October 6, 1961

electronics

A McGraw-Hill Publication 75 Cents

SERVOED STYLUS

draws 3-D curves
NEC highlights, p 61
(photo below)

ANTENNAFIERS & ANTENNAVERTERS

Tunnel diodes in dipoles, p 68

"WORST-CASE" DESIGN

Transistor leakage current, p 74

R-L-C Standards and Components — #3 of a series

Capacitance...

μf

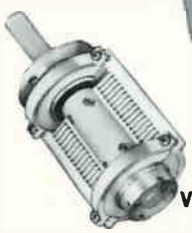
Use of quality materials, careful assembly and calibration of G-R standards under ASTM standard laboratory conditions of temperature and humidity insure Low Dielectric Loss, High Stability and High Accuracy.

NEW DESIGN —Type 1422
PRECISION VARIABLE CAPACITANCE STANDARDS

Replace Type 722 line, offer better stability and higher accuracy. These air-capacitance standards approach the ideal circuit element. Backlash has been reduced to the point of negligible effect. Dial may be set to one part in 25,000. Each unit is mounted in a rigid cast aluminum frame and supported with very low loss polystyrene insulation.

2-Terminal Type	Range (pf)	Accuracy	3-Terminal Type	Range (pf)	Accuracy
1422-D, $265	100 to 1150 35 to 115	±0.03% or ±0.6pf* ±0.03% or ±0.1pf*	1422-CB, $250	50 to 1100	±0.03% or ±0.6pf*
1422-MD†, $265	0 to 1050 0 to 105	±0.03% or ±0.6pf* ±0.03% or ±0.08pf*	1422-CC, $280	5 to 110	±0.03% or ±0.15pf*
1422-ME†, $255	0 to 105 0 to 10.5	±0.03% or ±0.08pf* ±0.03% or ±0.02pf*	1422-CD, $280	0.5 to 11 0.5 to 1.1	±0.03% or ±0.04pf* ±0.03% or ±0.008pf*
1422-N, $250 (For R-F Use)	100 to 1150	±0.03% or ±0.6pf*			

*Whichever is greater; correction chart supplied permits greater accuracy—highest accuracy may be obtained from precision calibration chart which is available at extra cost.
†Indicate Capacitance Removed (For bridge substitution measurement)



TYPE 1420 VARIABLE AIR CAPACITORS

3 models: 13-70 pf, $30; 14-130 pf, $32; 16-260 pf, $33. Rotors and stators are machined from solid aluminum extrusions for minimum inductance and resistance, maximum mechanical and thermal stability . . . 0.2% typical linearity with low dielectric loss . . . meets MIL-T-945-A shock and vibration tests . . . diameter is 1⅞".

Type 1421 Variable Air Capacitors: 1421-J, 22 to 575 pf, $55. 1421-K, 29 to 1120 pf, $58. Similar to 1420 series . . . larger, 3¾" diameter.

New PRECISION DECADE CAPACITOR

100 pf to 1.111 μf Increments of 100 pf to an accuracy of ±0.05% . . . unique four dial in-line readout . . . uses four decades of G-R Type 505 (silvered mica) Capacitors (see table at right) . . . double shielding — for either two- or three-terminal use. **TYPE 1423-A . . . $695**

NEW STANDARD POLYSTYRENE DECADE CAPACITOR

1 to 10 μf Provides integral microfarad values from 1 to 10 with accuracy of 0.25% . . . minimum series inductance and resistance for use over broad frequency range . . . double shielding allows either two- or three-terminal connection with negligible difference in absolute capacitance. **TYPE 1424-A . . . $325.**

. . . the following air- and solid-dielectric capacitors are precision-engineered circuit elements offering outstanding characteristics.

Type	Range	Characteristics
 **980 Decade-Capacitor Units** 3 Polystyrene types, $51-$66 3 Silvered-Mica types, $50-$165 3 Paper or molded mica, $34-$44 **2 additional units** Polystyrene, $57 ± (1% + 2pf) Mica, $48 ± (0.5% + 2pf)	1.0μf total, in 0.1μf steps 0.1μf total, in 0.01μf steps 0.01μf total, in 0.001μf steps 0.001μf total, in 0.0001μf steps	High quality capacitors mounted on 11-point switch to give total capacitance variation of 10:1 in equal increments; knob and dial plate provided. Each unit aged for highest stability. Polystyrene units calibrated ±1.0%; D < 0.0002. Silvered-mica calibrated ±0.5%; D < 0.0003. Molded mica calibrated ±1%; D < 0.001. Paper calibrated ±1.5%; D < 0.005.
 **Decade-Capacitance Boxes** 1419-A Polystyrene, $205 1419-B Polystyrene, $262 1419-K Silvered Mica, $315 1419-M Paper & Molded Mica, $145	1419-A, K, M: 1.110μf total, in steps of .001μf 1419-B: 1.1110μf total in steps of .0001μf	Type 980 Decade-Capacitor Units in metal cabinet.
 **1401 Standard Air Capacitor** 4 types, $50-$58	100, 200, 500, 1000pf	Highly-stable standards, each adjusted to ±(0.1% + 0.1 pf) at 1 kc. Low-loss: D < 0.00001 for 1000 pf unit, < 0.0001 for 100 pf.
 **1403 Standard Air Capacitor** (3 terminal) 6 types, $45-$60	0.01, 0.1, 1.0, 10, 100 and 1000pf	Units accurate to ±0.1% except 0.01pf (±0.3%). D is 0.00001 for all units.
 **1409 Standard Capacitor** 10 types, $32-$160	0.001 to 1.0μf ±0.05% in 1-2-5 sequence	Calibration certificate provided . . . stability within ±0.01% per year is maintained by careful, controlled construction and aging. Cast aluminum case with combination binding-post and plug-type terminals for stacking.
 **505 Capacitors** 12 types, $7.50-$65	100pf to 0.5μf in 1-2-5 sequence	±0.5% or ±3pf whichever larger; preaged for added accuracy. D<0.0003 for nine larger units to 0.0006 for smallest 100pf unit; silvered mica, foil pile, and low-loss case used.

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October 6, 1961

electronics

A McGraw-Hill Publication 75 Cents

Three-dimensional display at Chrysler Missile division is formed of ink traces deposited in clear gel by servo-driven stylus. See p 61 COVER

FREQ STDS.

AND PRECISION FORK UNITS 1 TO 40,000 CYCLES

TYPE 10
1⅜" x 1⅜" x ⅜"

This frequency standard (360 or 400 cycles) is accurate to ± 50 parts per million at 10° to 35°C. Aging has been greatly minimized.

External power of 1.4 volts at 6 microamperes powers the unit.

TYPE 2007-6 FREQUENCY STANDARD

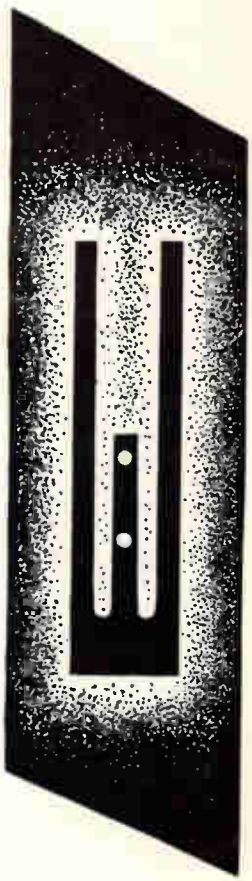
Transistorized, Silicon type
Size, 1½" dia., x 3½" H., Wt., 7 oz.
Frequencies: 360 to 1000 cy.
Accuracies:
2007-6 ± 0.2% (—50° to +85°C)
R2007-6 ± .002% (+15° to +35°C)
W2007-6 ± .005% (—65° to +85°C)
Input: 10 to 30V DC at 6 ma.
Output: Multitap, 75 to 100,000 ohms

TYPE 2001-2 FREQUENCY STANDARD

Size, 3¾" x 4½" x 6" H., Wt., 26 oz.
Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at +20° to +30°C
Output: 5V at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V, at 5 to 10 ma.
Accessory Modular units are available to divide, multiply, amplify and power this unit.

TYPE K-5A FREQUENCY STANDARD

Size, 3½" x 3" x 1¾"
Weight, 1½ lbs.
Frequency: 400 cycles
Accuracy: .03%, —55° to +71°C
Input: 28V DC ±10%
Output: 400 cy. approx. sq. wave at 115V into 4000 ohm load (approx. 4W)



TYPE 25 PRECISION FORK

Size, ⅝" dia. x 2⁹⁄₁₆"
Weight: 2 ounces
Frequencies: 200 to 1000 cy.
Accuracies:
R-25T and R-25V ± .002% (15° to 35°C)
25T and 25V ± .02% (—65° to 85°C)
For use with tubes or transistors.

INQUIRIES INVITED

For over 20 years we have made frequency standards and precision fork units for applications where consistent accuracy and rugged dependability are vital. Shown are just a few typical examples.

Some users integrate our products with instruments of their own manufacture. In other cases we develop complete assemblies to meet special needs.

You are invited to submit any problems within the area of our activity for study by our engineering staff.

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SPECIFY ARNOLD IRON POWDER CORES...

COMPLETE RANGE OF SIZES AND SHAPES FOR YOUR DESIGNS

Arnold offers you the widest range of shapes and sizes of iron powder cores on the market.

In addition to toroids, bobbin cores and cup cores—typical groups of which are illustrated below—Arnold also produces plain, sleeve and hollow cores, threaded cores and insert cores, etc., to suit your designs. Many standard sizes are carried in warehouse stock for prompt shipment, from prototype lots to production quantities. Facilities for special cores are available to order.

The net result is extra advantage and assurance for you. No matter what shapes or sizes of iron powder cores your designs require, you can get them from a single source of supply—with undivided responsibility and a single standard of known quality. And Arnold's superior facilities for manufacture and test assure you of dependably uniform cores, not only in magnetic properties but also in high mechanical strength and dimensional accuracy.

● For more information on Arnold iron powder cores, write for a copy of our new 36-page Bulletin PC-109A. *The Arnold Engineering Company, Main Office and Plant, Marengo, Illinois.*

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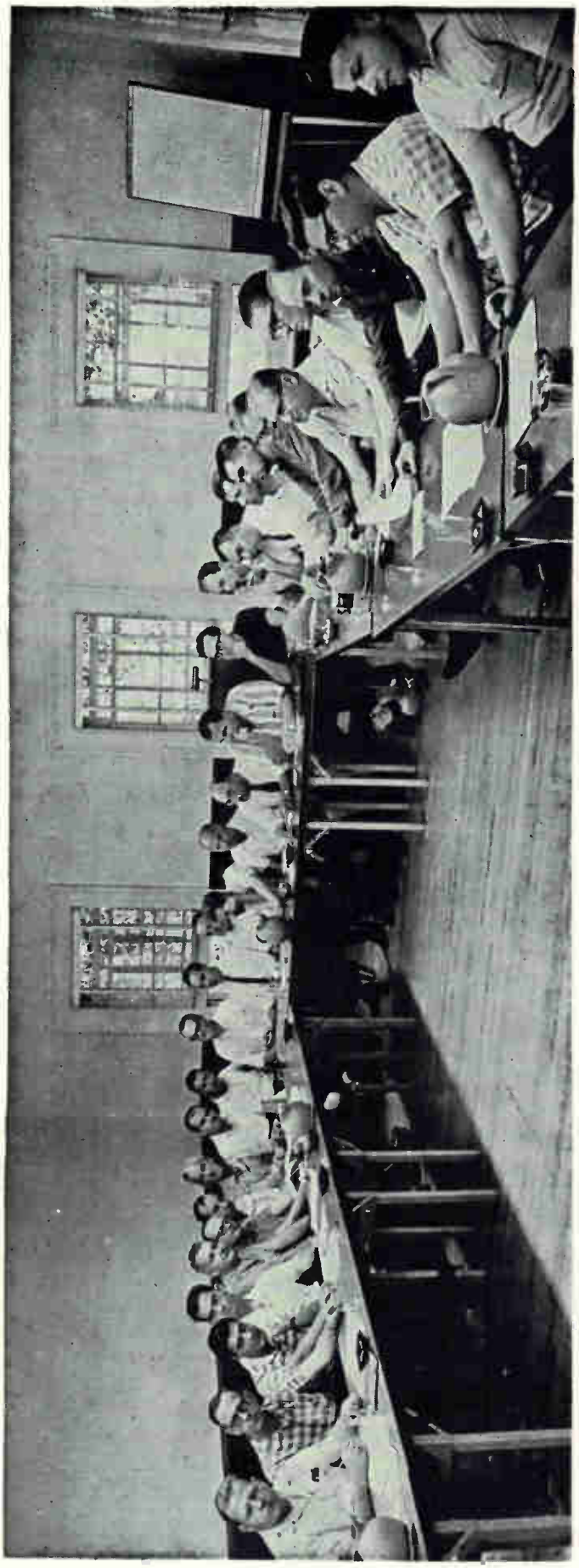
Men Make the Magazine



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electronics
October 6, 1961 Volume 34 No. 40

Published weekly, with Electronics Buyers' Guide and Reference issue, as part of the subscription, by McGraw-Hill Publishing Company, Inc. Founder: James H. McGraw (1860-1948).

Executive, editorial, circulation and advertising offices McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Telephone Longacre 4-3000. Teletype TWX N.Y. 1-1636. Cable McGrawhill, N. Y. PRINTED IN ALBANY, N. Y.; second class postage paid.

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription rates: United States and Possessions, $6.00 one year; $9.00 two years; $12.00 three years. Canada, $10.00 one year. All other countries $20.00 one year. Single Copies, United States and Possessions and Canada 75¢; Buyers' Guide $3.00; Single copies all other countries $1.50; Buyers' Guide $10.00.

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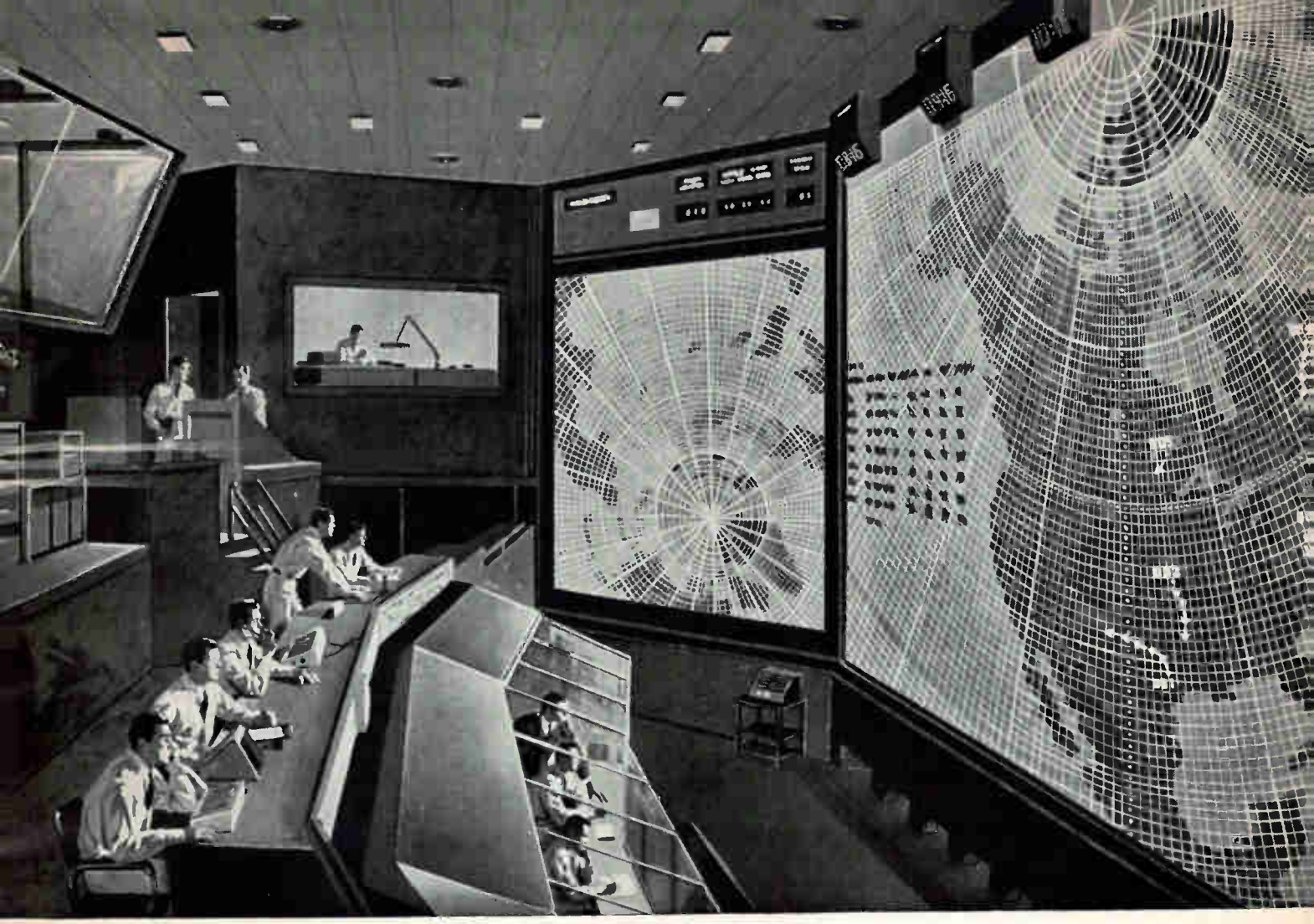

NORAD ON THE ALERT

Inputs from BMEWS Provide Instantaneous Missile Data Direct to NORAD Headquarters

From our vast outer defense perimeter, over thousands of miles, to the nerve center of the North American Air Defense Command at Colorado Springs, the most advanced concept of data handling and checkout is being utilized in the BMEWS system. The stakes are high, for the purpose is defense of the North American Continent.

At BMEWS installations operated by USAF Air Defense Command, computers read out missile tracking data from giant radars. This information is simultaneously relayed to NORAD's Combat Operations Center.

The Radio Corporation of America is prime systems contractor for BMEWS. At the COC, RCA's Display Information Processor computing equipment automatically evaluates missile sightings, launch sites and target areas. By means of data processing and projection equipment installed by RCA and a team of other electronics manufacturers, the findings are displayed on huge, two-story high map-screens in coded color symbols, providing the NORAD battle staff with an electronic panorama of the North American and Eurasian land masses.

The handling of BMEWS inputs at NORAD is an example of how RCA data processing capabilities are assuring the high degree of reliability so vital to continental defense.

Out of the defense needs of today a new generation of RCA electronic data processing equipments has been born. For tomorrow's needs RCA offers one of the nation's foremost capabilities in research, design, development and production of data processing equipment for space and missile projects. For information on these and other new RCA scientific developments, write Dept. 434, Defense Electronic Products, Radio Corporation of America, Camden, N. J.

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COMMENT

Oceanographic Instrumentation

This is in reference to the *Washington Outlook* column in the September 1 issue of ELECTRONICS (p 14) regarding the first government-industry oceanographic instrumentation symposium held recently.

You stated that 42 companies have already requested reports on the symposium. Would you please let us know where we can get these reports.

D. R. FEWER
TEXAS RESEARCH AND ELECTRONIC CORPORATION
DALLAS, TEXAS

The Government-Industry Oceanographic Instrumentation Symposium was sponsored by the Instrumentation Panel of the Interagency Committee on Oceanography. The ICO was established by the Federal Council for Science and Technology and is responsible for coordinating the U.S. National Oceanographic Program, as it involves federal agencies having an interest in this subject.

Government agencies participating included: Department of Defense, U.S. Navy (Hydrographic Office, Office Naval Research, Bureau of Ships, Bureau of Weapons); National Science Foundation, Commerce Dept. (U.S. Coast and Geodetic Survey, Weather Bureau); Department of Interior (Bureau of Commercial Fisheries, Geological Survey, Bureau of Mines, Bureau of Sport Fisheries and Wild Life); and Atomic Energy Commission.

Chairman of the ICO in charge of meetings was Donald L. McKernan, Director of Bureau of Commercial Fishery, Department of Interior, Washington 25, D.C.

Microwave Band Letter Codes

Your publication of "Letter Code Designations for Microwave Frequency Bands" (June 2, p 58) reminds me of my disappointment over the failure of any U.S. group to adapt the British designation VHFI, which is short for Very High Frequency, Indeed.

J. KENT THOMPSON
BAY VILLAGE, OHIO

Electronic Cane

The blind man featured on the cover of your June 23 issue, in connection with Part IV of your Medical Electronics series (p 43), is Norman Hayes, Philadelphia, Pa.

Mr. Hayes has been employed by the Molded Insulation Company since January 30, 1961.

Incidentally, much of the development work on this "electronic cane" (a radio-frequency guidance device) was done in our plant in cooperation with the Franklin Institute.

FRED C. HEEREMANS
MOLDED INSULATION COMPANY
PHILADELPHIA, PA.

We're glad to have our coverman identified, and several copies of the cover have been sent to him.

A-C Measurement Talks

In reference to your coverage given to North Atlantic Industries, Inc., in the Sept. 1 issue (p 9), I would like to bring to your attention that the a-c measurement talks are being sought for the 1962 IRE, not WESCON.

IRVING A. GREENFIELD
GROODY ADVERTISING COMPANY
NEW YORK 16, N. Y.

Photo Credit

Please give credit for Figure 1B of my article, "Electron Beam: A Versatile Tool and a Mushrooming Technology," (July 28, p 39), to the Pulp and Paper Research Institute of Canada.

R. BAKISH
ALLOYD ELECTRONICS
CAMBRIDGE, MASS.

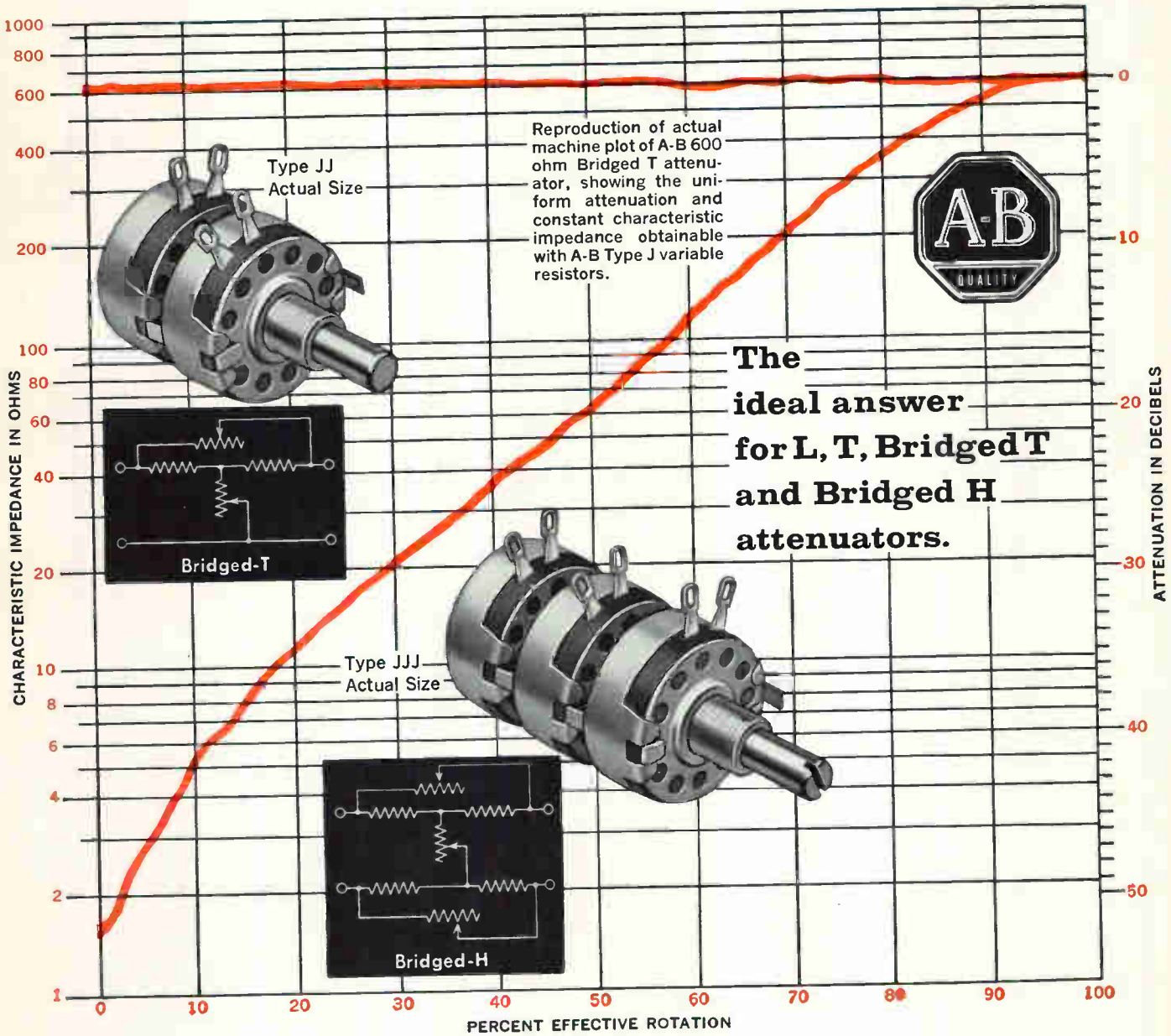
Access System

Thank you very much for your excellent story on our Access system (Aircraft Communications Electronic Signaling System) which appeared in *Washington Outlook* in the Sept. 8 issue (p 14).

Your story was exceptionally well done and nicely covered the highlights of our Access system.

R. E. KILLACKEY
MOTOROLA INC.
SCOTTSDALE, ARIZONA

Use Low Cost Allen-Bradley Type J Pots for Constant Impedance Attenuators



Allen-Bradley dual and triple Type J variable resistors are widely used in attenuators in electronic circuitry because they provide dependably smooth and uniform attenuation plus constant characteristic impedance.

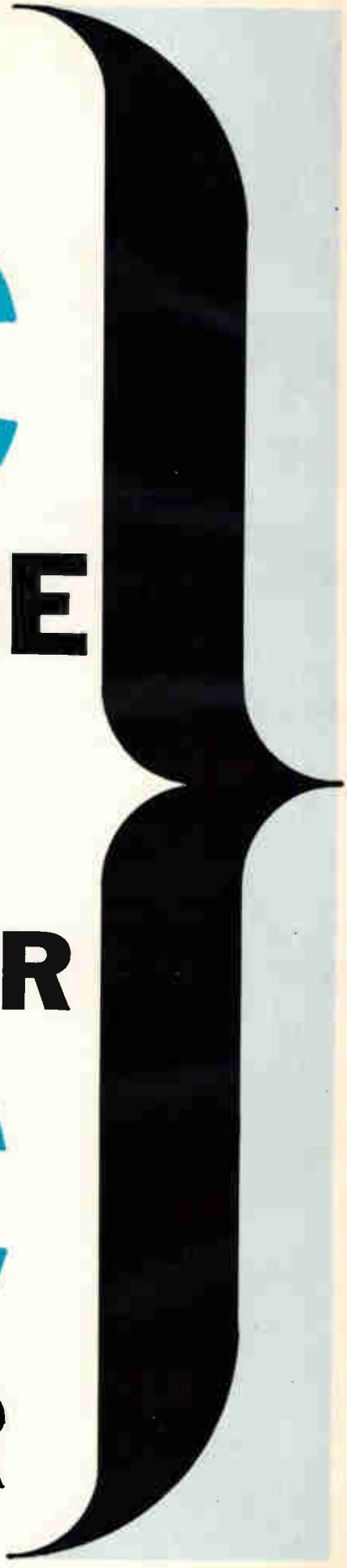
Stability, high wattage, long life, ideal uniformity, plus remarkable compact structure are combined in the Type J to assure top performance. The solid resistance element—made by A-B's exclusive hot molding process—provides smooth control at all times.

With this precise control over the resistance-rotation characteristics during production, A-B attenuators have a consistently uniform attenuation that approaches calibration accuracy . . . and the characteristic impedance can be held to ±10% over *entire* rotation—*end* to *end*. The virtually infinite resolution eliminates the definite incremental steps of wire-wound units, while freedom from inductance insures excellent high frequency response. For full details on Type J variable resistors, send for Publication 6024.

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis. · In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY QUALITY ELECTRONIC COMPONENTS

MEASURE AC VOLTAGE to 500 KC WITH YOUR DC VOLTMETER



NEW hp 457A AC TO DC CONVERTER

New hp 457A AC to DC Converter lets you inexpensively measure ac voltage, 50 cps to 500 KC, with the ease and high resolution of a dc digital voltmeter.

The highly accurate, average-responding 457A permits ac measurements to ±0.3% ±0.001 v to 50 KC and ±0.75% ±0.001 v to 500 KC. This accuracy permits you to read ac voltages on a dc digital voltmeter (such as the hp 405BR/CR) with three digits resolution.

Waveform errors are minimized by this new converter. The dc output of the 457A is always between 0 and 1 volt for up to full scale input. Full scale is selected manually in decade ranges. Your measurement convenience is further increased with overranging by more than 2 to 1 and an input impedance of 1 megohm.

The 457A Converter can be used with an hp 560 series Digital Recorder, plus a digital voltmeter, to provide a permanent printed record. Either the 457A analog or digital voltmeter output data is suitable for other data logging equipment. The digital data may be transferred, for example, to card or tape punches.

New hp instrument modular packaging permits easy stacking of instruments on the bench and simple conversion to rack mount.

Specifications

Input Range:	0 to 300 v rms, in 4 decade ranges corresponding to 1, 10, 100 and 1,000 v rms full scale.
Frequency Range:	50 cps to 500 KC.
Accuracy:	±0.3% ±1 mv, 50 cps to 50 KC; ±0.75% ±1 mv, 50 KC to 500 KC.
Output:	0 to 1.0 v dc, responding to average value of ac input, with output calibrated as rms value of sine wave.
Output Impedance:	10,000 ohms.
Input Impedance:	1 megohm, shunted by 30 pf.
Size:	16¾" wide, 3⅜" high, 13¼" deep. Weight, 12 lbs.
Price:	$350.00

hp DEPENDABLE AUTOMATIC DIGITAL VOLTMETERS

hp 405BR/CR Digital Voltmeter

Ideal for use with the hp 457A AC to DC Converter, the hp 405BR/CR Digital Voltmeters feature automatic ranging, simple touch-and-read measurement and bright, clear readout. By using the hp 405 in conjunction with the hp 457A, you can read ac voltages on the 405 to three digits with an overall accuracy of ±0.4% of reading ±0.001 v to 50 KC, ±0.75% of reading ±0.002 v to 500 KC. The hp 405BR and CR are identical except that the 405CR includes (a) provision for external sampling command, (b) digital recording outputs, plus (c) reading hold-off capability, (d) print command when overranging, and (e) remote readout outputs.

Specifications

Ranges:	0.001 to 999 v dc, 4 ranges.
Presentation:	3 significant figures, polarity indicator.
Accuracy:	±0.2% of reading ±1 count.
Ranging Time:	0.2 sec to 2 sec.
Input Impedance:	11 megohms to dc, all ranges.
Response Time:	Less than 1 sec.
AC Rejection:	3 db at 0.7 cps; min. 44 db at 60 cps.
Size:	7" high, 19" wide, 13⅞" deep behind panel. Weight, 26 lbs.
Price:	hp 405BR, $850.00; hp 405CR, $925.00.

FOR EVEN GREATER SYSTEMS FLEXIBILITY, USE DYMEC 2401 INTEGRATING DIGITAL VOLTMETER!

DY-2401 Integrating Digital Voltmeter

Unique flexibility for simple and complex systems applications is yours with the Dymec 2401 Integrating Digital Voltmeter, which effectively eliminates the effects of noise and hum by reading the average value of voltage applied over a definite, selected sample period. Range, sample period and sample rate are externally programmable. Applications are further extended by the nature of the 2401, actually a voltage-to-frequency converter, combined with a 300 KC electronic counter.

Equally versatile in systems application is the Dymec Model 2410 Multi-Converter (not shown), which converts ac volts, resistance and dc volts to a proportional dc voltage with 1 volt nominal full-scale output. $1,975.00.

Specifications

DC Voltage Ranges:	±0.1, 1, 10, 100, 1,000 v nominal full scale.
Overall Accuracy:	0.05% nominal.
Stability:	Greater than 0.01%/day, 1 v range and above.
Input Impedance:	1 megohm on 1 v and higher ranges, 100,000 ohms on 0.1 v range.
Price:	$3,750.00.

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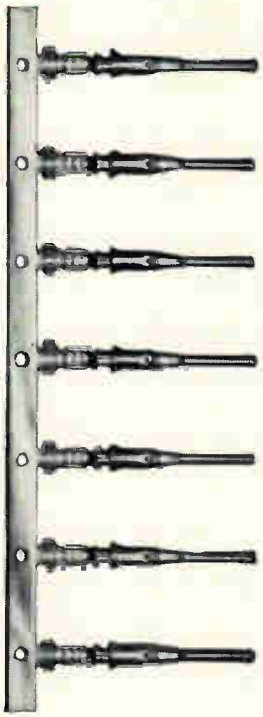

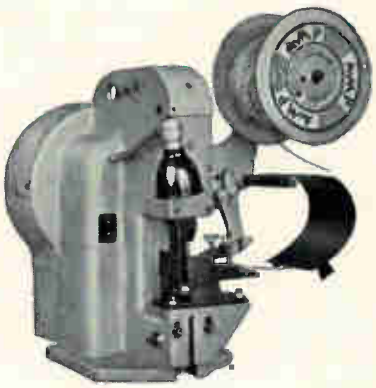

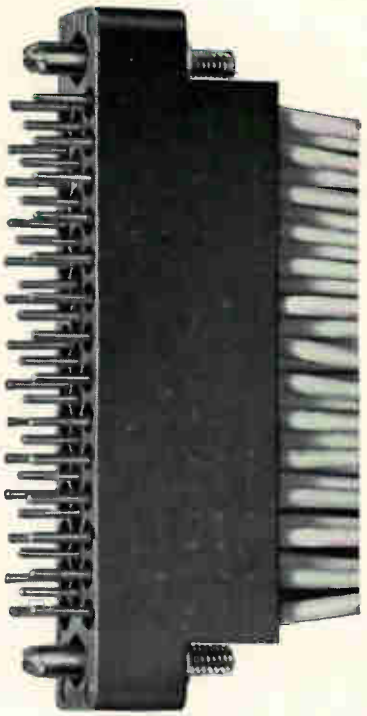

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AMPin-cert Connectors cost less to buy and . . . less to apply—give you connector performance of extreme reliability at the lowest installed cost in the industry.
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ELECTRONICS NEWSLETTER

Superconductivity Makes Powerful Magnet

SUPERCONDUCTING MAGNET has been built by a Westinghouse Electric research team headed by J. K. Hulm. The company says the magnet is for its size and energy consumption "the most powerful ever built."

It weighs one pound, draws a few watts from a storage battery (to overcome lead wire losses) and develops a flux density of 43,000 gauss. The field is twice as strong as that created by an electromagnet weighing 20 tons and drawing 100,000 watts.

Hulm says that superconducting magnets will make possible crucial scientific experiments, brighten chances for direct generation of electric power, increase the possibility of thermonuclear power and make more feasible some of the "far-out" methods proposed for space travel.

Key developments were methods of forming brittle niobium-zirconium alloy into 10-mil wire. The two-inch solenoid is made of 5,000 turns of this wire. Immersed in liquid helium, the wire carries 20 amperes. Processing of other materials with better magnetic properties is under study, the company said.

Ion Engine Will Get Space Trail in 1962

HUGHES RESEARCH LABS last week showed newsmen the first of a series of ion propulsion devices which may someday drive interplanetary craft at speeds of two million miles a day. Exhaust velocity is potentially 30 times that of chemical engines.

Working prototype ionizes cesium atoms, accelerates the ions by electrodes and neutralizes the positive ion beam by injection of electrons. Ions are formed into a thin, hollow beam.

First flight test unit, with thrust estimated at 0.1 pound, will be boosted to an altitude of 5,000 miles by a Scout rocket late next year. Follow-on systems of clusters of engines with concentric beams are expected to attain thrusts of 10 pounds and to operate continuously for several months. The first nuclear-electric system is tentatively scheduled for flight test in 1965.

M. R. Currie, associate lab director, says that techniques were spawned by work in microwave tubes and electron optics. Future problems are similar to those found in super-power tubes—better optics with higher compression guns, greater beam densities and larger emitting surfaces. Initial development costs of $460,000 were paid by NASA.

Brainwave Retarder Relaxes Insomniacs

CHICAGO — Relaxing machine for electro-hypnotic treatment of insomnia and other mild mental disorders will be displayed at the National Electronics Conference by the newly-formed Electronic Polyphase Ionic Corp.

Reportedly redesigned from a Russian invention of the early 30's, Electroson passes a pulsed 5-ma current from eye-socket electrodes, through the brain to base of the skull. The pulses stimulate brain cells, reducing the flicker frequency which indicates the brain's level of excitability, the company says.

Device has been classed as a clinical tool, for sale to medically qualified persons only. Early models will use vacuum tubes, but a transistor unit is in the prototype stage.

Line Transmitter Turns Radar Picture into Tv

LOW-COST METHOD of relaying radar pictures over telephone lines was unveiled last week at the Canadian IRE Show by Raytheon Canada.

Called slowed-down video, the system is expected to stimulate simultaneous routing of radar results. It was developed under a contract from the Canadian Department of Transport. The technique can be used with all types of radar presentation. Among expected applications are visual hand-on control of planes from one air traffic control center to the next and monitoring of ship traffic in the St. Lawrence Seaway.

The system feeds radar signals into a scan-converter which stores the information and converts it to a form suitable for telephone lines. At the receiver, the signals are reconverted and can be viewed on a conventional tv receiver. Bandwidth of the transmitted signals is less than 3 Kc, about 500 times less than the base band for microwave relay or coaxial cable.

Broadband Discriminator Uses Passive Components

CHICAGO—Multiple radio and radar signal frequencies in the space communications and electronic warfare bandwidths of 500-12,000 Mc can be directly identified without tuning by a receiver under development by Hallicrafters.

Accuracy is reported as one percent over an octave of bandwidth, with intercept probability 100 percent. The broadband frequency discriminator employs passive sections and diode detectors instead of active r-f devices. In strip line, the discriminator weighs 0.1 pound. Received frequencies are shown as angular lines on a crt.

Applications are seen in electromagnetic reconnaissance satellites, electronic warfare alarms that would guide tuning of convventional receivers and jammers, and in rocket-borne expendable jammers that would provide electronic cover for troop movements.

Basic approach of using reactive transmission line elements for frequency sensing was suggested by Stanford Electronics Laboratory.

Estimate 6 Million Tv Set Sales This Year

CHICAGO — More than six million television sets will be sold this year, Joseph S. Wright, Zenith president, told the Chicago Investment Analysts Society last Thursday. His own company anticipates 1961 will

be its third straight million-plus tv set year.

Wright said color tv should add considerable impetus and dollar volume, but he sees no hope for an early breakthrough that would permit color tv prices to drop under two or three times black and white prices. In five years, a million color sets will be sold annually,

Second set and replacement market will also increase steadily during the next five years, he said, adding 20 percent to unit sales. Dollar volume will rise more, because of color. Subscription tv will help color sales, Wright said, and will stimulate interest in large screen devices for wall display.

Simulation Lab to Study Air Traffic in the 1970's

SYSTEM DEVELOPMENT CORP. will launch a detailed study of air traffic control problems in the post-1970 era. A simulation model is under construction at the company's new $3 million systems simulation research lab in Santa Monica. The model will be based on actual conditions in the San Francisco-Oakland terminal complex and on predictions of the air environment and technological developments likely to exist during the next decade.

The complex simulated is 100 by 130 nautical miles in area and four miles high, has both terminating and overflight traffic and two jet transport airports. A computer has been programed to generate and move simulated aircraft, maintain displays, provide conflict-prediction information at fixes and sequence information for aircraft at runways, and to reduce and record system performance information.

The laboratory, which will stress the study of man-machine relationships, will also be used for research in system training and theory, medical data processing and automated teaching.

Phased Array Radar Is Controlled by Computer

PHASED ARRAY radar system is being given evaluation tests at Sylvania's laboratories in Waltham, Mass. The work is part of the Army's Project Defender research into ballistic missile defense. Sylvania's part, called Codiphase, for Coherent Digital Phased Array, is financed by some $2 million in Army contracts.

The experimental system incorporates new signal processing and beam forming techniques designed for simultaneous search and tracking of multiple targets, improved ranging accuracy, countermeasures resistance, lower cost and greater flexibility. Digital computer circuits are used to process and control the radar signal returns.

Superconducting Sheets Give Compact Memories

CONTINUOUS SHEET superconductive memory cell under development by RCA is reported to promise high packing densities and lower costs. Trapped flux phenomenon is used to "punch" normal areas in a continuous film and thus store a persistent current. Use of a continuous plane is said to eliminate edge effects which limited uniformity and reproducibility of two-hole cryoelectric cells.

RCA group working under Lesley L. Burns has made planes of 100 cells and stored information in a cell in less than three nanoseconds. The sheets can use x-y selection, but have no delta noise because of shielding by the superconducting plane. Packing density of 10^7 per cubic inch is reported possible.

Soviets Bid for TV Business in Morocco

TELEVISION task force from the Soviet Union is making a bid for Morocco's television business. Official sources say that the Moroccan minister of information is conferring in Rabat with a group of engineers led by the Soviet vice minister of communications. The USSR approach reportedly combines financial and technical knowhow. Earlier this year, Morocco's government indicated it would install a government-owned network.

In Brief . . .

University of Wisconsin's Orbiting Astronomical Observatory will be built by Cook Electric, under a NASA contract. Satellite will carry five telescopes focused by ground command.

Crashproof recorder of cockpit conversations will be developed for FAA by United Data Control. Recordings, to be used for accident analysis, are to be made snoopproof.

Kollsman Instrument has received a $9 million contract from Autonetics for astro trackers and spares for Hound Dog missiles.

Navy has awarded Motorola $6.3 million in sonobuoy contracts.

Boeing is buying $1 million in transistors—mostly silicon planar devices—from Fairchild Semiconductor, for Minuteman.

Air Force contract of $950,000 given Technical Operations for Project Omega will cover computer simulation of air warfare.

Philco is buying $3.6 million of ferrite core memories from Ampex.

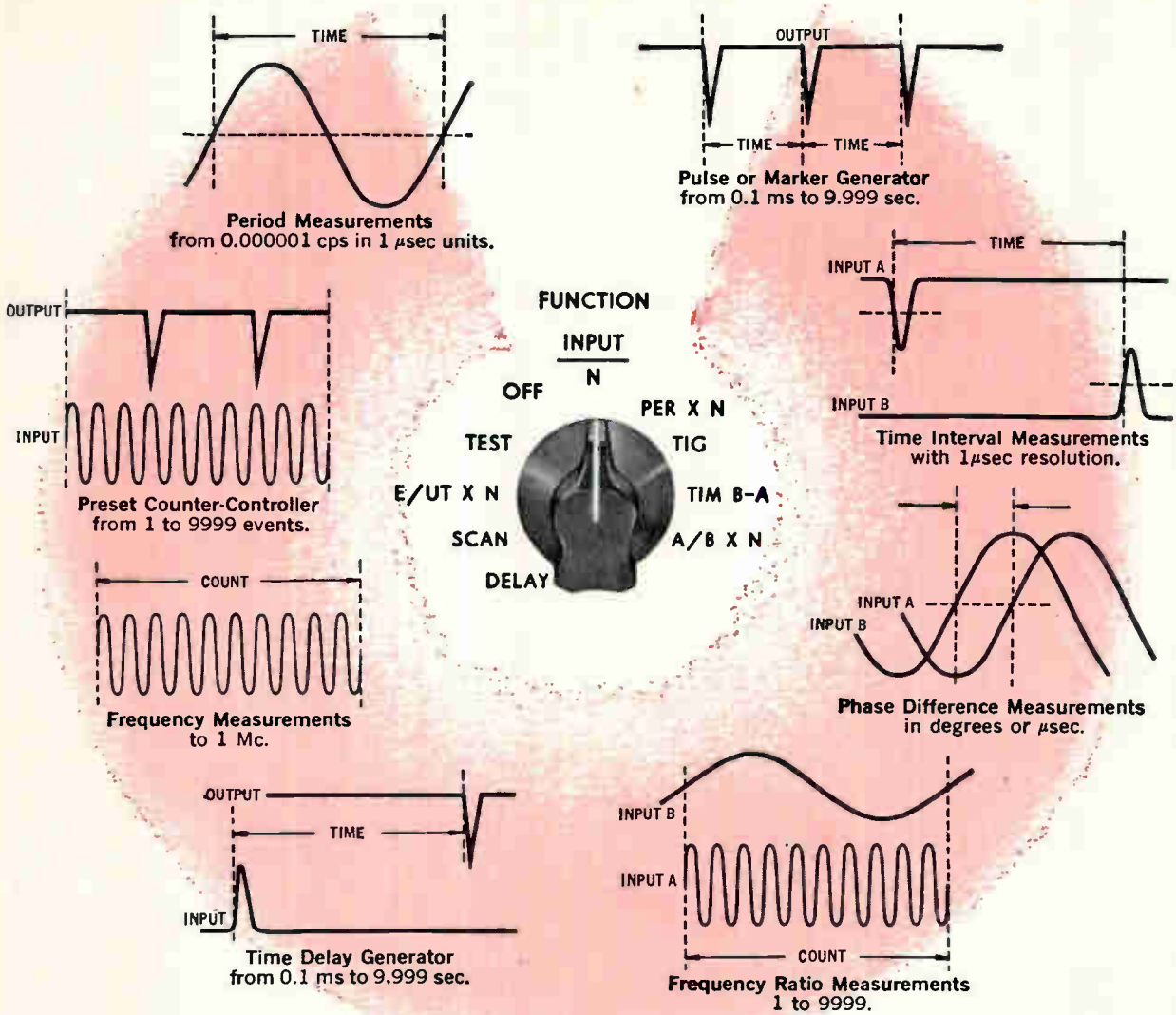
Avien reports $685,000 in military and space contracts, including multiband tracking, telemetry and command antennas for Tiros IV satellite.

Consolidated Electrodynamics has a $375,000 contract for Polaris Instrumentation recorders, from Interstate Electronics.

Lufthansa German Airlines will install Collins doppler navigation units on all its jet airliners. Order is for 22 units, with options for 20 more. Collins also got a $190,559 Navy contract for navigation equipment.

NATO receives bids in Rome October 11 for a $1.3 million radio center.

Westland Aircraft, England, orders $633,000 in Ryan Doppler navigators for its helicopters.



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T-42

WASHINGTON OUTLOOK

MULTI-MILLION-DOLLAR space contracts to be let in the next few months will mean millions of dollars in subcontracts for the electronic industry. Coming up are some of the basic contracts for putting a three-man astronaut team on the moon by 1967-69. Overall cost of the moon program is put at $20-$40 billion.

Contracts to be awarded include production of the 1.5-million-pound thrust S-1 booster that will be first stage on the Saturn C-1. Production will run to 30 or more of the big boosters, to be built at the government-owned Michoud Ordnance plant near New Orleans. Cost of each S-1 runs around $6 million with cost of complete C-1 with upper staging $12-$15 million. A follow-on version of the S-1 booster, the S-1-B, will be contracted for by the end of the year. It will produce three million pounds of thrust in the first stage.

MULTI-BILLION contract to develop and build the three-man Apollo capsule will be made in the next month or so. Some $160 million will be pumped into the project this year just to get it started.

Construction of facilities to produce and test the space vehicles will call for million-dollar electronic contracts, too. Launching facilities will be built on a newly acquired 80,000 acre tract of land at Cape Canaveral, Florida. Cost of building a half dozen launching pads plus support laboratories is estimated at $3-$5 billion before a lunar manned mission is attempted. Building the new manned space flight center near Houston, Tex. will cost an initial $160 million with the long range cost put well above this figure.

Still to be selected is a test center where the big boosters can be static tested before shipment to Cape Canaveral. This will be located near the Michoud Production Plant, probably in Texas along the Intercoastal Waterway.

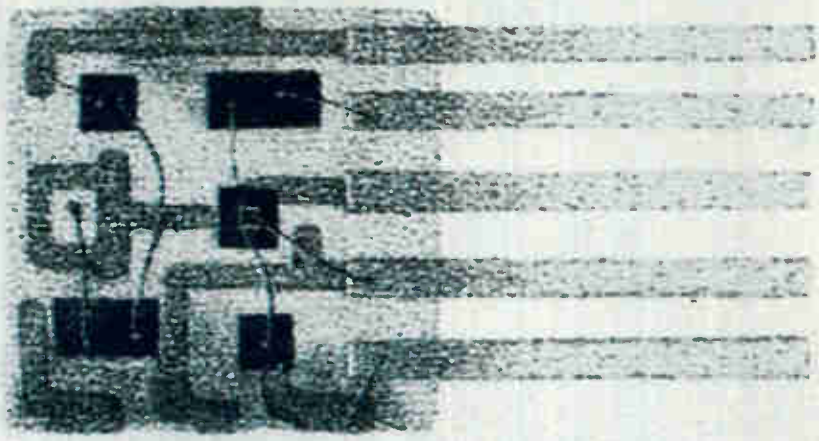
FEDERAL AVIATION AGENCY'S plan to make a start next year toward automating air traffic control has faltered. A special purpose digital computer, built to FAA's specifications by the Librascope Division of General Precision Inc., will not be installed in the New Boston Air Traffic Control Center early in 1962 as originally contemplated. The computer, which is to be the heart of a traffic data processing and display system, is still under evaluation by FAA.

The system not only is behind schedule, but its whole future is under a cloud. A presidential task force which has been evaluating air traffic control plans will make a formal report soon. Advance word is that it will propose using only part of the data processing system and that it will recommend against adoption of Sage air defense computers for FAA use. It will suggest increased reliance on radar and wider use of transponders or automatic altitude reporting.

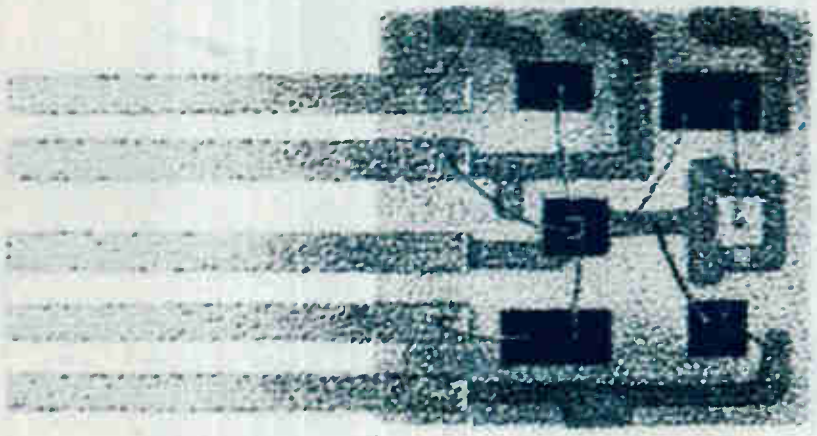
FEDERAL COMMUNICATIONS COMMISSION'S move to increase available tv channels by pushing uhf tv broadcasting faces rough sledding. Opposition in the broadcasting industry and in Congress is tuning up. Already, FCC has postponed the deadline for comments from this month until January 8.

By the time FCC gets around to a final decision, therefore, it may have a reading on whether uhf will work in big cities. The crucial test of uhf feasibility in cities gets underway in New York this fall. FCC is committed to try to make the best use of the 82-channel uhf-vhf spectrum. To do this, FCC wants to "deintermix" eight markets by pulling out their single vhf assignments, and leaving them with only uhf. Congressmen representing these areas are seeking legislation to block the move, claiming it will leave the cities with inadequate programming.

