MARCH · 1953

Proceedings of the I·R·E

Volume 41 Number 3

Convention Program and Summaries of Technical Papers appear on pages 401-427

IN THIS ISSUE

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The IRE Standard on Television: Definitions of Color Terms, appears in this issue.

The Institute of Radio Engineers

for *Stock* Hermetically Sealed Components

For over fifteen years UTC has been the largest supplier of transformer components for military applications, to customer specifications. Listed below are a number of types, to latest military specifications, which are now catalogued as UTC stock items.

RCOF CASE

Length 1 25/64
Width 61/64
Height 1 13/32
Mounting 1 1/8
Screws ....4-40 Fil.
Cutout ....7/8 Dia.
Unit Weight ....1.5 oz.

MINIATURE AUDIO UNITS...RCOF CASE

Type No.	Application	MIL Type	Pri. Imp. Ohms	Sec. Imp. Ohms	DC in Pri., MA	Response ± 2db. (Cyc.)	Max. level dbm	List Price
H-1	Mike, pickup, line to grid	TF1A10YY	50,200 CT, 500 CT*	50,000	0	50-10,000	+5	$16.50
H-2	Mike to grid	TF1A11YY	82	135,000	50	250-8,000	+21	16.00
H-3	Single plate to single grid	TF1A15YY	15,000	60,000	0	50-10,000	+6	13.50
H-4	Single plate to single grid, DC in Pri.	TF1A15YY	15,000	60,000	4	200-10,000	+14	13.50
H-5	Single plate to P.P. grids	TF1A15YY	15,000	95,000 CT	0	50-10,000	+5	15.50
H-6	Single plate to P.P. grids, DC in Pri.	TF1A15YY	15,000	95,000 split	4	200-10,000	+11	16.00
H-7	Single or P.P. plates to line	TF1A13YY	20,000 CT	150/600	4	200-10,000	+21	16.50
H-8	Mixing and matching	TF1A16YY	150/600	600 CT	0	50-10,000	+8	15.50
H-9	82/41:1 input to grid	TF1A10YY	150/600	1 meg.	0	200-3,000 (4db.)	+10	16.50
H-10	10:1 single plate to single grid	TF1A15YY	10,000	1 meg.	0	200-3,000 (4db.)	+10	15.00
H-11	Reactor	TF1A20YY	300 Henries-0 DC, 50 Henries-3 Ma. DC, 6,000 Ohms.					12.00

RC-50 CASE

Length 1 5/8
Width 1 5/8
Height 2 5/16
Mounting 1 5/16
Screws ....#6-32
Cutout ....1 1/2 Dia.
Unit Weight ....8 oz.

COMPACT AUDIO UNITS...RC-50 CASE

Type No.	Application	MIL Type	Pri. Imp. Ohms	Sec. Imp. Ohms	DC in Pri., MA	Response ± 2db. (Cyc.)	Max. level dbm	List Price
H-20	Single plate to 2 grids, can also be used for P.P. plates	TF1A15YY	15,000 split	80,000 split	0	30-20,000	+12	$20.00
H-21	Single plate to P.P. grids, DC in Pri.	TF1A15YY	15,000	80,000 split	8	100-20,000	+23	23.00
H-22	Single plate to multiple line	TF1A13YY	15,000	50/200, 125/500**	8	50-20,000	+23	21.00
H-23	P.P. plates to multiple line	TF1A13YY	30,000 split	50/200, 125/500**	8 BAL.	30-20,000	+19	20.00
H-24	Reactor	TF1A20YY	450 Hys.-0 DC, 250 Hys.-5 Ma. DC, 6000 ohms . . . 65 Hys.-10 Ma. DC, 1500 ohms.					15.00

SM CASE

Length 11/16
Width 1/2
Height 29/32
Screw ....4-40 Fil.
Unit Weight ....8 oz.

SUBMINIATURE AUDIO UNITS...SM CASE

Type No.	Application	MIL Type	Pri. Imp. Ohms	Sec. Imp. Ohms	DC in Pri., MA	Response ± 2db. (Cyc.)	Max. level dbm	List Price
H-30	Input to grid	TF1A10YY	50***	62,500	0	150-10,000	+13	$13.00
H-31	Single plate to single grid, 3:1	TF1A15YY	10,000	90,000	0	300-10,000	+13	13.00
H-32	Single plate to line	TF1A13YY	10,000****	200	3	300-10,000	+13	13.00
H-33	Single plate to low impedance	TF1A13YY	30,000	50	1	300-10,000	+15	13.00
H-34	Single plate to low impedance	TF1A13YY	100,000	60	.5	300-10,000	+6	13.00
H-35	Reactor	TF1A20YY	100 Henries-0 DC, 50 Henries-1 Ma. DC, 4,400 ohms.					11.00

The impedance ratings are listed in standard manner. Obviously, a 15,000 ohm primary impedance can operate from a tube representing a source impedance of 7700 ohms, etc. In addition, transformers can be used for applications differing considerably from those shown, keeping in mind that impedance ratio is constant. Lower source impedance will improve response and level ratings . . . higher source impedance will reduce frequency range and level rating.

* 200 ohm termination can be used for 150 ohms or 250 ohms, 500 ohm termination can be used for 600 ohms.
** 200 ohm termination can be used for 150 ohms or 250 ohms, 125/500 ohm termination can be used for 150/600 ohms.
*** can be used with higher source impedances, with corresponding reduction in frequency range. With 200 ohm source, secondary impedance becomes 250,000 ohms . . . loaded response is −4 db. at 300 cycles.
****can be used for 500 ohm load . . . 25,000 ohm primary impedance . . . 1.5 Ma. DC.

United Transformer Corp.
150 VARICK STREET • NEW YORK 13, N. Y.
EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y. CABLES: "ARLAB"

What to SEE at the Radio Engineering Show

March 23-26 1953

at Grand Central Palace, New York

405 Radio Electronic Exhibits

Firm	Booth

Ace Engineering & Machine Co., Inc. Philadelphia 40, Pa. — 3-204 & 205
ACE cell type shielded enclosure and auxiliaries.

Aerovox Corporation
New Bedford, Mass.
Booth 1-602 & 604
Ceramin Capacitors, wire wound resistors choke coils trimmers.

Aircraft-Marine Products, Inc.
Harrisburg, Pa.
Booth 4-502
PLUGS
OILFILLED AND PLASTIC
Insulated capacitors. AN Standard and Multiple circuit connectors. Rivet or Stud and wire end terminals.

Aircraft Transformer Corp.
Long Branch, N.J.
Booth 4-213
Transformers for electronic application in military and high quality commercial equipment. Featuring new and revolutionary coatings for high and low temperature environments. Transformers for missiles, radar, supersonics, communications, test equipment, computers, etc.

Air-Marine Motors, Inc.
Seaford, L.I., N.Y.
Booth 4-315
Sub-fractional hp electric motors, fans and blowers for operation on 60, 400 cps and variable frequencies.

Firm	Booth

Airpax Products Co., Baltimore 20, Md. — 4-212
Choppers, vibrators, power supplies.

Airtron, Inc.
Linden, N.J.
Booth 3-102
Flexible waveguides, rigid waveguides, duplexers, tapered flexible waveguides, waveguide bends, crystal mixers, directional couplers, waveguide switches.

Alden Products Co.
Brockton 64, Mass.
Booth 2-143
Alden will show how leaders in the fields of Computers, Business Equipment and Electronic Controls have designed for 30 second servicing, maintenance and operation by unskilled personnel through use of Alden Basic Components, including Terminal Card Mounting System, Basic Chassis, Plug-in Packages, Sensing and Indicating devices, Pre-wired Connectors and Unit Cables.

Alden Electr. & Impulse Recording Equipment Co.
Westboro, Mass.
Booth 2-144
Recorders.

