A factors which decrease by factors of 10-2000 from 300° to 1100 °K. Heats of formation for ethyl, isopropyl, and *t*-butyl radicals have been found to be 10, 10 and 20 kJ higher than currently accepted numbers from metathesis reactions.

18111. Tsang, W., **Thermal decomposition of cyclopentane and related compounds**, *Int. J. Chem. Kinet.* X, 599-617 (1978).

Key words: biradical; concerted; cyclopentane; cyclopropane; decomposition; decyclization; heat of formation; isomerization; shock tube; trimethylene; 1-pentene.

Cyclopentane has been decomposed in comparative-rate single-pulse shock-tube experiments. The pyrolytic mechanism involves isomerization to 1-pentene and also a minor pathway leading to cyclopropane and ethylene. This is followed by the decomposition of 1-pentene and cyclopropane. The rate expressions over the temperature range of 1000°-1200°K are

$$k(c\text{-C}_5\text{H}_{10} \rightarrow 1\text{-C}_5\text{H}_{10}) = 10^{16.1} \exp(-42,700/T) \text{ sec}^{-1}$$

$$k(c\text{-C}_5\text{H}_{10} \rightarrow c\text{-C}_3\text{H}_6 + \text{C}_2\text{H}_4) = 10^{16.25} \exp(-47,840/T) \text{ sec}^{-1}$$

$$k(1\text{-pentene} \rightarrow \text{C}_3\text{H}_6 + \text{C}_2\text{H}_4) \sim 10^{16} \exp(-35,900/T) \text{ sec}^{-1}$$

$$k(1\text{-pentene} \rightarrow \text{C}_3\text{H}_6 + \text{C}_2\text{H}_4) \sim 10^{12.5} \exp(-28,900/T) \text{ sec}^{-1}$$

$$k(c\text{-C}_3\text{H}_8 \rightarrow \text{C}_3\text{H}_8) = 10^{14.3} \exp(-31,100/T) \text{ sec}^{-1} \text{ at 5 atm}$$

$$k(c\text{-C}_3\text{H}_8 \rightarrow \text{C}_3\text{H}_8) = 10^{14.1} \exp(-31,000/T) \text{ sec}^{-1} \text{ at 1.7 atm}$$

Details of the cyclopentane decomposition processes are considered, and it appears that if the trimethylene radical is an intermediate, then $\Delta H_f(\text{trimethylene}) \leq 280 \text{ kJ/mol}$ at 300°K .

18112. Tsang, W., **Thermal stability of intermediate sized acetylenic compounds and the heats of formation of propargyl radicals**, *Int. J. Chem. Kinet.* **X**, 687-711 (1978).

Key words: acetylenic; decomposition; heat of formation; hexyne-1; methyl propargyl; propargyl; resonance energy; shock tube; thermal properties; 4-methylheptyne; 4-methylhexyne-1; 5-methylhexyne-1.

4-Methylhexyne-1, 5-methylhexyne-1, hexyne-1, and 6-methylheptyne-2 have been decomposed in comparative-rate single-pulse shock-tube experiments. Rate expressions for the initial decomposition reactions at 1100°K and from 2 to 6 atm pressure are

$$k(\text{HC} \equiv \text{CCH}_2\text{-}i\text{C}_4\text{H}_9 \rightarrow \text{HC} \equiv \text{CCH}_2 \cdot + i\text{C}_4\text{H}_9 \cdot) = 10^{15.9} \exp(-35,000/T) \text{ sec}^{-1}$$

$$k(\text{HC} \equiv \text{CCH}_2\text{-}i\text{C}_4\text{H}_9 \rightarrow \text{allene} + n\text{C}_4\text{H}_8) = 10^{12.9} \exp(-28,000/T) \text{ sec}^{-1}$$

$$k(\text{HC} \equiv \text{CCH}_2\text{-}i\text{C}_4\text{H}_9 \rightarrow \text{HC} \equiv \text{CCH}_2 \cdot + i\text{C}_4\text{H}_9 \cdot) = 10^{16.1} \exp(-36,700/T) \text{ sec}^{-1}$$

$$k(\text{HC} \equiv \text{CCH}_2\text{-}i\text{C}_4\text{H}_9 \rightarrow \text{allene} + i\text{C}_4\text{H}_8) = 10^{2.3} \exp(-27,500/T) \text{ sec}^{-1}$$

$$k(\text{HC} \equiv \text{CCH}_2\text{-}n\text{C}_3\text{H}_7 \rightarrow \text{HC} \equiv \text{CCH}_2 \cdot + n\text{C}_3\text{H}_7 \cdot) = 10^{15.9} \exp(-36,300/T) \text{ sec}^{-1}$$

$$k(\text{HC} \equiv \text{CCH}_2\text{-}n\text{C}_3\text{H}_7 \rightarrow \text{allene} + \text{C}_3\text{H}_6) = 10^{12.7} \exp(-28,400/T) \text{ sec}^{-1}$$

$$k\text{CH}_3\text{C} \equiv \text{CCH}_2\text{-}i\text{C}_4\text{H}_9 \rightarrow \text{CH}_3\text{C} \equiv \text{CCH}_2 \cdot + i\text{C}_4\text{H}_9 \cdot) = 10^{16.2} \exp(-36,800/T) \text{ sec}^{-1}$$

$$k(\text{CH}_3\text{C} \equiv \text{CCH}_2\text{-}i\text{C}_4\text{H}_9 \rightarrow 1,2\text{-butadiene} + i\text{C}_4\text{H}_8) = 10^{12.3} \exp(-28,700/T) \text{ sec}^{-1}$$

In combination with previous results, rate expressions for propargyl C—C bond cleavage are related to that for the alkanes by the expression

$$k_B(\text{alkyne}) = 1/(3 \pm 1.5) \exp(+4.25/T) k_B(\text{alkane})$$

These results yield a propargyl resonance energy of $D(n\text{C}_3\text{H}_7\text{-H}) - D(\text{C}_3\text{H}_3\text{-H}) = 36 \pm 2 \text{ kJ}$, in excellent agreement with a previous shock-tube study. They also lead to $D(\text{CH}_3\text{C} \equiv \text{CCH}_2\text{-H}) - D(\text{C}_3\text{H}_3\text{-H}) = 0.6 \pm 3 \text{ kJ}$, $D(i\text{C}_4\text{H}_9\text{-H}) - D(i\text{C}_3\text{H}_7\text{-H}) = 0 \pm 3 \text{ kJ}$, $D(i\text{C}_4\text{H}_9\text{-H}) - D(n\text{C}_3\text{H}_7\text{-H}) = 2 \pm 3 \text{ kJ}$, and $D(n\text{C}_3\text{H}_7\text{-H}) - D(i\text{C}_3\text{H}_7\text{-H}) = 13.9 \pm 3 \text{ kJ}$ (all values are for 300°K). The systematics of the molecular decomposition process are explored.

18113. Tsang, W., **Thermal stability of primary amines**, *Int. J. Chem. Kinet.* **X**, 41-66 (1978).

Key words: alkyl amines; alkyl-amino radicals; amino radical; bond energies; fall-off behavior; heats of formation; hydrazine; recombination; single pulse shock tube; t-amyl amine; unimolecular decompositions.

Tertiary-amyl amine has been decomposed in single-pulse shock-tube experiments. Rate expressions for several of the important primary steps are

$$k(t\text{C}_5\text{H}_{11\text{-NH}_2} \rightarrow t\text{C}_5\text{H}_{11} \cdot + \text{NH}_2 \cdot) = 10^{15.9} \exp(-39,700/T) \text{ sec}^{-1}$$

$$k(\text{C}_2\text{H}_5\text{-C}(\text{CH}_3)_2\text{NH}_2 \rightarrow \text{C}_2\text{H}_5 \cdot + \cdot\text{C}(\text{CH}_3)_2\text{NH}_2) = 10^{16.5} \exp(-38,500/T) \text{ sec}^{-1}$$

$$k(t\text{C}_5\text{H}_{11}\text{NH}_2 \rightarrow \text{C}_5\text{H}_{10} + \text{NH}_3) < 10^{14.5} \exp(-37,200/T) \text{ sec}^{-1}$$

This leads to $D(\text{CH}_3\text{-H}) - D(\text{NH}_2\text{-H}) = -10.5 \text{ kJ}$ and $D[(\text{CH}_3)_2\text{C-H}] - D[(\text{CH}_3)_2\text{NH}_2\text{-H}] = +6 \text{ kJ}$.

The present and earlier comparative rate single-pulse shock-tube data when combined with high-pressure hydrazine decomposition results (after correcting for fall off effects through RRKM calculations) gives

$$[k_r(t\text{C}_5\text{H}_{11} \cdot, \text{NH}_2 \cdot) / k_r(t\text{C}_5\text{H}_{11} \cdot, t\text{C}_5\text{H}_{11} \cdot) \cdot k_r(\text{NH}_2 \cdot, \text{NH}_2 \cdot)]^{1/2} \sim 2 \text{ at } 1100^\circ\text{K}$$

where $k_r(\dots)$ is the recombination rate involving the appropriate radicals. This suggests that in this context amino radical behavior is analogous to that of alkyl radicals. If this agreement is exact, then

$$k_\infty(\text{N}_2\text{H}_4 \rightarrow 2\text{NH}_2 \cdot) = 10^{16.25} \exp(-32,300/T) \text{ sec}^{-1}$$

Rate expressions for the primary step in the decomposition of a variety of primary amines have been computed. In the case of benzyl amine where data exist the agreement is satisfactory. The following differences in bond energies have been estimated:

$$D(i\text{C}_3\text{H}_7\text{-H}) - D[\text{CH}_3(\text{NH}_2)\text{CH-H}] = 14.3 \text{ kJ}$$

$$D(\text{C}_2\text{H}_5\text{-H}) - D(\text{NH}_2\text{CH}_2\text{-H}) = 15.9 \text{ kJ}$$

18114. Cookson, J. A., Fowler, J. L., Hussain, M., Schwartz, R. B., Uttley, C. A., **The angular distribution of neutron scattering from hydrogen at 27.3 MeV**, *Nucl. Phys.* **A299**, 365-380 (May 1978).

Key words: measured $\sigma(\theta)$ from 34.2° to 116.3° c.m.; nuclear reactions $\text{H}(n,n)p$, $E = 27 \text{ MeV}$.

The angular distribution for np scattering at 27.3 MeV has been measured at 7 angles between 17° and 57.9° in the lab system. The neutrons scattered by a small plastic scintillator were detected in another plastic scintillator whose absolute efficiency had been measured between 5 and 25 MeV by use of the associated particle method. It was found to be necessary to investigate the effect on the angular distribution of the $^{12}\text{C}(n,n'\gamma)$ reaction occurring in the target scintillator. The data overlap, and are combined with, existing angular distribution data at the same energy obtained by detecting recoil protons. The asymmetry about $1/2\pi$ of the resulting angular distribution is in better agreement with predictions from phase-shift analyses than with those from meson-theoretical models.

18115. Campbell, P. G., Post, M. A., **Nontoxic yellow traffic striping**, *Federal Highway Administration Report FHWA-RD-78-1*, 74 pages (Available from the National Technical Information Service, Springfield, VA 22161, Jan. 1978).

Key words: alkyd traffic paint; chlorinated rubber traffic paint; hot thermoplastic coatings; lead chromate; organic yellow pigments; yellow traffic paint.

A study was carried out to examine the performance characteristics of alternative pigments which might be used in yellow traffic paints if the use of lead chromate were curtailed. Thirty-six yellow traffic paints were prepared using lead chromate and alternative pigments as the yellow color source. Screening tests were used to evaluate the initial color stability and durability characteristics of the paint formulations. The thermal stabilities of selected yellow pigments for use in thermoplastic marking applications were evaluated. Also, outdoor exposures and a small scale field test were used to evaluate the performance of formulations containing lead chromate and alternative pigments. The performance of the alternative organic yellow pigments, as measured by color change under the various exposure conditions, was found to be at least as good as that of lead chromate.

18116. Koidan, W., Hruska, G. R., **Acoustical properties of the National Bureau of Standards anechoic chamber**, *J. Acoust. Soc. Am.* **64**, No. 2, 508-516 (Aug. 1978).

Key words: acoustical environments; acoustical wedges; anechoic chambers; anechoic chamber testing.

The acoustical properties of the large anechoic chamber at the National Bureau of Standards were investigated by two methods over the frequency range 40-63 000 Hz. In the first method described, deviations of mean-square sound pressure from an assumed inverse square law were measured as a sound source and microphone were moved apart. Over most of the frequency range, the deviations were found from a least-squares curve-fitting procedure by means of digital-computer processing of the data. The effective acoustic centers of the sources were obtained as a by-product of the procedure. In the second method, the source and microphone were kept at a fixed separation as they were moved together across the chamber, and deviations from the mean value of the sound pressure level were estimated from recordings. The significances of the two methods are discussed with a view towards their application.

18117. Maxwell, L. R., Sr., Bennett, L. H., **Behavior of different nuclear probes for detection of cancer by nuclear magnetic resonance**, *Physiol. Chem. & Phys.* **10**, 59-62 (1978).

Key words: cancer; nuclear; phosphorus-31; protons; spin-lattice relaxation.

A physical explanation is given for the finding that the spin-lattice relaxation time T_1 , obtained by nuclear magnetic resonance from equivalent malignant and nonmalignant samples, is greater for the phosphorus isotope ^{31}P than for the proton ^1H . The nuclear relaxation of the phosphorus proceeds by way of its interaction with associated cell water. Within limits determined by other variables, T_1 is expected to vary inversely as the square of the gyromagnetic ratio.

18118. Evans, J. M., Jr., **CAM standards directions**, *Proc. CAD/CAM VI Conf., Los Angeles, CA, Sept. 19-21, 1978*, 10 pages (Society of Manufacturing Engineers, Dearborn, MI, 1978).

Key words: computer aided manufacturing; computers; interface standards; manufacturing systems; numerical control; productivity.

The integration of computers into job shop manufacturing is having a profound impact on industrial productivity. However, a serious impediment to the increased use of CAM is the inability to interconnect modules procured from different vendors without undue engineering and/or software expense. The use of formal, well defined standards to describe the many interfaces in a CAM system holds the key to solution. Standards for programming languages and for digital data communications are examined in detail and are shown to be adequate for present and near future needs.

18119. Evans, J. M., Jr., **The role of standards in integrated manufacturing systems**, *Proc. Numerical Control Society Meeting, Washington, DC, May 19-21, 1975*, 11 pages (Numerical Control Society, Spring Lake, NJ, May 1975).

Key words: automation; computer aided manufacturing systems; computer integrated manufacturing systems; interfaces; motivation for standardization; standards.

Computer controlled integrated manufacturing systems offer increases in labor productivity of up to an order of magnitude or more and cost reductions of factors of 2 or 3 or more. Large user industries are building such systems; however, the cost of special engineering and computer programming and the risk involved preclude medium and small firms from gaining these benefits. The role of standards in constructing integrated systems with components from competitive manufacturers is discussed and the NBS program aimed at the development of those standards is reviewed.

18120. Evans, J. M., Jr., Smith, B. M., **Strategies for modular CAD/CAM systems**, *Proc. 15th Numerical Control Society Annual Meeting & Technical Conf., Chicago, IL, Apr. 9-12, 1978*, pp. 29-38 (Numerical Control Society, Spring Lake, NJ, Apr. 1978).

Key words: automation; computer aided design; computer aided manufacturing; communications; interface standards; standards.

This paper describes work done at the National Bureau of Standards (NBS) defining the many interfaces present in a totally integrated CAD/CAM system. It describes those interfaces and identifies the standards which apply to the use of computer based control systems for automation equipment. It is intended to serve both as a technical guide and as a summary of existing and forthcoming standards applicable to computer control systems. Selected defacto standards are also included for completeness.

18121. Haber, S., Shisha, O., **On the nonomnipotence of regular summability methods**, *Adv. Math.* **28**, No. 3, 231-232 (June 1978).

Key words: convergence; counterexamples; divergent series; limits; summability; transforms.

It is shown that for any regular summability method there exists a bounded divergent sequence whose transform by that summability method diverges just as badly as the original sequence; often the divergence of the transform is worse than that of the original sequence.

18122. Jacox, M. E., **Matrix isolation study of the reaction of carbon atoms with molecular nitrogen. Electronic transitions of the CNN free radical in the 2600- to 1900-Å spectral region**, *J. Mol. Spectrosc.* **72**, 26-35 (1978).

Key words: carbon atom reactions; CNN; combustion; matrix isolation; molecular orbitals; ultraviolet absorption spectrum.

Previous matrix isolation studies have demonstrated that ground-state carbon atoms react with molecular nitrogen to form CNN, for which the esr spectrum, the three ground-state vibrational fundamentals, and a prominent electronic transition near 4200 Å have been reported. Extension of the ultraviolet absorption studies to shorter wavelengths has permitted the assignment to CNN of two new band systems, between 2500 and 2150 Å and near 2060 Å. These band systems, observed using several different photolytic sources of carbon atoms, correspond well with the valence transitions of CNN predicted by molecular orbital theory. Assignments of the band structures,

involving excitation of the upper-state stretching vibrations of CNN, are proposed.

18123. Roitman, P., **Electron beam induced currents in metal oxide silicon devices, (Abstract only), Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978, pp. 36A-36C (June 1978).**

Key words: electron beam induced currents; metal-oxide-silicon capacitor; oxidation-induced stacking faults; scanning electron microscope.

18124. Rothwell, H. L., Leep, D., Gallagher, A., **High-power discharge in Na-Xe vapor, J. Appl. Phys. 49, No. 8, 4396-4400 (Aug. 1978).**

Key words: discharge; sodium; xenon.

High-power (10-100 MW/liter) pulsed discharges in Na-doped Xe vapor have been studied at Na densities of 10^{13} – 10^{16} cm^{-3} and Xe densities of 10^{18} – 10^{20} cm^{-3} , as appropriate for excimer-laser use. Stable steady-state discharges are obtained for a number of microseconds in a small-volume cell, without use of preionization or sustainers. This stability is attributed to the observed positive V - I characteristic. Measured spectra are interpreted to yield Na excited-state densities, and the implications for a potential excimer laser are discussed.

18125. Hofmann, H., Leone, S. R., **Quenching and reactions of laser-excited $I(5^2P_{1/2})$ atoms with halogen and interhalogen molecules, J. Chem. Phys. 69, No. 2, 641-646 (July 15, 1978).**

Key words: deactivation; energy transfer; quenching; reactive quenching; spin-orbit excited $I(5^2P_{1/2})$.

Rate constants for the collisional deactivation of spin-orbit excited $I(5^2P_{1/2})$ atoms with the halogens I_2 , Br_2 , Cl_2 , and interhalogens IBr , ICl , and $BrCl$ have been determined using laser-excited, time-resolved infrared fluorescence techniques. The measured rate constants are ($\text{cm}^3 \text{ molecule}^{-1} \cdot \text{sec}^{-1}$) $3.1 \pm 0.5 \times 10^{-11}$, $5.2 \pm 0.3 \times 10^{-11}$, $1.7 \pm 0.2 \times 10^{-12}$, $6.6 \pm 0.3 \times 10^{-11}$, $2.3 \pm 0.2 \times 10^{-11}$, and $2.7 \pm 0.2 \times 10^{-11}$, respectively. These results are discussed in terms of a collision complex formation model in which reactive-type collisions may predominate in the deactivation process under investigation. An excited Br^* product is observed in the reactive collision systems $I^* + Br_2 \rightarrow IBr + Br^*$ and $I^* + IBr \rightarrow I_2 + Br^*$. With an appropriate analysis of the kinetics involved, the fractions of the total deactivation rate constants attributed to these reactive channels are $15\% \pm 5\%$ and $13\% \pm 5\%$, respectively.

18126. Knauss, D. C., **A theory for the isotropic Raman line shape in the condensed state, Mol. Phys. 36, No. 2, 413-427 (1978).**

Key words: collective modes; condensed state; correlation functions; harmonic oscillator; nitrogen-argon mixture; projection operator; Raman line shape; Van Hove limit.

A theory for the isotropic Raman line shape (width and shift in particular) of diatomic molecules in the condensed state (liquid or solid) within the linear response formalism is presented. The prototypic system considered is that of a nitrogen argon mixture in any proportion. The two much discussed mechanisms which effect the lineshape (the vibrational modulation and the resonance transfer effects) appear naturally. The explicit concentration dependence of the width and shift is found while only the qualitative temperature dependence is determined. In particular, it is shown that the different temperature dependences of the line width in the liquid and solid states are simply related to the different types of collective modes which exist in the two states. It is also shown that

the contributions to the width and shift of the above two mechanisms depend differently upon concentration and so can be separated experimentally.

18127. Clark, A. F., **Effects of stress on practical superconductors, Proc. Int. Conf. 6th Magnet Technology (MT-6), Bratislava, Czechoslovakia, Aug. 29-Sept. 2, 1977, 2, 612-618 (ALFA, Bratislava, Czechoslovakia, 1978).**

Key words: critical current; degradation; stress effects; superconductors.

The effects of stresses and the resultant strains on practical superconductors are reviewed with respect to magnet design. The mechanical and electrical behavior of superconductors subject to both static and dynamic stresses is discussed. Emphasis will be on the mechanical properties of superconducting wires, the degradation of critical current in wires under stress, and their correlation with superconducting coil composite behavior.

18128. Clark, A. F., Arp, V. D., Ekin, J. W., **Properties of a superconducting coil composite and its components, Proc. Int. Conf. 6th Magnet Technology (MT-6), Bratislava, Czechoslovakia, Aug. 29-Sept. 2, 1977, 2, 673-679 (ALFA, Bratislava, Czechoslovakia, 1978).**

Key words: coil composite; mechanical properties; physical properties; stress analysis; superconducting magnet.

The physical and mechanical properties of a superconducting coil composite and its components are systematically studied in order to accurately predict the coil behavior from the constituent material behavior. Multidirectional measurements of the Young's modulus, Poisson's ratio, shear modulus, thermal conductivity, thermal expansion, specific heat and the critical current behavior under stress were made on a Cu:NbTi and fiberglass-epoxy composite superconducting coil. Similar measurements were performed on the superconducting wire, fiberglass and epoxy in order to establish the role of each component. A stress analysis for manufacture, cool down, and operation of the coil can be used to predict behavior under operating conditions from component properties.

18129. Gallorini, M., Greenberg, R. R., Gills, T. E., **Simultaneous determination of arsenic, antimony, cadmium, chromium, copper, and selenium in environmental material by radiochemical neutron activation analysis, Anal. Chem. 50, No. 11, 1479-1481 (Sept. 1978).**

Key words: multielement; radiochemical; selectivity; sensitivity; toxic.

A multielement radioanalytical procedure for the simultaneous determination of As, Cr, Se, Sb, Cd, and Cu has been developed. An inorganic ion exchanger coupled to a solvent extraction system was used for the selective separation of these elements from neutron activated matrices. The method has been used for centrifugation of environmentally related NBS SRMs.

18130. Hord, J., **Is hydrogen a safe fuel?, Int. J. Hydrogen Energy 3, No. 2, 157-176 (1978).**

Key words: explosion; fire; fuel; gasoline; hydrogen; methane; safety.

The safety aspects of hydrogen are systematically examined and compared with those of methane and gasoline. Physical and chemical property data for all three fuels are compiled and used to provide a basis for comparing their various safety features. Each fuel is examined to evaluate its fire hazard, fire damage, explosive hazard and explosive damage characteristics. The fire characteristics of hydrogen, methane and gasoline,

while different, do not largely favor the preferred use of any one of the three fuels; however, the threat of fuel-air explosions in confined spaces is greatest for hydrogen. Safety criteria for the storage of liquid hydrogen, liquefied natural gas (LNG) and gasoline are compiled and presented. Gasoline is believed to be the easiest and perhaps the safest fuel to store because of its lower volatility and narrower flammable and detonable limits. It is concluded that all three fuels can be safely stored and used; however, the comparative safety and level of risk for each fuel will vary from one application to another. Generalized safety comparisons are made herein but detailed safety analyses will be required to establish the relative safety of different fuels for each specific fuel application and stipulated accident. The technical data supplied in this paper will provide much of the framework for such analyses.

18131. Morrissey, B. W., Han, C. C., **The conformation of γ -globulin adsorbed on polystyrene latices determined by quasielastic light scattering**, *J. Colloid Interface Sci.* **65**, No. 3, 423-431 (July 1978).

Key words: conformation of adsorbed γ -globulin; flocculation and stabilization; quasielastic light scattering.

Measurements of the conformation of γ -globulin adsorbed on monodisperse polystyrene latices, and the subsequent rates of flocculation of the latices, have been carried out *in situ* using quasielastic light scattering. The molecular extension was found to depend on the protein solution concentration, with end-on adsorption indicated at high surface coverage. Application of the Deutch-Felderhof model for the translational friction coefficient of microscopic multisubunit assemblies established, through a comparison of calculated with experimental values of the molecular extension, the possibility of a flattening in the adsorbed conformation at low surface concentration. Changes in adsorbed conformation as a function of pH were also found. Although the initial rate of flocculation was too great to measure, the particle radius at a given time after mixing varied with the concentration exhibiting a maximum at approximately 0.05 mg·ml⁻¹ final protein concentration.

18132. Steihler, R. D., **Getting the right angle**, *Eng. Educ.* **5**, No. 2, 1 page (Aug. 2, 1978).

Key words: plane angle; SI units; torque unit; trigonometric functions.

Confusion exists concerning units for torque, energy, and other quantities involving rotation. This confusion stems from the treatment of plane angle and trigonometric functions in schools.

A plane angle is the divergence between two intersecting straight lines. The magnitude of the divergence can be expressed in a variety of measurement units, such as radian, grad, degree, minute, or second. The magnitude is *not* a number without units. An arc of a circle is frequently expressed in the same unit as plane angle. Actually, an arc of 30 degrees means a length on the circumference subtended by two radii having a divergence of 30 degrees; the length of the arc being 30 kr, where $k = 0.01745$ per degree. If the arc (s) and radius (r) are expressed in the same unit and angle (Θ) is in radians, k must have the value: 1 rad⁻¹. Since $s/r = k\Theta$, the practice of using the ratio s/r as synonymous with Θ is misleading. It implies that Θ is dimensionless. This practice is the source of the controversy concerning the radian in SI.

Trigonometric functions (sine, cosine, tangent, etc.) are mathematical designations for the ratios of lengths of sides in a right triangle. The functions are designated in reference to one of the angles other than the right angle in order to specify the two sides involved in a particular function.

18133. Steward, W. G., **Transient helium heat transfer. Phase I—Static coolant**, *Int. J. Heat Mass Transfer* **21**, No. 7, 863-874 (1978).

Key words: cooling of pulsed superconductors; helium cooling of superconductors; helium heat transfer; helium transient heat transfer; pulsed superconductor cooling; pulse heating.

Transient heat-transfer data have been obtained for flat heating surfaces in static liquid and supercritical helium. Measurements start $2(10)^{-5}$ s after step power inputs, and cover a heat flux range of 0.05-20 W/cm², pressures from 0.09-0.3 MPa, and four different heater orientations. Initial heat-transfer coefficients, being limited primarily by the Kapitza resistance, are 10-100 times greater than steady state, and the time to reach steady state varies 10^{-5} to 1 s. For heat flux below the steady state peak nucleate boiling limit the temperature follows calculations based on pure conduction to the steady state nucleate boiling level. Above that limit the transient conduction period leads to an apparent metastable nucleation period followed by a transition to film boiling.

18134. Blaha, J. J., Rosasco, G. J., **Raman microprobe spectra of individual microcrystals and fibers of talc, tremolite, and related silicate minerals**, *Anal. Chem.* **50**, No. 7, 892-896 (June 1978).

Key words: mineralogy; Raman microprobe; Raman spectroscopy; sheet and chain silicates.

With a recently developed Raman microprobe, vibrational spectra have been obtained from individual microcrystals and fibers of sheet and chain silicate minerals. Species such as talc, tremolite, low-iron anthophyllite, and actinolite give distinct spectra. No systematic differences exist between spectra of the fibrous and nonfibrous forms of a given mineral.

18135. Blaha, J. J., Rosasco, G. J., Etz, E. S., **Raman microprobe characterization of residual carbonaceous material associated with urban airborne particulates**, *Appl. Spectrosc.* **32**, No. 3, 292-297 (1978).

Key words: air particulates; environmental carbon; laser effects; microanalysis; Raman microprobe; Raman spectroscopy.

Analyses of individual urban airborne particulates were conducted in the Raman microprobe. In addition to the spectral features characteristic of the particle, two features at ~ 1350 and ~ 1600 cm⁻¹ have been observed. The appearance of these bands is found to vary as a function of the laser irradiance. By modeling experiments, it is demonstrated that these two bands can be explained by the presence of carbon in a form analogous to polycrystalline graphite. In air particulates the source of the carbon can be either "graphitic soot" or an organic "contaminant" which converts to polycrystalline graphite upon exposure to the laser beam.

18136. Birnbaum, G., **Report on the symposium on nondestructive testing standards**, (Proc. ARPA/AFML Review of Progress in Quantitative NDE, Asilomar, CA, Aug. 31-Sept. 3, 1976), *AFML-TR-77-44 Report*, p. 158 (Science Center, Rockwell International, Thousand Oaks, CA, Sept. 1977).

Key words: National Bureau of Standards; nondestructive calibrations; nondestructive evaluation; nondestructive evaluation calibrations; symposium.

A symposium on nondestructive testing (NDT) standards reflecting widespread current concern with this area was held at the National Bureau of Standards (NBS) May 19-21, 1976. The symposium was cosponsored by the National Bureau of

Standards (NBS), the American Society for Testing and Materials (ASTM), the American Society for Nondestructive Testing (ASNT), with the American National Standards Institute (ANSI) cooperating. The meeting provided the first general forum encompassing discussions on the processes by which NDT codes, standards, and specifications become accepted, and discussions on the status and needs that exist in all NDT methods. Major themes included standards documents, the status of standards in the major methods used in NDT and future directions. A summary of this meeting is presented.

18137. Hong, J. D., Davis, R. F., Newbury, D. E., **Ion microprobe analysis of ^{30}Si diffusion in $\alpha\text{-SiC}$** , *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 30A-30H (June 1978).

Key words: alpha-SiC; ion microprobe analysis; Si-containing materials.

18138. Hudson, R. P., **Recent advances in cryothermometry at NBS**, (Proc. Comm. AI-2 International Institute of Refrigeration, Zurich, Switzerland, Mar. 1-3, 1978), Paper in *Advances in Refrigeration at the Lowest Temperatures*, pp. 137-142 (International Institute of Refrigeration, Paris, France, 1978).

Key words: fixed points; IPTS; low temperature scales; thermometry.

When the International Practical Temperature Scale of 1968 is replaced in the future it will be extended below its present limit of 13.81K, perhaps to 0.001K. At NBS, several studies are in progress which are aimed to furnish the information which will facilitate that extension. We present here a brief summary of the present situation in these researches which bear upon thermometry utilizing noise, nuclear orientation, NMR, gas expansion, and germanium resistance, and upon superconducting fixed points.

18139. Huebner, R. H., Celotta, R. J., Mielczarek, S. R., **Apparent oscillator strengths for mercury vapor**, (Proc. Xth Int. Conf. Physics of Electronic and Atomic Collisions, Paris, France, July 1977), *Argonne National Lab. Report ANL-77-65*, Pt. I, pp. 11-15 (Oct. 1976-Sept. 1977).

Key words: electron energy loss; oscillator strengths; photoabsorption; water.

Energy-loss measurements for mercury show many interesting excitation phenomena commonly occurring in complex atomic systems. This system has been studied extensively by Lassette and co-workers. We have obtained energy-loss spectra for mercury vapor for zero-angle scattering of 100 eV incident electrons. These data were analyzed to yield the apparent oscillator strength distribution shown in Figure 1. The analysis was carried out using the small-angle method described in detail elsewhere. The spectra were normalized to yield an f value of 1.11 for the intense $6^1\text{P}_1 \leftarrow 6^1\text{S}_0$ transition observed at 6.71 eV.

18140. Mandel, J., **Accuracy and precision: Evaluation and interpretation of analytical results**, Chapter 5 in *Treatise on Analytical Chemistry*, 2d Edition, I. M. Kolthoff and P. J. Elving, Eds., I, Pt. I, Sec. B, 243-298 (John Wiley & Sons, Inc., Somerset, NJ, 1978).

Key words: accuracy; analytical chemistry; calibration; precision; sensitivity; statistics.

This is a chapter on the use of statistical methodology in the analytical chemical laboratory. It deals primarily with statistical methods for the evaluation of the precision and accuracy of analytical methods, with calibration problems and with the comparison of analytical methods.

18141. Mountain, R. D., **Monte Carlo study of the structure of expanded fluid rubidium**, *J. Phys. F: Metal Phys.* **8**, No. 8, 1637-1642 (1978).

Key words: Grüneisen parameter; liquid state; liquid structure factor; Monte Carlo; pseudopotential; rubidium, liquid.

The liquid structure factors for four high-temperature states of fluid rubidium are constructed using the Monte Carlo method and the effective pair potential developed by D. L. Price. The calculations are compared with the measured structure factors of R. Block *et al* (1977 *Liquid Metals 1976 Inst. Phys. Conf. Ser. No. 30* pp 126-32) and are found to differ significantly in the vicinity of the principal maximum. The prescription used to construct this pair potential does not appear to provide the necessary density dependence. Some details of procedures used to construct the structure factors are included in the discussion.

18142. Olver, F. W. J., **General connection formulae for Liouville-Green approximations in the complex plane**, *Philos. Trans. R. Soc. London, Ser. A: Math. Phys. Sci.* **289**, No. 1364, 501-548 (July 27, 1978).

Key words: asymptotic approximations; Bessel functions; connection formulae; error bounds; JWKB approximation; Liouville-Green approximation; optical potential; ordinary differential equations; principal curves; scattering problems; Stokes lines; transition point; turning point; wave transmission; wave trapping.

This paper is concerned with differential equations of the form

$$d^2w/dz^2 = \{u^2f(u,z) + g(u,z)\}w,$$

in which u is a positive parameter and z is a complex variable ranging over a simply connected open domain D that is not necessarily one-sheeted, and may be bounded or unbounded.

In the first part we assume that for each value of u the function $(z-c)^{2-m}f(u,z)$ is holomorphic and nonvanishing throughout D , where c is an interior point of D and m is a positive constant. It is also assumed that $g(u,z)$ is holomorphic in D , punctured at c , and $g(u,z) = O\{(z-c)^{\gamma-1}\}$ as $z \rightarrow c$, where γ is another positive constant. Thus c is a fractional transition point of the differential equation of multiplicity (or order) $m-2$, and there are no other transition points in D . Uniform asymptotic approximations for the solutions, when u is large, are constructed in terms of Bessel functions of order $1/m$, complete with error bounds.

In the second part of the Bessel function approximants are replaced by their uniform asymptotic approximations for large argument, yielding the connection formulae for the Liouville-Green (or J.W.K.B.) approximations to the solutions, again complete with error bounds. These results are then applied to solve the general problem of connecting the Liouville-Green approximations when D contains any (finite) number of transition points of arbitrary multiplicities, integral or fractional.

The third, and concluding, part illustrates the theory by means of three examples.

An appendix describes a numerical method for the automatic computation and plotting of the boundary curves of the Liouville-Green approximations, defined by

$$\text{Re} \int_c^z f^{1/2}(u,t) dt = 0,$$

where c again denotes a transition point.

18143. Person, J. C., Huebner, R. H., Celotta, R. J., Mielczarek, S. R., **The oscillator-strength distribution of water. A comparison of new photoabsorption and electron energy-loss measurements**, (Proc. Xth Int. Conf. Physics of Electronic

and Atomic Collisions, Paris, France, July 1977), *Argonne National Lab. Report ANL-77-65*, Pt. 1, pp. 16-18 (Oct. 1976-Sept. 1977).

Key words: electron energy loss; mercury vapor; oscillator strengths; photoabsorption.

Oscillator strengths for mercury vapor are determined by electron energy loss measurements. They are compared to previous determinations, where available, over the energy range of 4-20 eV.

18144. Rescigno, T. N., Bender, C. F., McKoy, B. V., Langhoff, P. W., **Photoabsorption in molecular nitrogen: A moment analysis of discrete-basis-set calculations in the static-exchange approximation**, *J. Chem. Phys.* 68, No. 3, 970-982 (Feb. 1, 1978).

Key words: molecular nitrogen; nitrogen, molecular; photoabsorption in molecular nitrogen.

Theoretical investigations of photoexcitation and ionization cross sections in molecular nitrogen are reported employing the recently devised Stieltjes-Tchebycheff moment-theory technique in the static-exchange approximation. The coupled-channel equations for photoabsorption are separated approximately by identifying the important physically distinct excitation processes associated with formation of the three lowest electronic states of the parent molecular ion. Approximate Rydberg series and pseudospectra of transition frequencies and oscillator strengths are constructed for the seven individual channel components identified using Hartree-Fock ionic core functions and normalizable Gaussian orbitals to describe the photoexcited and ejected electrons. Detailed comparisons of the theoretically determined discrete excitation series with available spectral data indicate general accord between the calculated and observed excitation frequencies and oscillator strengths, although there are some discrepancies and certain Rydberg series have apparently not yet been identified in the measured spectra. The total Stieltjes-Tchebycheff vertical photoionization cross section obtained from the discrete pseudospectra is in excellent agreement with recent electron-ion coincidence measurement of the cross section for parent-ion production from threshold to 50 eV excitation energy. Similarly, the calculated vertical partial cross sections for the production of the three lowest electronic states in the parent molecular ion are in excellent accord with the results of recent electron-electron coincidence and synchrotron-radiation branching ratio measurements. The origins of particularly intense resonancelike features in the discrete and continuum portions of the photoabsorption cross sections are discussed in terms of excitations into valencelike molecular orbitals. Small discrepancies between theory and experiment are attributed to specific autoionization process and channel couplings not included in the calculations. In contrast to previously reported model or local potential studies, the present results employ the full nonlocal and nonspherical molecular Fock potential in *ab initio* photoabsorption calculations. The excellent agreement obtained between theory and experiment in molecular nitrogen suggests that highly reliable photoabsorption cross sections for diatomic molecules can be obtained from Hilbert space calculations and the Stieltjes-Tchebycheff method in the static-exchange approximation under appropriate conditions.

18145. Righini, F., Rosso, A., Coslovi, L., Cezairliyan, A., McClure, J. L., **Radiance temperature of titanium at its melting point**, *Proc. Seventh Symp. Thermophysical Properties, Gaithersburg, MD, May 10-12, 1977*, pp. 312-318 (American Society of Mechanical Engineers, New York, NY, 1977).

Key words: high-speed measurements; high temperature; normal spectral emittance; radiation; thermal radiation properties; titanium.

Radiance temperature at two wavelengths, 653 and 997 nm, of titanium at its melting point was measured using a subsecond duration pulse heating technique. Specimens in the form of strips with initially different surface roughnesses were used. The results do not indicate any dependence of radiance temperature (at the melting point) on initial surface or system operational conditions. The average radiance temperature at the melting point of titanium is: 1800 K at 653 nm and 1711 K at 997 nm, with a standard deviation of 0.4 K at 653 nm and 0.8 K at 997 nm. The total inaccuracy in radiance temperature is estimated to be not more than ± 6 K.

18146. Powell, C. J., **Application of Auger-electron spectroscopy and x-ray photoelectron spectroscopy to the characterization of particles**, *Proc. 13th Annual Conf. Microbeam Analysis Society, Ann Arbor, MI, June 19-23, 1978*, pp. 64A-64B (June 1978).

Key words: Auger-electron spectroscopy; characterization of particles; spectroscopy, Auger-electron; x-ray photoelectron spectroscopy.

18147. Powell, C. J., **Solid-state and atomic features in the valence-band Auger spectra of copper, silver, and gold**, *Solid State Commun.* 26, No. 9, 557-562 (1978).

Key words: Auger-electron spectroscopy; copper; density of electronic states; electronic structure; gold; silver.