Flip



These magnified halves when combined in this actual size Flip Flop ▬ contain 2 transistors, 2 diodes, 6 resistors, and 2 capacitors



Flop

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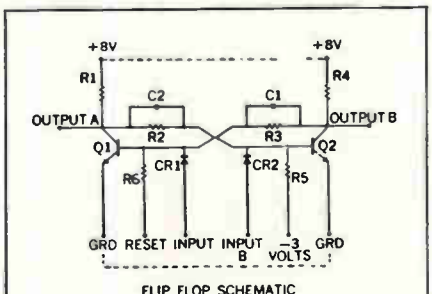

FLIP FLOP SCHEMATIC

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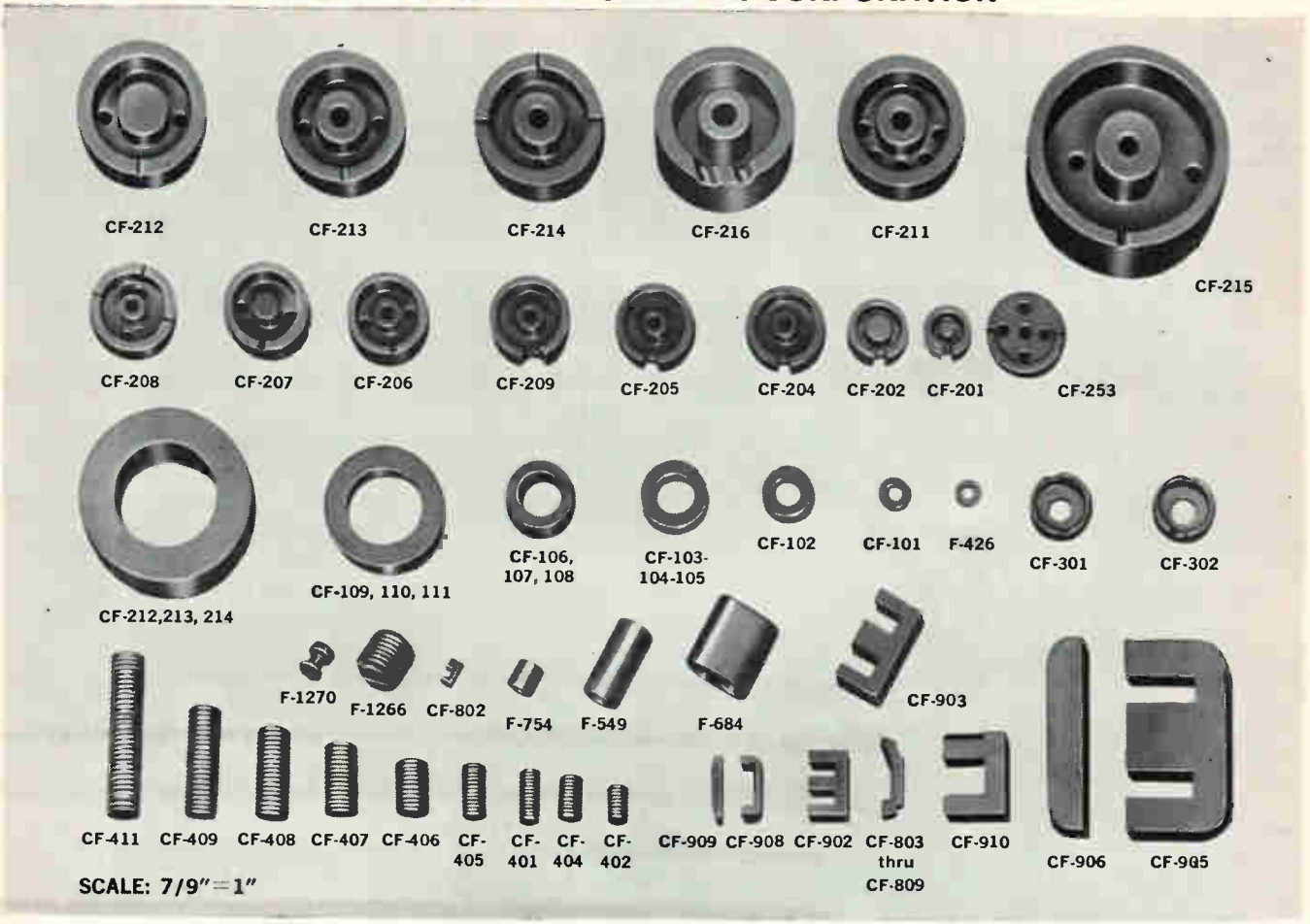

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*Filter Inductors	High μ Q, magnetic stability, sometimes adjustable	Up to 200 kcs 200 kcs-10 mcs 10 mcs-60 mcs	"Q-3", "T-1" "Q-1" "Q-2"	Cup cores, toroids, C-cores, E-cores, slugs
*IF Transformers	Moderate Q, high μ, magnetic stability, adjustable	465 kcs 40 mcs other	"Q-1" "Q-2" Materials for filter inductors apply	Cup cores, threaded cores, toroids
*Antennae Cores	Moderate Q, high μ, magnetic stability	5-10 mcs 10-60 mcs	"Q-1" "Q-2"	Rods, flat strips
*Wide Band Transformers	High U, moderately low loss	1 kc-400 kcs 1 kc-1 mc 200 kcs-30 mcs 10 mcs-100 mcs	"Q-3", "T-1" "H" "Q-1" "Q-2"	Cup cores, toroids, C-cores, E-cores
*Adjustable Inductors	High μ, moderately low loss	Same as Wide Band Transformers	Same as Wide Band Transformers	Rods, threaded cores, tunable cup cores
*Tuners	High μ, moderate to high Q, magnetic stability, as much as 10-to-1 adjustability with mechanical or biasing methods	Up to 100 mcs	For high Q selective circuits, materials under filter inductors apply. For others, materials under wide band transformers apply	Threaded cores or rods for mechanical tuning. Toroids, C-cores, E-cores for biasing methods.
*Pulse Transformers	High μ, low loss, high saturation	Pulse	Materials under wide band transformers apply	Cup cores, toroids, C-cores, E-cores
Recording Heads	High μ, low loss, high saturation, resistance to wear	Audio, pulse	"H" "O-3", "T-1"	

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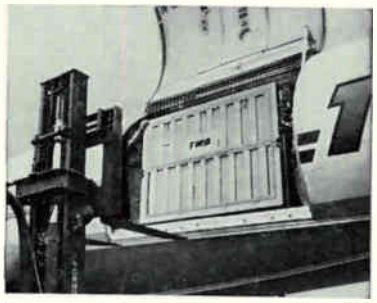

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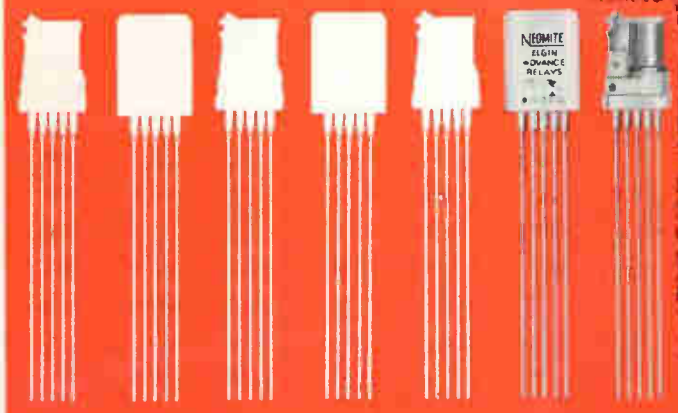

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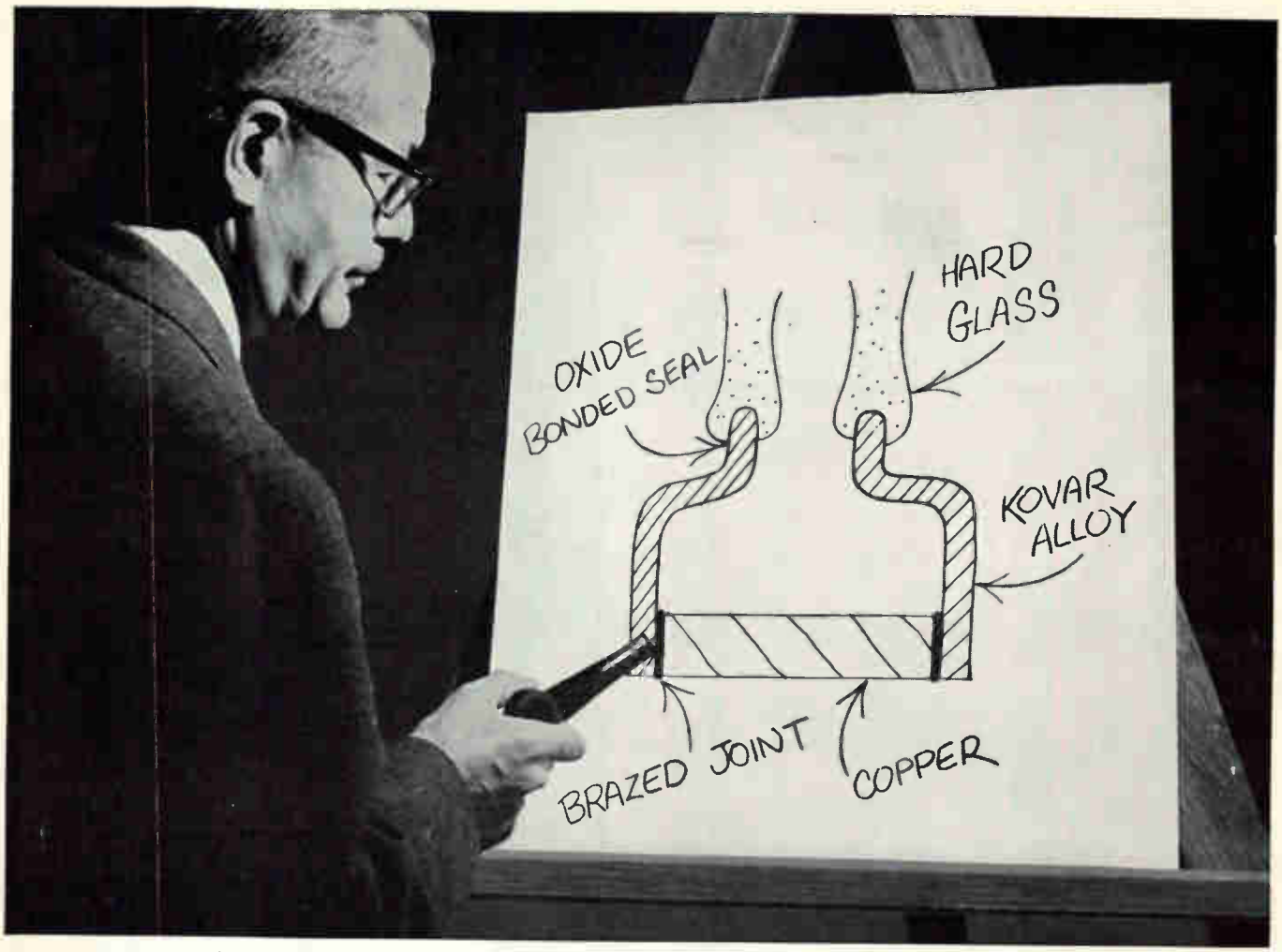

Engineering hints from Carborundum

How to Join KOVAR® Alloy to Other Metals

KOVAR, the original iron-nickel-cobalt alloy, has a thermal expansion curve which matches almost perfectly that of several hard glasses. It is a widely accepted answer to the problem of producing vacuum and pressure tight glass-to-metal seals.

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1. KOVAR ALLOY has a considerably lower expansivity than most other metals.
2. WELDED AND BRAZED JOINTS WITH KOVAR ALLOY are frequently made in close proximity to a glass seal.
3. FOR HIGH VACUUM APPLICATIONS it is essential that no brazing alloy is used which contains a high vapor pressure constituent, such as cadmium, zinc or lead.

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1. BRAZING SURFACE to be free of longitudinal scratches.
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4. DESIGN THE JOINT to avoid tensional stressing of the Kovar Alloy during the brazing operation. If the higher expansion member is on the inside, allow sufficient clearance between the parts.
5. USE A EUTECTIC BRAZING ALLOY, such as 72% silver, 28% copper.
6. THE BRAZING TEMPERATURE should be applied uniformly, such as in an atmosphere controlled furnace or high frequency induction heating.

New Technical Bulletin 100EB2A, available on request, gives additional information on welding, brazing, and soldering of Kovar Alloy to other metals. Individual engineering reports are also furnished on specific customer problems on Kovar Alloy joints.

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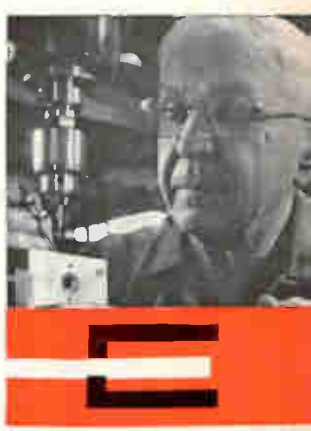

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NEC MIDWEST SPAWNS

Minnesota's Shepard—*"fourth largest electronics center."*

Ohio State's Bolz—*"Terman missed the research leaders."*

Michigan's Von Tersch—*"I brought Terman in to speak."*

By CLETUS M. WILEY
Midwestern Editor

CHICAGO—OUTSIDE of the Chicago metropolitan area, interest in electronics R&D ranges from fevered activity in Minneapolis-St. Paul to apathy in towns like Milwaukee and Cincinnati. Universities such as Purdue, Michigan and Ohio State are actively working with industry to improve the climate for R&D in their areas.

"Electronics certainly does lag, generally, throughout the Midwest," Prof. William Dow, chairman, University of Michigan electrical engineering department agrees, "but not in southern Michigan.

"The University of Michigan is the Midwest's center of research." Prof. Dow declares. "Electronic research activities here total about $9.7 million annually."

The community around Ann Arbor has also been expanding its research activities. Public and private sources invested more than $20 million in new research facilities during the past two years. Ten of the 18 firms in Ann Arbor's new research park are electronic or electronics-oriented.

Four formed or located there within the past year and a half and still another major electronics firm is expected to announce purchase of space there momentarily. "The nation's first state-supported program for space research is advancing education and encouraging development of space technology at the University of Michigan's Institute of Science and Technology (former Willow Run Labs.). Bendix research, Burroughs, General Motors and Ford have set up research labs in the Detroit area."

The Minneapolis area is conceded by some to be the fourth largest electronics center in country, according to William Shepherd, head, University of Minnesota electrical engineering and chairman of a governor-appointed state Electronics Industry Committee.

The number of Twin Cities' electronics companies has nearly doubled over past five years—from 86 to 140—including more than 20 new companies started since January 1, 1961. Employment is up from 26,000 to 40,000 in the five-year period. The industry produced $720 million in annual sales during 1960, according to Chamber of Commerce figures.

Success of Control Data and other young companies of the same type inspired dozens of aggressive young Twin Cities engineers to spin off from large corporations. They initiated their own ventures in a sort of contagion, catalyzed by demand for products in dollar volumes that would not interest the larger corporations, Shepherd explains.

Trending toward industrial electronic products and applications, the most significant direction of Twin Cities growth is in specialized digital systems, peripheral equipment and industrial and commercial production. But military products still account for a large share of the volume.

Extra attraction is a still-unnamed research and development institute to be initiated this fall or early next year as a nonprofit, university-connected center for work in electronics, R&D and economic studies.

Dr. Lawrence Von Tersch, Michigan State head of electrical engineering, comments "I was the one,

Ann Arbor's research park. University of Michigan is teamed up with 18 industrial companies, foundations and agencies in $50-million development

NEW RESEARCH ACTIVITY

as president of NEC, who brought Terman in to speak. But his talk has done more good at other universities and in other states than it has here."

"The general electronic situation is even worse in the Midwest and in Michigan than Terman said it was," Von Tersch continued. "People in our state who are in a position to influence development of electronics are not aware they should be doing anything different. Unless we stop losing our best electrical engineering graduates, Midwest electronics will be a second-rate operation." John Ryder, dean of engineering, agrees "only stronger research activity and the addition of more electronic research to this area will remedy our loss of intellectual power."

Purdue reasserted scientific leadership with the recent announcement that its Research Foundation has signed its first tenant to occupy the first building on the first six acres of the 100-acre McClure Research park to be developed a mile and a half from the campus. The foundation will sell or lease land on which companies may erect their own buildings or will build and lease to them.

"McClure will provide near-university employment for the inventive genius, the potential entrepreneur and the fertile minds who might otherwise go elsewhere," says Professor Tom Jones, electrical engineering head. "No more than 15 percent of Midwestern Ph.D.'s have stayed here, up to now, and these have gone into the teaching profession almost to a man. Our new R & D environment will cause a significant portion of our Ph.D.'s to choose permanent locations here—some will even return to Lafayette as result of it," Jones predicted.

Purdue's sponsored electronics research program has grown over the past three years from $20,000 annually to a current $600,000. Rate of electronic Ph.D. production has expanded during the same period from 6 a year to more than 20, with an annual electronic Ph.D. goal of more than 30 a couple of years from now.

At Iowa State, Dr. George Town, dean of the engineering college, reports the new Instrumentation Research Lab, ready for occupancy around January 1, has enrolled 13 graduate students for the 1961-62 academic year.

Ohio State failed in its attempt to get $15 million enabling legislation enacted this summer for setting up just such a center on the periphery of its campus.

With Columbus industry Ohio State is eyeing NASA plans to utilize more research in universities and other nonprofit institutions and suggesting closer cooperation between Case, Western Reserve and the University of Cincinnati — pointing out that research activities of the kind sought typically develop industries within a 150-mile radius.

Dean Harold Bolz of Ohio State's College of engineering says "Terman failed to point out Midwest research leaders such as Ohio State, the University of Illinois, ARF, National Cash Register and Battelle are contributing more significant and original developments to their field than his general indictment of Midwest universities and industries would indicate."

Midwest "anti-intellectual" concern with profitable refinement, production and marketing of existing products is blamed by Prof. James Yocum, associate director of Ohio State's bureau of business research, as an important factor in the Midwest areas present electronics lag.

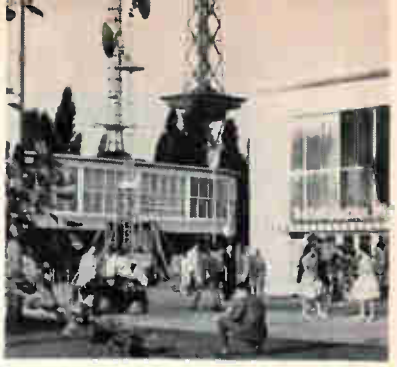
University of Illinois could use electronics production facilities as a cross-tie for students studying electronics, Dean William Everitt commented.

However, Illinois is already deeply involved in the new electronics, with a $5 million annual research program, which makes the university one of the largest electronic research centers; including a Coordinated Scientific Lab, physics and computer labs along with a $5½ million program by the Atomic Energy Commission and additional solid state and nuclear engineering programs.

Electronics in Midwest. Stars show industry centers; dots show new R&D

Uhf antenna consists of two bow-tie dipoles; plastic hood makes antenna into lamp (Telefunken)

All-transistor East German computer uses 650 transistors, 1,500 diodes. Speed is 5 microsec for addition, 280 for multiplication



Gardens and pavilions av West Berlin fair. Average exposition amounted to

A TALE OF TWO FAIRS: Leipzig

West Germans stress radio and tv. East Germans show desk-sized computer

By JIM MORRISON,
McGraw-Hill World News

BONN—STRIFE-BOUND BERLIN was given a fleeting air of normality last month when after an absence of 22 years West Germany's radio and television industries staged their annual show. Since 1949 the shows have been held alternately in Frankfurt or Dusseldorf.

Two days of time and 100 miles of high-speed autobahn separated the autumn exposition in Soviet-controlled Leipzig. The show displayed consumer goods predominently with heavy emphasis on radio, tv and similar equipment.

In Berlin, 160 West German exhibitors occupied more than 600,000 sq ft of covered space. Average attendance at the 10-day show was 45,000 a day.

In Leipzig, the whole might of East Germany's radio-tv industry was concentrated on three small floors of a state-operated store occupying a pre-war building on one of the city's side streets.

Radio production in West Germany reached 4.6 million in 1960 with sales of $190 million. Production in the first half of 1961 increased 4.1 percent although manufacturers see a flattening out with major sales emphasis on transistor portable and auto radios.

Already 87 percent of 18.5 West German households have one or more radios. Last year 43 percent of radio production was exported with one fourth going to U. S. Target for this year is 48 percent.

German manufacturers report that rising labor costs have opened the door to low-cost Japanese transistor portables that sell for as little as $18. By contrast, this year's German radios sell from 10 to 15 percent higher than last year's with little improvement.

During 1960 2.3 million tv sets with a value of $350 million were made. Production in the first half of 1960 totaled 988,400 sets worth $168 million. Presently only 28 percent of West German households are tv-equipped; this year manufacturers look to 40 percent.

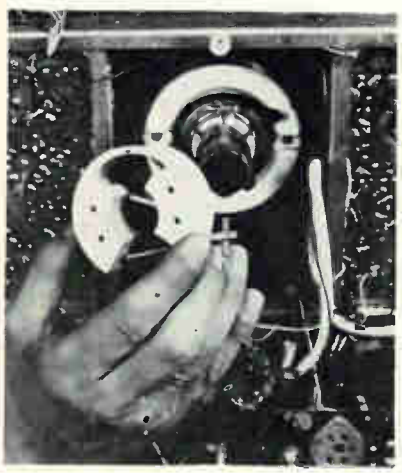
West Germany seems to be ahead of U. S. in uhf tv. The Federal Post Office is now operating 82 transmitters in the uhf band.

Ninety-five percent of tv sets made this year have 23-in. screens; some portables use 19-in. screens. There is widespread use of 19 and 23-in. square-cornered screens. One year ago, 68 percent of West German tv sets used 21-in. screens.

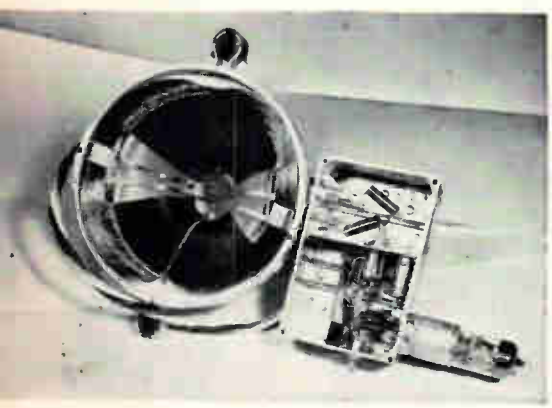
Most tv makers are offering remote control. Twin-tone and triple-tone ultrasonic devices permit channel changing, solume control or picture adjustment. One model has an automatic light meter connected through a resistor to the picture tube. The arrangement automatically adjusts brightness or contrast to meet changing ambient light.

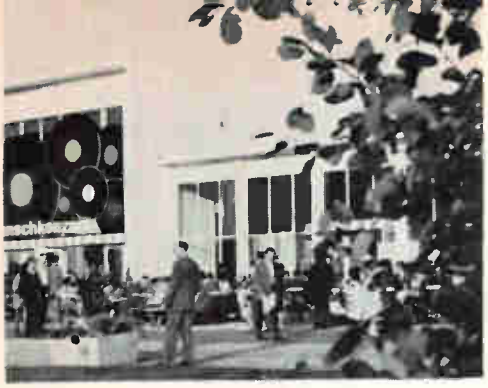
Three manufacturers showed so-called lineless tv. These sets get rid of the raster lines at distances of 10 ft or more. However, the resulting images often appear murkey and to have lost definition.

Telefunken attaches a $4 magnetic device to the picture tube that draws normally round raster dots



Lineless tv attachment: Telefunken magnets (top) make raster dots egg shaped; Grundig wobbler uses 13.56-Mc crystal oscillator coupled to secondary winding of sweep unit (below)





ailable to exhibitors and public at daily attendance at the ten-day 45,000 visitors

and Berlin

into egg shapes. Grundig uses a wobbler circuit that staggers the dots of the raster out of a straight line; it turns the normally straight line of dots into a saw tooth. Saba puts a transparent plastic screen sheet over the picture-tube screen. The plastic sheet has many fine dots milled into it.

Stereo does not seem to be catching on in Germany. Out of two million record players made in 1960 only 18 percent were stereo. Less than seven percent of records pressed in Germany are stereophonic.

Unveilings at the Leipzig autumn fair included a transistor computer about the same size as an office desk and the first transistor portable radio of East German manufacture.

At the simultaneous show of radio and tv equipment, one state-subsidized firm showed a tape recorder said to be the first East German consumer product to use printed circuits.

Stereo hi-fi was also in the spotlight although there is only one stereo record available in East Germany: a Bach cantata. A couple of the newer tv receivers use 23-in. tubes imported from West Germany. In fact, 30 percent of all components used in East German electronic equipment come from West Germany.

Otherwise, West German participation in the East German autumn fair was sharply reduced. Last year 1,000 West German firms exhibited. This year 700 were expected; 278 showed up according to Tass.

NEC

Is a Rebirth of Midwest

CHICAGO—AT LAST YEAR'S NEC Dr. Frederick E. Terman, vice president and provost of Stanford University dropped a verbal atom bomb when he chided Midwest electronics, on its home grounds, for failure to provide the creative content necessary to retain its brighter electronic engineering graduates. The beneficial fallout from this blast is still with us.

On the eve of the 17th annual National Electronics Conference, local business and academic sources agree that aggressive planning, industry-university cooperation and a modicum of financial backing can bring about an R&D rennaissance in Midwest electronics.

Here are a few developments of the past year:

• Small new electronics companies such as those springing up in the Minneapolis-St. Paul area are proving the commercial value of advanced science and technology.

• Electronics parks are under construction on the borders of Michigan, Ohio State and Purdue campuses.

• A depth survey is underway to demonstrate the exact rate of decline (or growth) of 75 electronics companies in the Chicago area. Results will lay a foundation for action recommendations and will be presented to the NEC on Monday, Oct. 9 by Professor Albert Rubenstein of Northwestern, survey chairman.

• Mayor Richard Daley of Chicago is giving top priority to electronics development with a two-month-old committee including more than 100 business, industrial and civic leaders.

One plan for a Midwest R&D rennaissance is proposed by John Kennedy, president of James Electronics and chairman of the subcommittee on electronics of the Chicago Association of Commerce and Industry. He proposes formation of a Regional Research and Development Company—Company X. The company would concentrate on systems management and would mobilize the resources of the Chicago area. One ambitious project selected for the proposed company would be development of an electronic deterrent to nuclear war.

The association subcommittee goes on to point out some business problems facing the Chicago-area electronics industry today.

One cause of frustration is the relative lack of government contracts in the area.

Chicago still leads the nation with $900 million worth of electronic consumer products; 45 percent of the business in radios, tv sets, phonographs, organs and other consumer electronics.

However, this consumer market is expected to grow only half a billion—to a total of $2½ billion—by 1965.

In the government electronics market, growth to $7¾ billion is anticipated by 1965. Last year Chicago's share was only 2.7 percent —$150 million—in the national total of $5½ billion, according to figures reported by the electronics subcommittee of Chicago Association of Commerce and Industry.

In industrial electronics growth to a national market of $3½ billion is anticipated by 1965.

The Chicago area accounted for only about 5.6 percent—$98 million worth—of the nation's total output of $1¾ billion worth of industrial electronics during 1960, according to the subcommittee's figures.

On a population basis, Chicago's 1960 share of government electronics business should have been more than three times the actual 4.7 percent, reported by the association's subcommittee. Tax-wise, the Chicago area got back only 18 cents in government business for every dollar collected in taxes for electronic work. California received $2.86 in contracts for each of these dollars paid in taxes.

Chicago and the Midwest have many more electronic firms than

R&D Underway?

MIDWEST R&D SCORECARD

CHARGES *that Chicago-area companies lag those on the East and West Coasts will be answered during the National Electronics Conference at a roundtable Oct. 11 at 2:30 p.m. in the Banquet Room of Chicago Stockyard Inn.*

Professors Terman and Rubenstein will be there. Also Admiral Rawson Bennett, former Chief of Naval Research, now with Sangamo Electric; Daniel Noble of Motorola; and Dean William L. Everett of University of Illinois. A. A. Mac Donald chairman of the committee on NEC Electronic Research and Development will moderate

the West Coast; Illinois alone has 550 such companies, compared to 650 in 11 Western states. But West Coast has been getting more than half of the government's missile business.

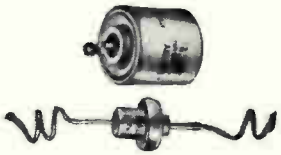
University of Illinois' Dean William Everett contradicts charges that Midwestern universities have failed to produce their share of electronic scientists with figures showing Illinois produced 100 electronics Ph.D.'s over the past six years compared to Stanford's 128, and 21 Ph.D.'s compared to Stanford's 24 for 1960.

Northwestern is preparing to make its 105 acre golf course available as a regional research and development center of the Company X type, according to W. F. Kerr, vice president.

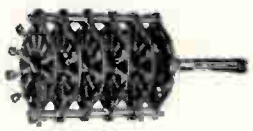
"Our mission is to do basic and fundamental research and to develop the corps of research personnel industry needs," says Dr. Harold Gottas, dean of Northwestern's Technological Institute.

Majority of Chicago area companies report that favorable earnings result from the stable volume offered by consumer markets. But scores of firms have contributed research talent and products to parts of the Mercury man in space program. However, experts add that most Chicago companies still have much to learn about how to bid for a prime weapons-system contract.

Immediate delivery at factory prices... from Mallory industrial

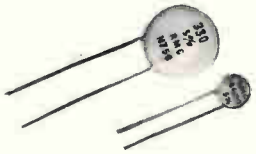


TANTALUM CAPACITORS Industry's broadest line. Microminiature to high capacity: 0.33 to 1300 mfd. Sintered wet slug, solid and foil types. Temperature ratings —55 to +200°C.



SELECTOR SWITCHES Push-button, lever action, rotary, wafer, multi-section. Phenolic or ceramic insulation.

VITREOUS ENAMEL RESISTORS Complete line of fixed and adjustable wire-wound resistors including MIL types. 5 to 200 watts, resistances to 100,000 ohms.



CERAMIC DISC CAPACITORS All standard temperature coefficients. Ratings from 50 volts general purpose to 6000 volts. Made by Radio Materials Company, a Mallory division.

SUBMINIATURE SNAP-ACTION SWITCHES Milli-Switch line of precision push-button switches; toggles and auxiliary actuators for slide or cam action. Temperature ratings to 300°F. Also hermetically sealed types.

HIGH-CAPACITY, HEAVY-DUTY ELECTROLYTICS High-capacity HC type and non-polarized NP type. Plastic case. Compact, leak-proof design. High ripple current rating, cool operation. From 3V, 6700 mfd. to 450V, 88 mfd.

These Mallory industrial distributors stock the lines indicated by numerals:

Key: 1—Tantalum capacitors
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Standard Radio Parts	1						Tucson, Ariz.
Newark Electronics		2				6	Inglewood, Calif.
California Electronics	1	2				6	Los Angeles, Calif.
Electronic Supply	1	2				6	Los Angeles, Calif.
Federated Purchaser		2				6	Los Angeles, Calif.
Kierulff Electronics	1	2		4	5	6	Los Angeles, Calif.
Radio Product Sales	1	2				6	Los Angeles, Calif.
Lynch Electronics	1	2				6	Monrovia, Calif.
Brill Electronics						6	Oakland, Calif.
Elmar Electronics	1	2		4		6	Oakland, Calif.
Zack Electronics	1	2	3		5	6	Palo Alto, Calif.
Elwyn W. Ley		2				6	Paramount, Calif.
Shanks & Wright				4			San Diego, Calif.
Peninsula Electronics					5		San Jose, Calif.
Denver Electronics	1					6	Denver, Colo.
Westconn Electronics	1	2					Bridgeport, Conn.
Radio Appliance Co.		2					E. Hartford, Conn.
Westchester Electronics		2					Stamford, Conn.
Capitol Radio	1					6	Washington, D.C.
Electronic Indus. Sales	1	2				6	Washington, D.C.
Electronic Equipment						6	Miami, Fla.
East Coast Radio	1			4		6	Orlando, Fla.
Thurow Electronics	1						Tampa, Fla.
Allied Radio	1	2				6	Chicago, Ill.
Chauncey's, Inc.				4			Chicago, Ill.
Newark Electronics	1	2				6	Chicago, Ill.
Melvin Electronics						6	Oak Park, Ill.
Bruce Electronics			3			6	Springfield, Ill.
Graham Electronics	1	2	3	4	5	6	Indianapolis, Ind.
Radio Supply					5		Wichita, Kansas
P. I. Burks & Co.		2				6	Louisville, Ky.
D & H Distributing						6	Baltimore, Md.
Kann-Ellert Electron.		2					Baltimore, Md.
Radio Elec. Serv.	1				5		Baltimore, Md.
Cramer Electronics	1	2				6	Boston, Mass.
DeMambro Rad.Sup.	1	2				6	Boston, Mass.
Lafayette Radio	1	2	3			6	Boston, Mass.
Radio Shack		2					Boston, Mass.
Radio Specialties		2					Detroit, Mich.
Northwest Radio	1	2		4			Minneapolis, Minn.
Burstein-Applebee		2				6	Kansas City, Mo.
Walters Radio		2				6	Kansas City, Mo.
Interstate Indus. Elec.				4			St. Louis, Mo.
Olive Electronics	1				5		St. Louis, Mo.
General Radio		2				6	Camden, N. J.
Eastern Radio		2				6	Clifton, N. J.
Federated Purchaser	1	2				6	Mountainside, N. J.
Aaron Lippman & Co.		2					Newark, N. J.
Lafayette Radio	1					6	Newark, N. J.
Atlas Electronics	1	2				6	Perth Amboy, N. J.
Nidisco, Inc.		2					Union City, N.J.
State Electronics		2		4		6	Whippany, N. J.
Ft. Orange Radio		2					Albany, N.Y.
Federal Electronics	1	2				6	Binghamton, N. Y.
GEM Electronics		2				6	Brooklyn, N.Y.
Radio Equipment		2					Buffalo, N. Y.
Standard Electronics, Inc.		2				6	Buffalo, N.Y.
Summit Dists.		2					Buffalo, N.Y.
Wehle Electronics	1					6	Buffalo, N. Y.
Statewide Electronics					4		East Syracuse, N.Y.
Lafayette Radio		2					Jamaica, N. Y.
Greylock Electronic		2					Kingston, N. Y.
Peerless Radio						6	Lynbrook, L.I., N.Y.
Bruno-New York		2				6	New York, N. Y.
Electronic Center		2				6	New York, N. Y.
Harrison Radio	1	2	3	4		6	New York, N. Y.
Harvey Radio	1	2				6	New York, N. Y.
Lafayette Radio	1	2	3			6	New York, N. Y.
Milo Electronics	1	2				6	New York, N. Y.
Terminal HudsonElec.	1	2				6	New York, N. Y.
Higgins & Sheer Elec.		2					Poughkeepsie, N.Y.
Morris Electronics						6	Syracuse, N. Y.
Valley Indus. Elec.		2					Utica, N. Y.
Westchester Electron.	1	2					White Plains, N.Y.
Dalton-Hege Inc.	1						Winston-Salem, N.C.
Akron Electronic Sup.		2					Akron, Ohio
United Radio	1		3	4			Cincinnati, Ohio
Pioneer Electronics	1					6	Cleveland, Ohio
Thompson Radio		2		4			Columbus, Ohio
Whitehead Radio			3				Columbus, Ohio

Lag Seen In Microwave Profits

WARNING came this week to manufacturers of private microwave systems that they should not expect much volume in business over the next two or three years. Common-carrier competition and the need for customer education were seen as stumbling blocks.

The admonition was made in a 198-page report by eight graduates of the Harvard Business School. Titled "Microwave Communications: Commercial Possibilities in the 60's", the document is the result of a six-month study on the impact of the Federal Communications Commission decision in 1959 opening frequencies above 890 Mc to private users.

The report says that private microwave thus far has been characterized by bitter competition and adds that profits from the private market were negligible.

The report urges manufacturers to concentrate now on markets such as railroads, petroleum companies, gas pipelines and the military. But by 1966 the maximum growth rate of the market will be reached. The researchers anticipate a market plateau by the end of the decade.

One change in outlook urged is that communications men play a more important role in overall systems development so that they may assume a more significant role in data transmission and applications of microwave radio other than voice communications.

High speed data transmission is seen as the most important growth area for private microwave. This will put emphasis on data processing, telemetering and remote control.

The study says the greatest contribution manufacturers can now make to market growth is in customer education and marketing.

Instant Circuits May Speed Space Hardware

JET PROPULSION Laboratory is studying mechanization of circuit preparation as a way to speed implementation of space hardware. A group of logical elements are prepotted and pretested, but not interconnected. When a circuit is needed in a hurry, the logical equation is fed to a computer, which prints out a circuit that will do the job.

The circuit is photo-reduced and printed on the block of logical elements to wire the element terminals. The module is then plugged into the space system. Some of the components will be wasted. JPL estimates that in high-density packages, component use will be about 75 percent.

Navy Finances Thin-Film Mass Production

IBM FEDERAL SYSTEMS division has a $\$\frac{1}{2}$ million contract from Navy to develop a high-volume production system for thin-film subassemblies. The pilot production line is to be delivered within a year to the Naval Avionics Facility, Indianapolis.

The equipment will consist of a line of four vacuum chambers. Substrates will be deposited under automatic control. Navy will use the line to produce experimental devices and will encourage other companies to install such equipment as part of the Navy industrial readiness plan. IBM plans to market equipment or establish other sources of supply.

Plasma Propulsion Engine Runs 60 Hours in Test

REPPAC III, a repetitively pulsed plasma propulsion engine (ELECTRONICS, p 4, Sept. 1, 1961), ran continuously for 60 hours at General Electric's Space Laboratory. Firing rate was 1,000 a minute. GE says the system can operate long enough to fulfill requirements of a year-long space mission.

Run in a high-vacuum chamber to prevent interaction of plasma exhaust and residual gases, the engine developed 20 millipounds of thrust with a specific impulse of 5,000 seconds. It used seven kilowatts of power and operated at 32 percent efficiency.

MEETINGS AHEAD

BROADCAST SYMPOSIUM, PGB of IRE; Willard Hotel, Washington, D. C., **Oct. 6-7.**

NATIONAL ELECTRONICS CONF., IRE, AIEE, EIA, SMPTE; Int. Amphitheatre, Chicago, **Oct. 9-11.**

AUDIO ENGINEERING SOCIETY, Convention and Exhibit; Hotel New Yorker, New York City, **Oct. 9-13.**

PRINTED CIRCUITS, Institute of, Annual; Sheraton-Chicago Hotel, Chicago, **Oct. 10-11.**

STANDARDS, National Conf. on, ASA; Rice Hotel, Houston, Texas, **Oct. 10-12.**

DIGITAL COMPUTERS, Application to Automated Instructions, ONR, Systems Devel. Corp.; Dept. of Interior Audit., C Street, Wash., D. C., **Oct. 11-13.**

WRITING & SPEECH, Engineering, PGEWS of IRE; Kellogg Center, Mich. State Univ., East Lansing, Mich., **Oct. 16-17.**

VACUUM SCIENCE and Technology, American Vacuum Society; Sheraton Park Hotel, Washington, D. C., **Oct. 16-19.**

QUALITY CONTROL, American Society for; Chase-Park Plaza Hotel, St. Louis, Mo., **Oct. 19-20.**

RELIABILITY, Electronic, IRE; N.Y.U. Coll. of Eng., Univ. Heights, N. Y. C., **Oct. 20.**

TELLURIC AND GEOMAGNETIC Field Variations, URSI, Univ. of Texas, ONR; Student Union Bldg., Austin, Texas, **Oct. 20-21.**

AERONAUTICAL & NAVIGATIONAL Elec., East Coast Conf., PGANE of IRE; Lord Baltimore Hotel, Baltimore, Md., **Oct. 23-25.**

URSI-IRE FALL MEETING, URSI, PGAP of IRE; Univ. of Texas Student Union Bldg., Austin, Texas, **Oct. 23-25.**

AEROSPACE NUCLEAR PROPULSION Internat. Symp.; Las Vegas, Nev., **Oct. 23-26.**

QUALITY CONTROL, American Society, ASQC; Sheraton Hotel, Philadelphia, **Oct. 24-25.**

NEREM, Northeast Research & Engineering Meeting, Commonwealth Armory and Somerset Hotel, Boston, **Nov. 14-16.**

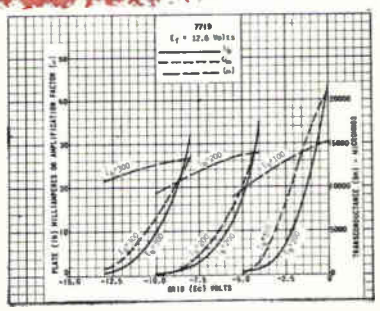
IRE INTERNATIONAL CONVENTION, Coliseum & Waldorf Astoria Hotel, New York City, **Mar. 26-29, 1962.**

INDUSTRIAL ELECTRONICS Exp., Electronic Representatives Inc., Detroit Artil. Armory, Detroit, **Oct. 24-26.**

TUNG-SOL HIGH PERFORMANCE

GENERAL PURPOSE MINIATURE COMPUTER TRIODE

7719



Directly replaces parallel-connected 5965 and 7062 twin-triodes while providing these added advantages for designers of computer circuits:

- **Higher transconductance**
- **Much higher plate dissipation**
- **Very high perveance**
- **Very sharp cut-off**
- **Linear transfer characteristics**
- **Improved reliability**

The Tung-Sol 9-pin miniature 7719 general purpose triode is the latest addition to the Tung-Sol family of top-rated, high-reliability tubes for computer service. Rated at 6 watts plate dissipation, the 7719 incorporates many design and construction features which assure computer users the maximum number of hours of trouble-free peak performance.

CHECK THESE ADDITIONAL BENEFITS:

- Freedom from cathode interface and reduced electrical leakage . . . Achieved through use of a passive cathode alloy and lower heater power per unit area.
- Minimization of grid emission . . .The 7719 is designed with heavy grid support wire and a double connection to the grid for cooler operation allowing use of 1 megohm grid circuit resistance.
- High stability . . . Use of heavier stock plate material assures more even distribution of heat and lower plate temperature. Cool operation further guaranteed by cool cathode and low bulb temperature (175°C at 6 watt dissipation).
- Very little "island" formation . . . Optimized geometry minimizes island formation thereby providing sharp cut-off, linearity and high perveance.

Typical applications of the 7719 are found in totem pole amplifiers to drive function-generating potentiometers, cathode followers, and multivibrators. Full technical details on the 7719 are available immediately on request.

RATINGS

Heater Voltage (Series)	12.6±0.6	Volts
Heater Voltage (Parallel)	6.3±0.3	Volts
Maximum Plate Voltage	330	Volts
Maximum Plate Dissipation	6.0	Watts
Maximum DC Cathode Current	40	Ma.
Maximum Heater–Cathode Voltage:		
Heater Negative With Respect to Cathode		
Total DC and Peak	200	Volts
Heater Positive With Respect to Cathode		
DC	100	Volts
Total DC and Peak	200	Volts
Maximum Bulb Temperature	175	°C

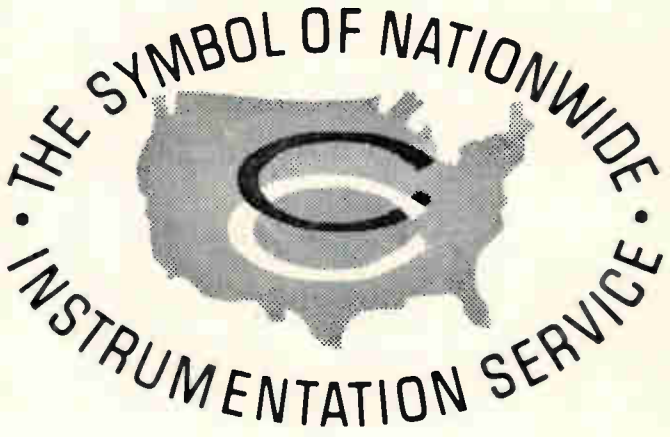
TUNG-SOL®

Technical assistance is available through: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Seattle, Wash. In CANADA: Abbey Electronics, Toronto, Ontario

SPERRY

ELECTRONIC TUBE DIVISION

SPERRY RAND CORPORATION



CAIN & COMPANY

Improved customer service forecast as Sperry Electronic Tube Division names Cain & Co. national representatives

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St. Petersburg, Florida
410 — 150th Avenue
Madeira Beach Prof. Bldg.
391-0151

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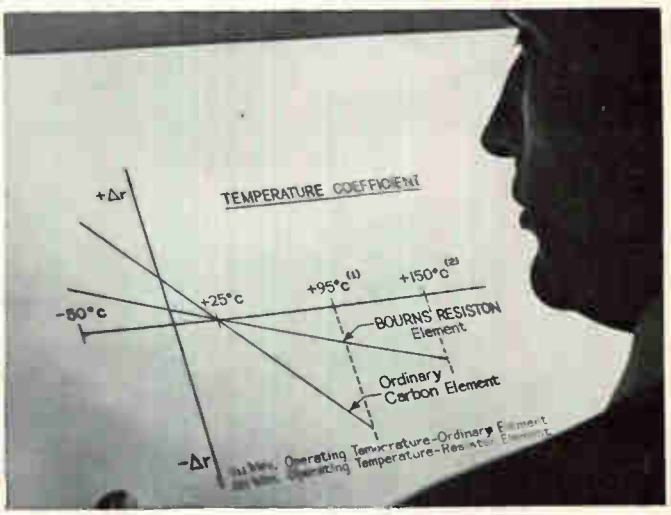
Bourns Resiston® Carbon Potentiometers Now Available in Any Trimpot® Configuration

Use Them up to 150°C—They're Twice as Stable as Competitive Units!

Whatever carbon potentiometer type or configuration you need, Bourns can now fill it with Trimpot Resiston models—potentiometers incorporating the exclusive carbon-film element that virtually eliminates problems of heat and humidity. Most models operate at temperatures to 150°C and under cycling humidity conditions with only half the resistance shift of ordinary carbon potentiometers.

All units feature infinite resolution and standard resistances up to 1,000,000 ohms. Check the expanded selection below. It offers you eight ways of obtaining high resistance values and infinite resolution without sacrificing reliability. You can get the exact environmental specs you need, and you can find the right price range for your budget. Write for complete data and list of stocking distributors.



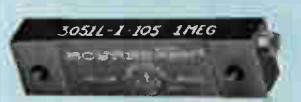
General-Purpose Resiston® Carbon Trimpot®—Model 215. Operates to 125°C / L, S, P terminals / ¼ watt / 20K to 1 Meg. Unsealed.

Humidity-Proof Resiston Carbon Trimpot—Model 235. Operates to 125°C / L, S, P terminals / ¼ watt / 20K to 1 Meg. Sealed. Meets Mil Specs for cycling humidity.

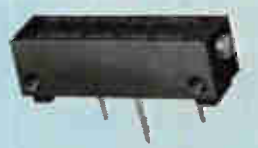
High-Quality, Low Cost Commercial Carbon Trimit®—Models 272, 274, 276. Operates to 85°C / L, S, P terminals / 0.2 watt / 20K to 1 Meg. Unsealed.

¾-Inch-Long Carbon Trimpot—Model 3001. Operates to 150°C / P terminals / 0.2 watt / 20K to 1 Meg. Sealed. Meets Mil Specs for cycling humidity.

High-Temperature Humidity-Proof Resiston Carbon Trimpot—Model 3011. Operates to 150°C / L, P terminals / ¼ watt / 20K to 1 Meg. Sealed. Meets Mil Specs for cycling humidity.



High-Temperature Humidity-Proof Resiston Carbon Trimpot—Model 3051. Only .19" wide. Operates to 150°C / L, S, P terminals / ¼ watt / 20K to 1 Meg. Sealed. Meets Mil Specs for cycling humidity.



Extra Low-Cost Commercial Resiston Carbon E-Z Trim® Potentiometer—Model 3068. Operates to 85°C / S, P terminals / 0.2 watt / 20K to 1 Meg. Meets Steady-State Humidity Specs Less than $1 in production quantities.

½" Square Resiston Carbon Trimpot—Model 3251. Operates to 150°C / L, P, W terminals / ½ watt / 20K to 1 Meg. Sealed. Meets Mil Specs for cycling humidity.

KEY TO TERMINALS
L—insulated stranded leads
W—uninsulated wires
S—solder lugs
P—printed circuit pins

Write for complete data and list of stocking distributors

BOURNS

BOURNS, INC., TRIMPOT DIVISION
6135 MAGNOLIA AVE., RIVERSIDE, CALIF.
PHONE: OVERLAND 4-1700 · TWX: RZ9222
CABLE: BOURNSINC.

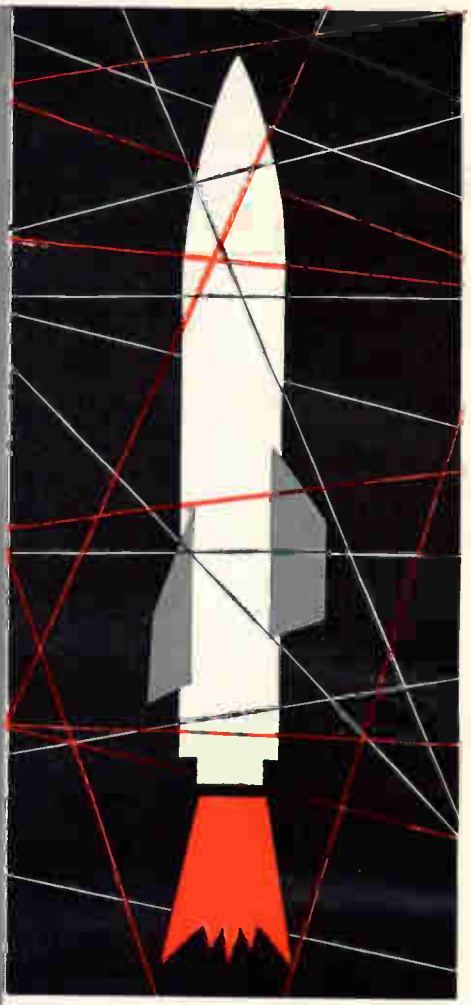
Manufacturer: Trimpot® potentiometers; transducers for position, pressure, acceleration. Plants: Riverside, Calif.; Ames, Iowa; and Toronto, Canada

New developments in TEFLON® 100 FEP speed use in wire and cable insulation

New ML jacketing gives increased reliability to thin-wall constructions

The wire and cable industry is finding exciting new uses for TEFLON 100 FEP-fluorocarbon resin. This new melt-processible member of the family of TEFLON resins is being extruded in long, continuous lengths of wire insulation . . . and as jacketing for wire and cable.

One new development promises to extend the usefulness of FEP still further, especially in applications where miniaturization is important. This is the use of ML Wire Enamel to provide FEP insulations that have greatly increased resistance to mechanical abuse. This is accomplished with only a thin coating of ML. Hence, mechanical reliability is increased without appreciable change in the insulation thickness, and with no effect on the thermal and nonflammability properties of FEP. Nor are the outstanding electrical properties of TEFLON 100 affected significantly. (ML Wire Enamel is a new Class H insulating material supplied by Du Pont's Fabrics and Finishes Department.)



MIL-W-16878D inclusion of FEP permits new design in military hook-up wire

The recently issued "D" revision of Bureau of Ships MIL-W-16878 specification for hook-up wire includes FEP as insulation for continuous service up to 200°C. Construction covered in the new specifications are:

Type KT—250 v. service (6-mil insulation)
Type K—600 v. service (10-mil insulation)
Type KK—1,000 v. service (15-mil insulation)

In all three types, the user can obtain TEFLON FEP over either tin-plated or silver-plated conductors.