Alfax Paper & Engineering Co., Westboro, Mass. — 2-145
Electrosensitive recording papers.

Allegheny Ludlum Steel Corp., Pittsburgh 22, Pa. — 1-406& & 408
Magnetic Materials.

Allied Control Co., Inc., New York 21, N.Y. — 2-209
Electrical Relays and Electrical coils.

Alpha Metals, Inc., Jersey City, N.J. — 3-512
Non-ferrous, excluding copper, and powdered metals. Solder: acid core, fluxes, plain, pre-forms, rosin core.

Alpha Wire Corp., New York 13, N.Y. — 4-604
Electronic Wire and Cable. Government Specification and commercial types for Rado—Sound—Aircraft—Radar—Television.

Firm	Booth

Altec Lansing Corp., New York 13, N.Y. — 3-317
Exhibit a complete line of speech input equipment for radio and TV, featuring our newly designed 230B Control Console for small stations and 250A Control Console for large stations, along with Plug-In Pre-Amplifiers, Line Amplifiers, Monitor Amplifiers and Power Supplies for special fabrication. New High Fidelity speakers having a guaranteed response from 30 to 22,000 cycles as well as the new "20-20 Plus" line of Peerless transformers will also be featured.

American Electric Motors, Inc., Los Angeles 22, Calif. — 4-717
A complete display of Miniaturized Motor-driven Fans and Blowers, and variable Frequency Drive Motors utilizing a minimum of eighty different laminations to give maxmum ratings in the smallest frame size. Also samples of high frequency ground Power Supplies of the non-slip ring, maintenance-free inductor design are displayed.

ALSIMAG®
Custom Made Technical Ceramics
BOOTH 1-606
Engineers in attendance to advise on special electronic applications.
AMERICAN LAVA CORPORATION
Chattanooga 5, Tennessee
BRANCHES IN PRINCIPAL CITIES

American Phenolic Corp.
Chicago 50, Ill.
Booths 1-101 & 102
Amphenol is presenting a 40 page manual of "OK Methods" for assembly of all types of connectors to all types of cable and wire.
AMPHENOL

American Radio Hardware Co., Inc., Mount Vernon, N.Y. — 4-701
Radio Hardware parts.

American Television & Radio Co.
St. Paul 1, Minn.
Booth 2-304
ATR Vibrators, ATR DC-AC Inverters, ATR Vibrator Power Supplies, ATR Rectifier Power Supplies.

(Continued on page 12A)

PROCEEDINGS OF THE I.R.E. March, 1953, Vol. 41, No. 3. Published monthly by the Institute of Radio Engineers, Inc., at 1 East 79 Street, New York 21, N.Y. Price per copy: members of the Institute of Radio Engineers $1.00; non-members $2.25. Yearly subscription price: to members $9.00; to non-members in United States, Canada and U.S. Possessions $18.00; to non-members in foreign countries $19.00. Entered as second class matter, October 26, 1927, at the post office at Menasha, Wisconsin, under the act of March 3, 1879. Acceptance for mailing at a special rate of postage is provided for in the act of February 28, 1925, embodied in Paragraph 4, Section 412, P. L. and R., authorized October 26, 1927.

How Hammarlund Solves Your Signaling Problems

VERSATILITY

This small, compact unit—transmitter, frequency selective receiver and power supply in a single package—is a vastly improved, new approach to remote signaling and supervisory control system design. It may be used for remote on-off switching, continuous supervisory indication of operating conditions, ringdown signaling, dialing terminal equipment, automatic detection of system functional failures, or for providing channels for transmitting and receiving telemetering information.

FLEXIBILITY

These Hammarlund Duplex Signaling Units have the flexibility required for efficient system design. Up to 36 individual functions can be controlled over a single circuit when they are installed in multiple. Transmitters and receivers operate on the same or different frequencies between 2000 and 6475 cycles per second. Center frequencies in the 2000 to 3500-cycle range are spaced at 100-cycle intervals. And center frequencies in the 3625 to 6475-cycle range are spaced at 150-cycle intervals.

RELIABILITY

Ruggedized, quality-recognized components throughout. A highly stable tone generator, and an amplifier designed for bridging a 600-ohm circuit, assure reliable operation over wire lines, telephone or power line carrier, and radio or microwave communications circuits. It is designed to operate in the range of —30° to +60° C. with excellent frequency stability, and under high humidity and other adverse conditions. Harmonic distortion is negligible.

Write for detailed information

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RADIO-ELECTRONICS
A Preview of Progress
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RADIO ENGINEERING SHOW

405
Exhibits

WALDORF-ASTORIA HOTEL
GRAND CENTRAL PALACE
NEW YORK CITY
MARCH 23-26 1953

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March 23, 24, 25 & 26, 1953
Radio Engineering Show Grand Central Palace, New York City
Exhibits Manager: Wm. C. Copp, 303 W. 42nd St., New York 36, N.Y.

Δ

April 11, 1953
NEREM—New England Radio Engineering Meeting, University of Connecticut, Storrs, Conn.
Exhibits: H. W. Sundius, The Southern New England Tel. Co., 227 Church St., New Haven, Conn.

Δ

April 18, 1953
Spring Technical Conference of the Cincinnati Section, Cincinnati, Ohio
Exhibits: R. H. Lehman, The Baldwin Co., 1801 Gilbert Ave., Cincinnati 2, Ohio

Δ

May 11, 12 & 13, 1953
National Conference on Airborne Electronics Hotel Biltmore. Dayton. Ohio.
Exhibits: Paul Clark, 120 West Second St., Dayton 2, Ohio.

Δ

August 19, 20, 21, 1953
1953 Western Electronics Show and Convention, Civic Auditorium, San Francisco, Calif.
Exhibits: Heckert Parker. 1355 Market St., San Francisco 3, Calif.

Δ

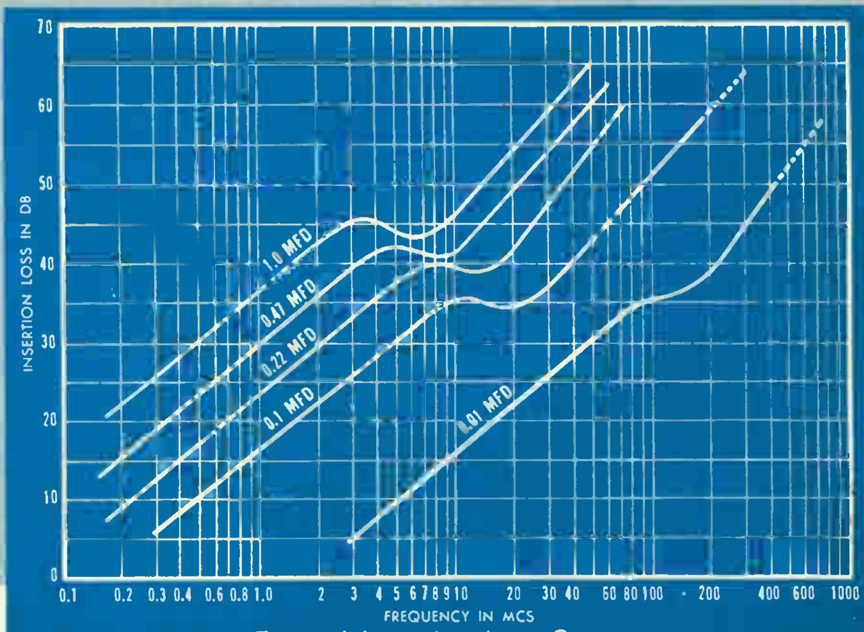
September 21-25, 1953
Eighth National Instrument Conference and Exhibit. Hotel Sherman, Chicago, Ill.
Exhibits: Richard Rimbach, 921 Ridge Ave., Pittsburgh 12, Pa.