High-resolution measurements of the L_{3VV} , M_{45VV} , and N_{87VV} Auger spectra are reported for copper, silver, and gold, respectively. Qualitative trends in the spectra and experimentally determined values of $U_{eff}/2W$ (U_{eff} is the effective energy required to excite two holes on the same atom; W is the d-electron bandwidth) are shown to be consistent with recent predictions by Sawatzky and Cini concerning the relative importance of atomiclike and bandlike features in Auger spectra.

18148. Wineland, D. J., Drullinger, R. E., Walls, F. L., **Radiation-pressure cooling of bound resonant absorbers**, *Phys. Rev. Lett.* 40, No. 25, 1639-1642 (June 19, 1978).

Key words: atomic spectroscopy; Doppler narrowing; Doppler shifts; frequency standards; high-resolution spectroscopy; ion storage; laser spectroscopy; Penning trap; radiation pressure.

We report the first observation of radiation-pressure cooling on a system of resonant absorbers which are elastically bound to a laboratory fixed apparatus. Mg II ions confined in a Penning electromagnetic trap are cooled to < 40 K by irradiating them with the $8\text{-}\mu\text{W}$ output of a frequency doubled, single-mode dye laser tuned to the low-frequency side of the Doppler profile on the $^2S_{1/2} \leftrightarrow ^2P_{3/2}$ ($M_J = +1/2 \leftrightarrow M_J = +3/2$ or $M_J = -1/2 \leftrightarrow M_J = -3/2$) transitions. Cooling to approximately 10^{-3} K should be possible.

18149. Antonucci, J. M., **Aldehyde methacrylates derived from hydroxybenzaldehydes**, *J. Dent. Res.* 57, No. 3, 500-505 (Mar. 1978).

Key words: adhesion; aldehyde methacrylate; collagen; condensation reactions; copolymerization; coupling agents; dentin; functional monomers; hydroxybenzaldehydes; isomers; polymerization; synthesis.

Aldehyde methacrylates were synthesized from the 3 isomeric hydroxybenzaldehydes by facile condensation reactions. The 3 monomers are relatively low-melting crystalline solids which can be liquified by simple admixture of the isomers.

18150. Bowen, R. L., **Adhesive bonding of various materials to hard tooth tissues. XIV. Enamel mordant selection assisted by ESCA (XPS)**, *J. Dent. Res.* 57, No. 4, 551-556 (Apr. 1978).

Key words: adhesion; analysis; bonding; chemistry; dental; enamel; ESCA; mordant.

Surface analysis by XPS (X-ray photoelectron spectroscopy), also called ESCA (electron spectroscopy for chemical analysis), indicates that only certain cations are appreciably sorbed by enamel from an acid etching solution containing phosphoric acid and equimolar concentrations of candidate mordant salts.

18151. Brauer, G. M., **Properties of sealants containing Bis-GMA and various diluents**, *J. Dent. Res.* **57**, No. 4, 597-607 (Apr. 1978).

Key words: Bis-GMA; dental resins; pit and fissure sealants; preventive dental materials; protective coatings; sealant, evaluation; sealant, formulation; sealants; sealant testing procedures.

Properties of commercial and a series of experimental pit and fissure sealants, based on Bis-GMA were determined using rapid test procedures. By proper selection of monomeric diluent and addition of a photocrosslinking agent, the characteristics of sealant formulations can be varied widely.

18152. Currie, L. A., **Sources of error and the approach to accuracy in analytical chemistry**, Paper in *Treatise on Analytical Chemistry*, I. M. Kolthoff and P. J. Elving, Eds., Part I, Sec. B., Chapter 4, 1, 95-242 (John Wiley & Sons, Inc., Somerset, NJ, 1978).

Key words: accuracy; bias detection; chemical analysis; chemical measurement process; data reporting; detection limits; exploratory techniques; patterns; performance characteristics; precision; random error; standards; systematic error; testing of assumptions; validation.

This is a chapter on errors in chemical analysis, prepared for the *Treatise on Analytical Chemistry*, at the invitation of the editors. It begins with a brief assessment of the current state of the art including the accuracy requirements for various practical purposes and the consequent demands being placed on the analyst. The introductory section concludes with an evaluation of communication needs (terminology, reporting adequacy) and a survey of basic texts and review papers.

The major part of the text is devoted to a systematic evaluation of the Chemical Measurement Process (CMP) with detailed examination of systematic and random error sources which may operate at each step of the CMP. Underlying assumptions concerning the structure of the CMP, including chemical components and physical and error models, are illustrated and discussed, together with means for testing such assumptions. The discussion culminates with a section on validation and the role of standard materials and standard methods.

The chapter concludes with a presentation of simplified numerical and graphical techniques. The utility of such techniques for rapid and assumption-free error detection is illustrated with intercomparison and trace analysis data.

18153. Loebenstein, W. V., **Coupling agents for improved bonding of dental composites (Annotation)**, *J. Dent. Res.* **57**, No. 3, 480 (Mar. 1978).

Key words: coupling agent; dental adhesives; dental composites; dental polymer; polymerization coupler; tensile strength.

18154. MacDonald, R. A., Tsai, D. H., **Molecular dynamical calculations of energy transport in crystalline solids**, *Phys. Rep.* **46**, No. 1, 1-41 (Sept. 1978).

Key words: heat pulse propagation; molecular dynamics; one-, two-, three-dimensional lattice models; second sound; shock wave propagation; solitons; thermal conductivity; thermal diffusivity; thermal equilibrium.

Thermal conductivity (diffusivity), heat pulse propagation, and shock wave propagation in one-, two-, and three-dimensional lattices have been studied by the method of molecular dynamics, a method well suited to nonequilibrium and strongly anharmonic problems. In this review, particular attention has been paid to the approach to thermal equilibrium after a disturbance. In one dimension, it is shown that energy sharing between modes of vibration is difficult, therefore it is doubtful that the soliton concept is a useful one in nonlinear problems where thermal relaxation is involved. In two and three dimensions, energy sharing occurs readily. Under appropriate conditions heat flow occurs by diffusion and a temperature gradient is set up. The computed value of lattice thermal conductivity is in agreement with experiment. In pulsed heating, the coupling between the thermal and elastic disturbances generates a composite second sound wave which leads to a simple explanation of the temperature dependent second sound velocity observed experimentally. In shock compression, the thermal relaxation behind the shock front causes the shock profile to be nonsteady overall, in contradiction to the steady profile assumed in the usual Hugoniot relations for a continuum. The PVT relationships deduced from shock wave data are affected to a significant extent at high compressions.

18155. Misra, D. N., Bowen, R. L., **Adhesive bonding of various materials to hard tooth tissues. X. Initial rates of adsorption of nickel or copper ions on hydroxyapatite surface**, *J. Biomed. Mater. Res.* **12**, 505-515 (1978).

Key words: hydroxyapatite or bone-mineral; ion-exchange adsorption; Langmuir-adsorption rate equation; mordanting and adhesion; polymer bonding with hard tooth tissues; rates of Ni(II) and Cu(II) ion-exchange.

Initial rates of ion-exchange adsorption of nickelous or cupric ions with calcium ions on the surface of synthetic hydroxyapatite were studied in aqueous nitrate solutions. A kinetic interpretation has been proposed. The determination of the initial rates is important for a systematic investigation of adhesion of certain properly designed substances that may mediate a chemical bonding between dental resins and "mordanted" calcified tissues.

18156. Paule, R. C., Mandel, J., **Statistical evaluation of CAP survey results for calcium, potassium, and blood urea nitrogen**, *Am. J. Clin. Pathol.* **70**, No. 3, 471-480 (Sept. 1978).

Key words: blood urea nitrogen; calcium; CAP survey results 1975; clinical accuracy; clinical precision; inter-laboratory tests; potassium.

Through the use of the statistical technic known as the linear model, a complete analysis has been made of data obtained in the College of American Pathologists Survey of 1975 for calcium, potassium, and blood urea nitrogen (BUN). The analysis allows a separation of laboratories into core and noncore categories. It also allows for determination of the reproducibility of each analytic technic involved in this Survey. For Ca and K, the results obtained by each analytic method were compared with the results obtained by the National Bureau of Standards through use of the definitive method. For BUN, the comparison was made with the average of values for all laboratories and all methods.

18157. Brauer, G. M., Dulik, D. M., Antonucci, J., Argentar, H., **New amine accelerators for composite restorative resins**, *Polym. Prepr. Am. Chem. Soc., Div. Polym. Chem.* **19**, No. 2, 585-590 (Sept. 1978).

Key words: amine accelerators; composite restorative resins; dimethylaminoglutethimide; dimethylaminophen-

ylacetic acid and esters; properties of composites; tertiary aromatic amines.

Tertiary aromatic amines have been employed for many years as accelerators for the peroxide-catalyzed polymerization of acrylic resins and composites. These accelerators are especially useful in room temperature curing systems in resins or composites which have found applications as dental and medical restorative materials. Although the accelerator comprises only a minor component of the composite resin it affects greatly the properties of the cured material. Many amines have been suggested as accelerators, but esthetic and biocompatibility requirements have greatly limited the number of compounds that can be used.

The structure-property relationship previously found for correlating the reactivity of tertiary amines in their reaction with benzoyl peroxide as measured by the polymerization rate of vinyl monomers indicated that amines with aryl substituents having a σ^+ value close to -0.20 would be the most reactive. The aims of this investigation therefore were 1) to synthesize new tertiary amines which should be highly reactive and biocompatible and should give cured composites of greater color stability and 2) to compare these and other amines with presently used accelerators with regard to their effect on physical properties of the cured composite.

18158. Coveleskie, R. A., Parmenter, C. S., **Rotational relaxation within the $^1B_{2u}(S_1)$ state of benzene**, *J. Chem. Phys.* 69, No. 3, 1044-1054 (Aug. 1, 1978).

Key words: argon; benzene; excited electronic state; rotational relaxation.

Relaxation from nonequilibrium rotational distributions to a Boltzmann-like distribution within the zero point level of S_1 benzene vapor is studied using ground state benzene and argon as collision partners. The initial distributions are established by excitation with a narrow-band (0.3 cm^{-1}) laser tuned to various positions within the rotational contour of the 6_1^0 absorption band. The course of rotational relaxation is then followed by observations of the dependence of rotational contours in fluorescence bands upon gas pressure. Arguments are given to suggest that relaxation approximates a single-step process, with collisions taking the initial nonequilibrium distribution directly to a broad distribution of $J' K'$ levels reminiscent of the Boltzmann distribution. The rate constant for this relaxation is about $9 \times 10^7\text{ torr}^{-1}\text{ sec}^{-1}$ for benzene as a collision partner, which is about eight times the gas kinetic value. This constant is observed for each of two different initial distributions. It is likely that switching of electronic energy in collisions between S_1 benzene and rotationally equilibrated S_0 benzene makes a substantial contribution to this relaxation. The rate constant for relaxation in argon collisions is much smaller and depends on the initial distribution, being 1.5×10^7 and $3.5 \times 10^7\text{ torr}^{-1}\text{ sec}^{-1}$ for the two cases measured. Some applications of these data to rotational effects in radiationless transitions are discussed.

18159. Estin, A. J., Daywitt, W. C., **Evaluation of signal plus noise detection error in an envelope detector with logarithmic compression**, (Proc. Conf. on Precision Electromagnetic Measurements, Ottawa, Canada, June 26-29, 1978), *IEEE Cat. No. 78CH 1320-1 IM, CPEM Digest*, pp. 103-104 (Institute Electrical Electronics Engineers, New York, NY, 1978).

Key words: logarithmic detector; logarithmic weighted averaging; signal/noise correction factor.

A correction factor is derived for the detected output of a modulated sinusoidal signal with added Gaussian noise, as processed by an envelope detector with logarithmic compression. Supporting experimental data are presented, which were obtained on a typical commercial system using such a detector.

18160. Garvey, R. M., Hellwig, H., Jarvis, S., Jr., Wineland, D. J., **Two-frequency separated oscillating fields technique for atomic and molecular beam interrogation**, (Proc. Conf. on Precision Electromagnetic Measurements, Ottawa, Canada, June 26-29, 1978), *IEEE Cat. No. 78CH 1320-1 IM, CPEM Digest*, pp. 8-9 (Institute Electrical Electronics Engineers, New York, NY, 1978).

Key words: atomic and molecular beam spectroscopy; atomic frequency standard; cavity phase shift; Ramsey cavity; two-frequency interrogation.

We report on a novel method to reduce the effects of cavity phase shift upon atomic beam interrogation in Ramsey cavity configurations. Two distinct cavities driven at different frequencies are employed to produce a cavity phase shift which advances (or retards) at a constant rate.

18161. Hebner, R. E., **Discussion on F 76 455-6 "Automatic data acquisition of power network overvoltages and of laboratory impulses"**, by B. Beaumont, J. Jouaire, and A. Sabot, *IEEE Trans. Power Appara. Syst.* PAS-96, No. 2, 381 (Mar./Apr. 1977).

Key words: automation; data acquisition system; high voltage; impulse; pulse measurement; transient digitizer.

18162. Hebner, R. E., **Discussion on F 77 205-8, "Cavity resonance effect in large HV laboratories equipped with electromagnetic shield"**, by R. Malewski, D. Traia, and A. Dechamplain, *IEEE Trans. Power Appara. Syst.* PAS-96, No. 6, 1870 (Nov./Dec. 1977).

Key words: cavity resonance; electromagnetic interference; high voltage; impulse; pulse measurement; step response.

18163. Kintner, E. C., **Method for the calculation of partially coherent imagery**, *Appl. Opt.* 17, No. 17, 2747-2753 (Sept. 1, 1978).

Key words: Fourier optics; micrometrology; microscopy; optical imagery; partial coherence; photomasks.

The tedious numerical computations associated with the calculation of partially coherent imagery are alleviated by a method which uses dimensionless coordinates and takes advantage of the properties of the Fourier transform. A 1-D periodic object function can model many objects of practical interest, including nonperiodic objects. The properties of a given optical system are described in terms of the transmission cross coefficient. For aberration-free systems with circular pupils, including annular sources (dark-field illumination), the cross coefficient can be calculated analytically. For aberrated or apodized systems, a 1-D approximation can be used. The effect of a convolving slit in the image plane of a scanning microscope can also be included.

18164. Lawton, S. A., Phelps, A. V., **Excitation of the $b^1\Sigma_g^+$ state of O_2 by low energy electrons**, *J. Chem. Phys.* 69, No. 3, 1055-1068 (Aug. 1, 1978).

Key words: electrons; excitation; metastable; molecule; oxygen; rate coefficient.

Rate coefficients for excitation of the $b^1\Sigma_g^+$ state of O_2 by low energy electrons have been measured using a drift tube technique. The time dependence of the absolute intensity of the 762 nm band emission was measured for O_2 densities between 10^{16} and 2×10^{16} molecules/cm³. When corrected for electron attachment, ionization, and metastable diffusion, the number of $b^1\Sigma_g^+$ molecules produced per centimeter of electron drift and per O_2 molecule calculated from the 762 nm emission varied from $1.3 \times 10^{-18}\text{ cm}^2$ at $E/N = 5 \times 10^{-17}\text{V cm}^2$ to $2.1 \times 10^{-18}\text{ cm}^2$ at $E/N = 2 \times 10^{-15}\text{V cm}^2$. These values of electric field to ox-

xygen density ratio E/N correspond to mean electron energies of 0.75 and 6 eV, respectively. Measured decay constants for the 762 nm radiation yield a value for the product of the diffusion coefficient and the O_2 density of $(5.0 \pm 0.3) \times 10^{16} \text{ cm}^{-1} \text{ sec}^{-1}$ and a quenching coefficient for the $b \ ^1\Sigma_g^+$ state of $(3.9 \pm 0.2) \times 10^{-17} \text{ cm}^3 \text{ sec}^{-1}$. Comparison of measured excitation coefficients with values calculated using a recommended set of electron collision cross sections for O_2 show that the cross sections for direct excitation of the $b \ ^1\Sigma_g^+$ state are accurate near threshold and suggest that essentially all of the O_2 molecules excited to levels at and above 1.63 eV result in the formation of molecules in the $b \ ^1\Sigma_g^+$ state.

18165. Mecherikunnel, A. T., Richmond, J. C., **Solar spectral irradiance at ground level**, *Proc. Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, MD, May 22-24, 1978*, pp. 83-107 (Institute of Environmental Sciences, Mt. Prospect, IL, 1978).

Key words: atmospheric absorption; solar constant; solar energy; solar irradiance; spectral atmospheric absorptance; spectral distribution of solar energy; spectral solar irradiance; terrestrial solar spectral irradiance.

Available quantitative data on solar total and spectral irradiance is examined in the context of utilization of solar irradiance for terrestrial applications of solar energy. A brief review is given on the extraterrestrial solar total and spectral irradiance values. Computed values of solar spectral irradiance at ground level for different air mass values and various levels of atmospheric pollution or turbidity are also presented. Wavelengths are given for computation of solar absorptance, transmittance and reflectance by the 100-selected-ordinate method and by the 50-selected-ordinate method from air mass two solar spectral irradiance for the four degrees of atmospheric pollution. Total solar spectral irradiance measured with a prism monochromator is examined to evaluate the direct solar spectral irradiance for a surface normal to the sun's rays and to compare the computed spectrum with the experimentally observed one.

18166. Stein, S. R., Risley, A. S., **Progress in far-infrared frequency synthesis**, (Proc. Conf. on Precision Electromagnetic Measurements, Ottawa, Canada, June 26-29, 1978), *IEEE Cat. No. 78CH 1320-1 IM, CPEM Digest*, pp. 68-69 (Institute Electrical Electronics Engineers, New York, NY, 1978).

Key words: far-infrared laser; frequency modulation; frequency multiplication; frequency synthesis; phase-lock loop; Stark effect.

Experiments are being performed to synthesize far-infrared frequencies with a precision of 10^{-13} . An electric (Stark) field tuning technique has been developed for optically pumped lasers operating in the 500 μm to 70 μm wavelength region. Using this technique, a tunable laser has been phase-locked to a reference laser.

18167. Young, M., Lawton, R. A., **Saturation of optical detectors at high modulation frequency**, (Proc. 1977 Annual Meeting Optical Society of America, Toronto, Canada, Oct. 12, 1977), *J. Opt. Soc. Am.* **67**, 1398 (1977).

Key words: frequency response; mode-beating; modulation frequency; optical detector; responsivity; saturation.

We find that high-frequency responsivity of a typical photodiode saturates at high irradiance and that uniform dc responsivity need not imply uniform high-frequency responsivity.

18168. Ackerson, B. J., Straty, G. C., **Rayleigh scattering from methane**, *J. Chem. Phys.* **69**, No. 3, 1207-1212 (Aug. 1, 1978).

Key words: coexistence curve; critical point; methane; Rayleigh scattering; thermal conductivity; thermal diffusivity.

The decay rate of spontaneous thermal fluctuations in methane has been determined from Rayleigh scattering experiments. Measurements have been made in a broad region about the critical point, along the coexistence curve, the critical isochore, and an isotherm 0.8 K above the critical temperature. Values of thermal diffusivity obtained from the data are compared with other available data. In the immediate critical region the measured thermal diffusivity is compared with calculated thermal diffusivity values based on a recent prediction of the anomalous thermal conductivity of methane. The comparison involves assumptions concerning the scattered wave vector dependence of the decay rate in the critical region but involves no adjustable parameters. In addition, the critical isochore data are also fitted by other theoretically predicted forms for the decay rate to estimate parameters in these theories. Good agreement between measurement and prediction is found.

18169. Hiza, M. J., **An empirical excess volume model for estimating liquefied natural gas densities**, *Fluid Phase Equilib.* **2**, No. 1, 27-38 (Aug. 1978).

Key words: density prediction; excess volume model; LNG components; molar volumes; multicomponent systems; orthobaric liquid.

The mathematical model presented herein was developed to represent excess volumes at saturation for multicomponent liquid mixtures of nitrogen and the low molecular weight alkanes between 105 and 120 K. Parameters of the model were determined from experimental excess volumes for binary liquid mixtures of nitrogen, methane, ethane, propane, isobutane, and normal butane. Comparisons made with selected experimental excess volumes reported in the literature for multicomponent liquid mixtures of the above components demonstrate the predictive capability of the model in two simple forms. An extension of the model to include mixtures containing isopentane and normal pentane is also proposed. Pure component molar volumes are given at 0.5 K intervals from 105 to 116 K to facilitate the use of the present model in estimating liquefied natural gas (LNG) densities.

18170. Johnson, E. G., Jr., **Evaluating the inequivalence and a computational simplification for the NBS laser energy standards**, *Appl. Opt.* **16**, 2315-2321 (Aug. 1977).

Key words: calorimeter; four point method; inequivalence; laser energy; laser power; NBS laser standard.

A model with two time constants is used to estimate the inequivalence in response between a laser energy pulse and an electrical energy pulse put into a calorimeter of the C series type. The results are as follows: the calorimeter labeled C41 showed a 0.15 percent inequivalence and the calorimeter labeled C46 showed none. We also find that the complicated model currently used to get the corrected temperature rise of a measurement can be replaced by a simpler four-data-point method with no significant loss in accuracy. This simplification means we can substitute a microprocessor for a large computer to get the corrected temperature rise in an electrical calibration or laser energy measurement.

18171. Kanda, M., **A relatively short cylindrical broadband antenna with tapered resistive loading for picosecond pulse measurements**, *IEEE Trans. Antennas Propag.* **AP-26**, No. 3, 439-447 (May 1978).

Key words: broadband antenna; measurements; picosecond pulse; resistive loading; the method of moments.

A relatively short cylindrical antenna with continuously tapered resistive loading has been studied for the purpose of picosecond pulse measurements. The antenna considered is a nonconducting cylinder with continuously deposited varying-conductivity resistive loading. The current distributions on the antenna were numerically calculated using the method of moments. Using these current distributions, other quantities such as input admittance, near-field and far-field radiation patterns, and radiation efficiency, were also numerically calculated and compared with the results using the Wu-King's approximate current distribution. Agreement is relatively good except at high frequencies $kh > \pi/2$ where the method of moments appears to give better results. To verify the theoretical results, several resistively loaded antennas were fabricated, and their picosecond pulse receiving characteristics were analyzed for the frequency range between 5 kHz and 5 GHz. The experimental results indicate excellent linear amplitude and phase response over the frequency range. This provides the unique capability of this antenna to measure fast time-varying electromagnetic fields with minimal pulse-shape distortion due to nonlinear amplitude or phase characteristics.

18172. Miller, R. C., Hiza, M. J., **Experimental molar volumes for some LNG-related saturated liquid mixtures**, *Fluid Phase Equilib.* **2**, No. 1, 49-57 (Aug. 1978).

Key words: excess volumes; liquid mixtures; LNG components; molar volumes; multicomponent systems; orthobaric.

Saturated (orthobaric) liquid molar volumes are reported for some methane-rich mixtures containing ethane, propane, isobutane, normal butane and nitrogen at temperatures between 100 and 115 K. These data were obtained with a gas-expansion system calibrated against pure methane orthobaric liquid molar volumes. Comparisons are shown between the experimental molar volumes and the results of some recent calculational methods. Discrepancies between experimental and calculated values are all within ± 0.15 percent. The more accurate correlations generally predict the molar volumes within ± 0.1 percent.

18173. Stock, M., Drullinger, R. E., Hessel, M. M., **Energy transfer kinetics in the excimer states of mercury**, (Proc. Third Summer Colloquium on Electronic Transition Lasers, Snowmass Village, CO, Sept. 7-10, 1976), Paper in *Electronic Transition Lasers II*, L. E. Wilson, S. N. Suchard, and J. I. Steinfeld, Eds., pp. 219-223 (MIT Press, Cambridge, MA, 1977).

Key words: kinetics; mercury excimers.

Significant differences have been observed between electron beam pumping and optical pumping of Hg Excimers. We have used the frequency doubled output of a nitrogen laser pumped dye laser to produce mercury diatomic excimers directly in a bound excimer state. The use of time resolved fluorescence spectroscopy has allowed the direct observation of both vibrational and electronic thermalization within the manifold of excimer states. This technique avoids the complicating presence of electron collisions and population in highly excited states which can both absorb and radiate. Our results are inconsistent with the interpretation of e-beam produced mercury excimer fluorescence. We will discuss the time evolution of these systems and the mechanism leading to excimer fluorescence emission.

18174. Warner, B. E., Gerstenberger, D. C., Reid, R. D., McNeil, J. R., Solanki, R., Persson, K. B., Collins, G. J., **1 W**

operation of singly ionized silver and copper lasers, *IEEE J. Quant. Electron.* **QE-14**, No. 8, 568-570 (Aug. 1978).

Key words: change transfer; hollow cathode; metal ion laser.

We report a multi-line output power of one watt from the 800.4, 825.5, and 840.4 nm Ag II transitions and 350 mW from the 408.6 nm Ag II transition resulting from pulsed operation of silver hollow cathode laser. Continuous output of 1 W was obtained in a copper hollow cathode from the 780.8 nm Cu II transition. Design considerations for continuous high power operation of the hollow cathode discharge are also discussed.

18175. Zapf, T. L., Harvey, M. E., Larsen, N. T., Stoltenberg, R. E., **Ultrasonic calorimeter for beam power measurements from 1 to 15 megahertz**, (Proc. 1976 Ultrasonics Symp., Annapolis, MD, Sept. 29-Oct. 1, 1976), *IEEE Cat. No. 76CH 1120-5 SU*, pp. 573-576 (Institute of Electrical Engineers, New York, NY, 1977).

Key words: calorimeter; ultrasonic calorimeter; ultrasonic power measurements.

A twin, series flow, ultrasonic comparator has been constructed at the National Bureau of Standards for the measurement of beam power from ultrasonic transducers in the 1 to 15 MHz frequency range. Uncertainties are believed to be less than $\pm(7\% + 0.2 \text{ mW})$. An ultrasonic sound beam absorbed in one vessel can be compared rapidly with accurately-measured dc electrical power in the other vessel. Absorbing liquid enters each vessel near the ultrasonic input port. The temperatures of the absorbing liquid at the input ports are equalized by a heat exchanger, and the mass-flow rates are the same in both vessels. Twin temperature sensors, connected in the output flow from the vessels, are connected in an electrical bridge circuit. In automatic operation, the bridge is connected to a feedback circuit. With ultrasonic power introduced into one vessel, the feedback circuit promptly applies power to an electrical heater in the other vessel to regain balance. The ultrasonic power then equals the measured dc power corrected for known errors.

18176. Andrews, J. R., Nahman, N. S., **The measurement of pulse transition duration**, *Proc. Union Radio Scientifique Internationale Comm. A Symp., Lannion, France, Oct. 3-7, 1977*, pp. 159-164 (International Union of Radio Science, Paris, France, Dec. 1977).

Key words: measurement assurance program; pulse; pulse generator; risetime; transfer standard; transition duration; transition time.

Pulse-transition duration (10%-90% risetime) is a parameter that all engineers understand intuitively. However it is one of the more difficult parameters to precisely measure due to the difficulty in determining the baseline and topline (0% and 100% levels). The currently accepted standard for pulse terms, definitions, and measurements is IEC publication 469, issued in 1974. This paper discusses how NBS has implemented IEC-469 to establish a measurement service to calibrate transition duration transfer standards such as pulse generators and low pass filters. NBS designed transfer standards are also discussed.

18177. Birnbaum, G., **"New" candidates for ultrasonic NDE standards and calibrations**, *Proc. ARPA/AFML Review of Progress in Quantitative NDE, Ithaca, NY, June 14-17, 1977*, pp. 289-293 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, May 1978).

Key words: acoustic emission; calibrations; nondestructive evaluation; reference blocks; spectral response; standards; transducers; ultrasonics.

The National Bureau of Standards program in acoustic-ultrasonic calibrations and standards, aimed at solving some of the immediate problems, is reviewed. Work on acoustic emission transducers is directed at the determination of sensitivity and spectral response by the use of a reproducible stress impulse. Also in the area of acoustic emission is a program to develop a theoretical basis for acoustic emission signal analysis to characterize moving cracks or defects. Work on the characterization of ultrasonic transducers which should lead to formal calibration services in the near future includes determination of spectral characteristics by measuring the pressure of the ultrasonic radiation field, determination of the radiation pattern from near field measurements and total power by calorimetry. Although the current NBS program is oriented toward standards and calibrations, instrumentation problems are being addressed including the improvement of signal-to-noise ratio by methods such as pulse compression and signal averaging, and the characterization of the important variables in ultrasonic instrumentation. The reliability of flat-bottom hole aluminum reference blocks, which are in wide use, has been improved and a calibration service is now available. Further directions for this effort will include calibration services for steel and titanium blocks, the development of material independent blocks and the development of well-characterized fatigue cracks that could provide calibration for many NDE tests. The use of theoretically characterized scattering from spheres as a standard has recently come into prominence, and Rockwell and NBS have begun to explore this possibility. However, many other standards and calibration procedures for ultrasonic NDE have been proposed or are in use. To provide a fresh look at this area, particularly as it applies to DoD systems, NBS has initiated a program funded by ARPA to assess the status of the field, determine current and future needs, and propose a plan for realizing these needs.

18178. Brennan, J. A., Kneebone, C. H., Jenkins, E., **Transfer standards in cryogenic flow measurement**, *Proc. Conf. Flow Measurement of Fluids, Groningen, Netherlands, Sept. 11-15, 1978*, H. H. Dijkstra and E. A. Spencer, Eds., 503-512 (North-Holland Publ. Co., New York, NY, 1978).

Key words: cryogenic flow measurements; flow measurement, cryogenics; fluids, flow measurements.

The use of transfer or secondary standards for testing custody transfer flowmeters is described. Test procedures and recommended practices developed during five years experience are included where appropriate. Test results showing the effect of fluid temperature, flow rate, flowmeter interchangeability and transfer standard stability during tests in liquid nitrogen are shown.

Results of some comparative testing using liquid nitrogen, liquid argon and liquid oxygen are also included. Apparent flowmeter fluid dependencies are discussed relative to fluid PVT and flow facility uncertainties.

18179. Danielson, B., Day, G., Franzen, D., **Fiber optics metrology at NBS**, *Proc. Union Radio Scientifique Internationale Comm. A Symp., Lannion, France, Oct. 3-7, 1977*, pp. 430-431 (International Union of Radio Science, Paris, France, Dec. 1977).

Key words: attenuation; bandwidth; coupling; fiber optics; power.

Recently a fiber optics program was initiated in the Electromagnetics Division, Guided Wave Metrology Section of the National Bureau of Standards. The purpose of the program is to develop standards and measurement methodology as needed by fiber optics technology. Our activities are concerned with the following fiber measurements: attenuation, bandwidth, power and coupling.

18180. Ellerbruch, D. A., Belsher, D. R., **Electromagnetic technique of measuring coal layer thickness**, *IEEE Trans. Geosci. Electron. GE-16*, No. 2, 126-133 (Apr. 1978).

Key words: automation; coal; coal mine safety; dielectric constant; energy; microwave measurement; nondestructive testing; thickness of coal layer.

An FM-CW microwave system was investigated for measuring coal layer thickness. Measurements were made in three different mines near Pittsburgh, PA, Fairview, WV, and Coffeen, IL. Microwave frequencies in the range 1-2 GHz were used to measure samples up to 55-cm thick. All samples were backed with a naturally occurring shale. Measurements were also made on coal and shale samples compounded in the laboratory at the Bureau of Mines Pittsburgh Mining and Safety Research Center near Bruceton, PA.

The results indicate that layer thickness can be determined in most cases, although the large anomalies may, in some cases, produce misleading results. Many anomalies that were detected with the FM-CW system were verified visually by drilling into the coal layer.

The dielectric constant of coal apparently varies significantly within a coal seam. It appears that this technique has the potential of measuring changes in the dielectric constant of a coal seam and providing an output that can be used for real-time corrections in layer thickness measurement.

18181. Hellwig, H., Allan, D. W., Stein, S. R., Prichard, K. A., **Transcontinental and intercontinental portable clock time comparison**, (Proc. 31st Annual Symp. Frequency Control, Atlantic City, NJ, June 1-3, 1977), Paper in *IEEE Trans. Instrum. Meas.* **IM-27**, No. 1, 65-68 (Mar. 1978).

Key words: atomic time; Loran C; portable clocks; time comparison; universal coordinated time.

Because of the relatively low transportation costs of the rubidium portable clock, a schedule of relatively frequent comparisons with two of the main counterparts of NBS (Boulder, Colorado) have been executed: nearly monthly comparisons with the U.S. Naval Observatory (USNO) in Washington, DC and trips every quarter year to the International Time Bureau (BIH) in Paris, France. The measurement results of the the USNO and BIH comparisons are analyzed as a time series using a least squares quadratic fit. The measurements (time readings) yield a standard deviation of about 100 nanoseconds and indicate time scale drifts of about 1×10^{-13} per year. Comparison with Loran C data demonstrates the superior time comparison ability of portable clock trips, exceeding that of Loran C by up to one order of magnitude.

18182. Lawton, R. A., Ondrejka, A. R., **Standards for the measurement of impulsive fields radiated by a TEM horn antenna**, *Proc. Union Radio Scientifique Internationale Comm. A Symp., Lannion, France, Oct. 3-7, 1977*, pp. 1-4 (International Union of Radio Science, Paris France, Dec. 1977).

Key words: antenna; conical; fields; impulse; standard; TEM horn.

This report describes the construction and evaluation of a TEM horn antenna of NBS design. Our purpose in the evaluation was to analyze the different electrical field generation and measurement techniques thoroughly enough to determine the major sources of error and establish a standard of impulsive field strength having a well established statement of accuracy.

The evaluation of this horn was done in two independent ways: by placing the horn in a conical transmission line and by a three antenna intercomparison. The two methods were found to agree within ± 3 dB over the frequency range of 0.5 to 5 GHz. Part of this disagreement is due to the assumption of far-

field conditions, and an experimental technique is described which determines the frequency range over which this assumption is valid.

18183. Nahman, N. S., **Picosecond-domain waveform measurements**, *Proc. IEEE* 66, No. 4, 441-454 (Apr. 1978).

Key words: laser; oscilloscope; picosecond; pulse terms and definitions; risetime; sampling; streak camera; time domain measurements; transition duration.

A review of the state-of-the-art of picosecond time-domain measurements is presented which draws together techniques from the electrical and optical regions of the electromagnetic spectrum. Measurement methods are listed in categories which exhibit the commonality between electrical and optical methods. State-of-the-art values for temporal resolution are presented with reference citations to specific methods and related technical topics.

18184. Nahman, N. S., **Signal waveform metrology at NBS**, *Proc. Wescon/77, Electronics at the Golden Gate, San Francisco, CA, Sept. 19-21, 1977*, 10 pages (1977).

Key words: electrical; measurements; metrology; optical; pulse; waveform signal.

The Electromagnetics Division of the National Bureau of Standards (Boulder, Colorado) has a major effort in time domain measurements within the Signal Waveform Metrology Section. The technical responsibilities of the section include physical standards and measurement methods relevant to the characterization of both electrical and optical waveforms, their measurement systems, and the time domain responses of components and networks through which such waveforms pass. The technical activities of the program are reviewed relative to picosecond/nanosecond domain, continuous and sampled data measurements in real and equivalent time for both electrical and optical signal waveforms. Applications of the NBS Automatic Pulse Measurement System/Time Domain Automatic Network Analyzer (APMS/TDANA) to such measurements will be presented.

18185. Taggart, H. E., Workman, J. L., Nelson, R. E., **Emergency locator transmitters—Effective radiated power levels and techniques of determining effective radiated power**, Paper in *Report of the National Bureau of Standards Studies Emergency Locator Transmitters Effective Radiated Power Levels and Techniques of Determining Effective Radiated Power, Report No. FS-130-4*, 1-53 (Department of Transportation, Federal Aviation Administration, Washington, DC, Nov. 1, 1971).

Key words: emergency transmitters; measurement procedures; radiated power.

This report is concerned with the specifications and methods of evaluating Emergency Locator Transmitters (ELT's) for lost aircraft. Heretofore, there were no uniform methods of evaluating the effectiveness of the various types of ELT's, and the minimum amount of power required for these devices to operate satisfactorily has been a point of much discussion. The purpose of this report is to clarify some of these areas by: (1) Establishing the minimum effective radiated power from an ELT required to generate a reliable field strength for a search aircraft located 25 nautical miles from the ELT at an altitude of 3500 feet above the ELT; (2) Developing an accurate measurement technique for evaluating an ELT; (3) Developing a measurement technique for testing ELT's on a production line basis. The results contained in this report are supported by both theoretical data and independently obtained measured data. The agreement between the two are used to establish limits of error for the ELT evaluation techniques.

18186. Berger, H., Mordfin, L., **Calibrations and standards for nondestructive testing**, (Proc. American Society Nondestructive Testing 37th National Fall Conf., Detroit, MI, Oct. 3-6, 1977), Paper in *Mater. Eval.* 36, No. 11, 36-39 (American Society for Nondestructive Testing, Evanston, IL, Oct. 1978).

Key words: calibrations; measurements; nondestructive testing; radiography; reproducibility; standards.

Improved nondestructive testing (NDT) standards and calibrations are needed to provide greater reproducibility of NDT measurements and to provide improvements in the quantitative characterization of defects. Different calibration and standards concepts may be required to meet these two needs. This theme is developed and illustrated by radiographic measurements of Trans-Alaska oil pipeline girth welds.

18187. Collins, L. A., Norcross, D. W., **Electron collisions with highly polar molecules: Comparison of model, static, and static-exchange calculations for alkali-metal halides**, *Phys. Rev. A* 18, No. 2, 467-498 (Aug. 1978).

Key words: electron-molecule collision; electron scattering.

Calculations of cross sections for (vibrationally and electronically) elastic collisions of electrons with several alkali-metal halides were performed for energies in the range of 0.13 to 20.0 eV. The applicability of the adiabatic (fixed-nuclei) approximation for strongly polar systems is investigated by model calculations on CsF, KI, and LiF. We demonstrate that integrated, momentum transfer, and differential cross sections for polar systems can be reliably generated entirely within the body-frame, adiabatic approximation. We also suggest resolutions of several discrepancies between the results of earlier calculations and between these results and measurements. Close-coupling calculations, based on the adiabatic approximation and an alternative form of the frame transformation, were performed for electron-LiF collisions using the full static and static model-exchange surface. Reasonable agreement was found with measured differential cross sections at 5.44 and 20.0 eV. Shape resonances in the Σ and Π body-frame symmetries, centered near 1.8 and 1.5 eV, respectively, were observed. Similar features appeared in static-exchange calculation for NaF and NaCl. We also compare the results of the static and static-exchange calculations with the results of calculations using simpler model potentials and other approaches to the collision problem.

18188. Daney, D. E., **Helium storage at high density and discharge at high flow rates**, (Proc. Cryogenic Engineering Conf., Boulder, CO, Aug. 2-5, 1977), Paper K-2 in *Adv. Cryog. Eng.*, K. D. Timmerhaus, Ed., 23, 486-495 (Plenum Press, New York, NY, 1978).

Key words: cryogenic helium supply system; cryogenic storage; helium; helium supply system; high density helium storage; liquid helium storage; supercritical helium.

Equipment to store supercritical helium at high density and to demonstrate pulsed discharge at flow rates has been designed, fabricated and successfully demonstrated. A storage density of $0.193 \times 10^3 \text{ kg/m}^3$ (12.03 lb/ft³) at 8.3 MPa (81 atm) was achieved in a 135 liter (35 gal) dewar. Pulsed discharges of 2 seconds and 4 seconds duration were demonstrated at a flow rate of 1.0 kg/s (2.2 lb/s), and flow fluctuations of less than ± 1 percent were achieved without feedback control. In general, the system operated in a very stable and well behaved manner.

18189. Dunstan, L. P., Garner, E. L., **Chemical preparation of biological materials for accurate chromium determination by isotope dilution mass spectrometry**, *Proc. 11th Annual Conf. Trace Substances in Environmental Health, Columbia, MO,*

Key words: analytical blank; biological materials; chromium; isotope dilution; mass spectrometry; volatile chromium compounds.