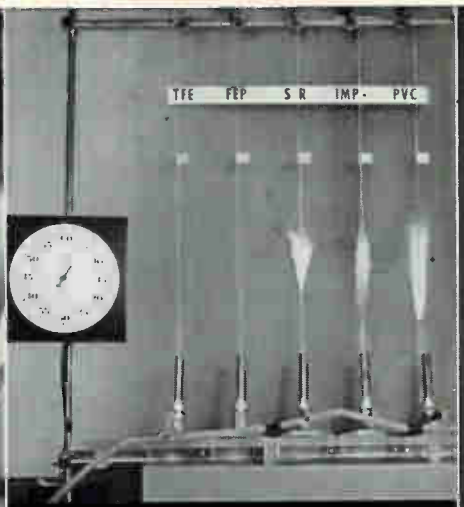
In all three constructions, the excellent dielectric properties of TEFLON 100 FEP . . . its thermal stability . . . its low-temperature toughness . . . and its resistance to chemicals and solvents of all kinds will provide another significant means for designers to obtain increased reliability.

Thus, FEP joins the older members of the family of TEFLON fluorocarbon resins, the TFE resins, as specified insulations under MIL-W-16878. Only TFE and FEP resins are permitted for thin-wall constructions under this spec.

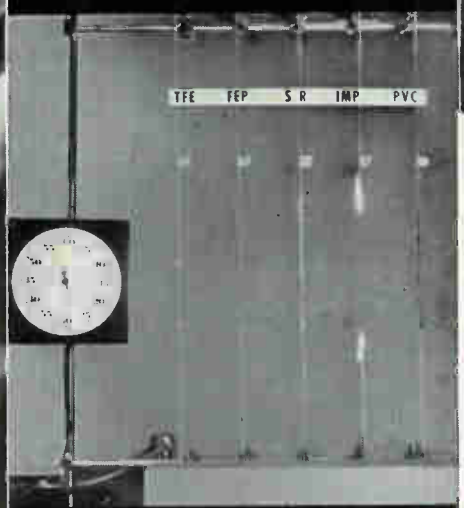
Another military application utilizing FEP resin is covered in MIL-C-17C—jacketing material for coaxial cable.

FEP used in computer-wire insulation

Within its brief commercial life, Du Pont TEFLON 100 FEP resin has been accepted as primary insulation for hook-up wire by major manufacturers of data-processing equipment. Modern high-speed circuits demand uniform low capacitance. This is provided by FEP, whose low dielectric constant is unaffected by frequency or temperature. New wire-wrap techniques, including high-speed automatic wire-wrapping, require high resistance to cut-thru. Here the combination of a primary insulation of TEFLON FEP with a jacket of "Zytel" nylon resin has proved outstanding. Also important to the computer industry is the availability of insulated wire in unlimited lengths, with tinned or silver-plated conductors . . . and the exceptional toughness and flexibility of FEP insulation.



Vertical flame test 5 seconds after ignition of burners. No indication of burning on either "Teflon" FEP or TFE resins. Other insulations flame vigorously.



15 seconds after removal of flame (30 seconds after ignition), FEP and TFE show only slight discoloration. Other insulations (at right) are still burning or are badly charred. These insulations are silicone rubber, irradiated modified polyethylene and polyvinyl chloride, respectively.

FEP insulation does not burn

One very important property of TEFLON 100 FEP resin is its complete nonflammability, illustrated above. For many applications, this nonflammability, with its accompanying safety factors, is a critical consideration.

TEFLON 100 has a dielectric constant of only 2.1. This value remains constant over the entire frequency range measured to date, and is essentially unaffected by temperature. Further, FEP retains both its electrical and mechanical properties on heat aging, and is recommended for continuous use at temperatures as high as 200°C.

Downward price trend of TEFLON 100 FEP resin extends markets in insulation

In July, 1961, the price of TEFLON 100 FEP resin was reduced by 30%. This was the third reduction by Du Pont since the resin was introduced in June, 1957, and represented a 65% change from the original price. Increased sales and technical breakthroughs permit such price reductions.

This history of price decreases parallels that of TEFLON TFE resins, today selling at about one-fifth of their introductory price. In terms of today's designs, as well as for long-term development programs, reliability costs less with TEFLON.

• • •

Would you like more information about TEFLON 100 FEP-fluorocarbon resin? Just write to: E. I. du Pont de Nemours & Co. (Inc.), Dept. E-106, Room 2526T, Nemours Bldg., Wilmington 98, Del. *In Canada:* Du Pont of Canada Limited, P.O. Box 660, Montreal, Que.

TEFLON®

FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

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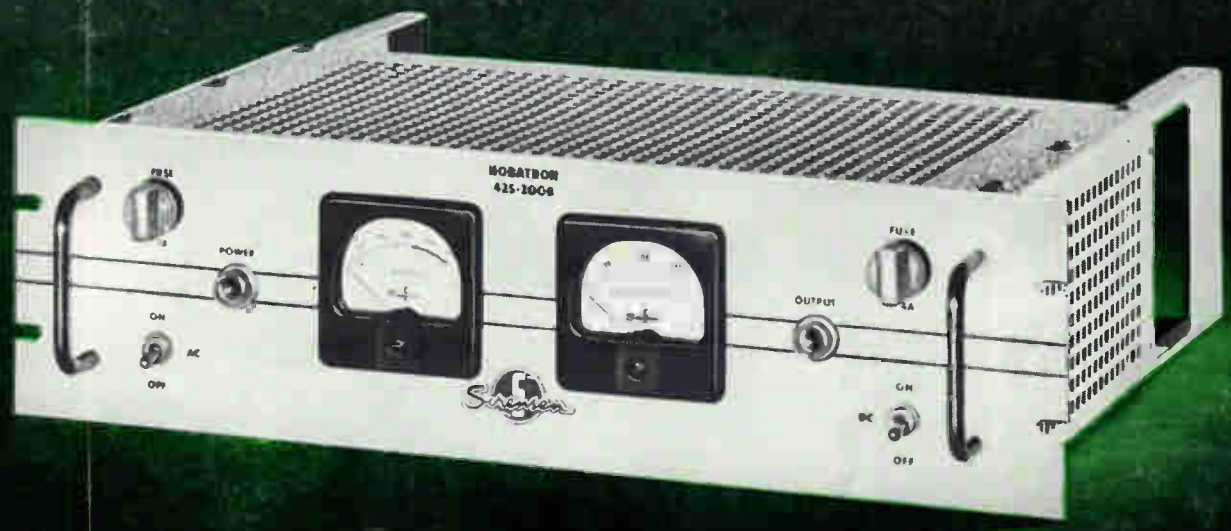

Regulated, variable-output

B SUPPLIES

2 voltage ranges at 200, 400 and 800 MA

TRANSISTORIZED SINE WAVE INVERTER—The QISB, a rugged, low-cost, compact inverter, provides up to 60 VA of 115V AC at 60 or 400 cycles from a DC source. Output will not vary more than ±3% with load variations. The QISB is easy to install and starts instantly. It has no moving parts and is not damaged by momentary overloads or output shorts.

3-PHASE FREQUENCY CHANGER—The FCR 3P300 variable frequency power source supplies 0-130 volts line to neutral; 300 VA 3-phase, 200 VA 2-phase, or 300 VA single phase with ±1% regulation for both output frequency and voltage. Frequency may be varied from 45 to 2000 cps in two ranges. Suitable for many laboratory and industrial applications.

Close regulation, constant current output and provisions for external programming distinguish these versatile new B Supplies. Available with 125-325 VDC or 325-525 VDC output, they also provide 6.5 VAC for powering external tube filaments. Mechanically designed for easy access to tubes and circuits, all models are designed for standard 19" rack mounting and include front-panel output voltmeters and ammeters. These compact new plate and filament supplies are ideal for use in a broad variety of industrial and laboratory electronic equipment. Ask for complete specifications and literature.

SPECIFICATIONS

INPUT VOLTS:	105-125 volts AC 50-400 Cycles All Models
DC OUTPUT VOLTS:	125-325 V DC or 325-525 V DC
DC OUTPUT CURRENT (MA):	200, 400 or 800
LINE & LOAD REGULATION COMBINED:	±(0.1% + .05 V)
RIPPLE:	3 millivolts RMS
AC OUTPUT VOLTS (unregulated):	6.5 V (at full load, 115 V AC Input)

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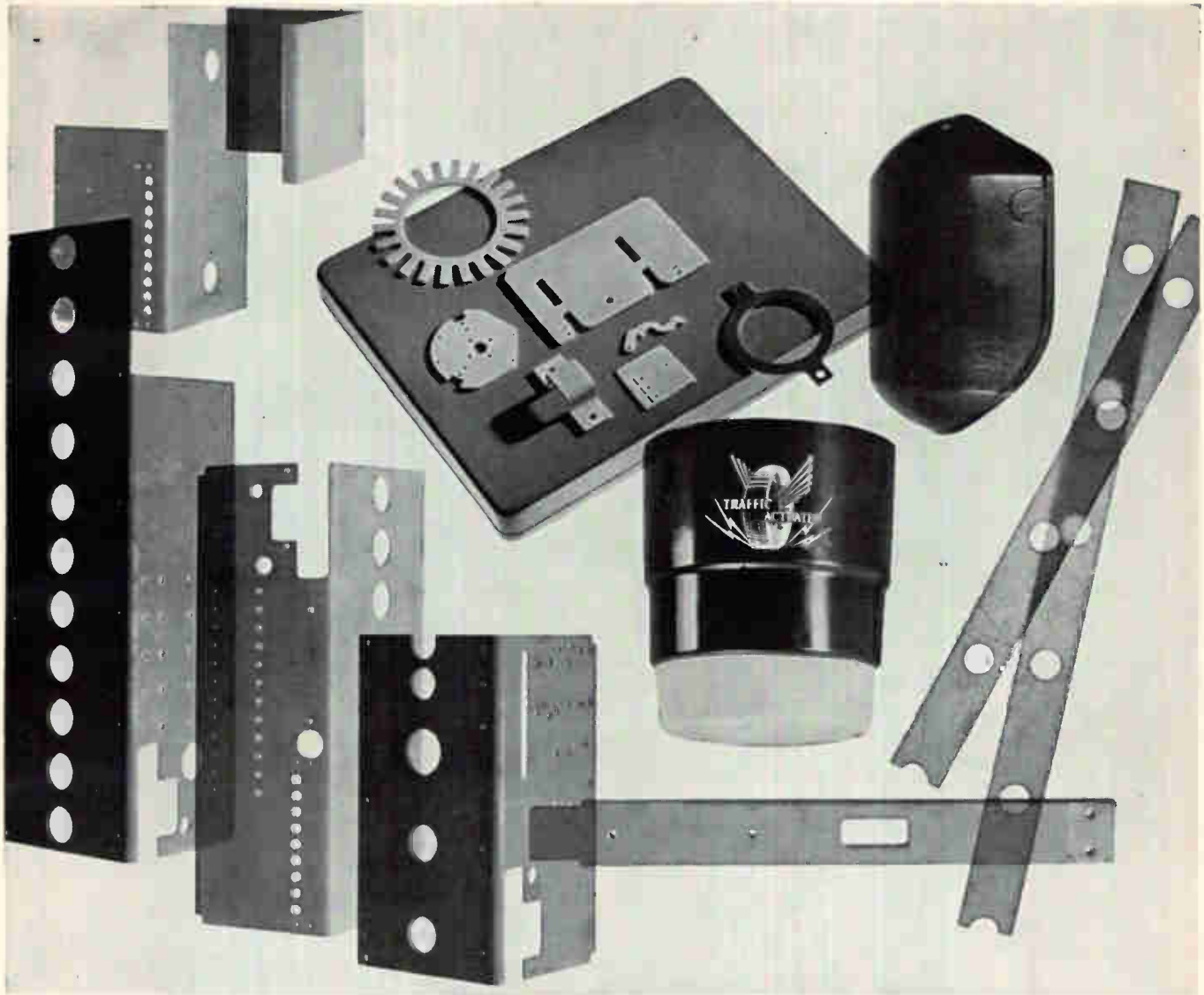

Have you explored the full design potentials of molded polyester-glass?

Few materials offer the designer so many opportunities for product design simplification and cost reduction.

Added to the inherent toughness and strength of polyester-glass are good electrical and thermal properties, weather resistance—and flame retardance if you need it.

Using advanced molding and machining techniques, complex shapes and structures can be produced to reduce product weight or the number of parts, eliminate costly machining or stamping operations, simplify product assembly, improve product performance, life, or reliability.

These are the kinds of results our customers are achieving. For a few thought-starters—and facts about NVF polyester-glass products and molding services—contact your nearby NVF Sales Office, or write for our new folder, Dept. HH-10, Wilmington, Delaware.

116 Choices: One Source This is the latest count of the different plastics and grades NVF can offer in your search for the *one best material*. Add to this total *the* one special grade that can be developed from scratch to meet your particular need. This full range of materials is backed by complete engineering services . . . from application assistance up to and including the delivery of 100% usable, precision-fabricated parts . . . in any quantity, on time!

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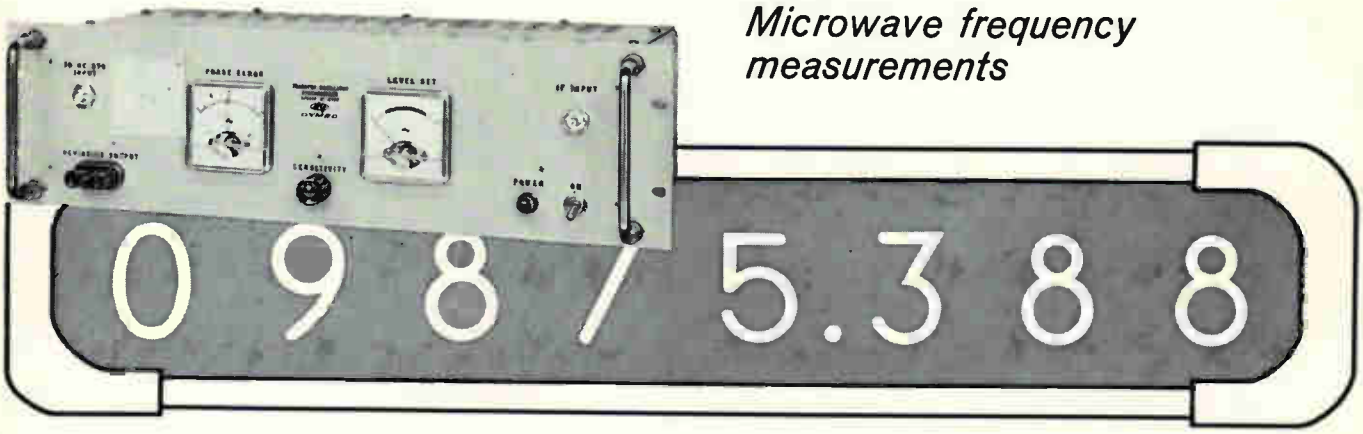
MEASURE FREQUENCY, 200 MC to 12.4 GC,

with COUNTER ACCURACY!

Faster
More accurate
More useful
Microwave frequency measurements



Introduce counter accuracy to your microwave frequency measurements with the unique Dymec Transfer Oscillator Synchronizer! Model DY-5796, used with a Hewlett-Packard Transfer Oscillator and an ◆ Counter, permits high-accuracy automatic frequency measurements, even on varying signals, all the way to 12.4 GC.

With the ◆ 540A/B Transfer Oscillator and ◆ 524/525B Frequency Counter, the DY-5796 Synchronizer provides positive locking of the transfer oscillator to the signal frequency . . . thus giving you measurement accuracy equal to that of the counter time base. Higher accuracies can be achieved with an external frequency standard, such as the ◆ Model 103A Quartz Oscillator, which provides short term stability better than 5 parts in 10^{10}. The ◆ 524C and 525B Frequency Converter covers 100 to 220 MC, and the ◆ 540A (with external ◆ 934A Harmonic Mixer) or 540B (with the mixer built in) extends your measuring range to 12.4 GC.

By keeping the transfer oscillator and the signal frequency in permanent synchronization, the DY-5796 also permits long term measurements of low drift rates at microwave frequencies. FM deviations up to 0.2% of the carrier frequency can be measured with the addition of a VTVM and/or oscilloscope. Further, this instrument and the associated equipment greatly simplify determination of the harmonic number and microwave frequency.

The DY-5796 Synchronizer is available from Dymec for use with your present ◆ Transfer Oscillator* and Counter—or you can use the Dymec 5854 Frequency Measuring System composed of the Synchronizer and the optimum related ◆ equipment mounted in only 52½" of rack space.

SPECIFICATIONS

DY-5796 Transfer Oscillator Synchronizer

Frequency Range:	200 MC to 12.4 GC
Lock-on Range:	± 0.2% of signal frequency, maximum*
Price:	$685.00

*With Modification Kit 9200-0028 for 540A/B Oscillator. $65.00

DY-5854 Frequency Measuring System

Includes synchronizer, modified transfer oscillator, electronic counter with frequency converter, digital recorder with analog output, cabinet and interconnecting cables.

Frequency Range:	200 MC to 12.4 GC
Lock-on Range:	± 0.2% of signal frequency, maximum
Accuracy:	± 1 count ± stability
Stability:	$3/10^8$ short term, $5/10^8$ per week with 524C/D internal time base. May be used with external frequency standard, e.g., ◆ 103AR, for greater accuracy.
Registration:	9 places: first 2 on converter dial, next 7 on counter.
Printout:	Full readout of counter printed on paper tape.
Analog Output:	For Potentiometer Recorder: 0-100 mv. Minimum load resistance 0.5M. Calibrate control. For Galvanometer Recorder: 0-1 ma into 5000 ohms or less. Zero and calibrate controls.
FM Measurement:	Deviations up to 0.2% of signal frequency at rates to 1 kc. Above 1 kc, max. deviation limit reduced at 20 db/decade to max. of 0.001% at 200 kc.
Price:	$6,405.00.

Data subject to change without notice. Prices f.o.b. factory.

Write to your Dymec/Hewlett-Packard representative or contact us directly for complete information.

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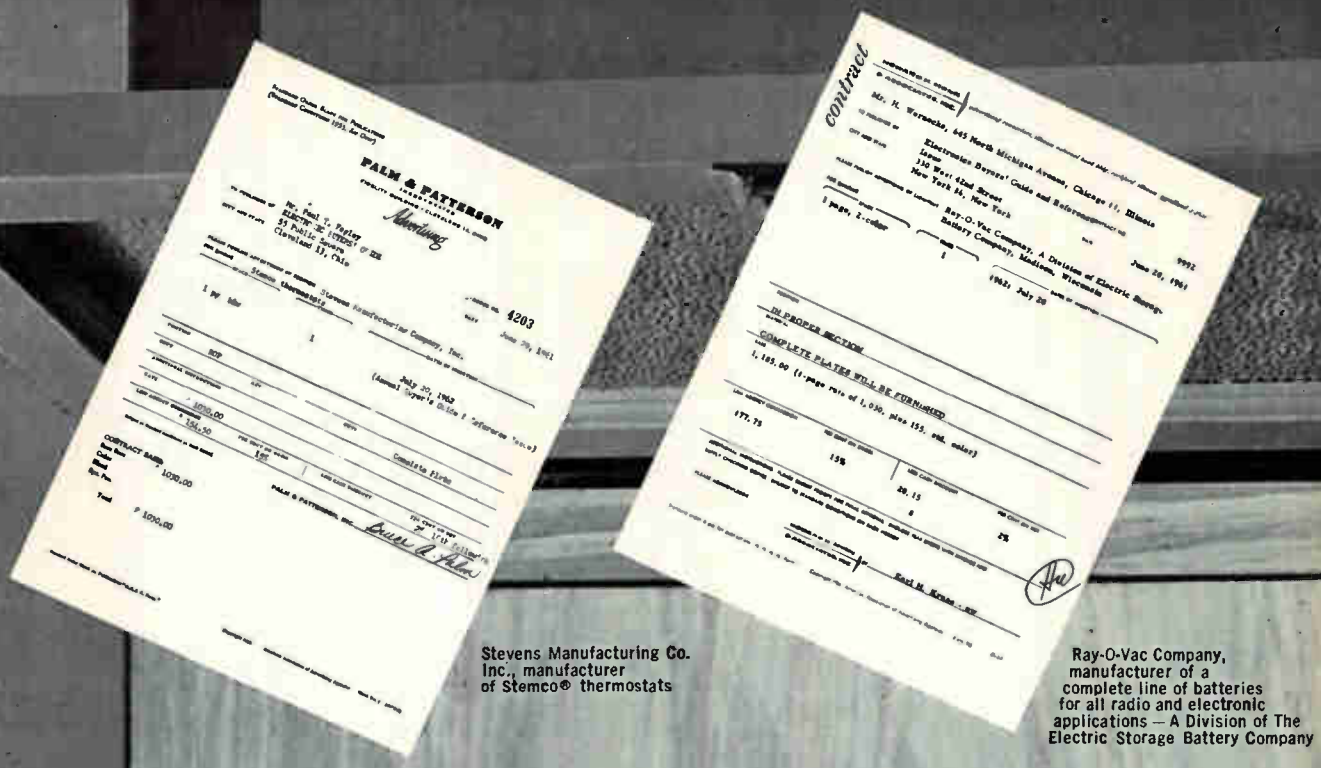

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OVER THE TRANSOM — *More than a year prior to issue date*

One month before the 1961-62 **electronics** BUYERS' GUIDE and Reference Issue was off press, unsolicited, signed contracts for space in the 1962-63 EBG started coming in... an outstanding display of advertiser confidence!

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electronics BUYERS' GUIDE and Reference Issue

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A statement about the Zenith electron-beam parametric amplifier

In every new development, there comes a time for a review of progress and a look into the future. That time has come for the electron-beam parametric amplifier—the Zenith "EBPA." As a low-noise amplifier, its noise performance is in the 1 db range, with gain up to 45 db. Its utility and value have been proved in field tests of many systems. Every design engineer who is working toward performance ultimates in radar, radio-telemetry, satellite and deep-space-probe tracking and ranging, radio-astronomy, radio-navigation, and phase- and frequency-modulation communication systems should know these facts.

THIS IS WHAT THE EBPA DOES, how it has proved itself, and what we believe it can do—

CAPSULE DESCRIPTION OF OPERATION

The EBPA system consists of a quadrupole-amplifier tube operating in a magnetic field, an RF pump generator, and a power supply. Within the tube, the signal is coupled onto an electron beam and amplified by the action of the quadrupole structure, using energy from the RF pump generator. The power supply furnishes voltages for the tube electrodes, solenoid, and RF pump generator.

PERFORMANCE CHARACTERISTICS

Noise Figures Obtainable: From 0.6 to 1.5 db, as measured with broadband noise source. No cryogenic apparatus is required. Single-channel noise figure depends on antenna and application—typically, 2.5 db. Mixer noise is negligible because of high gain.
Range of Center Frequencies: 350 to 1800 Mc (tubes of higher frequency are in development).
Phase Stability: Better than 1°.
Amplitude Stability: ±0.05 db has been measured.
Gain: Usually operated at 25 db; gain up to 45 db has been obtained.
Bandwidth: Up to 10 per cent of operating frequency.

OPERATING FEATURES

The EBPA not only provides low-noise performance, but also offers characteristics unattainable with other low-noise systems, such as:

- Unconditional stability with respect to input and output terminations without the use of a circulator.
- High gain, with complete freedom from regenerative effects.
- Relatively large bandwidth independent of gain; no tuning required.
- Freedom from burnout; insensitivity to overload—several watts average, several hundred watts peak power.
- Fast recovery time (30 nanoseconds).

SYSTEM DESIGN CONSIDERATIONS

System Protection. The EBPA tube not only withstands large amounts of incident overload power but also reflects most of it. In radars, this characteristic means that TR tubes can be eliminated. In addition, the EBPA protects mixer crystals from "spikes," and eliminates need for harmonic filters and shutters; also, down time and maintenance are reduced.
Ease of Installation. EBPA systems have been installed in minutes and have operated immediately. Once installed, they are very stable and operate for long periods without adjustment.
Reliability. Life expectancy of the EBPA tube is of the order of 10,000 hours.
Adaptability to Systems. The EBPA is normally installed as a simple insertion unit in the system front end and does not entail radical alteration of existing designs.

APPLICATIONS

Radar: Search Type. In tests conducted on eight such radars, MDS improvements of 4 to 10 db were attained.
Radar: Phased-Arrays. The unusual phase and amplitude stability of the EBPA makes it a natural candidate for application as a preamplifier in phased-arrays. Power supply and RF pump are common to all units in such an installation to insure maximum uniformity. An experimental installation of this kind, involving 16 EBPA units, was recently delivered. (Data on this installation will be available soon.)
Tracking System. A set of three EBPA units has been completed for use in a tracking system. A common power supply and common RF pump were provided. Maximum noise figure of the equipment as shipped is 1.2 db. Lab tests indicate the equipment will meet the differential phase stability requirements for monopulse applications. (Data on this installation will be available soon.)
Radio-Astronomy. The EBPA has found its way into a number of big dishes used in radio-astronomy. It is usually installed as close to the feed as possible to cut transmission losses. It has been used for hydrogen-line work at 1420 Mc, and to amplify radar returns from the planet Venus at approximately 400 Mc. The high phase stability and large bandwidth have proved particularly useful in interferometer applications.
Radio-Navigation System. When installed in a Tacan ground station receiver, the EBPA improved MDS by 4.5 db.
Radio Direction-Finder. When installed in a Rawin set, the EBPA improved MDS by 15.0 db.
P-M and F-M Systems. In phase-lock receiving systems, it is feasible to use synchronous pumping with a degenerate EBPA, resulting in an effective noise figure of about 1 db. Applications are space-probe tracking, scatter communication, and in general, all systems using only phase or frequency modulation.

COMING SOON

- EBPA tubes for operation at C-band.
- Tunable EBPA tubes: single-knob tuning will cover range of over 100 Mc.
- A metal-ceramic tube for operation from 400 Mc to about 1500 Mc; features are external tuning, lower cost, and greater resistance to adverse environment.
- More compact power supply.
- Non-degenerate EBPA tubes.

If you wish more information, send for booklet **The Electron-Beam Parametric Amplifier, Operation and Applications.** Please address requests and any questions or comments to the Special Products Division, Dept. E-10, Zenith Radio Corporation; 6001 W. Dickens Ave.; Chicago 39, Illinois.

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RATED TO 400 VOLTS PRV

IR SILICON CONTROLLED RECTIFIERS are the remarkable solid-state devices that provide complete control of current turn on at microsecond switching speeds with no moving parts — no contacts. In the field of high-frequency power conversion they offer a totally new concept for versatile, contemporary circuitry highly efficient in operation... dramatically smaller in size.

THE TABLE BELOW lists the devices now in full production at International Rectifier that feature.

- **Low Gate Currents that Control High Load Currents**
- **Fast Switching Speeds**
- **Low Forward Voltage Drop**
- **Low Forward and Reverse Leakage**

Int'l Type No.	Max. Rep. PRV, Volts	Max. Average Forward Current @ 25°C, Amps	Gate Power, Watts		Max. Forward Voltage Drop @ Rated Current, Volts
			Peak	Average	
3 AMPERE RATED SERIES — 8 TYPES — TEMP. RANGE: −30°C to +105°C					
3RC2 thru 3RC40	25 thru 400	3	5	0.5	1.25
5 AMPERE RATED SERIES — 8 TYPES — TEMP. RANGE: −30°C to +105°C					
5RC2 thru 5RC40	25 thru 400	4.7	5	0.5	1.0
10 AMPERE RATED SERIES — 8 TYPES — TEMP. RANGE: −30°C to +100°C					
10RC2 thru 10RC40	25 thru 400	10	5	0.5	1.25
16 AMPERE RATED SERIES — 8 TYPES — TEMP. RANGE: −30°C to +125°C					
16RC2 thru 16RC40	25 thru 400	16	5	0.5	0.85

For detailed data on all types, request Bulletin IR-250 thru 254.

Circle Reader Card Number___

Beyond the advanced design opportunities they present, International Rectifier Silicon Controlled Rectifiers possess significant technical advantages: ELECTRICAL CHARACTERISTICS representative of the highest state of the art. MECHANICAL CHARACTERISTICS that provide rugged packages in configurations that have become industry standards...directly interchangeable with other makes. RELIABILITY that stems from two and a half years of continuous refinement of production techniques, test procedures and rigid military quality control programs including the U.S. Army Signal Corps RIQAP plan, a distinguishing mark of quality assurance awarded to International Rectifier for six consecutive years. As a source of supply, International Rectifier extends these benefits: APPLICATION ASSISTANCE without delay from three strategically located engineering groups. DELIVERY from stock on most types...from the factory or from 65 industrial distributors. PRICE AND DELIVERY attractively competitive on both counts...TRY US!

WRITE FOR DETAILS ON HOW YOU MAY OBTAIN SAMPLE SCR's AT NO COST ON THE NEW IR COOPERATIVE SAMPLING PROGRAM!

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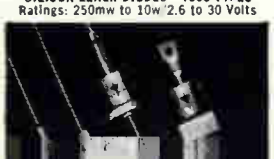
Four of the Twenty Product lines that comprise

THE INDUSTRY'S WIDEST

SILICON ZENER DIODES—1863 TYPES
Ratings: 250mw to 10w/2.6 to 30 Volts



HIGH VOLTAGE RECTIFIERS—157 TYPES
Ratings: to 440ma/to 16,000 PRV

SILICON POWER RECTIFIERS—187 TYPES
Ratings: to 250 amps/to 600 PRV

SUBMINIATURE GLASS DIODES—49 TYPES
Ratings: to 200ma/to 380 PRV

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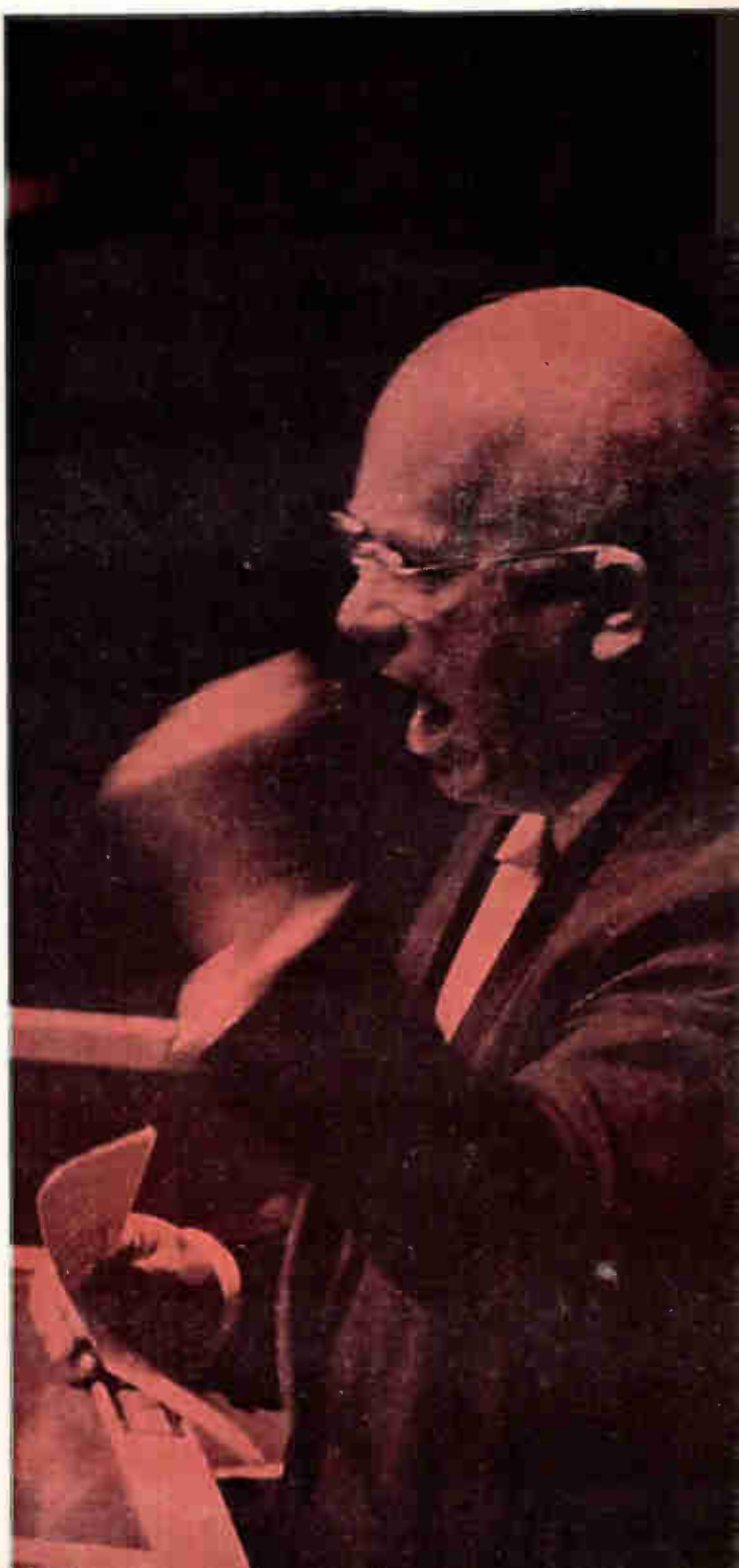
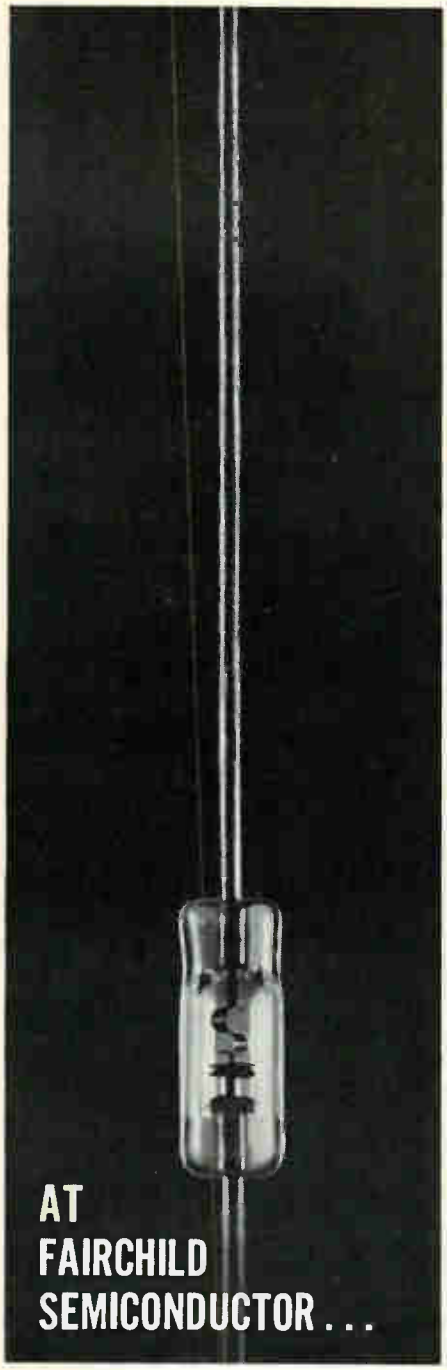




THIS IS A
PRECISION PRODUCT . . .

Thousands of minute potential transistors or diodes undergo diffusion simultaneously in this high-temperature electric furnace at the Fairchild Semiconductor diode plant in San Rafael, California. It's a *precision* process that demands *precision* voltage control. That's why Fairchild engineers specified General Electric Inductrol® voltage regulators for this and a number of other exacting manufacturing and testing operations.

Inductrol regulators may also be the ideal solution to *your* critical voltage problem. Operating on the inherently simple, inherently reliable, *induction* voltage regulation principle, Inductrol regulators can be used to hold fluctuating voltage to precise limits or, in other instances, to provide a variable voltage output from a relatively constant supply.

THIS IS A
PRECISION PROCESS . . .

These advanced General Electric voltage regulators are available in three basic types—automatic, motor-driven, and hand-operated—and a wide range of ratings to meet your exact needs. Ask your G-E Sales Engineer for full information. Or write for Bulletin GEC-1450 to General Electric Company, Section 457-06, Schenectady 5, N. Y. *Voltage Regulator Products Section, Pittsfield, Mass.*

THIS IS
PRECISION VOLTAGE CONTROL BY G.E.

INDUCTROL REGULATOR FEATURES

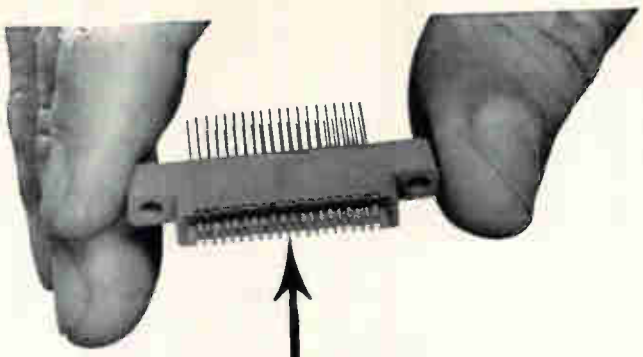
- Reliable design and operation
- Automatic 1% control accuracy
- Stepless, drift-free controls
- 100% overload capacity up to one hour
- 97 to over 99% efficiency
- Load, power-factor and frequency compensated
- 25 X normal short-circuit capabilities
- No harmful waveform distortion
- Rugged, compact design

Progress Is Our Most Important Product

GENERAL ELECTRIC

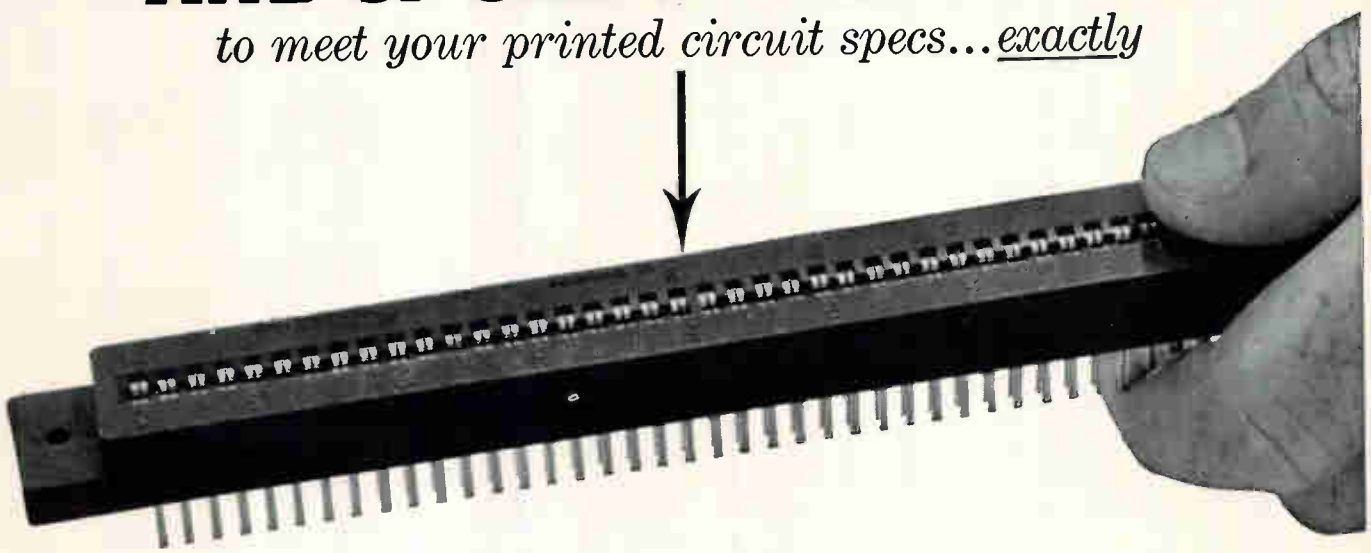
←CIRCLE 43 ON READER SERVICE CARD

CIRCLE 44 ON READER SERVICE CARD



AND 67 SIZES IN BETWEEN

to meet your printed circuit specs...exactly



Continental's line of PC connectors include nearly seventy sizes and types. Name your requirement—and the chances are Continental has a standard production type that meets it *exactly*.

These service-proven connectors are available with up to 210 contacts, for 1/32, 3/64, 3/32, 1/16 and 1/8" PC boards, in both single- and double-row construction. Wiring styles include eyelet lug, wire wrap lug, taper tab and contacts for dip soldering. Continental's patented Bellowform contacts permit use of undersized or oversized boards while maintaining low contact resistance.

New PC connector designs are constantly under development. Our Engineering Department will be pleased to assist you in solving special connector problems. Simply call or write, stating your requirements.

DESIGNERS' DATA FILE

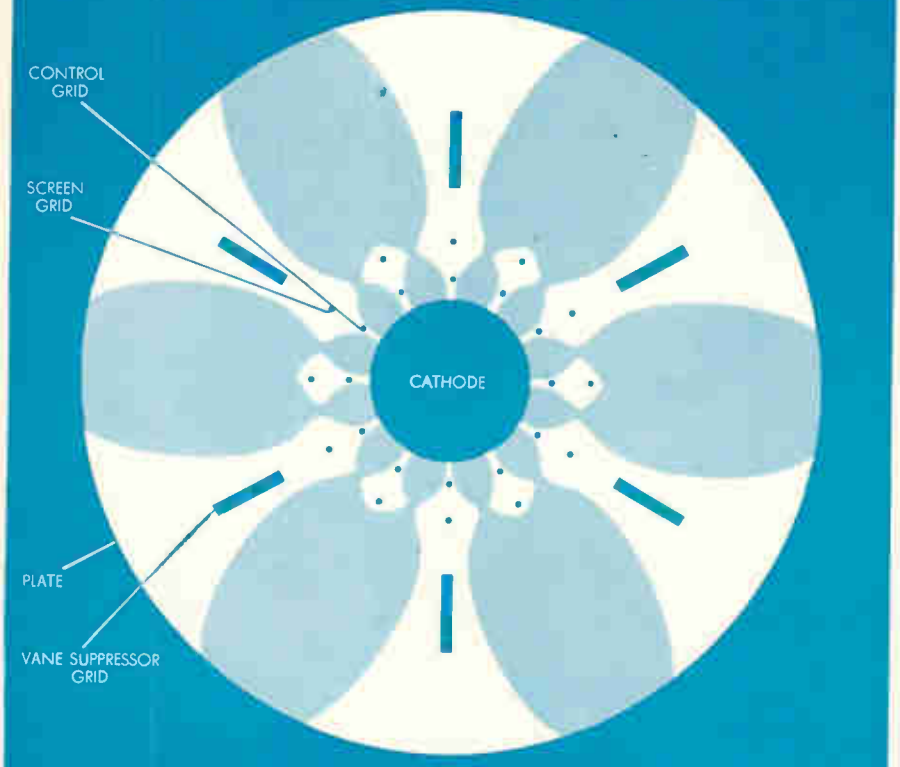
If you're designing around printed circuits you'll want to have Continental's Con-Dex File PC, compiled to help you select and specify the PC connectors best suited to your needs. For your copy, please write to: Electronic Sales Division, DeJur-Amsco Corporation, Northern Boulevard at 45th St., Long Island City 1, New York (Exclusive Sales Agent) RAvenswood 1-8000.

MICRO-MINIATURE • SUB-MINIATURE • MINIATURE • PRINTED CIRCUIT • RIGHT ANGLE PIN & SOCKET • CENTER SCREWLOCK

CONTINENTAL CONNECTORS

CONTINENTAL CONNECTOR CORPORATION • WOODSIDE 77, NEW YORK

DESIGN FOR PERFORMANCE



■ HERE IS A STRAIGHTFORWARD approach to the problem of preventing electrons from returning to the screen region of a transmitting tube. When channeled into beams like those above, electrons reach the anode, where they do their useful work. Penta's exclusive, patented vane-type suppressor grid does the trick.

■ THE CHARACTERISTICS of Penta tubes employing this electrode geometry approach those of the theoretically perfect beam tube. Plate current is practically independent of plate voltage. Kinks and wiggles are absent. Plate voltage can swing well below screen voltage without appreciable loss of current.

■ THE RESULT IS OUTSTANDING LINEARITY, efficiency, stability. Penta's PL-172, for example, delivers 1000 watts of Class AB_1 useful output at only 2000 plate volts... more than 1500 watts at maximum Class AB_1 ratings. Introduced in 1955, Penta tubes with vane-type suppressor grids are in important equipment the world over, and their use in high-quality linear amplifiers is growing daily.

■ YOU TOO CAN ENJOY the advantages of this years-ahead design by specifying the PL-177A, PL-175A or PL-172 for 100-watt to 1.5 kilowatt power output applications. Detailed, factual data sheets are available for the asking. Ask also for your copy of "Transmitting Tubes for Linear Amplifier Service," which explains how and why this exclusive Penta design provides outstanding performance.

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You can now get fine, seamless tubing in columbium and tantalum from UNIFORM TUBES and profit from UNIFORM's standard policies of (1) top quality, (2) close tolerances, (3) fast delivery and (4) low prices. Drawn to your specifications with tolerances of ± 0.0005" or better, columbium and tantalum tubing is available with any specified O.D. from 0.010" to 0.500". Wall thicknesses range from 0.065" to 0.001" with equally close tolerances.

Although drawn specially to your order, columbium and tantalum tubing will normally be shipped within 2 to 3 weeks.

This tubing is offered in random straight lengths to 20' or cut to specific lengths, free of burrs. For subsequent ease of fabrication, tube lengths are fully annealed in vacuum furnaces. If you prefer, UNIFORM will fabricate columbium and tantalum tubular parts for you with the same skills and care that enable us to draw the original tubing to such close tolerances. Besides placing full responsibility with one supplier, you get the advantages of UNIFORM's low prices when tubular parts are fabricated "at the mill."

If you use or specify columbium or tantalum for their high-temperature strengths, corrosion resistances to hot acids, molten metals and metallic salts, or for their other outstanding properties, then write today for details on fine seamless tubing and fabricated parts of these rare metals.

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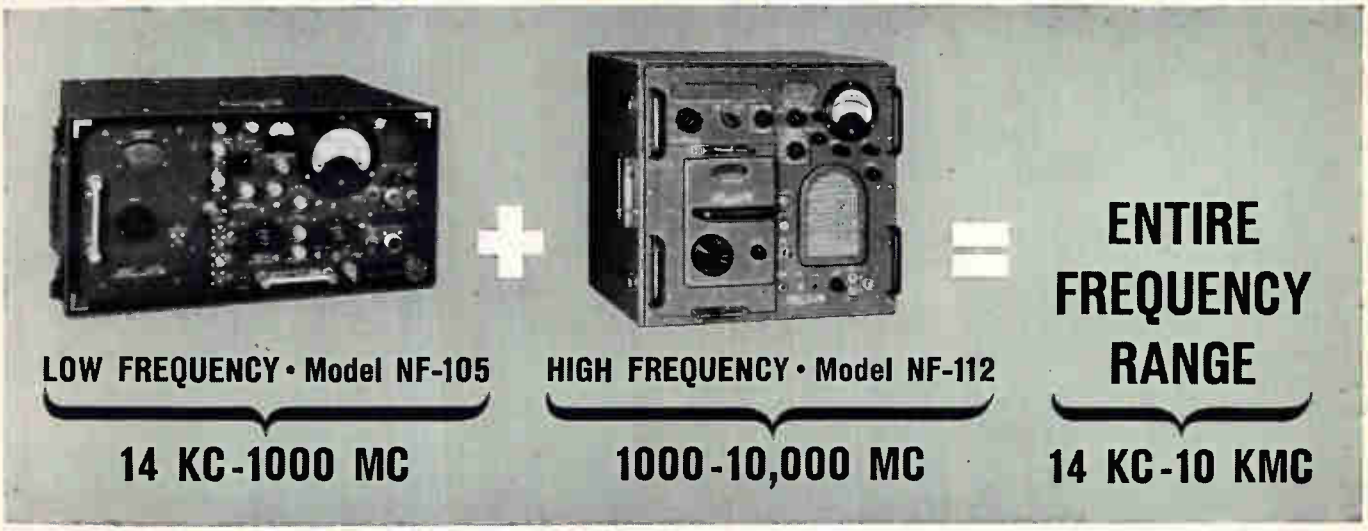
HUxley 9-7276 TWX-CGVL 1044

THE ONLY SIMPLE FORMULA FOR

COMPLETE INTERFERENCE MEASUREMENTS



Through years of hard field use Model NF·105 has acquired an outstanding reputation as a noise and field intensity meter for the frequency range from 150 kilocycles to 1000 megacycles. The versatility of this instrument has now been expanded through the introduction of a new tuning unit extending its coverage down to 14 kilocycles. What is more, this unique measuring equipment has been joined by Model NF-112 which covers the frequency range from 1000 to 10,000 megacycles. The same simplicity, accuracy and speed of operation and reliability of performance which made Model NF·105 so successful have been designed into Model NF-112. Each instrument uses an impulse generator as its calibrator; each combines in one basic unit the components common to all frequency ranges, including the power supply, calibrator, attenuators and metering circuits. All frequency determining components and circuits are contained in plug·in tuning units. Model NF·112, incidentally, uses one single antenna for the entire range from 1000 to 10,000 megacycles.
You save considerably in SIZE, WEIGHT and COST by letting these two instruments do your entire interference measuring job from 14 KC all the way up to 10,000 MC.

For complete technical information, send for Catalog 614.

Plan to attend our next seminar on interference instrumentation. Details upon request.

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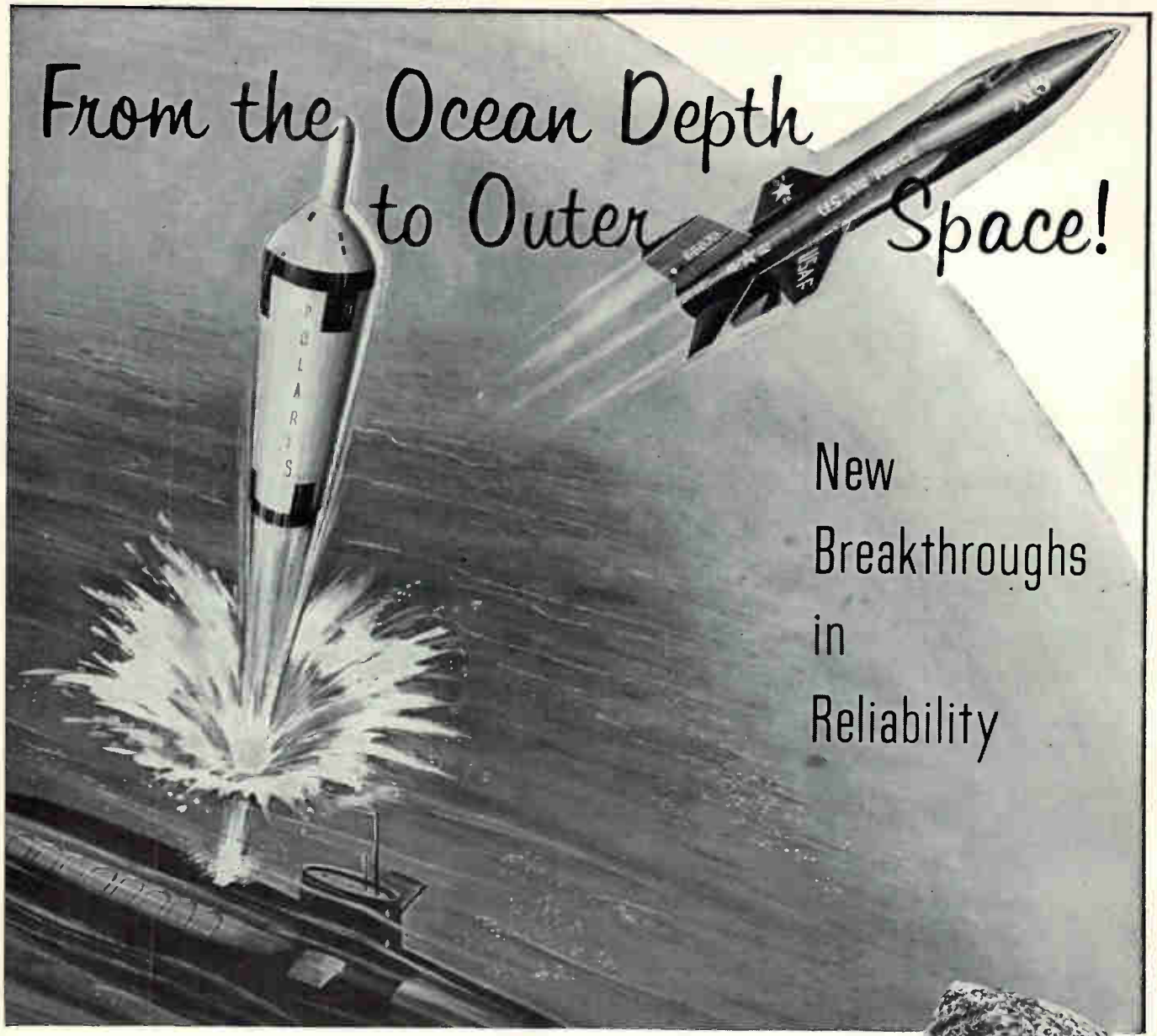
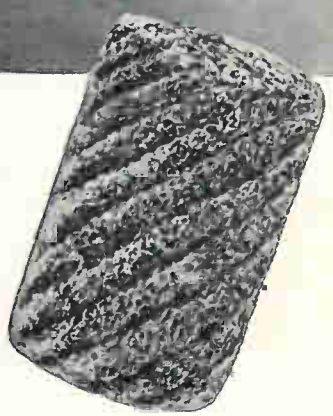


Vibration and Shock Control for any Environment

Aboard the latest nuclear powered Polaris Submarines, Robinson MET-L-FLEX mounting systems safeguard performance and long-term reliability of inertial guidance and single sideband communications equipment —plus critical components in the Polaris missiles themselves. Robinson ***low-frequency*** shipboard mounting systems combine ***both*** vibration and shock protection—a new design breakthrough now available for the underwater and surface fleets of the U. S. Navy.