Δ

September 28, 29 & 30, 1953
National Electronic Conference Hotel Sherman, Chicago.
Exhibits: Orville Thompson, c/o DeForrest's Training Inc., 2735 N. Ashland Ave., Chicago 14, Ill.

THE MOST EFFECTIVE CAPACITORS FOR R-F NOISE SUPPRESSION...

...are the *NEW* SPRAGUE THRU-PASS CAPACITORS



Typical Insertion Loss Curves

THRU-PASS CAPACITORS are a new Sprague development for use in radio interference reduction in communication and radar equipment.

• Thru-Pass Capacitors not only reduce to a negligible value the effect of external connection inductance to a capacitor but they also have a minimum length of internal path for radio interference currents. *Their performance is closer to that of a theoretically ideal capacitor than that of any other paper capacitor!*

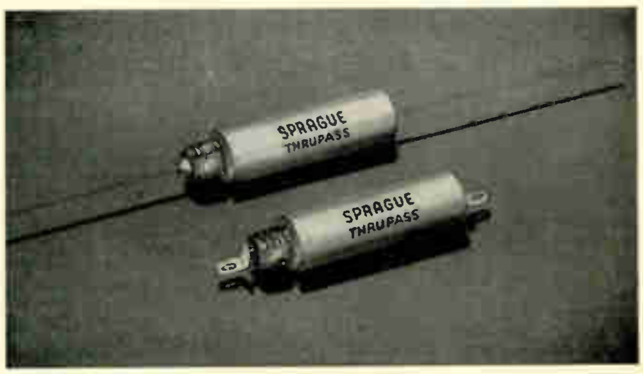
• Electrically, Thru-Pass Capacitors are three-terminal feed-thru devices which are connected in a circuit in a manner similar to a low pass filter; the tab or lead terminals are connected in series with the circuit being filtered while the case is grounded.

• The threaded-neck mounting on Type 102P and 103P Subminiature Thru-Pass Capacitors is designed to give a firm metallic contact with the mounting surface over a closed path encircling the feed-thru conductor and to eliminate unwanted contact resistance so that the theoretical effectiveness of these new units is realized in practice. The milled flats on the threads help ensure vibration-proof mounting since the capacitors cannot rotate if mounted in a flatted opening instead of the usual circular hole.

• Type 102P and 103P Capacitors are all hermetically encased. Glass-to-metal solder-seal terminals are employed in order to assure positive protection against severe atmospheric conditions.

• Both types are impregnated with Vitamin Q, Sprague's exclusive inert synthetic impregnant, in order to provide maximum insulation resistance and minimum capacitance change with temperature. Type 102P units are processed for −55°C to +85°C operation while Type 103P units have their top operating temperature extended to +125°C.

• Engineering Bulletin 215 gives full details and standard ratings. Write on your business letterhead for your copy to Sprague Electric Co., 235 Marshall St., North Adams, Massachusetts.



TYPES 102P AND 103P 5 AMPERE THRU-PASS CAPACITORS SHOWING CHOICE OF LEAD OR TAB TERMINALS

SPRAGUE WORLD'S LARGEST CAPACITOR MANUFACTURER

EXPORT DIVISION: CABLE SPREXDIV, NORTH ADAMS, MASS.

"THRU-PASS" AND VITAMIN "Q" ARE SPRAGUE TRADEMARKS.

SEE US AT THE I.R.E. SHOW—BOOTHS 1-410 & 1-412

Need Precision Pots *NOW?*

CALL HELIPOT!

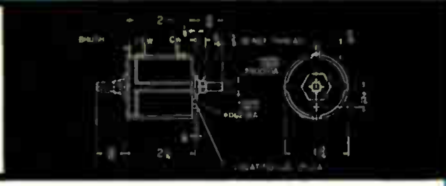
When you need top quality potentiometers *fast*, call Helipot . . . first in precision potentiometers!

Shown on these pages are various types and ranges of Helipots—both single and multi-turn—that Helipot now stocks for immediate delivery. You can have stock prototypes immediately. On large orders for stock items, initial deliveries in substantial quantities will be made promptly, with balance on close schedule.

Prompt attention will be given your requirements for Precision Pots to your individual specifications.

Helipot's objective is to give you the same flexibility and efficiency as a department of your own company. Our trained personnel and unequalled facilities are ready to serve your needs, whether for standard units shown here or for special designs in quantity to meet particular applications.

For fast service, call the nearest representative listed below. Or write, wire or phone direct!

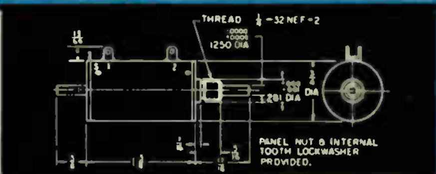
MODEL A HELIPOTS

The most widely adaptable of all multiturn Helipots. A 10-turn unit of convenient, compact size offering resolution accuracies 12 to 14 times that of conventional single-turn units of same diameter. 10-turn range permits direct decimal readings.

10-turns . . . Power rating 5 watts . . . Coil length 46.5" . . . Linearity tolerances: ±0.5% (Std. all values), (±0.1% 5K and up, ±0.25% below 5K).*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
25-AZ	25	3,000	.00071
50-AZ	50	3,200	.00071
100-AZ	100	3,800	.00071
200-AZ	200	4,750	.00071
500-AZ	500	4,000	.00002
1,000-AZ	1,000	5,000	.00002
2,000-AZ	2,000	6,500	.00002
5,000-AZ	5,000	7,200	.00013
10,000-AZ	10,000	9,000	.00013
20,000-AZ	20,000	10,000	.00013
30,000-AZ	30,000	11,500	.00013
50,000-AZ	50,000	12,500	.00013
100,000-AZ	100,000	15,000	.00013
200,000-AZ	200,000	15,500	.00013
300,000-AZ	300,000	16,000	.00013

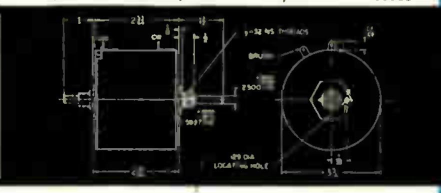
MODEL AJ HELIPOTS

The AJ is a high performance 10-turn helical potentiometer of miniature size (¾" dia.) and light weight (1 oz.). Available with bushing mount (AJ) or servo mount (AJS), both with sleeve bearings. Servo mount also available with precision ball bearings (AJSP).

10-turns . . . Power rating 2 watts . . . Coil length 18" . . . Linearity tolerance ±0.5% (Std.) . . . Starting torque 0.75 oz. in. . . . Wgt. 1 oz. . . . Dia. ¾".*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
100-AJZ	100	3,000	.00071
500-AJZ	500	2,500	.00002
1,000-AJZ	1,000	3,400	.00002
5,000-AJZ	5,000	4,250	.00013
10,000-AJZ	10,000	4,000	.00013
20,000-AJZ	20,000	5,350	.00013
30,000-AJZ	30,000	5,450	.00002
50,000-AJZ	50,000	6,550	.00002

MODEL B HELIPOTS

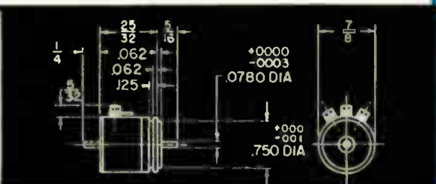
A large diameter (3-5/16") 15-turn Helipot with 139" slide wire length providing the highest resolution (.01% to .003%) and adjustment accuracy available today in a standard mass-production unit. Rugged, dependable, low in cost.

15-turns . . . Power rating 10 watts . . . Coil length 139" . . . Linearity tolerance ±0.5% (Std.).*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
1,000-BZ	1,000	10,900	.00002
5,000-BZ	5,000	19,600	.00002
10,000-BZ	10,000	17,700	.00013
25,000-BZ	25,000	21,800	.00013
50,000-BZ	50,000	25,400	.00013
100,000-BZ	100,000	34,100	.00013

Please note that 1000 volts is highest that may be applied across coil regardless of resistance value.