The current interest in trace elements in biological materials has created a need for accurate methods of analysis. The source of discrepancies and variations in chromium concentration determinations is often traceable to inadequate methods of sample preparations. Any method of Cr analysis that requires acid digestion of a biological matrix must take into consideration the existence or formation of a volatile Cr component. In addition, because Cr is often present at concentrations less than 1 $\mu\text{g/g}$, the analytical blank becomes a potential source of error.

Chemical procedures have been developed for the digestion of the biological matrix and the separation of Cr without either large analytical blanks or significant losses by volatilization. These procedures have been used for the analysis of NBS Standard Reference Material (SRM) 1569 Brewers Yeast; SRM 1577 Bovine Liver; SRM 1570 Spinach and other biological materials including human hair and nails. At this time, samples containing 1 μg of Cr can be determined with an estimated accuracy of 2 percent.

18190. Ehrlich, M., **Criteria for testing personnel dosimetry performance in the United States of America**, (Proc. International Symp. National and International Standardization of Radiation Dosimetry, Atlanta, GA, Dec. 5-9, 1977), Paper in *National and International Standardization of Radiation Dosimetry, IAEA-SM-222/16, 1*, 419-420 (International Atomic Energy Agency, Vienna, Austria, 1978).

Key words: acceptable limits of uncertainty; beta particles; criteria; Health Physics Society Standards Committee; neutrons, performance; personnel dosimetry; photons; standard.

Under the auspices of the Health Physics Society Standards Committee, a standard has been developed that specifies procedures for testing the performance of suppliers of personnel-dosimetry services in the United States of America.

18191. Goodwin, R. D., **On the nonanalytic equation of state for propane**, (Proc. Cryogenic Engineering Conf., Boulder, CO, Aug. 2-5, 1977), Paper M-8 in *Adv. Cryog. Eng.*, K. D. Timmerhaus, Ed., **28**, 611-618 (Plenum Press, New York, NY, 1978).

Key words: equation of state for propane; propane; thermodynamic properties.

This type of equation is advantageous for computing thermodynamic properties because it originates on a given, liquid-vapor coexistence boundary, and yields a maximum in the isochoric specific heats at the critical point. With only five least-squares coefficients to be adjusted from experimental P - ρ - T data, it describes a $P(\rho, T)$ surface free of irregularities, and consistent with the known behavior of specific heats at all densities. Following its application to methane and ethane, small but essential modifications for propane now are reported, together with all constants for the vapor-pressure equation, the orthobaric-densities equations, and the equation of state, as needed for computations.

18192. Gramlich, J. W., Machlan, L. A., Murphy, T. J., Moore, L. J., **The determination of zinc, cadmium and lead in biological and environmental materials by isotope dilution mass spectrometry**, *Proc. 11th Annual Conf. Trace Substances in Environmental Health, Columbia, MO, June 6-10, 1977*, D. D. Hemphill, Ed., pp. 376-380 (University of Missouri, 1977).

Key words: biological materials; cadmium; environmental materials, isotope dilution; lead; mass spectrometry; zinc.

Techniques have been developed for the accurate and precise determination of the concentration of zinc, cadmium and lead using thermal ionization mass spectrometry. These techniques have been applied to the analysis of a variety of biological materials such as blood, hair and nails, and to environmentally related materials such as water, air particulates and fossil fuels.

Uncertainty in the accuracy of the isotope dilution method is less than 0.5 percent for all 3 elements, and is nearly independent of element concentration from the percent level down to the ng/g (ppb) range where the analytical blank becomes a significant contribution to the uncertainty.

The mass spectrometric methodology and chemical separation procedures are presented along with examples showing the effect of sample impurities on the quality of the analytical data.

18193. Hanley, H. J. M., **Prediction of the thermal conductivity of fluid mixtures**, *Proc. 7th Symp. on Thermophysical Properties, Gaithersburg, MD, May 10, 1977*, A. Cezairliyan, Ed., pp. 668-673 (American Society Mechanical Engineers, New York, NY, 1977).

Key words: corresponding states; critical point; internal degrees of freedom; mixtures; prediction technique; thermal conductivity coefficient.

A corresponding states method, introduced previously, to predict transport coefficients of a pure fluid or mixture over a wide range of experimental conditions is expanded in this work. The thermal conductivity coefficient is discussed in detail. It is shown that this coefficient can be predicted given only values for a reference fluid and thermodynamic data. Comparisons between calculated results and data are satisfactory. The effect of internal degrees of freedom is discussed. The behavior of the thermal conductivity coefficient at the critical point (for a pure fluid) or the plait point (for a mixture) is also mentioned briefly.

18194. Hiza, M. J., Haynes, W. M., **Liquid mixture excess volumes and total vapor pressures using a magnetic suspension densimeter with compositions determined by chromatographic analysis: Methane plus ethane**, (Proc. Cryogenic Engineering Conf., Boulder, CO, Aug. 2-5, 1977), Paper M-6 in *Adv. Cryog. Eng.*, K. D. Timmerhaus, Ed., **23**, 594-601 (Plenum Press, New York, NY, 1978).

Key words: binary system; ethane; excess pressures; excess volumes; methane; molar volumes; orthobaric liquid; total vapor pressures.

The experimental results discussed in this paper demonstrate the feasibility of using a magnetic suspension densimeter to obtain isothermal phase equilibria and liquid density data simultaneously. In this study, densities and total vapor pressures for methane + ethane liquid mixtures were measured between 35 and 75 mole percent methane at 135 K and at 50 mole percent methane at 125 K, with compositions determined by chromatographic analysis of liquid samples. Derived excess volumes are in excellent agreement with those from densities of gravimetrically prepared mixtures obtained with the same apparatus. Excess pressures, derived from the total vapor pressures, are in good agreement with comparable values from phase equilibria data in the literature. The predominant source of error in the present experimental procedure clearly results from problems in obtaining representative liquid mixture samples from the equilibrium cell for analysis.

18195. Hubbard, C. R., Mighell, A. D., Pomerantz, I. H., **2,3,7,8-tetrachlorodibenzofuran**, *Acta Cryst.* **B34**, No. 7, 2381-2384 (July 1978).

Key words: inducer of enzymes; industrial contaminant; single crystal; toxic material; x-ray diffraction; 2,3,7,8-tetrachlorodibenzofuran.

$C_{12}H_4Cl_4O$, $M_r = 305.97$, monoclinic, $C2/c$, $a = 14.702$ (4), $b = 12.886$ (4), $c = 6.256$ (1) Å, $\beta = 99.90$ (2), $V = 1168$ Å³, $\rho_{obs} = 1.72$ (floatation), $\rho_{calc} = 1.74$ g cm⁻³, $Z = 4$. The structure has been determined by direct methods and refined to $R = 0.042$ for 1863 independent reflections. The molecule is essentially planar. A crystallographic twofold axis bisects a C—C bond and passes through the O atom of the five-membered furan ring. The two unique C—Cl distances are 1.725 (2) and 1.732 (2) Å, the C—O distance is 1.385 (2) Å, and the benzenoid ring C—C distances range between 1.366 (2) and 1.404 (2) Å. The longest C—C bond distance within the benzenoid rings joins the C atoms to which the Cl atoms are attached. The title compound is closely related in structure to the highly toxic 2,3,7,8-tetrachlorodibenzo-*p*-dioxin.

18196. Khayrallah, G. A., Smith, S. J., **Radiative lifetime measurement of the 3¹S, 3¹D, 4¹D, 4¹F, and 5¹F excited states of helium**, *Phys. Rev. A* 18, No. 2, 559-570 (Aug. 1978).

Key words: electron; excitation; helium; lifetimes; optical; radiation.

The lifetimes of the 3¹S, 3¹D, 4¹D, 4¹F, and 5¹F states of He have been determined experimentally to be 54.5 ± 0.8 , 16.7 ± 0.8 , 36.4 ± 1.2 , 67 ± 10 , and 142 ± 20 nsec, respectively. The measurements were made at several incident electron energies using a pulsed-electron time-delayed-coincidence technique.

18197. Kunasz, P., Van Blerkom, D., **Mass loss from P Cygni. II. An equivalent two-level-atom approach**, *Astrophys. J.* 224, No. 1, 193-197 (Aug. 15, 1978).

Key words: mass loss from stars; P Cygni; radiation transfer; stellar envelopes.

The formation of the Balmer-line spectrum of P Cygni is investigated by using an equivalent two-level-atom formalism. This approach eliminates the artificial distinction between a continuum-emitting core and line-emitting envelope, and also does not employ a supersonic approximation in the line-transfer problem. The results support the conclusion that a velocity distribution similar to the linear law $v(r) \propto r$ exists in the envelope, and can account for the observed Balmer lines. A more complicated velocity law derived from infrared continuum measurements does not give a good representation of the Balmer lines.

18198. Levron, D., Phelps, A. V., **Quenching of N₂(A³Σ_u⁺, $\nu = 0, 1$) by N₂, Ar, and H₂**, *J. Chem. Phys.* 69, No. 5, 2260-2262 (Sept. 1, 1978).

Key words: argon; hydrogen; metastable nitrogen; radiation; rate coefficient; ultraviolet.

This note presents improved measurements of rate coefficients for the quenching of the $\nu = 0$ and $\nu = 1$ levels of the A(³Σ_u⁺) metastable state of N₂ by N₂, Ar, and H₂ using very low levels of excitation and high gas purity. Designating the $\nu = 1$ and $\nu = 0$ vibrational levels of the A(³Σ_u⁺) state by A¹ and A⁰, respectively, our rate coefficients or their upper limits vary from agreement with published values for N₂(A⁰) quenching by H₂ to 100 times smaller than published values for N₂(A⁰) and N₂(A¹) quenching by Ar.

18199. Loevinger, R., **Medical dosimetry standards programme of the National Bureau of Standards**, (Proc. International Symp. National and International Standardization of Radiation Dosimetry, Atlanta, GA, Dec. 5-9, 1977), Paper in *National and International Standardization of Radiation*

Dosimetry, IAEA-SM-222/58, 1, 159-174 (International Atomic Energy Agency, Vienna, Austria, 1978).

Key words: brachytherapy sources; calibration; dissemination; gamma-ray calibration; measurement assurance; medical dosimetry; radiation dosimetry; radiation standards; x-ray calibration.

In the field of radiation dosimetry for medicine and radiation protection, the National Bureau of Standards has the responsibility to establish, verify, maintain and make available suitable measurement standards, and to carry out studies to assure that dosimetry measurements made in the United States of America are in adequate agreement with NBS standards. The physical quantities involved are exposure and absorbed dose, and the measurement standards are free-air chambers, graphite cavity chambers, calorimeters, extrapolation chambers, and radium standards. These NBS standards have been verified after construction, and periodically since that time, by comparison with each other, and with other national and international standards. Calibration services based on the NBS standards are offered for x-ray and gamma-ray measuring instruments, beta-particle and gamma-ray brachytherapy sources, and x-ray penetrameters; irradiation of passive dose meters is offered in photon beams with maximum energies from 10 keV to 1 MeV. Exposure-measuring and absorbed-dose-measuring instruments are subjected to a variety of pre-calibration tests. Calibration data are handled by an automatic data acquisition system and are processed by computer. Measurement assurance studies have been carried out for cobalt-60 teletherapy sources and for high-energy electron beams by means of passive dose meters irradiated by the medical user and evaluated at NBS; measurement assurance studies are being made to test the calibration of a limited number of medical beams by taking the NBS portable calorimeter directly to the medical beam and comparing the calorimeter measurement with a conventional calibration. Traceability to NBS standards of the calibration of instruments used in medicine and radiation protection is established in part by three Regional Calibration Laboratories accredited by the American Association of Physicists in Medicine, in part by direct calibration of field instruments at NBS, and in part by informal calibration procedures about which little information is available.

18200. Mitchell, R. A., Baker, S. M., **Characterizing the creep response of load cells**, *Proc. International Measurement Confederation (IMEKO) International Conference on Measurement of Force and Mass, Braunschweig, W. Germany, Sept. 13-15, 1978*, pp. 43-48 (VDI-VERLAG GMBH, Dusseldorf, W. Germany, 1978).

Key words: creep; creep recovery; force measurement; force transducer; load cell; pressure sensitivity; spring-dashpot model.

A procedure is being developed for characterizing the creep response of load cells. A constant force is applied to the load cell in a dead weight machine and the creep response is recorded using a high precision direct-current indicator. Initial test results on eleven strain-gage load cells indicate a great variety in the magnitude, direction and complexity of creep and creep recovery.

A rheological model consisting of multiple spring and dashpot elements in parallel and in series is fitted to the creep data. A search algorithm is used to solve the nonlinear least squares problem for the multiple stiffness and time constants of the rheological model. Within the limitations imposed by non-linearity in the creep response, the fitted model can be used to estimate the creep response due to more general loading.

18201. Peters, K. R., Rutter, G., Gschwender, H. H., Haller, W., **Derivatized silica spheres as immunospecific markers for high resolution labelling in electron microscopy**, *J. Cell Biol.* **78**, 309-318 (1978).

Key words: DDS; electron-microscopy; immuno-marker; markers; silica spheres.

For high resolution labeling of influenza virus cell surface antigens on HeLa cells, an immunospecific marker is used with silica sphere cores of 13-14 nm average diameter. These markers are formed using commercially available silica sphere sols. Two other size ranges are available, 7-8 nm and 22-25 nm. The steps for chemical derivatization are described in detail. Amino and aldehyde functions are covalently introduced onto the sphere surface. Sols of these derivatized silica spheres (DSS) are physicochemically stable and therefore usable for years. Coupling of IgG to DSS followed by permeation chromatography on controlled pore glass results in size-defined immunospecific silica sphere markers (DSS-markers). Saturation labeling of cell surface antigens on HeLa cells on cover slips is obtained with the final sphere concentration of 10^{14} DSS-marker/cm² within 20 min. With usual protective conditions, the marker stability and labeling ability are preserved for months. The visibility and the fine structure of the DSS-marker on cell surfaces are shown by using transmission electron microscopy (TEM) with stereo replicas and ultrathin sections.

18202. Rainwater, J. C., Hanley, H. J. M., **The bulk viscosity of a fluid: The inverse power potential**, *Chem. Phys. Lett.* **58**, No. 1, 39-42 (Sept. 1, 1978).

Key words: bulk viscosity coefficient; kinetic theory; modified Enskog theory; numerical integration.

The bulk viscosity coefficient of a moderately dense gas has been evaluated numerically for an inverse power potential. The calculation, to order density squared, is based on the microscopic theory of Snider et al. The results are compared to those from the corresponding expression of the modified Enskog theory. Agreement between the sets of values is within 1 percent.

18203. Symuleski, R. A., **An evaluation of the applicability of pyrolysis-gas-liquid chromatography for the identification of microorganisms in water and sewage treatment plant effluents**, *Proc. 3d National Conference on Complete Water Reuse, Cincinnati, OH, June 27-30, 1976*, pp. 457-461 (American Institute of Chemical Engineering, United Engineering Center, New York, NY, 1976).

Key words: bacterial identification; gas-liquid chromatography; potable water; pyrolysis; sewage treatment plant effluent; water reuse.

Recent studies have shown pyrolysis-gas-liquid chromatography to be a valuable tool in the rapid identification of bacteria. Most of the work to date has been involved with the detection of anaerobic bacteria in clinical samples. The present study indicates that the technique may also have promise in detecting those facultative bacteria present in samples of environmental origin. This paper describes on-going work in the evaluation of this procedure for the rapid identification of bacteria in water and sewage treatment plant effluents. Preliminary results from the analysis of one species of bacteria are presented along with a discussion of current problems encountered in the analytical procedure.

18204. Taggart, H. E., Jickling, R. M., **RF coaxial cable assemblies for mobile transceivers**, *NILECJ-STD-0212.00*, 9 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: cable assembly; coaxial cable; insertion loss; mobile antenna; mobile transceiver; transmission.

This standard specifies the connector plug at the mobile transceiver for an rf coaxial cable lead-in from a mobile antenna. Four performance requirements are listed, with detailed test methods for measuring characteristics such as standing wave ratio and insertion loss.

18205. Bennett, L. H., Schone, H. E., Gustafson, P., **Nuclear-magnetic-resonance studies of amorphous Ni-P alloys**, *Phys. Rev. B* **18**, No. 5, 2027-2030 (Sept. 1, 1978).

Key words: amorphous Ni-P alloys; chemical deposition; electroplating; Knight shifts; local electronic structure; metastable phases.

Measurements of NMR linewidth, Knight shifts, and relaxation time have been made on amorphous Ni-P alloys with phosphorous content between 15 percent and 25 percent. Alloys prepared by different techniques (electroplating and chemical deposition) give different Knight shifts, suggesting different local structures. Linewidth measurements support a binary dense random packing of hard-spheres model in which phosphorous atoms have only nickel neighbors.

18206. Lozano, C., Olver, F. W. J., **Asymptotic approximations for parabolic cylinder functions**, *J. Phys. B: Atom. Molec. Phys. Lett.* **11**, No. 18, L531-L533 (1978).

Key words: asymptotic approximations; connection formulae; JWKB approximations; Liouville-Green approximations; parabolic cylinder functions; Schrodinger equations; turning points.

Methods are discussed for the construction of uniform asymptotic expansions of parabolic cylinder functions of large order, based on integral representations and the theory of linear differential equations. Some previous errors in the literature are corrected.

18207. Rabolt, J. F., Piermarini, G., Block, S., **Raman spectroscopic evidence for conformational deformation in the high pressure phase of polytetrafluoroethylene**, *J. Chem. Phys.* **69**, No. 6, 2872-2876 (Sept. 15, 1978).

Key words: crystallinity; diamond anvil cell; high pressure; polytetrafluoroethylene; Raman spectroscopy; TFE-HFP copolymer.

An investigation of polytetrafluoroethylene (PTFE), $nC_{20}F_{42}$, and a random copolymer of tetrafluoroethylene and hexafluoropropylene (TFE-HFP) under pressure has been carried out using Raman spectroscopy in conjunction with a diamond anvil cell. Both $nC_{20}F_{42}$ and the TFE-HFP copolymer were found to undergo a phase transition in the 7-9 kbar range similar to PTFE as evidenced by the observation of the 625 cm⁻¹ Raman band characteristic of phase III. With increasing pressure in the 10-52 kbar range, a continual variation in intensity of the bands at 285 and 395 cm⁻¹ was observed and found to differ for the three fluorocarbon materials studied. By correlating a change in the I_{285}/I_{395} ratio with a change in sample crystallinity (as determined by x ray), it has been determined that an increase in transplanar content with pressure is responsible for the observed band intensity changes in the high pressure phase of PTFE.

18208. Scott, P. B., Johnson, S. E., Watson, G. W., Berger, H., **Neutron radiographs using the ionographic process**, *J. Appl. Phys.* **49**, No. 10, 5078-5080 (Oct. 1978).

Key words: direct imaging; electronic radiography; ionography process; neutron radiographs; radiography; thermal neutrons.

Thermal neutron radiographs have been made using ionographic techniques. With a fluence of 10^7 neutrons/cm² at the image plane, image resolution of three line pairs per mm was demonstrated. The apparatus for these demonstration experiments is described, and alternative modes of operation are discussed. It appears possible to make ionographic neutron radiographs using a transmitted fluence of 10^9 neutrons/cm².

18209. Kelley, E. F., Hebner, R. E., Jr., **Measurement of prebreakdown electric fields in liquid insulants**, *Proc. 1978 Annual Report, Conf. Electrical Insulation and Dielectric Phenomena, Pocono Manor, PA, Oct. 30-Nov. 2, 1978*, pp. 206-212 (National Academy of Sciences, Washington, DC, 1978).

Key words: electrical breakdown; electric field; Kerr effect; liquid insulants; nitrobenzene; space charge; transformer oil; treeing; water.

Prebreakdown events in liquid insulants are investigated by combining time-resolved shadowgraphs with time-resolved electric field measurements using the electro-optic Kerr effect. The fluids studied are transformer oil, water, and nitrobenzene. In transformer oil and nitrobenzene, three types of prebreakdown phenomena are observed: the cathode bush, the cathode streamer, and the anode tree. In water, no cathode streamer was identified.

18210. Mansbach, P. A., **Comparison of sound power determinations conducted in four different acoustic environments**, *Proc. Inter-Noise 78 Conf., San Francisco, CA, May 8-10, 1978*, pp. 269-276 (Institute of Noise Control Engineering, Poughkeepsie, NY, May 1978).

Key words: acoustics; noise emission; reference sound source; sound power measurement.

The sound power levels emitted by five vacuum cleaners and one reference sound source were determined in four different acoustic environments in accordance with appropriate domestic and international measurement standards, and also using only four measurement locations, to ascertain any differences between the various procedures. The study shows general agreement among the results, (rms differences between A-weighted sound power levels of 1.0 to 1.5 dB). Determinations conducted in the reverberation room appear systematically low by about 0.8 dB (A-weighted sound power level); determinations made using four microphones may be biased if the microphones are located too close to the source. Use of the comparison (reference sound source) method eliminated systematic bias and improved the agreement between environments (rms differences of 0.5 to 1.0 dB).

18211. Rubin, R. J., Weiss, G. H., **Boundaries of constrained random flight polymer chains**, *Macromolecules* 11, No. 5, 1046-1049 (Sept.-Oct. 1978).

Key words: adsorption; constrained Hollingsworth radius; diffusion approximation; extent of cilium; polymer chains; random flight chains.

We call the radius of the smallest sphere which contains all segments of a random flight chain and is centered at the starting point of the chain the Hollingsworth radius of the chain R . In this paper, we consider two cases in which the configurations of random flight chains are constrained. In each case, we calculate the probability density of the Hollingsworth radius for the constrained chains. In the first case, the end-to-end distance of the chains is constrained to the value r . In the second case, all segments of the chain are constrained to lie on one side of an impenetrable plane through the starting point.

18212. Braithwaite, M., Leone, S. R., **Laser-initiated chemical reactions: $\text{Cl} + \text{H}_2\text{S} \rightarrow \text{HCl} + \text{HS}$: Rate constant, product energy distribution, and direct detection of a chain mechanism**, *J. Chem. Phys.* 69, No. 2, 839-845 (July 15, 1978).

Key words: chain mechanism; infrared chemiluminescence; laser photolysis; reaction dynamics; vibrational partitioning.

Laser-initiated, time-resolved infrared chemiluminescence techniques are used to study the detailed kinetics of chlorine/hydrogen sulfide systems. Measurements on the $\text{Cl} + \text{H}_2\text{S} \rightarrow \text{HCl} + \text{HS}$ reaction are carried out by pulsed laser photolysis of $\text{S}_2\text{Cl}_2 \rightarrow \text{S}_2\text{Cl} + \text{Cl}$ in a flowing mixture with H_2S , while detecting vibrational chemiluminescence from the HCl product. The measured rate constant for the $\text{Cl} + \text{H}_2\text{S}$ reaction is $6.0 \pm 1.2 \times 10^{-11}$ cm³ molecule⁻¹ sec⁻¹ at 296°K. The vibrational product distribution is predominately excitation of HCl to $v = 1$ and $v = 2$, with the ratio ($v = 1$):($v = 2$) = 15. The dynamical interpretation of the $\text{Cl} + \text{H}_2\text{S}$ reaction data is discussed. Photolysis of $\text{Cl}_2 \rightarrow 2\text{Cl}$ in the presence of H_2S produces a rapid chain reaction, $\text{Cl} + \text{H}_2\text{S} \rightarrow \text{HCl} + \text{HS}$, $\text{HS} + \text{Cl}_2 \rightarrow \text{HSCl} + \text{Cl}$. The chain mechanism and its real time development are observed directly from the product chemiluminescence signal.

18213. Nicodemus, F. E., **The NBS self-study manual on optical radiation measurements**, *Proc. Seminar Testing Solar Materials Systems, Gaithersburg, MD, May 22-24, 1978*, pp. 256-257 (Institute of Environmental Sciences, Mt. Prospect, IL, 1978).

Key words: optical radiation measurements; photometry; radiometry.

A background discussion of the need for the NBS *Self-Study Manual on Optical Radiation Measurements* is followed by the general plan and objectives for preparation of the Manual. The content and level of presentation are reviewed, followed by a list of chapters already published in NBS Tech Notes, a list of chapters currently in preparation, and a list of topics for future chapters through 1981. Ordering information is provided, particularly stock numbers and prices, for obtaining copies of published NBS Tech Notes with Manual chapters from the Superintendent of Documents at the U.S. Government Printing Office. Availability is described for routine notification by both GPO and NBS of the publication of additional Manual chapters in the future.

18214. Poulsen, O., Hall, J. L., **Spectroscopic investigations in ^{209}Bi using tunable-cw-dye-laser spectroscopy**, *Phys. Rev. A* 18, No. 3, 1089-1096 (Sept. 1978).

Key words: energy levels; hyperfine structure; laser spectroscopy; lifetime.

Tunable-cw-dye-laser spectroscopy of an atomic-beam sample, combined with interferometric wavelength measurements, has been applied to the measurement of energy levels, hyperfine structure, and lifetimes of ^{209}Bi I. We find $E[(6p)^3 \ ^2P_{3/2}] = 33\ 164.7000(7)$ cm⁻¹, $E[(6p)^2 7s \ ^4P_{3/2}] = 48\ 489.7593(8)$ cm⁻¹, and $E[(6p)^2 7s \ ^2P_{3/2}] = 49\ 460.8014(8)$ cm⁻¹. The hyperfine coupling constants A , B , are for the $(6p)^2 7s \ ^4P_{3/2}$ level $(A, B) = [3717.4(5), -137.8(5.0)]$ MHz and for the $(6p)^2 7s \ ^2P_{3/2}$ level $(A, B) = [2830.6(5), -132.6(4.6)]$ MHz. The lifetimes are determined to (5.25 ± 0.30) and (5.18 ± 0.20) ns, respectively.

18215. Rush, J. J., Rowe, J. M., **Neutron quasielastic scattering study of ND_4^+ orientational fluctuations in β -phase ND_4Br** , *J. Chem. Phys.* 69, No. 6, 2928-2930 (Sept. 15, 1978).

Key words: ammonium bromide; correlation time; critical fluctuations; neutron scattering; phase transition; reorientation.

The ND_4^+ orientational fluctuations of ND_4Br have been studied in the $\beta(\text{C}_6\text{Cl})$ phase by coherent and incoherent neutron scattering. Correlation time for individual ND_4^+ reorientations were derived to be 2.5×10^{-11} sec and 5×10^{-11} sec at 252 and 232 K, respectively. The corresponding times for cooperative fluctuations of ND_4^+ ion clusters was found to be ≈ 10 times longer, in agreement with theoretical predictions.

18216. Schoenwetter, H. K., An RMS digital voltmeter/calibrator for very-low frequencies, *IEEE Trans. Instrum. Meas.* **IM-27**, No. 3, 259-268 (Sept. 1978).

Key words: ac/dc difference; ac voltage calibrator; infrasonic voltage measurements; rms measurements; rms voltmeter; vibration measurements.

A portable rms digital voltmeter has been developed at NBS to support vibration measurements over the ranges of 0.1 Hz to 50 Hz and 2 mV to 10 V. A self-contained calibrator provides for self-calibration and may be used for calibrating other very low frequency voltmeters. The calibrator basically consists of a Kelvin-Varley divider fed by a reference voltage (either dc or sine wave generated by a ROM-DAC combination). A multijunction thermal converter (MJTC) was selected as the sensing device in the rms/dc converter of the DVM since its low ac/dc difference facilitates calibration of the ac calibrator. Factors affecting accuracy and response time are analyzed. The DVM response time is 40s for the lowest input frequency. Its accuracy (percent of reading) is 0.1 percent above 0.5 Hz and 5 mV and 0.2 percent below these values. The ac calibrator accuracy is 0.02 percent. Measurement accuracy improves by a factor of about 4 for transfer measurements (comparing input voltages with ac calibrator voltages). Means for extending this accuracy to 0.01 percent are discussed.

18217. Flannery, M. R., Yang, T. P., Ionic recombination of Kr^+ and Kr_2^+ with F^- in dense buffer rare gases, *Appl. Phys. Lett.* **33**, No. 7, 574-576 (Oct. 1, 1978).

Key words: ion-ion recombination; rare gas-halide laser rates.

Rates, α , for the recombination of Kr^+ and Kr_2^+ with F^- in various buffer rare gases (He, Ne, Ar, Kr, Xe) at 300 K are calculated for a wide range of gas pressures. For pressures 1-5 atm, the population of KrF^* via recombination is greatest for Ne and Ar as third bodies, yielding $\alpha \sim 3 \times 10^{-6}$ $\text{cm}^3 \text{ sec}^{-1}$, while for pressures ≥ 10 atm, He is to be preferred as a buffer gas.

18218. Haisch, B. M., Linsky, J. L., Snee, O. B., Hearn, D. R., Walker, A. R., Rydgren, A. E., Nicolson, G. D., A coordinated x-ray, optical, and microwave study of the flare star Proxima Centauri, *Astrophys. J.* **225**, No. 1, L35-L37 (Oct. 1, 1978).

Key words: flare-stellar; optical flare emission; radio emission; soft x ray.

We report the results of a 3 day coordinated observing program to monitor the flare star Proxima Centauri in the X-ray, optical, and radio spectrum. During this interval 30 optical flares and 12 possible radio bursts were observed. The SAS 3 X-ray satellite made no X-ray detections. We derive an upper limit of $L_x/L_{opt} < 0.08$ for the brightest optical flare. The most sensitive of the radio telescopes failed to detect 6 cm emissions during one major and three minor optical flares, and on this basis we derive an upper limit on the flare radio emission, $L_R/L_{opt} < 2 \times 10^{-5}$.

18219. Stwalley, W. C., Uang, Y. H., Pichler, G., Pure long-range molecules, *Phys. Rev. Lett.* **41**, No. 17, 1164-1167 (Oct. 1978).

Key words: analytical potentials; chemical bond lengths; internuclear distance; long range molecules.

We describe a new type of molecular electronic state in which all vibrational levels occur entirely at internuclear distances large compared to ordinary chemical-bond lengths. We present explicit calculations for two such electronic states of O_2 and I_2 symmetry in the Na_2 molecule which are near the $\text{Na}(3P_{3/2}) + \text{Na}(3S_{1/2})$ dissociation asymptote. We feel experimental observation of such levels is possible.

18220. Booker, R. L., Luminance-brightness comparisons of LED alpha-numeric sources at suprathreshold levels, *J. Opt. Soc. Am.* **68**, No. 7, 949-952 (July 1978).

Key words: brightness; human observers; luminance; photometry; spectroradiometry; vision.

An experiment was conducted in which observers adjusted the luminance of a 2856 K white comparison source to appear equally as bright as a red, yellow, or yellowish-green LED alpha-numeric source. Although the present CIE photometric system predicts brightness-luminance ratios of 1.0, the ratios obtained in this experiment, for the mean observer, were 1.13 for the yellowish-green, 1.28 for the yellow, and 2.54 for the red. These results demonstrate that there can be substantial differences between photometric luminance based on the $V(\lambda)$ function and brightness as perceived visually.

18221. Bowen, R. L., Chandler, H. H., Wyckoff, H. O., Jr., Misra, D. N., Metal-filled resin composites. II, *J. Dent. Res.* **57**, No. 2, 213-220 (Feb. 1978).

Key words: adhesion; composite resins; coupling agents; fillers; metals; polymerization; silanes.

Various particulate materials were combined with a BIS-GMA resin, and the resulting composites were evaluated. The fillers prevented, altered, had no apparent effect, or accelerated polymerization. Coupling agents also influenced polymerization. Physical properties varied widely with different fillers.

18222. Bowen, R. L., McClendon, L. T., Gills, T. E., Adhesive bonding of various materials to hard tooth tissues. XV. Neutron activation analysis of dentin sorption of mordant salts, *J. Dent. Res.* **57**, No. 2, 255-260 (Feb. 1978).

Key words: adhesion; adsorption; dental materials; ion exchange; mordant; neutron activation.

Five metallic chlorides were compared simultaneously, with regard to their interaction with dentin surfaces. Neutron activation analysis was used to measure the quantities absorbed. Each metal was bound by dentin to some extent during a 60-second exposure, and was not removed during a 20-second rinse with distilled water. Quantitatively, the gram-atom amounts of ions sorbed increased in the order $\text{Co} < \text{Al} < \text{Zn} \sim \text{Cu} < \text{Fe}$. These mordant salts warrant further study as a possible means of improving adhesive bonding between dental resins (via polyfunctional surface-active comonomers) and dentin.

18223. Florin, R. E., Free radicals in stretched vinylidene chloride copolymer, *J. Polym. Sci.: Polym. Phys. Ed.* **16**, No. 10, 1877 (Oct. 1978).

Key words: chloranil; free radicals; mechanochemistry; vinylidene chloride polymer.

Free radicals were observed in filaments of vinylidene chloride copolymer, stretched to breaking, with the aid of chloranil as a free-radical trap.

18224. Herron, J. T., Huie, R. E., Stopped-flow studies of the mechanisms of ozone-alkene reactions in the gas phase

propene and isobutene, *Int. J. Chem. Kinet.* X, 1019-1041 (1978).

Key words: gas; isobutene; mass spectrometer; mechanism; ozone; propene; reaction.

The reactions of ozone with propene and isobutene have been studied in the gas phase at 298°K and 530 Pa (4 torr) using a stopped-flow reactor coupled to a photoionization mass spectrometer. Reactant and product concentrations were followed as a function of reaction time. The major reaction products monitored were CH₂O, CH₃CHO, CO₂, and H₂O from the propene reaction, and CH₂O, (CH₃)₂CO, CO₂, and H₂O from the isobutene reaction. The observations were interpreted on the basis of the Criegee mechanism for ozonolysis in solution for which we find $k_A \approx k_B$. In the gas phase the carbene peroxy radical is postulated to isomerize and decompose into molecular and free-radical products.

18225. Lamaze, G. P., Schrack, R. A., Wasson, O. A., A new measurement of the ⁶Li(n,α)T cross section, *Nucl. Sci. Eng.* 68, No. 2, 183-188 (1978).

Key words: flux measurement; H(n,p); neutrons; standards; time-of-flight; ⁶Li(n,α)T.

The shape of the ⁶Li(n,α)T cross-section curve has been measured from 3- to 800-keV neutron energy. The neutrons were produced by the National Bureau of Standards 140-MeV Linac, and the measurements were made along the 200-m above-ground drift tube. The neutron flux was monitored by a 61-cm-long hydrogen gas proportional counter giving a direct ratio of the ⁶Li(n,α) cross section to the H(n,p) cross section. The ⁶Li(n,α) events were detected in a 0.5-mm-thick piece of ⁶Li glass (NE-912). The results were normalized to ENDF/B-V in the region from 10 to 100 keV. Overall uncertainties in the measurement are ~2 percent in the range from 10 to 400 keV. Error analysis and comparisons with previous measurements are given.

18226. Little, J. L., A computer network protocol at the application level for libraries and other information science services, *J. Libr. Autom.* 11, No. 3, 239-245 (Sept. 1978).

Key words: application-level protocol; bibliographic services network; book vendors network; computer communications; computer network protocol; computer-to-computer protocol; control header structure; control messages; highest level protocol; interlibrary computer communications; library computer network; protocol.

This paper outlines the essential details of a computer network protocol at the application level for interchanging information between host computers in the community of libraries, including book publishers and bibliographic service centers. The protocol was developed by a task force of seven experts appointed by the National Commission on Libraries and Information Science, with technical assistance from the National Bureau of Standards and from selected consultants. The protocol is confined to the header portion of control and data messages at the application level, which is independent of the topology of the communications subnetwork supporting the network. Control header structure is detailed and a skeleton outline is given for 20 header field types and 15 control message types.

18227. Lyon, G., Packed scatter tables, *Commun. ACM* 21, No. 10, 857-865 (Oct. 1978).

Key words: assignment problem; backtrack programming; hashing; open addressing; recursion; scatter table rearrangements.

Scatter tables for open addressing benefit from recursive entry displacements, cutoffs for unsuccessful searches, and auxiliary cost functions. Compared with conventional methods, the new techniques provide substantially improved tables that resemble exact-solution optimal packings. The displacements are depth-limited approximations to an enumerative (exhaustive) optimization, although packing costs remain linear—O(n)—with table size n. The techniques are primarily suited for important fixed (but possibly quite large) tables for which reference frequencies may be known: op-code tables, spelling dictionaries, access arrays. Introduction of frequency weights further improves retrievals, but the enhancement may degrade cutoffs.

18228. Schrack, R. A., Lamaze, G. P., Wasson, O. A., A measurement of the ¹⁰B(n,αγ)⁷Li cross section in the keV energy region, *Nucl. Sci. Eng.* 68, No. 2, 189-196 (1978).

Key words: alpha particle; boron; neutron cross section; neutron flux; standard; time-of-flight.

The ¹⁰B(n,αγ)⁷Li relative cross section has been measured using the 200-m flight path of the National Bureau of Standards Linac neutron time-of-flight facility. Results are presented from 5 to 700 keV, showing the 5/2- level of ¹¹B at 500 keV.

The neutron flux was monitored with a hydrogen proportional counter. The known n-p scattering cross section was then used to normalize the data to obtain a relative cross section. No attempt was made to obtain an absolute normalization experimentally. Overall accuracy is estimated to be better than 3 percent from 10 to 400 keV.

18229. Wasson, O. A., Schrack, R. A., Lamaze, G. P., Neutron flux monitoring and data analysis for neutron standard reaction cross sections, *Nucl. Sci. Eng.* 68, No. 2, 170-182 (1978).

Key words: hydrogen gas proportional counter; ion pair defect; neutron flux monitor; neutron standards.

The common features used in the measurement ⁶Li(n,α), ¹⁰B(n,αγ), and ²³⁵U(n,f) cross sections presented in three subsequent papers are described. The experiments were performed on the 200-m flight path of the National Bureau of Standards Linac and cover the neutron energy region from 5 to 800 keV. The neutron flux monitor was a hydrogen-filled gas proportional counter located at the end of the flight path, while the primary detectors specific to each of the three cross-section measurements were placed 70 m along the flight path. The properties of the neutron source, the detailed operation of the flux monitor, the data acquisition system, and the data analysis procedure are described. The systematic errors in the neutron flux measurement are given.

18230. Yonemura, G. T., Light and vision, Paper in *Developments in Lighting-1*, J. A. Lynes, Ed., Chapter 2, 25-45 (Applied Science Publishers Ltd., Essex, England, 1978).

Key words: illumination; illumination levels; lighting; task lighting; vision.

Three levels of visual information needs are defined. The psychological responses associated with these information requirements are identified and correlated with their stimulus counterparts. The criteria for recommending levels of illumination should be 'goodness of seeing' rather than 'just barely able to see'. Blur is introduced as a parameter that has been neglected in task description for lighting. The Modulation Transfer Function is recommended as a technique that analyti-

cally describes the classical parameters associated with visual sensory performance as well as blur. The relative contributions of physiological and psychological variables in visual task performance studies are discussed.

18231. Crowder, R. M., **Libraries and the Consumer Communications Reform Act**, *J. Libr. Autom.* **11**, No. 3, 206-222 (Sept. 1978).

Key words: Bell Bill; Consumer Communications Reform Act; history; libraries; library; networks; regulation; telecommunications.

The communications industry is heavily shaped by decisions of the Federal Communications Commission (FCC) and its counterpart commissions in the various states. Responding to liberalized regulations that allowed increased competition, AT&T and other independent carriers supported a bill in the last session of Congress called the Consumer Communications Reform Act (CCRA), familiarly known as the "Bell Bill." Although the bill was never acted on, and the focus of congressional attention is now on the Communications Act of 1978, it is important to understand the issues that the bill addressed. This article reviews the history of federal regulation in the communications industry, places the "Bell Bill" in some historical perspective, and relates the significance of activities in the regulatory sphere to the concerns of libraries.

18232. Dillard, D. D., Waxman, M., Robinson, R. L., Jr., **Volumetric data and virial coefficients for helium, krypton, and helium-krypton mixtures**, *J. Chem. Eng. Data* **23**, No. 4, 269-274 (Oct. 1978).