Nearly every aircraft and missile delivered to the Air Force since 1950 carries MET-L-FLEX mounting systems designed and produced by Robinson. In the X-15 aero-space research vehicle, for example, MET-L-FLEX mounts protect 24 vital electronic and electro-mechanical equipment units. Robinson has also pioneered in the development of high performance, high temperature resistant all-metal mounting systems for jet and rocket engine installations.



MET-L-FLEX cushions, fabricated from stainless steel wire, will not deteriorate!

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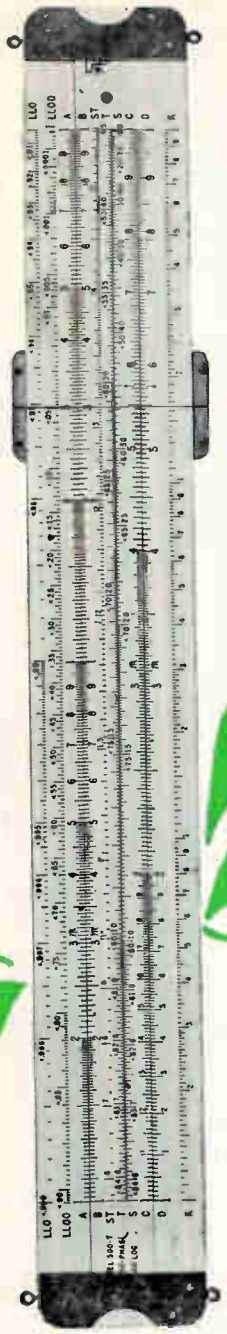
WEST COAST ENGINEERING OFFICE: SANTA MONICA, CALIFORNIA

GREATER RELIABILITY IN THE SPACE AGE THROUGH ENVIRONMENTAL CONTROL BY ROBINSON

DESIGNERS AND MANUFACTURERS OF VIBRATION CONTROL SYSTEMS



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Lockheed-California Company proves this every day. For nowhere do Scientists and Engineers find a more creative, more stimulating, more academic climate.

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Painting in background: "The Piping Shepherd," by Sir Joshua Reynolds, P. R. A. (1723–1792)

New cost savings for users of dielectric materials

. . . a progress report on the MYCALEX METHOD from Jerome Taishoff, President, Mycalex Corporation of America

"I don't have to tell you about the profit squeeze. It's a hard fact-of-life throughout our industry today. That's why we feel the *MYCALEX METHOD*—the unique molding and finishing technique we recently developed—offers so much promise.

Sample quotations point to cost savings up to 84%

"The many months spent in the developing of this new process enable us to turn out better-performing products for less: savings we, in line with our policy, will pass along directly to our customers. And those savings promise to be substantial! Note the typical parts shown in the photograph below, as well as the two mechanical diagrams. As you can see, this new production technique reveals cost reductions of 78% and 84%, respectively, when compared to previous cost quotations." Just as important, the savings are in *addition to* the high reliability SUPRAMICA® ceramoplastics and MYCALEX® glass-bonded micas are noted for.

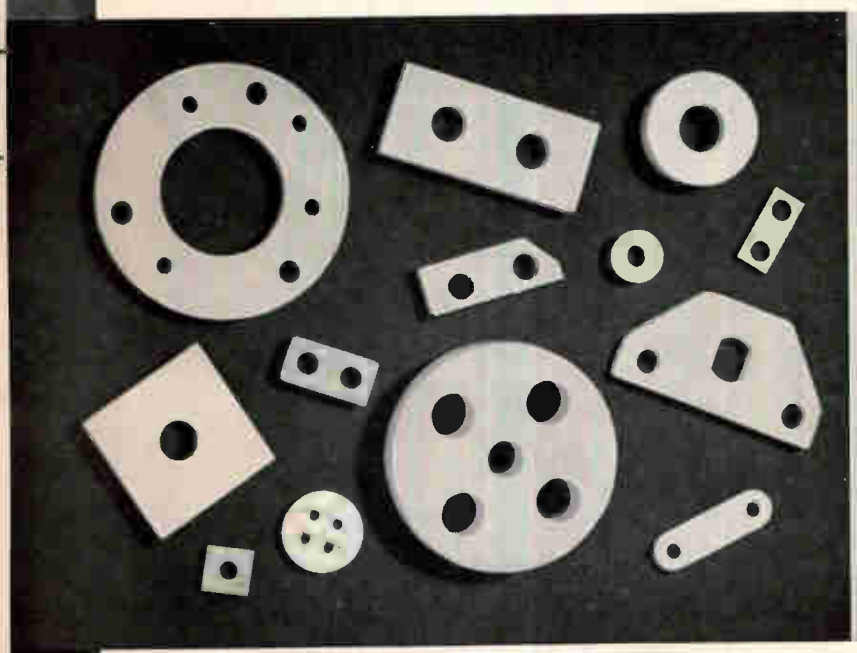
Savings plus quality with the MYCALEX METHOD

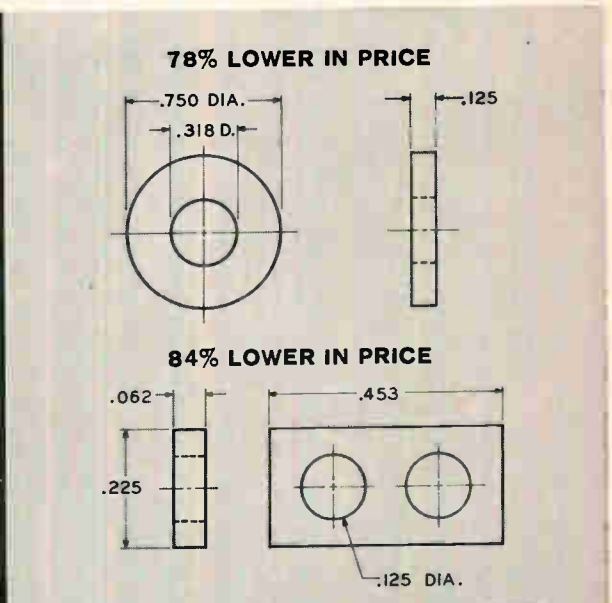
Though these intricate parts now cost much less to make—they offer the temperature endurance, total dimensional stability, high dielectric strength and low loss that SUPRAMICA and MYCALEX formulations have been delivering for years.

Choose from any of these famous materials

SUPRAMICA 620 "BB", 560 and 555 ceramoplastics and MYCALEX 410 glass-bonded mica. *Maximum Temperature Endurance* (unstressed): 1200, 930, 650 and 650°F; *Loss Factor* (10^6 cycles/sec.): 0.020, 0.010, 0.013, 0.010; *Compressive Strength* (psi): 30,000, 25,000, 40,000 and 40,000, respectively.

So for electronic insulation materials with the high-performance properties you must have—at a profit-protecting price — look into the new *MYCALEX METHOD*. Send your blueprints and drawings for specific quotations and information.





We are exhibiting at the N.E.C. Show
Booth 346-348 • Oct. 9-11 • Chicago, Ill.

General Offices and Plant: 120 Clifton Boulevard, Clifton, N. J.
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World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

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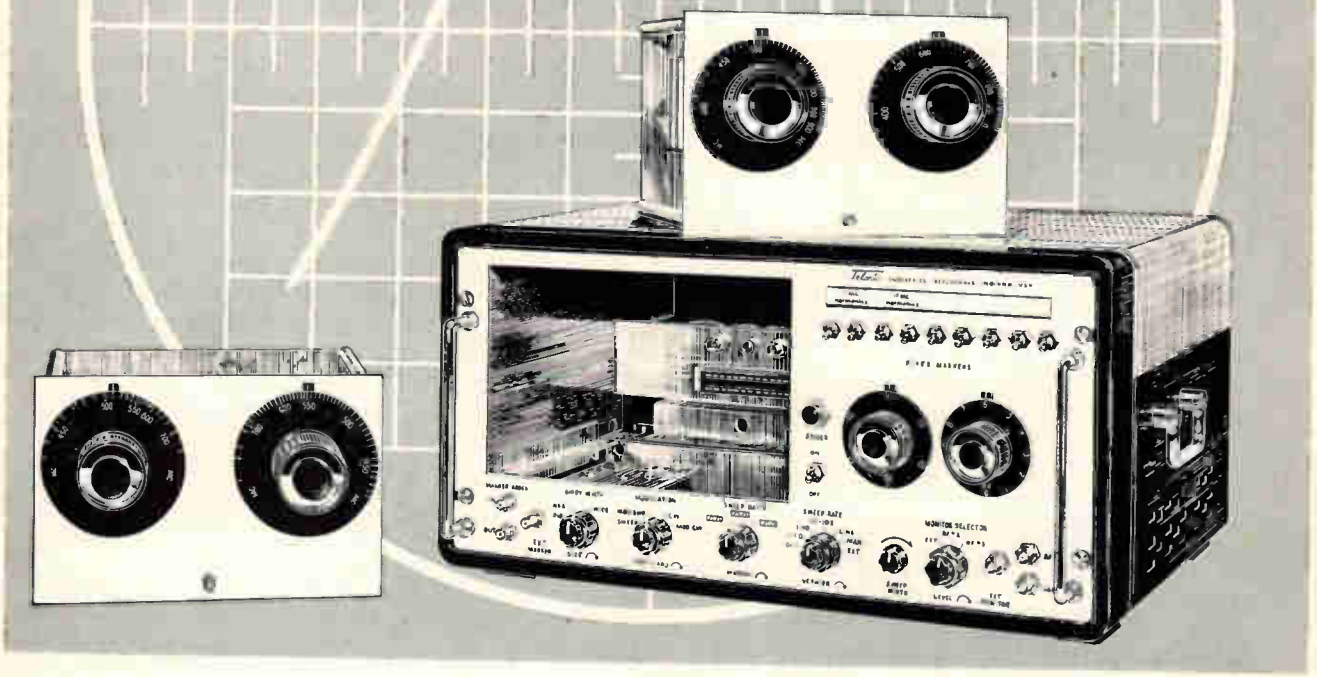
This is TELONIC Versatility...

A Sweep/Signal Generator for Audio to 3000 MC



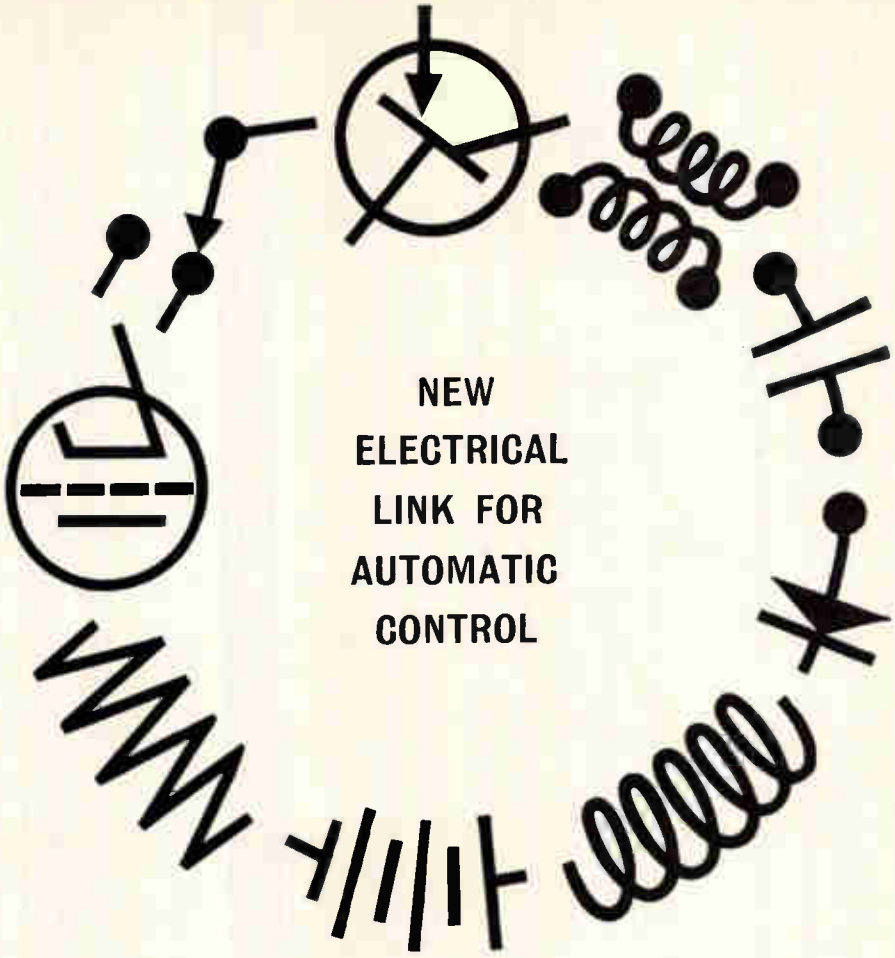
As a major designer and manufacturer of RF instruments and components, Telonic once again leads the field with the introduction of the SM-2000 Sweep and CW Signal Generator. New from every standpoint, the SM-2000 provides unmatched versatility for laboratory or production operations. Now, with **one instrument** and several, interchangeable plug-in oscillators, an engineer can cover a frequency range from audio to 3000 mc.

Telonic has designed 19 different oscillator heads for specific and general purposes that enable the user to change range of the SM-2000 in a matter of seconds. For general applications, only two plug-in units are necessary to cover frequencies from .5 to 2000 mc. And, in addition, the operator may select four different functional modes with the SM-2000—swept RF, modulated swept RF, CW, and modulated CW. He can set attenuation from 0 to 60 db in 1 db steps with the two built-in attenuators. He also has provisions in the instrument for use of an external marker, or for adding up to eight fixed, plug-in markers if desired.

All these features are combined with the fine basic performance that has made the name Telonic synonymous with the best in RF instrumentation—low VSWR, high display linearity and excellent workmanship. If you would like more complete details on this new sweep generator please write for Technical Bulletin T-233.

Telonic Industries, Inc.

BEECH GROVE, INDIANA—PHONE STATE 7-7241



New Veeder-Root high speed digital readout counter meets new needs in automation and system design. It's precision engineered to record, display and electrically transmit accumulated digital levels. More than that, it's a fresh approach to a widening range of automation needs . . . an ingenious electrical link for digital indication, data recording, storage and transmission, automatic sequencing, predetermining control. See what this versatile unit can do for your equipment or designs. Write Electrical Section, Veeder-Root Inc., Hartford 2, Connecticut. **count on . . . VEEDER-ROOT**

Visit Booth (No. 3617-3619)
at the Wescon Show
San Francisco Cow Palace
August 22-25

Series 1744 High-Speed Digital Readout Counter saves time and labor by eliminating manual counting and recording of production. It counts twice as fast, resets ten times as fast as previous units.

CIRCLE 53 ON READER SERVICE CARD 53

PUT PEP PLANAR PITAXIAL PASSIVATED DIODES IN YOUR DESIGNS

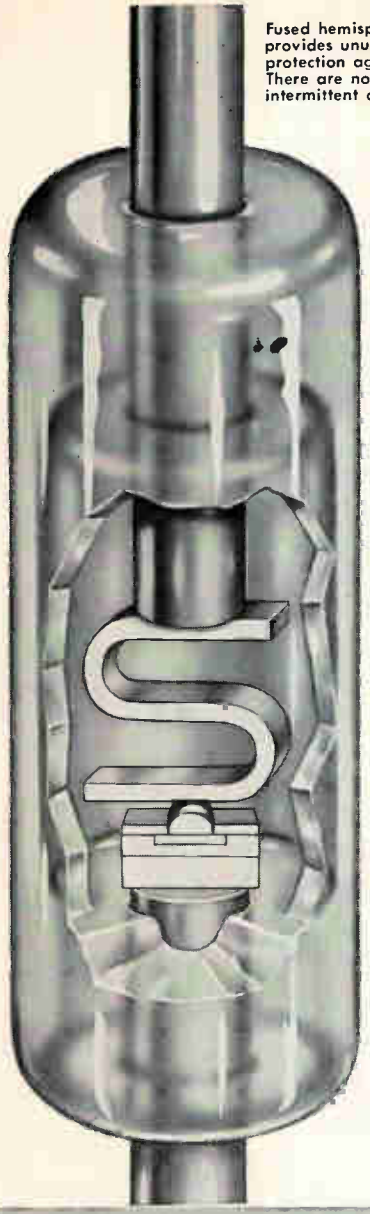
HIGH CONDUCTANCE, 2 NSEC SWITCHING, LOW LEAKAGE CURRENT

PUT PEP IN YOUR DESIGNS

ELECTRICAL CHARACTERISTICS AT 25°C

Breakdown Voltage at $I_R = 5$ μa	B_V	75 volts min.
Forward Voltage at $I_F = 50$ ma	V_F	1 volt max.
Reverse Current at $V_R = -50$ volts	I_R	.05 μa max.
Reverse Current (150°C) at $V_R = -50$ volts	I_R	50 μa max.
Reverse Recovery Time, $I_f =$ 10 ma, $I_r = 10$ ma	t_{rr}	4 nsec. max.
Reverse Recovery Time, $I_f =$ 10 ma, $V_r = -6$ v, $R_L = 100\Omega$	t_{rr}	2 nsec. max.
Capacitance at $V_R = 0$ volts	C_o	2 pf max.

FOR FAST DELIVERY OF *PEP* DIODES AT FACTORY-LOW PRICES CALL YOUR G-E SEMICONDUCTOR DISTRIBUTOR



Fused hemisphere front contact provides unusually good mechanical protection against shock and vibration. There are no loose parts to cause intermittent operation.

General Electric's new *PEP* silicon diodes bring you a unique design combination that can add important assurances of performance and reliability in your high speed switching circuits.

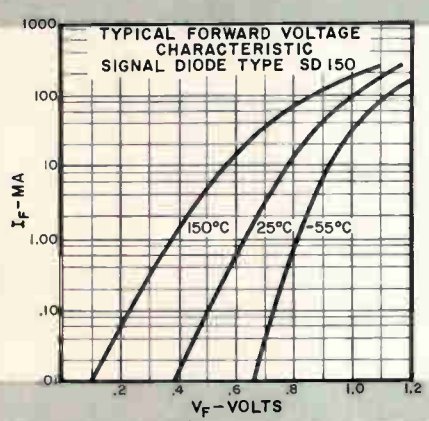
Gaseous *planar* diffused junction means high breakdown voltage with low capacitance.

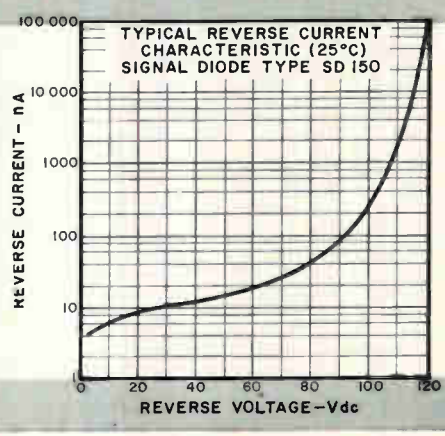
Thin *epitaxial* layer on low resistivity substrate gives negligible body drop and increased uniformity from diode to diode.

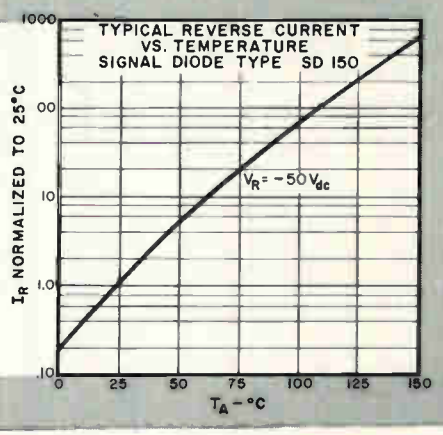
Surface *passivation* is applied before the junction is formed for maximum protection against contamination.

In addition to ultra-fast switching speed, your designs benefit from a 5-to-1 improvement in conductance over presently available units. All General Electric diodes are aged at 200°C for a minimum of 60 hours. A life test of 1000 hours (50 volt reverse bias at 150°C) is made on a sample from each lot before lot shipment is allowed. This is a more severe test than the usual high temperature storage test without applied voltage. Other restrictive tests performed on a sample from each lot are: oven storage, temperature cycling, room temperature storage, moisture resistance, solderability and lead fatigue. Criteria for lot acceptability are: stability of forward voltage, breakdown voltage and reverse current.

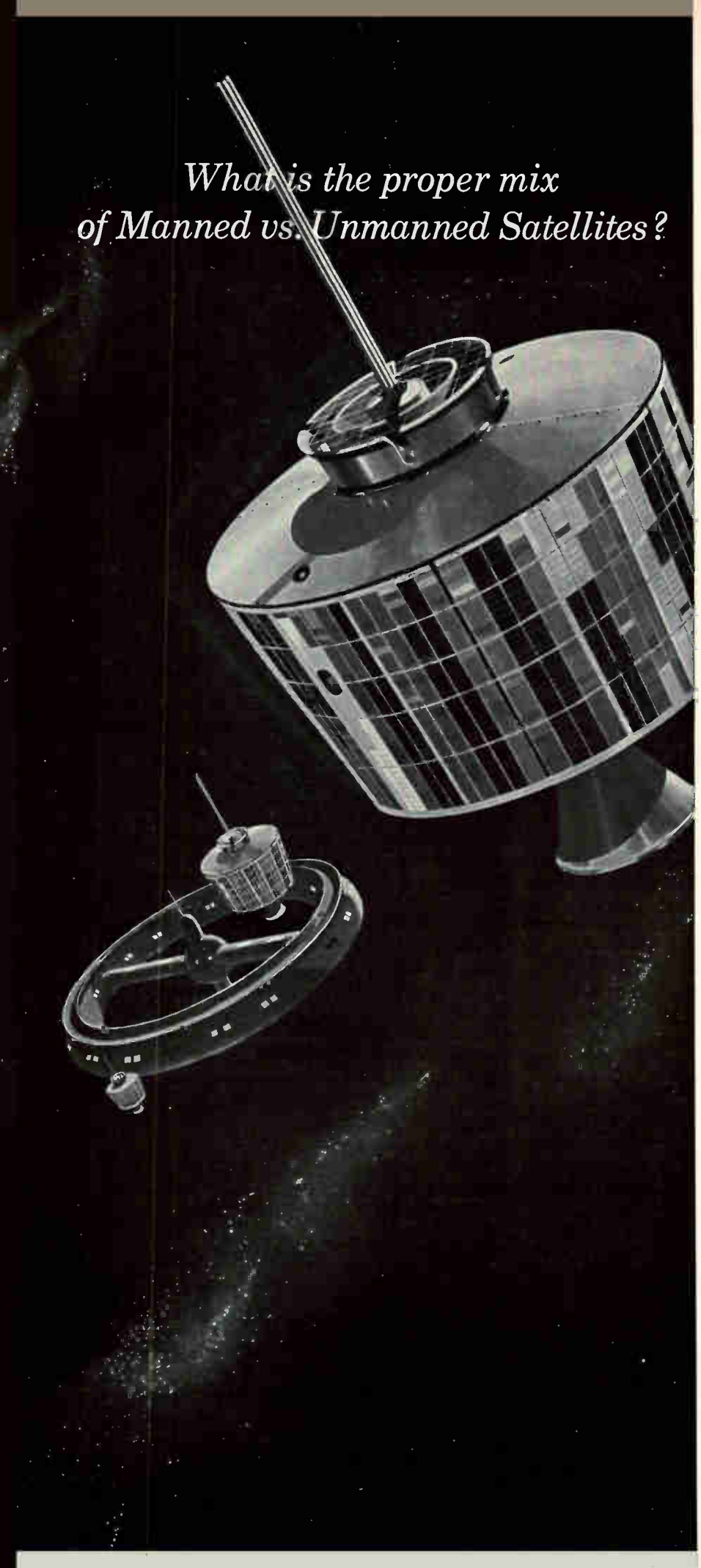
Put *PEP* in your designs with General Electric High Speed Diodes. For complete technical information call your Semiconductor Products District Sales Manager, or write Semiconductor Products Department, Section 25J109, General Electric Company, Electronics Park, Syracuse, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ont. Export: International General Electric, 150 E. 42nd St., New York 17, N. Y.







GENERAL ELECTRIC



opportunities for

systems analysts

Hughes Aerospace Engineering Division has openings for Systems Analysts to consider and analyze a wide spectrum of basic problems such as:

What are the requirements for manned space flight?

Justify choice of systems considering trade-off of choice in terms of cost effectiveness.

Automatic target recognition requirements for high speed strike reconnaissance systems or unmanned satellites.

IR systems requirements for ballistic missile defense.

Optimum signal processing techniques for inter-planetary telecommunications.

Analysis of weapon systems from conception through development, test and customer use.

Design concepts for new airborne weapon systems.

The positions involved with the solution of these basic and critical questions present opportunities for the optimum application of the technical and analytical backgrounds of graduate physicists and engineers with both systems and specialized experience.

If you are interested in helping to solve these questions and are a graduate physicist or engineer with a minimum of three years experience in weapon systems analysis, operations analysis, IR, physics of space, signal processing or communication theory, we invite your inquiry. For immediate consideration, please airmail your resume to: **Mr. Robert A. Martin,** Supervisor, Scientific Employment, Hughes Aerospace Engineering Division, Culver City 13, California.

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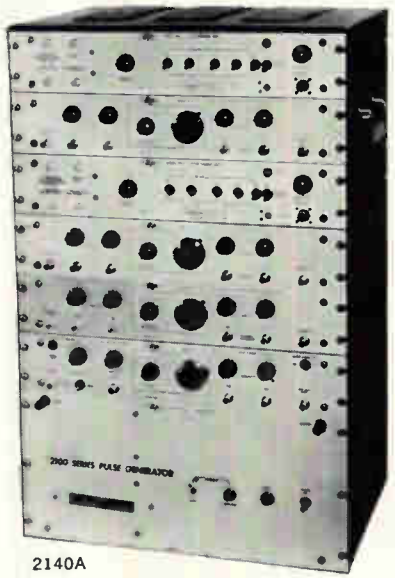
Precision E-P **double** pulse generator provides separate or mixed output



2140A

Features fast rise time and calibrated controls

One of the most flexible units in the broad *Electro-Pulse* instrument line, the precision double pulse generator provides an excellent general-purpose instrument combining high versatility and high accuracy.

A multiplicity of output signals (both separate and mixed), high power, accuracy to 0.5%, fast 0.02 μsec rise time, and rep rate to 100 kc make the instrument applicable to a broad range of pulse simulation and control problems.

Integral accurate calibrated controls make it easy to set up reliable output parameters on the instrument itself, rather than relying on calibration and monitoring equipment. Add traditional *Electro-Pulse* modular flexibility . . . and you realize impressive savings both in time and dollars.

A standard of comparison for pulse generating equipment, the instrument is particularly adaptable to programmed operation in conjunction with semi-automatic checkout systems.

The precision pulse generator has been specified as standard ground support and test equipment for major digital computers and as part of aircraft weapons systems.

Other applications include: telemetry development, radar echo simulation, RF and microwave modulation, and a broad range of transient test and general pulse circuitry applications.

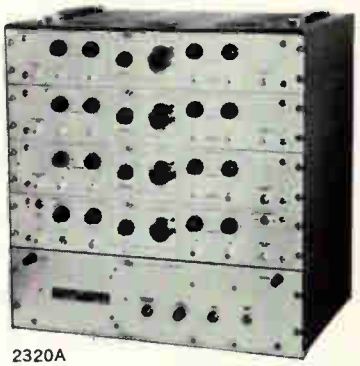
For special applications, the modular block units may be interconnected, as required, by front panel patching or special plug-in signal cables to give a broad variety of configurations.

Where extensive modifications are called for, the instrument can be furnished in fully equivalent modular plug-in form, allowing even greater flexibility in tailoring to custom applications.

One of 33 cataloged instruments in the broad *Electro-Pulse* line (which includes as many as 200 standard pulse and digital circuit modules—both tube and transistor types), the E-P precision pulse generator couples advanced pulse techniques and circuitry with traditional Servo Corp. instrument quality and reliability.

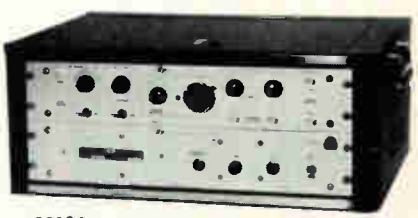
Fill in coupon for details.

A few of the mixed output possibilities: 0.5 μs wide; 25 v pulses; 93 ohm load.


2320A

E-P Time Delay and Gate Generators

Generate trigger-type outputs at accurately controllable delays from external triggers or from an internally generated sync pulse. E-P gate pulse and linear triangle outputs are also available, with precise control of duration.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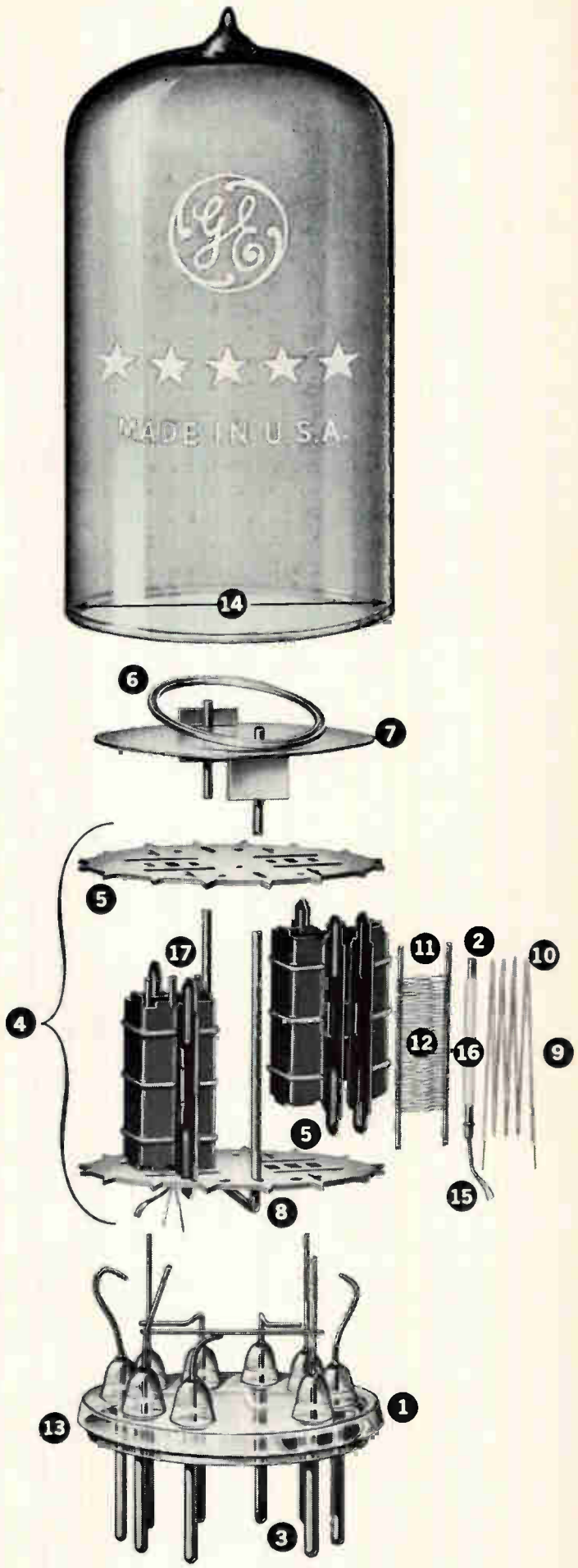
ELECTRONICS

17 reasons why you get highest reliability with G-E Five-Star tubes

In industrial and communication equipment—critical sockets where there can be no compromise with electronic tube performance—you can depend on the proven reliability of G-E Five-Star tubes. Let these 17 features of a typical Five-Star tube tell you why:

1. *Stem design minimizes welds—fewer points of possible failure—less chance of short-causing particles from weld splash.*
2. *Passive cathode alloys assure reliability and long life in low-duty cycle circuits where interface tends to develop.*
3. *Pins are annealed to prevent glass strain at socket insertion.*
4. *Short, sturdy cages increase rigidity of tube structure.*
5. *Two mica spacers, with additional anti-leakage slots, brace internal parts, provide superior inter-element insulation and improve vibration characteristics. 12 or 16 contact points give firmer fit between bulb and mount.*
6. *Highly efficient getter performs throughout tube life and guides flash to avoid inter-element leakage.*
7. *A getter flash shield improves initial leakage characteristics.*
8. *U-bolt construction through top and bottom micas firmly secures the cage assembly.*
9. *Folded heater design proved most reliable under shock, vibration and heater cycling conditions. Heater is temperature controlled to further improve reliability and lengthen life.*
10. *Cataphoretic coating of all heater bends after forming insures complete heater-cathode insulation.*
11. *Smooth grid legs prevent a "sawing" action on the mica, reducing grid vibration and microphonic noise.*
12. *Critical grids are plated with gold or silver to minimize grid emission.*
13. *Lead glass stems help ward off glass electrolysis.*
14. *Controlled inside diameter on bulbs improves vibration and microphonics.*
15. *Low thermo-conductivity cathode tab prevents terminal heat loss.*
16. *Outside diameter and density of cathode coating is statistically controlled.*
17. *Plate ears are embossed for added strength and improved mica fit.*



G-E Five-Stars are not tubes selected from standard receiving types. Their high reliability is a result of these special design features, special manufacturing processes, special tests, and stabilizing periods which may even exceed 200 hours of full-voltage operation. Order G-E Five-Star tubes from your General Electric tube distributor. He has them in stock. General Electric Company, Distributor Sales, Room 7150A, Owensboro, Kentucky.

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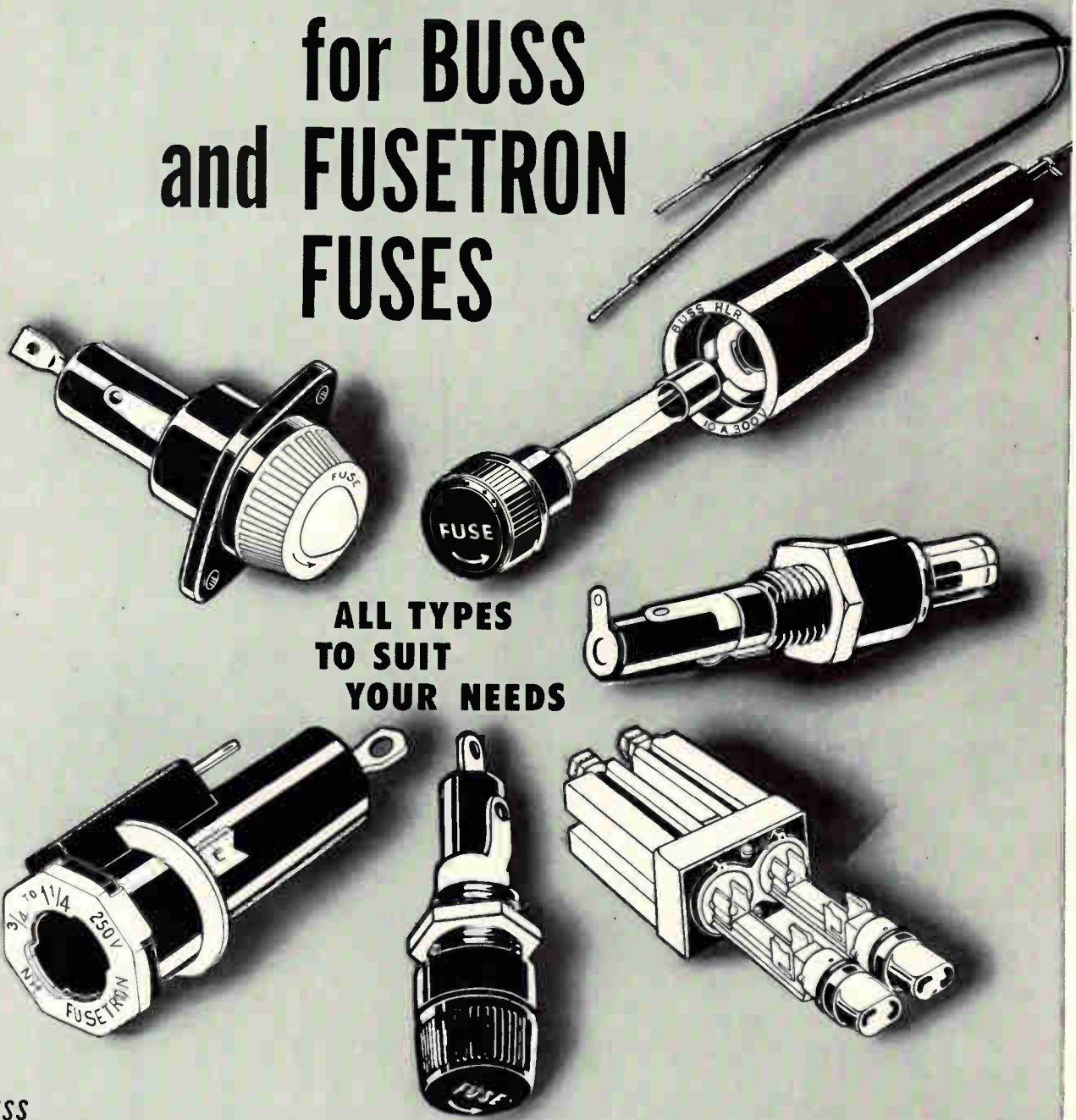

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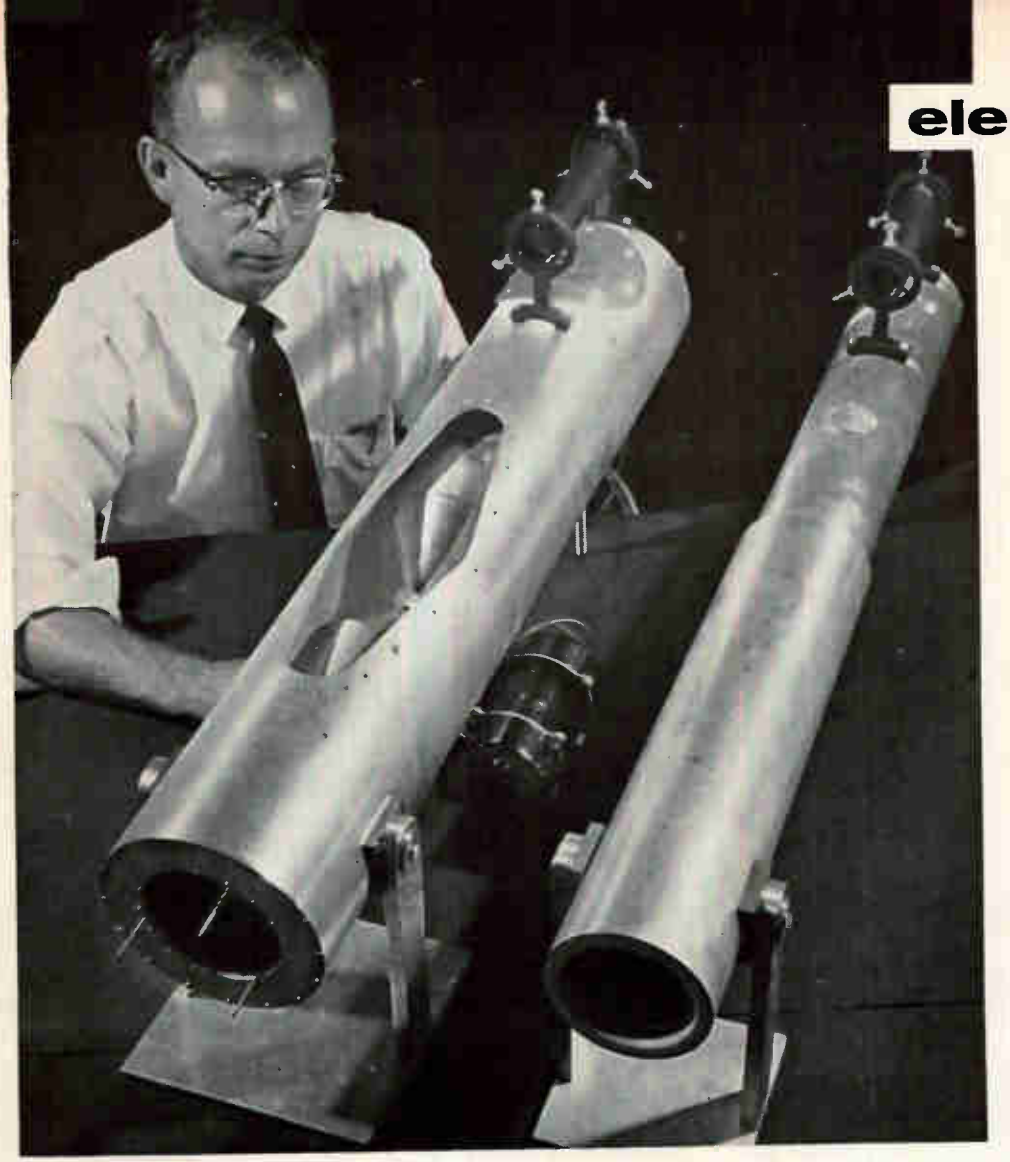


Optical communications session at

NEC

will include paper summarizing developments by Gordon Jacobs, shown here with experimental transmitting equipment; c-w light modulator operates at 200 Mc

BIONICS ON PROGRAM AT Midwest's NEC

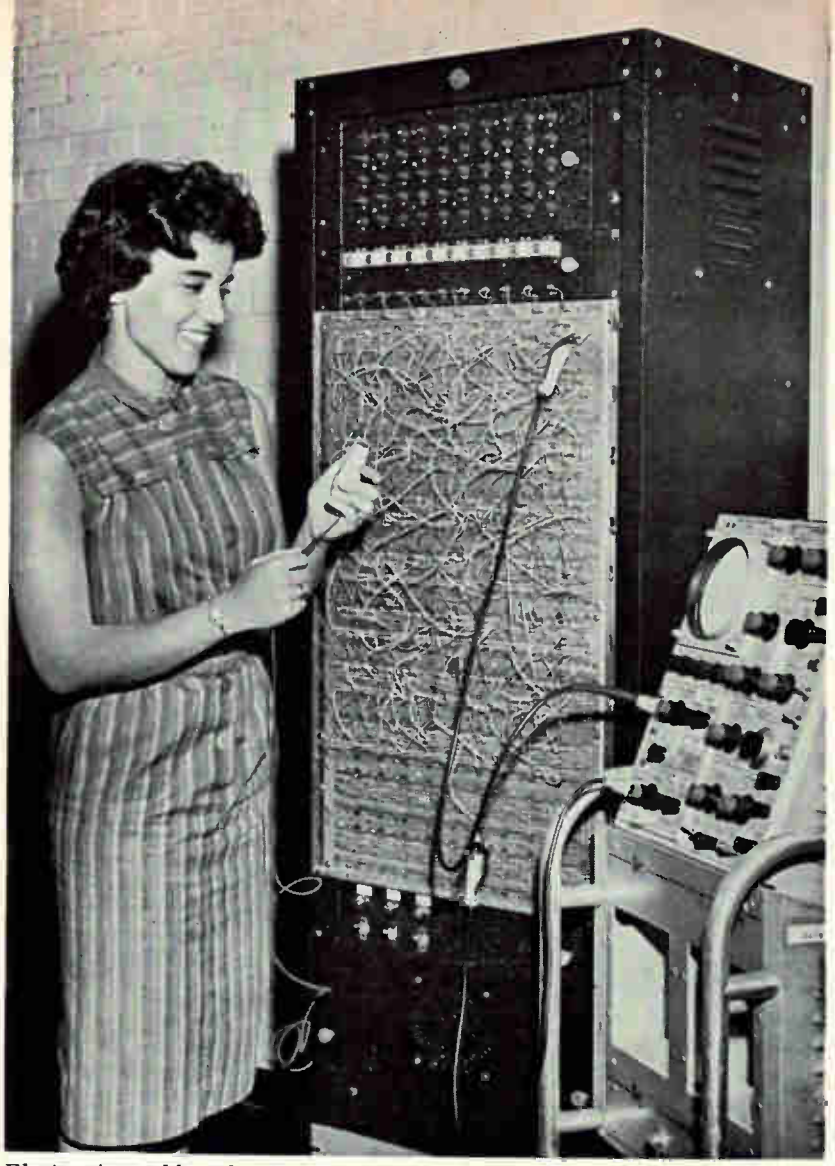
Bionics, optical communications and a panel on synnoetics are a few of the areas to be covered at the 17th annual National Electronics Conference.

By CLETUS M. WILEY,
Midwestern Editor

CRITICAL look at Midwest Electronics—its development, its progress and especially its future—will be the theme of the three-day National Electronics Conference opening in Chicago's International Amphitheatre on Monday, October 9.

The region has been buzzing for past year over the controversial charge of Frederick Terman of Stanford at the 1960 NEC. He had stated that Midwestern emphasis on relatively slow-growing consumer electronics causes top native engineering and scientific talent to leave home to find more challenging and rewarding jobs.

At the Monday afternoon engineering management session, reports will be made of a year-long study of R&D status in the Midwest launched by IRE, sponsored by NEC and supported by contributions from more than 25 Chicago electronics companies, and on "Relative Activity of (all types) Research in the Midwest." "New Products and Diversification" will be discussed by research and industry panelists Monday evening, and Wednesday afternoon a panel dis-



Electronic cochlea developed at RCA in step toward speech-controlled equipment duplicates characteristics of biological systems

greater than that of individual components. Duplicate morning and afternoon workshop sessions covering structure and programming of digital computers, operational components and problem setup of analog computers, as well as detailed examples of problem solving on both should permit most of the 12,000 delegates to attend workshops in special Amphitheatre area without missing conference papers. Several commercial computer systems will be demonstrated continuously throughout exhibit hours.

Lloyd Berkner, IRE president, will discuss "Electronics, Nerve System of Industry" at the Monday Luncheon. On Tuesday, Brig. Gen. David P. Gibbs will comment on "NORAD Communications and Electronics," and Robert W. Galving, president, Motorola, will speak on "Electronics Unlimited" at the final Wednesday luncheon.

Nearly 1,000 high school science leaders and their teacher guests will have a series of lectures, discussions and exhibit tours arranged to encourage youthful interest in science and engineering. Delegates will be offered afternoon guided tours of Argonne, Cook Research

cussion will be held on "Re-evaluating Electronics Research and Development in the Chicago Area." Not only will Dr. Terman be returning for this session, but the participants will include Admiral Rawson Bennett, former chief of Naval Research, survey's director and Northwestern professor Albert Rubenstein and other Chicago electronics leaders like Daniel Noble, executive vice president, Motorola.

Computers will get extensive coverage with conference-long workshops focused on everyday needs of engineers (including elementary engineering mathematics) A Monday morning panel will cover "Synnoetics"—a new philosophy embracing composite systems of persons, mechanisms, plant or animal organisms and automata-sharing ability to invent, create or reason using total "mental power"

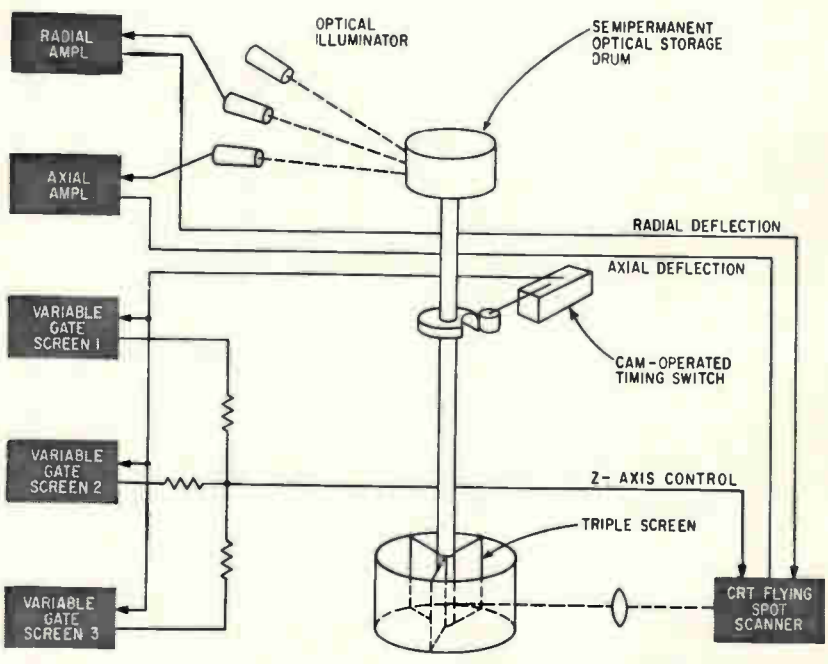


FIG. 1—Three-dimensional display system at left was made by Chrysler Missile Division to verify concept. In proposed system at right light is

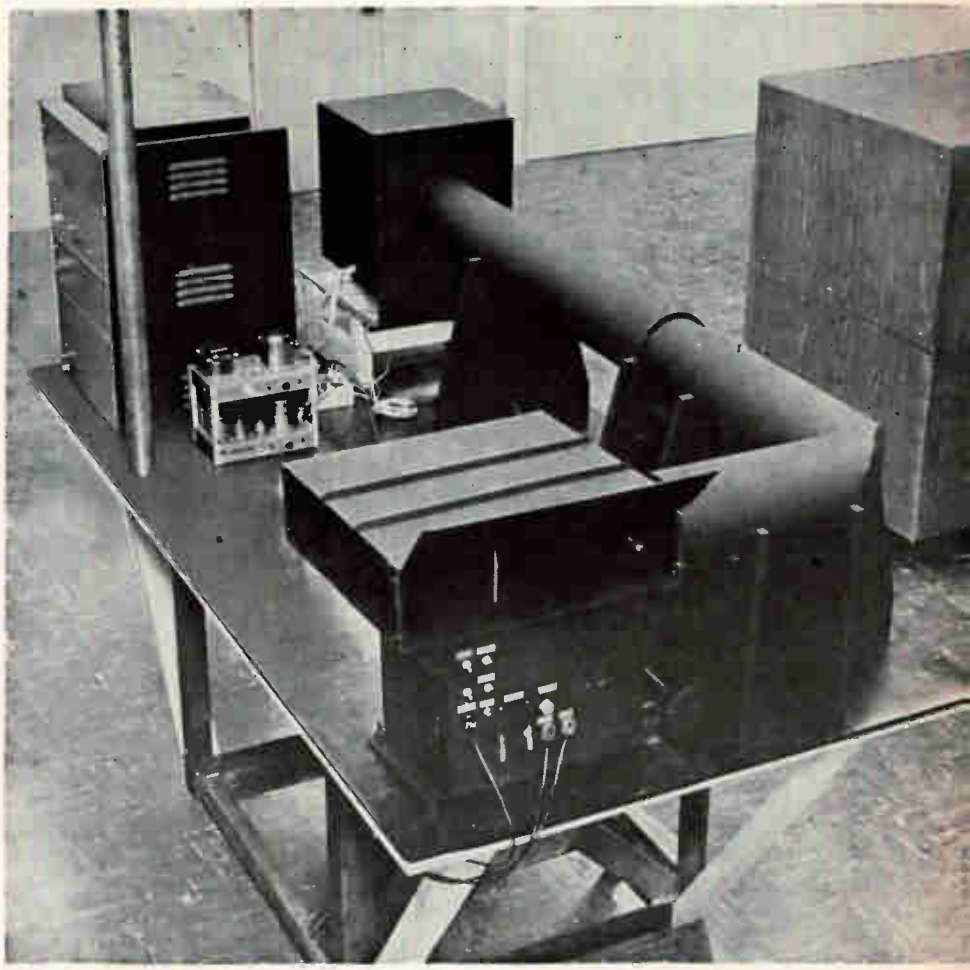
and Armour Research Foundation on Monday, Tuesday and Wednesday as part of the program, which includes more than 80 technical papers arranged in 20 sessions.