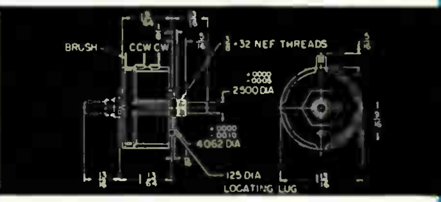
MODEL T HELIPOTS

A single-turn, continuous-rotation servo-mounting unit of minimum weight (0.56 oz.) requiring very small cubic space and operating with negligible torque. Shaft rotates on precision ball bearings—unit built throughout to highest possible precision.

1-turn . . . Power rating ½ watt . . . Coil length 2" . . . Linearity tolerance ±0.5% (Std.) . . . Starting torque .015 in. oz. (Running torque is negligible) . . . Wgt. 0.56 oz.*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
1,000-TZ	1,000	705	various
2,000-TZ	2,000	750	various
5,000-TZ	5,000	800	various
10,000-TZ	10,000	1,650	various
20,000-TZ	20,000	1,500	.00002
25,000-TZ	25,000	1,500	.00002
30,000-TZ	30,000	1,400	.00002
50,000-TZ	50,000	1,400	.00002
100,000-TZ	100,000	1,500	.00002

MODEL C HELIPOTS

Identical in general design to Model A except has only 3 helical turns of resistance winding and proportionately shorter length. Ideal for high-accuracy applications with restricted behind-panel depths.

3-turns . . . Power rating 3 watts . . . Coil length 13½" . . . Linearity tolerance ±0.5% (Std.) . . . Behind-Panel Length 1-9/64".*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
10-CZ	10	1,000	.00071
50-CZ	50	1,390	.00071
100-CZ	100	1,100	.00002
500-CZ	500	1,850	.00002
1,000-CZ	1,000	1,360	.00013
5,000-CZ	5,000	2,500	.00013
10,000-CZ	10,000	3,100	.00013
20,000-CZ	20,000	3,900	.00013
30,000-CZ	30,000	4,400	.00013
50,000-CZ	50,000	4,250	.00013

*ON SPECIAL ORDER most of the above potentiometers are available with Rear Shaft Extensions . . . Extra Spot Welded Taps at any location . . . Ganged Assemblies . . . Special Temp. Coefficients, Resolutions, etc. Write for details!

[illegible]

Engineering Sales Representatives are located near you to assure personal attention. Teletype connects our New York, Boston, Chicago and Los Angeles offices for rapid information on orders and deliveries. And our Mountainside, New Jersey plant, now under construction, will soon be in production to further assist you.

THE Helipot CORPORATION

A Subsidiary of Beckman Instruments Inc.

SOUTH PASADENA CALIFORNIA

MODEL J HELIPOTS

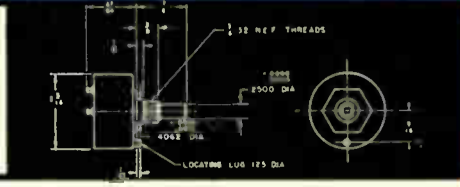
First production potentiometer equipped with ball-bearing shaft supports as standard and 3-way servo-type mounting. Ganged assemblies can be independently phased after installation without external clamps or brackets.

1-turn . . . Power rating 5 watts . . . Coil length 5½". . . 360° Cont. Mech. Rotation . . . Linearity tolerance ±0.5% . . . Starting torque 1.0 ± .25 oz. in.*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
100-JZ	100	630	.00002
1,000-JZ	1,000	875	.00017
5,000-JZ	5,000	1,300	.00017
10,000-JZ	10,000	1,475	.00017
20,000-JZ	20,000	1,900	.00017
30,000-JZ	30,000	1,975	.00017
50,000-JZ	50,000	2,260	.00002

Please note that 400 volts is highest that may be applied across coil regardless of resistance value.



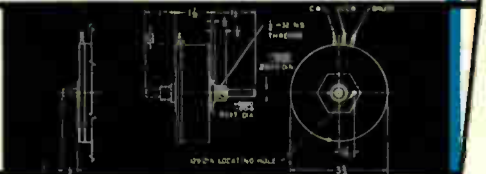
MODEL G HELIPOTS

A small, extra rugged single-turn pot developed initially for aircraft servo mechanisms. Its compact size, high accuracy, long life make it ideal for many instrumentation and servo-mechanism applications.

1-turn . . . Power rating 2 watts . . . Coil length 3¼". . . 360° Cont. Mech. Rotation . . . Linearity tolerance ±0.5% (Std.) . . . Wgt. 2 Oz. . . . Dia. 1-5/16".*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
10-GZ	10	300	.00071
100-GZ	100	400	.00002
500-GZ	500	500	.00013
1,000-GZ	1,000	650	.00013
5,000-GZ	5,000	750	.00013
10,000-GZ	10,000	950	.00013
20,000-GZ	20,000	1,200	.00013



MODEL F HELIPOTS

A 3" dia. single-turn high-precision potentiometer with continuous mechanical rotation and minimum dead spot between electrical ends. Versatile in application. Ideal where continuous rotation simplifies circuitry.

1-turn . . . Power rating 5 watts . . . Coil length 9¼". . . Linearity tolerance ±0.5%.*

TABLE OF STOCK VALUES

Catalog No.	Total Resistance (Ohms)	Wire Turns	Temperature Coefficient
100-FZ	100	800	.00002
500-FZ	500	1,300	.00002
1,000-FZ	1,000	1,200	.00013
5,000-FZ	5,000	2,000	.00013
10,000-FZ	10,000	2,500	.00013
20,000-FZ	20,000	2,700	.00013
50,000-FZ	50,000	4,000	.00013
100,000-FZ	100,000	5,000	.00002

Please note that 400 volts is highest that may be applied across coil regardless of resistance value.

NOT CARRIED IN STOCK but quickly available on order

MODELS AN and CN HELIPOTS

Mechanically precise, highly linear potentiometers of same general dimensions as Models A and C, except have servo-mountings, ball-bearing shafts and are built to highest precision possible. Have approximately 2:1 advantage in linearity accuracies over corresponding A and C Helipots. (Model AN linearity tolerances as close as ±.025% in values of 5K and above.) **AN** (10-turns) resistance ranges, 100 to 250,000 ohms . . . **CN** (3-turns) 30 to 75,000 ohms.

Write for full details on linearity tolerances, special features, etc.

MODELS D and E HELIPOTS

Large diameter (3-5/16"), wide range Helipots with extremely long resistance windings for highest possible resolutions coupled with close linearity tolerances.

Model D has 25 turns, 234" coil length, 9000° of rotation, is 4-9/64" deep behind the panel, and is available in ranges from 100 to 750,000 ohms.

Model E has 40 turns, 373" coil length, 14,400° of rotation, is 6-1/64" deep behind panel, resistances 200 to 1,000,000 ohms.

Write for full details on linearity tolerances, special features, etc.

OTHER UNIQUE HELIPOT PRODUCTS

MODEL RA Precision DUODIALS

A beautiful, precision-built, multi-turn dial of compact dimensions (1-13/16" dia.) for all types of quality multi-turn installations. Features unique "jump" mechanism that keeps secondary dial stationary until primary dial has completed a full turn —then secondary dial "jumps" to new position. A vibration-proof lock holds dial settings whenever desired.

Black nylon knobs, satin aluminum dials, quality "feel" and appearance throughout. Available in 10-turn design for use with 3 and 10-turn Helipots and in RAJ version for use with small AJ Helipots.

Write for full details.