Key words: helium; helium-krypton mixture; interaction second virial coefficients; krypton; virial coefficients; volumetric data.

Volumetric data for helium, krypton, and three mixtures of helium and krypton (24.8, 49.7, and 74.6 mol % helium) were obtained by the Burnett technique. Measurements were made at temperatures of -50, 0, and 50 °C at pressures between 7 and 150 bar. Compressibility factors and virial coefficients are presented for the pure substances and mixtures, as are the interaction second virial coefficients, B_{12} .

18233. Guiho, J. P., Simoen, J. P., Domen, S. R., **Comparison of BNM-LMRI and NBS absorbed-dose standards for ^{60}Co gamma rays**, *Metrologia* **14**, 63-68 (1978).

Key words: absorbed dose; calorimeters; comparison; national standards; ^{60}Co .

The first comparison of national standards of absorbed dose for ^{60}Co gamma radiation has been carried out by the Laboratoire de Métrologie des Rayonnements Ionisants (LMRI) and the National Bureau of Standards (NBS). The graphite calorimeters were compared in the LMRI ^{60}Co gamma-ray beam. The ratio of the response of the NBS calorimeter to the LMRI calorimeter was 1.003, with a 95 percent confident limit of ± 0.6 percent, and an estimated upper bound to the systematic uncertainties of ± 0.3 percent.

18234. Holton, J. K., **Critical performance standards for passive solar buildings**, *Proc. Conf. Second National Passive Solar Buildings*, Philadelphia, PA, Mar. 16-18, 1978, **11**, 294-297 (University of Delaware, Newark, DE, 1978).

Key words: passive solar systems; performance standards; system classification.

An outline of a limited number of performance standards and evaluation criteria for passive solar buildings is presented. Three levels of criteria are described which are intended to categorize these into a few most needed criteria concerning

basic thermal performance, health and safety, and two levels of additional criteria that are thought desirable to assess long term usefulness of passive installations. Status of development of the criteria is also discussed.

18235. Hudson, R. P., **EPT-76: A provisional temperature scale for the region 0.5K to 30K**, *Proc. ISA-78 National Conf. and Exhibit*, Philadelphia, PA, Oct. 15-19, 1978, pp. 7-11 (Instrument Society of America, Pittsburgh, PA, 1978).

Key words: cryothermometry; temperature; temperature scale; thermometry.

The Advisory Committee on Thermometry (CCT) of the International Committee on Weights & Measures (CIPM) has developed a provisional low temperature scale to cover the range 0.5K to 30K. This scale is intended to serve low temperature scientists in the period between now and the next revision of the International Practical Temperature Scale. The development and implementation of PTS-76 will be discussed.

18236. Retcofsky, H. L., VanderHart, D. L., **^{13}C - ^1H cross-polarization nuclear magnetic resonance spectra of macerals from coal**, *Fuel* **57**, 421-423 (July 1978).

Key words: coal; cross-polarization; C-13; macerals; NMR; solids.

The carbon aromaticities (f_a) of vitrinite, exinite, micrinite and fusinite from a high-volatile A bituminous coal have been determined by ^{13}C - ^1H cross-polarization nuclear magnetic resonance spectrometry. Values of f_a for the four macerals were found to decrease in the order: fusinite > micrinite \approx vitrinite > exinite. Estimates of the average ring size using the f_a value and the elemental composition of each maceral indicated that the fusinite contained the largest polynuclear condensed aromatic ring system (>5 rings) whereas the mean structural unit of the vitrinite contains 3-4 condensed rings.

18237. Schroeder, L. W., Mathew, M., Brown, W. E., **XO_4^{2-} ion hydration. The crystal structure of $\text{Mg}_3(\text{PO}_4)_2 \cdot 22\text{H}_2\text{O}$** , *J. Phys. Chem.* **82**, No. 21, 2335-2340 (1978).

Key words: crystal structure; hydrate; magnesium phosphate; phosphate hydration.

$\text{Mg}_3(\text{PO}_4)_2 \cdot 22\text{H}_2\text{O}$ is triclinic, space group $P\bar{1}$, with $a = 6.902(2)$, $b = 6.961(2)$, $c = 15.982(4)$ Å, $\alpha = 87.66(2)$, $\beta = 85.22(2)$, and $\gamma = 60.81(2)^\circ$. The structure was refined to $R_w = 0.033$, $R = 0.058$ for 1317 observed reflections. The most interesting feature of the structure is that all cations and anions are completely surrounded by water molecules. The $\text{Mg}(\text{H}_2\text{O})_6$ octahedra and PO_4 tetrahedra form a layer structure with the stacking sequence BAABAA.... Each $\text{Mg}(\text{H}_2\text{O})_6$ octahedron in an A layer shares three faces with tetrahedra, and each tetrahedron shares faces with three octahedra in a pseudotrigonal arrangement. The immediate environment of the PO_4 ion consists of 12 water molecules, all of which are hydrogen bonded to PO_4 oxygens. The water molecules are arranged approximately at the vertices of a cuboctahedron. The pair distances associated with this environment may be used to aid in investigations of the structure of phosphate solutions.

18238. Van Blerkom, D., **HD 45166: A dwarf in Wolf-Rayet clothing**, *Astrophys. J.* **225**, No. 1, 175-180 (Oct. 1, 1978).

Key words: binary system; mass loss; stellar atmospheres; Wolf-Rayet stars.

A coarse analysis of the hydrogen and helium lines of HD 45166 is performed, which supports the interpretation that the object is a binary composed of a late B star and a star of approximately one solar radius with a continuous energy distribution very much like that of ζ Pup. It is surrounded by an en-

velope expanding at 150 km s^{-1} formed by mass ejection at a rate of only $5 \times 10^{-6} M_{\odot} \text{ yr}^{-1}$. The small size and low ejection velocity give densities of He II in the envelope of about 10^{11} cm^{-3} . The envelope environment is thus much like that of a normal Wolf-Rayet star, which it mimics with remarkable consistency.

18239. Broadhurst, M. G., Davis, G. T., McKinney, J. E., Collins, R. E., **On the calculation of piezoelectricity and pyroelectricity in polyvinylidene fluoride**, *Proc. 1978 Annual Report Conf. on Electrical Insulation and Dielectric Phenomena*, Gaithersburg, MD, Nov. 3-6, 1975, pp. 85-94 (National Academy of Sciences, Washington, DC, 1978).

Key words: dipoles; piezoelectric; polarization; polymer; polyvinylidene fluoride; pyroelectric; space charge.

A description is given of the molecular and morphological structure of polyvinylidene fluoride and from this description a classical model is proposed for calculating the piezo- and pyroelectric properties. The model consists of an array of crystal lamellae with a net moment from aligned dipoles in the crystals and compensating space charge on the crystal surfaces. The results for no compensation and complete compensation essentially bracket experimentally observed results and indicate that the largest contribution to the activity of this polymer arises from bulk dimensional changes, rather than from changes in molecular dipole moments.

18240. Broadhurst, M. G., Davis, G. T., McKinney, J. E., Collins, R. E., **Piezoelectricity and pyroelectricity in polyvinylidene fluoride—A model**, *J. Appl. Phys.* 49, No. 10, 4992-4997 (Oct. 1978).

Key words: dipoles; piezoelectric; polarization; polymer; polyvinylidene fluoride; pyroelectric; space charge.

A description is given of the molecular and morphological structure of polyvinylidene fluoride and from this description a classical model is proposed for calculating the piezoelectric and pyroelectric properties. The model consists of an array of crystal lamellae with a net moment from aligned dipoles in the crystals and compensating space charge on the crystal surfaces. The results for no compensation and complete compensation essentially bracket experimentally observed results and indicate that the largest contribution to the activity of this polymer arises from bulk dimensional changes rather than from changes in molecular dipole moments.

18241. Davis, G. T., McKinney, J. E., Broadhurst, M. G., Roth, S. C., **Electric-field-induced phase changes in poly(vinylidene fluoride)**, *J. Appl. Phys.* 49, No. 10, 4998-5002 (Oct. 1978).

Key words: chain conformation; corona poling; crystal phase transformation; field-induced phase change; piezoelectric polymer polar crystal; polarization; poly(vinylidene fluoride); pyroelectric polymer.

The antipolar crystal form of poly(vinylidene fluoride) can be made piezoelectric and pyroelectric by the temporary application of electric fields in excess of 1 MV/cm at room temperature. Infrared and x-ray diffraction data reveal that the polarization occurs in two stages. At fields near 1 MV/cm, a phase transition to a polar form II occurs with presumably no change in chain conformation. Fields near 5 MV/cm cause a change in conformation to produce form I. Our results indicate that at least a portion of the residual polarization occurs within the crystal phase of the polymer.

18242. Dise, J. R., **Quality in concrete testing**, *Am. Soc. Test. Mater., Spec. Tech. Publ.* 169-B, 44-48 (1978).

Key words: concrete; laboratory evaluation; quality assurance; quality of testing; significance of testing; testing.

Quality in testing of concrete is of interest to everyone concerned with its use in construction. Some of the causes of failures to obtain satisfactory test results are enumerated; and ways of avoiding difficulties or of obtaining assistance when problems occur are discussed. Some of the more significant efforts that are being made to advance the quality of concrete testing are described with the hope that this recognition will be of assistance to the sponsoring organizations.

18243. Eberly, J. H., **Application of extended two-level model theory to Doppler-, laser- and collision-broadened bound-bound multiphoton absorption**, *Phys. B* 11, No. 20, L611-L614 (1978).

Key words: Doppler broadening; laser bandwidth effects; multiphoton absorption; multiphoton resonance; two-level model.

It is pointed out that recent observations allow the first quantitative tests of the ability of theories of multiphoton-resonant processes to deal with Doppler, laser and collisional broadening in bound-bound transitions. We compare the predictions of a certain extended two-level (ETL) model of multiphoton-resonant phenomena with these observations.

18244. Etz, E. S., Rosasco, G. J., Heinrich, K. F. J., **Chemical analysis of stationary source particulate pollutants by micro-Raman spectroscopy**, *Interim Report U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/2-78-193 Report*, 46 pages (Available from National Technical Information Service, Springfield, VA 22161, Aug. 1978).

Key words: air pollution; chemical analysis; particles; Raman spectroscopy; sulfates; vanadium oxides.

The application of laser-Raman spectroscopy to the molecular characterization of individual particulates from stationary sources is described. This research was performed using the NBS-developed Raman microprobe. Analytical capability to identify the principal molecular species present in microparticles is demonstrated on the basis of Raman spectra of selected compounds and materials. Among the inorganic species studied are sulfates, nitrates, carbonates and oxides, for which Raman spectra are discussed for single, solid particles of size down to 1 micrometer. Preliminary results on liquid sulfate particles generated from sulfuric acid aerosol are presented. The method of micro-Raman analysis is applied to the characterization of microparticles from power plant emissions. Raman spectra have been obtained from microparticles of oil-fired power plant emissions collected by the EPA with cascade impaction samplers.

Vanadium pentoxide, V_2O_5 , has been identified as a major component of microparticles present in such samples. The presence of certain other vanadium containing species such as vanadyl, VO^{2+} , and ortho-vanadate, VO_4^{3-} is not indicated from the results of these measurements. Other Raman spectra show evidence of crystalline sulfate, SO_4^{2-} , as a species present in major proportions. However, the exact nature of the associated cation specie(s) has not been determined. Many of the spectra obtained from fly ash particles show Raman bands characteristic of polycrystalline graphite. These carbon bands appear to derive, in the majority of cases, from the presence of carbonaceous material associated with the particles. The need for further work is indicated from these exploratory measurements. Recommendations are made as to the scope and direction for this work.

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18245. Harman, G. G., Cannon, C. A., **The microelectronic wire bond pull test—How to use it, how to abuse it**, *IEEE Trans. Components, Hybrids, Manuf. Technol.* CHMT-1, No. 3, 203-210 (Sept. 1978).

Key words: bond; interlaboratory comparison; microelectronic; pull test; ultrasonic bond; wire bond.

The wire bond pull test is the most universally accepted method for controlling the quality of the wire bonding operation, and thereby offering added assurance that semiconductor devices will not fail in the field due to weak wire bonds. Specific test procedures and pull-force values are called out in military and other device purchase specifications, and yet there has never been a carefully controlled interlaboratory comparison of this important test. All of the variables that are known to affect the bond pull test are examined including ones that cannot be treated theoretically, such as bond peeling and tearing. Careless pulling methods and other abuses that affect test results are described and the results of an eight-organization interlaboratory pull test experiment are given. The conclusions are 1) attempts to cut costs during the test by following nonstandard procedures will generally result in pull-force values that are lower than those that would be obtained were the test conducted carefully in accordance with standard procedures; 2) Overdeformed bonds tend to show a larger percentage change in pull strength due to nonstandard pulling procedures than do less deformed bonds; 3) Although artificially inflated pull-force values can be obtained when one bond is significantly stronger than the other, the effort of intentionally exploiting this difference (cheating) in most cases is greater than any benefit derived.

18246. Hofmann, H., Leone, S. R., **Tunable laser photodissociation of Hgl₂: Quantum yield for formation of excited I(5²P_{1/2}) atoms**, *J. Chem. Phys.* 69, No. 8, 3819-3825 (Oct. 15, 1978).

Key words: mercuric iodide; photodissociation; photofragment spectroscopy; quantum yield; tunable laser.

Tunable laser, infrared fluorescence techniques are used to study the detailed photodissociation dynamics of the linear triatomic molecule Hgl₂. The quantum yield of excited I(5²P_{1/2}) atoms has been measured in the first long wavelength absorption band of Hgl₂ from 265 to 320 nm. From quantitative measurements of the yield of excited I atoms, it is shown that the total absorption cross section in this region is actually composed of two distinct components. These components correspond to states leading to both excited and ground state I atoms according to the processes Hgl₂ → Hgl + I or I*. From the time decay of the excited I* atoms as a function of Hgl₂ pressure, the collisional deactivation rate of I* by the parent Hgl₂ molecule has been obtained. This quenching rate constant is $4.5 \pm 0.2 \times 10^{-10} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ at $T = 453 \text{ K}$, which, is essentially a gas kinetic rate.

18247. Kelch, W. L., Linsky, J. L., **Physical properties of solar chromospheric plages. III. Models based on Ca II and Mg II observations**, *Sol. Phys.* 58, No. 1, 37-45 (1978).

Key words: line formation; sun, atmosphere; sun, chromosphere; sun, plages.

We compute a new grid of plage models to determine the difference in temperature versus mass column density structure $T(m)$ between plage regions and the quiet solar chromosphere, and to test whether the solar chromosphere is geometrically thinner in plages. We compare partial redistribution calculations of Mg II h and k and Ca II K to NRL *Skylab* observations of Mg II h and k in six active regions and Ca II K intensities obtained from spectroheliograms taken at approximately the

same time as the Mg II observations. We find that the plage observations are better matched by models with linear (in log m) temperature distributions and larger values of m_0 (the mass column density at the 8000 K layer in the chromosphere), than by models with larger low chromosphere temperature gradients but values of m_0 similar to the quiet Sun. Our derived temperature structures are in agreement with the grid originally proposed by Shine and Linsky, but our analysis is in contrast to the study by Kelch which implies that stellar chromospheric geometrical thickness is not affected by chromospheric 'activity'. We conclude that either the stellar Mg II observations upon which the Kelch study was based are of poorer quality than had been assumed, or that the spatial averaging of inhomogeneous structures, which is inherent in the stellar data, does not lead to a best fit one-component model similar in detail to that of a stellar or a solar plage.

18248. Light, J., Szöke, A., **Four-state model of optical collisions: Sr + Ar**, *Phys. Rev. A* 18, No. 4, 1363-1372 (Oct. 1978).

Key words: collisions; collisions in the presence of lasers; high-intensity lasers; interactions with high-intensity lasers.

The semiclassical theory of electronic excitation of an atom in a strong nonresonant laser field due to a collision with another atom is presented. It is shown that in the presence of asymptotic degeneracy of the excited state the Landau-Zener two-state model is inaccurate, the exact solution of a two-state model is inaccurate, and both differ qualitatively from the accurate solutions of the equations when all (four) states are included. With parameters chosen to model the process $\text{Sr}(^1S) + \text{Ar} + \hbar\omega \rightarrow \text{Sr}(^1P) + \text{A}_1$, cross sections on the order of 10^{-14} cm^2 are obtained for $\hbar(\omega - \omega_0) \sim 17 \text{ cm}^{-1}$ over a large range of the Rabi frequency. Depolarization predominates at high field strengths.

18249. Mattis, R. L., Doggett, M. R., **A microelectronic test pattern for analyzing automated wafer probing and probe card problems**, *Solid State Technol.* 21, No. 11, 76-79 (Nov. 1978).

Key words: automated measurements; integrated circuits; probe card; probe pads; probing; test pattern; wafer testing.

The testing of integrated circuits or test patterns at the wafer level requires reliable probing capability in order that apparent defects or device failures can be confidently attributed to processing problems rather than probing problems. A test pattern has been developed which consists primarily of interconnected probe pads of several sizes. Using this pattern, high-speed probing capability can be evaluated, and probing problems such as misorientation between wafer and probes and prober run-out can be detected.

18250. McClintock, W., Henry, R. C., Linsky, J. L., Moos, H. W., **Ultraviolet observations of cool stars. VII. Local Interstellar hydrogen and deuterium Lyman-alpha**, *Astrophys. J.* 225, No. 2, 465-481 (Oct. 15, 1978).

Key words: deuterium; interstellar, abundances; interstellar, matter; ultraviolet, spectra.

We present and analyze high-resolution *Copernicus* observations of the interstellar hydrogen and deuterium $\text{Ly}\alpha$ lines toward ϵ Eri (3.3 pc) and ϵ Ind (3.4 pc). We also reanalyze previous observations toward α Cen A (1.3 pc) and α Aur (14 pc). For these stars the hydrogen and deuterium interstellar parameters are derived independently, with no assumptions concerning the deuterium-to-hydrogen ratio. In all cases profile synthesis leads to a range of acceptable parameters, since very similar absorption profiles result from increasing the hydrogen

density (n_H) while decreasing the Doppler dispersion parameter (b_H) and similarly for n_D and b_D . We conclude that all the stellar and solar system data are consistent with a homogeneous region within 3.5 pc of the Sun in which $n_H \approx 0.10\text{--}0.15 \text{ cm}^{-3}$ and in which the flow velocity is 22 km s^{-1} from the direction $\alpha = 252^\circ$, $\delta = -15^\circ$. Beyond 3.5 pc density probably decreases as $n_H = 0.04\text{--}0.05 \text{ cm}^{-3}$ toward α Aur, but the flow vector is unchanged. There is no conclusive evidence that the deuterium-to-hydrogen ratio toward the four stars is significantly different from the value $1.8 \pm 0.4 \times 10^{-5}$ derived by York and Rogerson toward OB stars. We also conclude that the existence of a nearby interstellar cloud, which Vidal-Madjar *et al.* have proposed as approaching the solar system from 0.03 pc, is not supported by the data.

18251. Prince, E., Wlodawer, A., Santoro, A., **Flat-cone diffractometer utilizing a linear position-sensitive detector**, *J. Appl. Cryst.* **11**, 173-178 (1978).

Key words: diffraction geometry; diffractometer; flat cone; neutron diffraction; position sensitive detector; x-ray diffraction.

The recent development of linear position-sensitive detectors for neutrons and x-rays leads to the possibility of large improvements in the efficiency of data collection in single-crystal diffractometers. In order to take advantage of the properties of a linear position-sensitive detector it is desirable to use a diffraction geometry which causes the diffracted beams from many different reflecting planes to lie in a common plane. A design for a diffractometer utilizing the flat-cone geometry is described, and the relevant mathematical formulas are summarized. An instrument using this design has been constructed as a modification to an existing four-circle diffractometer and is now operating. Practical details of its construction, of the collection and handling of data, and of data rates are discussed.

18252. Rogers, W. T., Olsen, J. O., Dunn, G. H., **Absolute emission cross section for electron-impact excitation of Li^+ to the (2^3P) level**, *Phys. Rev. A* **18**, No. 4, 1353-1362 (Oct. 1978).

Key words: electron impact; excitation cross sections; Li^+ ; positive ion.

Crossed beams of electrons and Li^+ ions have been used to measure the absolute emission cross section for the process, $e + \text{Li}^+(1^1S) \rightarrow e + \text{Li}^+(n^3I) \rightarrow h\nu$ (548.5 nm), from below the threshold at 61.26 to 162 eV. The cross section exhibits the sharp onset at threshold characteristic of positive-ion excitation. The cross section at threshold is deduced to be $2.0 \times 10^{-18} \text{ cm}^2$, decreasing to $0.2 \times 10^{-18} \text{ cm}^2$ at 162 eV. Total uncertainties at a 68 percent confidence level are typically about ± 15 percent. Pronounced structure is observed in the near-threshold region. From about 1.5 times the threshold energy to the highest energies measured, the cross section follows the generally predicted E^{-3} behavior for $1S$ to $3P$ transitions. Theoretical predictions of the cross sections differ from one another by up to a factor of 2, and none appears to fit the data really well.

18253. Rowe, J. M., Rush, J. J., **The dynamics of hydrogen in metals**, Paper IAEA-SM-219/131 in *Neutron Inelastic Scattering 1977*, II, 303-316 (International Atomic Energy Agency, Vienna, Austria, 1978).

Key words: coherent; dynamics; hydrides; metals; neutron scattering; phonons.

The results of a series of measurements of the acoustic and optic modes of the phonon dispersion relation of high concentration metal-hydrogen alloys are presented. The data are correlated with other physical properties where possible and points

of similarity and difference for various types of alloy are brought out.

18254. Ventre, F. T., **Decision-aiding communications in the regulatory agency: The partisan uses of technical information**, *Ind. Forum* **8**, No. 1, 15-28 (1977).

Key words: building codes; decision making; public policy; regulation.

Based on a nationally representative survey of 1200 municipal building departments, the partisan uses of information in a regulatory setting are described. Each of the surveyed agencies was facing a specific decision to alter its regulations to accommodate innovative building techniques. The agencies identified the various members of the building community—builders, designers, vendors, users, regulators—who came forward to initiate the change, to discuss its advantages or disadvantages, and then to assert a position, either supporting or resisting the agency decision, to modify the regulations. The local building industry—accused by many of being the greatest source of resistance to technical innovation—was found to be the strongest force for change, equalling and sometimes surpassing the positive influence of the model code groups.

18255. Weber, L. A., **Thermodynamic and related properties of oxygen from the triple point to 300 K at pressures to 1000 bar**, *NASA Reference Publication 1011*, 162 pages (NASA Lewis Research Center, Cleveland, OH, 1977).

Key words: density; enthalpy; entropy; oxygen; properties of fluids; specific heat; velocity of sound.

NBS compressibility measurements and thermodynamic properties calculations for oxygen have been extended to higher pressures. The results of a new experimental program are presented in the form of PVT data in the temperature range 58-300 K at pressures up to 800 bar. Tables of the derived thermodynamic properties on isobars to 1000 bar are given, including density, internal energy, enthalpy, entropy, specific heats at constant volume and constant pressure, velocity of sound, and the surface derivatives $(\partial P/\partial T)_\rho$ and $(\partial P/\partial \rho)_T$. Auxiliary tables in engineering units are also given. The accuracy of the data is discussed and comparisons are made with previous data.

18256. Broadhurst, M. G., Davis, G. T., Roth, S. C., Collins, R. E., **Pyroelectricity and charge transport in a copolymer of vinylidene fluoride and tetrafluoroethylene**, *Proc. Conf. Electrical Insulation and Dielectric Phenomena, Buck Hill Falls, PA, Oct. 18-21, 1976*, pp. 38-47 (National Academy of Sciences, Washington, DC, 1978).

Key words: charge transport; piezoelectric; polarization distribution; poling temperature; polyvinylidene fluoride copolymer; pyroelectric; thermal pulse.

A copolymer of 73 weight percent vinylidene fluoride and 27 weight percent tetrafluoroethylene can be made piezoelectric and pyroelectric by the temporary application of high electric fields. The application of a thermal pulse technique to the active films reveals that they are polarized preferentially near the positive electrode and that the polarization extrudes further into the film as the poling temperature is increased. These observations can be made consistent with earlier data which show the piezoelectric and pyroelectric coefficient to be independent of poling temperature by proposing charge transfer through the unpoled region of the polymer. Transient charge flow following a step-increase in temperature and pyroelectric response from layered structures support this explanation.

18257. Kurylo, M. J., **Flash photolysis resonance fluorescence investigation of the reaction of OH radicals with dimethyl sulfide**, *Chem. Phys. Lett.* **58**, No. 2, 233-237 (Sept. 15, 1978).

Key words: atmospheric; kinetics; OH radical; resonance fluorescence; sulfur cycle.

Rate constants for the reaction of OH radicals in a homogeneous gas phase reaction with dimethyl sulfide have been determined using the flash photolysis resonance fluorescence technique over the temperature range 273-400 K. The data (combined with the results of another recent study) can be fit to the Arrhenius expression $k = (6.08 \pm 2.54) \times 10^{-12} \exp[(134 \pm 135)/T] \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ applicable from 273-426 K. The results are discussed in terms of reaction mechanisms and in light of recent suggestions that dimethyl sulfide plays an important role in the transport of natural sulfur to the earth's atmosphere.

18258. Kurylo, M. J., **Flash photolysis resonance fluorescence investigation of the reactions of OH radicals with OCS and CS₂**, *Chem. Phys. Lett.* **58**, No. 2, 238-242 (Sept. 15, 1978).

Key words: atmospheric; kinetics; OH radicals; resonance fluorescence; sulfur cycle.

Rate constants for the reaction of OH radicals with OCS and CS₂ have been determined at 296 K using the flash photolysis resonance fluorescence technique. The values derived from this study are $k_{OH+OCS} = (5.66 \pm 1.21) \times 10^{-14} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ and $k_{OH+CS_2} = (1.85 \pm 0.34) \times 10^{-13} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$, where the uncertainties are 95 percent confidence limits making allowance for possible systematic errors.

18259. Larrabee, R. D., **"X"-levels in indium-doped silicon**, *Proc. Joint Meeting IRIS Specialty Groups on Infrared Detectors and Imaging, Annapolis, MD, June 13-15, 1978*, pp. 253-261 (Infrared Information and Analysis Center, Arlington, VA, Aug. 1978).

Key words: detectors; electrical measurements; Hall measurements; optical measurements; semiconductors; silicon.

Evidence for the existence of a new acceptor level in indium-doped silicon was reported at last year's IRIS Detector Specialty Meeting and subsequently reported in the literature. Since the apparent activation energy of this level does not correspond to any known elemental dopant or dopant complex, its nature is somewhat obscure; thus, it has been called the "X"-level. One of the major applications of indium-doped silicon is for monolithic infrared imaging arrays, and such arrays can be seriously degraded by the presence of "X"-levels. Therefore, a project was initiated to independently reproduce the evidence for "X"-levels, to reexamine that evidence, and to determine if this evidence necessarily implies the existence of a new acceptor level or represents some artifact of the measurement or analysis techniques used. A donor addition experiment was performed with Hall and detector samples of indium-doped silicon that clearly demonstrated the validity of the "X"-level interpretation of the original Hall data. These results show that, in spite of the assumptions inherent in the analysis of Hall data, this technique forms the basis of a definitive method for measuring "X"-level concentrations in silicon heavily doped with indium.

18260. Lee, S. A., Helmcke, J., Hall, J. L., Stoicheff, B. P., **Doppler-free two-photon transitions to Rydberg levels: Convenient, useful, and precise reference wavelengths for dye lasers**, *Opt. Lett.* **3**, No. 4, 141-143 (Oct. 1978).

Key words: dye laser spectroscopy; rubidium atoms; two-photon spectroscopy; wavelength reference.

We used a tunable cw dye laser to observe Doppler-free two-photon transitions to alkali-atom Rydberg levels. Real-time signals were obtained in an ionization cell of appropriate construction. The two-photon transition wavelengths to rubidium *s* levels were measured up to $n = 50$ with better than 1×10^{-7} ab-

solute accuracy and can be represented to within the experimental precision by a simple function of the principal quantum number. Other related transitions and future possibilities are considered.

18261. Linsky, J. L., **In-flight performance of the IUE**, *Nature* **225**, 377-385 (Oct. 5, 1978).

Key words: binary stars; chromospheres; stellar spectra; ultraviolet.

After the IUE's successful launch into an eccentric geosynchronous orbit, and following initial spacecraft checkout, observations were made of a set of high priority targets as an insurance against premature failure of the system. These were followed by the systematic performance evaluation of the various spacecraft and scientific instrument sub-systems, some of which were optimized in orbit. The optical performance of the telescope and spectrograph and the photometric performance of the SEC cameras used as spectrum detectors all seem satisfactory, but the ground data processing system although operational needs further development.

18262. Prince, E., Choi, C. S., **Ammonium azide**, *Acta Cryst.* **B34**, 2606-2608 (1978).

Key words: ammonium azide; ammonium compounds; azide compounds; crystal structure; neutron diffraction; structure refinement.

NH₄N₃, orthorhombic, *Pmna*, $Z = 4$, $a = 8.948(3)$, $b = 3.808(2)$, $c = 8.659(3) \text{ \AA}$, $D_c = 1.352$ and $D_m = 1.352 \text{ g cm}^{-3}$. Final *R* was 0.054 for 233 observed neutron reflections and a constrained model in which two independent azide groups were treated as rigid bodies. The corrected N—N distance is 1.186(4) Å in both azide groups. There are two strong N—H...N hydrogen bonds, with N—N distances of 2.975(4) and 2.967(3) Å.

18263. Uriano, G. A., **Standard reference materials and quality control**, (Proc. 25th Western Regional Conf., Las Vegas, NV, Oct. 19-20, 1978), Paper in *In Pursuit of Perfection*, pp. 27-36 (American Society for Quality Control, Milwaukee, WI, 1978).

Key words: accuracy; measurement systems; standard reference materials.

The use of NBS Standard Reference Materials (SRM's) in assuring the accuracy of measurements is reviewed with emphasis on the role of SRM's in production quality control. Examples are given of the use of recently developed SRM's in quality control applications involving the production of copper, electronic components and clinical thermometers.

18264. Van Cott, H. P., Kramer, J. J., **Toward the collection of critically evaluated ergonomics data**, *Proc. Human Factors Society 22d Annual Meeting, Detroit, MI, Oct. 16-19, 1978*, pp. 617-619 (Human Factors Society, Santa Monica, CA, 1978).

Key words: anthropometry; critical evaluation; data bases; ergonomics; human engineering; human factors; human performance; information systems.

At the 1977 meeting of the HFS a concept was presented for a Standard Ergonomics Reference Data System. The system would have two goals (1) the critical evaluation and integration of data from the existing published ergonomics literature, and (2) the development and application of standard measurement methods to collect key ergonomics data representative of the U.S. population not found in the published literature in a reliable form. This presentation will cover progress made in 1978 to assess user data needs and develop critical evaluation

criteria, in light of significant overall program planning changes.

18265. Billick, I. H., Hall, W. G., Shier, D. R., *Analysis of lead level measurements obtained in a survey of dwelling units in Pittsburgh, Pennsylvania*, *Proc. 4th Joint Conf. on Sensing of Environmental Pollutants, New Orleans, LA, Nov. 6-11, 1977*, pp. 810-813 (American Chemical Society, New York, NY, 1978).

Key words: data analysis; housing; lead paint; lead poisoning; survey; x-ray fluorescence.

This paper presents statistical analyses carried out using lead paint levels from approximately 3300 dwelling units, randomly selected from the city of Pittsburgh, Pennsylvania. The primary purpose of the survey was to assess (using a detailed series of lead level measurements) the extent, magnitude and distribution of lead-based paint within the dwelling units. In addition, measurements of lead levels were recorded for exterior surfaces of some of the dwelling units. The lead level measurements (in mg Pb/cm²) were obtained using a portable x-ray fluorescence lead detector. Measurements typically were taken from walls, ceilings, windows, doors and baseboards in all accessible rooms of the dwelling unit. Statistical analyses of the x-ray fluorescence measurements confirmed and quantified certain expected relations: namely, that older dwelling units exhibit considerably greater lead levels than newer housing units and that exterior surfaces show higher levels than corresponding interior surfaces. In addition, the variation of lead levels by occupancy class, room type, surface type, and surface condition were analyzed. The relations between such variables and observed lead levels can prove useful in focusing on which dwelling unit types (and at which locations in dwelling units) excessive lead levels are likely to be found.

18266. Harrison, J. O., Jr., *Approaches to program correctness*, *J. Tech. Councils Am. Soc. Civ. Eng.* **104**, No. TCI, 39-41 (Nov. 1978).

Key words: correctness proof; diagnostics; program specifications; program testing; program verification; structured programming.

At the beginning of the computer age, programs were verified primarily by spot checking them against precomputed values. Except for programmed diagnostics, which detect only specific classes of errors, this is still the only verification technique in general use today.

A great deal of research is being devoted to new approaches. Generally speaking, these fall into three broad categories: systematic program testing, mathematical proofs of program correctness, and writing programs so that they are known to be correct in the first place. The last of these, writing programs that are known to be correct, appears to be already developed and ready for use. The first, systematic program testing, has reached the computer assisted stage. The extent of its usefulness in this form and the prospects for extending it to a fully automatic technique remain to be seen. The second, mathematical proofs of program correctness, will be restricted in its application to relatively trivial problems until at least one serious fundamental difficulty is overcome—the development of more powerful theorem provers.

18267. Kayser R. F., Jr., Raveché, H. J., Wood, W. W., *Comments on the closure problem in the statistical theory of fluids*, *J. Chem. Phys.* **69**, No. 10, 4617-4620 (Nov. 15, 1978).

Key words: closure; fluids; nonconservative forces; path dependence; potential of mean force; quadruplet correlation.

It is shown that if the BBGKY hierarchy is truncated by the approximation for the quadruplet correlation function $g_{1234} =$

$g_{12}g_{13}g_{14}g_{23}g_{24}g_{34}$, the resulting system of equations yields solutions for g_{12} and g_{123} which are path dependent. This result is consistent with an earlier argument by Raveché and Green that the closure leads to a nonconservative force on a particle in a fixed triplet of particles. The magnitude of the path dependence is investigated and its consequences are discussed.

18268. Pezoldt, V. J., Persensky, J. J., RameySmith, A. M., *Lawnmower safety research*, *Proc. Human Factors Society 22d Annual Meeting, Detroit, MI, October 16-19, 1978*, pp. 659-663 (Human Factors Society, Santa Monica, CA, 1978).

Key words: anthropometry; human factors; lawn mowers; psychophysics; reaction time; safety research.

The Human Factors Group at the National Bureau of Standards (NBS) has supported the Consumer Product Safety Commission (CPSC) during the development and evaluation of a power lawn mower safety standard. This support provided CPSC with data concerning how lawn mower users interact with power mowers. Three studies assisted CPSC in resolving specific questions concerning requirements in the proposed safety regulation based on a report from Consumers Union (Consumers Union, 1975).

18269. Schneeberger, T. J., Linsky, J. L., Worden, S. P., *The helium triplet-to-singlet ratio in T Tauri stars*, *Astron. Astrophys.* **62**, 447-448 (1978).

Key words: helium lines; T Tauri stars.

The He I lines at $\lambda 5876$ and $\lambda 6678$ are used to determine the triplet-to-singlet ratio for T Tauri stars DF Tau and BP Tau. The ratio is approximately 3. Line profiles and absolute intensities are presented.

18270. Van Blerkom, J., Van Blerkom, D., *The effect of an expanding dust cloud on radial velocity measurements*, *Astrophys. J.* **225**, No. 2, 482-487 (Oct. 15, 1978).

Key words: cosmic maser sources; radial velocities; radiation transfer; scattering.

Radial velocities of "supergiant" maser sources, such as VY CMa, do not always agree with what would be expected if the maser emission originates in an expanding spherical shell. It has been proposed that the photospheric absorption lines are shifted to the red by scattering off dust grains in the shell. A Monte Carlo computation of this process is performed here. The results strongly support the scattering hypothesis, although the question of how the redshift can disappear in only a few years is bothersome. In particular, it is shown that if the spectrum of α Her is passed through an expanding dust shell, the emergent spectrum is remarkably close to that of VY CMa.

18271. Alvarez, R., Rook, H. L., *Standard reference materials 1567, Wheat Flour, and 1568, Rice Flour, certified for concentrations of selected trace element nutrients and environmentally important constituents*, *Proc. 10th National Conf. on Wheat Utilization Research, Tucson, AZ, Nov. 16-18, 1977*, pp. 156-162 (U.S. Dept. of Agriculture, Berkeley, CA, Aug. 1978).

Key words: flour, unfortified; NBS standard reference materials 1567; nutrients, wheat and rice flour; rice flour; wheat flour.

The National Bureau of Standards has issued two unfortified flour Standard Reference Materials—a bleached wheat flour and a rice flour. The Certificates of Analysis for SRM 1567, Wheat Flour, and SRM 1568, Rice Flour list concentration values for selected trace element nutrients, environmentally important elements, and other trace elements of undefined func-

tion. These SRM's were developed because of the importance of trace elements, which are present in foods at or below the parts-per-million level and because of the difficulty of determining them reliably. The certified reference materials are intended primarily for evaluating the accuracy of these elemental determinations in flours and other cereal foods. They will be useful for developing reliable trace element methods, for calibrating the instrumentation used in these analyses, and for providing certified values to which experimental data acquired at different times by the same or different laboratories can be compared.

18272. Bowen, R. L., **Adhesive bonding of various materials to hard tooth tissues—Solubility of dentinal smear layer in dilute acid buffers**, *Int. Dent. J.* **28**, No. 2, 97-107 (1978).

Key words: acid; adhesion; buffer; dental materials; dentin; disturbed layer; pH; pK; smear layer; solubility; surface; toxicity.

Adhesion between composite restorative materials and dentin or cementum surfaces of teeth is severely limited by a "smear layer" (a disturbed surface region), which persists on the surface after it has been cut or mechanically disturbed. Clinically feasible means of removing this layer with acidic solutions were studied; the purpose was to find a solution of highest pH that would accomplish this removal, as evidenced by scanning electron microscopy. Buffer solutions were used, at concentrations isosmotic with tissue fluids. Acids were selected on the basis of pK values, covering the range of 5.12 to 0.64. An attempt was made to avoid toxic compounds, those forming chelate complexes, and those that would precipitate solid phases due to the common ion effect. Freshly cut dentin surfaces were exposed to each solution for 30 seconds, rinsed, dried and examined with SEM. The results suggest that the smear layer dentin can be removed by exposure to a 0.16 molar solution (isotonic with tissue fluids) of monobasic acids with pK values in the range of about 3.8 to about 2.5. Solutions having pH values of about 2.5 ± 0.6 should be given further study.

18273. Candela, G. A., Kahn, A. H., Negas, T., McDaniel, C. L., **Magnetic susceptibility of cerium tantalate compounds**, (Proc. 13th Rare Earths Research Conf., Olgebay Park, WV, Oct. 16-20, 1977), Paper in *The Rare Earths in Modern Science and Technology*, pp. 441-446 (Plenum Press, New York, NY, 1978).

Key words: cerium tantalate; magnetic susceptibility; paramagnetism; theoretical.

The cerium oxide-Ta₂O₅ system contains three trivalent Ce compounds, CeTa₃O₉ (perovskite-type), CeTaO₄ (LaTaO₄ structure-type), and CeTa₂O₁₉. Preparation of single crystals, crystallographic properties, and several unusual oxidation-reduction reactions were detailed in the Proceedings of the 12th Rare Earth Research Conference, 1976. These phases have been further characterized by measurement of the paramagnetism of the Ce³⁺. We have measured the magnetic susceptibilities of the compounds over the temperature range 2 K to 265 K. In contrast to previous interpretation, the data can be explained on the basis of noninteracting Ce³⁺ ions under the influence of cubic crystalline field. The Ce³⁺ ion has the ground state ²F_{7/2} with an effective $g = 6/7$. A cubic field splits the ground state into a quartet Γ_8 and a doublet Γ_7 . An analysis of the susceptibility gives a good fit to the data over the complete temperature range. An orbital reduction of the Ce³⁺ magnetic moment of 8 percent was found for the CeTa₃O₉.