Optical communications is expected to be one of the best attended technical sessions at the NEC. Invited papers from four authorities will be featured, according to Clarence Novy, Motorola chairman.

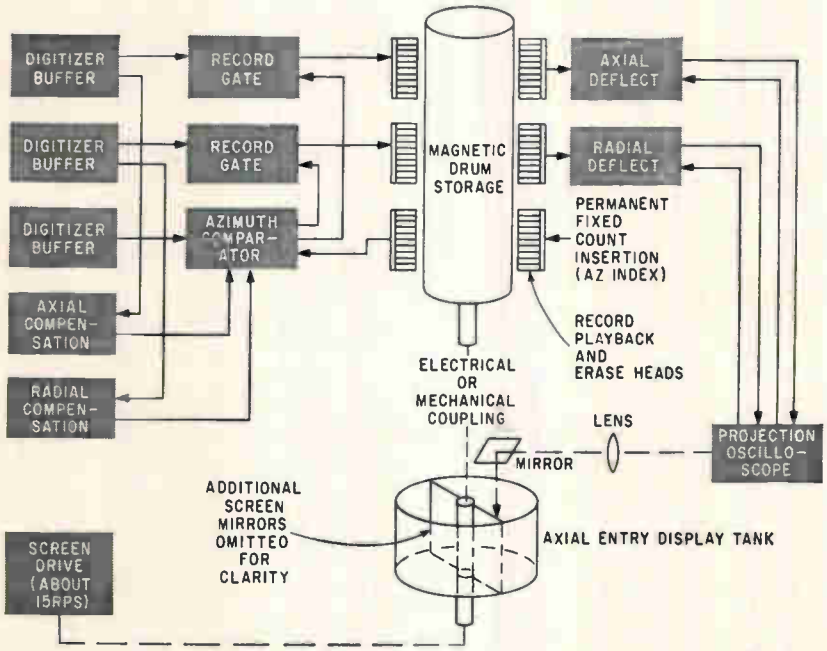
The state of the art in optical communications will be summarized by Gordon Jacobs of GE. He will show how 350 watts of primary power used in a ruby-laser burst-communications system can provide a range of 10,000 nautical miles at 400 bits per second or a mercury-arc system with 150 watts primary power could provide about 750 miles range at about 800,000 bits per second.

In an experimental equipment GE used a KDP (potassium dihydrogen phosphate) crystal to continuously modulate a light source at 200 Mc for optical communication. The cell is mounted between heavy aluminum cones that serve as both heat sinks and carriers of large charging currents. The cones are part of a double re-entrant cavity that is resonant at 200 Mc. The light to be modulated enters and leaves through the center of the hollow cones. The fixed iris of a conventional two-lens telescope receiver confines the field of view to three milliradians. The image of a distant transmitter was focused on the face of a multiplier phototube in experiments exploring feasibility of wideband ground-to-ground optical communications. Measurements were made of the effects of backgrounds, such as rain, in a near-ground path.

An optical range finder using a ruby laser will be described by Lawrence Goldmuntz, Technical Research Group, Inc. It is accurate within 25 ft at ranges to 15,000 ft. A pseudo-correlation technique is used in which the intensity of the range sweep on a crt is reinforced many times by the reflections of



Laboratory model of electronic three-dimensional display system was developed by Chrysler Missile Division to determine feasibility



directed from projection oscilloscope axially into viewing space by lens and mirror

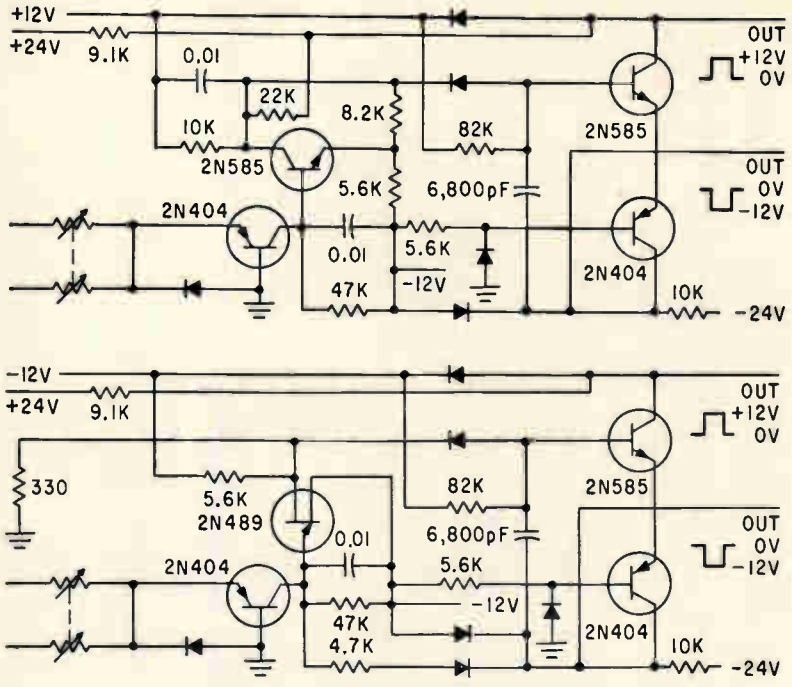


FIG. 2—Improved transistor neuron models by RCA include receptor type at top with integrator quench circuit which is omitted from logic type below

transmitted light pulses, eliminating the effects of randomly occurring reflections.

R. J. Collins of Bell Labs will discuss the Fabry-Perot interferometer for geometric form-mode selection in an optical maser multimode cavity. He will also describe experiments demonstrating the unique character of light emitted by optical masers.

Helium-neon will be considered by A. Javan, also of Bell Labs, as an amplifying medium for the c-w optical maser using gaseous discharge for oscillations in the near infrared (about 2×10^{14} cps).

Three-dimensional display systems will be discussed in a paper by C. K. Auvil and C. W. Gattas of the Chrysler Corporation Missile Division. One of two basic types produced the display on the front cover. The electronic-type display systems in the block diagrams in Fig. 1 are a laboratory feasibility model and a newer system proposed on the basis of greater experience.

The display systems accept computer inputs and show objects, concepts and phenomena dynamically in three axes. A wide variety of military, industrial and commercial applications are possible, including air-traffic control and military coordinating functions.

In the electronic systems, light is directed at a screen rotating around a vertical axis at 15 rps rendering it invisible. When a pencil beam of light is projected into the display volume through which the screen sweeps, a line is generated. A ribbon beam generates a surface.

By synchronizing light generation and the relative positions of the projected beams and the screen, all or part of the display can be repeated during each revolution to form a continuous image. With combinations of beam entry, curved and sloping screens, simultaneous forward and reverse memory readout and other techniques, many images can be shown simultaneously. The past history of objects can be displayed with fixed references and identifying codes, such as aircraft in landing patterns.

The older gel-type system uses a stylus to deposit an ink trace in a transparent solution to form images like that on the cover. A servo system drives the stylus in three axes within the volume of the tank containing the gel. Possible applications of the system include satellite and space-rendezvous tracking antimissile and trajectory plotting, airport stacking-pattern control and machine-tool control

Bionics, another new session for NEC, is made up completely of invited papers. They will cover current efforts to create electronic models of the nervous system and consider whether the same type logic applies as in computers.

Speech-controlled equipment using frequency discrimination, pitch extraction and masking effects used to help neural networks determine true speech invariants will be discussed by Putzrath and Martin of RCA. A model cochlea (ear labyrinth) combines the digital and nonlinear analog functions of biological systems using a series of low-pass filters each having a successively lower cut-off frequency.

Improved transistor neuron models, like those shown in Fig. 2, will be described by E. P. McGrohan of RCA. Outputs are combined from 100 or more circuits so that experiments can be repeated consistently. Improved performance is achieved with only small increases in complexity. Drawing identical performances from a wide range of transistor parameters, the simulator overcomes the difficulties inherent in other neuron models by obtaining its properties statically and with minimal interaction. Catastrophic failure is avoided should outputs inadvertently become shorted to ground.

An adaptive component using electroluminescent and photoconductive elements for the neuron circuits and multihole magnetic devices for time-stable analog memory elements will be described by T. E. Bray of GE. More than 40 analog multipliers and 20 analog memory elements occupy 2.5 cubic inches. About one-half watt is consumed in processing 20 analog signals through multipliers to provide one analog output in a unit currently under evaluation. The transflux or magnetic memory element is wound with only 150 turns for both control and readout, also reducing power and volume requirements.

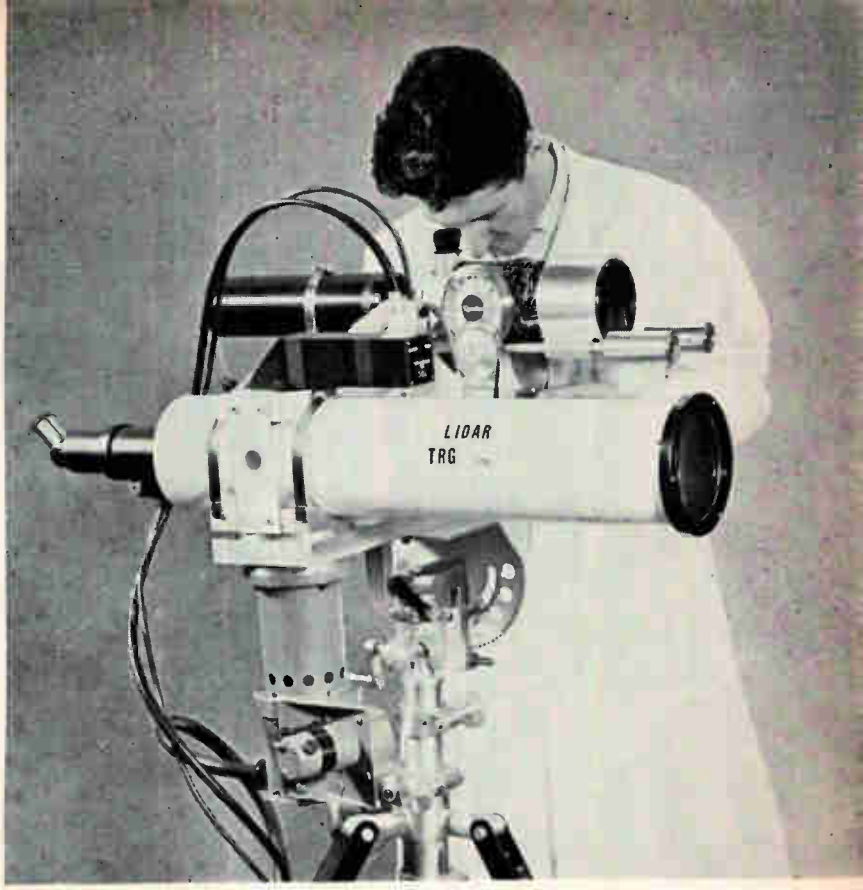
Four-layer switching diodes and conventional diodes are the only active components in a compact audio amplifier that will be introduced by Michael J. Cudahy of Cozzens and Cudahy during the

solid-state session. The amplifier concept is said to produce nearly distortion-free power amplification in the frequency range from d-c to 15,000 cps or higher.

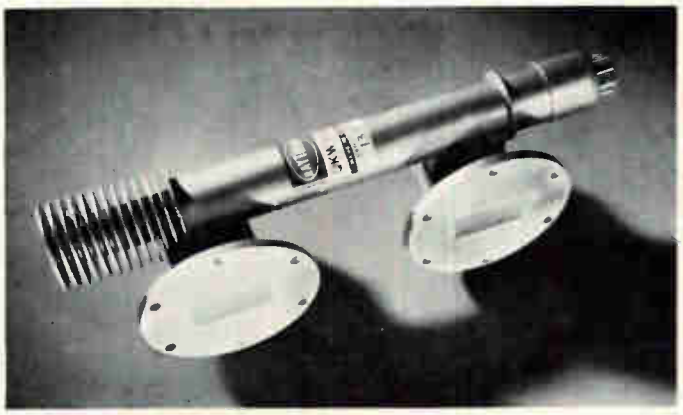
One section consists of a pulse modulator using two four-layer diodes in two relaxation oscillators. One positive-going and one negative-going sawtooth is provided by the modulator to switch a bistable multivibrator in the second section to produce a symmetrical square-wave output. Audio input alters the phase relationship of the two sawtooths and therefore symmetry of the multivibrator output. By shifting the zero line of the audio signal, peak audio output can be made nearly equal to d-c input.

Currently available four-layer switching diodes are rated at 20 to 200 volts with current capabilities from 50 ma to 5 amp. These make possible the matching of semiconductor devices to almost any load from 2 to 30,000 ohms to many points in the circuit with different impedances without using an output transformer. Practical applications of the amplifier could include high-power p-a systems, transmitter modulators, servo systems, instrumentation amplifiers, vibration table exciters, sonar or high-fidelity audio amplifiers, according to Cudahy.

Electron-beam parametric amplifiers will be evaluated as low noise system components by William S. Van Slyck of Zenith. The increased sensitivity of the electron-beam parametric amplifier produced a 68 percent increase in range for TACAN when it was inserted between the preselector cavities and the normal ground-receiver input. Use of these amplifiers makes possible lower powered aircraft transmitters, reducing volume, weight and power consumption. High sensitivity of this type amplifier also produced a 560 percent increase in range of RAWIN, the 1,700-Mc balloon-tracking system. Operating gain was improved 20-25 db in the 28-foot radiotelescope at Cornell Aeronautical Labs operating at 915 Mc using in-passband pumping to improve minimum discernible signal. In-passband pumping also produced 70 percent increases in the range of eight L-



Pseudo-correlation technique is used to display range on crt of Technical Research Group, Inc. optical range finder



Long-life twt (above) suitable as a microwave repeater station amplifier and backward-wave oscillator that can be used as a swept local oscillator will be introduced by Raytheon

Molten-salt process is used at Lockheed to metalize titanium film on inorganic substrate. Electroplating another metal on substrate develops terminations and photoetching converts selected areas to resistive or dielectric materials to form all passive electronic components

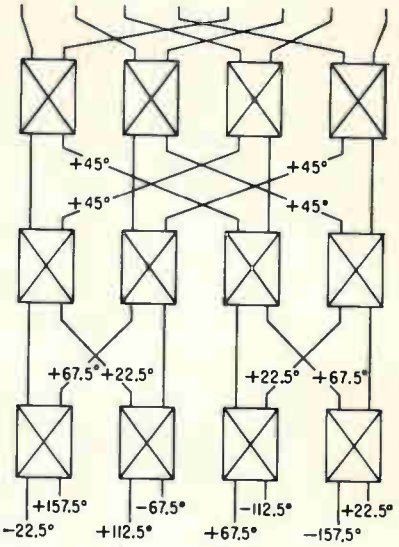


FIG. 3—Multiple-feed system for eight-element antenna developed by Aero Geo Astro for satellites provides eight beam positions

band installations. Vectorial addition of the information in the idler channel to that in the signal channel results in an operating single-channel noise figure almost equivalent to the broadband noise figure.

The ebpa, probably the only low-level amplifier doubling as a t-r device, by eliminating the gas tube, betters noise performance, reduces recovery time, eliminates harmonic filters and mechanical shutters, and protects semiconductors from the radar. The device can cope with heavy overloads (15-watt average, 10-Kw peak input) to protect the mixer crystal. The paper reports that a metal-ceramic version is in the final development stages. Low induction leads to the quadrupole and couplers project radially through the ceramic envelope. A simple 200-Mc band-tuning mechanism avoids built-in tuned circuits and permits construction of tunable amplifiers.

An experimental transducer capable of measuring blood velocity in animals without opening the arteries will be described by Fred Johanson of Jaeger Labs. Relatively large drive requirements can be met with either of two exciter circuits. They drive any one of several different sized transducer implants which allow for different arterial diameters. A pair of monostable blocking oscillators supply magnetizing force up to 2,000 ampere turns at a repetition rate of 400 pps or less. Reset flux of the square loop cores controls pulse duration. Pulse excitation and zero exciting current during the gating interval improve sensitivity and long term stability of system, which promises to eliminate many problems associated with present-day flowmeter transducers.

Titanium thin-film circuits which permit improvements in reliability, reproduction versatility, product range, size reduction and economy, will be discussed by W. D. Fuller of Lockheed. A molten salt process metallizes an inorganic substrate with a thick film of titanium. Terminations are developed by electroplating another metal on the substrate, and all passive electronic components are fabricated in one continuous pattern by photoetching. An anodic process converts selected areas into resistive or dielectric material; the electrolyte and parameters of the electrical process determine the resulting material. A jig restricts the electrolytes to a selected area.

A dynamic control process measures the electrical parameters, R, C, or dissipation factor. Further anodizing or mechanical operations are used to trim R individually to precise values. The addition of counterelectrolyte to the dielectric pattern is used to form C. Active components are attached to the thin film by spot welding, thermal compression bonding or soldering. The process is practical for application now and can be adapted to meet evolutionary requirements by integrating new and improved active semiconductor devices as they are developed.

Recent progress with ceramic filters in solving the frequency-shift problem at high temperatures will be brought to the NEC by Curran and Koneval of Clevite, who describe an unusual approach to ceramic filter design at higher frequencies. Their paper will discuss independent activation of discrete portions of a ceramic Uniwafer to form a ladder filter within a single two-dimensional structure. Design parameters and performance data are for the 10-Mc range.

Erectable scanning antenna suitable for space vehicles will be described by Kelleher and Coleman of Aero Geo Astro. Electronic scanning permits antenna directivity to be changed, minimizing the problem of vehicle attitude control. A Schmidt lens configuration permits a 90-degree scan angle of the one-degree beam.

An unusual switching method, using a combination of transmission lines to provide the multiple inputs corresponding to different beam positions, permits microsecond switching of the feeds with gas tubes or diodes. Compact stripline

techniques are used in the feed networks with one or more printed circuit panels for hybrid interconnection with coaxial lines. A multiple hybrid junction and phase shifters in the network provide beam positions equal to the number of array elements. An experimental model of the array provides eight beam positions with about half power crossover. An eight-element feed system is shown in Fig. 3.

Techniques for microwave diagnostics of solids will be described by Morris Brodwin of Northwestern. A small powdered sample placed in the center of microwave junctions indicates excitation of arms as a function of static magnetic field. Line width and electron spins are measured for ferrites and paramagnetic materials.

As a follow-up to a 1960 NEC paper on antennas, Baker and La Grone, Southern Methodist University, will describe a method for calculating mutual impedance between any two thin linear center-fed antennas having sinusoidal current distribution.

Among the more than four hundred exhibits, a serial memory capable of storing 1,600 bits at input rates as high as 16 megabits a second will be introduced by Computer Control. A newly developed fused-silica acoustic delay line that obviates temperature control requirements will also be shown. Pulse delays range from 20 to 100 microseconds at operating frequencies from 8-16 Mc.

Punched-tape transmission and reception can be combined with voice communications over telephone circuits in a 100-character-per-second, 1,000 word-per-minute system that will be shown by Teletype Corp.

The Industrial Components division of Raytheon plans to announce a 10,000-hour life warranty on electron tubes. It provides OEM's ten times the previously offered protection and includes full coverage against catastrophic failures within 1,000 hours.

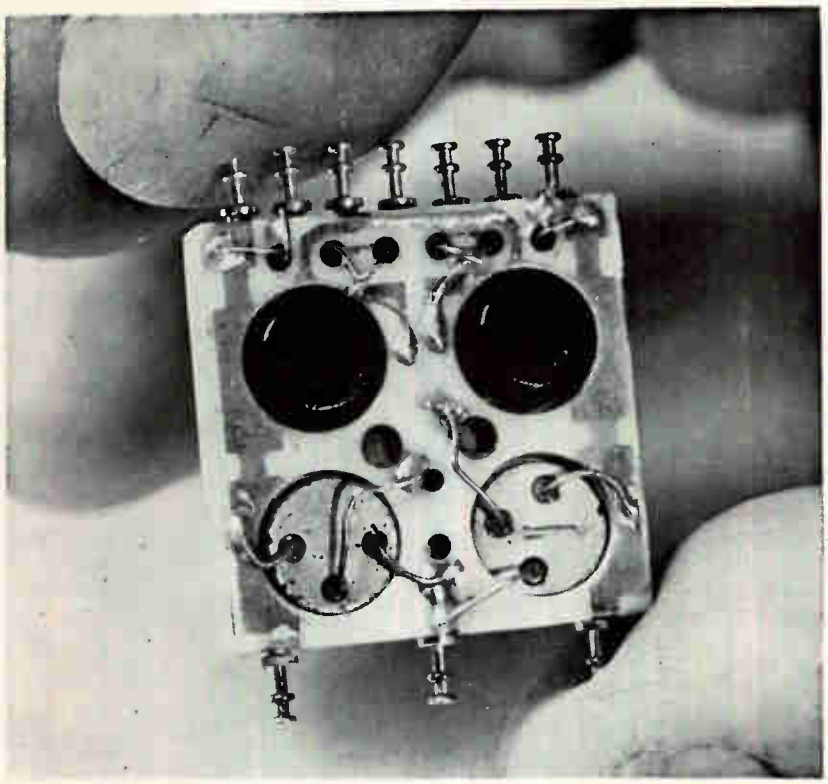
A new low-cost, long-life traveling-wave tube designed as a power amplifier will be introduced by Raytheon for microwave relay repeater stations in systems operating in the 5,925-7,125 Mc range. With coaxial fittings, the range can be extended to 4,000-8,000 Mc for test equipment. Two new rugged K-band backward wave oscillators will be announced extending frequency coverage to 26.5 Gc. They can be used as swept local oscillators for space, airborne and ground-based receivers and test equipment, and the high power output makes them suitable for furnishing pump power to parametric amplifiers. The same company will show double-ended subminiature germanium transistors, germanium epitaxial mesa transistors offering lower saturation voltage for high-speed logic circuits, a 36-volt transistorized power supply and a high-voltage Raysistor isolator to control x-ray power supplies.

An exceptionally wide-band transfer voltmeter to be introduced by Ballantine can be used in standards laboratories to calibrate r-f sources, as an r-f voltmeter for frequency-response measurements in amplifiers and other devices and to measure unknown a-c voltages with high accuracy in terms of d-c voltage. Impedance of the probe is flat from 25 cycles to 30 Mc.

Radio-frequency interference suppressor that attenuates interference at the point of origin will be introduced by Relcoil affiliate of Hi G, Inc., for switching circuits. The manufacturer says that one unit replaces both the usual load and power-supply filters. Decreases in weight and cost result from eliminating the need for additional shielding of the suppressor and leads, while reduced arcing is claimed to increase contact life up to 400 percent.

Conforming Matrix Corp. is offering powdered resin coater to increase production rates of axial-lead components. Coating thicknesses are variable from 5 to 15 mils.

An automatic resistor sorting system that can evaluate 500 components an hour will be shown by Electro Scientific Industries. The calibrated console uses four terminal measurements to sort resistors into ±0.01 percent or ±0.1 percent ratings. An indicator lamp shows the tolerance in use and illuminates the resistor container.



Titanium thin-film integrated circuit designed by Lockheed for computer function can accommodate new active elements as they are developed

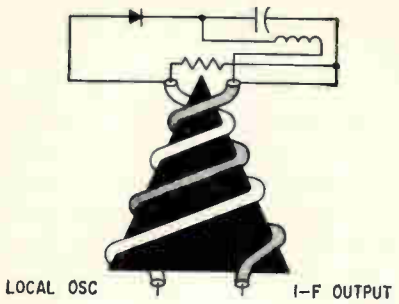


FIG. 1—Antennaverter on conical spiral antenna showing circuit

Combining semiconductor mixer and r-f devices within the antenna structure produces a lightweight, maintenance-free receiving system that has few component parts and excellent electrical performance

Design of Antennaverters and

By JOHN R. COPELAND
WILLIAM J. ROBERTSON
Antenna Laboratory,
The Ohio State University,
Columbus, Ohio

ANTENNAVERTERS and antennafiers are antenna-receiving system combinations in which part of the receiver circuit has been integrated into the antenna. The antennaverter combines the antenna and converter into a single unit while the antennafier combines the antenna and r-f amplifier into a single unit. Antennaverters and antennafiers are practical with presently available solid-state devices such as the tunnel diode. Advances in solid-state circuits and molecular electronics should soon make practical the integration of an entire receiver (except perhaps for output display) into the antenna structure.[1]

The use of semiconductor devices in antennaverters and antennafiers should make them maintenance-free, with the ability to operate reliably in severe environments, while printed circuits, solid-state devices, and molecular electronics make it practical to place lightweight circuits in what would normally be wasted space in the antenna.

Integration of receiver circuits into antenna structures should not degrade the performance of the receiving system as a whole, and in many instances should improve the overall performance. For example, the matching problems between a broadband antenna and its corresponding receiver may be materially reduced by designing the receiver as part of the antenna. In another example, the effects of transmission losses between elements of large receiving arrays can be reduced to insignificance by using an antennafier for each element. In such a system, an effective amplitude taper might be obtained by adjusting the gain of each antennafier element.

One of the simplest types of integrated receiving systems is the antennaverter, or integrated antenna and heterodyne converter. The antennaverter used for detailed measurements was built into the feed terminals at the tip of a conical spiral antenna, as shown in Fig. 1. This type of antenna was chosen because of its broadband capability: typically a 10:1 ratio of frequencies or more.[2] The arms, or radiating elements of the spiral antenna, were the outsides of the two coaxial cables while the cables themselves were used as transmission lines for i-f and local oscillator signals. The diode mixer element can be either a conventional mixer diode or a tunnel diode.

The radiation pattern of the conical spiral antenna is a single, broad, circularly polarized beam directed off the tip of the cone.[3] The down-converter circuit does not affect the radiation properties of the antenna.

Where the tunnel diode is used for the converter element, the d-c bias current is introduced through the i-f cable. Conversion power gain can be realized in the tunnel-diode down converter, whereas a conventional diode mixer can give a theoretical limit of 3 db conversion loss at best. A block diagram of the tunnel-diode down converter is shown in Fig. 2A. In place of tuned circuits, filters having the property of appearing as pure resistances in their passbands, and as short circuits outside their passbands are used.

An analysis of the tunnel-diode down converter may be done with a midfrequency equivalent circuit and an approximation of the tunnel-diode I-V characteristic. If the tunnel diode is d-c biased at a point on the positive conductance portion and near the peak of the curve as shown in Fig. 2B, the relationship

$$I = G_o V - pV^2 \qquad (1)$$

may be assumed, where G_o and p are chosen to approximate the I-V characteristic in the region of the bias point.

The midfrequency equivalent circuit shown in Fig. 2C is obtained by using Eq. 1 and the properties of the filters. Conductance G_o appears across each of the filters because the three passbands do not overlap. The circuit parameters are: ω_s is signal frequency, ω_i is intermediate frequency, ω_o is local-oscillator frequency, G_1 is loss conductance of filter No. 1, G_2 is loss

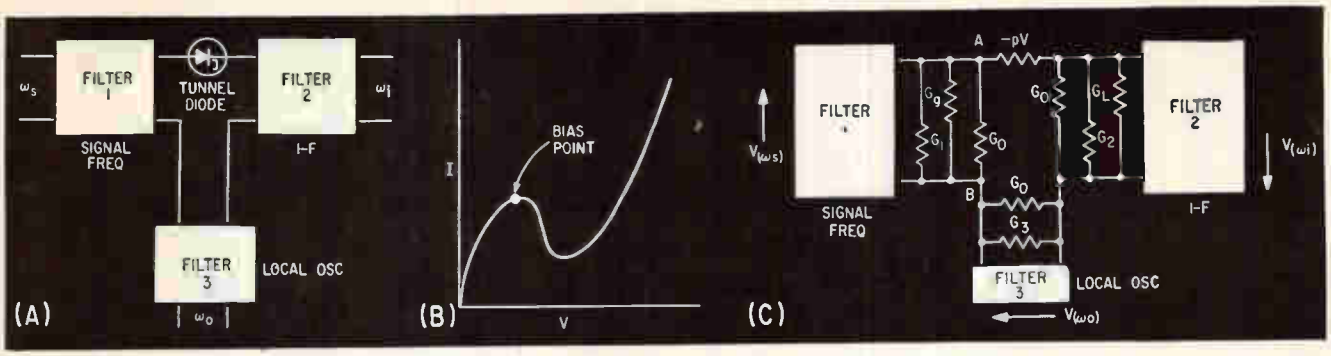


FIG. 2—Tunnel-diode down converter (A), tunnel-diode characteristics (B) and down converter equivalent circuit (C)

Antennafiers

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conductance of filter No. 2, G_s is loss conductance of filter No. 3, G_l is load conductance and G_g is the generator (or antenna) conductance.

Because detailed analysis is lengthy, only the solution for conversion power gain will be given. The additional details of the derivation are available.[4]

Conversion gain may be written

$$g_c = \frac{4\,p^2\,V_o^2\,G_L\,G_g}{[(G_s+G_2+G_L)\,(G_g+G_1+G_o)-p^2\,V_o^2]^2} \quad (2)$$

where V_o is the peak value of the pump (or local-oscillator) voltage.

This gain equation reveals that the denominator can go to zero for some value of pump voltage, so the gain may be made arbitrarily large. It is implied however, that the loss conductances of the filters and the generator and load conductances are not so large as to require excessively high pump voltages, which would exceed the assumed small-signal characteristic of the tunnel diode.

In practice, only limited gain is necessary to mask the noise contribution of the i-f amplifier, so instability problems inherent in high-gain negative-resistance amplifiers can be avoided. This conversion gain is in contrast to a conventional crystal mixer in which the conversion loss usually makes the i-f amplifier noise appear as a major portion of the total noise output of the system.

In a typical coaxial configuration of the downconverter using a 1N2939 tunnel diode, a stable conversion gain of 9 db has been measured, with an overall two-channel noise figure of approximately 7 db in the uhf range.

Figure 3A shows the test setup used for measuring the antennaverter. At the top is shown a conventional receiving system used as the standard of comparison. The half-wavelength dipole was matched into a coaxial mixer, and the intermediate frequency was fed into the i-f amplifier and detector. For each measurement the transmitter output was adjusted to give receiver signal output equal to noise output.

The antennaverter has its own built-in mixer so it only needs to be fed local-oscillator signal, and its output is the intermediate frequency. The operating frequency of the antennaverter is exactly the sum or difference of the local-oscillator and intermediate frequencies, and frequency scan over the entire bandwidth of the antenna may be accomplished by adjusting the local oscillator.

The two diodes used in the antennaverter for these tests were the 1N832 X-band mixer diode and the 1N2939 tunnel diode.

Figure 3B gives the results of measurements over the full bandwidth of the spiral antenna used. Zero db corresponds to the sensitivity of the standard dipole system with the coaxial mixer.

The lower curve shows that the antennaverter has 8-db gain over the standard, and since that closely represents the spiral-antenna gain over a dipole, it must be concluded that the noise figure of the 1N832 diode was about the same as that of the coaxial mixer.

The upper curve shows that use of the tunnel-diode downconverter provides significant improvement over a conventional diode, in this

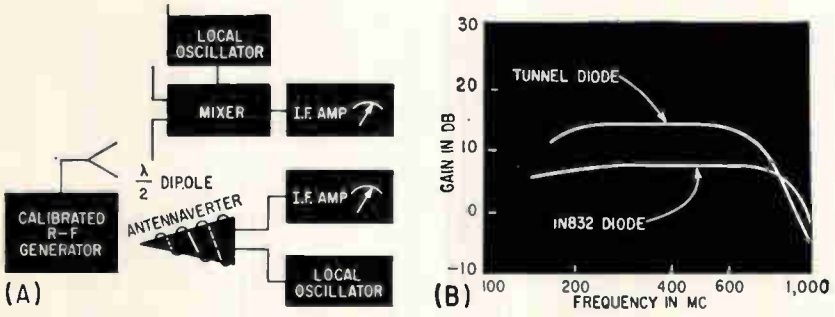

FIG. 3—Antennaverter test setup (A) and performance compared with a conventional dipole and coaxial mixer (B)

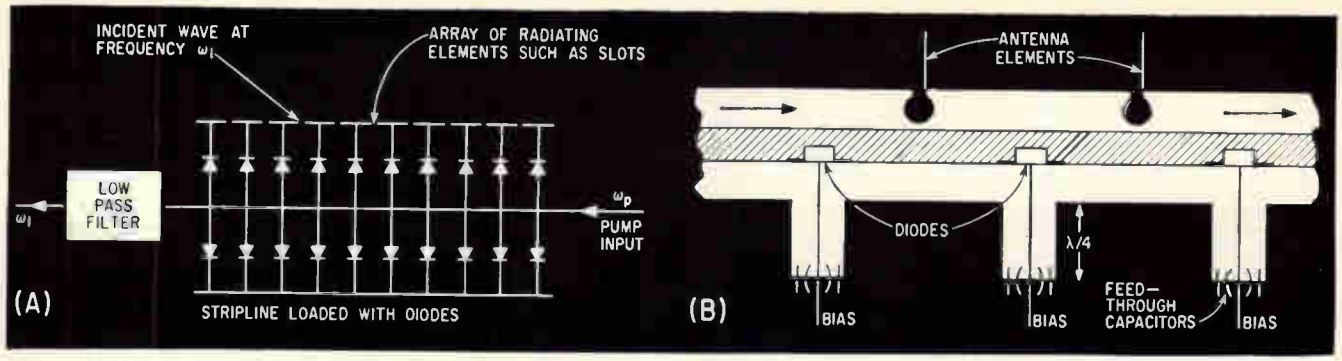

FIG. 4—Traveling-wave parametric antennafier (A) with diode-loaded transmission line (B)

case about 7 db. Careful designing and improved diodes could increase this significantly.

A more complex example of the integration of receiver components into the antenna structure is the antennafier, in which the radio-frequency amplifier and the antenna become a unified structure.[6] In a traveling-wave antenna the amplifier may be a traveling-wave parametric or traveling-wave tunnel diode amplifier, with signals coupled into or out from the radiating portion of the structure, usually at periodic intervals. Alternatively, the r-f amplifier consists of amplifier elements distributed throughout the antenna structure, or the antenna may be used as a bandpass filter in a lumped circuit amplifier.

Figure 4A shows an antennafier. Here the idea of locating a preamplifier close to the antenna has been carried to the limit by distributing the amplification through the antenna structure itself. Some thought has been given to controlling the radiation pattern of such a structure by adjusting the gain of each amplifying element.

Such a system has extremely low noise potential because amplification occurs immediately at the point of signal reception before any transmission losses occur in the antenna. The amplifying elements themselves would be inherently low-noise.

The traveling-wave amplifier may use variable-capacitance diodes or tunnel diodes. Amplification can be made to be undirectional for the variable-capacitor amplifier; however, in the tunnel diode traveling-wave amplifier amplification is bidirectional and ferrite isolators are generally used to suppress the backward-traveling wave caused by mismatch, which could otherwise create instability. In the tunnel-diode antennafier this backward wave is radiated from the antenna structure, and the isolation problem is eliminated or greatly simplified.

Tunnel-diode antennafiers may be designed as shown in Fig. 4B. Here a diode-loaded transmission line uses $\lambda/4$ shunt stubs to provide isolation from the bias source. Radiating elements may be coupled into the line. Individually biasing the diodes would control the gain and thereby determine the radiation pattern. A 4-element research model has produced 3 to 4-db gain per stage with stable operation.

Figure 5 shows a resonant half-wave dipole with a gamma-match arrangement for adjusting the impedance seen by the tunnel diode. Because of the wide range of adjustment possible with the gamma-match, this antennafier can be made to oscillate at the dipole resonant frequency and usable modulated signals have been radiated. When used as an oscillator the device has been tentatively called an antennamitter, since it is a unified antenna and transmitter.

If the gamma-match is adjusted so that oscillations do not occur, the antennafier resembles a conventional tank-type tunnel-diode amplifier. Arrays of such elements may form highly directive antennas. A practical supergain structure could be built with the necessarily violent amplitude distributions obtained by adjusting the gains of the individual antennafier elements.

Parasitic array excitation is also being studied, as well as the application of the gamma-match to the wide-band log-periodic dipole-array antennafier.

The gain of an amplifier is by no means a measure of its quality. It must also have a low noise figure if it is to be used for an r-f amplifier in any of the antennafiers discussed above. The noise figure of a conventional two-port amplifier may be measured easily by connecting a calibrated noise source to its input and measuring the signal-to-noise ratio at its output.

The noise figure of the amplifier in an antennafier is not so easily measured, however, because its input terminals are distributed throughout the antenna and are not accessible. The parameter which can be measured is the field-strength sensitivity of the receiving system.

Field-strength sensitivity is defined as the field strength of the electromagnetic wave in which the antenna must be immersed to provide signal output equal to noise output. This implies an electric field strength, but it is more convenient to deal in terms of power density. That is,

$$FSS = P \Big]_{S_o = N_o} \qquad (3)$$

where P is the magnitude of the Poynting vector of the incoming wave (assumed to be from the direction of the beam maximum), S_o is signal power output of the receiving system and N_o is the noise power output of the receiving system, with the effective temperature at the input equal to the IRE standard noise temperature of 290 K.

By measurement of field-strength sensitivities, the noise figure of the amplifier may be deduced. The field-strength sensitivity is measured on the test range by adjusting the power level of the transmitting source so that the signal output of

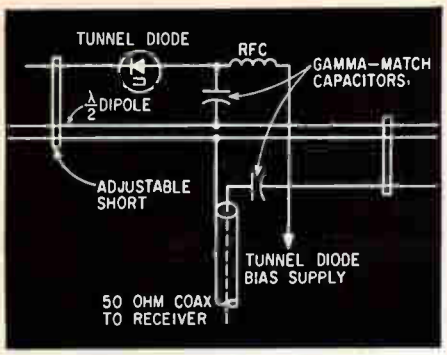

FIG. 5 — Driven element for gamma-match antennafier

the receiving system is equal to its noise output. This transmitter power may be on an arbitrary db scale because it will be necessary to know only the relative field strength of two different measurements, and the absolute power level is unimportant.

Assume amplifier gain G and the receiver noise figure NF_r can be measured with reasonable precision. The signal-to-noise power ratio at the input to the amplifier will be denoted by S_i/N_i. The signal power at the output of the amplifier is GS_i, but noise power is $GN_i + EN$, the amplified input noise plus the excess noise. The field strength sensitivity of the antennafier may now be written in terms of the effective aperture

$$FSS = \frac{S_i}{A}\Bigg]_{S_o=N_o} = \frac{N_i+(EN/G)}{A} \quad (4)$$

The amplifier noise figure is defined by

$$NF_a = \frac{S_i/N_i}{S_o/N_o}$$

$$= \frac{S_i/N_i}{GS_i/(GN_i+EN)} = 1+\frac{EN}{GN_i} \quad (5)$$

where the effective input noise temperature also must be 290 K. Hence,

$$FSS = (N_i/A)NF_a \quad (6)$$

Since the available noise power is frequently written kT_eB where k is Boltzmann's constant, T_e is 290 K and B is the bandwidth,

$$FSS = (kT_eB/A)NF_a \quad (7)$$

This demonstrates that the field-strength sensitivity of a receiving system is directly proportional to the operating noise figure.

Two measurements of field-strength sensitivity are sufficient to determine NF_a. For the first measurement, the amplifier should be removed or disabled in the antennafier so that the antenna connects directly to the receiver. This gives

$$FSS_1 = (kT_eB/A)NF_r \quad (8)$$

The second measurement is with the antennafier ahead of the receiver. It is necessary to account for the noise contribution of the receiver as well as that of the antennafier. This is done by including the quantity $(NF_r - 1)$ in the expression for noise power at the output of the amplifier. This last expression is the excess noise power of the receiver referred to the receiver input terminals. The field-strength sensitivity becomes

$$FSS_2 = \frac{k\,T_e\,B}{A}\left[NF_a + \frac{(NF_r-1)}{G}\right] \quad (9)$$

The ratio of these two terms is

$$\frac{FSS_2}{FSS_1} = FSSR = \frac{NF_a+(1/G)\,[NF_r-1]}{NF_r} \quad (10)$$

Thus the noise figure of the amplifier in the antennafier may be deduced from the field-strength sensitivity ratio, provided the gain of the amplifier and the noise figure of the receiver are known. The effective aperture of the antenna need not be known, if it is not altered by addition of the amplifier, but it is assumed that the effective temperature T_e, which includes background or sky temperature and antenna losses, remains 290 K for both measurements. Variations in T_e from 290 K will have little effect on the measurements except in extremely low-noise systems.

This method was developed for use with antennafiers, but has also been extended for use with antennaverters in which the output frequency is different from the input frequency. Then it is no longer possible to disable the active portion of the antennaverter for the measurement of FSS_1. Instead, it is necessary to use an identical antenna (or the same antenna with the down converter removed), and a separate mixer circuit whose characteristics are known.

Since it is necessary for the effective noise bandwidth to be the same for both measurements (usually the effective bandwidth of the i-f amplifier), the bandwidth of the separate mixer circuit must not be smaller than the remainder of the system.

The conversion gain or loss of the separate mixer must be known accurately. This may be measured on the bench at any signal level sufficiently far above the noise level for linear operation. The local oscillator drive should be adjusted for the same level that gives optimum performance in the receiving system, and the r-f signal power input to the mixer for an arbitrary reference output of the i-f amplifier should be measured. With the mixer removed, an i-f signal generator should be connected to the amplifier and the power level required to give the same reference output level should be measured. The ratio of these two signal power inputs is by definition the conversion gain (or loss) of the mixer.

The noise figure of the separate mixer may be measured in the usual fashion with a broadband noise source, and substituted for the term NF_r in the equation for field-strength sensitivity ratio. The quantity NF_a then would become the noise figure of the mixer or down converter built into the antennaverter.

These techniques are not limited to integrated system designs. They should find application for evaluating overall system performance wherever low-noise preamplifiers and/or mixers are compared. In particular, the behavior of negative-resistance devices such as parametric amplifiers and masers may be studied while functioning as part of the complete receiving system.

Results presented in this article were obtained under contract AF 33(616)-6211 issued from Aeronautical Systems Division, Air Force Systems Command, United States Air Force, Wright-Patterson Air Force Base, Ohio. The authors acknowledge the contributions and suggestions of Edwin M. Turner of ASD, and Carlton H. Walter of The Ohio State University Antenna Laboratory.

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PLASMA GUIDE COUPLERS

Feasibility of using a plasma guide selective coupler for controlling microwave transmissions

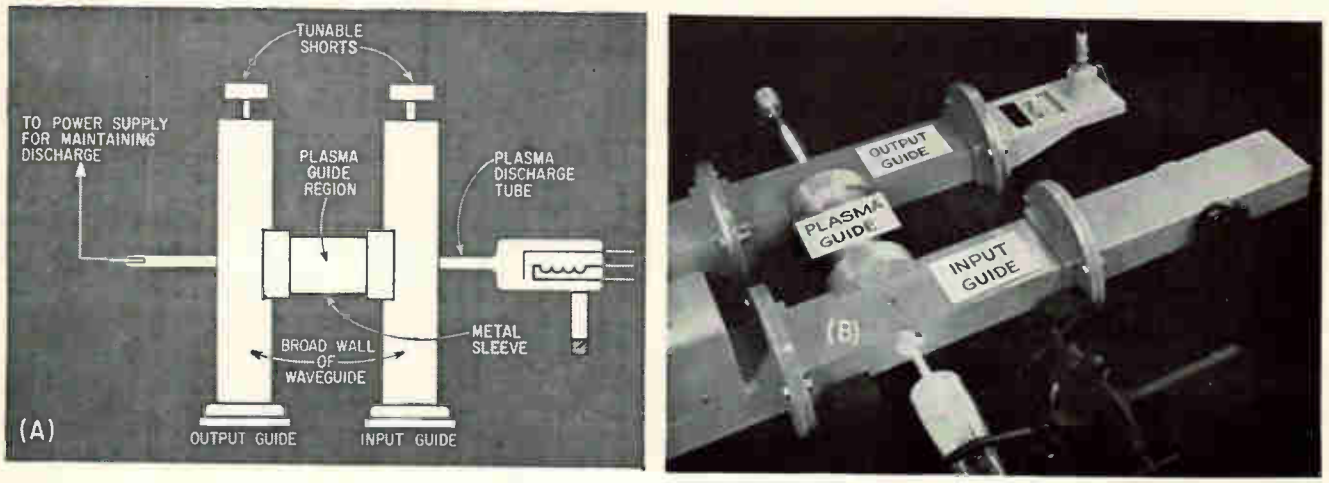

FIG. 1—Schematic of plasma guide microwave selective coupler (A), and experimental model of S-band coupler (B)

By W. H. STEIER*
I. KAUFMAN,
Space Technology Laboratories, Inc.
Canoga, Calif.

SPACE CHARGE WAVES that propagate along the plasma column of a gas discharge can control and switch microwave power at both S-band and X-band.

Because of the propagating nature of microwaves, there are two methods of electronically controlling energy transferred along a transmission system. These are: (1) localized switching, where a lumped-constant element, such as an open or short circuit, is introduced at a point of the transmission system; and (2) distributed switching, where the transmission characteristics of a length of transmission line or waveguide are altered. Examples of the first method are the transmit-receive tube and switching diode. This article presents results of a preliminary investigation of a type (2) switch—the plasma guide selective coupler.[1] Coupling of microwave power has been varied over a greater range than 30 db, by varying the current in a low pressure mercury-vapor discharge tube, both in c-w and pulsed operation. Switching times were on the order of 2 to 5 μsec.

The amount of energy coupled by the plasma guide coupler is controlled by varying the propagation characteristics of a coupling tube that links two waveguides, as in Fig. 1A. This tube is composed of a cylindrical discharge, surrounded by a coaxial region of vacuum or dielectric, and an outer metal cover. The discharge, called the plasma, is contained by a glass tube, although this is not requisite.

Analysis[2, 3] shows that the coupling tube has the properties of a waveguide, and that the transmission characteristics are controlled by the properties of the plasma. There are, however, these differences between this plasma guide and the ordinary hollow waveguide: (1) In a hollow metal waveguide, the propagated energy is all carried by the electromagnetic field. In transmission of microwave power by the plasma guide, only a part of the energy resides in the electromagnetic field; the rest in kinetic energy of oscillating plasma electrons. (2) In the hollow guide, nearly loss-free transmission can occur only if the applied frequency is higher than the cutoff frequency. In a plasma guide containing a plasma of a fixed electron density, transmission occurs chiefly at signal frequencies lower than a cutoff frequency.

It is common to characterize the electron density of a plasma by the quantity f_p, the plasma frequency. For an electron density of N electrons per cubic centimeter, $f_p \approx 9{,}000\ N^{\frac{1}{2}}$.

For the plasma guide, the cutoff frequency is

$$f_{co} = f_p\,(1 + K_e)^{-1/2}$$

Here K_e is the dielectric constant of the material immediately adjacent to the plasma. Transmission will occur through the coupling tube at frequencies below f_{co}. Note that f_{co} is independent of the physical dimensions. Conversely, for a given signal frequency f_s, propagation occurs only if the electron density exceeds the number N given by

$$N_{co} = (f_s/9{,}000)^2\,(1 + K_e)$$

Density N in the plasma is controlled externally from below to above the cutoff value N_{co}. A simple method is a change of anode voltage, which changes the discharge current and thereby the electron density. When a plasma guide is a coupling guide between

* Consultant from University of Illinois, Urbana, Ill.

CONTROL MICROWAVE POWER

has been demonstrated at S-band and X-band. Switching times, 2 to 5 μsec

two ordinary waveguides, as in Fig. 1A, it can become an electronically controllable microwave switch.

Although a hollow tube waveguide propagates energy just above cutoff, the signal is, nevertheless, attenuated rapidly by ohmic losses. A similar situation exists for the plasma guide when the density is just above the value needed for propagation. When operated with a variable anode voltage in this region of densities, the coupler therefore becomes an electronically controllable variable attenuator. As the density is increased beyond this region, the losses decrease correspondingly.

As the density in the coupling tube is increased to higher and higher values, the operation of this tube approaches that of a coaxial waveguide with metal center conductor. For efficient high density coupling, the outer metal conductor must be large enough to allow the appropriate coaxial mode to propagate. If transmission is in the angularly symmetric mode, there is no dimension restriction. But if, as in Fig. 1A, transmission is in the mode with angular variation, the diameter of the metal sleeve must be chosen large enough. However, to prevent coupling at low or zero currents, the diameter must be small enough to prevent conduction in a circular waveguide mode. Therefore, although dimensions did not enter into the low density cutoff expressions, they are important in practical coupler design.

Experimental models of the plasma guide coupler have been built and tested at both S and X-bands. The S-band device is shown in Fig. 1B. A mercury-vapor quartz discharge tube was used to produce the plasma column. The discharge tubes were 5 mm inside and 7 mm outside diameter or 6 mm inside and 8 mm outside, and of various lengths. The inner diameter of the metal sleeve must be large enough to allow a coaxial TE_{11} mode for good coupling at high densities. The diameter was made 50 mm at S-band. Length of the plasma guide region is not critical and was made 12 cm.

Figure 2 shows the response of the S-band coupler as a function of the discharge current. The coupling between input and output guides could be varied electronically from −11 db to less than −40 db. The X-band coupler had a similar response with a maximum coupling of −8.5 db. Probing of the fields along the plasma column indicates that the maximum coupling is determined by impedance matching and not by losses along the column. Better matching between the rectangular guide and the plasma guide should increase the maximum coupling.