MODEL W DUODIALS

A large diameter (4¾") multi-turn dial ideal for primary control applications. The inner dial shows the exact position of the slider on any multi-turn Helipot while the outer dial shows the particular turn on which the slider is moving. Thus with 10-turn units, readings can be made directly in decimal equivalents of total resistance winding.

Since primary dial is direct-connected to shaft, backlash is eliminated.

Available in 10:1, 15:1, 25:1, and 40:1 Ratios for use with various Helipot models as well as with other multi-turn equipment.

Write for full details.

LABORATORY HELIPOT—MODEL T-10A

This unit combines in a handsome walnut case a 10-turn Helipot, an "RA" Duodial, and three-way binding posts for quickly setting up and changing experimental or temporary circuits. Ideal for laboratory and instruction purposes . . . is far more compact, simpler and 5 times faster to set than decade boxes.

Power rating 5 watts . . . Linearity 0.1% . . . Standard Resistance Ranges 100 . . . 500 . . . 1,000 . . . 5,000 . . . 10,000 . . . 20,000 . . . 50,000 . . . 100,000 ohms in stock. Other ranges on order.

Write for full details.

1. NEW YORK [illegible]

2. ROCHESTER [illegible]

3. SCHENECTADY, N. Y. [illegible]

4. BOSTON [illegible]

5. PHILADELPHIA [illegible]

6. CLEVELAND [illegible]

7. CHICAGO [illegible] Chicago 41, Illinois [illegible]

8. ST. LOUIS [illegible] St. Louis 9, Missouri [illegible]

9. FORT MYERS [illegible] Fort Myers, Florida [illegible]

10. LOS ANGELES [illegible]

11. SEATTLE [illegible]

12. DALLAS [illegible]

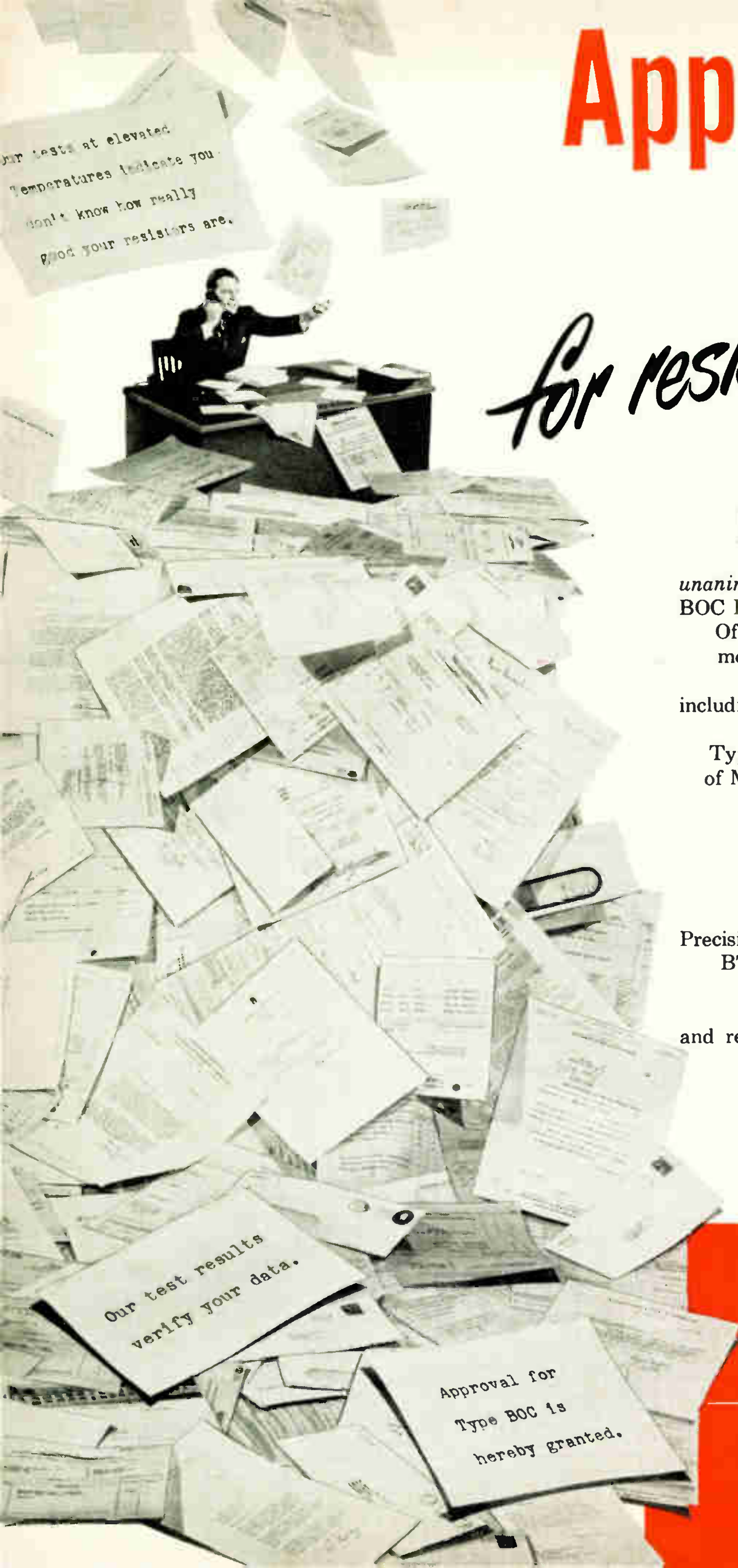
13. DETROIT [illegible]

14. SOUTH CENTRAL [illegible]

15. CANADA [illegible]

EXPORT AGENT: [illegible]

Approval is *for resistors too!*

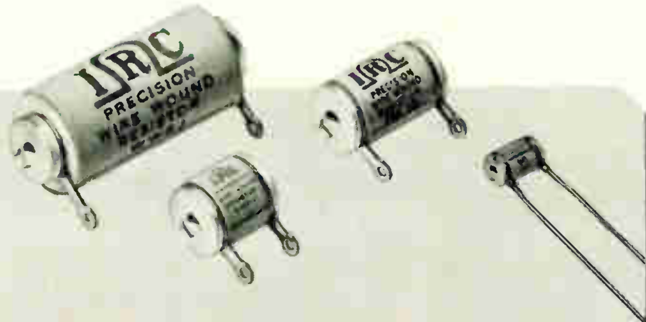


In all our experience, no resistor has been so extensively tested—*and so unanimously approved*—as IRC's new Type BOC Boron-Carbon ½-watt PRECISTOR. Of the 3,000,000 already manufactured, more than 100,000 were given the most stringent tests-in-production, including critical temperature cycling and 500-hour load-life tests. Result:—Type BOC conforms to *all* requirements of MIL-R-10509A! Also, customers have conducted their own laboratory and field tests—and they express their approval of Type BOC in letters like those shown here.

In the case of IRC's new JAN Type Precision Wire Wounds and Advanced Type BT Resistors, too, rigid quality control and continued testing have won industry-wide approval. Most stable and reliable of all precision wire wounds, Type WW's far surpass JAN-R-93 Characteristic B Specifications. And Type BT's continue to meet and beat JAN-R-11 Specifications.