18274. Engen, G., **Instrumentation: Six-ports simplify network analysis**, *Microwave Syst. News*, pp. 54-55 (Jan. 1978).

Key words: automatic network analyzer; microwave; microwave measurements; six-port.

The concept of the 6-port microwave measuring system is introduced and placed in the context of the evolution of microwave measurement technique.

18275. Feldman, A., **Measurement of the photoelastic constants of optical materials**, *Opt. Eng.* **17**, No. 5, 453-462 (Sept.-Oct. 1978).

Key words: acousto-optic; Brillouin scattering; elasto-optic; Fabry-Perot; figure of merit; Fizeau; interferometer; photoelastic; piezobirefringence; piezo-optic; strain; stress; stress birefringence; Twyman-Green.

The photoelastic constants describe the effect of stress or strain on the refractive indices of materials. These coefficients are important in several applications. They are required for the computation of stress-induced optical distortion in optical systems such as high-power laser systems and they are needed for computing figures of merit for materials to be used in acousto-optic devices. Interferometric and polarimetric techniques are described for measuring piezo-optic coefficients under static loading conditions. Acousto-optic and Brillouin scattering techniques are described for measuring elasto-optic constants.

18276. Feldman, A., **Ultralinear bistable electro-optic polarization modulator**, *Appl. Phys. Lett.* **33**, No. 3, 243-245 (Aug. 1, 1978).

Key words: differential optical gain; optical bistability; Pockels cell; polarizer; power limiting; ultralinear modulator.

An optical device utilizing optical feedback has been constructed with a Pockels cell and polarizing components. Two modes of operation of the device are demonstrated. Both modes exhibit optical bistability. It is demonstrated that in one mode of operation the nonlinear dependence of the output intensity as a function of an input optical or electrical signal can be made arbitrarily small compared to the linear dependence.

18277. Kim, C. K., Feldman, A., Horowitz, D., Waxler, R. M., **Temperature dependence of Szigeti effective charge of alkali halides**, *Solid State Commun.* **25**, 397-399 (1978).

Key words: alkali halides; deformation dipole model; KBr; KCl; LiF; NaF; Szigeti effective charge.

The second Szigeti relation was used to obtain the temperature dependence of the Szigeti effective charge, e_s . The results are discussed in the framework of the deformation dipole model. Recent experimental data are used to show that the volume derivatives of e_s of most ionic solids are positive, thus providing evidence that the deformation dipole model is qualitatively valid.

18278. Munro, R. G., **Theory of the pressure dependence of a prototype exchange integral**, *Phys. Rev. B* **17**, No. 12, 4660-4665 (June 15, 1978).

Key words: applications; exchange integral; pressure dependence; theory.

The variation of electron exchange integrals in solids subjected to hydrostatic pressures P is considered by examining a prototype exchange integral J . The quantity $(1/J)(dJ/dP)$ is determined within the context of a theory of solids under hydrostatic pressures in which the application of pressure is represented in terms of the crystal compressibility and two parameters which are associated with electronic screening and wave-function-distortion effects. Pressure variations of magnetic-phase boundaries, exchange-enhanced susceptibilities, and exchange interactions of pairs of Cr³⁺ ions in ruby are considered as examples of the applications of the results.

18279. Peterson, R. L., Gayley, R. I., **Multiple magnetic flux entry into superconducting quantum-interference devices (SQUIDS): A general way of examining the $\cos\phi$ conductance**, *Phys. Rev. B* 18, No. 3, 1198-1206 (Aug. 1, 1978).

Key words: magnetic fields; magnetic flux quanta; Josephson junctions; SQUID's; superconductivity.

A new type of experiment is proposed for obtaining information about the $\cos\phi$ conductance of the Josephson effect. Based on measurement of fluxoid entry into a superconducting ring broken by a Josephson junction, the technique is to operate in the low-damping regime for which the voltage excursions associated with fluxoid entry are small. For this case, the constant-voltage expression containing the $\cos\phi$ conductance should be valid. It is shown that the erraticity associated with the low-damping regime has a predictable statistical pattern, which is rather insensitive to noise but quite sensitive to the $\cos\phi$ term. A shunt resistance can be used to vary the average voltage. Statistics can be accumulated over a large number of similar loops, or over one or a few loops at slightly varying bath temperature between runs, or even over one loop at one temperature provided the noise at the junction has appropriate properties. Thus, the technique would appear to be capable of estimating the controversial coefficient of the $\cos\phi$ term as a function of voltage and temperature for any type of junction for which low damping can be achieved.

18280. Rosasco, G. J., Bennett, H. S., **Internal field resonance structure: Implications for optical absorption and scattering by microscopic particles**, *J. Opt. Soc. Am.* 68, No. 9, 1242-1250 (Sept. 1978).

Key words: complex refractive index; efficiency factor for absorption; electric multipole; internal fields; magnetic multipole; Mie scattering theory; Raman scattering; resonances; small particles.

Mie scattering theory is used to calculate the efficiency factors for absorption by microscopic dielectric spheres. Resonances in the efficiency factors for absorption and resonances in the amplitudes of the electric and magnetic multipoles which occur in an expansion of the fields inside the dielectric sphere are discussed. Several trends in the strengths and width of the various resonances as functions of the absorption coefficient of the sphere, size parameter, multipole order, and multipole resonance number are given. A formal solution for elastic (Mie) and inelastic (Raman) scattering by microscopic particles is derived from the extinction theorem. With this background, some implications of the resonances in the interpretation of absorption, fluorescence, and Raman scattering by microscopic particles are discussed.

18281. Unassigned.

18282. Siedle, A. R., Candela, G. A., Finnegan, T. F., Van Duyne, R. P., Cape, T., Kokozska, G. F., Woyciesjes, P. M., Hashmall, J. A., Glick, M., Ilsley, W., **Metal-tetrathiaethylenes**, (Proc. Synthesis and Properties of Low-Dimensional Materials, New York, NY, Sept. 29, 1978), Paper in *Ann. NY Acad. Sci.* 313, 377-381 (1978).

Key words: charge transfer complex; chlorocuprates; coordination compounds; donor-acceptor complex; electron spin resonance; low dimensional materials; tetrahydrotetrathiafulvalene; tetrathiafulvalene.

Recent results describing the chemistry of metal complexes of tetrathiafulvalene (TTF) and tetrahydrotetrathiafulvalene (H_4TTF) are reviewed. Three broad classes of materials have been prepared: crystal complexes, donor-acceptor complexes, and salts.

Crystal complexes include (H_4TTF)($HgCl_2$)₃, characterized by a single crystal x-ray diffraction study, and (TTF) [Pd(acac)₂].

The donor acceptor complexes include (TTF)₂MX₂ (M = Pd, Pt; X = Cl, Br) which have been studied by x-ray photoelectron, electronic, Raman and infrared spectroscopy and by measurement of electrical conductivity. Evidence for sulfur lone pair-metal interaction is presented.

Electron spin resonance and magnetic susceptibility data indicate the presence of three dimensional magnetic exchange fields in the new chlorocuprate salts (TTF)₂CuCl₄ and (TTF)CuCl₄.

18283. Washington, M. A., Genack, A. Z., Cummins, H. Z., Bruce, R. H., Compaan, A., Forman, R. A., **Spectroscopy of excited yellow exciton states in Cu_2O by forbidden resonant Raman scattering**, *Phys. Rev. B* 15, No. 4, 2145-2153 (Feb. 15, 1977).

Key words: band structure; cuprous oxide; exciton; optical spectra; Raman scattering; resonant Raman scattering.

The Raman-scattering spectrum of Cu_2O at 4 °K was measured with a tunable cw dye laser as the exciting source. The dye laser was tuned to several hundred frequencies in the range 17 135-17 600 cm^{-1} which spans the range of the excited states of the yellow exciton series. At each laser frequency, the cross section for normally forbidden Raman scattering from the strongest odd-parity phonons Γ_{12}^- (109 cm^{-1}) and $\Gamma_{15}^{-(1)}$ (LO, 154.5 cm^{-1}) was determined. The Γ_{12}^- cross section increases dramatically when either the laser or the scattered light is resonant with excited S or D, yellow exciton states. The location and polarization of these peaks in the cross section is entirely consistent with the quadrupole-dipole Raman-scattering mechanism which has previously been observed when the laser is resonant with the lowest 1 S yellow exciton state. The dependence of the Γ_{12}^- cross section on incident laser frequency thus provides a new spectroscopic technique for locating dipole-forbidden but quadrupole-permitted excitonic states without the application of symmetry-breaking perturbations such as electric fields. Interpretation of the resonance enhancement of the $\Gamma_{15}^{-(1)}$ phonon feature is considerably more complicated. Extremely large enhancement of the LO (but not the TO) component was observed when the laser was tuned close to states previously identified as $3D_2$ and $4D_2$. We ascribe these resonances to an intraband double resonance mediated by the Fröhlich exciton-lattice interaction. We consider two potential microscopic models for those resonances: (i) optical quadrupole, dipole Fröhlich, optical dipole; (ii) optical dipole, quadrupole Fröhlich, optical dipole. The predicted behavior of these two models is compared with polarization measurements, and with the dependence of the Raman intensity on scattering angle, electric field, and laser frequency. It is found that neither model is consistent with all of the data.

18284. Engen, G. F., **Design considerations for automatic network analyzers based on the six-port concept**, *Proc. Conf. IEE Euromas 77, Sussex, England, Sept. 5-9, 1977*, pp. 110-111 (Institution of Electrical Engineers, London, England, 1977).

Key words: automatic network analyzer; automation; microwave measurements; six-port.

Although the six-port measurement technique is rapidly gaining the attention of the microwave community, the theories developed to date yield but limited insight into the question of how best to design the six-port so as to best exploit the concept.

This paper presents an alternative introduction to the general subject which yields substantially improved insight into the design question.

18285. Crawford, M. L., Workman, J. L., Thomas, C. L., **Expanding the bandwidth of TEM cells for EMC measurements**, *IEEE Trans. Electromagn. Comp.* EMC-20, No. 3, 368-375 (Aug. 1978).

Key words: absorber loaded; expanded bandwidth; TEM cells.

This paper discusses the development of a modified (absorber-loaded) transverse electromagnetic TEM cell with expanded bandwidth for use in accurately characterizing electromagnetic interference (EMI) fields within a shielded environment. The cell is analyzed experimentally, both before and after the modification, to determine its radio-frequency (RF) characteristics, both as an RF transmission line and as an electromagnetic (EM) field simulator or detector. Comparative measurements are given to show the performance of the modified versus the unmodified cell in parameters such as voltage standing-wave ratio (VSWR), insertion loss, test-field uniformity, and reverse-coupling characteristics. The results of these measurements indicate an approximate two-fold increase in the upper useful frequency of the modified cell. An example of using the cell to evaluate the radiated emissions from a common electronic module (microprocessor timing circuit) is given. Finally, the technique of absorber loading is extended to larger cells, specifically a $3 \times 3 \times 6$ -m cell.

18286. Hill, J. E., Jenkins, J. P., Jones, D. E., **Testing of solar collectors according to ASHRAE Standard 93-77**, *ASHRAE Trans.* 84, Part 2, 107-126 (1978).

Key words: heat transfer; measurement; radiation; rating; solar; standards; testing.

A proposed procedure for testing and rating solar collectors based on thermal performance was published by the National Bureau of Standards (NBS) in 1974. The procedure prescribed that a series of outdoor steady-state tests be conducted to determine the near-solar-noon efficiency of the collector over a range of temperature conditions. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has recently adopted ASHRAE Standard 93-77. It is similar to the original NBS procedure but calls for additional tests to determine the collector time constant as well as an incident angle correction factor that can be applied to the near-solar-noon efficiency to determine collector performance both early in the morning and late in the day.

Two test facilities have been built at NBS in accordance with ASHRAE Standard 93-77, one for modular water-cooled collectors and the other for air heaters. The purpose of this paper is to describe the recently adopted test procedure, provide a description of the facility at NBS, and to give results of a complete series of tests made according to the Standard on several commercially available collectors.

18287. Hill, J. E., Richtmyer, T. E., Jenkins, J. P., **Initial test results for a solar-cooled townhouse in the Mid-Atlantic region**, *ASHRAE Trans.* 82, Part II, 389-404 (1976).

Key words: absorption; air-cooling; computer; hot-water; measurement; residential; solar; testing.

A factory-produced four-bedroom townhouse unit equipped with a solar heating, cooling, and domestic hot water supply system is currently under test at the National Bureau of Standards in Gaithersburg, Maryland. The test house has approximately 110^2 (1200 ft²) of floor area. The solar system consists of 45 m² (485 ft²) of double-glazed flat-plate solar collector having a nonselective coating on the absorber, a water-to-air heat exchanger in a forced-air distribution system for space heating, two large water tanks for thermal storage, and a lithium-bromide absorption refrigeration unit. In addition, domestic

hot water is preheated from the solar system through a water-to-water heat exchanger.

Results are given for the first summer's cooling tests conducted in 1975. It was found that approximately 20 percent of the required cooling energy was obtained from the sun and approximately 75 percent of the energy for domestic hot water. The test results were compared with predicted results for the same conditions. It was found that solar collector array thermal output was less than one-half of what had been expected based both on manufacturers' published data and previous tests done on one part of the array at NBS. Due to the poor performance of the collector array, it was found that no effective use could be made of thermal storage.

18288. Kanda, M., **Transients in resistively loaded antennas, and their comparison with conical antennas and TEM horns**, *Proc. 1978 Int. Symp. Digest, Washington, DC, May 15-19, 1978*, pp. 13-16 (IEEE Antennas & Propagation Society, University of MD, College Park, MD, 1978).

Key words: conical antenna; effective length; FFT; moment method; resistively loaded antenna; TEM horn; time domain measurement; transient response.

The receiving and transmitting transient responses for a relatively short linear antenna with continuous resistive loading are investigated theoretically and experimentally. The antenna considered is a nonconducting cylinder with continuously deposited, varying-conductivity, resistive loading.

The current distribution, the corresponding effective length, and the driving point impedance are calculated by use of the method of moments and compared with the Wu-King approximation. The receiving and transmitting transient responses are calculated in the frequency domain using the results of the effective length and the driving point impedance. The final use of FFT then allows the determination of transient fields given a known input waveform. As a comparison, the receiving and transmitting transient responses for a conical antenna and a TEM horn are also investigated theoretically.

Time domain measurements are performed using a time domain antenna range with a time domain automatic network analyzer. The agreements between theory and experiments of the receiving and transmitting transient responses for the resistively loaded antenna, the conical antenna, and the TEM horn are satisfactory.

The receiving transient response of the resistively loaded antenna indicate that the impulse shape of 70 ps duration is well preserved. This provides the unique capability of this antenna to measure fast, time-varying, transient fields with minimal pulse-shape distortion due to nonlinear amplitude or phase characteristics.

18289. Boyle, D. R., **The agonies of automating almost anything**, *Agric. Eng.*, pp. 50-52 (Oct. 1978).

Key words: automation; design; hardware; implementation; laboratory automation; minicomputers; software.

This paper is written to the scientist or engineer who would like to use automation in his laboratory but who is not a computer specialist. The discussion attempts to illuminate some of the major problem areas which are commonly encountered in the development of a minicomputer based automation system, and give suggestions for reducing their adverse impact. Problem areas discussed include: system design, procurement, hardware and software aspects of system integration, and maintenance.

18290. Huie, R. E., Long, N. J. T., Thrush, B. A., **The radiative lifetimes of the first excited states of BO and BO₂**, *J. Chem. Phys. Lett.* 55, No. 3, 404-406 (May 1, 1978).

Key words: BO; BO₂; fluorescence; laser; lifetime; quenching rate.

A pulsed dye laser has been used to study the fluorescence of BO and BO₂ in the gas phase at low pressure. Radiative lifetimes of 87.2 ± 2.6 and 76.3 ± 1.4 ns were obtained for the (000) and (100) levels of BO₂(A ²Π_u) and of 131 ± 15 and 103 ± 6 ns for levels v' = 1 and 2 of BO(A ²Π). Unlike BO₂(A ²Π_u), BO(A ²Π) is strongly quenched by the oxygen carrier.

18291. Huie, R. E., Long, N. J. T., Thrush, B. A., **Laser induced fluorescence of the PH₂ radical**, *J. Chem. Soc. Faraday Trans. II*, **74**, 1253-1262 (1978).

Key words: fluorescence; laser; lifetime; PH₂; quenching rate.

A pulsed dye laser has been used to excite PH₂ radicals from the ²B₁ to the ²A₁ state. The radiative lifetime of the excited state is 4 ± 1 μs for v' = 0-3 and decreases to 0.35 μs for v' = 4. Weak, short lived fluorescence excited at higher frequencies could not be positively assigned to v' = 5. The quenching rate constant for hydrogen increases steadily from 1.24 × 10¹⁰ dm³ mol⁻¹ s⁻¹ for v' = 0 to ≈ 1.6 × 10¹¹ dm³ mol⁻¹ s⁻¹ at v' = 4. Below 22 000 cm⁻¹ the rotational and vibrational structure corresponds to that expected on the basis of the known absorption spectrum of PH₂.

18292. McNall, P. E., Pierce, E. T., Barnett, J. P., **Control strategies for energy conservation in buildings**, *Proc. Symp. Honoring A. Pharo Gage on Energy Conservation Strategies in Buildings: Comfort, Acceptability, and Health*, Hartford, CT, Jan. 25, 1978, pp. 1-12 (J. B. Pierce Foundation Laboratories, Hartford, CT, 1978).

Key words: comfort conditions in buildings; compared comfort control strategies; energy conservation potential; set point controls; temperature controls.

Three control strategies allowing zone temperatures to "drift" between a minimum and a maximum set point, without energy use, were imposed on two example commercial buildings. Each building was simulated on a different computer load program in several locations in the U.S. Comparisons of the energy demands were made for the various cases, showing significant energy saving potentials while maintaining inside thermal conditions which could probably be made acceptable to the occupants.

18293. Brungraber, R. J., Adler, S. C., **Technical support for a slip-resistance standard**, *Am. Soc. Test. Mater. Spec. Tech. Publ.* **649**, pp. 40-48 (1978).

Key words: coefficient of friction; friction; performance standards; safety engineering; slip resistance; test methods.

In the spring of 1975, ASTM Subcommittee F15.03.01 on Specifications and Test Methods for Slip Resistance of Bathing Facilities, requested technical assistance from the Building Safety Section (BSS) of the National Bureau of Standards (NBS) in developing a performance test for establishing quantitatively an acceptable level of slip resistance for bathtubs and shower bases. Close cooperation between the subcommittee members and the BSS staff, coupled with financial support from the Consumer Product Safety Commission (CPSC), resulted in the development of a performance test which approximates the conditions that are likely to occur on bathtub or shower base surfaces, is reliable and repeatable, and discriminates adequately between currently available bathtub and shower base materials.

18294. Ducas, W., Streed, E., Holton, J., Angel, W., **Thermal data requirements and performance evaluation procedures for passive buildings**, *Proc. 2d Natl. Conf. on Passive Solar Heating and Cooling*, Philadelphia, PA, Mar. 16-18, 1978, **2**, 411-430 (Mid-Atlantic Solar Energy Association, Philadelphia, PA, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

A systematic classification of passive solar buildings and performance factors are proposed to standardize evaluation procedures for these buildings. Two measurement levels are described with appropriate sensors and data acquisition systems to obtain either detailed data for complete component and system evaluation or to obtain "critical" data for evaluating the energy saved at many sites.

18295. Hall, J. H., **Stabilized lasers and precision measurements**, *Science* **202**, 147-156 (Oct. 13, 1978).

Key words: experimental tests of special relativity; high resolution spectroscopy; laser frequency measurements; precision measurements; stabilized lasers.

This article traces the development of stabilized lasers from the Massachusetts Institute of Technology passive-stabilization experiments of the early 1960's up through the current epoch of highly stabilized helium-neon and carbon dioxide and continuous wave dye lasers. The utility, present performance, and limitations of stabilized lasers as standards of length or frequency for precision measurements are discussed. Examples considered of laser applications to physical measurements of outstanding scientific interest include determination of the speed of light, redefinition of the meter, resolution of the photon recoil-induced spectral doubling, use of optical "Ramsey" interference fringes from ultrahigh-resolution spectroscopy, and two improved tests of special relativity.

18296. Hill, J. E., Streed, E. R., **A method of testing for rating solar collectors based on thermal performance**, *Sol. Energy* **18**, 421-429 (1976).

Key words: measurement; radiation; rating; solar; standards; testing.

This paper describes a proposed test method for determining the efficiency of solar collectors under specified outdoor "steady-state" conditions. The prescribed series of tests should provide useful data for the rating of solar collectors based on thermal performance. A study was made of existing theory, measurement practices and a number of collector test procedures in use prior to the publication of the proposed method.

The test apparatuses and major components have been prescribed so a liquid or air can be used as the transfer fluid. The energy of the fluid entering and leaving the collector is determined by making appropriate measurements and these quantities are then compared to the energy incident upon the collector (also determined by measurement) in order to calculate the collector efficiency.

The series of tests to be conducted consists of determining the average efficiency for 15 min periods (integrating the energy quantities) over a range of temperature differences between the average fluid temperature (average of inlet and outlet) and the ambient air. The test apparatuses have been designed so that the temperature of the fluid entering the collector can be controlled to a selected value. This feature is used to obtain the data over the temperature range desired. At least sixteen "data points" are required for a complete test series and they must be taken symmetrical with respect to solar noon (to prevent biased results due to possible transient effects).

18297. Hill, J. E., Jenkins, J. P., **The application of ASHRAE Standard 93-77 to concentrating collectors**, *Proc. ERDA Conf. on Concentrating Solar Collectors*, Atlanta, GA, Sept. 26-28, 1977, pp. 6-1-6-8 (College of Engineering, Georgia Institute of Technology, Atlanta, GA, 1977).

Key words: measurement; radiation; rating; solar; standards; testing.

The American Society of Heating, Refrigerating, and Air Conditioning Engineers, (ASHRAE) has recently adopted ASHRAE Standard 93-77 for testing and rating of solar collectors based on thermal performance. Four separate tests are required to be conducted. This paper will briefly explain the tests and indicate how they might be adapted for use with concentrating collectors.

18298. Jones, D. E., **System performance measurements for a packaged solar space heating system equipped with air-heating collectors**, *Proc. Conf. on Performance Monitoring Techniques for Evaluation of Solar Heating and Cooling Systems*, Washington, DC, Apr. 2-5, 1978, pp. 105-114 (U.S. Department of Energy, Conservation and Solar Applications, Solar Heating and Cooling Research and Development Branch, Washington, DC, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

This paper describes the approach and instrumentation used at the National Bureau of Standards for determining system performance of a packaged solar space heating system equipped with air heating collectors. A method of measuring air flow rate accurately without disturbing system performance through use of the collector as a flow measuring element is the major unique feature of the experimental approach.

18299. Jones, D. E., Hill, J. E., **Testing of flat-plate air heaters according to ASHRAE Standard 93-77**, *Proc. American Section, Int. Solar Energy Society 1977 Annual Meeting, A Solar World*, Orlando, FL, June 6-10, 1977, pp. 2-1-2-4 (American Section of the International Solar Energy Society, Inc., Killeen, TX, 1977).

Key words: measurement; radiation; rating; solar; standards; testing.

A proposed procedure for testing and rating solar collectors was published by the National Bureau of Standards (NBS) in 1975. In early 1977, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) adopted ASHRAE Standard 93-77 which is a modified version of the NBS procedure. A test facility for air heaters has been built at NBS in accordance with this Standard. The purpose of this paper is to briefly explain the recently adopted test procedure, describe the NBS test facility, and to give typical test results for a commercially available air-cooled solar collector.

18300. Kusuda, T., Bean, J. W., McNall, P. E., Jr., **Potential energy savings using comfort-index controls for building heating and cooling systems**, *Proc. Int. Indoor Climate Symp., Copenhagen, Denmark, Aug. 30-Sept. 1, 1978*,

Key words: computer simulation; energy conservation; heating and cooling load calculation; planned heating and cooling; thermal comfort indices.

Significant energy savings are possible through the use of thermal comfort index controls of building heating and cooling systems. In order to study the potential energy saving by comfort index controls, Fanger's Predicted Mean Vote (PMV) and Predicted Percent Dissatisfied (PPD) indices have been incorporated into NBSLD (National Bureau of Standards Heating and Cooling Load Calculation Program) to determine hourly profiles of indoor thermal comfort conditions under various operating conditions which allow inside control points to vary. Discussed in this paper are the potential applications of this computer program (NBSPMV) for the evaluation of selected energy conservation options, from the standpoint of indoor habitability and energy conservation. These options include increased temperature deadband, natural cooling, nighttime ther-

mostat setback, passive solar heating, evaporative cooling, temperature ramp controls, intermittent heating and cooling, and programmed heating and cooling.

18301. Liu, S. T., Shih, K., Wood, B. D., **Experimental validation of the solar simulation program TRNSYS for a solar domestic hot water heating system**, *Proc. DoE Symp. on Systems Simulation and Economic Analysis for Solar Heating and Cooling*, San Diego, CA, June 27-29, 1978, pp. 193-194 (U.S. Department of Energy, Conservation and Solar Applications, Solar Heating and Cooling Research and Development Branch and Barriers and Incentives Branch, Washington, DC, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

TRNSYS, a transient simulation program developed by the University of Wisconsin, is currently the most widely used computer simulation program in the solar heating and cooling field. This program has been used to predict system performance of numerous solar heating and cooling systems. Although it is widely used, the accuracy of the prediction has not yet been sufficiently validated with experimental data.

The primary objective of a project currently underway at the National Bureau of Standards is to carry out experiments to validate the TRNSYS program for solar domestic water heating systems. Two approaches are being taken. One is to use the program to predict the performance of six representative solar water heating systems and then to gather long-term experimental data (12 months) on these systems in actual operation at an outdoor test site in Gaithersburg, Maryland. The second approach is to use a laboratory apparatus which has been designed around the typical components simulated in TRNSYS and to gather detailed short-term experimental data on the performance of these components when subjected to closely controlled experiments. The results are then compared with the predictions of TRNSYS for the same experiments.

This paper presents some of the initial results of comparisons obtained using the laboratory apparatus and associated TRNSYS simulation. The specially-designed indoor test configuration will be described. Comparison of test results for several different combinations of hot water use schedule, piping configuration, and assumed solar collector output with those predicted by the applicable component models in TRNSYS under similar conditions will be shown. Emphasis has been placed on comparing the degree of temperature stratification in the storage tanks and heat loss from the tanks.

18302. Richtmyer, T. E., **The use of computer-controlled data acquisition systems in determining solar heating and cooling system performance**, *Proc. Monitoring Techniques for Evaluation of Solar Heating and Cooling Systems*, Washington, DC, Apr. 2-5, 1978, pp. 95-104 (U.S. Department of Energy, Conservation and Solar Applications, Solar Heating and Cooling Research and Development Branch, Washington, DC, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

For the past few years, NBS has been conducting a number of solar energy related projects. Two, in particular, are solar heated and cooled buildings that use computer controlled data acquisition systems. This paper describes those buildings, their data acquisition systems and discusses problems that have been experienced. Finally, a list of recommendations and suggestions are offered based on those experiences that should help prevent similar problems on future projects.

18303. Santoro, A., Maeland, A., Rush, J. J., **Neutron powder diffraction study of titanium copper deuteride $TiCuD_{0.90}$** , *Acta Cryst. B34*, 3059-3062 (1978).

Key words: deuterium-titanium bond; neutron powder diffraction; profile analysis; rule of reversed stability; structure determination; titanium-copper deuteride.

TiCuD_{0.90}, tetragonal, *P4/nmm*, $a = 3.020$ (1), $c = 6.837$ (3) Å (parameters determined by x-ray powder diffraction), $Z = 2$. The structure has been refined by the method of total-profile analysis of a neutron diffraction powder pattern. The composition obtained from the refinement corresponds to the formula TiCuD_{0.90(1)} (TiCuD_{0.98} by thermal analysis). The D atoms are located at the centers of distorted tetrahedra of Ti atoms, with a Ti—D distance of 1.927 (4) Å.

18304. Streed, E. R., A comparison of flat-plate solar collector thermal performance data obtained indoors and outdoors, *Proc. 1978 Annual Meeting of the International Solar Energy Society, Denver, CO, Aug. 28-31, 1978*, 2.1, 352-361 (American Section of the International Solar Energy Society, Inc., Killeen, TX, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

Standard test methods for the determination of the thermal performance of flat-plate solar collectors are needed on an international basis to provide consistent and reproducible data for the world market. Indoor and outdoor test methods have been proposed by a task group of the International Energy Agency. The National Bureau of Standards is assisting in the evaluation of these methods. In this paper, a comparison is made of pertinent data obtained within the United States for the thermal efficiency of several state-of-the-art water-heating flat-plate solar collectors. The data was obtained both outdoors as well as indoors using a solar simulator. In addition, the values of the collector heat loss coefficient obtained indoors and outdoors both under nonirradiated conditions is compared with values indicated from the outdoor tests to determine thermal efficiency (irradiated conditions). The comparisons indicate that relatively good agreement is achieved using the various methods but that some of the environmental parameters may require better control and/or simulation during the tests.

18305. Walls, F. L., Stein, S. R., A frequency-lock system for improved quartz crystal oscillator performance, *IEEE Trans. Instrum. Meas.* IM-27, No. 3, 249-252 (Sept. 1978).

Key words: frequency discrimination; frequency lock system; frequency stability; frequency stabilization; oscillator systems; phase modulation; quartz crystal oscillators; quartz crystals.

The intrinsic noise of the best quartz crystal resonators is significantly less than the noise observed in oscillators employing these resonators. Several problem areas common to traditional designs are pointed out and a new approach is suggested for their solution. Two circuits are described which frequency lock a spectrally pure quartz crystal oscillator to an independent quartz crystal resonator. The performance of the composite system is predicted based on the measured performance of its components.

18306. Ayres, T. R., Linsky, J. L., Margon, B., Bowyer, S., Upper limits on extreme ultraviolet radiation from nearby main sequence and subgiant stars, *Astron. Astrophys.* 70, No. 3, 431-434 (Nov. 1978).

Key words: extreme ultraviolet; stellar coronae; x-ray sources.

Flux upper limits for 44-800 Å radiation were measured in a sample of five nearby main sequence stars and one subgiant star using the Apollo-Soyuz grazing incidence telescope. Comparisons of emission measure upper limits with the predictions

of three different methods for estimating coronal properties cannot yet determine which, if any, are valid. Our data do rule out α Centauri A and B having active coronae with emission measures comparable to those of solar plages.

18307. Bedijn, P. J., Habing, H. J., de Jong, T., Model infrared spectra for accreting stars, *Astron. Astrophys.* 69, No. 1, 73-84 (1978).

Key words: accretion; circumstellar shells; star formation.

We have calculated infrared spectra for dusty circumstellar shells that accrete onto stars in free fall. The dust consists of silicate and graphite particles. We solve simultaneously the equation of radiative transfer and the two equations of thermal equilibrium, one for each of the dust species. In four cases (BN object; OMC 2/IRS 3; RCW 57/IRS 1; Mon R 2/IRS 2) model spectra are compared with spectra of observed infrared point sources. In each case good agreement between observation and prediction is obtained for a wide range of models. By using additional criteria (1. radiation pressure does not stop the inflow; 2. A_V/τ_{10} should be larger than 10) we are able to narrow the range of permissible models and to obtain an estimate of the accretion rate \dot{M} . Given the accretion time $M/\dot{M} \geq 10^6$ yr and the number of similar objects known we conclude tentatively, that the four objects are very young early type stars at the end of their accretion phase.

18308. Casinelli, J. P., Castor, J. I., Lamers, H. J. G., Expanding envelopes of early type stars: Current status, *Publ. Astron. Soc. Pac.* 90, No. 537, 496-505 (Oct. 1978).

Key words: early-type stars; stellar winds.

There are currently four theoretical models that have been developed to explain the winds or the origin of the anomalous ionization in the winds of early type stars. This paper reports the results of a workshop on stellar winds that was held at JILA in Boulder, Colorado, from 3 to 6 October 1977. Subsequent work that answered some of the questions raised at the meeting is also presented. The conferees concluded that the winds are probably due to radiation pressure in ultraviolet resonance lines, but that the anomalously high degree of ionization in the winds requires the input of nonthermal energy. Several as yet unexplained observations are mentioned, and areas for future studies are outlined.

18309. Doschek, G. A., Feldman, U., Mariksa, J. T., Linsky, J. L., Electron densities in stellar atmospheres determined from IUE spectra, *Astrophys. J. Lett.* 226, No. 1, L35-L38 (Nov. 15, 1978).

Key words: chromospheres, stars; emission line, stars; late-type, ultraviolet spectra; stars.

An EUV spectroscopic method is described for determining the electron density in solar and stellar plasmas for densities less than $\approx 10^{11}$ cm⁻³ and for temperatures near $\approx 5 \times 10^4$ K. The method is applied to IUE spectra of α Aur, HR 1099, and λ And. Preliminary results give densities of $\approx 10^{10}$ cm⁻³ for Aur and λ And, and $\approx 2 \times 10^9$ cm⁻³ for HR 1099.

18310. Fairchild, C. E., Stone, E. J., Lawrence, G. M., Photofragment spectroscopy of ozone in the uv region 270-310 nm and at 600 nm, *J. Chem. Phys.* 69, No. 8, 3632-3638 (Oct. 15, 1978).

Key words: atom fragments; ozone, photofragment spectroscopy; photofragment spectroscopy of ozone; spectroscopy of ozone, photofragment.

Both O(³P) and O(¹D) atom fragments are observed in the photofragment spectroscopy of O₃ in the Hartley band absorption region 270-300 nm. The quantum yield for O(³P) is 0.1

at 274 nm. The dissociation partner for $O(^3P)$ is $O_2(X^3\Sigma_g^-)$ and that for $O(^1D)$ is $O_2(a^1\Delta_g)$. The $O_2(X^3\Sigma_g^-)$ fragment is populated in a range of vibrational levels, $\nu = 0-10$. For the $O_2(a^1\Delta_g)$ fragment, all energetically accessible vibrational levels are populated at each energy of bombardment. In the Chappuis bands at 600 nm the $O_2(X^3\Sigma_g^-)$ photofragment is produced principally with $\nu = 0, 1$. Photofragment angular distributions are measured in the uv for both O atom dissociation products at each wavelength of bombardment. A theoretical angular distribution for $O(^1D)$ is derived and the resultant prediction is in good agreement with the experimental results.

18311. Geltman, S., **Ionisation dynamics of a model atom in an electrostatic field**, *J. Phys. B*: **11**, No. 19, 3323-3337 (1978).

Key words: dc discharges; dc Stark effect; field emission; ionization theory; spectral density; tunneling.

The time evolution of the ionisation probability of a simple one-dimensional model atom under the influence of an electrostatic field is evaluated by an exact solution of the time-dependent Schrödinger equation. It is shown that in the low-field, long-time limit the decay of the bound state is exponential in time with the decay constant identical to that obtained in the quasiclassical tunnelling theories. For shorter times, however, there are large departures from exponential decay, which lead to ionisation probabilities much higher than expected on the basis of the quasiclassical theories. The potential importance of this in the analysis of DC discharge phenomena is pointed out.

18312. Giampapa, M. S., Linsky, J. L., Schneeberger, T. J., Worden, S. P., **Chromospheric emission lines in the red spectrum of AD Leonis. I. The nonflare spectrum**, *Astrophys. J.* **226**, No. 1, 144-150 (Nov. 15, 1978).

Key words: flare stars; helium; x-ray emission.

High resolution red (5300-7300 Å) spectra of the flare star AD Leonis were obtained with the Kitt peak 4m echelle spectrograph system at a spectral resolution of 0.22 Å at H α . A series of time-trailed plates with 5 hours integration were averaged together to obtain a very deeply exposed representation of the star's nonflaring spectrum. The He I λ 5876 triplet line and λ 6678 singlet line appear in emission with measured equivalent widths of 0.312 ± 0.016 Å and 0.058 ± 0.029 Å, respectively. The corresponding triplet-to-singlet line flux ratio is 3.7, close to the ratio of the level statistical weights. We argue that the He I lines are not produced by recombination and cascade following photoionization by $\lambda < 504$ Å coronal photons, but are instead collisionally excited. We suggest that these lines are formed in a geometrically thin chromospheric layer at 20-50,000 K with a column density $n_e \ell \approx 6 \times 10^{18}$ cm $^{-2}$. The sodium D lines (λ 5890, λ 5896) are found to be stellar in origin, with measured FWHM of 0.7 Å for both lines, and the H α lines has a FWHM of 1.4 Å. A search for other chromospheric emission lines in this spectral region produced negative results.

18313. Linsky, J. L., **IUE observations of cool stars: α Aurigae, HR1099, λ Andromedae, and ϵ Eridani**, *Nature* **275**, 389-394 (Oct. 5, 1978).

Key words: binary stars; chromospheres; stellar spectra; ultraviolet.

Initial IUE observations of four cool stars are reported. Observed fluxes and surface fluxes are given for several UV emission lines in the special range 1,175-2,000 Å, obtained at low and high dispersion with the short-wavelength spectrograph and camera. These lines are formed in the outer atmospheres of these stars, in regions presumably analogous to the solar chromosphere and transition region. The surface fluxes in the lines increase along the sequence: quiet Sun, ϵ Eri, λ And, α

Aur, and HR1099. The 2.8-d RS CVn-type binary HR1099, observed on 1 March 1978 near the end of a major flaring episode, has line surface fluxes ~ 100 times that of the quiet Sun, similar to those seen in solar flares. Line profiles and flux ratios in multiplets for Capella are presented, and comments given on the opacity of the lines and on a tendency of line width to increase with temperature of formation.

18314. Teubner, P. J. O., Buckman, S. J., Noble, C. J., **Differential cross sections for the elastic scattering of intermediate-energy electrons from sodium**, *J. Phys. B*: **11**, No. 13, 2345-2354 (1978).

Key words: differential cross sections; elastic scattering; sodium.

Differential cross sections for the elastic scattering of electrons from sodium have been measured with high angular resolution for incident energies of 54.4, 75, 100 and 150 eV and over an angular range of 12-140°. The experimental data are compared with calculations based on the first Born approximation, the Glauber approximation and a close-coupling impact-parameter calculation. Calculations have been carried out for an optical model using the prescription of Vanderpoorten for localising the absorptive part of the potential. Of the theoretical calculations, the optical model is found to reproduce best the general features of the cross section at all energies.

18315. Gills, T. E., Gallorini, M., Rook, H. L., **The determination of trace elements in new food grain SRM's using neutron activation analysis**, *J. Radioanal. Chem.* **46**, 21-25 (1978).

Key words: accuracy; food grain; instrumental; radiochemical; standard reference materials; toxic elements.

Potentially toxic metals in the food chain that can lead to deleterious effects on human health have been well documented. Because of the toxicity of some metals, levels of 1 ppm or less must be routinely monitored in foods to ensure human safety. To ensure the accuracy of measurement, NBS in a cooperative interagency agreement with the Food and Drug Administration is involved in developing and certifying selected elements in food grain as a part of the Standard Reference Material program. Both instrumental and radiochemical neutron activation analysis were used to analyze two food grain standard reference materials (Rice and Wheat Flours) for trace element certification.

18316. Sheahan, T. P., **Opportunities to apply physics to energy conservation problems in process industries. Examples from textiles and papermaking**, *Proc. Conf. on Physics Careers, Employment and Education, State College, PA, Aug. 1-3, 1977*, pp. 201-206 (American Physical Society, New York, NY, 1978).

Key words: moisture; paper; physics careers; textiles.