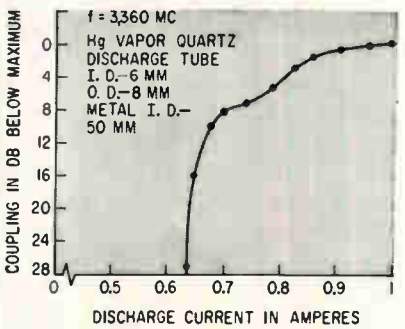

FIG. 2—How coupled power varies with discharge current

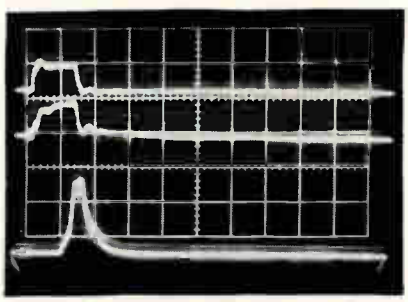

FIG. 3—Switching of c-w microwave power with plasma coupler. Upper trace is switching voltage pulse, center is pulse of discharge current, and lower is coupled microwave power. Time scale: 2 μsec/major division

The switching operation is shown in Fig. 3. Low level c-w microwave power at 3,360 Mc is fed into the input guide while a 3 μs, 23 volt pulse is applied to the anode of the discharge tube. The upper trace is the switching voltage pulse, the center trace is the discharge current, and the lower trace is the resultant pulse of coupled microwave power. The quiescent discharge current was set at 0.16 amperes. Observed switching time is 2 μsec.

The coupler can be used with low level c-w microwave signals or medium level pulsed signals. High level input microwave power can increase the plasma density in the column sufficiently to make the switch always conducting. The experimental X-band switch could handle 128 watts of pulsed microwave power.

The plasma guide coupler could find many applications in the electronic control and switching of microwave power. The device offers the advantages of distributed switching over point switching and requires no magnetic fields as do ferrite devices.

Problems for further research: plasmas whose densities can be well-controlled must be obtained; better broad-band impedance-matching elements between rectangular and plasma guides are needed; for vhf applications, high density plasmas are needed.

The authors gratefully acknowledge the work of R. P. Kemp in the laboratory investigations of these couplers.

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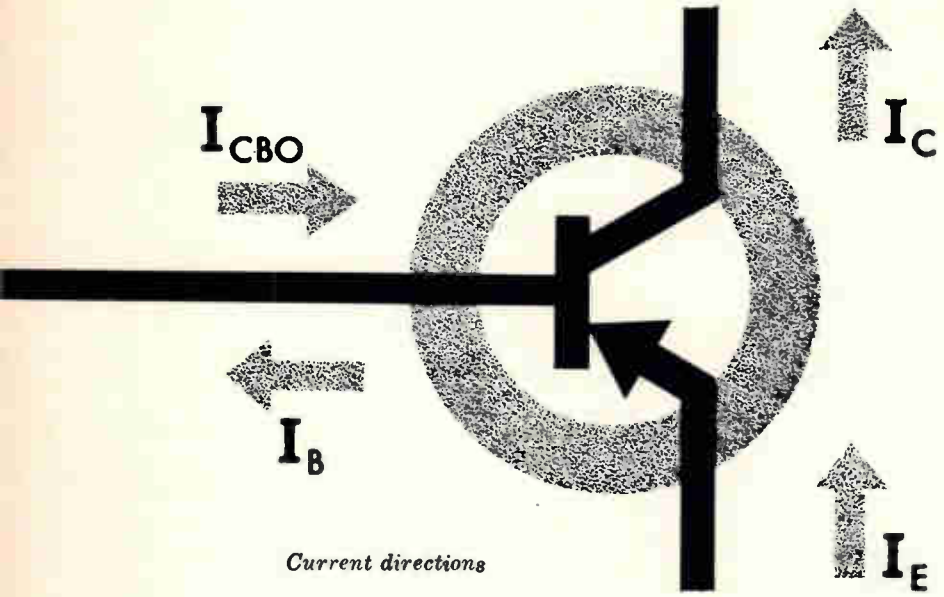
CALCULATING "WORST-CASE"



Current directions

By ELVIN D. PETERSON,

Military Electronics Div.,
Motorola, Inc.,
Phoenix, Arizona

EVALUATION of worst-case leakage current in transistors is often oversimplified. Leakage current is easily determined by direct measurement. When using a large quantity of transistors in a complex of equipment, individual measurement is usually not feasible. The magnitude of the leakage current is not a constant parameter but is subject to variation by environment, aging, applied voltage levels, and by the manufacturing process.

The approach to evaluation of leakage current considers the problem as applied to equipment in which large quantities of transistors are used. The technique also applies to a single isolated transistor circuit when certain simplifications in the analysis are made.

Evaluation of transistor leakage current yields a numerical quantity which is the total leakage current that can be expected to flow in the collector-to-base diode junction and which allows for the worst-case conditions of circuit operation. The solution involves determining: (1) most elevated junction temperature; (2) leakage current contributed by the thermal component; and (3) leakage current contributed by the surface component.

The first source of data normally encountered is the transistor specification sheet. Most sheets list the I_{CBO} and the I_{EBO} leakage currents that exist at 25 C (sometimes referred to as I_{CO} and I_{EO}). A third leakage current that may be encountered is I_{CEO}. To clarify which leakage current is applicable to the design problem, the three leakage currents are defined thus: I_{CBO} is the collector current that flows in a transistor when the emitter is open-circuited and the collector-to-base diode is back-biased; I_{EBO} is the emitter current that flows when the collector is open-circuited and the base-to-emitter diode is back-biased; I_{CEO} is the collector current that flows from the collector through the emitter when the base is open-circuited and normal bias is applied to the collector.

Current I_{CBO} is actually the leakage current that flows within the collector-to-base diode and is composed of two leakage components. One is thermal leakage which is the result of diode action and which varies exponentially with temperature. This leakage component is relatively independent of the collector-to-base voltage (V_{CB}). The other is surface leakage which results from surface contamination and is directly proportional to the collector-to-base voltage. This component is also affected by temperature but not to the degree that the thermal component is. An increase in temperature will usually increase the surface leakage component although the rate of increase varies widely for different transistors.

Leakage current I_{EBO} is similar to I_{CBO} and is caused by the base-to-emitter diode action. It is also composed of two components: one caused by thermal characteristics of base-to-emitter diode action and the second by the surface contamination (in the normal operating region). Leakage currents I_{CBO} and I_{EBO} are often of comparable magnitudes. Current I_{EBO} is important in switching circuits where the emitter-to-base diode is commonly reverse-biased. In the general case of small-signal applications, the base-to-emitter diode is forward-biased and I_{EBO} is not applicable.

Leakage current I_{CEO} is not as easily explained. The explanation which is given in "Transistor Kinks"[1] will be followed. Consider a transistor with the base open-circuited, the collector-to-base diode reverse-biased and the base-to-emitter diode forward-biased. The I_{CBO} leakage current that normally flows in the collector-to-base diode is not able to flow in the base lead, since the base is now open-circuited. A compensating current must be visualized. This current will flow in the emitter and is equivalent to the base current that would flow if the base were not open-circuited, but the emitter were open-circuited. Since the base current that would flow is normally I_{CBO}, an expression can be developed for the emitter current that does flow, to give a corresponding operating point.

Leakage current I_{CBO} would like to flow from base-to-collector for the *pnp* transistor shown in the figure. Since the base is open-circuited, the I_{CBO} cannot flow from the base. An imaginary current I_n can be postulated which flows in a direction opposite to that of I_{CBO} in the base. The two currents can-

TRANSISTOR LEAKAGE CURRENT

cel in the base lead, which satisfies the condition of an open base. An emitter current is required to produce imaginary current I_B. This emitter current is given by:

$$I_E = \frac{1}{1-\alpha} I_B. \quad (1)$$

This expression involves the current gain (α) from the emitter to the collector. The collector current is composed of two components.

$$I_C = \alpha I_E + I_{CBO} \quad (2)$$

$$I_C = \frac{\alpha}{1-\alpha} I_{CBO} + I_{CBO} \quad (3)$$

$$I_C = (\beta + 1) I_{CBO} = I_{CEO} \quad (4)$$

From Eq. 4 it is seen that the leakage current I_{CEO}, which flows when the base is open, can be very much larger than that which flows when there is a low-resistance circuit path between the base and emitter.

This large value of collector leakage current frequently causes thermal runaway in transistors operated with the base open or with large values of resistance inserted between the base and emitter.

The transistor specification sheet often gives the values of I_{CBO} and I_{EBO} at two different voltage operating points (V_{CB} or V_{EB}). This enables the surface leakage component to be segregated from the thermal leakage component. If there is only one value of I_{CBO} or I_{EBO} given, actual physical measurements will be required to segregate the two leakage components.

The increase in the thermal leakage component with temperature can generally be determined by using the rule of thumb that the thermal leakage component doubles for every 10 deg C rise in junction temperature from that given in the specification sheet. (The ambient temperature given on most specification sheets is 25 C.)

It has previously been indicated that the surface leakage component is directly proportional to the applied voltage (V_{CB} or V_{EB}). The voltage dependent magnitude is therefore a straightforward calculation; that is, if the applied voltage in the circuit is twice as great as that stated on the transistor specification sheet, the surface leakage component is doubled. The temperature dependency of the surface leakage component is difficult to estimate. A pessimistic rule of thumb is[2]: the increase in the surface leakage component with temperature can be considered as one-half the increase of the thermal leakage component.

It cannot be too strongly emphasized that the data available on most transistor specification sheets represent *zero life time* parameter values. To use the value of I_{CBO} or I_{EBO} directly from the specification sheet, without allowing for the inevitable increase due to aging, could greatly contribute to decreased equipment reliability. A realistic figure for I_{CBO} or I_{EBO} that allows for life degradation is best obtained by actual accelerated life measurements on an acceptable sample lot of the transistor. If this information is not available it is recommended that at least a 40-percent increase in the total calculated leakage current be allowed. Many older and poorer specifications allow an end limit of 2 (100-percent increase) at a poor 4-percent AQL for a 1,000-hour life test.

Theoretically, the thermal portion of the leakage current in silicon transistors increases at a faster rate than in germanium transistors. However, actual measurements indicate that the rate of increase is for all practical purposes the same. The equations to be presented can be used for both silicon and germanium transistors.

The problem states that the maximum elevated junction temperature must be known before calculation of the leakage current.

The junction temperature will be influenced by the following factors: (1) Maximum ambient temperature stated in the performance specification of the equipment. (2) Internal rise of temperature of the equipment due to its own power dissipation. The occurrence of possible hot-spots within the equipment should be allowed for. (3) The power dissipation within the transistor involved.

Finally the circuit designer should take into account the worst-case parameter fluctuations of the power source and the compensating circuit.

Total junction temperature is:

$$T_J = T_A + T_E + \Delta T_{PD} \quad (5)$$

where T_A = maximum ambient temperature given in the performance specification, T_E = maximum expected rise in temperature due to the power dissipation within the equipment, T_J = total maximum temperature of the collector junction, and ΔT_{PD} = increase in junction temperature over ambient due to heat generated by power dissipation in the collector junction. The term ΔT_{PD} in Eq. 5 is a linear function of the dissipated power in the transistor.

$$\Delta T_{PD} = K \times PD \quad (6)$$

where K = thermal resistance factor in deg C per mw, and PD = total transistor power dissipation.

The constant K is a measure of the thermal resistance between the collector junction and the case of the transistor or heat sink. This constant is given on most transistor specification sheets. Where K is not given, the specification sheet will usually give sufficient information so that the constant can be calculated. Two pieces of information are required for this calculation: (1) maximum allowable junction temperature, T_J (max), and (2) maximum allowable power dissipated at a specified temperature, PD_{ST}. From these, the constant is:

$$K = \frac{T_J\,(\text{max}) - T_{specified}}{PD_{ST}} \quad (7)$$

The total power dissipation required for the solution of Eq. 6 is:

$$PD = V_{CE} I_C + V_{BE} I_B \quad (8)$$

The PD may also be expressed as:

$$PD = I_C \left(V_{CE} + \frac{V_{BE}}{h_{FE}} \right) \quad (9)$$

where V_{CE} = d-c collector-to-emitter voltage, V_{CB} = d-c collector-to-base voltage, V_{BB} = d-c base-to-emitter voltage, I_C = d-c collector current, I_B = d-c base current, and h_{FE} = I_C/I_B = the d-c current gain of the transistor in the common emitter configuration (h_{FE} is frequently referred to as the d-c beta).

Having determined the most elevated junction temperature, the

designer is now prepared to calculate the worst-case value of leakage current. The thermal and surface components are first segregated from the value of I_{CBO} or I_{EBO} leakage current stated on the transistor specification sheet. This can be done by actual measurements or by using the data on the specification sheet in the event that the I_{CBO} or I_{EBO} is given at two different readings of V_{CB} or V_{EB}.

If the general rule of thumb is used (doubling the thermal leakage component for every 10 deg C increase in temperature above the ambient temperature given in the specification sheet) a thermal constant M_T is obtained. The specification sheet ambient temperature is assumed to be 25 C for:

$$M(T) = \frac{T_J - 25\ deg\ C}{10} \qquad (10)$$

The zero life thermal leakage component is:

$$I_{TO} = I_{TO\ (25\ C)} \times 2^{M(T)} \qquad (11)$$

where I_{TO} = the zero life thermal leakage component, and $I_{TO(25\ C)}$ = the segregated thermal component derived from the transistor specification sheet. The surface leakage component is then calculated. Assume I_{CBO} as the type of leakage current that is applicable:

$$I'_{SO} = \frac{V_{CB1}}{V_{CB2}} \times I_{SO\ (25\ C)}, \qquad (12)$$

where I'_{SO} = the zero life, voltage dependent surface leakage component; V_{CB1} = the d-c collector-to-base voltage selected by the designer; V_{CB2} = the d-c collector-to-base voltage given by the transistor specification sheet; and $I_{SO(25\ C)}$ = the segregated surface leakage component derived from the specification sheet.

As previously stated, a pessimistic rule of thumb that accounts for deviations in the surface leakage with temperature changes is a multiplying factor which symbolically can be shown as:

$$\frac{2^{M(T)}}{2} \qquad (13)$$

The zero life surface leakage current (I_{SO}) can be pessimistically stated as:

$$I_{SO} = I'_{SO} \times \frac{2^{M(T)}}{2} \qquad (14)$$

The total zero life leakage current (I_{LO}) can now be determined:

$$I_{LO} = I_{TO} + I_{SO} \qquad (15)$$

If the additional increase in the leakage current due to aging of the transistor is not available as a result of physical measurement, an increase in I_{LO} of at least 40 percent should be considered. The new value of leakage current obtained represents the total leakage current (I_L) that must be compensated for.

$$I_L = I_{LO} \times 1.4 \qquad (16)$$

The final step to insure reliable design required that the parameter tolerances, affecting the leakage current compensating networks, be accounted for. For an example, assume a constant current compensating circuit consisting of a single resistor of 5-percent total tolerance and a power source of 1-percent total tolerance. A worst-case factor of 6 percent should be accounted for by increasing the total leakage current (I_L) by this amount.

The following problem illustrates the described technique.

GIVEN: A transistor circuit that is part of a complex equipment. Assume I_{CBO} to be the applicable leakage current affecting circuit operation. The specification sheet has the following pertinent data (at an ambient temperature of 25 C unless otherwise stated):

$I_{CBO}\ (Max) = 4\ \mu a \quad (V_{CB} = 2$ v d-c)
$I_{CBO}\ (Max) = 5\ \mu a \quad (V_{CB} = 6$ v d-c)

Maximum allowable junction temperature = 85 C.
Maximum allowable power dissipation at 25 C = 300 mw; $h_{FE(Min)} = 5$.

The transistor is operated under the following conditions: (This assumes worst case for d-c or low frequencies where the thermal constant of the junction is small with reference to the period of the signal being amplified.): V_{CB} = 10 v d-c, V_{CE} = 12 v d-c, V_{BB} = 2 v d-c, and I_C = 6 ma. The power sources have 1-percent total tolerance ratings. Resistive components have 5-percent total tolerance ratings. The equipment performance specification indicates a maximum ambient temperature requirement of 50 C. It has been determined that the rise in temperature due to the power dissipation within the equipment is 10 C.

PROBLEM: Determine the worst-case transistor leakage current.

SOLUTION: Power dissipation is:

$$PD = I_C\left(V_{CE} + \frac{V_{BE}}{h_{FE}}\right) \qquad (9)$$

$$= 6\ (12 + 2/5) = 74.4\ \text{mw}.$$

The thermal resistance factor K is:

$$K = \frac{T_{J\ (Max)} - T_{specified}}{PD_{ST}} \qquad (7)$$

$$= \frac{85 - 25}{300} = 0.2\ \text{C/mw}$$

and

$$\Delta T_{PD} = K \times PD$$
$$= 0.2 \times 74.4 \cong 15\ \text{C} \qquad (6)$$

The junction temperature is then:

$$T_J = T_A + T_E + \Delta T_{PD}$$
$$= 50 + 10 + 15 = 75\ \text{C} \qquad (5)$$

The thermal constant is:

$$M_T = \frac{T_J - 25\ deg\ C}{10} = 5 \qquad (10)$$

The segregated leakage components at 25 C are:

$$I_{TO\ (25\ C)} + I'_{SO\ (25\ C)} = 4\ \mu a$$
$$I_{TO\ (25\ C)} + 3\,I'_{SO\ (25\ C)} = 5\ \mu a$$
$$2\,I'_{SO\ (25\ C)} = 1$$
$$I'_{SO\ (25\ C)} = 0.5\ \mu a$$

At V_{CB} = 2 v d-c, $I_{TO\ (25\ C)} = 3.5\ \mu a$

The zero life thermal leakage component is:

$$I_{TO} = I_{TO\ (25\ C)} \times 2^{M(T)}$$
$$= 3.5 \times 32 = 112\ \mu a \qquad (11)$$

The zero life voltage dependent surface leakage component is:

$$I'_{SO} = \frac{V_{CB1}}{V_{CB2}} \times I'_{SO\ (25\ C)} \qquad (12)$$

$$= \frac{10}{2} \times 0.5 = 2.5\ \mu a$$

The temperature dependent value of the surface leakage component is:

$$I_{SO} = I'_{SO} \times \frac{2^{M(T)}}{2}$$

$$= 2.5 \times 16 = 40\ \mu a \qquad (14)$$

The zero life leakage current is:

$$I_{LO} = I_{TO} + I_{SO}$$
$$= 112 + 40 = 152\ \mu a \qquad (15)$$

The leakage current with a 40-percent increase to account for aging of the transistor is:

$$I_L = I_{LO} \times 1.4$$
$$= 152 \times 1.4 = 213\ \mu a \qquad (16)$$

Allowing for the tolerances of the parameters of the compensating circuit, the total worst-case transistor leakage current is:

$$I_L \times 1.06 = 213 \times 1.06$$
$$= 226\ \mu a$$

REFERENCES

(1) Valor Instruments, Inc., Transistor Kinks, No. 1, Nov. 1958.
(2) P. G. Thomas, Determining *Ico* at Elevated Temperatures and Power Dissipations, *Electrical Design News*, Jan. 1960.

Solid-State 30-Channel Multiplexer

DESIGNED FOR MINIMUM COMPONENTS

By R. C. ONSTAD,
General Dynamics Astronautics,
San Diego, California

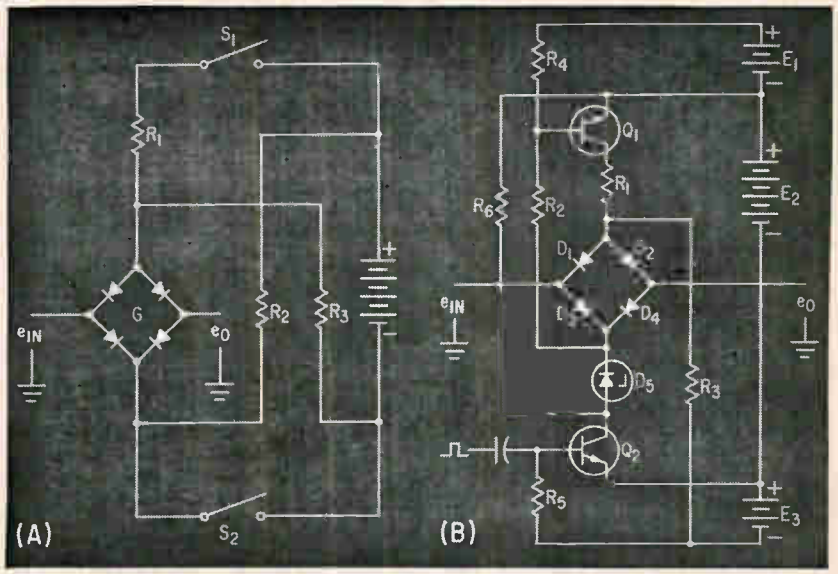


FIG. 1—Basic gate with floating supply from battery (A); transistor version (B) with transistor switches replacing the mechanical ones

Permits gate-switching-transistors to double in ring counter and control sequencing.

Static inverter provides two power supplies and ring-counter stepping waveform

IN DESIGNING a missile-borne pcm telemetry system it was necessary to provide a multiplexer having 10-samples-per-second basic sampling rate for input signals within the range 0-to-5 volts, and an allowable error consistent with the resolution provided by an eight-bit pcm coder. Other desirable features included simplicity, reliability and compactness.

The final multiplexer design uses a four-diode-bridge for each gate, a single transformer-coupled floating voltage source being switched to each gate in succession by using a two-transistors switching circuit gate. In stepping conduction from one gate to the next, one of the switching transistors doubles as an element in a ring counter.

First it was determined that a four diode gate would meet the accuracy, linearity and stability requirements. However, the conventional way of enabling (operating) the gates, using precise voltage sources requiring balancing networks with individual adjustments proved unsatisfactory. Use of an individual floating voltage source for each gate is satisfactory except that weight, size and power become prohibitive. At the required low sampling rate, separate driving transformers for each gate would be too large to be feasible. The final design *enables* each gate in succession from a single floating voltage source, yet completely disconnects all other gates not immediately required. Such a device has been built and proved in the laboratory. The floating voltage source is provided by a transformer that also has an additional winding to provide power for the pcm coder.

Figure 1A illustrates the operation of the multiplexer. The floating voltage source is represented by a battery. When switches S_1 and S_2 are open, gate G_1 diodes are reverse biased by potentials established across them by resistors R_2 and R_3. Gate G_1 is connected to the common output, but isolated from any other gate supplied from the same voltage source. To open a gate, switches S_1 and S_2 are closed simultaneously to forward-bias the diodes. Resistors R_2 and R_3 remain in the circuit but their resistance is so high that their effect is overcome during gate conduction. The signal e_o then appears across the output in response to an input signal e_{in}. Several gates may be connected to the single floating voltage source without producing noticeable crosstalk. By using transistors to switch the gates in sequence, and connecting the outputs of all the gates to a common load, the device becomes an electronic multiplexer.

Figure 1B shows how transistors can be substituted for the switches of Fig. 1A. With no positive pulse

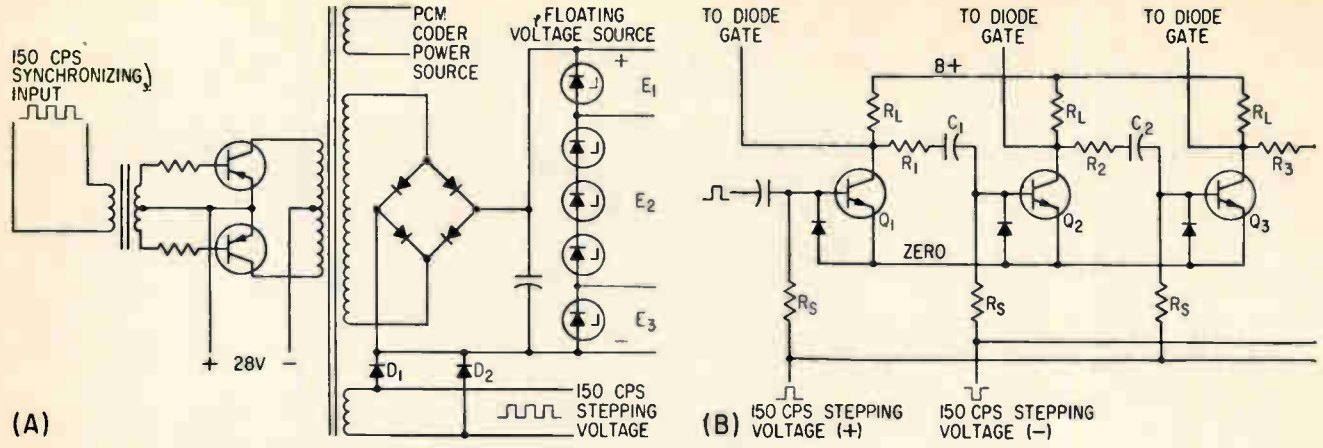


FIG. 2—Inverter provides floating voltage sources, as well as power for the pcm coder and stepping pulses for the ring counter (A); inverter transients are synchronized with the step-along interval. Alternate ring-counter stages are pulsed from opposite ends of the inverter stepping winding (B)

present at the base of transistor Q_2, transistor Q_1 is reverse biased through R_4-connection to a positive potential. The diodes in the gate are reverse biased because R_3 connects the upper end of the gate to a negative potential while R_2 and R_4 in series connect the lower end of the gate to a positive potential. The gate is thus completely isolated fom all other gates supplied by the floating voltage source.

With a positive pulse applied to transistor Q_2, negative bias is overcome and Q_2 conducts through its collector load resistor, R_6. Transistor Q_2 becomes saturated so that its collector potential is slightly above emitter voltage. The negative collector swing forward biases the base of Q_1 through resistor R_2. Transistors Q_1 and Q_2 are now both conducting, providing a forward current path to the four diode bridge thus *enabling* the gate. A signal, e_{in} is now transmitted by the gate and appears across the output load as e_o. By pulsing the gates in time-sequence from a ring counter having the same number of counting stages as there are gates, each input is connected sequentially to the common output as required. By incorporating transistor Q_2 as an element in the ring counter, the design of the multiplexer is simplified and the number of components reduced. A disadvantage of this approach is reduced flexibility.

Battery cells would work well as a floating voltage source for the multiplexer. For a missile application, a floating supply can be provided by rectifying and filtering a-c from a transformer winding, however, the resulting ripple can introduce undesirable noise and crosstalk.

Static inverters are notorious for producing switching spikes that are impossible to completely eliminate. However, if the static inverter spikes can be made to occur only at the instant that one gate turns off and the next gate turns on, the spikes can be tolerated A static inverter is successfully used as the floating voltage source for the multiplexer. Figure 2A illustrates how a static inverter establishes the floating potential required. The inverter uses a toroid transformer with square-loop core and provides a square wave at its output. To synchronize the inverter spikes with the switching period of the multiplexer, the inverter is driven by a 150-cps square wave that is a submultiple of the main synchronizing clock signal. The 150 cps frequency is required for the inverter because the multiplexer is designed for 10 samples per second for each of the 30 data channels. The period for each sample is then $1 \times 10^6/10 \times 30$ microsec $= 3{,}333$ μsec, which corresponds to a frequency of 150 cps. The square wave output is full-wave-bridge rectified and filtered, uses a Zener diode string to establish the three potentials E_1, E_2 and E_3. Switching transients normally associated with a static inverter are minimized by winding the transformer for minimum of leakage inductance and by placing an r-c filter at the output of the bridge rectifier. Since the transient spikes occur only during the short interval that one gate in the multiplexer turns off and the following gate turns on they do not affect the operation of the multiplexer.

The pcm coder is designed so that it does not encode during the switching interval, thereby permitting it to tolerate the static inverter switching-transients. The static inverter has a third winding to serve as a power supply source for the pcm coder circuits, while a fourth winding delivers the 150-cps stepping square wave to the controlling ring counter.

The rise time of the multiplexer gate is determined both by the source resistance of the gate input signal and rise time of the ring counter, as well as the capacitance between the floating voltage source and ground. This capacitance is minimized by separating the transformer windings by layers of Teflon. Filter capacitors of the floating voltage source are not returned to ground.

In explaining how transistors are used as switches in the multiplexer gate, it was stated that transistor Q_2 of Figure 1A doubled as one stage of the controlling-ring counter. Figure 2B shows 3 successive stages of the ring counter portion of the multiplexer. The ring counter has one transistor per stage, while stages are interconnected by resistance and capacitance in series. The 150 cps stepping voltage is supplied by a separate winding on the static inverter transformer. This winding

is connected by two diodes D_1 and D_2 to the most negative end of the floating voltage source as Fig. 2A shows. One end of this winding goes through isolating resistors to all even numbered ring-counter stage while its other end connects to odd-numbered stages (Fig. 2B). Adjacent stages are thus supplied with stepping voltages of opposite polarity.

In Fig. 2B assume transistor Q_1 is in the transition from conduction to nonconduction. The collector potential is rising rapidly from slightly above zero to $B+$ and capacitor C_1 is charging towards the collector potential of transistor Q_1. The stepping voltage at Q_1 is swinging negative, which aids in turning-off Q_1. Charging current from capacitor C_1 causes transistor Q_2 to go into conduction and holds it there. The stepping voltage at Q_2 is swinging positive to speed up the turning on of Q_2. The diode connected between base and emitter of each transistor clamps the base potential at -0.5 volt with respect to the emitter when the collector of the transistor in the previous stage swings negative. The time constant R_1 C_1 or R_2 C_2 is selected so that capacitor charging current will supply base drive to a conducting transistor for the sampling duration of 3,333 μsec. The stepping voltage on Q_2 occurs approximately when this conducting transistor has depleted the charge on capacitor C_1 and so assists in cutting the transistor abruptly off. The positive swing of the collector of Q_2 occurring simultaneously with a positive swing of the stepping voltage at the base of transistor Q_3 results in a rapid turn on of transistor Q_3. The output waveform appearing at the collector of each stage is a negative square-topped pulse.

To start the first stage of the ring counter and to ensure that the stepping voltage is phased correctly, a 10 pps start-pulse is derived from the same clock that supplies the reference frequency for driving the static inverter.

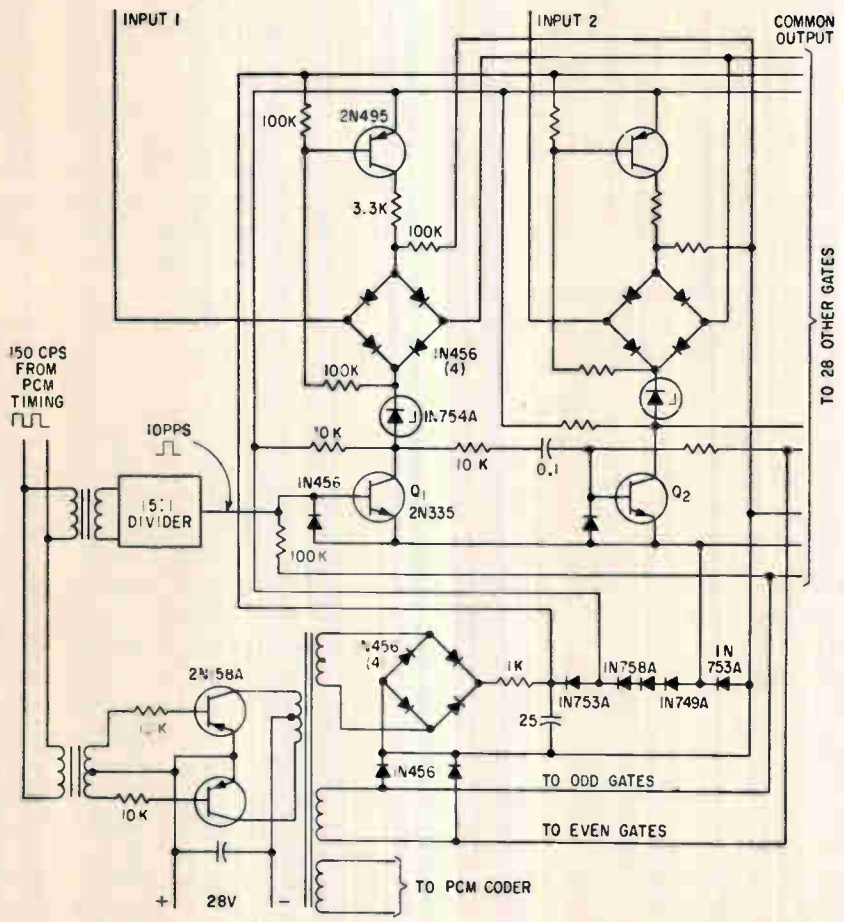


FIG. 3—Portion of final circuit shows two gate-switching-stages, with a transistor from each, Q_1 and Q_2, doubling as ring counter elements

The trailing edge of the ring counter waveform appearing on the collector falls off rapidly to half-amplitude and then falls off slowly until cut-off. In providing for rapid shutting of the diode gate, a Zener diode (D_5 of Fig. 1B) is inserted between the collector of Q_2, Fig. 1B, and the lower end of the diode gate. During turn-off, the potential across diode D_5 becomes less for the steep portion of the collector waveform of Q_2 than its cut-off value and the gate is therefore abruptly cutoff.

In optimizing the gate design, tests were made with the basic four-diode-bridge. Gate offset or error was measured for various values of gate current for input signal levels of 0 to 5 volts and over temperatures from -20 C to 80 C. The IN456 silicon diode was selected for gate usage because of its low back current characteristics (maximum of 0.025 μa at -25 v and 25 C). These tests showed that gate offset variation with temperature was minimum when the current supplied to the gate lay in the region 0.75 to 1.5 ma. By matching diodes the maximum gate offset can be kept within ± 1 millivolt for the temperature and input signal range.

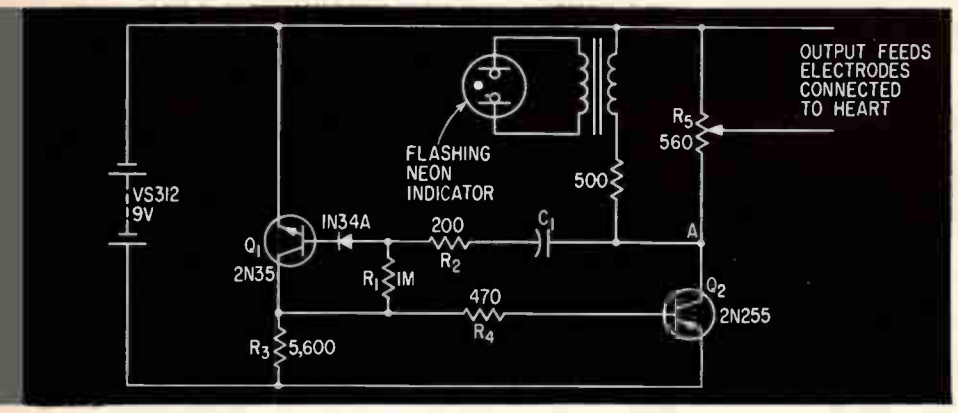
Figure 3 shows the working model of the multiplexer. Silicon transistors are used in the gates because of their superior performance at high temperatures. Packaging design is partially complete. Prototypes of printed circuit boards and potted modules of the individual gates have been built. According to preliminary estimates the multiplexer including the floating voltage source should occupy less than 50 cubic inches. The transformer is by far the largest component in the multiplexer.

Higher sampling rates have not been attempted. However, the device should operate equally well at 10 or more times the present rate. The size can also be reduced since the inverter transformer can be smaller at the higher frequency.

In applications where the unit is not required to operate above normal room temperatures, cheaper germanium transistors may be substituted for silicon.

For low-level signal applications, a transistor gate might be substituted for the four-diode bridge.

Cardiac Pacemaker Triggers Heartbeats



Pacemaker circuit incorporates neon indicator to give visual indication of stimulation rate. Potentiometer provides amplitude control of output

Two-transistor unit produces triggering pulses that stimulate heatbeats during surgery to insure even circulation of blood

By W. E. GILSON
H. F. KLINGE,
University of Wisconsin Medical School, Madison, Wisconsin and GME, Middleton, Wisconsin

THE MAIN DESIGN requirement of this instrument was to provide a cardiac pacemaker that used internal body-connections and was sufficiently simple to be built by anyone with a modicum of electronic skill. The cost of the parts is low —about $10 at a minimum, and around $18 with a miniature output control and transformer for activating a flashing neon lamp.

Test runs show that the pacemaker operates for about a week on one small battery. Measurements, including the battery, are 3 × 4 × 10 cm, and weight is 155 grams. It can thus be conveniently carried by or attached to an experimental animal.

The output pulse is 4 milliseconds in duration, with an 8 volt peak that sends a current of 16 ma into a 500-ohm load.

When the battery is connected (see illustration), transistor Q_1 is biased into conduction. Until this time, the Q_2 has not conducted because it is not forward biased. When the Q_1 conducts, the current flows through both its emitter-collector circuit and the base-emitter circuit of the Q_2, causing Q_2 to conduct. Voltage drop across R_5 provides the output pulse. At the same time, C_1 is charged, with the positive end of the battery effectively connected to point A by the low conducting-resistance of Q_2. The capacitor is charged through the base-emitter circuit of Q_1, holding this transistor on. When the base current of the Q_1 is sufficiently low (due to C_1 becoming charged) the collector current of Q_1 drops, reducing base current of Q_2. This action is regenerative and both Q_1 and Q_2 are rapidly turned off. The charging period is then ended.

Charge on capacitor C_1 is dissipated through R_1, R_2, R_3 and R_5, the rate being determined mainly by R_1. The 1N34A diode prevents leakage of the charge through the base of Q_1. When the capacitor is discharged sufficiently, the cycle is repeated. Repetition rate is determined by C_1 and R_1, the pulse length by C_1, R_2, R_3, and by the internal resistance of Q_1. Resistor R_1 may be variable when a change in repetition rate is desirable.

WHAT A CARDIAC PACEMAKER DOES

The pacemaker delivers electrical pulses to the heart so that heartbeats continue at their normal steady rate independently of erratic or defective natural heartbeat stimuli. Cardiac pacemakers are carried by persons whose hearts cannot be relied on to beat normally without external assistance in much the same way as hearing-aids are carried by the hard-of-hearing. They are also used in the operating theater during surgery where they maintain steady circulation where the heart responds less effectively to its natural drive-pulses.

The pacemaker described is a free-running relaxation oscillator that delivers 4 millisecond pulses to the heart—to which it is directly connected by steel electrodes. It was designed for surgery rather than everyday application. Pulses at normal heartbeat frequency from the pacemaker cause muscle contractions that trigger the heart more reliably than natural stimuli, especially when the heart itself is being worked upon

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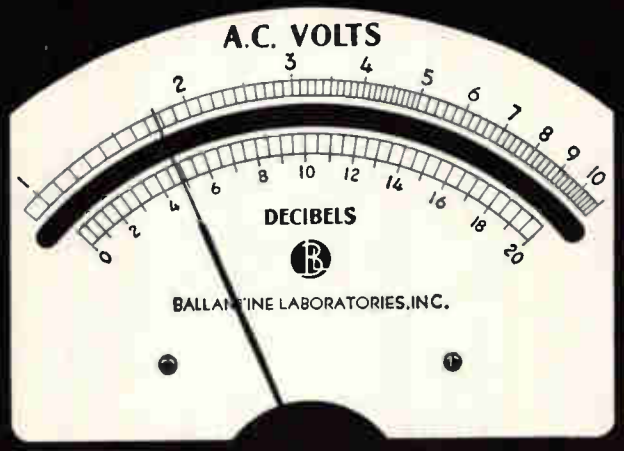

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300E	30 cps-100 kc	300 μV-300 V	2 MΩ shunted by 20 to 30 pF	2%	$260
300G	10 cps-250 kc	1 mV-1000 V	2 MΩ shunted by 10 to 25 pF	1% 20 cps-20 kc, 1 mV-250 V; 2% elsewhere	$315
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310A	10 cps-2 Mc; 5 cps-4 Mc as a null detector	100 μV-100 V (Down to 40 μV as null detector)	2 MΩ shunted by 9 to 19 pF	3% 15 cps-1 Mc; 5% elsewhere	$250
314 Wide Band	15 cps-6 Mc	1 mV-1000 V (100 μV-1 mV without probe)	11 MΩ shunted by 8 pF with probe, or 1 MΩ shunted by 25 pF without probe	3% 15 cps-3 Mc; 5% elsewhere	$300
316 Infrasonic	0.05 cps-30 kc; 0.01 cps with corrections supplied	0.02 V-200 V Peak-to-Peak	10 MΩ shunted by 17 to 40 pF	3%	$330
317 Wide Band	10 cps-11 Mc	300 μV-300 V	10 MΩ shunted by 7 pF with probe; 2 MΩ shunted by 11 to 24 pF without probe	2% 20 cps-2 Mc 4% 10 cps-6 Mc 6% 10 cps-11 Mc	$495 with probe
320 True RMS	5 cps-500 kc	100 μV-320 V	10 MΩ shunted by 8 to 18 pF	3% 15 cps-150 kc; 5% elsewhere	$445
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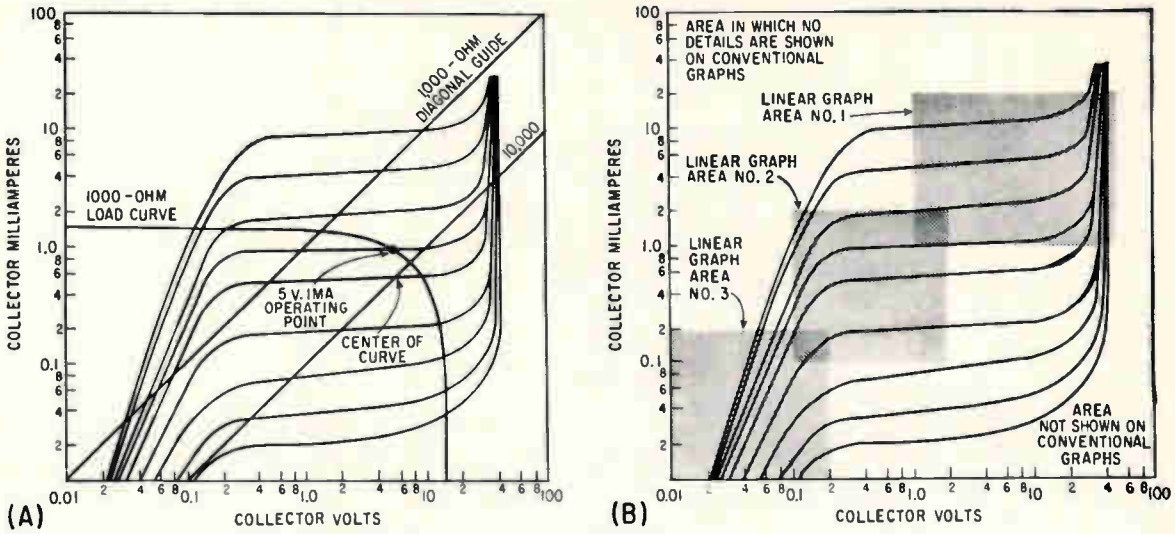

Presenting transistor characteristics on log-log paper encompasses wide operational range

LOG-LOG PRESENTATION OF

Transistor Characteristics

By J. ADAMS,
Semiconductor And Materials Division, RCA,
Somerville, New Jersey

A SINGLE GRAPH having logarithmic scales for both current and voltage, such as the log-log graph of transistor collector characteristics shown in (A) presents more of the useful operating range in one comprehensive plot than three or more conventional graphs. As shown in (B), the superimposed linear graphs that present transistor collector characteristics for different applications often have overlapping areas.

For example, mesa and planar transistors have low leakage currents and high breakdown voltages that permit operation at currents ranging from a few microamperes to hundreds of milliamperes over a wide voltage range; logarithmic scales make it possible to extend both current and voltage scales to include the entire operating range of such transistors.

Although the log-log plot, (B), does not include a zero point on either scale, the lowest decade of the scale provides greater detail for useful areas of operation than the comparatively small low-current low-voltage areas of the linear plots. In linear plots, the saturation curve is a nearly vertical straight line from which it is difficult to obtain accurate readings, while the region from zero current level, the first step of base current, shows little information.

The log-log plot shows the beta linearity over the total current range by a logarithmic spacing of the base current steps. Because of these continuous plots of current, the calculation of beta linearity from a log-log plot is easier than the conventional correlation of three linear graphs.

Since the load lines of log-log plots are a family of hyperbolic curves (just as the load lines on linear plots are all straight lines), a standard load-line hyperbola traced on a clear plastic template can be made to represent any load curve on the graph.

The collector characteristics of the transistor are plotted on the log-log scale from linear plots of the characteristics. The 1,000-ohm diagonal guide is then constructed by drawing a straight line through the decade points at which the collector voltage divided by the collector current equals 1,000 ohms. For example, $V_c = 0.1$, $I_c = 0.1$ and $V_c = 10$, $I_c = 10$. The hyperbolic load curve is then obtained by transferring a linear load line point-by-point from a linear graph to the log-log graph.

The load curve and the diagonal guide (which passes through the center of the curve) may then be traced on a sheet of clear plastic and used as a standard load line. For example, when the center of the standard curve is shifted along the 1,000-ohm diagonal guide, a family of parallel load curves of 1,000-ohm resistive value is obtained. When the curve is centered on a similarly constructed 10,000-ohm diagonal guide by aligning the diagonal guide and the line through the center of the curve on the template, resistive values are 10,000 ohms.

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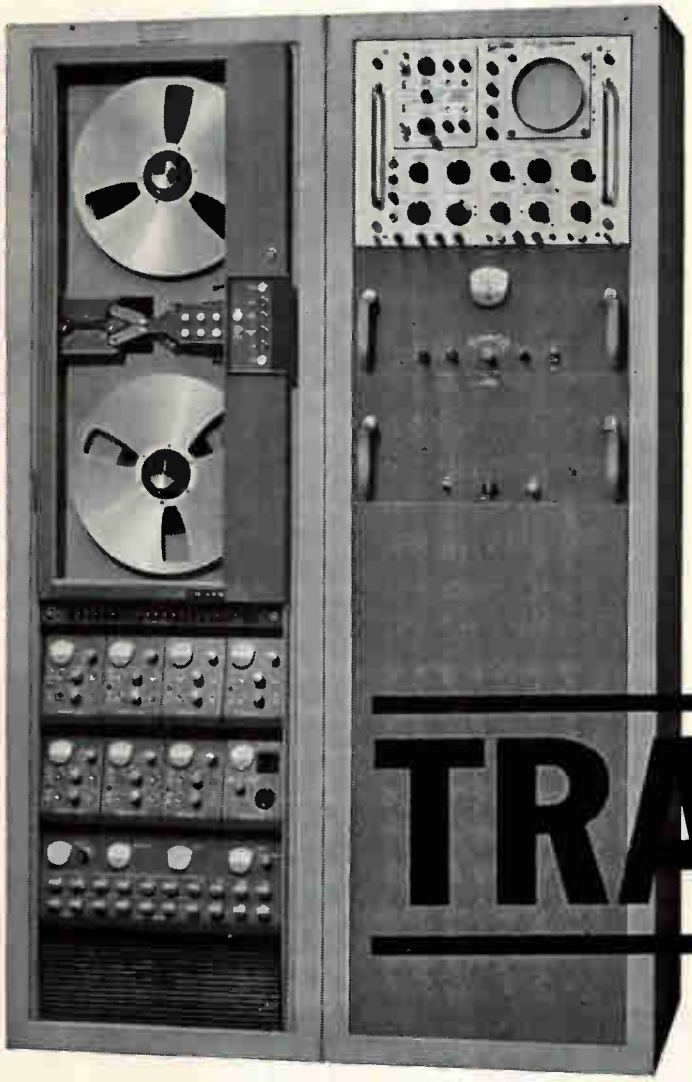
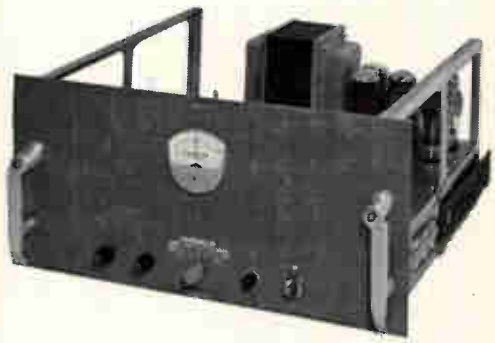


Shown here with the Mincom Series CM-100 1.5-mc Instrumentation Recorder/Reproducer, a standard auxiliary rack houses (from the top down) an oscilloscope monitor unit, the new **Tracklok**, and a demodulator.



The Tracklok

Completely Compatible: The new **Tracklok** is designed to improve the predetection performance of Mincom's 1-mc Series CM-100 Instrumentation Recorder/Reproducer (which now, on special order, performs to 1.5 mc at 120 ips). **Tracklok** can be incorporated into all existing Series CM-100 systems, since it is compatible with CM-100 or any comparable recorder-reproducer in the standard IF carrier frequencies.

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Retaining Linearity in Demodulator Filters

By D. FRANKLIN,
E.M.I. Electronics Ltd.
Hayes, Middlesex, England

ADDITION of a diode and a current generator to keep it conducting can eliminate a source of nonlinearity in some demodulators using low-pass filters. The circuit modifications overcome the effects of energy storage in the filter.

In several types of data transmission systems, intelligence is contained in the power of incoming pulse trains. Examples include pulse-duration and pulse-rate modulation systems. Sometimes frequency-modulated carriers are also converted into pulse trains in which pulse rate contains the information.

Data can be recovered from these systems with a low-pass filter, which rejects frequency components higher than the upper frequency limit of the information. However, charging effects resulting from reactance of the filter can cause a loss of linearity in the demodulated output.

A method for compensating this effect can be demonstrated by a linear frequency discriminator for an f-m carrier. An electronic switching device, such as a monostable multivibrator or a square-loop magnetic switching element, can produce a pulse of constant amplitude and duration for each cycle of input signal. A low-pass filter after the switch should average current so that it is a linear function of input pulse repetition frequency.

An on-off electronic switch followed by a filter can be represented as in Fig. 1A. When the switch is closed, the shunt capacitors are charged. When the switch is opened again, voltage across the filter input does not return to zero immediately because of the time required for the stored charge to be dissipated in the load.

This difficulty would disappear if variations in impedance at the switch output were of negligible duration, which would ensure linearity. Incorporating a linear amplifier between the switch and the filter would provide constant source impedance, but the advantages of using switches as circuit elements would be sacrificed.

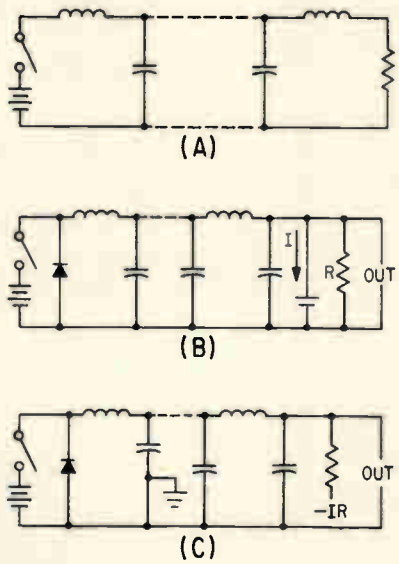

FIG. 1—Stored charge in low-pass filter (A) can be removed by diode (B) which is kept conducting by application of voltage —IR at (C)

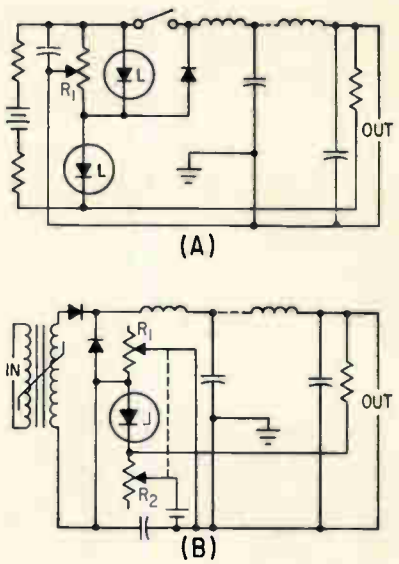

FIG. 2—Zero output for unmodulated carrier frequency can be obtained from on-off switch (A) and magnetic switching circuit (B)

When the switch is closed, source impedance to the filter is essentially zero. It could also be made zero when the switch is open if another switch contact were to connect the switch contact arm to ground when the switch is off. However, electronic switches other than on-off types can be inconvenient, but the alternate arrangement in Fig. 1B can be used with an on-off switch. It provides an alternate current path through the diode, which is kept conducting by the bias current source.