IRC

important

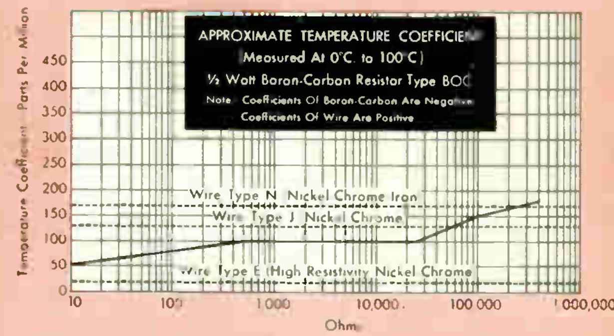


New JAN Type Precision Wire Wound Resistors Excel JAN-R-93 Characteristic B Specifications

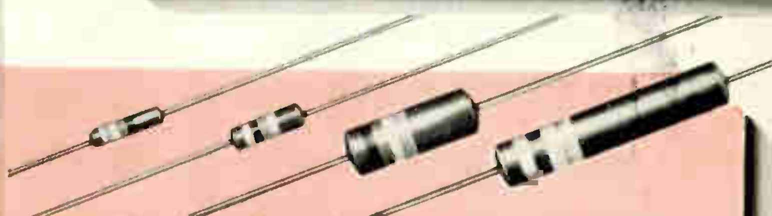
	Original Resist	1st Cycle % Chge	2nd Cycle % Chge	3rd Cycle % Chge	4th Cycle % Chge	Resist at End of 100 hrs load	Total % Chge	% Chge from Last Temp Cycle to End of 100 hrs load %	Resistance Chge at End of 100 Hrs Load only % no cycling	
1	100,010	+ 04	+ 04	+ 05	+ 05	100,050	+ 04	— 01	100,040	— 02
2	100,000	+ 03	+ 04	+ 03	+ 05	100,060	+ 06	+ 01	100,000	0
3	100,000	+ 01	+ 02	+ 02	+ 05	100,000	0	+ 05	100,050	— 02
4	100,000	+ 02	0	+ 02	+ 02	100,000	0	— 02	100,040	— 01
5	100,010	+ 03	+ 04	+ 04	+ 05	100,000	0	— 05	100,030	— 03
6	100,000	0	+ 03	+ 04	+ 04	100,100	+ 1	+ 06	99,980	0
7	100,000	+ 04	+ 05	+ 04	+ 04	100,070	+ 07	+ 03	100,000	0
8	100,000	+ 03	+ 05	+ 05	+ 05	100,050	+ 05	0	100,000	0
9	100,000	+ 04	+ 03	+ 05	+ 04	100,010	+ 01	— 03	100,050	0
10	100,000	+ 02	+ 02	+ 02	+ 04	100,010	+ 01	— 03	100,000	0
11	100,000	0	+ 01	+ 01	+ 03	100,000	0	— 03		

Most *reliable* and *stable* of all wire-wound precisions, these new Type WW's have proved their superiority in unbiased tests. Severe cycling and 100-hour load tests resulted in virtually zero changes in resistance. Other stringent tests proved JAN Type WW's high mechanical strength, freedom from shorting, resistance to high humidity. New winding forms—new winding technique—new type insulation—and new terminations assure long life, accuracy, ruggedness in service. IRC JAN Type WW's are becoming the choice of leading producers of military equipment. Get full technical data in Catalog Bulletin D-3.

Type BOC Boron-Carbon ½-Watt Resistor Surpasses Signal Corps Specification MIL-R-10509A



The ultimate in *stable, reliable* non-wire-wound resistors, Type BOC's are especially designed for military electronic equipment—radar, gunnery control, communications, telemetering, computing and service instruments. Greatly improved temperature coefficients of resistance permit their use in place of costlier wire wound precisions in many critical applications. Lower capacitive and inductive reactance suit them to circuits where wire-wound stability is needed. Small size makes them ideal in limited space. *Tolerance:*—1%, 2% and 5%. *Resistance Values:*—10 ohms to ½ megohm. Send for full technical data in Catalog Bulletin B-6.



Type BT Advanced Fixed Composition Resistors Meet and Beat JAN-R-11 Specifications

Type BTS Meets and Beats Rigid G Characteristic

These are the famous Advanced Type BT's whose characteristics set new performance records for fixed composition resistors. They combine a unique filament-type resistance element with exclusive construction features to assure extremely low operating temperature and excellent power dissipation. Yet they are compact, light in weight, fully insulated. Intensive tests by independent agencies have proved their superiority under actual field conditions. For full technical data, send for Catalog Bulletin B-1.

You'll see even newer resistor developments at IRC's Booth 1-110 during the 1953 IRE show.

Boron-Carbon PRECISTORS • Power Resistors • Voltmeter Multipliers • Insulated Composition Resistors • Low Wattage Wire Wounds • Volume Controls • Voltage Dividers • Precision Wire Wounds • Deposited Carbon PRECISTORS • Ultra HF and High Voltage Resistors • Insulated Chokes • Selenium Rectifiers

Wherever the Circuit Says

INTERNATIONAL RESISTANCE COMPANY

401 N. Broad Street, Philadelphia 8, Pa.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

Mail Coupon Today for Full Details of These IRC Resistors

INTERNATIONAL RESISTANCE COMPANY
405 N. Broad St., Philadelphia 8, Pa.

Please send me full data on the following checked items:—

- ☐ Type BOC Boron-Carbon PRECISTORS
- ☐ Type WW Precision Wire Wound Resistors
- ☐ Type BT Advanced Fixed Composition Resistors
- ☐ Name and Address of Nearest IRC Distributor

NAME ______________________

TITLE ______________________

COMPANY ______________________

ADDRESS ______________________

AT THE PUSH OF A BUTTON...

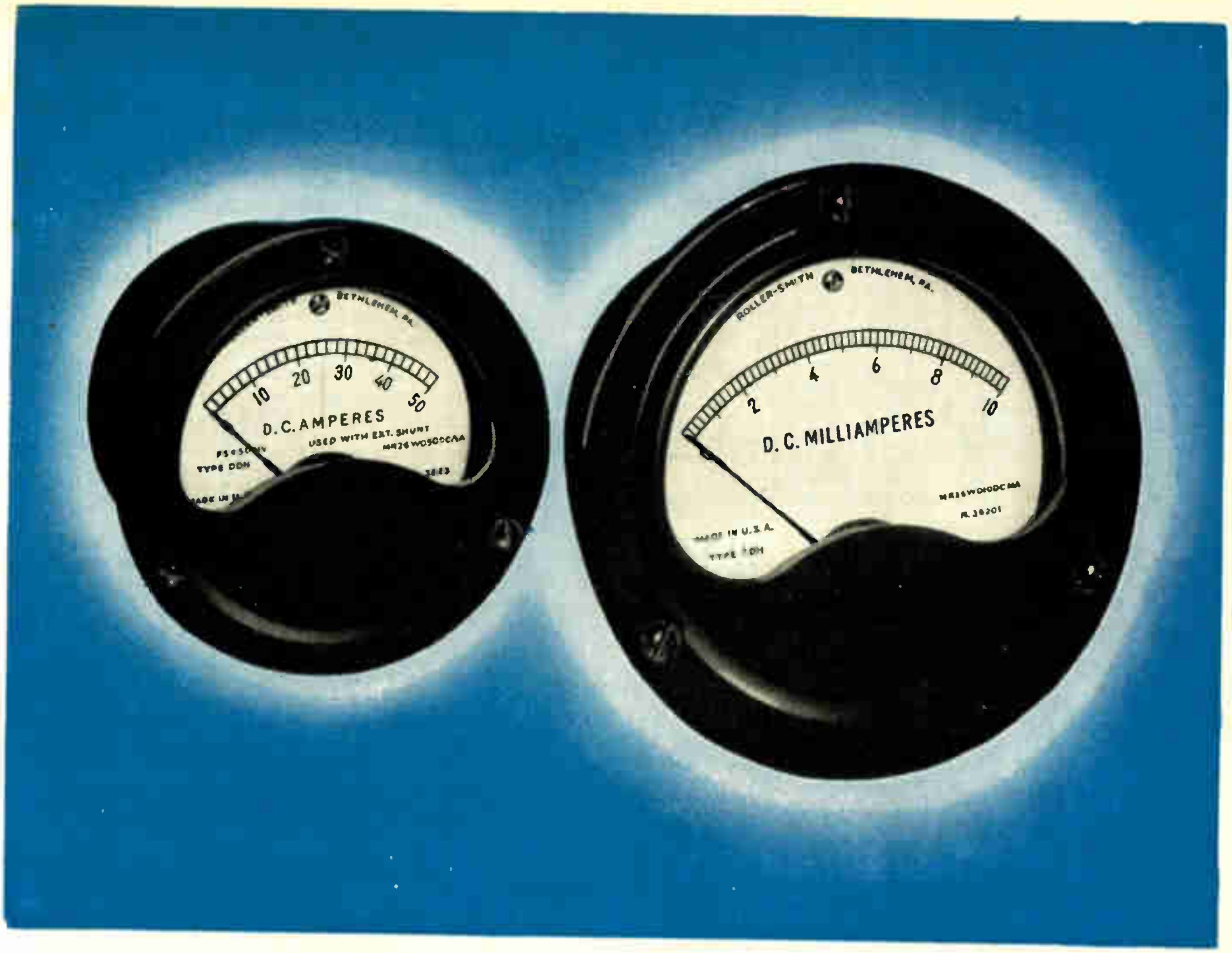
Once you zero-set a new Du Mont Type 304-A it is almost automatic to measure potentials of the waveforms on the screen of the cathode-ray tube. And you'll be surprised to find out how much more you know about your circuit; how much easier circuit development and production testing become when amplitude calibration is in front of you every time you examine a waveform. The new Du Mont Type 304-A will make your job easier, will greatly simplify measurements that formerly were difficult or inconvenient to make. The Type 304-A is not just another oscillograph; it is a true cathode-ray voltmeter, made possible by a precision calibrator and the tight-tolerance, flat-face Type 5ADP- Cathode-ray Tube. Only through the combined facilities, unique in the industry, of the Du Mont Cathode-ray Tube and Instrument Divisions could the Type 304-A Cathode-ray Oscillograph have evolved.