The large mills that convert raw materials into finished products are generally thought of as engineering wonders, with no need for physics beyond classical mechanics. However, there are many improvements possible through the application of new measurement concepts that are only now emerging from the research laboratories (laser optics is an obvious example). This paper suggests that there are many such applications, and illustrates the point with two specific cases, both of which deal with means of industrial energy conservation: (1) The process of making paper is predominantly a matter of water removal. Moisture gauges can easily be fooled by impurities in the input pulp, especially where paper is recycled; and thus substantial energy can be wasted by overdrying paper. Application of remarkably simple physical insight helps to overcome this problem. (2) Textiles must be held very straight while being

heat-set in order to lead to good quality clothing, and either discarding or re-setting misaligned cloth wastes labor as well as energy. When combined with properly designed plates, the threads comprising the fabric generate Moire patterns that can be used to observe and regulate textile straightness.

The limitations of the applications of physics are set by limits of imagination, not in training.

18317. Roth, P. F., Gass, S. I., Lemoine, A. J., **Some considerations for improving federal modeling**, *Proc. 1978 Winter Simulation Conf., Miami Beach, FL, Dec. 4-6, 1978*, pp. 213-217 (The Institute of Electrical and Electronics Engineers, New York, NY, Dec. 1978).

Key words: development of models; mathematical models; operations research; prediction models; problem oriented languages; simulation theory; systems research; testing of models.

There is a growing awareness of the need for better communication and management techniques to improve the process of developing computerized models. Modeling is defined as the process of solving complex system problems and making decisions using experimental data generated by a computerized conception of the system. The process is subtle and sophisticated and often misunderstood.

The Government is a large underwriter of models. The Government's modeling process has been criticized by several GAO Reports.

Some critical issues involved in improving the Government modeling process are disclosed, evaluated by expert practitioners, and ranked according to importance: better communication between users and developers of models is important; special bureaucracies to address modeling is unimportant.

The responsibility for sponsorship of research is addressed.

5. LISTING OF NBS PAPERS BY MAJOR SUBJECT AREAS

This section provides a listing of 1978 papers organized by primary subject matter as follows:

Acoustics and Sound
Analytical Chemistry
Atomic and Molecular Studies
Building Technology
Computer Science and Technology
Consumer Information and Protection
Electromagnetic Metrology
Electronic Technology
Energy Conservation and Production
Engineering, Product and Information Standards
Environmental Studies: Pollution Measurement
Failure Analysis
Fire Research
Fluids: Liquids, Gases and Plasmas
General Theoretical Chemistry and Physics
Health and Safety
Instrumentation and Experimental Methods
Lasers and Their Applications
Low Temperature Science and Engineering
Mathematical and Statistical Methods
Measurement Science and Technology:
 Policy and State-of-the-Art Surveys
Measurement Science and Technology:
 Physical Standards and Fundamental Constants
Mechanics: Design, Testing and Measurement
Metrology: Physical Measurements

Nuclear Physics and Radiation Technology
Operations Analysis and Applications
Processing and Performance of Materials
Properties of Materials: Electronic, Magnetic and Optical
Properties of Materials: Structural and Mechanical
Properties of Materials: Thermodynamic and Transport
Standard Reference Data
Standard Reference Materials
Surfaces and Interfaces
Thermodynamics and Chemical Kinetics
Technology Incentives
Other Subjects of General Interest

It permits users of this catalog to scan the Bureau's output by major subject category. The user should bear in mind that a paper is listed once by major subject even though it might well contain other secondary subject matters of interest. The key-word index permits the reader to determine the overall context of a paper, and provides an excellent secondary reference source.

The categories currently in use for classifying NBS publications are listed below and are followed by a listing of each paper by category. Full citations (including key-words and abstracts) will be found under the appropriate publication series, which is included in the paper title. Also of use will be the key-word index (mentioned above) and the author index.

- BSS84. Design Guide for reducing transportation noise in and around buildings, D. S. Pallett, R. Wehrli, R. D. Kilmer, and T. L. Quindry, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 84*, 176 pages (Apr. 1978) SN003-003-01687-0.
- NBSIR 77-1383. Interactive computer program for the determination of reverberation time, T. W. Bartel, 127 pages (Dec. 1977). Order from NTIS as PB275574.
- NBSIR 78-1454. The evaluation of search units used for ultrasonic reference block calibrations, D. J. Chwirut and G. D. Boswell, 30 pages (Feb. 1978). Order from NTIS as PB280311.
- NBSIR 78-1520. Ultrasonic transducer power output by modulated radiation pressure (with details), M. Greenspan, F. R. Breckenridge, and C. E. Tschiegg, 53 pages (July 1978). Order from NTIS as PB289961.
- NBSIR 78-1541. Techniques for the measurement of acoustic impedance of asphalt, P. A. Mansbach and C. I. Holmer, 95 pages (Oct. 1978). Order from NTIS as PB287936.
17502. Clarke, R. M., Kilmer, R. D., Blomquist, D. S., Locomotive in-cab noise—Towards a standardized measurement methodology, *Proc. NOISE-CON 77 Conf. on Noise Control Engineering, NASA Langley Research Center, Hampton, VA, Oct. 17-19, 1977*, pp. 431-442 (Noise Control Foundation, Poughkeepsie, NY, Oct. 1977).
17504. Corley, D. M., Empirical model for predicting in-service truck tire noise levels, *Proc. SAE Highway Tire Noise Symp., San Francisco, CA, Nov. 10-12, 1976*, pp. 303-309 (Society of Automotive Engineers, Inc., Warrendale, PA, 1977).
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Analytical Chemistry

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- Computer technology; energy conservation and research; fire research; radiation safety; standard reference data; standard reference materials; standards development; technology transfer; weights and measures; basic research; building technology; *SP498*.
- Computer timings; curve fitting; estimation; gradient; Newton-Raphson; perturbation methods; quasi-Newton; simplex method; variable metric method; *SP503*, pp. 373-378 (Mar. 1978).
- Computer-aided design; fire computer program; fire research; fire safety; human performance; model documentation; modeling technique; programming; simulation; architectural psychology; architectural research; building fires; *NBSIR 78-1514*.
- Computer-aided manufacturing; goal-directed systems; hierarchical control; robots; sensory feedback; task decomposition; *17882*.
- Computerized banking; computerized checkout; computerized retail checkout; computers; electronic funds transfer; optical character recognition; Universal Product Code; *CIS10*.
- Computerized checkout; computerized retail checkout; computers; electronic funds transfer; optical character recognition; Universal Product Code; computerized banking; *CIS10*.
- Computerized fingerprint matching; fingerprint readers, semiautomatic; fingerprints; latents; minutiae; pattern recognition; *17568*.
- Computerized international documentation system; data; drafts; general average; inventory records; letters of credit; Shipper's Export Declaration; trade data; trade documents; bill of lading; *CARDIS*; commercial invoice; *NBSIR 78-1446*, pp. 135-137 (Apr. 1978).
- Computerized retail checkout; computers; electronic funds transfer; optical character recognition; Universal Product Code; computerized banking; computerized checkout; *CIS10*.
- Computerized typesetting; digital plotting; plotting; type fonts; type setting; vectorized characters; alphabets; COM; computer graphics; *SP500-32*.
- Computers; computer system hardware; data processing; data processing equipment; information systems; magnetic tape recording; magnetic tapes; magnetic tape transports; standards; communications; *FIPS PUB 50*.
- Computers; computer system hardware; data processing; data processing equipment; information systems; magnetic tape recording; magnetic tapes; magnetic tape transports; standards; communications; *FIPS PUB 51*.
- Computers; control systems; industrial equipment; interface standards; microcomputers; standards; coal mining; *NBSIR 77-1301*.
- Computers; cryogenic measurements; electronics standards; encryption standard; fire safety; lasers; microcircuit fabrication; nickel standard; rheology; time signals; cereal foods; *DIM/NBS 62*, No. 7/8, 1-32 (1978).
- Computers; data processing; data processing equipment; information systems; microfiche; microfilm; standards; COM formats and reduction ratios; communications; computer output microform; computer system hardware; *FIPS PUB 54*.
- Computers; data processing; Federal Information Processing Standards; information processing; computer magnetic tape file properties; *FIPS PUB 53*.
- Computers; digital electronics; gravitational studies; high-Q cavities; infrared detectors; magnetometers; magnets; microwave detectors; space; superconductivity; *NBSIR 78-885*.
- Computers; digital-cosine; information resources; insulation; ion metal; metric; standard reference data; *DIM/NBS 62*, No. 10, 1-32 (1978).
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- Computers; fusion reactors; gas flow; microwaves; smoke detectors; spectroscopic tool; stainless steel; standards; telescope; time and frequency; attic ventilation; chemical kinetics; *DIM/NBS 62*, No. 4, 1-32 (1978).
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- Concrete fire resistance; CSTB; fire; fire codes; France; translations; calculating concrete fire resistance; codes; *TN710-10*.
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- Concrete (reinforced); design (criteria); loads; probability theory; reliability; statistical analysis; structural engineering; buildings (codes); *BSS110*.
- Concretes; creep; fire models; slabs (members); steels; stresses; structural materials; thermal analysis; building fires; computer programs; *NBS-GCR-78-114*.
- Concretes; creeps; failure analysis; fire models; steels; structural failure; structural materials; thermal degradation; building fires; computer programs; *NBS-GCR-78-115*.
- Concurrency; bottlenecks; overload; peakload; queue length; waiting time; *SP500-41*, pp. 83-92 (Oct. 1978).
- Condensation in buildings; energy conservation; energy measurements; fuel savings; heat-loss reduction; insulation properties; residential heat loss; retrofitting houses; thermal conductivity; thermal insulation; thermography; air infiltration; *BSS105*.
- Condensation reactions; copolymerization; coupling agents; dentin; functional monomers; hydroxybenzaldehydes; isomers; polymerization; synthesis; adhesion; aldehyde methacrylate; collagen; *18149*.
- Condensed gases; nitrogen; photoemission; CO; *17570*.
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- Conductivity; critical evaluation; data analysis; data compilation; data synthesis; electrical resistivity; metals; recommended values; thermal conductivity; thermoelectric power; *JPCRD 7*, No. 3, 959-1178 (1978).
- Conductivity; cross sections; electron; gases; magnetohydrodynamics; *17463*.
- Conference proceedings; CPEUG; hardware monitoring; on-line system evaluation; prediction methods; queuing models; simulation; software monitoring; workload definition; ADP

- life cycle; computer performance evaluation; computer performance measurement; *SP500-41*.
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- Consistent System; data; DATATRAN; linguistic expression; mnemonics; random number generation; statistical routines; time-sharing; algorithm, attributes; computer; *SP503*, pp. 357-361 (Mar. 1978).
- Consolute point; critical exponent; critical phenomena; deuterated isobutyric acid + heavy water; isobutyric acid + water; liquid density; liquid-liquid critical point; magnetic densimeter; coexistence curve; *17449*.
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- Constrained Hollingsworth radius; diffusion approximation; extent of cilium; polymer chains; random flight chains; adsorption; *18211*.
- Construction; court decisions; disasters; economics; legal approach; regulatory process; violations; building official; building regulations; code enforcement; *SP518*, pp. 381-390 (Aug. 1978).
- Construction; enforcement; inspection; legislation; manufactured building; rules and regulations; standards; building regulation; *NBSIR 78-1503*.
- Construction; existing buildings; rehabilitation; renovation; building codes; building research; code enforcement; *NBS-GCR-78-139*.
- Construction cost estimation; discounted payback period; economic analysis; economic evaluation; energy conservation; life-cycle costing; present value analysis; building; *NBSIR 78-1568*.
- Construction costs; earthquake resistant code; expected seismic force; object postulate; reliability theory; social utility; acceptable level of human risk; *SP523*, pp. V-102—V-116 (Sept. 1978).
- Construction Industries Coordinating Committee; Interstate Metric Committee; metrication; NCSBCS; State metric coordinators; *NBSIR 78-1441*.
- Construction industry metrication; metrication benefits; rationalization; technical issues in metrication; *17567*.
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- Construction methods; fire prevention; fire protection; fire safety; life safety; standards; building codes; building design; buildings; *NBS-GCR-78-118*.
- Construction stages; suspension bridge; aerodynamic stability; *SP523*, pp. II-1—II-19 (Sept. 1978).
- Consultative Committee for the Definition of the Second (CCDS); Coordinated Universal Time; Ephemeris Time; International Atomic Time (TAI); legal time; standard time; time; *17453*.
- Consumer; cost-benefit; fire hazard; market; regulation safety standards; upholstered furniture; *J. Res.* **83**, No. 5, 459-483 (1978).
- Consumer affairs; education; electronic devices; enforcement; Grain Standards Act; International Organization of Legal Metrology; labeling insulation and polyethylene products; metrication; model laws and regulations; national type approval; *SP517*.
- Consumer appliance retention; dishwasher; freezer; kitchen range; refrigerator; service-life expectancy; television set; washing machine; actuarial table; clothes dryer; *SP514*, pp. 131-138 (May 1978).
- Consumer behavior; consumer information; consumer products; energy conservation; government regulation; product design; product performance; product standards; safety; appliances; *17353*.
- Consumer Communications Reform Act; history; libraries; library; networks; regulation; telecommunications; Bell Bill; *18231*.
- Consumer exposure; Consumer Product Safety Act (CPSA); Consumer Product Safety Commission (CPSC); emberizing material; free-form asbestos; patching compounds; risk assessment; artificial fireplace ash; *SP506*, pp. 451-459 (Nov. 1978).
- Consumer information; consumer products; energy conservation; government regulation; product design; product performance; product standards; safety; appliances; consumer behavior; *17353*.
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- Consumer product safety; CPSC; product life; product performance; safety regulations; *SP514*, p. 177 (May 1978).

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- Consumer Product Safety Act (CPSA); Consumer Product Safety Commission (CPSC); emberizing material; free-form asbestos; patching compounds; risk assessment; artificial fireplace ash; consumer exposure; *SP506*, pp. 451-459 (Nov. 1978).
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- Consumer Product Safety Commission (CPSC); emberizing material; free-form asbestos; patching compounds; risk assessment; artificial fireplace ash; consumer exposure; Consumer Product Safety Act (CPSA); *SP506*, pp. 451-459 (Nov. 1978).
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- Consumer product technology; engineering psychology; ergonomics; human engineering; human factors; human performance; product safety; standard reference data; anthropometry; *NBSIR 77-1403*.
- Consumer product testing; durability; labeling products; Performance Life Disclosure Act; congressional action; *SP514*, pp. 19-28 (May 1978).
- Consumer product testing; life test method; useful life; *SP514*, pp. 42-53 (May 1978).
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- Consumer products; environmental factors; home safety; occupant behavior; survey technique; accidents; architectural psychology; *BSS108*.
- Consumer products; labeling; selection; consumer information; *NBSIR 78-1450*.
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- Consumer usage; product design; product durability; product life; remanufacturing; *SP514*, pp. 3-11 (May 1978).
- Consumers; durability; product lifetime; second-hand markets; small household electrical appliances; solid waste management; waste reduction; *SP514*, pp. 82-89 (May 1978).
- Containerless processing; materials science; micro-g; skylab; space processing; space shuttle; *SP520*.
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- Containers; failure analysis; flammable fluids; gasoline; hazards; kerosene; safety; standards; children; *NBSIR 78-1414 (CPSC)*.
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- Contamination; corrosion; heat exchanger; heat transfer fluids; potable water; solar energy; standards; toxicity; *NBSIR 78-1542*.
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- Continuum mechanics; defect; disclination; dislocation; distortion; dynamics; elasticity; Green's tensor; incompatibility; loop; plasticity; strain; Volterra; Burgers vector; compatibility; *17435*.
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- Contrast improvement; experimental method; exposure reduction; grid performance; radiography; x-ray grids; anti-scatter grids; *17648*.
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- Control chart; diagnostic tests; experimental error; linear regression; precision; tolerance intervals; accuracy; confidence intervals; *17591*.
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- Control systems; Delphi Forecast; industrial robots; robot applications; robotics research; sensors; *SP500-29*.
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- Field calibration; high accuracy; modular capacitive divider; portable system; truck-mounted; CCVT; compact; *17902*.
- Field data collection techniques; hair dryers; instrumented usage data; life cycle costing; repair data; small appliances; *NBSIR 78-1500*.
- Field demonstration; high traffic areas; laboratory findings; maintenance engineers; service conditions; solvent-thinned polyurethane system; vinyl tile; water-thinned polyurethane system; *NBSIR 77-1399*.
- Field emission; ionization theory; spectral density; tunneling; dc discharges; dc Stark effect; *18311*.
- Field emission; nitric oxide; nitrogen; oxygen; ruthenium; work function; catalysis; chemisorption; *17730*.
- Field ion microscopy; iron; noncrystalline films; passive films; repassivation; sensitization; stainless steel; uranium; x-ray photoelectron spectroscopy; crevice corrosion; *NBSIR 78-1429 (Navy)*.
- Field measurement; multi-component fields; multi-path propagation; radio holography; standing wave patterns; electromagnetic fields; *18097*.
- Field strength; magnetic fields; calibration; calibrators; electric fields; electric field strength; electric power transmission; *17420*.
- Field strength measurement; radar; rf probe; antenna; calibration; electromagnetic field intensity; *17813*.
- Field strength measurements; mobile communication systems; vehicular electronic systems; biological hazard; electromagnetic compatibility; *17356*.
- Field-electron emission; field-ion emission; ruthenium; surface characterization; tungsten; electron work function; *17384*.
- Field-induced phase change; piezoelectric polymer polar crystal; polarization; poly(vinylidene fluoride); pyroelectric polymer; chain conformation; corona poling; crystal phase transformation; *18241*.
- Field-ion emission; ruthenium; surface characterization; tungsten; electron work function; field-electron emission; *17384*.
- Fields; impulse; standard; TEM horn; antenna; conical; *18182*.
- Figure of merit; Fizeau; interferometer; photoelastic; piezobirefringence; piezo-optic; strain; stress; stress birefringence; Twyman-Green; acousto-optic; Brillouin scattering; elasto-optic; Fabry-Perot; *18275*.
- Figure of merit; germanium; photoelasticity; piezo-birefringence; piezo-optic; pressure; refractive index; stress; acoustic-optic; birefringence; elasto-optic; *17706*.
- Figure of merit; liquid scintillation counting; Poisson errors; precision; quenching; random error; reduced activity; systematic error; ^3H ; ^{32}P ; accuracy; blank; Cerenkov counting; *17510*.
- Figure of merit; measurement procedure; noise temperature; satellite communication; earth terminal; effective isotropic radiated power; *NBSIR 78-879*.
- Figure of merit; noise temperature; satellite communication; earth terminal measurement system; effective isotropic radiated power; *NBSIR 78-895*.
- Filar eyepiece; image shearing eyepiece; integrated circuits; linewidths; microelectronics; optical microscopes; calibration standards; closed-circuit TV systems; dimensional metrology; electron microscope; *17669*.
- Filar eyepiece; image shearing eyepiece; integrated circuits; linewidths; microelectronics; optical microscopes; calibration standards; closed-circuit TV systems; dimensional metrology; electron microscope; *17851*.
- File generator; retrieval; storage; ACIS; biomedical; clinical information; data base; *SP503*, pp. 157-164 (Mar. 1978).
- File handling; graphic analysis; IMS information retrieval; KWOC indexing; least-squares; linear regression; MIS; plotting; statistical analysis; Boolean search system; computer programs; curve fitting; data analysis; data base management; data retrieval; *H125*.
- File manipulation; macros; network access; network job execution; network operating systems; command language; computer network; *SP500-37*.
- Fill slope; priority; retaining wall; seismic forces; culverts; design principle; earth structure; earthwork manual; *SP523*, pp. V-45—V-52 (Sept. 1978).
- Filler; glass; microporous; radiopacity; composite; dental; *18083*.
- Fillers; metals; polymerization; silanes; adhesion; composite resins; coupling agents; *18221*.
- Film adhesion; glass-ceramics; IR reflectance; laser mirrors; low-expansion materials; copper film; *SP509*, pp. 215-221 (Dec. 1977).
- Film stress; infrared interferometer; stress interferometer; thin film thermal expansion coefficient; Young's modulus; zinc selenide; *SP509*, pp. 230-242 (Dec. 1977).
- Films, Ba and Mg; luminescence, chemisorptive; Ba and Mg films; chemisorptive luminescence; *17503*.
- Filter; finite Fourier expansion; prediction error; random variables; synthesis; wave; accelerogram; artificial earthquake; covariance; *SP523*, pp. IV-28—IV-47 (Sept. 1978).

- Filter transmittance test; photodetector; photometer; radiometer; spectral responsivity; detector; detector radiometry; detector spectral comparator; detector spectral response; *TN988*.
- Filters; airborne particulate; air monitoring; asbestos; chrysotile; *SP506*, pp. 355-362 (Nov. 1978).
- Financial analysis; product durability; product life; tax effects; discounted cash flow; *SP514*, pp. 12-18 (May 1978).
- Fine particles; mesothelioma; asbestos; asbestosis; carcinoma; epidemiology; *SP506*, pp. 121-131 (Nov. 1978).
- Fine-structure; hydrogen; plasma; spin; stark; broadening; *18105*.
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- Fingerprints; latents; minutiae; pattern recognition; computerized fingerprint matching; fingerprint readers, semiautomatic; *17568*.
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- Finite-level atom; finite-level molecule; intense laser; multiphoton absorption; Rabi oscillations; time dependent populations; coherent excitation; *18010*.
- Finite-level molecule; intense laser; multiphoton absorption; Rabi oscillations; time dependent populations; coherent excitation; finite-level atom; *18010*.
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- Fire; fire behavior; fire growth; fire safety; human behavior; models; phase; probability; rate constant; realm; sequence; state; state's-transition; system; systems approach; "and" gate; behavior; critical events; decision; decision tree; dominant factors; episode; event; *17967*.
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- Fire; flame resistant materials; flight attendants; garments; heat flux; protection; standards; tests; aircraft; fabrics; *17788*.
- Fire; fuel; gasoline; hydrogen; methane; safety; explosion; *18130*.
- Fire tests; PVC; smoke; walls; wiring; branch circuits; electrical codes; fire endurance; *NBSIR 78-1415*.
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- Fire alarm systems; fire detectors; high-rise communication systems; multiplex systems; NFPA standards; residential fire detector; sprinkler supervisory devices; control units; *TN964*.
- Fire alarms; Japan-U.S. cooperation; smoke aging; smoke detectors; smoke measurement; smoke properties; false detectors; fire; *17962*.
- Fire alarms; sleep research; alarms; arousal; auditory arousal thresholds; emergency signals; *NBSIR 78-1484 (HEW)*.
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- Fire behavior; fire growth; fire safety; human behavior; models; phase; probability; rate constant; realm; sequence; state; state's-transition; system; systems approach; "and" gate; behavior; critical events; decision; decision tree; dominant factors; episode; event; fire; *17967*.
- Fire behavior; flow measurement; metric; radar; spectroscopy; time; universe; Congress; electromagnetic interference; *DIM/NBS 62*, No. 5, 1-28 (1978).
- Fire behavior; human factors; mapping; methodology; performance (human); reaction (psychology); stress (psychology); building fires; case histories; critical incidents; decision making; escape; *NBS-GCR-77-106*.
- Fire codes; fire safety; governmental actions; life safety; regulation; risk assessment; societal goals; building codes; control measures; *SP518*, pp. 165-176 (Aug. 1978).
- Fire codes; France; translations; calculating concrete fire resistance; codes; concrete fire resistance; CSTB; fire; *TN710-10*.
- Fire computer program; fire research; fire safety; human performance; model documentation; modeling technique; programming; simulation; architectural psychology; architectural research; building fires; computer-aided design; *NBSIR 78-1514*.
- Fire detection systems; fire suppression; fire tests; flame research; flammability tests; smoke; smoke detectors; standards; toxicity; bibliographies; building fires; carpets; compartment fires; *NBSIR 78-1504*.
- Fire detectors; high-rise communication systems; multiplex systems; NFPA standards; residential fire detector; sprinkler supervisory devices; control units; fire alarm systems; *TN964*.
- Fire detectors; ionization detectors; light-scattering detectors; particle size distribution; smoke; smoke detectors; aerosol generators; detector testers; *TN973*.
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- Fire endurance; fire load; fire protection; fire severity; fire test; building fire; combustible contents; *17808*.
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- Fire growth; fire tests; flame spread; flashover; incidental fire; interior finish; life safety; mattress; mobile home; radiant heat flux; room fires; upholstered chairs; ASTM E-84 Tunnel Test; *NBSIR 78-1531*.
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Fire hazards; fire safety; fire scenarios; mass transportation; material fire performance; rail vehicles; subway car design; UMTA; BART; fire accidents; *NBSIR 78-1421*.

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Fire research; fire safety; human performance; model documentation; modeling technique; programming; simulation; architectural psychology; architectural research; building fires; computer-aided design; fire computer program; *NBSIR 78-1514*.

Fire research; gravity-driven flows; model equations; nonadiabatic flow; buoyant flow; *J. Res.* **83**, No. 3, 297-308 (1978).

Fire research; radiation safety; standard reference data; standard reference materials; standards development; technology transfer; weights and measures; basic research; building technology; computer technology; energy conservation and research; *SP498*.

Fire retardant materials; flame resistant fabrics; flame retardants; heat sources; ignition; ignition time; polyesters; pyrolysis; textiles; cellulosic materials; cotton fabrics; fabrics; *NBS-GCR-78-126*.

Fire retardants; fire tests; flammable materials; heat flux; heat transfer; fire research; *17672*.

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Fire safety; aircraft cabin fires; fire growth; fire growth model; fire hazard; *17957*.

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Fire safety; governmental actions; life safety; regulation; risk assessment; societal goals; building codes; control measures; fire codes; *SP518*, pp. 165-176 (Aug. 1978).

Fire safety; health; physical hazards; safety; solar heating and cooling; structural performance; toxicity; *NBSIR 78-1532*.

Fire safety; human behavior; models; phase; probability; rate constant; realm; sequence; state; states-transition; system's approach; "and" gate; behavior; critical events; decision; decision tree; dominant factors; episode; event; fire; fire behavior; fire growth; *NBSIR 77-1273*.

Fire safety; human behavior; models; phase; probability; rate constant; realm; sequence; state; state's-transition; system; systems approach; "and" gate; behavior; critical events; decision; decision tree; dominant factors; episode; event; fire; fire behavior; fire growth; *17967*.

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Fire safety; human research; research design; architectural psychology; environmental psychology; fire escape; *NBSIR 78-1508*.

Fire safety; lasers; microcircuit fabrication; nickel standard; rheology; time signals; cereal foods; computers; cryogenic measurements; electronics standards; encryption standard; *DIM/NBS 62*, No. 7/8, 1-32 (1978).

Fire safety; life safety; standards; building codes; building design; buildings; construction methods; fire prevention; fire protection; *NBS-GCR-78-118*.

Fire safety; rating criteria; solar collectors; structural performance; testing procedures; thermal performance; durability/reliability; *NBSIR 78-1305A*.

Fire scenarios; mass transportation; material fire performance; rail vehicles; subway car design; UMTA; BART; fire accidents; fire hazards; fire safety; *NBSIR 78-1421*.

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- Fire tests; flame spread; flashover; incidental fire; interior finish; life safety; mattress; mobile home; radiant heat flux; room fires; upholstered chairs; ASTM E-84 Tunnel Test; fire growth; *NBSIR 78-1531*.
- Fire tests; flame spread; flashover; interior finishes; life safety; mobile homes; radiant heat flux; room fires; ASTM E-84 Tunnel Test; carbon dioxide; carbon monoxide; fire growth; *NBSIR 78-1530*.
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- Fire tests; ignition source; incidental fires; mobile homes; repeatability; source fires; upholstered furniture; chairs; compartment fires; crib fires; *NBSIR 78-1522*.
- Fires; human behavior; human performance; life safety; panic; decision making; egress; emergencies; *NBS-GCR-78-120*.
- Firing ranges; flow measurement; fluorescence; laser-raman; measurements; metric myth; metric speakers; oxygen; phase transition; radiologic imaging; solar energy; space shuttle; biological tissue; computers; electromagnetic interference; *DIM/NBS 62, No. 3, 1-28 (1978)*.
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- Flame spread; flashover; interior finishes; life safety; mobile homes; radiant heat flux; room fires; ASTM E-84 Tunnel Test; carbon dioxide; carbon monoxide; fire growth; fire tests; *NBSIR 78-1530*.
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- Flammability tests; hazard analysis; human behavior; plastic fires; plastics; product safety; residential fires; accident analyses; fire hazards assessment; *NBSIR 78-1422*.
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- T*-test; ANOVA; regression; statistical comparison; system performance; *SP500-41*, pp. 227-238 (Oct. 1978).
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- Tungsten; alkoxy; bonding; chemical shifts; fluorides; nuclear magnetic resonance; *17491*.
- Tungsten; angular distribution; desorption; electron stimulated desorption; oxygen; single crystal; *17702*.
- Tungsten; electron work function; field-electron emission; field-ion emission; ruthenium; surface characterization; *17384*.
- Tuning; turnaround time; WWMCCS; computer; Honeywell 6000; performance evaluation; response time; *SP500-41*, pp. 297-303 (Oct. 1978).
- Tuning guides; UNIVAC 1108; computer performance management; measurement tools; operating system performance; performance guidelines; performance measurement; *SP500-34*.
- Tuning programs; variations in CPU charges; varying workloads; accounting/computer charges; CPU time; elapsed time; metering; system performance; *SP500-41*, pp. 243-253 (Oct. 1978).
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- Tunnel diode oscillators; acceleration; humidity; LC oscillators; linear motion; nuclear magnetic resonance; pressure; temperature; transducer; *17777*.
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Two-body wear; wear analysis of business machines; gear-type transmissions; input-output devices; one-body wear; tribological problems; *SP514*, pp. 121-127 (May 1978).

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- Ultraviolet; ions; molybdenum; spectra; structure; *17375*.
- Ultraviolet; window materials; dielectrics; free carrier; laser damage; lifetime; multiphoton; *SP509*, pp. 481-487 (Dec. 1977).
- Ultraviolet absorption spectrum; carbon atom reactions; CNN; combustion; matrix isolation; molecular orbitals; *18122*.
- Ultraviolet absorption spectrum; emission spectrum; HCO; hydrocarbon flame bands; matrix isolation; molecular orbitals; *17959*.
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- Ultraviolet photometry; air pollution; atmospheric monitoring; calibration; ozone; *SP529*.
- Ultraviolet reflectance; x-ray photoelectron spectroscopy; Auger electron spectroscopy; capacitance-voltage methods; dew-point sensing; dragging-stylus probe; electrical properties; electronics; four-probe method; hermeticity; hole mobility; infrared reflectance; *SP400-36*.
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- UMTA; BART; fire accidents; fire hazards; fire safety; fire scenarios; mass transportation; material fire performance; rail vehicles; subway car design; *NBSIR 78-1421*.
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- Unbalanced; ANOVA; contrast; hypothesis; mixed model; repeated measures; *SP503*, pp. 40-47 (Mar. 1978).
- Unbalanced data; analysis of variance; minimal model; two way classification; *SP503*, pp. 71-75 (Mar. 1978).
- Unbalanced data; analysis of variance; minimal model; two way classification; *SP503*, pp. 87-91 (Mar. 1978).
- Unbalanced data; analysis of variance; *SP503*, pp. 37-39 (Mar. 1978).
- Unbalanced data; ANOVA; hypothesis testing; missing cells; *SP503*, pp. 48-53 (Mar. 1978).
- Unbalanced data; automatic interaction procedures; default decisions; hypothesis testing; interactions; orthogonal contrasts; *SP503*, pp. 54-57 (Mar. 1978).
- Unbalanced data; linear models; tests of hypotheses; *SP503*, pp. 66-70 (Mar. 1978).
- Uncertainties; imperfect geometry; interferometry; methods divergence; step-height measurement; stylus instrument; surface texture; *17625*.
- Uncertainty; absorbed dose; cobalt-60; radiation therapy; random uncertainty; systematic uncertainty; *17446*.
- Uncoated optics; Argus; coated optics; damage; disks; laser; *SP509*, pp. 440-454 (Dec. 1977).
- Unfilled optics; coherence theory; effective incoherence; image scanning; microdensitometry; optical linearity; overfilled optics; sample scanning; *17456*.
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- Underground corrosion; buried cables; copper concentric neutral wires (CCN); corrosion detection methods; current-potential measurements; *NBSIR 78-1486 (DOE)*.
- Underground pipes; vibration experiments; dynamic water pressure; shaking table; *SP523*, pp. V-53-V-68 (Sept. 1978).
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- UNIVAC 1100 Series Operating System; computer performance analysis; computer performance measurement; EXEC-8; job accounting systems; Logger system; resource utilization measurement; standard unit of processing; SUP; SP500-43.
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- Upholstered furniture; consumer; cost-benefit; fire hazard; market; regulation safety standards; J. Res. 83, No. 5, 459-483 (1978).
- Upholstered furniture; upholstery fabrics; cigarette ignition; fabric classification; mock-up furniture samples; smoldering; NBSIR 78-1438.
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- Urals; U.S.S.R.; Wadsley defects; actinolite; ambient air; amosite; amphibole; amphibolite; anthophyllite; asbestos; asbestos stability; chrysotile; chrysotile emissions; chrysotile mining; crocidolite; cummingtonite; dust levels; SP506, pp. 49-70 (Nov. 1978).
- Uranium; accountability; analyses; plutonium; remote; safeguards; SP528, p. 19 (Nov. 1978).
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- Uranium assay; automation; chemical analysis; chemical separations; dissolution; isotopic analysis; plutonium assay; quality assurance programs; thorium assay; SP528, pp. 1-18 (Nov. 1978).
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- Vehicle management; fleet management; life cycle costing; patrol cars; police fleets; vehicle leasing; *SP480-15*.
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- Vehicle service life; automobile durability; automobile testing; design analysis; electronic field data collection program; *SP514*, pp. 107-120 (May 1978).
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X-ray emission spectrum; direct electron bombardment; $L\gamma$ valence-band spectrum; tellurium metal; 18099.

X-ray emission; iodine; $L\gamma_{2,3}$ spectra; tellurium; tin; 17683.

X-ray energy analysis; amphibole; analysis; asbestos; electron diffraction; electron microscopy; fibers; transmission electron microscopy; *SP506*, pp. 271-280 (Nov. 1978).

X-ray equipment; radiation safety; *H111, Revised*.

X-ray exposure; x-ray lithography; radiation damage; semiconductor devices; silicon-on-sapphire; silicon-sapphire interface; 17955.

X-ray fluorescence; activation analysis; characterization; chemical composition; chromatographic analysis; coulometry; electron probe microanalysis; ion-selective electrodes; mass spec-

- trometry; polarography; spectrochemical analysis; thermal analysis; wet chemistry; 17595.
- X-ray fluorescence; data analysis; housing; lead paint; lead poisoning; survey; 18265.
- X-ray fluorescence; fusion; gas-burner; lithium tetraborate; spectrometry; 18100.
- X-ray fluorescence analysis; actinides; freeze dried; gravimetric standards; high accuracy; particle size effects; radioactive samples; SP528, pp. 149-155 (Nov. 1978).
- X-ray fluorescence analysis; atmospheric pollutants; counting statistics; detection limits; energy vs. wavelength dispersion; imprecision; merit; quantitation limits; reporting of data; systematic error; 17507.
- X-ray fluorescence analysis; non-linear least squares; two-dimensional calibration; uranium; SP528, pp. 156-160 (Nov. 1978).
- X-ray fluorescence analysis; x-ray liquid and slurry sample cell; x-ray monochromator; analysis of solutions and slurries; high-precision, wavelength dispersive x-ray spectrometer; nuclear safeguards; rotating target x-ray tube; SP528, pp. 125-132 (Nov. 1978).
- X-ray fluorescence spectrometry; arsenic; cadmium; detection limits; lead; mercury; vanadium; NBSIR 77-1211.
- X-ray fluorescence spectrometry; baseline estimation; counting statistics; gamma-ray spectrometry; Lagrange multiplier; numerical analysis; spectrum analysis; 17509.
- X-ray fluorescent; accuracy; calibration; evaluation; lead; paint; poisoning; portable; precision; radiation; references; substrates; NBSIR 78-1466.
- X-ray fluorescent; accuracy; calibration; evaluation; lead; paint; poisoning; portable; precision; radiation; references; substrates; 17996.
- X-ray grids; anti-scatter grids; contrast improvement; experimental method; exposure reduction; grid performance; radiography; 17648.
- X-ray liquid and slurry sample cell; x-ray monochromator; analysis of solutions and slurries; high-precision, wavelength dispersive x-ray spectrometer; nuclear safeguards; rotating target x-ray tube; x-ray fluorescence analysis; SP528, pp. 125-132 (Nov. 1978).
- X-ray lithography; radiation damage; semiconductor devices; silicon-on-sapphire; silicon-sapphire interface; x-ray exposure; 17955.
- X-ray microanalysis; electron probe microanalysis; electron scattering; Monte Carlo calculations; particle analysis; scanning electron microscopy; 18051.
- X-ray monochromator; analysis of solutions and slurries; high-precision, wavelength dispersive x-ray spectrometer; nuclear safeguards; rotating target x-ray tube; x-ray fluorescence analysis; x-ray liquid and slurry sample cell; SP528, pp. 125-132 (Nov. 1978).
- X-ray optical activity; x-ray scattering; absorption of x-rays; polarization; rotation of polarization; silicon single crystal; 17950.
- X-ray photoelectron spectroscopy; adsorption; ESCA; physical adsorption; ruthenium; sulphur hexafluoride; 17708.
- X-ray photoelectron spectroscopy; adsorption; carbon dioxide; carbon monoxide; chemisorption; decomposition; formaldehyde; oxygen; 17783.
- X-ray photoelectron spectroscopy; aluminum oxide; indium; lead; surface analysis; 17580.
- X-ray photoelectron spectroscopy; amorphous materials; bonding; selenium; sulfur; tellurium; 17873.
- X-ray photoelectron spectroscopy; analysis; Auger-electron spectroscopy; electron spectroscopy; surface analysis; 18007.
- X-ray photoelectron spectroscopy; analytical methods; Auger-electron spectroscopy; ESCA; quantitative surface analysis; reference materials; 17856.
- X-ray photoelectron spectroscopy; appearance-potential spectroscopy; electron spectroscopy; high pressure; surface analysis; 17978.
- X-ray photoelectron spectroscopy; Auger electron spectroscopy; capacitance-voltage methods; dew-point sensing; dragging-stylus probe; electrical properties; electronics; four-probe method; hermeticity; hole mobility; infrared reflectance; ion implantation; SP400-36.
- X-ray photoelectron spectroscopy; Auger-electron spectroscopy; characterization of particles; spectroscopy, Auger-electron; 18146.
- X-ray photoelectron spectroscopy; crevice corrosion; field ion microscopy; iron; noncrystalline films; passive films; repassivation; sensitization; stainless steel; uranium; NBSIR 78-1429 (Navy).
- X-ray photoelectron spectroscopy (XPS); zinc selenide; adsorption; atmospheric contaminants; calcium fluoride coatings; laser window; oxygen contaminants; SP509, pp. 105-110 (Dec. 1978).
- X-ray photoemission; conduction band; intrinsic plasmons; loss spectra; 17976.
- X-ray powder diffraction; Calomel; crystal structure; mercurous chloride; phase transition; Raman spectroscopy; 17598.
- X-ray powder diffraction; diffractometer; neutron activation analysis; SRM; surface science; weights and measures; DIM/NBS 62, No. 11, 1-24 (1978).
- X-ray scattering; absorption of x-rays; polarization; rotation of polarization; silicon single crystal; x-ray optical activity; 17950.
- X-ray sources; extreme ultraviolet; stellar coronae; 18306.
- X-ray spectrometer; automation; energy dispersion; faster counting; in-line; nuclear fuel assay; SP528, pp. 20-36 (Nov. 1978).
- X-ray spectrometry; applied analysis; electron probe microanalysis; energy-dispersive analysis; lithium-drifted silicon detector; scanning electron microscope; 17545.
- X-ray spectrometry; curve fitting; electron beam microprobe; lithium-drifted silicon detector; scanning electron microscope; simplex; 18040.
- X-ray spectrometry; electron beams; ion beams; laser-Raman spectroscopy; microanalysis; microprobes; 18023.
- X-ray spectrometry; gamma-ray spectrometry; nondestructive analysis (NDA); plutonium isotopes; SP528, pp. 64-70 (Nov. 1978).
- X-ray spectroscopy; carbon contamination; electron diffraction; mineral fibers; transmission electron microscope; SP506, pp. 249-269 (Nov. 1978).
- X-ray spectrum; computer program; energy dispersive detector; multichannel analyzer; peak overlap; quantitative electron probe microanalysis; x-ray continuum; 17830.
- X-ray structure determination; hexakis(imidazole)nickel(II) chloride tetrahydrate; hydrate; hydrogen bonding; imidazole; transition metal complex; 17731.
- XTALLY; cross tabulations; hierarchical order; RPG-2; SP503, pp. 19-25 (Mar. 1978).