Current I must exceed the maximum discharge current that would flow in a grounded off switch contact to ensure that the diode conducts when the switch is open. Adding a current source in parallel with load R is equivalent to returning R to a voltage of $-IR$, as shown in Fig. 1C.

When the switch is closed, bias current I must be provided from the source in addition to the current provided to develop voltage at the filter input. It is therefore desirable to provide current I at a place in the circuit where it is not added to the pulse current in the filter.

With frequency-modulated signals, it is often necessary to make output voltage zero when carrier frequency is not modulated. This can be accomplished with the circuit in Fig. 2A in which voltage to be switched and voltage $-IR$ are both provided by zener diodes. Potentiometer R_1 establishes the operating voltage level of the circuit.

If magnetic flux switching is used, only the zener diode providing voltage $-IR$ is required and the circuit in Fig. 2B can be used. Potentiometer R_2 mechanically linked to R_1 limits demand on the power supply. However R_2 can be replaced with a fixed resistor if the range of R_1 is restricted.

By limiting the core flux in each direction, voltage from the output winding is equal during both halves of a cycle and must be suppressed during one half cycle with a series diode. Although current may flow

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SM 75-2M	0-75	0-2	SM 75-2MX
SM 160-1M	0-160	0-1	SM 160-1MX
SM 325-0.5M	0-325	0-0.5	SM 325-0.5MX

5¼" PANEL HEIGHT

SM 14-15M	0-14	0-15	SM 14-15MX
SM 36-10M	0-36	0-10	SM 36-10MX
SM 75-5M	0-75	0-5	SM 75-5MX
SM 160-2M	0-160	0-2	SM 160-2MX
SM 325-1M	0-325	0-1	SM 325-1MX

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SM-36-15M	0-36	0-15	SM 36-15MX
SM 75-8M	0-75	0-8	SM 75-8MX
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SM 325-2M	0-325	0-2	SM 325-2MX

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in the diode and the output winding during a part of the cycle, circuit operation is not adversely affected.

Time of Acceleration Is Measured by Sensor

By FRED W. KEAR

Lytle Corp., Albuquerque, N. M.

DURATION of acceleration in a particular direction is measured by an acceleration-sensing system that provides signals at the beginning and end of acceleration. It is used for environmental tests in which systems or devices must withstand specified levels of acceleration for required periods of time.

Acceleration in more than one direction can be measured without interrupting tests if the sensor, which is attached to the device under test, is rotated to the correctly identified positions. The acceleration-sensing system is also used for tests of small experimental rockets and linear accelerometers.

The acceleration-sensitive switch in Fig. 1 can switch a counter on and off at the required times.

The unbalanced mass is mounted on a lever that is supported on a leaf spring. The position of the mass along the lever can be adjusted by a knurled thumbscrew. Mass can be added by attaching it to the original mass with screws.

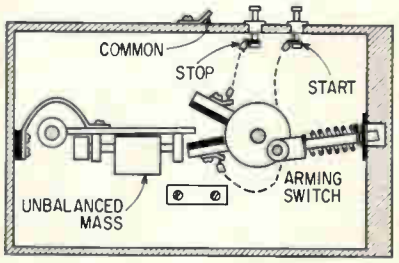


FIG. 1—Acceleration that moves mass downward operates arming switch, which returns to original position when acceleration stops

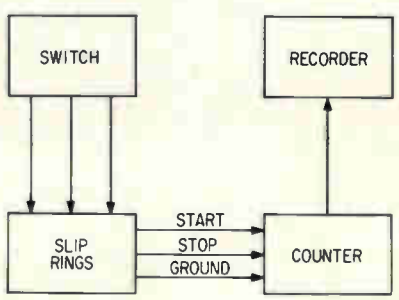


FIG. 2—Switch output applied through centrifuge slip rings is indicated on counter and recorded

If acceleration is in a direction that results in moving the mass downward in the figure, the mass-arm assembly forces the arming switch against its stop. The arming switch is held at this position by a spring-loaded cam. When acceleration stops, the spring-mounted arm assembly returns, which opens the arming switch again.

The arming switch is made of an insulating material of very low density to reduce inertia. If a heavier metallic switch were used, its greater inertia would oppose movement of the lever arm. The insulating material also provides d-c isolation of the start acceleration and stop acceleration signals.

Metallic strips are mounted on the actuating arms of the arming switch, and threaded holes are provided so that the signal leads can be attached with screws. The opposite ends of the leads are connected to press-fit terminals that make the signals accessible from outside the switch case.

When the acceleration-sensing switch is used in environmental tests using a rotating centrifuge, it is attached to the device under test. The signal terminals are connected to the centrifuge slip rings as shown in Fig. 2.

When acceleration in the direction of the axis of interest starts, the arming switch provides a start acceleration signal that triggers the start circuits of the counter. Similarly, the stop acceleration signal stops the counter when acceleration stops. The duration of acceleration is indicated on the counter and a permanent record of the time is provided by the recorder.

Time delays of the start acceleration and stop acceleration signals are made adjustable for measuring acceleration time for small experimental rockets and linear accelerometers. Using adjustable contacts on the arms of the arming switch enables both of these time delays to be adjusted. In environments where an acceleration field is in the opposite direction to switch sensitivity, a small negator spring is attached to the lever arm assembly to cancel the opposing field.

The lever arm had to be isolated electrically from ground in many switch applications, such as providing data for telemetering, firing a squib or controlling a transmitter.

New Ceramic Vacuum Capacitors

A GROWING MARKET for new types of vacuum capacitors with improved reliability, longer life, and greater resistance to shock and vibration has prompted Jennings Radio Mfg. Co., San Jose, Calif. to turn to ceramics for the answer.

Jennings will soon put eight ceramic vacuum capacitor configurations—four fixed and four variable—on the market alongside its established line of glass housed units.

Military requirements for small, high-powered radio transmitters, tough enough to withstand difficult assignments, are a prime impetus to development of tougher components. And looming more in the future are a variety of space applications which put a premium on toughness and long life.

Use of ceramic housing upgrades capacitor strength on all these counts, both directly and indirectly.

In preliminary tests, a prototype ceramic unit withstood 80 G's of shock for 11 milliseconds—twice the shock resistant ability of a glass housed unit. And the same unit withstood vibration of 20 G's at frequencies ranging from 5 to 2,000 cps.

There is also a direct improvement in heat tolerance; ceramic units can operate at 250 deg F, while highest ambient heat level for a glass capacitor is 180 F.

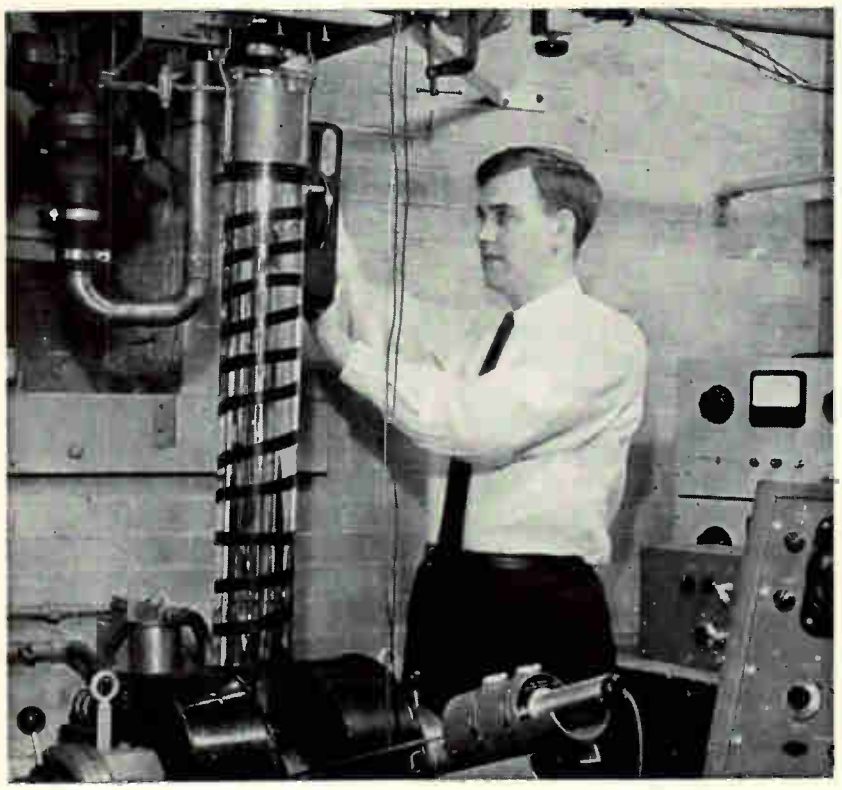
Although the ceramic capacitor was not designed for improved performance, primarily, company engineers discovered early that some palpable operational bonuses would accrue.

Because the most economical shape of a ceramic housing unit is cylindrical, a component is necessarily produced with a relatively clean angle at top and bottom of the housing. It is thus possible to locate the unit's concentric, cylindrical capacitance plates closer to the inside wall of the housing; this in turn means that more plates can be crammed into the same size capacitor, theoretically making possible a greater number of plates, but they will be of shorter length. This means that added capacitance, in effect, will be sacrificed for greater capacitance when needed, however.

Some of the forthcoming line of ceramic vacuum capacitors. Unit at left is variable, next three are fixed. Large unit on right is original experimental component which proved feasiblility of the process

Initial tests rated on ceramic capacitor at 45 amps, in the 25-35 kv range, at 180 deg F. A compara-

Materials Research at Brown Univ.



LIQUID helium cryostat with electromagnet, in laboratory of R. W. Morse of Brown's physics department, is but one tool used to study the electronic properties of metals. The operator is Arthur Myers, visiting research associate from the University of Leeds, England.

The recent $3.5 million Pentagon grant to Brown for materials investigation was the largest single grant awarded among five universities. Brown scientists already have won distinction in contributing new techniques, flowing from atomic discoveries, for testing crystalline solids, metals, plastics and other substances.

Brown's intention of keeping a prudent balance between the humanities and the sciences is shown by a recent $7.5 million award from the Ford Foundation for the pursuit of excellence in educating the whole man. Brown will draw on its alumni and the community to help it raise $15 million in matching funds.

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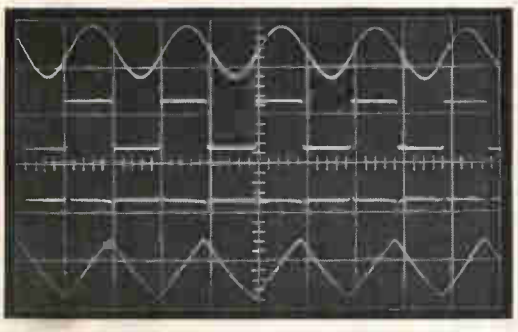

TYPE M UNIT Seventeenth in the letter-series of plug-in units, the new Type M Unit adds multiple-trace displays to the wide range of applications possible with your Tektronix oscilloscope.

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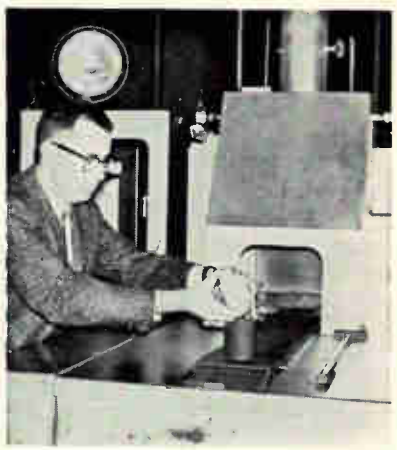
ble glass unit rated 40 amps, in the 20-30 kv range, at the same temperature.

The degree of higher capacitance made possible by higher ambient temperature of the ceramic units has been ascertained so far as that capacitance shift against temperature change will be less than with a glass unit.

Higher vacuums are possible because ceramics have greater outgassing properties than glass—that is—they give up trapped air molecules more readily under the heat of manufacture.

Although the bonding of ceramic to copper presented some formidable process problems at first, Jennings engineers later concluded that a powerful ceramic-to-copper

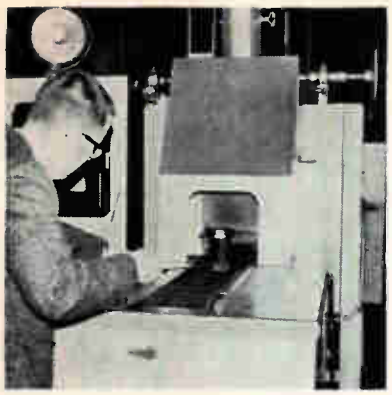


Robert W. Hansen, Jennings product engineer, demonstrates how copper subassembly and ceramic housing (on which bonding surfaces have been metalized) are put together in a baking cylinder prior to brazing

bond was no more difficult to achieve than a glass-to-copper bond. In fact, once the key process —metallizing the ceramic surface to be bonded—was solved, the manufacturing procedure turned out to be simpler in many ways than working with glass.

A physical expansion joint is utilized for the bond, the copper flange of the anode joined to the metallized ceramic surface by brazing. An additional ring of ceramic is brazed to the outer edge of the copper flange for added structural strength.

The same type of oven is used for the ceramic-to-copper braze as for the copper-to-copper brazing operation, earlier in the manufacturing



With weight on top, unit is fed into oven, where it brazes for 45 min. Moving belt automatically deposits completed unit at other end of oven. Evacuation is next

process, in which concentric capacitor plates are fixed into position.

The former operation requires higher temperature and increased atmospheres in the oven, however.

Relatively simple brazing operation—45 minutes in an oven, unwatched—contrasts sharply with the complex series of operations necessary to construct and affix glass envelopes.

Workers must carefully fire a glass bead to the metal surface to be joined, then a second worker takes over and fires the glass housing to the bead, being careful not to destroy the original glass-to-copper bond.

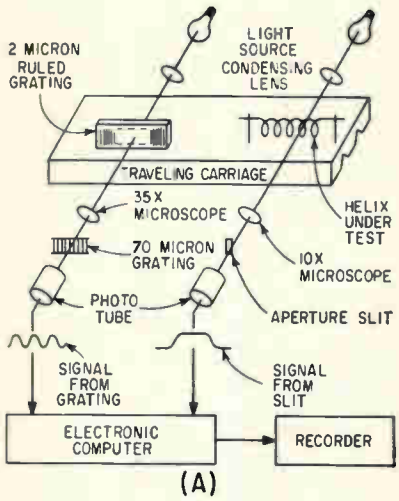
There are, however, some disadvantages to using ceramic housing. The cylindrical forms, which are made to precise specs, must be ordered well in advance. User is of necessity limited to fixed sizes and shapes, which in turn limits the scope of designs available. With glass, it is possible to design custom units in virtually any size or shape.

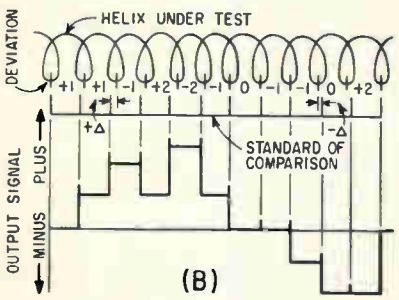
And because ceramic does not give, metal parts must be built to much closer tolerances than were previously necessary.

Indirectly tied to introduction of ceramic design, but there by virtue of expected rougher handling in store for the new units, a special mounting ring is built in.

New mounting ring also makes the units less subject to shock and vibration, once installed.

Price of the new components is expected to be the same as that of comparable glass-housed units.





Microdeviometer (A) uses light and ruled gratings to check twt helixes. Turn spacing deviations from standard produce positive or negative output signals (B)

Microdeviometer checks twt helixes quickly and accurately

Testing Traveling-Wave Tube Helixes

By C. W. COMOH, Western Electric Co., New York, N. Y.

HELIX PRECISION must be high in traveling-wave tubes if amplification is to be free of distortion. Turn-to-turn deviation must be limited to a few ten-thousandths of an inch and the helix must be free of measurable repeated error. Minute imperfections, especially periodic errors, are a principal source of internal signal reflection. Internal reflections are chiefly responsible for poor performance. Variations in pitch of helical windings for traveling-wave tubes can be measured with a microdeviometer[1] with greater speed and accuracy than with other precision techniques. Helices and helix assemblies can be completely evaluated within five minutes. The location of turns, in helices up to six inches long, can be measured within one micron (0.000039 inch).

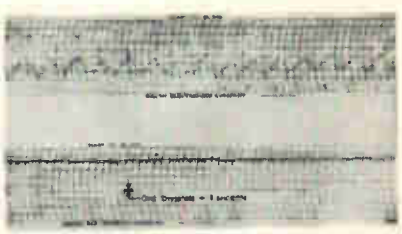
Western Electric's microdeviometer is a refinement, compatible with production requirements, of an instrument developed by Bell Laboratories. The measuring concept is shown in the drawing. A mechanical-optical system scans the helix while generating a precise measuring scale. The electronic system receives and computes the measuring information and records the deviation of each turn from a preselected ideal position.

The helix and the diffraction grating—ruled at two microns—are mounted on a movable carriage. Each of these are scanned by a fixed optical system. The slotted aperture plate is mounted in the microscope's focal plane. As the shadow-edge of a helix turn moves across the slit, a rapid light-to-dark transition causes a corresponding change in the photocell's output current. This electrical information is fed to the computer with similar information from the photocell viewing the gratings.

Gratings are ruled with extreme precision to obtain one-micron measuring accuracy. Superimposing the magnified image of a two-micron grating on the 70-micron grating also assures accuracy. If both gratings were ruled at two microns, they would have to pass within a few microns of each other to prevent diffraction effects from washing out the desired light modulation.

Carriage movement is kept free of jitter by pulling it along precision ways with a weight and pulley acting against the restraining force of a metered hydraulic system. Maximum operating speed is determined by the rate the computer can accept information from the diffraction grating.

The strip chart photo shows typ-



Deviation plot of unacceptable (top) and acceptable twt helixes

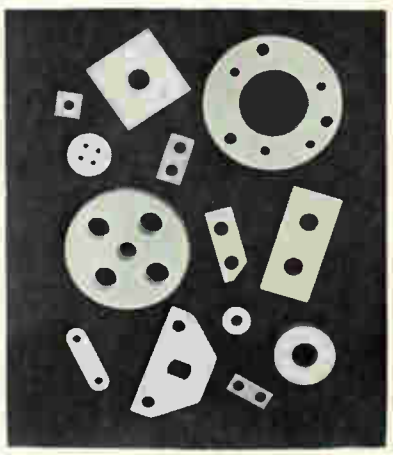
ical microdeviometer measurement records. One chart indicates periodic errors that make that helix unacceptable; other chart show an accurately wound helix. Each small chart division represents a one-micron deviation from perfect pitch.

REFERENCE

(1) H. T. Closson, W. E. Danielson and R. J. Nielsen, Automatic Measurement of Small Deviations in Periodic Structures, *Bell Telephone System Technical Publications*, Feb., 1959.

Simple Parts Molded Cheaper

Improved precision molding techniques that permit large reductions in the cost of parts molded from Mycalex or Supramica have been developed by Mycalex Corp. of America. Savings on some parts run as high as 84 percent. The techniques can be employed with Mycalex 410 glass-bonded mica and Supramica 555, 560 and 620 "BB" ceramoplastics. These materials



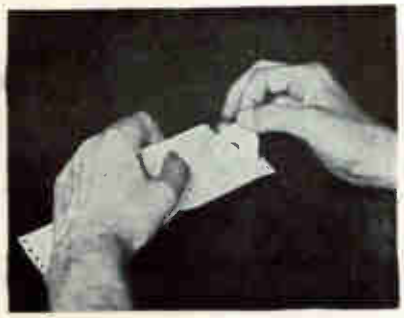
are suitable for producing such dielectric parts as relay spacers and motor end-plates. Parts with a small amount of contouring, or with small male or female excursions in topology, can also be produced.

Complex and involute shapes such as coil forms require the older and more complicated molding method, as do most parts into which metal members must be molded. Material characteristics of reliability, dielectric strength, low loss, mechanical strength, thermal endurance and dimensional stability are unchanged in the new tech-

niques. Some of the shapes that can be produced are shown.

Wire Spool Labels

Pressure-sensitive wire spool labels have been specially developed by Avery Label Co. for Western Electric, service organization for the Bell Telephone Co. The labels are fed through a high-speed data processing system where the information for making up wire spools is stored. Information on footage, job number, and similar data is on punch cards, and this is transferred to the labels by a high-speed printer. The Tabulabels then go to the wire department, which cuts the wire, winds it on spools, and fixes the labels to the spools. The advantage of the technique is that the information can be put on the labels automatically, rather than by individual typing or stamping.

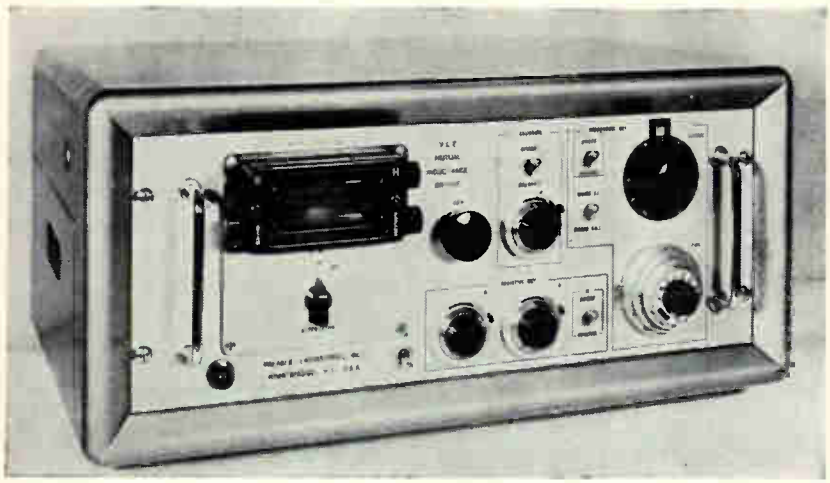


Solder Suction Cup

Attachment for soldering guns, made by Cyclops Mfg. Co., Detroit, Mich., sucks away old solder from printed circuit board terminals during repairs. As a tubular tip melts the solder, the operator squeezes a bulb to transfer the molten solder into a porcelain cup. The tube can be removed to empty solder from the cup

NEC

New On The Market



VLF Inductance Bridge

FOR CRYOGENIC APPLICATIONS

TRANSISTORIZED, high sensitivity, low noise vlf mutual inductance bridge for measuring susceptibility of paramagnetic materials at cryogenic temperatures is introduced by Cryotronics, Inc., 191 Mill Lane, Mountainside, N.J. The unit can also be used for the measurement of superconductors where frequency dependent parameters require very low frequencies. The signal generator can be tuned to either 17 or 155 cycles, with provision for quadrature component compensation. Sensitivity is approximately 2×10^{-4} microhenry, with reproducibility one part in 1,000.

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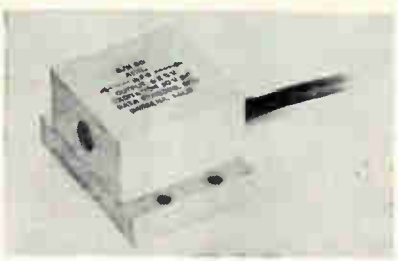
Ruggedized 7-In. CRT

ELECTROSTATIC FOCUS

HIGH-RELIABILITY crt (type WX 4545) is ruggedized 7-inch display tube with electrostatic focus and magnetic deflection. When mounted in a nonamplifying structure, tube will exceed MIL-E-5422 paragraph 4.2.1.1. The tube has a 70 degree deflection angle and decreased deflection power, making it suitable for transistorized applications. Faceplate is of clear glass and uses an aluminized screen. Anode operates at 8,000 volts. Manufacturer is Westinghouse Electronic Tube Div., P. O. Box 284, Elmira, N.Y.

CIRCLE 302 ON READER SERVICE CARD



Linear Accelerometers

PHOTORESISTIVE

MODELS AH1L and AH2L linear accelerometers use photoresistive principle to produce 5 volts or ±2.5 volts output without amplification, with 10 volts d-c excitation. Operating temperature is from −65 to 250 F. Instruments are suited for flight test instrumentation, vibration surveys, drop and shock tests, fatigue studies, and flight recorders.

Light, focused upon an area of photoresistive semiconductor material, is modulated by mass displacement resulting from acceleration. Delivery within 30 days, from Data Sensors Inc., 13112 Crenshaw Blvd., Gardena, Calif.

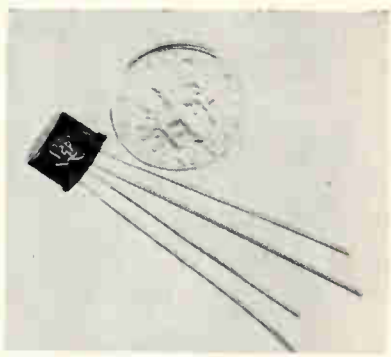
CIRCLE 303 ON READER SERVICE CARD

Two Image Orthicons

FIBER-OPTIC FACE

TWO IMAGE ORTHICONS with fiber-optic face plates have been developed by the General Electric Co., Schenectady 5, N.Y. Face plates up to 3 inches in diameter are available. Both tubes use a thin-film target of magnesium oxide, and produce clear pictures at light levels below 10^{-6} foot-candles. Type ZL-7809 has an S-10 photo surface that peaks at 4,500 angstroms; ZL-7810 uses an S-20 photo surface peaking at 4,250 angstroms. The tubes can be built with spectral sensitivity from the ultraviolet to infrared.

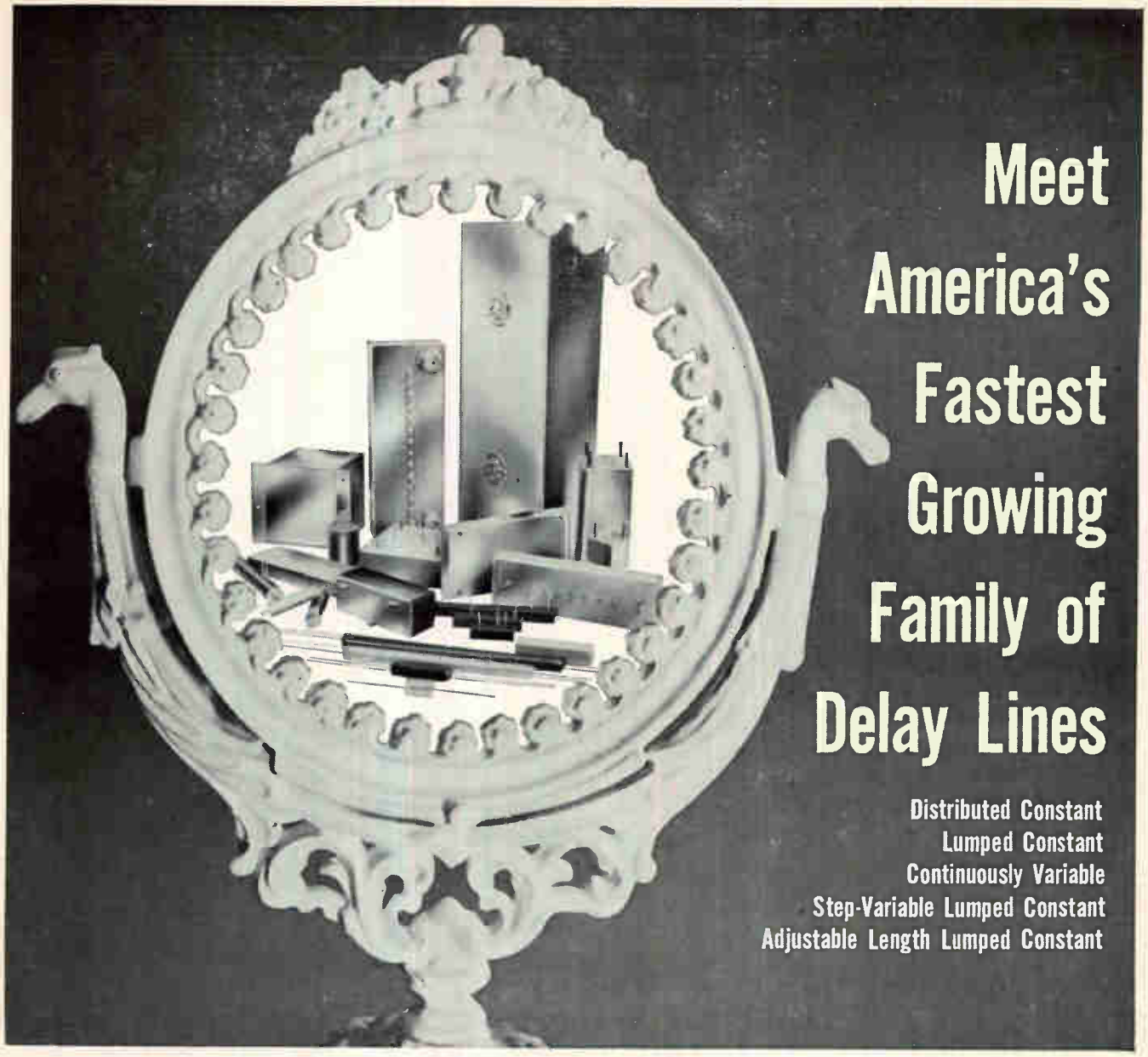
CIRCLE 304 ON READER SERVICE CARD



Field Effect Transistor

DIFFUSED SILICON

DEVELOPMENTAL type TIX 690 field effect transistor is an n-channel diffused silicon device with dual gate control. The transistor is a high-input-impedance, high-gain unit for the input stages of audio and d-c amplifiers, switching applications, voltage-controlled resistances, age circuits, voltage-controlled bandwidth amplifiers, analog multipliers, and other applications. Typical characteristics are a pinch-off volt-



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Whether you need immediate delivery from stock or custom-built designs, JFD has the delay line that pays off in premium performance. Increasing industry-wide acceptance is the proof!

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Perhaps this specialized skill and imagination can help solve your delay line problems? *Call any one of the five JFD sales offices or one of the twenty-five sales representatives nearest you for complete technical data.*

Write today for bulletins 212 or 213A covering our standard models of Lumped and Distributed Constant Delay Lines.

Tapped, Stepped Variable, Lumped Constant and Continuously Variable Lumped Constant Delay Lines can be custom designed to fit your needs, as well as filters and pulse forming networks of all types.

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Van Nuys, Calif., Phone: STate 1-3530

JFD MIDWESTERN
6414 W. Higgins Ave., Chicago, Illinois
Phone: SPring 4-4761

JFD NEW ENGLAND
Ruth Drive, Marlboro, Mass.
Phone: HUntley 5-7311

JFD CANADA
51 McCormack St., Toronto, Ontario, Canada
Phone: ROger 9-1129

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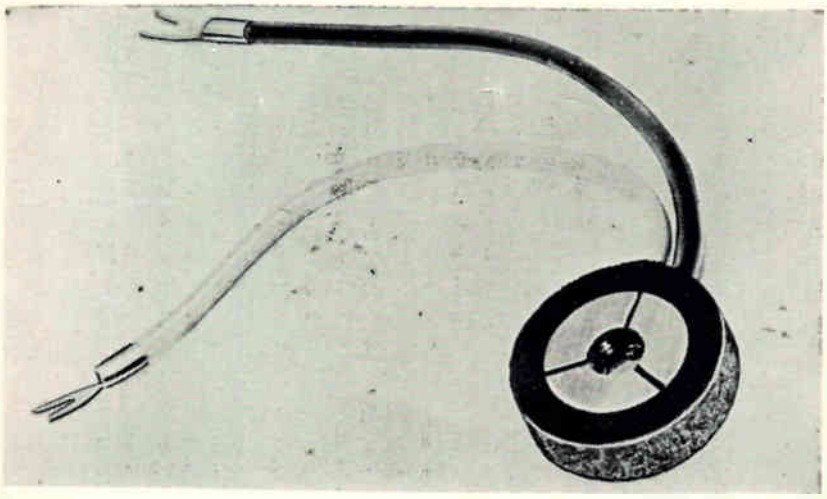
CIRCLE 97 ON READER SERVICE CARD

age of 4 v, a drain-to-source voltage of 20 v, and a transconductance of 2,500 micromhos. Unit is available in limited sample quantities from Texas Instruments Inc., P.O. Box 5012, Dallas 22, Tex.

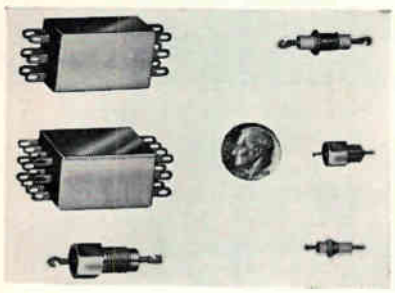
CIRCLE 305 ON READER SERVICE CARD



Thermoelectric Cooling Unit
FOR DIODES AND TRANSISTORS

FRIGISTOR F-3DC conforms to the component case shape for stud-mounted diodes and transistors, thus simplifies application and adds reliability. The cooler consists of 3 TE couples. Heat is pumped out and rejected to chassis, fins, or other heat sink. The unit will pump 4.25 watts across a temperature difference of 0 C; at zero watts load it will provide a temperature difference of 65 C. Manufacturer is General Thermoelectric Corp., P. O. Box 253, Princeton, N.J.

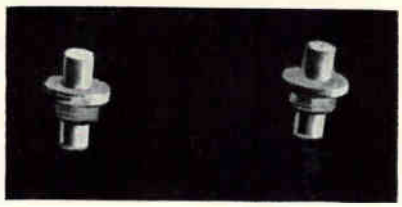
CIRCLE 306 ON READER SERVICE CARD



Line of UHF Filters
100 TO 2,000 MC

LINE OF THREE-TERMINAL, high frequency, low pass filters are designed to eliminate parallel resonance peaks in the uhf range of 100 to 2,000 Mc. Filters exceed the performance of a theoretical 1,000 pf capacitor in transfer impedance when measured in accordance with MIL-STD-220A. Filters use flat temperature characteristic Hi-K ceramic dielectrics and temperature stable ferrites, with minimum change in filtering due to temperature. Filtercons, by Erie Resistor Corp., Erie, Pa, are available in temperature ratings to 125 C, are priced from $.60 to $12.50.

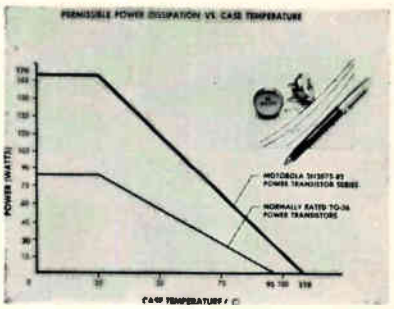
CIRCLE 307 ON READER SERVICE CARD



GaAs Varactors
30 VOLTS, ONE WATT

HIGH FREQUENCY gallium arsenide varactors with a 30 volt working voltage are diffused junction mesa structures in coaxial pin packages. They are for use in harmonic generators, r-f limiters, microwave switches and phase shifters, and have a power disposition of 1 watt. Types MS-2602 to MS-2606 have cutoff frequencies from 40 to 120 Gc. Other types have cutoff frequencies from 10 to 60 Gc. Availability in 1 to 4 weeks, from Micro State Electronics Corp., 152 Floral Ave., Murray Hill, N.J.

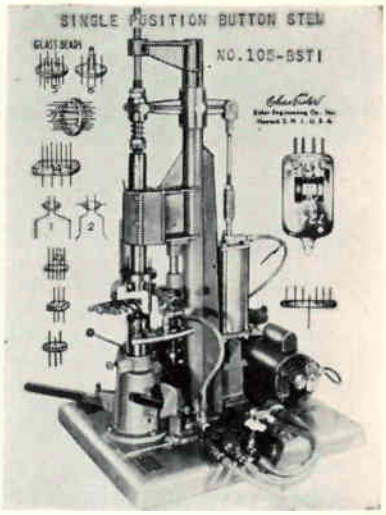
CIRCLE 308 ON READER SERVICE CARD



Power Transistors
GERMANIUM UNITS

MOTOROLA SEMICONDUCTOR PRODUCTS INC., 5005 E. McDowell Road, Phoenix 8, Ariz., offers a series of eight germanium power transistors with junction temperature ratings of 110 C and maximum power dissipation ratings of 170 w. They are packaged in the TO-36 (doorknob) case. Units are capable of 30 w power dissipation at 95 C case temperature.

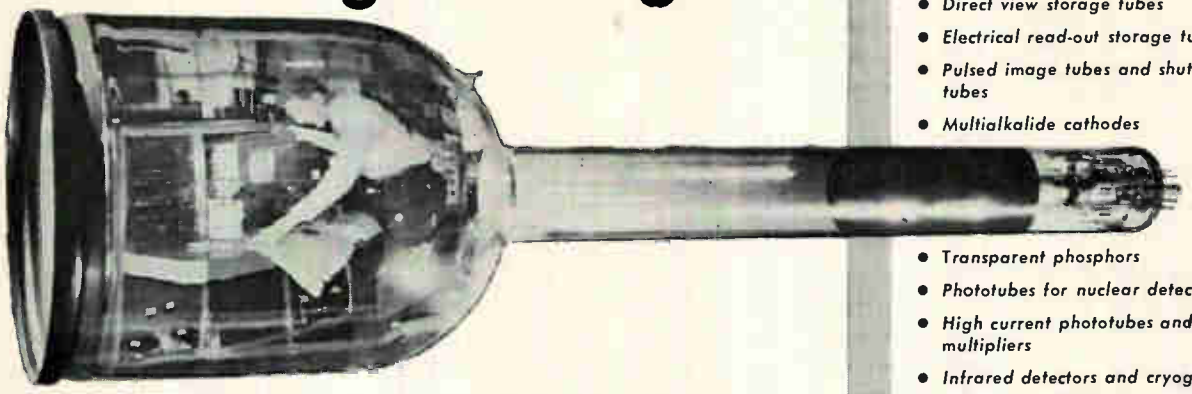
CIRCLE 309 ON READER SERVICE CARD



Button Stem Machine
SINGLE POSITION

EISLER ENGINEERING CO., INC., 750 S. 13th St., Newark 3, N. J., announces No. 105-BSTI single position button stem and wafer making machine. Operation: All components, lead wires, exhaust tube and glass cylinders are loaded into lower press die. The preset fire heats glass parts to proper con-

"bottled engineering"



- *Ultraviolet photodiodes and multipliers*
- *Infrared and visible photomultipliers*
- *Direct view storage tubes*
- *Electrical read-out storage tubes*
- *Pulsed image tubes and shutter tubes*
- *Multialkalide cathodes*
- *Transparent phosphors*
- *Phototubes for nuclear detection*
- *High current phototubes and multipliers*
- *Infrared detectors and cryogenics*
- *Infrared to visible image converter tubes*
- *Star tracking photomultipliers*
- *Image dissector tubes for spectrometry*
- *Image intensifiers and light amplifier tubes*

If you require something really special or unique in vacuum tubes, ITT can give you precisely the kind of advanced original thinking and hardware needed to satisfy your application. For 20 years our staffs have provided the level of engineering-in-a-bottle which establishes the threshold of knowledge in this field. ITT has created hundreds of tube types for radiation detection, light amplification, display and for many other purposes, including the representative types listed at right. With this unique facility at your disposal you need not design electronic systems around tube components that only "approach" your needs. You can get exactly the kind of "bottled engineering" required, from ITT. Send your requirements directly to Mr. Dean Davis, Tube Laboratory Manager.

If you design electronic systems requiring special purpose vacuum tubes, a new ITT-developed slide chart, "Phosphors and Photocathode Characteristics", will be of interest and value. Send requests to Component Sales.

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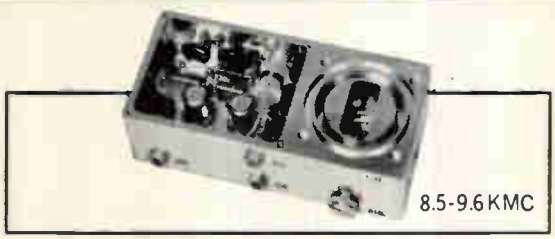
CIRCLE 206 ON READER SERVICE CARD

Very Small, Low Noise Mixer-Preamplifier



Newest in LEL's broad line of mixer-preamplifiers, the XBO-8 combining an Orthomode mixer and a Nuvistor preamplifier provides excellent noise figure, small size, very low power drain at lower cost. Other models are available for operating ranges from 3.95 to 10.5KMC.

SPECIFICATIONS

Gain	22db
IF	30, 60 or 70mcs
Bandwidth	12mcs
Noise figure	Less than 8db
Power	+40 VDC at 12ma 6.3 VAC at 0.4amp
Size	1-7/8" x 1-1/8" x 4"
Weight	10ozs.
Material	Aluminum, silver plate, rhodium flash

Send for 48 page Microwave RF/IF Equipment Catalog

LEL INC. / Akron Street
Copiague, L. I., N. Y.
AMityville 4-2200

CIRCLE 207 ON READER SERVICE CARD

BLOCK VACUUM VALVES

BELLOWS SEALED

Maximum Flow...
Minimum Space... Low Cost

NRC Equipment Corp.'s block valves assure you:

- Porosity-free body . . machined from sulphur-free solid brass.
- Freedom from stem leakage . . . positive bellows seal.
- Full opening . . . sizes from ¼" to 1½".
- Easy mounting . . . available in angle or in-line types — for soldered or screwed connections.
- Low-cost maintenance . . . bellows removable without removing valve from line.
- Neoprene disc gasket . . . teflon, viton or other materials available on request.

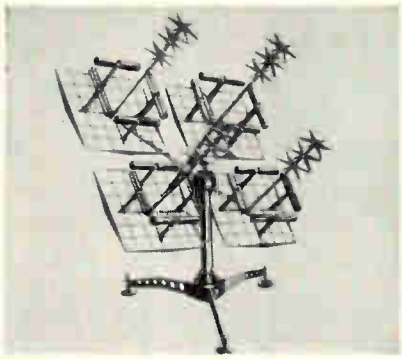
Write for data sheet on NRC Block Valves,
160 Charlemont Street, Dept. 4-H
Newton 61, Massachusetts
DEcatur 2-5800
A Subsidiary of National Research Corporation

NRC
EQUIPMENT CORPORATION

CIRCLE 99 ON READER SERVICE CARD

sistency. Upper press die is lowered by actuating air control valve. Finished stem is removed after rotation is stopped by action of clutch arrangement.

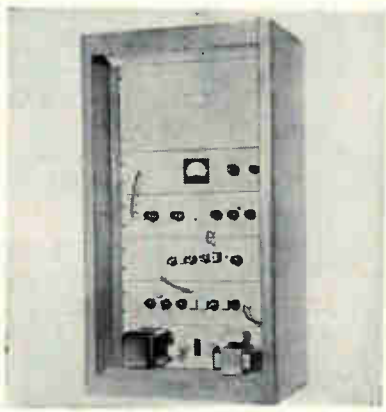
CIRCLE 310 ON READER SERVICE CARD



Antenna Arrays
DUAL POLARIZATION

AVIEN, INC., 58-15 Northern Blvd., Woodside 77, N. Y. Series 320 antenna arrays are designed to meet requirements in semi-fixed and mobile tracking and telemetry systems. Designed around the Bogner bipolarized end-fire element modules, they provide high gain, multi-octave frequency coverage, excellent side lobe control, rapid variation of beam width and accurate tracking in a small, light weight, transportable assembly.

CIRCLE 311 ON READER SERVICE CARD



Translator
VHF-TO-VHF

ADLER ELECTRONICS, INC., 1 LeFevre Lane, New Rochelle, N.Y. The VST-1 is a vhf-to-vhf translator for extending tv station coverage areas beyond distance and terrain barriers. Designed for unattended off-air pickup, it features operation on any vhf tv channel, 1 w output, heterodyne conversion, remote control facility, use of standard vhf receiving and transmitting antennas. Price is $2,100.

CIRCLE 312 ON READER SERVICE CARD

R-F Filters

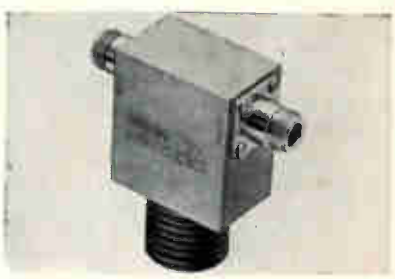
TELONIC ENGINEERING CORP., Laguna Beach, Calif., offers a series of r-f and microwave filters with hermetically sealed adaptors for miniature connectors.

CIRCLE 313 ON READER SERVICE CARD

Induction Generator
CONTINUALLY OPERABLE

INDUCTION HEATING CORP., Brooklyn, N. Y., has available a 40 Mc induction generator capable of continuous operation at 3 Kw output. Company engineers have been able to achieve extremely shallow case depths in hardening steel, and thin materials can be joined with a minimum of power and distortion. Unit was built for research in gas ionization and useful in plasma torch work.

CIRCLE 314 ON READER SERVICE CARD



Broadband Isolator
HIGH POWER

RANTEC CORP., Calabasas, Calif. Model IS-918 broadband coaxial isolator covers the band 2.7 to 3.4 Gc with isolation in excess of 20 db, insertion loss less than 0.3 db, vswr 1.25:1 max. Power handling capability is 150 w average with a

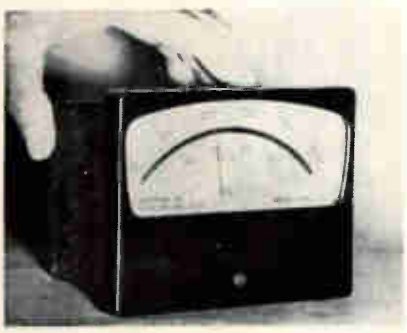
2:1 load vswr. The isolator is less than 3.4 in. long and operates from −55 C to +71 C.

CIRCLE 315 ON READER SERVICE CARD

Signal Generator
DIRECT READOUT

BABCOCK ELECTRONICS CORP., 1640 Monrovia Ave., Costa Mesa, Calif. The BSG-9 is a 406 to 549.5 Mc signal generator that electronically displays generated frequencies in 5-digit direct readout form. It is a self-contained uhf test generator and power supply, and features continuous tuning across the frequency band, generating continuous wave or f-m signals. Accurate to ±0.005 percent, the r-f output signal can be modulated to ±300 Kc by externally generated audio signals within the 300 to 100,000 cps range.

CIRCLE 316 ON READER SERVICE CARD



Electronic Pyrometer
PANEL-MOUNTING

METRONIX, INC., Chesterland, O. Temperatures may be measured and controlled at distances up to 10,000 ft with the model 600 transistorized pyrometer. Unit operates on signals from a thermocouple. Because of its high input resistance, it permits use of thermocouples with extremely long lead

lengths that formerly required much more complex instruments. Chopper stabilized, it requires no zero adjustment after it has been set at the factory. Price is $300.

CIRCLE 317 ON READER SERVICE CARD

D-C Controllers

KEITHLEY INSTRUMENTS, 12415 Euclid Ave., Cleveland 6, O. Millivolt discriminators are designed for automatic testing and process control.

CIRCLE 318 ON READER SERVICE CARD

Detector
& PHOTOMULTIPLIER

NATIONAL RADIAC, INC., 475 Washington St., Newark 2, N. J. In the series NRM light tight assemblies the scintillating detector is mounted directly to the photomultiplier tube and is hermetically sealed. A magnetic shield encloses the tube and is protected with an aluminum housing.

CIRCLE 319 ON READER SERVICE CARD

Volt-Ohmmeter

J-OMEGA CO., Los Altos, Calif., announces a low cost 0.1 percent semi-digital solid state volt-ohmmeter.

CIRCLE 321 ON READER SERVICE CARD

A-C Capacitors
SOLID TANTALUM

GENERAL INSTRUMENT CORP., 65 Gouverneur St., Newark, N. J.

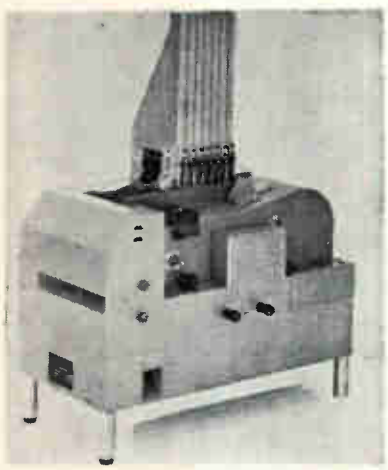
Continuous duty solid slug tantalum a-c capacitors have been developed. They operate at ambient temperature extremes ranging from — 80 C to + 125 C, and will operate as high as 85 C without derating. Units come in 4 case sizes (ranging from 0.155 in. in diameter and 0.600 in. long to 0.350 in. in diameter and 1.600 in. long). Capacitance range is from 1.2 μf to 170 μf.

CIRCLE 322 ON READER SERVICE CARD

P-C Connector

VIKING INDUSTRIES INC., 21343 Roscoe Blvd., Canoga Park, Calif. Connector provides two sets of twin receptacles to accommodate 1/16 in. p-c boards.

CIRCLE 323 ON READER SERVICE CARD



Automatic Sorter

FOR AXIAL-LEAD UNITS

DEVELOP-AMATIC ENGINEERING, 923 Industrial Ave., Palo Alto, Calif., announces the Test-Amatic, a device for sorting any like axial-lead components according to each unit's electronic value. Operating speed depends on the type of component under test; sorting resistors in standard, sequenced operation, the Test-Amatic handles 3,396 units per hr, one every 1.06 sec. Price is $1,475.

CIRCLE 324 ON READER SERVICE CARD

High Gain Amplifier

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif. Plug-in amplifier combines high common

mode rejection with 5 mv/cm sensitivity and low drift.

CIRCLE 325 ON READER SERVICE CARD

Servo Amplifier
TRANSISTORIZED

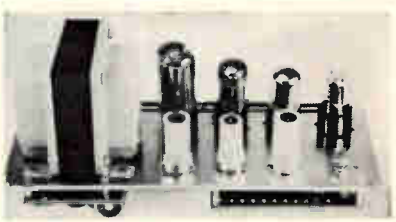
CONTROL TECHNOLOGY CO., INC., 41-16 29th St., Long Island City 1, N. Y. Model 930 will drive 3.5 w servo motors from low level 400 cps signals at ambient temperature of − 55 C to 125 C. It features 250,000 ohm input impedance, 3.5 w output, gain of 8,000, and 125 C operation. It will withstand MIL-E-5272 environmentals.

CIRCLE 326 ON READER SERVICE CARD

D-C Supply

ALFRED ELECTRONICS, 897 Commercial St., Palo Alto, Calif. Current regulated supply powers focusing solenoids for microwave tubes.

CIRCLE 327 ON READER SERVICE CARD



Power Modules
HIGHLY REGULATED

CALIFORNIA MAGNETIC CONTROL CORP., 11922 Valerio St., N. Hollywood, Calif. Series 5VT modular power supplies, designed to mount in customer equipment, deliver 150 to 425 v d-c, at 100 to 400 ma. Output regulation is 0.05 percent, line and load. Units feature less than 1 mv ripple, with either output terminal grounded or with both terminals floating.

CIRCLE 328 ON READER SERVICE CARD

Multipole Couplers

SPERRY MICROWAVE ELECTRONICS CO., Clearwater, Fla. Series of Micro-

line precision multihole couplers is characterized by flatness of coupling and high directivity over broad frequency ranges.