SPECIFICATIONS:

- Tight-tolerance, flat-face Type 5ADP- Cathode-ray Tube
- Vertical and horizontal amplifiers flat to d.c., 10% down at 100 KC
- Direct voltage measurement — Range, 0.1 to 1000 volts full scale, read directly from oscillograph scale; 5% overall accuracy
- High sensitivity — At full gain, 0.025 volts/inch
- Undistorted vertical and horizontal deflection more than 4 inches
- Expansion equivalent of 20 inches vertically and 30 inches horizontally with full positioning
- Driven and recurrent sweeps with sync limiting — Range, 2 to 30,000 cps; provision for extra-low frequency sweeps by externally connected capacitor; maximum writing rate, 1 inch/μsec
- Illuminated, numbered scale and suitable filter provided; scale illumination variable from zero to more than adequate for viewing and photography
- Improved stability of vertical amplifier

Price **$333.00**

DUMONT INSTRUMENT DIVISION, ALLEN B. DU MONT LABORATORIES, INC., 1500 MAIN AVE., CLIFTON, N. J.



Roller-Smith

Ruggedized Instruments

Shock-Proof • Vibration-Proof • Weather-Proof

Roller-Smith announces production of hermetically sealed *Ruggedized* 2½″ and 3½″ instruments conforming to MIL-M-10304.

In addition to *Ruggedized* instruments, a complete line of hermetically sealed and unsealed types in conformance with Government specifications are available.

ROLLER-SMITH CORPORATION
BETHLEHEM, PENNSYLVANIA

SEE US AT THE I.R.E. SHOW BOOTH 4-521

What to see at the Radio Engineering Show

(Continued from page 1A)

Amperex Electronic Corp.
Hicksville, L.I., N.Y.
Booths 1-310 & 312

Electronic Tubes. Transmitting, special purpose rectifier, electro-medical, U.H.F, Hydrogen thyratrons, magnetrons, geiger-mueller, power & industrial.

Ampex Electric Corp.
Redwood City, Calif.
Booths 4-405 & 407

Magnetic tape recorders for laboratory and industrial instrumentation uses. Featured will be the Ampex Model 306 which records independently of tape imperfections and records low frequency data, including direct measurements.

Firm	Booth
Amplifier Corp. of America, New York 13, N.Y. Miniature and sub-miniature tape recorders; dictation tape recorders; standard AC operated high fidelity tape recorders; audio amplifiers; regulated power supplies; electronic test equipment.	3-314

Andrew Corporation, Chicago

ANDREW **2-120**

Concentrating on new fields in 1953, Andrew Corporation will feature UHF coaxial line and waveguide samples and fittings at its IRE display.

For the communications industry, the emphasis will be on the type 225, 450-470 MC. Samples and illustrative material on the complete, new Andrew line—the type 225, the High Gain, the Corner Reflector and the Yagi—will be on display.

Anton Electronic Labs., Inc.
Brooklyn 37, N.Y.
Booth 4-108

The rugged Anton corona discharge voltage regulator tubes—fixed and variable. The new AN/PDR-32 high intensity radiological monitoring instrument. Stainless steel halogen quenched geiger counter tubes. Instrumentation in the electronic field such as a liquid level gauge and the new electronic "Meter-guard" utilized with galvanometers, microammeters, milliameters and millivoltmeters.

Applied Science Corp. of Princeton
Princeton, New Jersey
Booth 4-806

Radio Telemetering—data handling systems—high speed sampling switches—research and development services—product engineering and prototype production. Working displays of unusual uses of sampling switches and Radio Telemetering airborne and ground station equipment. Inquiries concerning specialized development, engineering and production will be carefully considered.

Visit all four floors!

(Continued on page 19A)

the switch is ON to GUARDIAN HERMETICALLY *Sealed* CONTROLS...

New SOLENOID CONTACTORS

Meeting or Exceeding MIL-R-6106—AN—JAN— and Proposed MIL-R Tests!

Resonance tests meet MIL, AN and JAN requirements for *all aircraft!* Contactor is completely assembled, wired and tested before insertion into the housing, insuring a properly assembled, adjusted, inspected and tested unit prior to hermetic sealing. Units are constructed to operate in ambient temperature up to 120° C., and to withstand up to 50 G shock.

(200 Amperes)

Contactors are wired from the top for accessibility during installation and wiring. Terminal panels are of polyester fibre glass molded insulation to provide maximum physical strength plus high insulation and arc resistance. INTERCHANGEABILITY permits replacement of 10 and 25 ampere (power or time delay) contactors with 50 ampere Guardian Sealed Contactors. The 100-200-250 ampere units are interchangeable with AN 3370 and AN 3380 contactors both mounting wise and dimension wise. New Contactor Bulletin tells more advantages. Write.

Relays FOR EVERY MILITARY PURPOSE

Myriad Guardian developments for the military include a complete line of ground or air-borne steppers—solenoids—multi-contact switches and relays for communications (Series 595 D.C. Relay shown), bombing, firing, radar, control sticks, control wheels, retractors, landing lights, guided missiles, rockets and other applications to government specifications.