Y

- YAG; damage temperature dependence; damage thresholds; GGG; $\text{La}_2\text{Be}_2\text{O}_5$; LiYF_4 ; Nd glass; SP509, pp. 399-409 (Dec. 1977).
- Yb 1; ytterbium; Zeeman effect; energy levels, Yb 1; spectrum, Yb 1; wavelengths, Yb 1; *J. Res.* 83, No. 1, 13-70 (1978).
- Yellow traffic paint; alkyd traffic paint; chlorinated rubber traffic paint; hot thermoplastic coatings; lead chromate; organic yellow pigments; 18115.
- Young's modulus; birefringence; fluorophosphate laser glass; glass density; nonlinear refractive index; phosphate laser glass; physical-optical properties; rupture strength; silicate

laser glass; thermo-optic distortion; *SP509*, pp. 416-433 (Dec. 1977).

Young's modulus; bulk modulus; composite; compressibility; copper; cryogenic temperatures; elastic constants; niobium-titanium; Poisson's ratio; shear modulus; *17919*.

Young's modulus; bulk modulus; compressibility; iron alloy; maraging steel; nickel alloy; Poisson ratio; shear modulus; sound velocity; *17428*.

Young's modulus; zinc selenide; film stress; infrared interferometer; stress interferometer; thin film thermal expansion coefficient; *SP509*, pp. 230-242 (Dec. 1977).

Ytterbium; energy levels; parametric calculations; resonance lines; spectrum analysis; *J. Res.* **83**, No. 3, 233-245 (1978).

Ytterbium; Zeeman effect; energy levels, Yb I; spectrum, Yb I; wavelengths, Yb I; Yb I; *J. Res.* **83**, No. 1, 13-70 (1978).

Yttria; ceramics; electrical conductivity; microchemical; microstructural; *17517*.

Yugoslavia science and technology; binational research cooperation; international scientific cooperation; physical science research administration; research planning; scientific research abstracts; Special Foreign Currency Program; *TN986*.

Z

Zeeman effect; atomic energy levels; atomic spectroscopy; electron configurations; ionization potentials; lanthanides; rare earths; spectra; *NSRDS-NBS60*.

Zeeman effect; energy levels, Yb I; spectrum, Yb I; wavelengths, Yb I; Yb I; ytterbium; *J. Res.* **83**, No. 1, 13-70 (1978).

Zimm theory; bead-spring model; block copolymers; dilute polymer solutions; limiting viscosity number; Mandelkern-Flory-Scheraga equation; molecular weight determination; sedimentation coefficient; translational diffusion coefficient; *17929*.

Zinc; biological materials; cadmium; environmental materials, isotope dilution; lead; mass spectrometry; *18192*.

Zinc selenide; absorption; dielectric coatings; thin films; *SP509*, pp. 276-280 (Dec. 1977).

Zinc selenide; adsorption; atmospheric contaminants; calcium fluoride coatings; laser window; oxygen contaminants; x-ray photoelectron spectroscopy (XPS); *SP509*, pp. 105-110 (Dec. 1978).

Zinc selenide; Auger analysis; bias-sputtering; calcium fluoride; Rutherford backscattering; sputter-etching; *SP509*, pp. 271-275 (Dec. 1977).

Zinc selenide; film stress; infrared interferometer; stress interferometer; thin film thermal expansion coefficient; Young's modulus; *SP509*, pp. 230-242 (Dec. 1977).

Zinc sulfide; dispersion; refractive index; temperature coefficient of refractive index; *SP509*, pp. 83-88 (Dec. 1977).

Zip length; degradation; deuterated poly- α -methylstyrene; molecular weight; poly- α -methylstyrene; pyrolysis; termination; transfer; *J. Res.* **83**, No. 4, 371-380 (1978).

ZnSe; alkali-halides; alkaline earth fluorides; As₂S₃; DF; electric breakdown; HF; laser damage; quartz; sapphire; spinel; *SP509*, pp. 118-125 (Dec. 1977).

ZnSe; BaF₂; CaF₂; KBr; KCl; LiF; NaF; refractive index; SrF₂; thermal coefficient of refractive index; *SP509*, pp. 74-82 (Dec. 1977).

ZrO₂; damage thresholds; half-wave films; hydroxyl content; MgF₂; refractive index; SiO₂; ThF₄; thin-films; *SP509*, pp. 244-250 (Dec. 1977).

1 mW HeNe MAP; laser MAP; laser Measurement Assurance Program; laser power and energy measurement; laser power and energy standards; MAP; measurement assurance program; *17603*.

1-butene; 1,3-butadiene; acetylene; butane; electron; energy-loss spectra; ethane; ethylene; isobutane; isobutylene; propane; propylene; *17620*.

1-D conductivity; granular films; superconductivity; tunneling; *17770*.

1-pentene; biradical; concerted; cyclopentane; cyclopropane; decomposition; decyclization; heat of formation; isomerization; shock tube; trimethylene; *18111*.

100 endurance test; electrode materials; materials characterization; MHD (magnetohydrodynamics); U.S.-U.S.S.R. program; *17464*.

10.6 μm optical components; absorptance; dielectric coated mirror; infrared laser windows; laser mirrors; pulsed CO₂ laser damage; reflectance; *SP509*, pp. 183-194 (Dec. 1977).

10.6- μm lasers; absorptance; antireflection coatings; chalcogenide glasses; laser damage; potassium chloride; *SP509*, pp. 222-228 (Dec. 1977).

1,2-Dicarba-*closo*-dodecarborane; 1,7-Dicarba-*closo*-dodecarborane; boron hydride; carborane; nuclear magnetic resonance; *17441*.

1,3-butadiene; acetylene; butane; electron; energy-loss spectra; ethane; ethylene; isobutane; isobutylene; propane; propylene; 1-butene; *17620*.

¹³C; aromaticity; coal; cross polarization; NMR; solid; *17677*.

¹³C; aromaticity; coal; NMR; *17778*.

¹³C; dipolar; NMR; polyethylene; structure; *17674*.

¹³C and ¹⁵N coupling constants; ¹⁴C and ¹⁵N labeled derivatives; acylation; isobutyric anhydride; mass spectrometry; nuclear magnetic resonance; uric acid; ¹³C chemical shifts; *17351*.

¹³C chemical shifts; ¹³C and ¹⁵N coupling constants; ¹⁴C and ¹⁵N labeled derivatives; acylation; isobutyric anhydride; mass spectrometry; nuclear magnetic resonance; uric acid; *17351*.

¹⁴C and ¹⁵N labeled derivatives; acylation; isobutyric anhydride; mass spectrometry; nuclear magnetic resonance; uric acid; ¹³C chemical shifts; ¹³C and ¹⁵N coupling constants; *17351*.

1.4-2.1 K; axial heat transport; forced convection; helium II; measurements; pressure drop; *TN1002*.

1.5-8 keV x rays; absolute x-ray detector; electron excitations; monoenergetic x rays; pulsed x-ray source; x-ray detector calibration; *17771*.

¹⁶⁵Ho; nuclear alignment; nuclear reformation; pion cross sections; proton and neutron form factors; *17647*.

1,7-Dicarba-*closo*-dodecarborane; boron hydride; carborane; nuclear magnetic resonance; 1,2-Dicarba-*closo*-dodecarborane; *17441*.

2-terminal; 3-terminal; dielectric measurements; electrical measurements; electrical properties of materials; precise measurements; *17890*.

2,3-dimethyl-butane; alkane; bond cleavage; butane; decomposition; ethyl; heats of formation; hexamethylethane; isopropyl; pre-exponential factor; radical buffer; radical combination; rate expressions; shock tube; tert-butyl; very-low-pressure pyrolysis; *18110*.

²³⁵U; averages; cross section; fission; high resolution; keV energies; structure; *17486*.

²³⁵U; fission; neutron detection; neutron multiplicity; resonance; time-of-flight; ν ; *17810*.

²³⁵U enrichment; gamma spectrometry; isotopic verification; nondestructive analysis; sodium iodide detection; *SP528*, pp. 221-246 (Nov. 1978).

²³⁵U(n,f); ²³⁸U(n,f); ²³⁹U(n,f); ²⁵²Cf; absolute; fission cross section; integral fission measurement; spontaneous fission spectrum; *17809*.

2,3,7,8-tetrachlorodibenzofuran; inducer of enzymes; industrial contaminant; single crystal; toxic material; x-ray diffraction; *18195*.

²³⁸U(n,f); ²³⁹U(n,f); ²⁵²Cf; absolute; fission cross section; integral fission measurement; spontaneous fission spectrum; ²³⁵U(n,f); *17809*.

- ²³⁸U(n,f); ²⁵²Cf; absolute; fission cross section; integral fission measurement; spontaneous fission spectrum; ²³⁵U(n,f); ²³⁸U(n,f); 17809.
- 2,4-dioxypyrimidine; 2,4(1H, 3H)-pyrimidinedione; calorimetry; density, enthalpy of solution, entropy of solution; nucleic acid bases; thermochemistry; uracil; *J. Res.* **83**, No. 6, 547-554 (1978).
- 2,4(1H, 3H)-pyrimidinedione; calorimetry; density, enthalpy of solution, entropy of solution; nucleic acid bases; thermochemistry; uracil; 2,4-dioxypyrimidine; *J. Res.* **83**, No. 6, 547-554 (1978).
- ²⁵²Cf; absolute; fission cross section; integral fission measurement; spontaneous fission spectrum; ²³⁵U(n,f); ²³⁸U(n,f); ²³⁸U(n,f); 17809.
- 298.15 K; Burnett method; low pressures; PVT; ultra-pure air; *J. Res.* **83**, No. 5, 415-418 (1978).
- ³H; ³²P; accuracy; blank; Cerenkov counting; figure of merit; liquid scintillation counting; Poisson errors; precision; quenching; random error; reduced activity; systematic error; 17510.
- ³He(e,e'), E = 28.8-95.0 MeV; deduced rms charge radius; measured $\sigma(E)$ at $\theta = 75^\circ$; nuclear reactions; 17623.
- 3-photon Bloch equations; ac Stark shift; adiabatic approximation; dissociation; harmonic generation; ionization; laser bandwidth; multiphoton absorption; multiphoton dynamics; nonresonant processes; n-photon Bloch equations; pole approximation; 17750.
- 3-terminal; dielectric measurements; electrical measurements; electrical properties of materials; precise measurements; 2-terminal; 17890.
- 310 stainless steel; electron channelling; erosive wear; scanning electron microscopy; solid particle impact; transmission electron microscopy; 17467.
- ³²P; accuracy; blank; Cerenkov counting; figure of merit; liquid scintillation counting; Poisson errors; precision; quenching; random error; reduced activity; systematic error; ³H; 17510.
- ^{36,40}Ar deduced levels J, π , Γ ; enriched ³⁶Ar target; measured $\sigma(E, \theta)$; 17523.
- 4-amino-2(1H)-pyrimidinone; calorimetry; cytosine; density, enthalpy of solution, entropy of solution; nucleic acid bases; thermochemistry; *J. Res.* **83**, No. 6, 539-546 (1978).
- (CCl₂)HF anion; electron capture; HCCIF anion; HCCl₂F; hydrogen bonding; infrared spectrum; matrix isolation; ultraviolet spectrum; vacuum ultraviolet photolysis; argon metastables; CCl₂; 17727.
- 4-methylheptyne; 4-methylhexyne-1; 5-methylhexyne-1; acetylenic; decomposition; heat of formation; hexyne-1; methyl propargyl; propargyl; resonance energy; shock tube; thermal properties; 18112.
- 4-methylhexyne-1; 5-methylhexyne-1; acetylenic; decomposition; heat of formation; hexyne-1; methyl propargyl; propargyl; resonance energy; shock tube; thermal properties; 4-methylheptyne; 18112.
- 4-plot analysis; assumptions; data analysis; distribution analysis; graphical analysis; in control; measurement process; predictability; probability plots; randomness; statistics; testing assumptions; 17935.
- (V-A)-currents; GIM model; neutrinos; partons; quarks; reconciliation; scattering; 17496.
- 5-methylhexyne-1; acetylenic; decomposition; heat of formation; hexyne-1; methyl propargyl; propargyl; resonance energy; shock tube; thermal properties; 4-methylheptyne; 4-methylhexyne-1; 18112.
- 5-methyl-uracil; 5-methyl-2,4 (1H, 3H)-pyrimidinedione; calorimetry; density; enthalpy of solution; nucleic acid bases; thermochemistry; thymine; *J. Res.* **83**, No. 6, 529-537 (1978).
- 5-methyl-2,4 (1H, 3H)-pyrimidinedione; calorimetry; density; enthalpy of solution; nucleic acid bases; thermochemistry; thymine; 5-methyl-uracil; *J. Res.* **83**, No. 6, 529-537 (1978).
- 50 K-473 K; accuracy; nuclear quadrupole resonance; precision; thermometry; 17776.
- ⁵⁵Fe, ⁸⁵Sr, ¹⁰⁹Cd, ¹²⁵I; defined solid angle spectrometer; standardization; 17785.
- 6-amino purine; adenine; calorimetry; density, enthalpy of solution, entropy of formation; nucleic acid bases; thermochemistry; *J. Res.* **83**, No. 4, 347-370 (1978).
- ⁶He; ⁶Li; electroproduction; nuclear structure; pions; virtual photons; 17627.
- ⁶Li; electroproduction; nuclear structure; pions; virtual photons; ⁶He; 17627.
- ⁶Li(n, α)T; flux measurement; H(n,p); neutrons; standards; time-of-flight; 18225.
- 6-port junction; automated measurements; bolometer unit calibration; broadband measurement; microwave power measurement; precision microwave measurements; 18067.
- ⁶⁰Co; absorbed dose; calorimeters; comparison; national standards; 18233.
- 8th Annual Conference; ASHRAE 90-P; building codes; mobile homes; National Conference of States on Building Codes and Standards; NCSBCS; proceedings; NBSIR 77-1413.1

APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

- Alexander City: Alexander City State Junior College, Thomas D. Russell Library (1967).
- Auburn: Auburn University, Ralph Brown Draughon Library (1907).
- Birmingham:
- Birmingham Public Library (1895).
 - Birmingham-Southern College Library (1932).
 - Jefferson State Junior College, James B. Allen Library (1970).
 - Samford University, Harwell G. Davis Library (1884).
- Enterprise: Enterprise State Junior College, Learning Resource Center (1967).
- Florence: University of North Alabama, Collier Library (1932).
- Gadsden: Gadsden Public Library (1963).
- Huntsville: University of Alabama, Huntsville Campus Library (1964).
- Jacksonville: Jacksonville State University, Ramona Wood Library (1929).
- Maxwell A.F. Base: Air University Library (1963).
- Mobile:
- Mobile Public Library (1963).
 - Spring Hill College, Thomas Byrne Memorial Library (1937).
 - University of South Alabama Library (1968).
- Montgomery:
- Alabama State Department of Archives and History Library (1884).
 - Alabama Supreme Court and State Law Library (1884).
 - Auburn University at Montgomery Library (1971)-REGIONAL.
- Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).
- St. Bernard: St. Bernard College, Herman J. Heidrich Library (1962).
- Troy: Troy State University, Lurleen B. Wallace Educational Resources Center (1963).
- Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).
- University:
- University of Alabama, School of Law Library (1967).
 - University of Alabama Library (1860)-REGIONAL

ALASKA

- Anchorage:
- Supreme Court of Alaska Library (1973).
 - University of Alaska, Anchorage Library (1961).
- College: University of Alaska, Elmer E. Rasmuson Library (1922).
- Juneau: Alaska State Library (1964).
- Ketchikan: Ketchikan Community College Library (1970).

ARIZONA

- Coolidge: Central Arizona College, Instructional Materials Center (1973).
- Flagstaff: Northern Arizona University Library (1937).

Phoenix:

- Department of Library and Archives (unknown)-REGIONAL.
 - AL.
 - Grand Canyon College, Fleming Library.
 - Phoenix Public Library (1917).
- Prescott: Yavapai College Library (1976).
- Tempe:
- Arizona State University, Matthews Library (1944).
 - Arizona State University, College of Law Library (1977).
- Thatcher: Eastern Arizona Junior College Library (1963).
- Tucson:
- Tucson Public Library (1970).
 - University of Arizona Library (1907)-REGIONAL.
- Yuma: Yuma City-County Library (1963).

ARKANSAS

- Arkadelphia: Ouachita Baptist University, Riley Library (1963).
- Batesville: Arkansas College Library (1963).
- Clarksville: College of the Ozarks Library (1925).
- Conway: Hendrix College, O. C. Bailey Library (1903).
- Fayetteville: University of Arkansas Library (1907).
- Little Rock:
- Arkansas Supreme Court Library (1962).
 - Little Rock Public Library (1953).
 - University of Arkansas at Little Rock Library (1973).
- Magnolia: Southern Arkansas University, Mogale Library (1956).
- Monticello: University of Arkansas at Monticello Library (1956).
- Pine Bluff: University of Arkansas at Pine Bluff, Watson Memorial Library (1976).
- Russellville: Arkansas Tech University, Tomlinson Library (1925).
- Searcy: Harding College, Beaumont Memorial Library (1963).
- State College: Arkansas State University, Dean B. Ellis Library (1913).
- Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

- Anaheim: Anaheim Public Library (1963).
- Arcadia: Arcadia Public Library (1975).
- Arcata: Humboldt State College Library (1963).
- Bakersfield:
- California State College, Bakersfield Library (1974).
 - Kern County Library System (1943).
- Berkeley:
- University of California, General Library (1907).
 - University of California, Law Library, Earl Warren Legal Center (1963).
- Carson:
- California State University, Dominguez Hills, Educational Resources Center (1973).
 - Carson Regional Library (1973).
- Chico: Chico State University Library (1962).
- Claremont: Pomona College Documents Collection, Honnold Library (1913).
- Coalingo: West Hills Community College (1978).

Compton: Compton Library (1972).
 Culver City: Culver City Library (1966).
 Davis:
 University of California at Davis Library (1953).
 University of California at Davis, School of Law Library (1972).
 Downey: Downey City Library (1963).
 Fresno:
 California State University Library (1962).
 Fresno County Free Library (1920).
 Fullerton: California State University, Fullerton Library (1963).
 Garden Grove: Garden Grove Regional Library (1963).
 Gardena: Gardena Public Library (1966).
 Hayward: California State College at Hayward Library (1963).
 Huntington Park: Huntington Park Library, San Antonio Region (1970).
 Inglewood: Inglewood Public Library (1963).
 Irvine: University of California at Irvine Library (1963).
 La Jolla: University of California, San Diego, University Library (1963).
 Lakewood: Angelo Iacoboni Public Library (1970).
 Lancaster: Lancaster Regional Library (1967).
 Long Beach:
 California State University at Long Beach Library (1962).
 Long Beach Public Library (1933).
 Los Angeles:
 California State College at Los Angeles, John F. Kennedy Memorial Library (1956).
 Los Angeles County Law Library (1963).
 Los Angeles Public Library (1891).
 Loyola University of Los Angeles Library (1933).
 Occidental College, Mary Norton Clapp Library (1941).
 Pepperdine University Library (1963).
 Southwestern University, School of Law Library (1975).
 University of California at Los Angeles Library (1932).
 University of California at Los Angeles, Law Library (1958).
 University of Southern California Library (1933).
 Menlo Park: Department of the Interior, Geological Survey Library (1962).
 Montebello: Montebello Library (1966).
 Monterey: Naval Postgraduate School Library (1963).
 Monterey Park: Bruggemeyer Memorial Library (1964).
 Northridge: California State University at Northridge, Delmar T. Oviatt Library (1958).
 Norwalk: Los Cerritos Regional Library (1973).
 Oakland:
 Mills College Library (1966).
 Oakland Public Library (1923).
 Ontario: Ontario City Library (1974).
 Pasadena:
 California Institute of Technology, Robert A. Millikan Memorial Library (1933).
 Pasadena Public Library (1963).
 Pleasant Hill: Contra Costa County Library (1964).
 Redding: Shasta County Library (1956).
 Redlands: University of Redlands, Armacost Library (1933).
 Redwood City: Redwood City Public Library (1966).
 Reseda: West Valley Regional Branch Library (1966).
 Richmond: Richmond Public Library (1943).
 Riverside:
 Riverside Public Library (1947).
 University of California at Riverside Library (1963).
 Sacramento:
 California State Library (1895)-REGIONAL.
 Sacramento City-County Library (1880).
 Sacramento County Law Library (1963).
 Sacramento State University Library (1963).
 San Bernardino: San Bernardino County Free Library (1964).

San Diego:
 San Diego State University, Love Library (1962).
 San Diego County Law Library (1973).
 San Diego County Library (1966).
 San Diego Public Library (1895).
 University of San Diego Law Library (1967).
 San Francisco:
 Mechanics' Institute Library (1889).
 San Francisco Public Library (1889).
 San Francisco State College, Social Science and Business Library (1955).
 Supreme Court of California Library (1972).
 U.S. Court of Appeals for Ninth Circuit Library (1971).
 University of San Francisco, Richard A. Gleeson Library (1963).
 San Jose: San Jose State College Library (1962).
 San Leandro: San Leandro Community Library Center (1961).
 San Luis Obispo: California State Polytechnic University Library (1969).
 San Rafael: Marin County Free Library (1975).
 Santa Ana:
 Orange County Law Library (1975).
 Santa Ana Public Library (1959).
 Santa Barbara: University of California at Santa Barbara Library (1960).
 Santa Clara: University of Santa Clara, Orradre Library (1963).
 Santa Cruz: University of California at Santa Cruz Library (1963).
 Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).
 Stanford: Stanford University Libraries (1895).
 Stockton: Public Library of Stockton and San Joaquin County (1884).
 Thousand Oaks: California Lutheran College Library (1964).
 Torrance: Torrance Civic Center Library (1969).
 Turlock: Stanislaus State College Library (1964).
 Valencia: Valencia Library (1972).
 Ventura: Ventura County Library Services Agency (1975).
 Visalia: Tulare County Free Library (1967).
 Walnut: Mount San Antonio College Library (1966).
 West Covina: West Covina Library (1966).
 Whittier: Whittier College, Wardman Library (1963).

CANAL ZONE

Balboa Heights: Canal Zone Library-Museum (1963).

COLORADO

Alamosa: Adams State College, Learning Resources Center (1963).
 Boulder: University of Colorado Libraries (1879)-REGIONAL.
 Colorado Springs:
 Colorado College, Charles Leaming Tutt Library (1880).
 University of Colorado, Colorado Springs Library (1974).
 Denver:
 Auraria Libraries (1978).
 Colorado State Library (unknown).
 Denver Public Library (1884)-REGIONAL.
 Department of Interior, Bureau of Reclamation Library (1962).
 Regis College, Dayton Memorial Library (1915).
 Supreme Court Library (1978).
 University of Denver, Penrose Library (1909).
 U.S. Court of Appeals for Tenth Circuit Library (1973).
 Fort Collins: Colorado State University Library (1907).
 Golden: Colorado School of Mines, Arthur Lakes Library (1939).

Grand Junction: Mesa County Public Library (1975).
 Greeley: University of Northern Colorado Library (1966).
 Gunnison: Western State College, Leslie J. Savage Library (1932).
 La Junta: Otero Junior College, Wheeler Library (1963).
 Lakewood: Jefferson County Public Library, Lakewood Regional Library (1968).
 Pueblo:
 Pueblo Regional Library (1893).
 University Southern Colorado Library, Learning Resources Center (1965).
 U.S. Air Force Academy: Academy Library (1956).

CONNECTICUT

Bridgeport: Bridgeport Public Library (1884).
 Danbury: Western Connecticut State College, Ruth A. Haas Library (1967).
 Danielson: Quinebaug Valley Community College (1975).
 Enfield: Enfield Public Library (1967).
 Hartford:
 Connecticut State Library (unknown)-REGIONAL.
 Hartford Public Library (1945).
 Trinity College Library (1895).
 Middletown: Wesleyan University Library (1906).
 Mystic: Marine Historical Association, Inc., G. W. Blunt White Library (1964).
 New Britain: Central Connecticut State College, Elihu Burritt Library (1973).
 New Haven:
 Southern Connecticut State College Library (1968).
 Yale University Library (1859).
 New London:
 Connecticut College Library (1926).
 U.S. Coast Guard Academy Library (1939).
 Stamford: Stamford Public Library (1973).
 Storrs: University of Connecticut, Wilbur Cross Library (1907).
 Waterbury:
 Post College, Traurig Library (1977).
 Silas Bronson Library (1869).
 West Haven: University of New Haven Library (1971).

DELAWARE

Dover:
 Delaware State College, William C. Jason Library (1962).
 State Department of Community Affairs and Economic Development, Division of Libraries (1972).
 State Law Library in Kent County (unknown).
 Georgetown:
 Delaware Technical and Community College, Southern Branch Library (1968).
 Sussex County Law Library (1976).
 Newark: University of Delaware, Morris Library (1907).
 Wilmington:
 Delaware Law School Library (1976).
 New Castle County Law Library (1974).
 Wilmington Institute and New Castle County Library (1861).

DISTRICT OF COLUMBIA

Washington:
 Administrative Conference of U.S. Library (1977).
 Advisory Commission on Intergovernmental Relations Library (1972).
 Civil Aeronautics Board Library (1975).
 Civil Service Commission Library (1963).
 Department of Commerce Library (1955).

Department of Health, Education, and Welfare Library (1954).
 Department of Housing and Urban Development Library (1969).
 Department of the Interior Central Library (1895).
 Department of Justice Main Library (1895).
 Department of Labor Library (1976).
 Department of State Library (1895).
 Department of State, Office of Legal Advisor, Law Library (1966).
 Department of Transportation, National Highway Traffic Safety Administration Library (1968).
 District of Columbia Public Library (1943).
 Federal City College Library (1970).
 Federal Deposit Insurance Corporation Library (1972).
 Federal Election Commission Library (1975).
 Federal Reserve System Law Library (1976).
 General Accounting Office Library (1975).
 General Services Administration Library (1975).
 Georgetown University Library (1969).
 Indian Claims Commission Library (1968).
 Library of Congress, Gift and Exchange Division (1977).
 National Defense University Library (1895).
 Navy Department Library (1895).
 Navy Department, Office of Judge Advocate General Library (1963).
 Office of Management and Budget Library (1965).
 Office of The Adjutant General, Department of Army Library (1969).
 Postal Service Library (1895).
 Research Library, Board of Governors of the Federal Reserve System (1978).
 Treasury Department Library (1895).
 U.S. Court of Appeals, Judge's Library (1975).
 U.S. Supreme Court Library (1978).
 Veterans' Administration, Central Office Library (1976).

FLORIDA

Boca Raton: Florida Atlantic University Library (1963).
 Clearwater: Clearwater Public Library (1972).
 Coral Gables: University of Miami Library (1939).
 Crestview: Robert F. L. Sikes Public Library (1978).
 Daytona Beach: Volusia County Public Libraries (1963).
 DeLand: Stetson University, duPont-Ball Library (1887).
 Fort Lauderdale:
 Broward County Library System (1967).
 Nova University Law Library (1967).
 Fort Pierce: Indian River Community College Library (1975).
 Gainesville: University of Florida Libraries (1907)-REGIONAL.
 Jacksonville:
 Haydon Burns Library (1914).
 Jacksonville University, Swisher Library (1962).
 University of North Florida Library (1972).
 Lakeland: Lakeland Public Library (1928).
 Leesburg: Lake-Sumter Community College Library (1963).
 Melbourne: Florida Institute of Technology Library (1963).
 Miami:
 Florida International University Library (1970).
 Miami Public Library (1952).
 North Miami: Florida International University, North Miami Campus Library (1977).
 Opa Locka: Biscayne College Library (1966).
 Orlando: Florida Technological University Library (1966).
 Palatka: St. Johns River Junior College Library (1963).
 Pensacola: University of West Florida, John C. Pace Library (1966).
 Port Charlotte: Charlotte County Library System (1973).

St. Petersburg:
St. Petersburg Public Library (1965).
Stetson University College Law Library (1975).

Sarasota: Selby Public Library (1970).

Tallahassee:

Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).

Florida State University, R. M. Stozier Library (1941). (1941).

Florida Supreme Court Library (1974).

State Library of Florida (1929).

Tampa:

Tampa Public Library (1965).

University of South Florida Library (1962).

University of Tampa, Merle Kelce Library (1953).

Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

Albany: Albany Public Library (1964).

Americus: Georgia Southwestern College, James Earl Carter Library (1966).

Athens: University of Georgia Libraries (1907)-REGIONAL.

Atlanta:

Atlanta Public Library (1880).

Atlanta University, Trevor Arnett Library (1962).

Emory University, Robert W. Woodruff Library (1928).

Emory University, School of Law Library (1968).

Georgia Institute of Technology, Price Gilbert Memorial Library (1963).

Georgia State Library (unknown).

Georgia State University Library (1970).

Augusta: Augusta College Library (1962).

Brunswick: Brunswick-Glyn County Regional Library (1965).

Carrollton: West Georgia College, Sanford Library (1962).

Columbus: Columbus College, Simon Schwob Memorial Library (1975).

Dahlonega: North Georgia College Library (1939).

Dalton: Dalton Junior College Library (1978).

Decatur: Dekalb Community College-South Campus, Learning Resources Center (1973).

Macon: Mercer University Library (1964).

Marietta: Kennesaw Junior College Library (1968).

Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).

Mount Berry: Berry College, Memorial Library (1970).

Savannah: Savannah Public and Chatham-Effingham Liberty Regional Library (1857).

Statesboro: Georgia Southern College Library (1939).

Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

GUAM

Agana: Nieves M. Flores Memorial Library (1962).

HAWAII

Hilo: University of Hawaii, Hilo Campus Library (1962).

Honolulu:

Hawaii Medical Library, Inc. (1968).

Hawaii State Library (1929).

Municipal Reference Library of the City and County of Honolulu (1965).

Supreme Court Law Library (1973).

University of Hawaii Library (1907)-REGIONAL.

Lae: Church College of Hawaii, Woolley Library (1964).

Lihue: Kauai Public Library (1967).

Pearl City: Leeward Community College Library (1967).

Wailuku: Maui Public Library (1962).

IDAHO

Boise:

Boise State University Library (1966).

Boise Public Library and Information Center (1929).

Idaho State Law Library (unknown).

Idaho State Library (1971).

Caldwell: College of Idaho, Terteling Library (1930).

Moscow: University of Idaho Library (1907)-REGIONAL.

Pocatello: Idaho State University Library (1908).

Rexburg: Ricks College, David O. McKay Library (1946).

Twin Falls: College of Southern Idaho Library (1970).

ILLINOIS

Bloomington: Illinois Wesleyan University Libraries (1964).

Carbondale: Southern Illinois University Library (1932).

Carlinville: Blackburn College Library (1954).

Cartersville: Shawnee Library System (1971).

Champaign: University of Illinois Law Library, College of Law (1965).

Charleston: Eastern Illinois University, Booth Library (1962).

Chicago:

Chicago Public Library (1876).

Chicago State University Library (1954).

DePaul University, Lincoln Park Campus Library (1975).

Field Museum of Natural History Library (1963).

John Crerar Library (1909).

Loyola University of Chicago, E. M. Cudahy Memorial Library (1966).

Northeastern Illinois University Library (1961).

University of Chicago Law Library (1964).

University of Chicago Library (1897).

University of Illinois, Chicago Circle Campus Library (1957).

Decatur: Decatur Public Library (1954).

De Kalb: Northern Illinois University, Swen Franklin Parson Library (1960).

Edwardsville: Southern Illinois University, Lovejoy Memorial Library (1959).

Elsah: Principia College, Marshall Brooks Library (1957).

Evanston: Northwestern University Library (1876).

Freeport: Freeport Public Library (1905).

Galesburg: Galesburg Public Library (1896).

Jacksonville: MacMurray College, Henry Pfeiffer Library (1929).

Kankakee: Olivet Nazarene College, Benner Library and Resource Center (1946).

Lake Forest: Lake Forest College, Donnelley Library (1962).

Lebanon: McKendree College, Holman Library (1968).

Lisle: Illinois Benedictine College, Theodore F. Lownik Library (1911).

Lockport: Lewis University Library (1952).

Macomb: Western Illinois University Memorial Library (1962).

Moline: Black Hawk College, Learning Resources Center (1970).

Monmouth: Monmouth College Library (1860).

Morton Grove: Oakton Community College Library (1976).

Mt. Carmel: Wabash Valley College Library (1975).

Mt. Prospect: Mt. Prospect Public Library (1977).

Normal: Illinois State University, Milner Library (1877).

Oak Park: Oak Park Public Library (1963).

Oglesby: Illinois Valley Community College Library (1976).

Palos Hills: Moraine Valley Community College Library (1972).

Park Forest South: Governors State University Library (1974).

Peoria:
 Bradley University, Cullom Davis Library (1963).
 Peoria Public Library (1883).
River Forest: Rosary College Library (1966).
Rockford: Rockford Public Library (unknown).
Springfield: Illinois State Library (unknown)-REGIONAL.
Urbana: University of Illinois Library (1907).
Wheaton: Wheaton College Library (1964).
Woodstock: Woodstock Public Library (1963).

INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).
Bloomington: Indiana University Library (1881).
Crawfordsville: Wabash College, Lilly Library (1906).
Evansville:
 Evansville and Vanderburgh County Public Library (1928).
 Indiana State University, Evansville Campus Library (1969).
Fort Wayne:
 Indiana-Purdue Universities, Walter E. Helmke Library (1965).
 Public Library of Fort Wayne and Allen County (1896).
Franklin: Franklin College Library (1976).
Gary:
 Gary Public Library (1943).
 Indiana University, Northwest Campus Library (1966).
Greencastle: De Pauw University, Roy O. West Library (1879).
Hammond: Hammond Public Library (1964).
Hanover: Hanover College Library (1892).
Huntington: Huntington College Library (1964).
Indianapolis:
 Butler University, Irwin Library (1965).
 Indiana State Library (unknown)-REGIONAL.
 Indiana Supreme Court Law Library (1975).
 Indiana University, Law Library (1967).
 Indianapolis-Marion County Public Library (1906).
Kokomo: Indiana University, Kokomo Regional Campus Library (1969).
Lafayette: Purdue University Library (1907).
Muncie:
 Ball State University Library (1959).
 Muncie Public Library (1906).
New Albany: Indiana University, Southeastern Campus Library (1965).
Notre Dame: University of Notre Dame, Memorial Library (1883).
Rensselaer: St. Joseph's College Library (1964).
Richmond:
 Earlham College, Lilly Library (1964).
 Morrison-Reeves Library (1906).
South Bend: Indiana University at South Bend Library (1965).
Terre Haute: Indiana State University, Cunningham Memorial Library (1906).
Valparaiso: Valparaiso University, Moellering Memorial Library (1930).

IOWA

Ames: Iowa State University of Science and Technology Library (1907).
Cedar Falls: University of Northern Iowa Library (1946).
Council Bluffs:
 Free Public Library (1885).
 Iowa Western Community College, Hoover Media Library (1972).
Davenport: Davenport Public Library (1973).
Des Moines:
 Drake University, Cowles Library (1966).
 Drake University Law Library (1972).

State Library Commission of Iowa (unknown).
 Public Library of Des Moines (1888).
Dubuque:
 Carnegie-Stout Public Library (unknown).
 Loras College, Wahlert Memorial Library (1967).
Fayette: Upper Iowa College, Henderson-Wilder Library (1974).
 Grinnell: Grinnell College, Burling Library (1874).
Iowa City:
 University of Iowa, Law Library (1968).
 University of Iowa Library (1884)-REGIONAL.
Lamoni: Graceland College, Frederick Madison Smith Library (1927).
Mason City: North Iowa Area Community College Library (1976).
Mount Vernon: Cornell College, Russell D. Cole Library (1896).
Orange City: Northwestern University, Ramaker Library (1970).
Sioux City: Sioux City Public Library (1894).

KANSAS

Atchison: Benedictine College Library (1965).
Baldwin City: Baker University Library (1908).
Colby: Colby Community Junior College Library (1968).
Emporia: Emporia State University, William Allen White Library (1909).
Hays: Fort Hays Kansas State College, Forsyth Library (1926).
Hutchinson: Hutchinson Public Library (1963).
Lawrence:
 University of Kansas, Watson Library (1869)-REGIONAL.
 University of Kansas Law Library (1971).
Manhattan: Kansas State University, Farrell Library (1907).
Pittsburg: Pittsburg State University, Porter Library (1952).
Salina: Kansas Wesleyan University, Memorial Library (1930).
Topeka:
 Kansas State Historical Society Library (1877).
 Kansas State Library (unknown).
 Kansas Supreme Court Law Library (1975).
 Washburn University of Topeka, Law Library (1971).
Wichita: Wichita State University Library (1901).

KENTUCKY

Ashland: Ashland Public Library (1946).
Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).
Bowling Green: Western Kentucky University, Cravens Graduate Center and Library (1934).
Covington: Thomas More College Library (1970).
Danville: Centre College, Grace Doherty Library (1884).
Frankfort:
 Kentucky Department of Libraries (1967).
 Kentucky State University, Blazer Library (1972).
 State Law Library (unknown).
Highland Heights: Northern Kentucky University, W. Frank Steely Library (1973).
Hopkinsville: Hopkinsville Community College Library (1976).
Lexington:
 University of Kentucky, Law Library (1968).
 University of Kentucky, Margaret I. King Library (1907)-REGIONAL.
Louisville:
 Louisville Free Public Library (1904).
 University of Louisville, Belknap Campus Library (1925).
 University of Louisville Law Library (1975).
Morehead: Morehead State University, Johnson Camden Library (1955).
Murray: Murray State University Library (1924).

Owensboro: Kentucky Wesleyan College Library (1966).
Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

LOUISIANA

Baton Rouge:

Louisiana State Library (1976).
Louisiana State University Law Library (1929).
Louisiana State University Library (1907)-REGIONAL.
Southern University Library (1952).

Eunice: Louisiana State University at Eunice, Le Doux Library (1969).

Hammond: Southeastern Louisiana University, Sims Memorial Library (1966).

Lafayette: University of Southwestern Louisiana Library (1938).
Lake Charles: McNeese State University, Frazar Memorial Library (1941).

Monroe: Northeast Louisiana University, Sandel Library (1963).
Natchitoches: Northwestern State University, Watson Memorial Library (1887).

New Orleans:

Isaac Delgado College, Moss Technical Library (1968).
Law Library of Louisiana (unknown).
Loyola University Library (1942).
New Orleans Public Library (1883).
Southern University in New Orleans Library (1962).
Tulane University, Howard-Tilton Memorial Library (1942).
Tulane University Law Library (1976).
U.S. Court of Appeals, Fifth Circuit Library (1973).
University of New Orleans Library (1963).

Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).

Ruston: Louisiana Technical University Library (1896)-REGIONAL.

Shreveport:

Louisiana State University at Shreveport Library (1967).
Shreve Memorial Library (1923).

Thibodaux: Francis T. Nicholls State University, Leonidas Polk Library (1962).

MAINE

Augusta:

Maine Law and Legislative Reference Library (1973).
Maine State Library (unknown).

Bangor: Bangor Public Library (1884).

Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).

Castine: Maine Maritime Academy, Nutting Memorial Library (1969).

Lewiston: Bates College Library (1882).

Orono: University of Maine, Raymond H. Fogler Library (1907)-REGIONAL.

Portland:

Portland Public Library (1884).
University of Maine Law Library (1964).