CIRCLE 329 ON READER SERVICE CARD

Grinder & Polisher
BUILDING BLOCK DESIGN

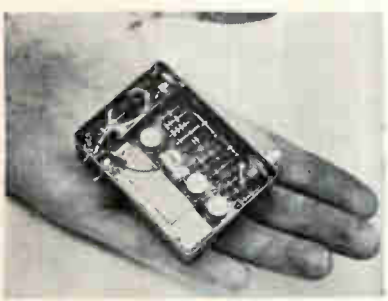
GEOSCIENCE INSTRUMENTS CORP., 142 Maiden Lane, New York 38, N. Y., announces the UNI-POL machine for fine lapping and polishing of semiconductor materials. It incorporates an 80-1,200 rpm variable speed control with a powerful semiconductor safeTcircuit ½ h-p d-c motor providing a constant torque at all loads. It is vibration and rollout resistant. Pan, lap, polishing wheel and cover can be changed as one unit in seconds.

CIRCLE 330 ON READER SERVICE CARD

Regulated Supply

PERKIN ELECTRONICS CORP., 345 Kansas St., El Segundo, Calif. Heavy-current silicon rectifier power supply has a dynamic load regulation of ± 6 v.

CIRCLE 331 ON READER SERVICE CARD



Memory Device
SERIAL TYPE

ANDERSEN LABORATORIES, INC., 501 New Park Ave., West Hartford 10, Conn., announces a transistorized serial type memory device. Utilizing a quartz delay line, this device stores 65 bits of information at a

10 Mc counting rate with an access time of less than 4 μsec. It may replace other components now used in digital computers which are substantially larger in size and cost.

CIRCLE 332 ON READER SERVICE CARD

Dual Polarized Horns

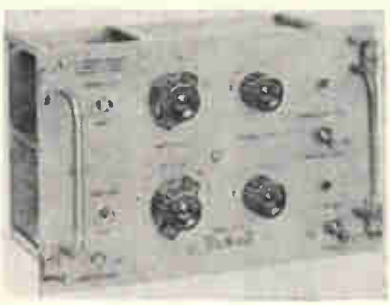
ANTENNA SYSTEMS, INC., Hingham, Mass., offers a line of dual polarized horns in all standard waveguide sizes from WR-430 through WR-2300.

CIRCLE 333 ON READER SERVICE CARD

K-Band Klystron
EXTREMELY RUGGED

RAYTHEON CO., Foundry Ave., Waltham 54, Mass. The QKK834 is a Ka-band klystron for local oscillator-transmitter service in aerospace applications. It uses a sapphire rod for smooth wide-range tunability from 34 to 35.6 Gc, and can be electronically tuned over any 110 Mc portion of its range. Tube requires a resonator voltage of only 400 v, and has a minimum power output of 10 mw.

CIRCLE 334 ON READER SERVICE CARD



Phase Unit
HIGHLY ACCURATE

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif. Model 526D phase unit for phase angle measurement with accuracy approaching ± 0.1 deg is designed as a plug-in for models 524B/C/D electronic counters. It equips the counter to measure any lead or lag phase angle between two signals in

the 1 cps to 20 Kc range. For frequencies from 396 to 404 cps, a × 3600 frequency multiplier provides readings direct in tenths of degrees.

CIRCLE 335 ON READER SERVICE CARD

Power Supply Modules

NJE CORP., 20 Boright Ave., Kenilworth, N. J. Line of transistor regulated power supply modules feature remote sensing and remote programming.

CIRCLE 336 ON READER SERVICE CARD

Converter-Voltmeter

HOUSTON INSTRUMENT CORP., P. O. Box 22234, Houston 27, Texas. Model HVC-30 a-c/d-c converter voltmeter provides 25 μv resolution on lowest scale with 0.5 percent ripple down to 5 cps.

CIRCLE 337 ON READER SERVICE CARD

Pattern Converter
DISPLAY TO DIGITAL

RABINOW ENGINEERING CO., INC., 7212 New Hampshire Ave., Washington 12, D. C. Converter transforms information from a display (map, chart, oscilloscope or graph) into digital X-Y coordinate scan points. Output can be to any conventional storage such as punched cards, punched paper tape, or magnetic tape. If required, the equipment could be on-line with any specified computer.

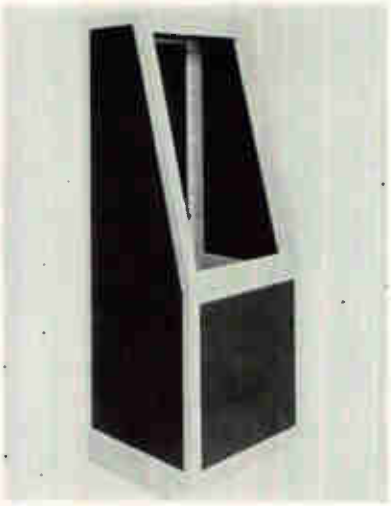
CIRCLE 338 ON READER SERVICE CARD

Microwave Windows

CERAMICS INTERNATIONAL CORP., 39 Siding Place, Mahwah, N. J. Ceramic microwave windows with

metal window envelopes are produced in sizes from 3/16 in. to 3 in. diameter, down to 0.010 in. thickness.

CIRCLE 339 ON READER SERVICE CARD



Vertical Rack
SLOPED FRONT

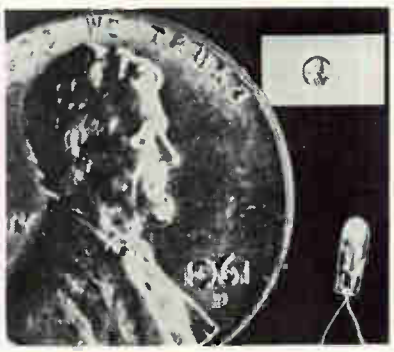
EQUIPTO ELECTRONICS CORP., 319 N. Webster St., Naperville, Ill. Sloped front vertical rack provides easier surveillance of instrumentation in large installations of meters, regulators, scopes and related equipment where easy read-out is of extreme importance.

CIRCLE 340 ON READER SERVICE CARD

Pre-Patch Panel

ELECTRONIC ASSOCIATES, INC., Long Branch, N. J. Removable panel for TR-10 general purpose analog computers permits problems to be programmed in advance.

CIRCLE 341 ON READER SERVICE CARD



Microminiature Lamp
LOW CURRENT DRAIN

MINIATURE LAMP ENGINEERING CO., 350 Broadway, New York 13, N. Y., introduces Micro Lamps that op-

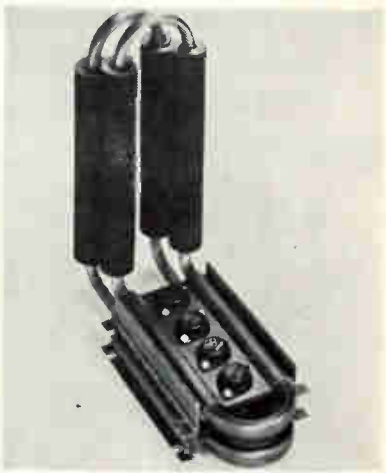
erate on 1.2 or 1.5 v, drawing only 5 ma—useful for operation on miniature batteries, or with transistors. The lamps are extremely small, starting with a lamp envelope diameter of 0.0139 in. with a length of 0.138 in. They give a light output of 40 to 45 millilumens, and have a life time of 1,000 hr, minimum. They can serve as indicator lamps, in computer read-out devices, or in photoelectric systems.

CIRCLE 342 ON READER SERVICE CARD

Electronic Micrometer

J. W. DICE CO., Englewood, N. J. Measuring system displays exact measurements to 10 millionths of an inch on a 5-digit counter and automatically plots the values on a chart recorder.

CIRCLE 343 ON READER SERVICE CARD



Heat Dissipator

USES COOLING LIQUID

INLAND CERTIFIED ELECTRONICS, 323 W. Washington Blvd., Pasadena, Calif., announces a thermal syphon for the dissipation of unwanted heat generated by transistors and diodes. It uses a cooling liquid to remove heat at a more efficient rate than air-cooled heat sinks. It is available in any length and includes a feature that permits the stacking of multiple units for compactness of installation.

CIRCLE 344 ON READER SERVICE CARD

Base Mount

ADVANCED VACUUM PRODUCTS, INC., 430 Fairfield Ave., Stamford, Conn. Semiconductor base mount consists of a metallized ceramic

EAST VS. WEST

DIAGRAMS VS. EQUATIONS

THE COMPUTER'S ANSWER TO A LONG-STANDING COMPUTER ISSUE.

For a decade East Coast and West Coast computer designers have been using different methods of representing computer logic—the Easterners with diagrams, the Westerners with equations.

```
LBSMI=
      (LXA1)(LXA2*)(LFCA*)
     +(LXA1*)(LXA2)(LFCA*)
     +(LXA1*)(LXA2*)(LFCA)
     +(LXA1)(LXA2)(LFCA)
LFCAJ=
      (LXA1)(LXA2)
LFCAK=
      (LXA1*)(LXA2*)
```

In the example illustrated here, the diagram and the equation tell us exactly the same thing. Either represents a serial full adder where the sequence of pulses at the output, LBSM, will represent a serial binary number that is the sum of two serial binary input numbers occurring at LXA1 and LXA2. (The asterisks indicate binary complements; for example, whenever LXA1 is energized LXA1* is not, and vice versa. LFCA is a carry flip-flop.)

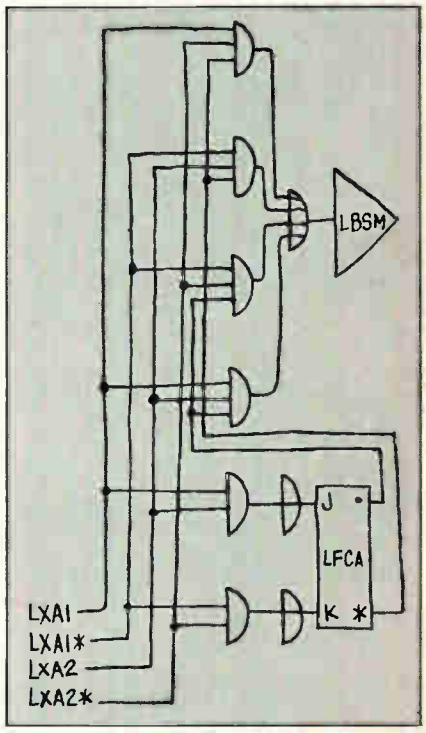
There are persuasive arguments on both sides. Eastern proponents of diagrams point out that the logical interconnections can be seen at a glance and followed through any number of stages by eye. The logical structure of an entire system can be understood from a diagram more directly and intuitively, they maintain, than from a set of equations.

The Western argument for equations goes like this. It's not true that diagrams communicate better to the viewer's intuition, except at first exposure. The human mind is highly adaptive. After working analytically with the equations for a while, the mind begins to operate intuitively in that symbology. Then the intrinsic superiority of equations over diagrams begins to make itself evident. One advantage, say the Westerners, is that equations can represent the same information more compactly and efficiently, as our illustration shows. Another is that equations lend themselves better to computer manipulation of logical design information.

As evidence of the latter advantage Westerners point to a recent achievement of some Litton Systems people: a completely mechanized procedure for translating logical designs into wiring lists, including operational simulation of the design to verify its accuracy. A procedure enormously facilitated by the computerizability of logical equations. It's easy to picture the benefits in cost, delivery schedules, reliability, price. Using only a partial development of this method Litton Systems recently brought a major computer system from concept to operation in less than a year.

Now under consideration at Litton: a machine that will accept as inputs a supply of standard computer components and a set of coded specifications defining the logical functions desired, and will crank out completely fabricated systems.

Maybe you think we've loaded the argument in favor of equations. You're right. But we're ready to listen to arguments on either side. Drop us a card. Or better still, drop in in person. You'll like the



imagination-stretching atmosphere generated by Litton management's appreciation of the rewards of creative controversy. And we have a few excellent opportunities for computer design people. Ask for S. L. Hirsch at Litton Systems, Inc., Data Systems Division, 6700 Eton Ave., Canoga Park, California.

An equal opportunity employer



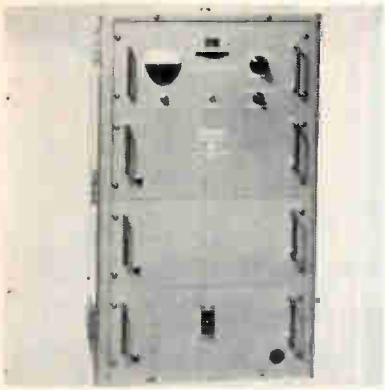
LITTON SYSTEMS, INC.

A DIVISION OF LITTON INDUSTRIES

DATA HANDLING & DISPLAY SYSTEMS · GUIDANCE & CONTROL SYSTEMS · COMPUTER SYSTEMS · SPACE SCIENCE · BIOELECTRONICS · ADVANCED COMMUNICATIONS TECHNOLOGY

wafer or washer in the order of 0.010 in. thick.

CIRCLE 345 ON READER SERVICE CARD



Electronic Generator

THREE-PHASE

INDUSTRIAL TEST EQUIPMENT CO., 55 E. 11th St., New York 3, N. Y. Model 150-3 has a frequency range of 45 cps to 2,000 cps and a total output power of 480 v-a. Frequency range is covered on two scales which provide high resolution and easy setability of any frequency within the range. New techniques insure accurate 3-phase displacement of output over entire frequency range. Output distortion and regulation are less than 1 percent.

CIRCLE 346 ON READER SERVICE CARD

Epoxy Resins

UNION CARBIDE PLASTICS CO., 270 Park Ave., New York 17, N. Y. Two new epoxy resins are for filament winding systems requiring high tensile elongation and good handling characteristics.

CIRCLE 347 ON READER SERVICE CARD

Fault Indicator

LATCH-IN TYPE

MINNEAPOLIS-HONEYWELL REGULATOR CO., Grenier Field, Manchester, N. H., has developed a miniature

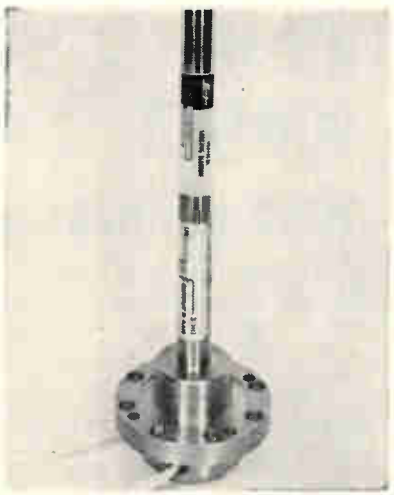
magnetic latch-in fault indicator. The disk type flag, which may be color coded or imprinted to designate the function being monitored, rotates behind a sector window. When unenergized, the flag is magnetically held in the "off" position. When energized, it rotates to the "on" position and is held there magnetically even if the energizing source is removed.

CIRCLE 348 ON READER SERVICE CARD

Shielded Coil Form

CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass. Double tuned shielded coil form is suitable for transformer applications that require tuning from both ends.

CIRCLE 349 ON READER SERVICE CARD



Vertical Sensing Element
HIGH SENSITIVITY

KEARFOTT DIVISION, General Precision, Inc., 1150 McBride Ave., Little Falls, N. J. The C701807000 vertical sensing element is a high accuracy, two-axis, electrical plumb bob. A frictionless wire-suspended pendulum acts as the moving portion of two orthogonally mounted differential transformers to provide phase sensitivity a-c output signals proportional to the tilt angle. A typical application is initial alignment of a gyro platform.

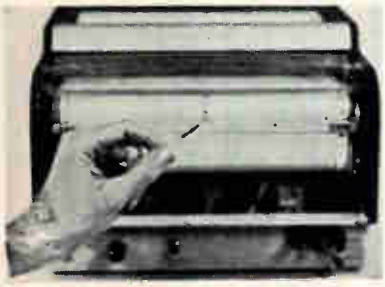
CIRCLE 350 ON READER SERVICE CARD

Terminal Header

ACE ELECTRONICS ASSOCIATES, INC., 99 Dover St., Somerville 44, Mass. Molded plastic terminal header ex-

tends potentiometer temperature and humidity tolerances.

CIRCLE 351 ON READER SERVICE CARD



Measuring System

CRYOGENIC

TEXAS INSTRUMENTS INC., P. O. Box 6027, Houston 6, Texas, has developed a low-temperature cryogenic measuring system. It includes a germanium thermometer and a special "servo/riter" potentiometric recorder. The thermometer is available in three versions: calibrated, uncalibrated, and standardized.

CIRCLE 352 ON READER SERVICE CARD

Coaxial Connectors

GENERAL RADIO CO., West Concord, Mass. Type 874 connectors now include locking cable and panel, and recessed locking panel types.

CIRCLE 353 ON READER SERVICE CARD

Electronic Voltmeter

12 RANGES

ORION ELECTRONIC CORP., 108 Columbus Ave., Tuckahoe, N. Y., introduces an electronic voltmeter with its voltage scale calibrated in rms voltage of a pure sine wave. Model V-100 provides measurements from 0.001 to 300 a-c volts over a frequency range of from 10 cps to 4 Mc. A direct reading of from — 72

db to + 52 db in 12 ranges provides convenient measurements of dbm.

CIRCLE 354 ON READER SERVICE CARD

Inverters

NJE CORP., 20 Boright Ave., Kenilworth, N. J. Line of d-c to a-c solid state inverters provides input current of any a-c frequency from 50 to 2,000 cps.

CIRCLE 355 ON READER SERVICE CARD

Decimal Indicators
TRANSISTORIZED

HOWARD INSTRUMENT CO., Red Bank, N.J. The 500 series decimal indicators accepting 0.1 mw binary-coded-decimal input and producing a projection-type decimal display is announced. Available from 3 digits to 6 digits, with parallel or serial inputs. The projection display provides in-line numerals in one plane, visible at wide angles.

CIRCLE 356 ON READER SERVICE CARD

Mesa Transistors

MOTOROLA SEMICONDUCTOR PRODUCTS INC., 5005 E. McDowell Road, Phoenix 8, Ariz., has available 1,000-Mc, low-noise epitaxial mesa transistors in four types.

CIRCLE 357 ON READER SERVICE CARD

Phase Shifter
BROADBAND

E & M LABORATORIES, 15145 Califa St., Van Nuys, Calif. Phase shifter covers the 8.5 to 10.2 Gc region,

Electroplated WIRES

Often, in the manufacture of formed wire parts it is more economical to form these parts from wire already electroplated than it is to plate the formed pieces after manufacture... Our facilities for continuous electroplating are regarded as the largest in the field. All our plating is consistently uniform and well-bonded to the base wire... Consult us about any specific electroplating problem.

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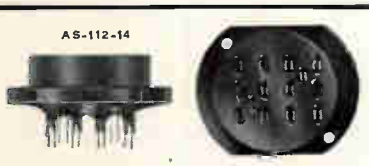
CIRCLE 218 ON READER SERVICE CARD

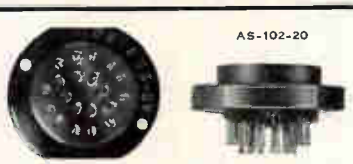
TEST FAST

WITH EECO DUAL-CONTACT SOCKET ADAPTERS FOR RELAYS AND OTHER SOLDER TERMINAL COMPONENTS

Now you can halve the time for acceptance testing or breadboard checking, by using EECO socket adapters. End clip lead fumbling. Dual insulated contacts for each pin eliminate effect of contact resistance in measuring voltage drop. Highest specifications. AS Series adapters $15 plus .50 per pin, substantial price breaks for quantity. Order from more than 50 configurations in catalog or send in your header and request quote at low standard price.

SEND FOR CATALOG AS-2





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CIRCLE 216 ON READER SERVICE CARD

Stepping Motors

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Compact and lightweight Curtiss-Wright bi-directional digital motors index precisely and lock positively between each angular rotation when converting electrical pulses to mechanical motion in missile, aircraft, automation and actuation applications. Ruggedly constructed and dynamically balanced for long life and reliable service under severe environmental conditions, shock and vibration. Low power required for high speed operation.

Temperature: —65°F to +165° F
Vibration: 20 G's to 500 CPS
Shock: 30 G's for 11 milliseconds along each axis

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Electronics Division
CURTISS-WRIGHT CORPORATION
East Paterson, New Jersey

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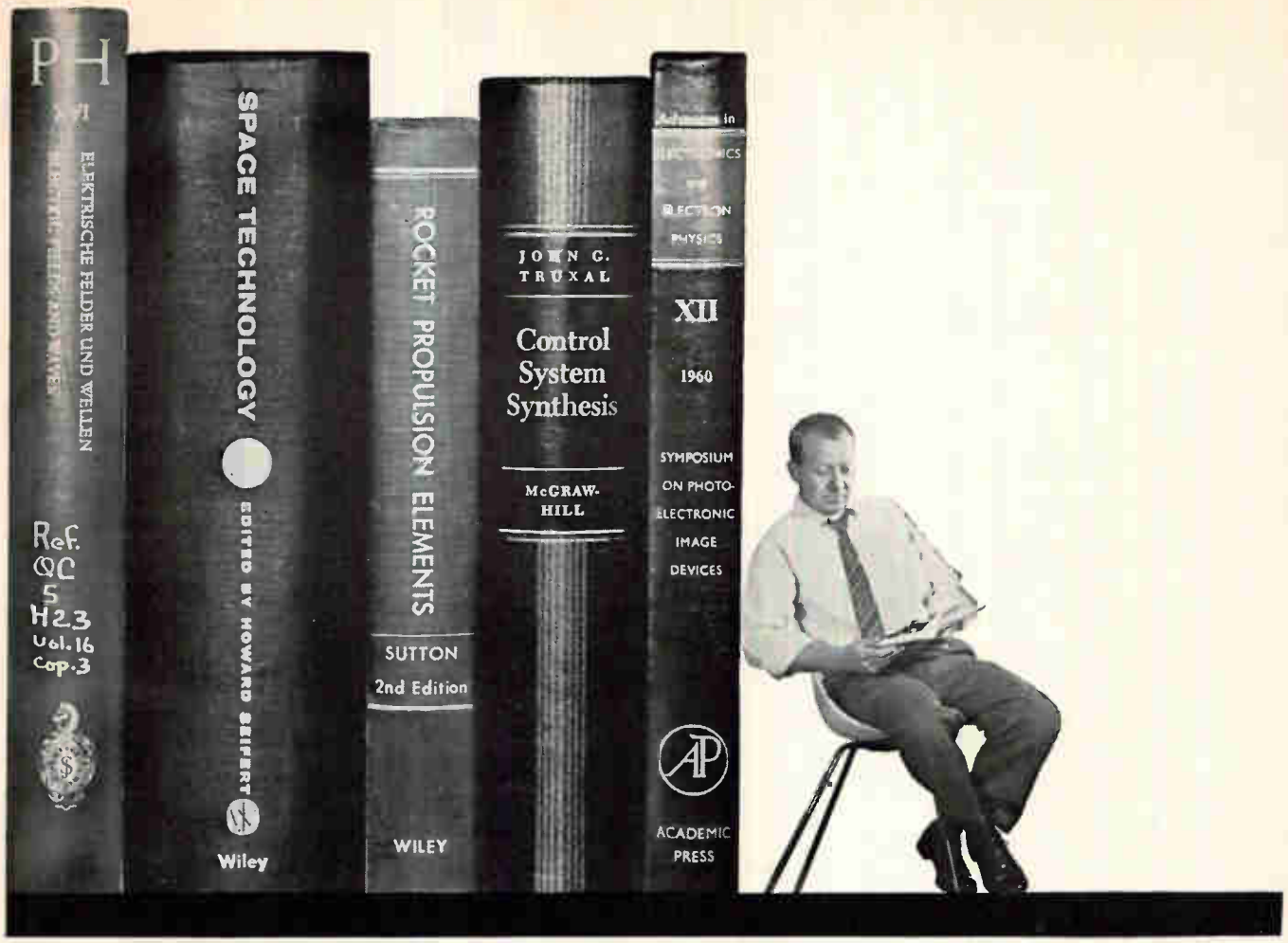

electronic and cybernetics engineers in a unique role

The engineers and scientists of Aerospace Corporation are in the forefront of a rapidly advancing state-of-the-art in sensing and information systems. Their unique role: a critical civilian link uniting government and the scientific-industrial team responsible for development of space systems and advanced ballistic missiles. In this mission Aerospace Corporation provides advanced systems analysis and planning, theoretical and experimental research, initial systems engineering, initial technical direction and general technical supervision. Specific areas of interest include inertial and radio guidance, automatic control, communications, instrumentation, space- and ground-based computing, telemetering, tracking, auxiliary power, infrared, television, optics, and photography. Immediate assignments exist for those highly skilled in these specialties and who are knowledgeable in inter-disciplinary problem solving. Men with advanced degrees are urged to contact Mr. Herndon, Aerospace Corporation, Room 110, P.O. Box 95081, Los Angeles 45, Calif.

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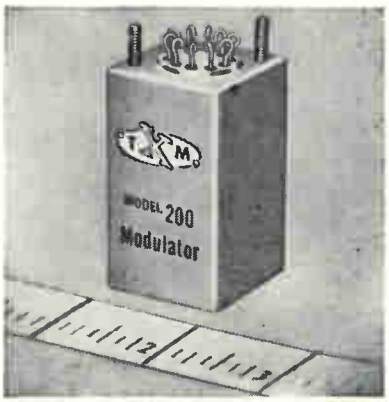
providing in excess of 600 deg phase shift above 9.8 Gc. Drive requirement is 800 ma of d-c current, which can be modified for other current levels and for a-c modulation. The length of 7¾ in., bandwidth, center frequency, and phase shift can also be varied to meet specific customer requirements.

CIRCLE 358 ON READER SERVICE CARD

Voltage Suppressors

INTERNATIONAL RECTIFIER CORP., 233 Kansas St., El Segundo, Calif. Klip-Sel voltage surge protectors increase circuit reliability, lower circuit cost.

CIRCLE 359 ON READER SERVICE CARD



Magnetic Modulator
MINIATURIZED

TRANSMAGNETICS INC., 40-66 Lawrence St., Flushing 54, N. Y. Model 200 is a lightweight all magnetic converter of low level bipolar input current to proportional phase reversing 400 cps sinusoidal output, operating from − 55 to + 105 C in servo applications in automatic control systems. Input control current range is 0 ± 250 μa with 0 to 3.5 v 400 cps sinusoidal output. Hysteresis is less than 0.1 percent, linearity better than 2 percent.

CIRCLE 360 ON READER SERVICE CARD

Switching Diodes

RADIO CORP. OF AMERICA, Somerville, N. J. Multiple silicon switching diodes housed in a subminiature package promise to simplify computer design and manufacturing while extending performance and reliability.

CIRCLE 361 ON READER SERVICE CARD

PRODUCT BRIEFS

VARIABLE R-F ATTENUATORS seven types. Ortho Filter Corp., 7 Paterson St., Paterson 1, N. J. (362)

CIRCUIT COMPONENT MODULES miniaturized. Control Logic, Inc., 11 Mercer Road, Natick, Mass. (363)

THIN WALL SHELLS non-burn epoxy. Cycle Products Co., Inc., 123 Central Ave., Newark 2, N. J. (364)

LOW TEMPERATURE CIRCULATORS ± 0.02 C accurate. Lauda Instruments, Inc., P. O. Box 422, Great Neck, N. Y. (365)

H-V POWER SUPPLY 15 to 40 Kv. Spellman High Voltage Co., 1930 Adee Ave., Bronx, N. Y. (366)

TIME DELAY solid state. Crane Electronics Co., 4345 Hollister Ave., Santa Barbara, Calif. (367)

RESISTOR NETWORKS lug-type. Reon Resistor Corp., 155 Saw Mill River Road, Yonkers, N. Y. (368)

POWER SUPPLY transistor regulated. Transistor Devices Inc., 40 Factory St., Cedar Grove, N. J. (369)

SHIELDED COIL FORM miniaturized. Cambridge Thermionic Corp., Cambridge, Mass. (370)

AIRCRAFT CIRCUIT BREAKER high current capacity. Metals & Controls Inc., 34 Forest St., Attleboro, Mass. (371)

MATCHING TRANSFORMERS high frequency. Barker & Williamson, Bristol, Pa. (372)

ROTARY SWITCH 16-position, miniature. Janco Corp., 3111 Winona Ave., Burbank, Calif. (373)

MULTITURN POTENTIOMETER with arbitrary turns. The Vogue Instrument Corp., 2350 Linden Blvd., Brooklyn, N. Y. (374)

GALVANOMETER PROTECTOR prevents coil burnout. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. (375)

SHAFT-POSITION ENCODERS industrial application. Wayne-George Corp., Boston, Mass. (376)

SEMICONDUCTOR HEAT DISSIPATOR forced air. Vemaline Products Co., Franklin Lakes, N. J. (377)

Literature of the Week

PUSHBUTTON SWITCH ASSEMBLIES Micro Switch, Freeport, Ill. Data sheet covers a millisecond-length pulse switch series. (378)

ION GENERATOR Philco Corp., 4700 Wissahickon Ave., Philadelphia 44, Pa., announces literature describing an ion generator and ion counter. (379)

RESISTORS Key Resistor Corp., 321 W. Redondo Beach Blvd., Gardena, Calif. Bulletin lists a line of complete up-to-date precision resistors. (380)

ANECHOIC CHAMBERS Emerson & Cuming, Inc., Canton, Mass. Brochure describes 14 microwave anechoic chamber designs. (381)

CERAMIC DISK CAPACITOR Erie Resistor Corp., 644 W. 12th St., Erie, Pa. Bulletin discusses Transcap, an ultra-high capacitance ceramic disk capacitor. (382)

IN-LINE BLENDING Potter Aeronautical Corp., U. S. Route No. 22, Union, N. J. Data sheet SY-2 describes digital and analog blending systems. (383)

TUNING FORK OSCLLATOR Fork Standards, Inc., 1915 N. Harlem Ave., Chicago 35, Ill. Brochure describes transistorized tuning fork oscillators. (384)

PRECISION GAGES Techni-Rite Electronics, Inc., 63 Centerville Road, Warwick, R. I. Catalog features transistorized, low-cost gaging instruments. (385)

SWITCHES & THERMOSTATS Metals & Controls Inc., division of Texas Instruments Inc., 34 Forest St., Attleboro, Mass. Forty-two Klixon switch packages and thermostat packages are shown in two technical bulletins. (386)

NONCORROSIVE GLASS Servo Corp. of America, 111 New South Road, Hicksville, L. I., N. Y., offers a folder on Servofrax arsenic trisulfide glass. (387)

SERVO CATALOG Daystrom, Inc., Transicoil Division, Worcester, Pa., has published catalog on servo components and packages. (388)

ZENER DIODES International Rectifier Corp., El Segundo, Calif. Subminiature glass silicon Zener diodes are covered in a bulletin. (389)

FREQUENCY CHANGER Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif. Two-page bulletin describes a 400 cycle solid state frequency changer. (390)

SEMICONDUCTOR POLISHING Linde Co., 270 Park Ave., New York 17, N. Y. Technical bulletin describes in detail the production polishing of semiconductors. (391)

RATE TURNTABLE Dunn Engineering Corp., 225 O'Brien Highway, Cambridge 41, Mass. Bulletin T900 describes an air bearing turntable for gyro testing. (392)

ULTRASONIC CLEANING PRINCIPLE Aircraft Porous Media, Inc., 30 Sea Cliff Ave., Glen Cove, N. Y., offers an article entitled "Focused Energy Cleans Filters. (393)

CHOPPERS Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif., has available literature describing its line of solid state electronic choppers. (394)

SPECIAL PURPOSE TUBES American Elite Inc., 48-50 34th St., Long Island City, N. Y., offers a 72-page manual on a line of Telefunken special purpose tubes. (395)

DATA TRANSMISSION Lenkurt Electric, San Carlos, Calif. Volume 10, No. 8 of *The Demodulator* covers novel uses of data transmission in telecommunications. (396)

COUNTER WITH A MEMORY General Radio Co., W. Concord, Mass. Bulletin describes a digital time and frequency meter with continuous readout to 10 Mc. (397)

MULTIPLE CONNECTORS AMP Inc., Eisenhower Blvd., Harrisburg, Pa., has published a folder describing three lines of multiple connectors, with data sheets for each. (398)

POT & SWITCH CTS Corp., Elkhart, Ind., has released a data sheet on a step-driven potentiometer and switch. (399)

SILICON RECTIFIER General Electric Co., W. Genesee St., Auburn, N. Y., has published a specification sheet on the 1N3289-1N3295 high current silicon rectifier. (400)

NEC

Exchange Plan to Expand Midwest R&D

ELECTRONICS exchange program is a new attack on the Midwest's most challenging electronics problem announced by Hallicrafter's Bob Halligan and the company he heads.

"We're too widely known as a manufacturing area only," says Halligan, youthful (35) president of Hallicrafters, long a producer of short-wave radio equipment. Company has been concentrating recent emphasis on R & D as well as production of military and communications equipment.

Hallicrafters launched its newest countermeasure to the area's general occupation with consumer electronics setting up an exchange of scientists and engineers with the University of Illinois during the past summer. The effort pins down possible inputs—from the company as well as the university—for development of future R & D contracts. A similar series of exploratory seminars is being organized with Northwestern University scientists and engineers this autumn. Several other Chicago-area universities are on the agenda for the future.

M. E. Krasnow, directs Hallicrafter's Chicago-based R & D setup, organized last spring, to study ecm, eccm, space and industrial communications, electromedicine, education aids and other special programs. Also Halligan is convinced the time is now ripe for development of new markets for short-wave, citizens-band, civil-defense, marine and industrial communications applications.

West Point, Air Force and company trained, Halligan was recommended for his Hallicrafters presidency by an outside firm of management consultants engaged to help select a successor for his father. William J. Halligan Sr., founded the company in 1932 to produce radio sets and equipment for radio amateurs.

Still vitally interested in Chicago electronics, the senior Halligan—one of more than 100 executive members appointed to a mayor's committee set up two months ago to study the area's electronics problems—recently outlined for the group his company's newest approaches to revitalizing Chicago area electronics.

Hallicrafters itself exemplifies many of the recent changes in Chicago area electronics. Although the communications-oriented company had evolved into production of a thousand tv sets a day by early 50's it abandoned the consumer tv business entirely a few years ago to work with the Air Force on development of Quick Reaction Capability to electronic challenges in the defense program. At least one-sixth of Hallicrafters total dollar sales now come from short-leadtime research under government contract. Integration of Santa Fe University into bidding for an R & D contract for microwave communications through a plasma sheath resulted from one of the company's earlier explorations of electronics university exchange arrangements.

An articulate spokesman for a team approach to capturing more prime military awards, Bob Halligan believes military electronics—demanding the scientific vitality and aggressiveness that goes with growth and leadership—is a big answer to the current lag in Chicago-area electronics.

"We're going to need even more team bidding if we're to reverse the flow of our most creative and imaginative professional scientific talent to the coasts," Halligan says. "Give a scientist a real challenge and he doesn't care where he works. Coast companies have simply been more aggressive than we, up to now, in providing such challenges."

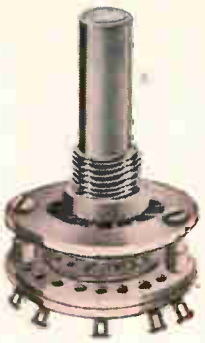
Halligan has also suggested political action by legislators and coordination by the area's electronics manufacturers, wherever possible, to pool lab facilities and to prepare basic information for team bidding and to locate additional plants in local areas.

Company Announces Change in Name

RAYTRON, the trade name introduced at the IRE Show last March by George Rattray & Co., Inc., of Hicksville, N. Y., manufacturer of custom-designed precision potentiometers, has become the nucleus of a new corporate name, Raytron Electronics, Inc.

A subsidiary of Instruments for Industry, Inc., the company has been renamed "for closer product identification and to reflect an ex-

Practical Products for Creative Engineering



MAKE YOUR CIRCUIT COUNT TO TEN

OAK DECADE SWITCH SECTIONS have been designed to fill a need in those applications where reliable decade counting is required—computers, process controls, L/C/R decade boxes, lab equipment, and other devices having read-in or read-out functions.

Although the decade counting function can be designed into almost any Oak low-power rotary switch, Type A, F, and H switches are particularly well-adapted to this purpose. Oak engineers have developed a special rotor blade design for these switch types to be used in resistance/capacitance/inductance decade boxes. It is a single section switch that not only saves space but also makes maximum use of a minimum number of components.

If yours is an application that calls for a counting function, inquire about Oak Decade Switch Sections. Because of the special nature of these switches, however, please submit details of use or number of functions required to the Oak Applications Engineering department for specific recommendations.

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OAK MANUFACTURING CO.

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APPLIANCE CONTROLS • ROTARY SOLENOIDS • CHOPPERS • CONTROL ASSEMBLIES

CIRCLE 127 ON READER SERVICE CARD 127

pansion of its basic product lines," according to Elston H. Swanson, president of IFI.

Hydro-Aire Hires Stanley Cory

STANLEY A. CORY has been appointed senior engineer in the motor division of Hydro-Aire Co., Burbank, Calif.

He will be chiefly responsible for the design of sophisticated synchronous rotor and stator assemblies for direct incorporation in computer memory drum motors. These motors are used for both airborne detection systems and for ground support equipment.

Cory worked for O'Keefe and Merritt and for the Bekey Division of Genisco, Inc., both of Los Angeles, before joining Hydro-Aire.

Algase Moves Up At IFI, Inc.

LAWRENCE I. ALGASE, chief engineer of Instruments for Industry, Inc., Hicksville, N. Y., has been promoted to director of engineering. He will be in charge of all electronic engineering projects at IFI, an independent developer of electronic countermeasure systems, amplifiers, precision potentiometers and related instruments.

Lockheed Aircraft Elects Sanders V-P

DAVID F. SANDERS, president of Lockheed Electronics Co. with headquarters in Plainfield, N. J., has been named a vice president of the Lockheed Aircraft Corp.

His election followed a merging of the electronics company into the parent corporation to produce a more cohesive relationship between the electronics company and the Lockheed divisions active in varied electronics fields.

Sanders continues as president of Lockheed Electronics Co. He will report to D. J. Haughton, executive vice president of the Lockheed Aircraft Corp.

PEOPLE IN BRIEF

Suzanne L. Wolfson leaves Philco Corp. to join the technical staff of Auerbach Electronics Corp. **Richard Rabin** ex-Ford Instrument Co., named manager of the military systems dept. at Epsco, Inc. **George A. Banino** moves from ITT Federal Laboratories div. to the post of v-p and g-m of the Communications System dept. of ITT-Kellogg. **Alfred J. Poté** former v-p, Itek Corp., is elected senior v-p and asst. to the president of Page Communications Engineers, Inc. **Richard H. Wilcox,** previously with General Dynamics Electronics, appointed asst. to the president of P. R. Mallory & Co. Inc. **John J. Connolly** promoted to v-p of Litton Systems, Inc., and g-m of the Data Systems div. **Donald A. Davis** ex-Cannon Electric Co., takes the new post of asst. to the president of Avnet Electronics Corp. **Robert C. Langford,** earlier with Daystrom, Inc., now heads up the new Kearfott Research Center. Martin-Orlando transfers **Robert W. Kluge** from director, advanced systems, to director, special defense program. **Charles E. Branscomb** elevated to systems manager, control systems, in the General Products div. of IBM Corp. **Frank D. Banta,** director of program management, is elected asst. v-p and an officer of General Precision, Inc.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
ERIE ELECTRONICS DIV. Erie Resistor Corp. Erie, Pa.	134	1
I B M CORP. New York, New York	27*	2
JET PROPULSION LABORATORY Pasadena, California	198, 199*	3
LAWRENCE RADIATION LAB. University of California Livermore, California	134	4
LOCKHEED CALIFORNIA CO. A Div. of Lockheed Aircraft Corp. Burbank, California	49	5
MITRE CORPORATION Bedford, Mass.	129	6
SCIENTISTS, ENGINEERS & EXECUTIVES INC. Washington, D. C.	199*	7
SIKORSKY AIRCRAFT Div. of United Aircraft Corp. Stratford, Conn.	133	8
TEXAS INSTRUMENTS INCORPORATED Apparatus Div. Dallas, Texas	202*	9
P-7498	199*	10

*These Advertisements appeared in the 9/29/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME .....

HOME ADDRESS.....

CITY..... ZONE..... STATE.....

HOME TELEPHONE.....

Education

PROFESSIONAL DEGREE(S).....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check) 1061

- ☐ Aerospace
- ☐ Antennas
- ☐ ASW
- ☐ Circuits
- ☐ Communications
- ☐ Components
- ☐ Computers
- ☐ ECM
- ☐ Electron Tubes
- ☐ Engineering Writing
- ☐ Fire Control
- ☐ Human Factors
- ☐ Infrared
- ☐ Instrumentation
- ☐ Medicine
- ☐ Microwave
- ☐ Navigation
- ☐ Operations Research
- ☐ Optics
- ☐ Packaging
- ☐ Radar
- ☐ Radio—TV
- ☐ Simulators
- ☐ Solid State
- ☐ Telemetry
- ☐ Transformers
- ☐ Other .....
- ☐ .....
- ☐ .....
- ☐ .....

CATEGORY OF SPECIALIZATION

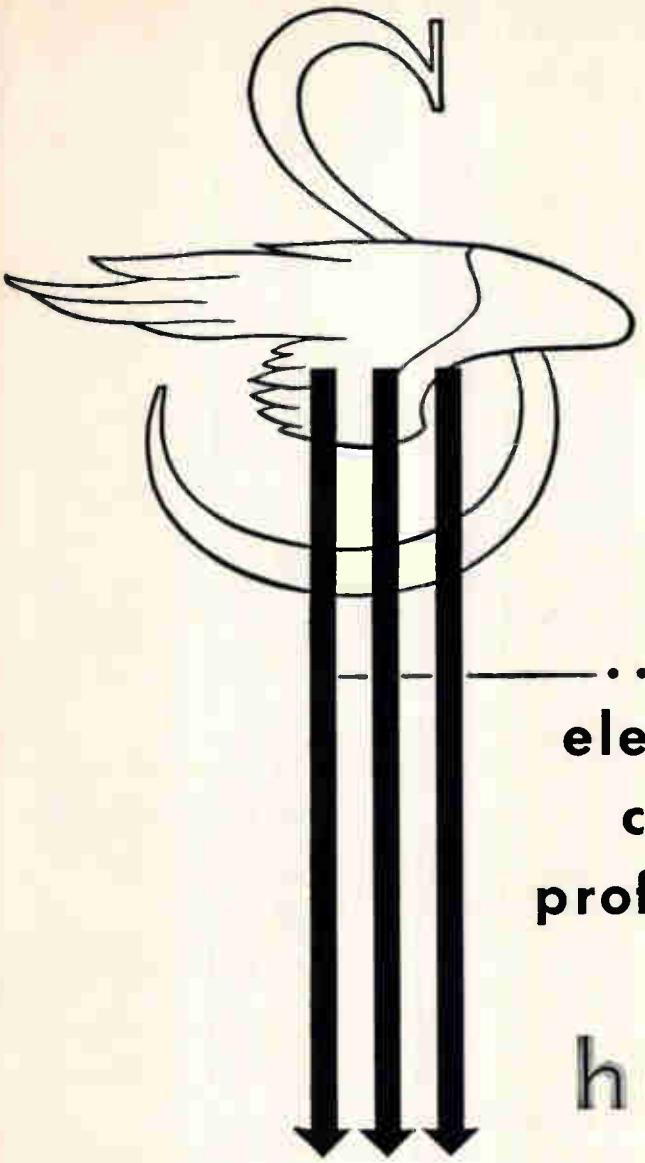
Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	.....	.....
RESEARCH (Applied)	.....	.....
SYSTEMS (New Concepts)	.....	.....
DEVELOPMENT (Model)	.....	.....
DESIGN (Product)	.....	.....
MANUFACTURING (Product)	.....	.....
FIELD (Service)	.....	.....
SALES (Proposals & Products)	.....	.....

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

pioneer and leading manufacturer of rotary wing aircraft



...at SIKORSKY electronic engineers can broaden their professional horizons in the field of helitronics

Today, as Sikorsky Aircraft's activities expand in significance and scope, particular emphasis is being directed to a sphere of activity which we term "*helitronics*". This area embraces a blending of two major technologies: *heli*copters and elec*tronics*. Specifically, helitronics means the integration of guidance and navigation systems, specialized electronic search and detection equipment to enhance the mission capability of the helicopter; specialized sensors and automatic controls to increase its versatility as an optimum military weapon system and a commercial carrier.

The need for more sophisticated electronic systems offers exceptional opportunities to competent electronic engineers with particular skills in: design • instrumentation • test • development • air-borne systems • production and service support equipment • trainers and simulators.

Unusually interesting openings as Avionics Instructors also exist for men with aircraft electronics experience and a desire to teach.

If you are interested in these career opportunities, please submit your resume, including minimum salary requirements, to L. J. Shalvoy, Personnel Department.

SIKORSKY AIRCRAFT STRATFORD, CONNECTICUT

DIVISION OF UNITED AIRCRAFT CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

EMPLOYMENT OPPORTUNITIES

(Additional Employment Opportunity Advertisement on page 133)

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES

EQUIPMENT • USED or RESALE

DISPLAYED RATE

The advertising rate is $24.75 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED RATE

$2.40 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.

PROPOSALS, 2.40 a line an insertion. BOX NUMBERS count as one line additional in undisplayed ads.

DISCOUNT OF 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

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Audited Paid Circulation

- See Advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.

INDEX TO CLASSIFIED ADVERTISERS

• See Advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

This index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but ELECTRONICS assumes no responsibilities for errors or omissions.

electronics

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Associated Business Publications

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reject ruinous common mode noise

– even with greatly unbalanced source impedance!

KIN TEL's 114C Differential DC Amplifier eliminates ground-loop problems in grounded thermocouple and strain-gage measuring systems...gives you extremely accurate, stable, drift-free amplification of microvolt level signals in the presence of volts of common mode noise, irrespective of whether load and transducer are grounded or floating, balanced or unbalanced.

In brief, it is a *true* differential amplifier –

- the input is completely isolated from the output; both are completely floating and isolated from chassis ground.
- common mode rejection is 180 db at DC, 130 db at 60 cps, with up to 1000 ohms unbalance in the input circuit.

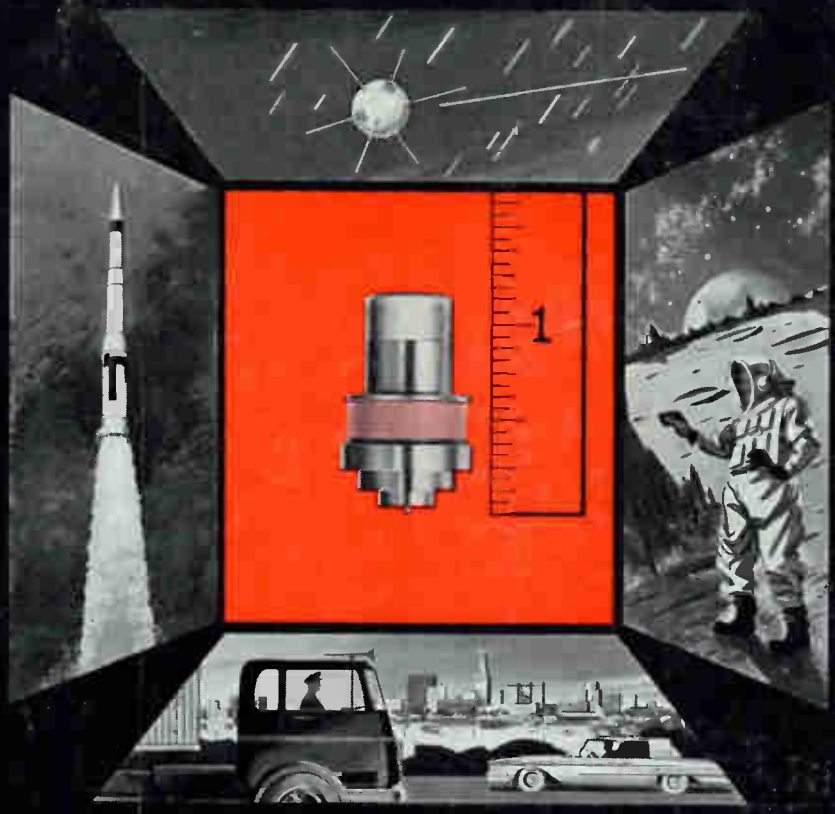
For further information on this exceptional amplifier, write today for detailed technical information or demonstration. There are Kin Tel engineering representatives in all major cities.

BRIEF SPECIFICATIONS

GAIN	10, 30, 100, 300, 1000 (plus vernier), accurate within 0.5%, stable within 0.02%
DRIFT	±2μv equivalent input for 40 hours.
INPUT Z	>30 megs (typically 50 megs)
OUTPUT Z	<0.25 ohm, DC to 500 cps
COMMON MODE REJECTION	180 db DC; 130 db at 60 cps with up to 1000Ω unbalance, 120 db with up to 10,000Ω unbalance
DC LINEARITY	±0.01% of FS (10 volts)
PRICE	$1000.00 in 195 cabinet (shown), $875.00 without cabinet

5725 Kearny Villa Road, San Diego 11, California • Phone: BRowning 7-6700

COHU ELECTRONICS, INC
KIN TEL DIVISION



Compact Power
in a Space Age Package

RCA-7801 Cermolox Tetrode Power Tube packs higher performance into a small package

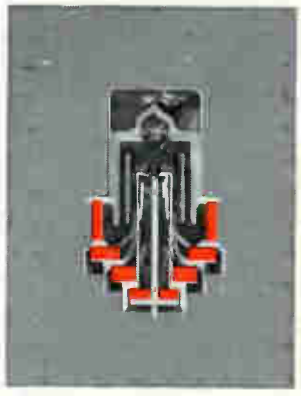
Combining high power-sensitivity, high efficiency and very small size, the new RCA-7801 is especially intended for application in small, compact equipment.

A conduction-cooled ceramic-metal beam power tube, small as an acorn, the 7801 performs excellently as an af or rf power amplifier, oscillator, modulator or voltage regulator in missiles, satellites, mobile communications equipment, telemetering systems—wherever space is at a premium.

In continuous commercial service, the 7801 delivers:

3.2 watts CW power output at 3,000 Mc
15.0 watts CW power output at 1,200 Mc
27.0 watts CW power output at 400 Mc

A wide gold-plated copper cylindrical plate terminal assures high thermal and electrical conductivity. Heater operates at 12.6 volts/0.5 amp; a companion tube, RCA-7870, is exactly the same except that its heater operates at 6.3 volts/1.0 amp.



"Cutaway of RCA-7801 showing unitized electrode and terminal construction"

Revolutionary Cermolox Line—and What It Means To You

"Cermolox" designates RCA's special line of beam power tetrodes with ceramic-metal construction and electrically-broached coaxial grids having perfect alignment. Advantages: High power output • High gain • High power sensitivity • Low driver power • Minimum screen current • Negligible grid emission • Exceptional strength • Small in size • Compact • High-temperature operation

For information on the 7801 or other Cermolox types for your new equipment designs, contact your RCA Field Representative. For technical bulletin on the 7801 write directly to Commercial Engineering, Section J-19-Q-1, RCA Electron Tube Division, Harrison, N. J.

RCA® The Most Trusted Name in Electronics

RCA Electron Tube Division Field Offices: INDUSTRIAL PRODUCT SALES... Newark 2, N. J., 744 Broad St., HU 5-3900 • Chicago 54, Ill., Suite 1154, Merchandise Mart Plaza, WH 4-2900 • Los Angeles 22, Calif., 6801 E. Washington Blvd., RA 3-8361 • Burlingame, Calif., 1838 El Camino Real, OX 7-1620 • GOVERNMENT SALES... Harrison, N. J., 415 South Fifth St., HU 5-3900 • Dayton 2, Ohio, 224 N. Wilkinson St., BA 6-2366 • Washington 7, D. C., 1725 "K" St., N.W., FE 7-8500