Springvale: Nasson College Library (1961).

Waterville: Colby College Library (1884).

MARYLAND

Annapolis:

Maryland State Library (unknown).
U.S. Naval Academy, Nimitz Library (1895).

Baltimore:

Enoch Pratt Free Library (1887).
Johns Hopkins University, Milton S. Eisenhower Library (1882).

Morgan State College, Soper Library (1940).
University of Baltimore, Langsdale Library (1973).
University of Maryland, Baltimore County Library (1971).
University of Maryland, School of Law Library (1969).

Bel Air: Harford Community College Library (1967).

Beltsville: Department of Agriculture, National Agricultural Library (1895).

Bethesda: National Library of Medicine Library (1978).

Chestertown: Washington College, Chester M. Miller Library (1891).

College Park: University of Maryland, McKeldin Library (1925)-REGIONAL.

Cumberland: Allegany Community College Library (1974).

Frostburg: Frostburg State College Library (1967).

Germantown: Energy Research & Development Adm. Library (1963).

Patuxent River: Naval Air Station Library (1968).

Rockville: Montgomery County Department of Public Libraries (1951).

Salisbury: Salisbury State College, Blackwell Library (1965).

Towson: Goucher College, Julia Rogers Library (1966).

Westminster: Western Maryland College Library (1896).

MASSACHUSETTS

Amherst:

Amherst College Library (1884).
University of Massachusetts, Godell Library (1907).

Belmont: Belmont Memorial Library (1968).

Boston:

Boston Athenaeum Library (unknown).
Boston College, Bapst Library (1963).
Boston Public Library (1859)-REGIONAL.
Northeastern University, Dodge Library (1962).
State Library of Massachusetts (unknown).

Brookline: Public Library of Brookline (1925).

Cambridge:

Harvard College Library (1860).
Massachusetts Institute of Technology Libraries (1946).
Middlesex County Law Library (1978).

Chicopee: Our Lady of the Elms College Library (1969).

Lowell: University of Lowell/North Campus, Alumni/Lydon Library (1952).

Lynn: Lynn Public Library (1953).

Marlborough: Marlborough Public Library (1971).

Medford: Tufts University Library (1899).

Milton: Curry College Library (1972).

New Bedford: New Bedford Free Public Library (1858).

North Dartmouth: Southeastern Massachusetts University Library (1965).

North Easton: Stonehill College, Cushing-Martin Library (1962).

Springfield: Springfield City Library (1966).

Waltham: Brandeis University, Goldfarb Library (1965).

Wellesley: Wellesley College Library (1943).

Wenham: Gordon College, Winn Library (1963).

Williamstown: Williams College Library (unknown).

Worcester:

American Antiquarian Society Library (1814).
University of Massachusetts, Medical Center Library (1972).
Worcester Public Library (1859).

MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).

Allendale: Grand Valley State College Library (1963).

Alma: Alma College, Monteith Library (1963).

Ann Arbor:

Great Lakes Basin Commission Library (1971).
University of Michigan, Harlan Hatcher Library (1884).

Benton Harbor: Benton Harbor Public Library (1907).

Bloomfield Hills: Cranbrook Institute of Science Library (1940).
Dearborn:
Henry Ford Centennial Library (1969).
Henry Ford Community College Library (1957).
Detroit:
Detroit Public Library (1868)-REGIONAL.
Marygrove College Library (1965).
Mercy College of Detroit Library (1965).
University of Detroit Library (1884).
Wayne State University Law Library (1971).
Wayne State University, G. Flint Purdy Library (1973).
Dowagiac: Southwestern Michigan College Library (1971).
East Lansing:
Michigan State University, Law Library (1971).
Michigan State University Library (1907).
Escanaba: Michigan State Library, Upper Peninsula Branch (1964).
Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).

Flint:
Flint Public Library (1967).
University of Michigan, Flint Library (1959).
Grand Rapids:
Calvin College Library (1967).
Grand Rapids Public Library (1876).
Houghton: Michigan Technological University Library (1876).
Jackson: Jackson District Library (1965).
Kalamazoo:
Kalamazoo Library System (1907).
Western Michigan University, Dwight B. Waldo Library (1963).

Lansing: Michigan State Library (unknown)-REGIONAL.
Livonia: Schoolcraft College Library (1962).
Marquette: Northern Michigan University, Olsen Library (1963).
Monroe: Monroe County Library System (1974).
Mt. Clemens: Macomb County Library (1968).
Mt. Pleasant: Central Michigan University Library (1958).
Muskegon: Hackley Public Library (1894).
Olivet: Olivet College Library (1974).
Petoskey: North Central Michigan College Library (1962).
Port Huron: Saint Clair County Library System (1876).
Rochester: Oakland University, Kresge Library (1964).
Saginaw: Hoyt Public Library (1890).
Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).
University Center: Delta College Library (1963).
Warren: Warren Public Library, Arthur J. Miller Branch (1973).
Wayne: Wayne Oakland Federated Library System (1957).
Ypsilanti: Eastern Michigan University Library (1965).

MINNESOTA

Bemidji: Bemidji State University, A. C. Clark Library (1963).
Collegeville: St. John's University, Alcuin Library (1954).
Duluth: Duluth Public Library (1909).
Mankato: Mankato State University Memorial Library (1962).
Minneapolis:
Anoka County Library (1971).
Hennepin County Libraries (1971).
Minneapolis Public Library (1893).
University of Minnesota, Wilson Library (1907)-REGIONAL.
Moorhead: Moorhead State University Library (1956).
Morris: University of Minnesota at Morris Library (1963).
Northfield:
Carleton College Library (1930).
St. Olaf College, Rolvaag Memorial Library (1930).
St. Cloud: St. Cloud State University Library (1962).
St. Paul:
Minnesota Historical Society Library (1867).

Minnesota State Law Library (unknown).
St. Paul Public Library (1914).
University of Minnesota, St. Paul Campus Library (1974).
Saint Peter: Gustavus Adolphus College Library (1941).
Stillwater: Stillwater Public Library (1893).
Willmar: Crow River Regional Library (1958).
Winona: Winona State University, Maxwell Library (1969).

MISSISSIPPI

Cleveland: Delta State University, W. B. Roberts Library (1975).
Clinton: Mississippi College School of Law Library (1977).
Columbus: Mississippi State University for Women, J. C. Fant Memorial Library (1920).
Hattiesburg: University of Southern Mississippi Library (1935).
Jackson:
Jackson State College Library (1968).
Millsaps College, Millsaps-Wilson Library (1963).
Mississippi Library Commission (1947).
Mississippi State Law Library (unknown).
Lorman: Alcorn Agricultural and Mechanical College Library (1970).
State College: Mississippi State University, Mitchell Memorial Library (1907).
University:
University of Mississippi Library (1833)-REGIONAL.
University of Mississippi, School of Law Library (1967).

MISSOURI

Cape Girardeau: Southeast Missouri State University, Kent Library (1916).
Columbia: University of Missouri Library (1862).
Fayette: Central Methodist College Library (1962).
Fulton: Westminster College, Reeves Library (1875).
Jefferson City:
Lincoln University, Inman E. Page Library (1944).
Missouri State Library (1963).
Missouri Supreme Court Library (unknown).
Joplin: Missouri Southern State College Library (1966).
Kansas City:
Kansas City Public Library (1881).
Rockhurst College Library (1917).
University of Missouri at Kansas City, General Library (1938).
Kirksville: Northeast Missouri State Teachers College, Pickler Memorial Library (1966).
Liberty: William Jewell College Library (1900).
Rolla: University of Missouri at Rolla Library (1907).
St. Charles: Lindenwood College, Margaret Leggat Butler Library (1973).
St. Joseph: St. Joseph Public Library (1891).
St. Louis:
Maryville College Library (1976).
St. Louis County Library (1970).
St. Louis Public Library (1866).
St. Louis University, Law Library (1967).
St. Louis University, Pius XII Memorial Library (1866).
University of Missouri at St. Louis, Thomas Jefferson Library (1966).
U.S. Court of Appeals, Eighth Circuit Library (1972).
Washington University, John M. Olin Library (1906).
Springfield:
Drury College, Walker Library (1874).
Southwest Missouri State College Library (1963).
Warrensburg: Central Missouri State College, Ward Edwards Library (1914).

MONTANA

- Billings: Eastern Montana College Library (1924).
Bozeman: Montana State University Library (1907).
Butte: Montana College of Mineral Science and Technology Library (1901).
Helena:
Carroll College Library (1974).
Montana Historical Society Library (unknown).
Montana State Library (1966).
State Law Library of Montana (1977).
Missoula: University of Montana Library (1909)-REGIONAL.

NEBRASKA

- Blair: Dana College, Dana-LIFE Library (1924).
Crete: Doane College, Whitin Library (1944).
Fremont: Midland Lutheran College Library (1924).
Kearney: Kearney State College, Calvin T. Ryan Library (1962).
Lincoln:
Nebraska Publications Clearinghouse, Nebraska Library Commission (1972)-REGIONAL.
Nebraska State Library (unknown).
University of Nebraska, Don L. Love Memorial Library (1907)-JOINT REGIONAL.
Omaha:
Creighton University, Alumni Library (1964).
Omaha Public Library (1880).
University of Nebraska at Omaha, University Library (1939).
Scottsbluff: Scottsbluff Public Library (1925).
Wayne: Wayne State College, U.S. Conn. Library (1970).

NEVADA

- Carson City:
Nevada State Library (unknown).
Nevada Supreme Court Library (1973).
Las Vegas:
Clark County District Library (1974).
University of Nevada at Las Vegas, James R. Dickinson Library (1959).
Reno:
Nevada State Historical Society Library (1974).
University of Nevada Library (1907)-REGIONAL

NEW HAMPSHIRE

- Concord:
Franklin Pierce Law Center Library (1973).
New Hampshire State Library (unknown).
Durham: University of New Hampshire Library (1907).
Franconia: Franconia College Library (1972).
Hanover: Dartmouth College, Baker Library (1884).
Henniker: New England College Library (1966).
Manchester:
Manchester City Library (1884).
New Hampshire College, H.A.B. Shapiro Memorial Library (1976).
St. Anselm's College, Geise Library (1963).
Nashua: Nashua Public Library (1971).

NEW JERSEY

- Bayonne: Bayonne Free Public Library (1909).
Bloomfield: Free Public Library of Bloomfield (1965).
Bridgeton: Cumberland County Library (1966).
Camden: Rutgers University-Camden Library (1966).

- Convent Station: College of St. Elizabeth, Mahoney Library (1938).
Dover: County College of Morris Library, Learning Resources Center (1975).
East Brunswick: East Brunswick Public Library (1977).
East Orange: East Orange Public Library (1966).
Elizabeth: Free Public Library of Elizabeth (1895).
Glassboro: Glassboro State College, Savitz Learning Resource Center (1963).
Hackensack: Johnson Free Public Library (1966).
Irvington: Free Public Library of Irvington (1966).
Jersey City:
Free Public Library of Jersey City (1879).
Jersey City State College, Forrest A. Irwin Library (1963).
Lawrenceville: Rider College Library (1975).
Madison: Drew University, Rose Memorial Library (1939).
Mahwah: Ramapo College Library (1971).
Mount Holly: Burlington County Library (1966).
New Brunswick:
Free Public Library (1908).
Rutgers University Library (1907).
Newark:
Newark Public Library (1906)-REGIONAL.
Rutgers-The State University, John Cotton Dana Library (1966).
Passaic: Passaic Public Library (1964).
Phillipsburg: Phillipsburg Free Public Library (1976).
Plainfield: Plainfield Public Library (1971).
Pomona: Stockton State College Library (1972).
Princeton: Princeton University Library (1884).
Rutherford: Fairleigh Dickinson University, Messler Library (1953).
Shrewsbury: Monmouth County Library (1968).
South Orange: Seton Hall University Library (1947).
Teaneck: Fairleigh Dickinson University, Teaneck Campus Library (1963).
Toms River: Ocean County College Learning Resources Center (1966).
Trenton:
New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).
Trenton Free Public Library (1902).
Union: Kean College of New Jersey, Nancy Thompson Library (1973).
Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).
Wayne: Wayne Public Library (1972).
West Long Branch: Monmouth College, Guggenheim Memorial Library (1963).
Woodbridge: Free Public Library of Woodbridge (1965).

NEW MEXICO

- Albuquerque:
University of New Mexico, Medical Center Library (1973).
University of New Mexico, School of Law Library (1973).
University of New Mexico, Zimmerman Library (1896)-REGIONAL.
Hobbs: New Mexico Junior College, Pannell Library (1969).
Las Cruces: New Mexico State University Library (1907).
Las Vegas: New Mexico Highlands University, Donnelly Library (1913).
Portales: Eastern New Mexico University Library (1962).
Santa Fe:
New Mexico State Library (1960)-REGIONAL.
Supreme Court Law Library (unknown).
Silver City: Western New Mexico University, Miller Library (1972).

NEW YORK

Albany:

- New York State Library (unknown)-REGIONAL.
- State University of New York at Albany Library (1964).

Auburn: Seymour Library (1972).

Bayside: Queensborough Community College Library (1972).

Binghamton: State University of New York at Binghamton Library (1962).

Brockport: State University of New York, Drake Memorial Library (1967).

Bronx:

- Herbert H. Lehman College Library (1967).
- New York Public Library, Mott Haven Branch (1973).

Bronxville: Sarah Lawrence College Library (1969).

Brooklyn:

- Brooklyn College Library (1936).
- Brooklyn Law School, Law Library (1974).
- Brooklyn Public Library (1908).
- Polytechnic Institute of Brooklyn, Spicer Library (1963).
- Pratt Institute Library (1891).
- State University of New York, Downstate Medical Center Library (1958).

Buffalo:

- Buffalo and Erie County Public Library (1895).
- State University of New York at Buffalo, Lockwood Memorial Library (1963).

Canton: St. Lawrence University, Owen D. Young Library (1920).

Cheektowago: Cheektowago Public Library (1978).

Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).

Cortland: State University of New York, College at Cortland, Memorial Library (1964).

Delhi: State University Agricultural and Technical College Library (1970).

Douglaston: Cathedral College Library (1971).

East Islip: East Islip Public Library (1974).

Elmira: Elmira College, Gannett-Tripp Learning Center (1956).

Farmingdale: State University Agricultural and Technical Institute at Farmingdale Library (1917).

Flushing: Queens College, Paul Klapper Library (1939).

Garden City: Adelphi University, Swirbul Library (1966).

Geneseo: State University College, Milne Library (1967).

Greenvale: C. W. Post College, B. Davis Schwartz Memorial Library (1965).

Hamilton: Colgate University Library (1902).

Hempstead: Hofstra University Library (1964).

Ithaca:

- Cornell University Library (1907).
- New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).

Jamaica:

- Queens Borough Public Library (1926).
- St. John's University Library (1956).

Kings Point: U.S. Merchant Marine Academy Library (1962).

Mount Vernon: Mount Vernon Public Library (1962).

New Paltz: State University College Sojourner Truth Library (1965).

New York City:

- City University of New York, City College Library (1884).
- College of Insurance, Ecker Library (1965).
- Columbia University Libraries (1882).
- Cooper Union Library (1930).
- Fordham University Library (1937).
- Medical Library Center of New York (1976).
- New York Law Institute Library (1909).
- New York Public Library (Astor Branch) (1907).
- New York Public Library (Lenox Branch) (1884).
- New York University Libraries (1967).
- New York University, Law Library (1973).

State University of New York, Maritime College Library (1947).

U.S. Court of Appeals Library (1976).

Newburgh: Newburgh Free Library (1909).

Niagara Falls: Niagara Falls Public Library (1976).

Oakdale: Dowling College Library (1965).

Oneonta: State University College, James M. Milne Library (1966).

Oswego: State University College, Penfield Library (1966).

Plattsburgh: State University College, Benjamin F. Feinberg Library (1967).

Potsdam:

- Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).

- State University College, Frederick W. Crumb Memorial Library (1964).

Poughkeepsie: Vassar College Library (1943).

Purchase: State University of New York, College at Purchase Library (1969).

Rochester:

- Rochester Public Library (1963).
- University of Rochester Library (1880).

St. Bonaventure: St. Bonaventure College, Friedsam Memorial Library (1938).

Saratoga Springs: Skidmore College Library (1964).

Schenectady: Union College, Schaffer Library (1901).

Southampton: Southampton College Library (1973).

Staten Island (Grymes Hill): Wagner College, Horrmann Library (1953).

Stony Brook: State University of New York at Stony Brook Library (1963).

Syracuse: Syracuse University Library (1878).

Troy: Troy Public Library (1869).

Uniondale: Nassau Library System (1965).

Utica:

- Utica Public Library (1885).

- Utica/Rome State University College Library (1977).

West Point: U.S. Military Academy Library (unknown).

Yonkers: Yonkers Public Library (1910).

Yorktown Heights: Mercy College at Fox Meadow Library.

NORTH CAROLINA

Asheville: University of North Carolina at Asheville, D. Hiden Ramsey Library (1965).

Boiling Springs: Gardner-Webb College, Dover Memorial Library (1974).

Boone: Appalachian State University Library (1963).

Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).

Chapel Hill: University of North Carolina Louis Round Wilson Library (1884)-REGIONAL.

Charlotte:

- Public Library of Charlotte and Mecklenburg County (1964).

- Queens College, Everette Library (1927).

- University of North Carolina at Charlotte, Atkins Library (1964).

Cullowhee: Western Carolina University, Hunter Library (1953).

Davidson: Davidson College, Hugh A. & Jane Grey Memorial Library (1893).

Durham:

- Duke University, William R. Perkins Library (1890).

- North Carolina Central University, James E. Shepard Memorial Library (1973).

Elon College: Elon College Library (1971).

Fayetteville: Fayetteville State University, Chesnut Library (1971).

Greensboro:

- North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).
- University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).

Greenville: East Carolina University, J. Y. Joyner Library (1951).

Laurinburg: St. Andrews Presbyterian College, DeTamble Library (1969).

Lexington: Davidson County Public Library System (1971).

Mount Olive: Mount Olive College, Moye Library (1971).

Murfreesboro: Chowan College, Whitaker Library (1963).

Pembroke: Pembroke State University, Mary Livermore Library (1965).

Raleigh:

- North Carolina State Library (unknown).
- North Carolina State University, D. H. Hill Library (1923).
- North Carolina Supreme Court Library (1972).
- Wake County Public Libraries (1969).

Rocky Mount: North Carolina Wesleyan College Library (1969).

Salisbury: Catawba College Library (1925).

Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).

Wilson: Atlantic Christian College, Clarence L. Hardy Library (1930).

Winston-Salem:

- Forsyth County Public Library System (1954).
- Wake Forest University, Z. Smith Reynolds Library (1902).

NORTH DAKOTA

Bismarck:

- North Dakota State Law Library (unknown).
- State Historical Society of North Dakota (1907).
- State Library Commission Library (1971).
- Veterans Memorial Public Library (1967).

Dickinson: Dickinson State College Library (1968).

Fargo:

- Fargo Public Library (1964).
- North Dakota State University Library (1907)-REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.

Grand Forks: University of North Dakota, Chester Fritz Library (1890).

Minot: Minot State College, Memorial Library (1925).

Valley City: State College Library (1913).

OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).

Akron:

- Akron Public Library (1952).
- University of Akron Library (1963).

Alliance: Mount Union College Library (1888).

Ashland: Ashland College Library (1938).

Athens: Ohio University Library (1886).

Batavia: Clermont General and Technical College Library (1973).

Bluffton: Bluffton College, Musselman Library (1951).

Bowling Green: Bowling Green State University Library (1933).

Canton: Malone College, Everett L. Cattell Library (1970).

Chardon: Geauga County Public Library (1971).

Cincinnati:

- Public Library of Cincinnati and Hamilton County (1884).
- University of Cincinnati Library (1929).

Cleveland:

- Case Western Reserve University, Freiburger Library (1913).

Cleveland Heights-University Heights Public Library (1970).

Cleveland Public Library (1886).

Cleveland State University Library (1966).

John Carroll University, Grasselli Library (1963).

Municipal Reference Library (1970).

Columbus:

Capital University Library (1968).

Ohio State Library (unknown)-REGIONAL.

Ohio State University, William Oxley Thompson Memorial Library (1907).

Ohio Supreme Court Law Library (1973).

The Public Library of Columbus and Franklin County (1885).

Dayton:

Dayton and Montgomery County Public Library (1909).

University of Dayton, Albert Emanuel Library (1969).

Wright State University Library (1965).

Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).

Elyria: Elyria Public Library (1966).

Findlay: Findlay College, Shafer Library (1969).

Gambier: Kenyon College, Gordon Keith Chalmers Memorial Library (1873).

Granville: Denison University, William Howard Doane Library (1884).

Hiram: Hiram College, Teachout-Price Memorial Library (1874).

Kent: Kent State University Library (1962).

Marietta: Marietta College, Dawes Memorial Library (1884).

Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).

New Concord: Muskingum College Library (1966).

Oberlin: Oberlin College Library (1858).

Oxford: Miami University, Alumni Library (1909).

Portsmouth: Portsmouth Public Library (unknown).

Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).

Springfield: Warder Public Library (1884).

Steubenville:

- College of Steubenville, Starvaggi Memorial Library (1971).
- Public Library of Steubenville and Jefferson County (1950).

Tiffin: Heidelberg College, Leon A. Beeghly Library (1964).

Toledo:

Toledo-Lucas County Public Library (1884).

University of Toledo Library (1965).

Westerville: Otterbein College (1967).

Wooster: College of Wooster, the Andrews Library (1966).

Youngstown:

- Public Library of Youngstown and Mahoning County (1923).

Youngstown State University, William F. Maag Library (1971).

OKLAHOMA

Ada: East Central Oklahoma State University, Linscheid Library (1914).

Alva: Northwestern Oklahoma State University Library (1907).

Bartlesville: United States ERDA-BERC Library (1962).

Bethany: Bethany Nazarene College, R. T. Williams Library (1971).

Durant: Southeastern Oklahoma State University Library (1929).

Edmond: Central State University Library (1934).

Enid: Public Library of Enid and Garfield County (1908).

Langston: Langston University, G. Lamar Harrison Library (1941).

Muskogee: Muskogee Public Library (1971).

Norman: University of Oklahoma Libraries (1893).

Oklahoma City:

- Oklahoma County Libraries (1974).

Oklahoma City University Library (1963).
 Oklahoma Department of Libraries (1893)-REGIONAL.
 Shawnee: Oklahoma Baptist University Library (1933).
 Stillwater: Oklahoma State University Library (1907).
 Tahlequah: Northeastern Oklahoma State University, John
 Vaughan Library (1923).
 Tulsa:
 Tulsa City-County Library Commission (1963).
 University of Tulsa, McFarlin Library (1929).
 Weatherford: Southwestern Oklahoma State University, Al
 Harris Library (1958).

OREGON

Ashland: Southern Oregon College Library (1953).
 Corvallis: Oregon State University Library (1907).
 Eugene: University of Oregon Library (1883).
 Forest Grove: Pacific University Library (1897).
 La Grande: Eastern Oregon College, Walter M. Pierce Library
 (1954).
 McMinnville: Linfield College, Northup Library (1965).
 Monmouth: Oregon College of Education Library (1967).
 Portland:
 Department of Energy, Bonneville Power Administration
 Library (1962).
 Lewis and Clark College, Aubrey R. Watzek Library
 (1967).
 Library Association of Portland (1884).
 Portland State University Library (1963)-REGIONAL.
 Reed College Library (1912).
 Salem:
 Oregon State Library (unknown).
 Oregon Supreme Court Library (1974).
 Willamette University Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).
 Allegheny: Allegheny County Law Library (1977).
 Altoona: Altoona Public Library (1969).
 Bethlehem: Lehigh University, Linderman Library (1876).
 Blue Bell: Montgomery County Community College, Learning
 Resources Center (1975).
 Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).
 Cheyney: Cheyney State College, Leslie Pinckney Hill Library
 (1947).
 Collegeville: Ursinus College, Myrin Library (1963).
 Coraopolis: Robert Morris College Library (1978).
 Doylestown: Bucks County Free Library, Center County Li-
 brary (1970).
 East Stroudsburg: East Stroudsburg State College, Kemp Li-
 brary (1966).
 Erie: Erie Public Library (1897).
 Greenville: Thiel College, Langenheim Memorial Library
 (1963).
 Harrisburg: State Library of Pennsylvania (unknown)-REGION-
 AL.
 Haverford: Haverford College Library (1897).
 Hazleton: Hazleton Area Public Library (1964).
 Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley
 Library (1962).
 Johnstown: Cambria Public Library (1965).
 Lancaster: Franklin and Marshall College, Fackenthal Library
 (1895).
 Lewisburg: Bucknell University, Ellen Clarke Bertrand Library
 (1963).
 Mansfield: Mansfield State College Library (1968).
 Meadville: Allegheny College, Reis Library (1907).
 Millersville: Millersville State College, Ganser Library (1966).
 Monessen: Monessen Public Library (1969).

New Castle: New Castle Free Public Library (1963).
 Newtown: Bucks County Community College Library (1968).
 Norristown: Montgomery County-Norristown Public Library
 (1969).

Philadelphia:
 Drexel University Library (1963).
 Free Library of Philadelphia (1897).
 St. Joseph's College Library (1974).
 Temple University, Samuel Paley Library (1947).
 Thomas Jefferson University, Scott Memorial Library
 (1978).
 U.S. Court of Appeals, Third Circuit (1973).
 University of Pennsylvania, Biddle Law Library (1974).
 University of Pennsylvania Library (1886).
 Pittsburgh:
 Bureau of Mines, Pittsburgh Research Center Library
 (1962).
 Carnegie Library of Pittsburgh, Allegheny Regional Branch
 (1924).
 Carnegie Library of Pittsburgh (1895).
 La Roche College, John J. Wright Library (1974).
 University of Pittsburgh, Hillman Library (1910).
 Pottsville: Pottsville Free Public Library (1967).
 Reading: Reading Public Library (1901).
 Scranton: Scranton Public Library (1895).
 Shippensburg: Shippensburg State College, Ezra Lehman
 Memorial Library (1973).
 Slippery Rock: Slippery Rock State College, Maltby Library
 (1965).
 Swarthmore: Swarthmore College Library (1923).
 University Park: Pennsylvania State University Library (1907).
 Villanova: Villanova University, School of Law Library (1964).
 Warren: Warren Library Association, Warren Public Library
 (1885).
 Washington: Washington and Jefferson College, Memorial Li-
 brary (1884).
 Waynesburg: Waynesburg College Library (1964).
 West Chester: West Chester State College, Francis Harvey
 Green Library (1967).
 Wilkes-Barre: King's College, D. Leonard Corgan Library
 (1949).
 Williamsport: Lycoming College Library (1970).
 York: York Junior College Library (1963).
 Youngwood: Westmoreland County Community College,
 Learning Resource Center (1972).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Li-
 brary (1928).
 Ponce: Catholic University of Puerto Rico Library (1966).
 Rio Piedras: University of Puerto Rico General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
 Newport: Naval War College Library (1963).
 Providence:
 Brown University, John D. Rockefeller, Jr. Library
 (unknown).
 Providence College, Phillips Memorial Library (1969).
 Providence Public Library (1884).
 Rhode Island College Library (1965).
 Rhode Island State Library (before 1895).
 Warwick: Warwick Public Library (1966).
 Westerly: Westerly Public Library (1909).
 Woonsocket: Woonsocket Harris Public Library (1977).

SOUTH CAROLINA

- Charleston:
Baptist College at Charleston Library (1967).
College of Charleston, Robert Scott Small Library (1869).
The Citadel Memorial Library (1962).
- Clemson: Clemson University Library (1893).
- Columbia:
Benedict College, Learning Resources Center (1969).
Richland County Public Library (1978).
South Carolina State Library (before 1895).
University of South Carolina Undergraduate Library (1884).
- Conway: University of South Carolina, Coastal Carolina Regional Campus Library (1974).
- Due West: Erskine College, McCain Library (1968).
- Florence:
Florence County Library (1967).
Francis Marion College, James A. Rogers Library (1970).
- Greenville:
Furman University Library (1962).
Greenville County Library (1966).
- Greenwood: Lander College Library (1967).
- Orangeburg: South Carolina State College, Whittaker Library (1953).
- Rock Hill: Winthrop College Library (1896).
- Spartanburg: Spartanburg County Public Library (1967).

SOUTH DAKOTA

- Aberdeen: Northern State College Library (1963).
- Brookings: South Dakota State University, Hilton M. Briggs Library (1889).
- Pierre: South Dakota State Library (1973).
- Rapid City:
Rapid City Public Library (1963).
South Dakota School of Mines and Technology Library (1963).
- Sioux Falls:
Augustana College, Mikkelsen Library and Learning Resources Center (1969).
Sioux Falls Public Library (1903).
- Spearfish: Black Hills State College Library (1942).
- Vermillion: University of South Dakota, I. D. Weeks Library (1889).
- Yankton: Yankton College, Corliss Lay Library (1904).

TENNESSEE

- Bristol: King College Library (1970).
- Chattanooga:
Chattanooga-Hamilton County Bicentennial Library (1908).
TVA Technical Library (1976).
- Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).
- Cleveland: Cleveland State Community College Library (1973).
- Columbia: Columbia State Community College Library (1973).
- Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).
- Jackson: Lambuth College, Luther L. Gobbel Library (1967).
- Jefferson City: Carson-Newman College Library (1964).
- Johnson City: East Tennessee State University, Sherrod Library (1942).
- Knoxville:
Public Library of Knoxville and Knox County, Lawson McGhee Library (1973).
University of Tennessee Law Library (1971).
University of Tennessee Library (1907).
- Martin: University of Tennessee at Martin Library (1957).

Memphis:

- Memphis and Shelby County Public Library and Information Center (1896).
Memphis State University, John W. Brister Library (1966).
- Murfreesboro: Middle Tennessee State University, Andrew L. Todd Library (1912).
- Nashville:
Fisk University Library (1965).
Joint University Libraries (1884).
Public Library of Nashville and Davidson County (1884).
Tennessee State Law Library (1976).
Tennessee State Library and Archives, State Library Division (unknown).
Tennessee State University, Martha M. Brown Memorial Library (1972).
Vanderbilt University Law Library (1976).
- Sewanee: University of the South, Jesse Ball duPont Library (1973).

TEXAS

- Abilene: Hardin-Simmons University, Rupert and Pauline Richardson Library (1940).
- Arlington:
Arlington Public Library (1970).
University of Texas at Arlington Library (1963).
- Austin:
Texas State Law Library (1972).
Texas State Library (unknown)-REGIONAL.
University of Texas at Austin Library (1884).
University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).
University of Texas, School of Law Library (1965).
- Baytown: Lee College Library (1970).
- Beaumont: Lamar University Library (1957).
- Brownwood: Howard Payne University, Walker Memorial Library (1964).
- Canyon: West Texas State University Library (1928).
- College Station: Texas Agricultural and Mechanical University Library (1907).
- Commerce: East Texas State University Library (1937).
- Corpus Christi: Texas A&I University at Corpus Christi Library (1976).
- Corsicana: Navarro Junior College Library (1965).
- Dallas:
Bishop College, Zale Library (1966).
Dallas Baptist College Library (1967).
Dallas Public Library (1900).
Southern Methodist University, Fondren Library (1925).
University of Texas Health Science Center Library at Dallas (1975).
- Denton: North Texas State University Library (1948).
- Edinburg: Pan American University Library (1959).
- El Paso:
El Paso Public Library (1906).
University of Texas at El Paso Library (1966).
- Fort Worth:
Fort Worth Public Library (1905).
Texas Christian University, Mary Coats Burnett Library (1916).
- Galveston: Rosenberg Library (1909).
- Houston:
Houston Public Library (1884).
North Harris County College, Learning Resource Center (1974).
Rice University, Fondren Library (1967).
University of Houston Library (1957).
- Huntsville: Sam Houston State University, Estill Library (1949).
- Irving: Irving Municipal Library (1974).

Kingsville: Texas Arts and Industries University Library (1944).
Lake Jackson: Brazosport College Library (1969).
Laredo: Laredo Junior College Library (1970).
Longview: Nicholson Memorial Public Library (1961).
Lubbock: Texas Tech University Library (1935)-REGIONAL
Marshall: Wiley College, Cole Library (1962).
Mesquite: Mesquite Public Library (1975).
Nacogdoches: Stephen F. Austin State University, Steen Library (1965).
Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).
Richardson: University of Texas at Dallas Library (1972).
San Angelo: Angelo State University, Porter Henderson Library (1964).
San Antonio:
 San Antonio College Library (1972).
 San Antonio Public Library, Business and Science Department (1899).
 St. Mary's University Library (1964).
 Trinity University Library (1964).
 University of Texas at San Antonio Library (1973).
San Marcos: Southwest Texas State University Library (1955).
Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).
Sherman: Austin College, Arthur Hopkins Library (1963).
Texarkana: Texarkana Community College, Palmer Memorial Library (1963).
Victoria: University of Houston, Victoria Campus Library (1973).
Waco: Baylor University Library (1905).
Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

Cedar City: Southern Utah State College Library (1964).
Ephraim: Snow College, Lucy A. Phillips Library (1963).
Logan: Utah State University, Merrill Library and Learning Resources Center (1907)-REGIONAL.
Ogden: Weber State College Library (1962).
Provo:
 Brigham Young University, Lee Library (1908).
 Brigham Young University Law Library (1972).
Salt Lake City:
 University of Utah, Spencer S. Eccles Medical Sciences Library (1970).
 University of Utah, Law Library (1966).
 University of Utah, Marriott Library (1893).
 Utah State Library Commission, Documents Library (unknown).
 Utah State Supreme Court Law Library (1975).

VERMONT

Burlington: University of Vermont, Bailey Library (1907).
Castleton: Castleton State College, Calvin Coolidge Library (1969).
Johnson: Johnson State College, John Dewey Library (1955).
Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).
Middlebury: Middlebury College, Egbert Starr Library (1884).
Montpelier: Vermont Department of Libraries (before 1895).
Northfield: Norwich University Library (1908).
Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

VIRGIN ISLANDS

Charlotte Amalie (St. Thomas):
 College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).
 St. Thomas Public Library (1968).
Christiansted (St. Croix): Florence Augusta Stephens Williams Public Library (1974).

VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
 University of Virginia, Alderman Library (1910)-REGIONAL.
 University of Virginia Law Library (1964).
Chesapeake: Chesapeake Public Library System (1970).
Danville: Danville Community College Library (1969).
Emory: Emory and Henry College Library (1884).
Fairfax: George Mason University, Fenwick Library (1960).
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Hampton: Hampton Institute, Huntington Memorial Library (1977).
Harrisonburg: James Madison University, Madison Memorial Library (1973).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
 Virginia Military Institute, Preston Library (1874).
 Washington and Lee University, Cyrus Hall McCormick Library (1910).
Martinsville: Patrick Henry Community College Library (1971).
Norfolk:
 Armed Forces Staff College Library (1963).
 Norfolk Public Library (1895).
 Old Dominion University Library (1963).
Petersburg: Virginia State College, Johnston Memorial Library (1907).
Quantico:
 Federal Bureau of Investigation Academy Library (1970).
 Marine Corps Schools, James Carson Breckinridge Library (1967).
Reston: Department of the Interior, Geological Survey Library (1962).
Richmond:
 State Law Library (1973).
 University of Richmond, Boatwright Memorial Library (1900).
 U.S. Court of Appeals, Fourth Circuit Library (1973).
 Virginia Commonwealth University, James Branch Cabell Library (1971).
 Virginia State Library (unknown).
Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg: William and Mary College Library (1936).
Wise: Clinch Valley College, John Cook Wyllie Library (1971).

WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).
Cheney: Eastern Washington State College Library (1966).
Ellensburg: Central Washington University Library (1962).
Everett: Everett Public Library (1914).

Olympia:
 Evergreen State College (1972).
 Washington State Library (unknown)-REGIONAL.
 Port Angeles: North Olympic Library System (1965).
 Pullman: Washington State University Library (1907).
 Seattle:
 Seattle Public Library (1908).
 University of Washington Library (1890).
 University of Washington, School of Law Library (1969).
 Spokane: Spokane Public Library (1910).
 Tacoma:
 Tacoma Public Library (1894).
 University of Puget Sound, Collins Memorial Library (1938).
 Vancouver: Fort Vancouver Regional Library (1962).
 Walla Walla: Whitman College, Penrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
 Bluefield: Bluefield State College Library (1972).
 Charleston:
 Kanawha County Public Library (1952).
 West Virginia College Graduate Studies (1977).
 West Virginia Library Commission (unknown).
 West Virginia Supreme Court Law Library (1977).
 Elkins: Davis and Elkins College Library (1913).
 Fairmont: Fairmont State College Library (1884).
 Glenville: Glenville State College, Robert F. Kidd Library (1966).
 Huntington: Marshall University Library (1925).
 Institute: West Virginia State College Library (1907).
 Morgantown: West Virginia University Library (1907)-REGIONAL.
 Salem: Salem College Library (1921).
 Shepherdstown: Shepherd College Library (1971).
 Weirton: Mary H. Weir Public Library (1963).

WISCONSIN

Appleton: Lawrence University, Seeley G. Mudd Library (1869).
 Beloit: Beloit College Libraries (1888).
 Eau Claire: University of Wisconsin, Eau Claire, William D. McIntyre Library (1951).
 Fond du Lac: Fond du Lac Public Library (1966).
 Green Bay: University of Wisconsin at Green Bay Library (1968).

La Crosse:
 La Crosse Public Library (1883).
 University of Wisconsin-La Crosse, Murphy Library (1965).
 Madison:
 Department of Public Instruction, Division for Library Services, Reference and Loan Library (1965).
 Madison Public Library (1965).
 State Historical Society Library (1870)-REGIONAL, in cooperation with University of Wisconsin, Memorial Library.
 University of Wisconsin, Memorial Library (1939).
 Wisconsin State Law Library (unknown).
 Milwaukee:
 Alverno College Library (1971).
 Milwaukee County Law Library (1934).
 Milwaukee Public Library (1861)-REGIONAL.
 Mount Mary College Library (1964).
 University of Wisconsin-Milwaukee Library (1960).
 Oshkosh: University of Wisconsin-Oshkosh, Forrest R. Polk Library (1956).
 Platteville: University of Wisconsin-Platteville, Elton S. Karrmann Library (1964).
 Racine: Racine Public Library (1898).
 River Falls: University of Wisconsin-River Falls, Chamer Davee Library (1962).
 Stevens Point: University of Wisconsin-Stevens Point, Learning Resources Center (1951).
 Superior:
 Superior Public Library (1908).
 University of Wisconsin-Superior, Jim Dan Hill Library (1935).
 Waukesha: Waukesha Public Library (1966).
 Wausau: Marathon County Public Library (1971).
 Whitewater: University of Wisconsin-Whitewater, Harold Andersen Library (1963).

WYOMING

Casper: Natrona County Public Library (1929).
 Cheyenne:
 Wyoming State Law Library (1977).
 Wyoming State Library (unknown)-REGIONAL.
 Laramie: University of Wyoming, Coe Library (1907).
 Powell: Northwest Community College Library (1967).
 Riverton: Central Wyoming College Library (1969).
 Rock Springs: Western Wyoming College Library (1969).
 Sheridan: Sheridan College, Mary Brown Kooi Library (1963).

APPENDIX B. LIST OF DISTRICT OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

ALABAMA

Birmingham—Gayle C. Shelton, Jr., Director, Suite 200-201, 908 South 20th Street, 35205, Area Code 205 Tel 254-1331, FTS 229-1331

ALASKA

••**Anchorage**—Robert E. Kistler, Director, 701 C Street, P.O. Box 32, 99513, Area Code 907 Tel 271-5041, FTS Dial 8 399-0150, Ask for 271-5041

ARIZONA

Phoenix—Donald W. Fry, Director, Suite 2950 Valley Bank Center, 201 North Central Avenue 85073, Area Code 602 Tel 261-3285, FTS 261-3285

ARKANSAS

••**Little Rock (Memphis, Tennessee District)**—1100 North University, Suite 109, 77207, Area Code 501 Tel 378-5157.

CALIFORNIA

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