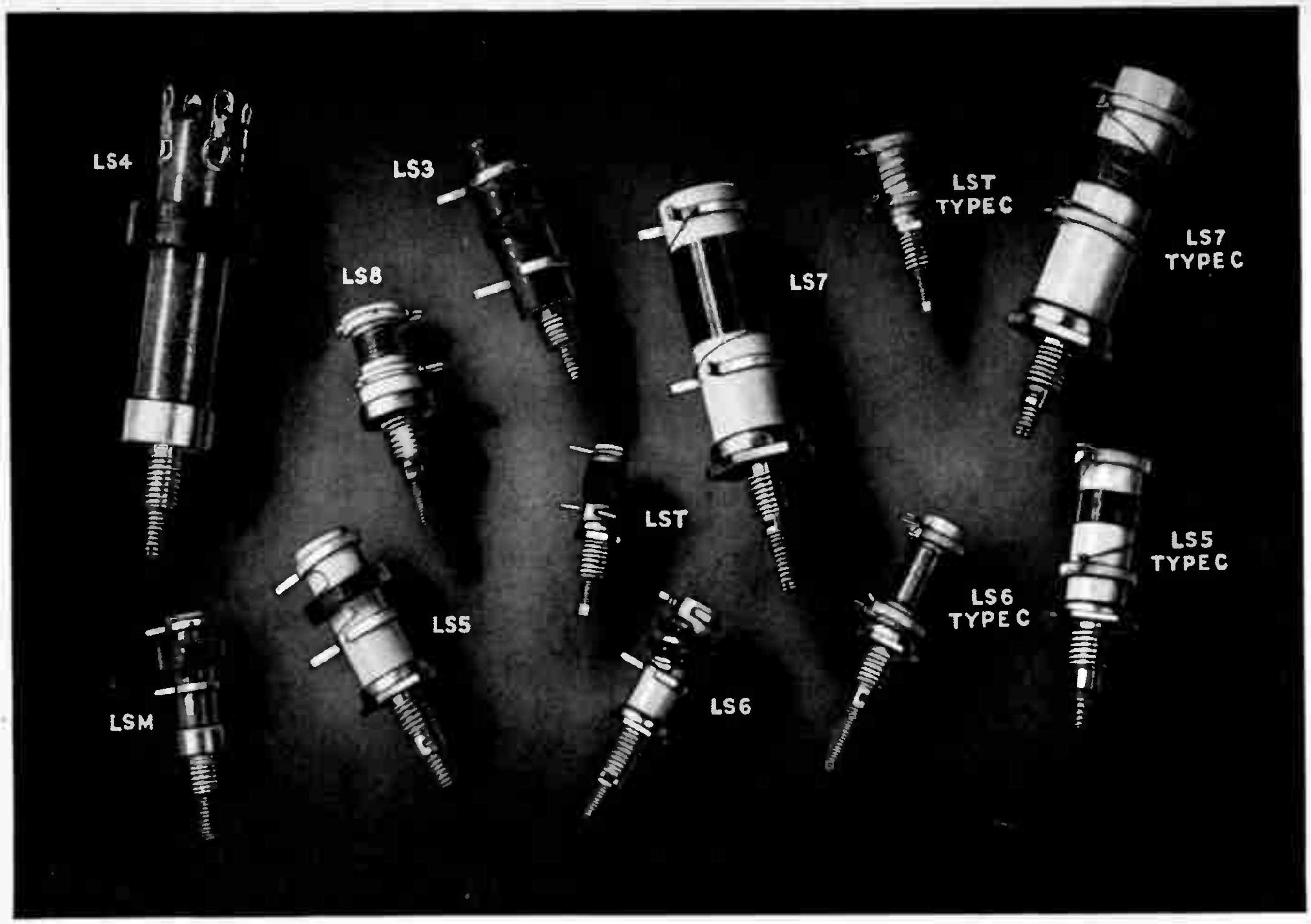
Series 595 D.C. Relay

GUARDIAN HERMETIC SEALING

Guardian *hermetically seals* a vast variety of relays to meet the most exacting military and industrial applications. If your application calls for expert *hermetic sealing*, we invite you to consult Guardian.

A.N. Approved Hermetic Seal

GUARDIAN ELECTRIC
1628-C W. WALNUT STREET CHICAGO 12, ILLINOIS
A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY



Here's how to get exactly the coils you need

You can get C.T.C. slug tuned coils, single layer or pie type windings to your exact specifications — military or personal — with expert workmanship and correct in every detail as to materials and methods.

C.T.C. coil forms are made of quality paper base phenolic or grade L-5 silicone impregnated ceramic. Mounting bushings are cadmium plated brass; ring type terminals are silver plated brass protected by water dip lacquer. Terminal retaining collars of silicone fibreglas which permit 2 to 4 terminals, are available on forms designated Type C above. Wound units can be coated with resin varnish, wax or lacquer. All units are furnished with slugs and mounting hardware.

A table of frequencies and permeabilities relating to the slugs used in the coils shown above is contained in C.T.C. catalog 400. Send for your copy, and ask for prices and specifications on the coils you need. Be sure to send complete specifications for specially wound coils.

All C.T.C. materials, methods and processes meet applicable government specifications. Cambridge Thermionic Corporation, 456 Concord Avenue, Cambridge 38, Mass. West coast manufacturers contact E. V. Roberts, 5068 West Washington Blvd., Los Angeles, and 988 Market Street, San Francisco, California.

COIL FORM SPECIFICATIONS

Coil Form	Material	Mounting Stud Thread Size	Form O.D.	Mounted O. A. Height
LST	L-5 Ceramic	8-32	3/16"	19/32"
LS6	L-5 Ceramic	10-32	1/4"	27/32"
LS5	L-5 Ceramic	1/4-28	3/8"	1 1/16"
LS8	L-5 Ceramic	1/4-28	25/64"	23/32"
LS7	L-5 Ceramic	1/4-28	1/2"	1 11/16"
LSM	Paper Phenolic	8-32	1/4"	27/32"
LS3	Paper Phenolic	1/4-28	3/8"	1 1/8"
LS4	Paper Phenolic	1/4-28	1/2"	2"

NOTE: Types LS5, LS6, LS7, LS8 have slug locking spring. Type LST, available with slug locking spring as type LSTL. Type LS4 has fixed lugs — all others have adjustable ring terminals.

CERAMIC COIL FORM KIT. Helps you spark ideas in designing electronic equipment or developing prototypes and pilot models. Contains 3 each of the following 5 C.T.C. ceramic coil form types: LST, LS5, LS6, LS7, LS8. Color-coded chart simplifies slug-identification and gives approximate frequency ranges and specifications. Fibreglas collars and metallic rings are furnished with kit for all ceramic coil forms except LS8 which is furnished only with clip terminals.

CAMBRIDGE THERMIONIC CORPORATION

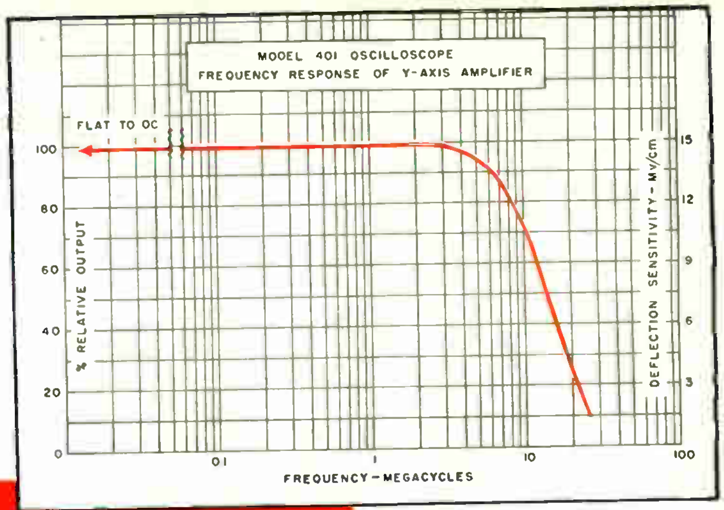
CTC

custom or standard . . . the guaranteed components

See us at Booth 2-218, IRE Show

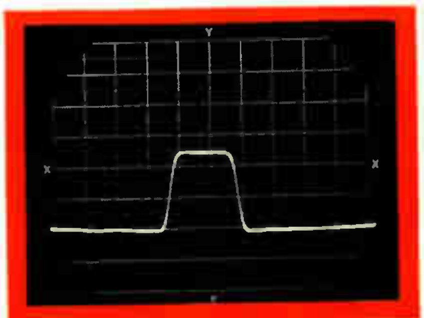
ONLY THE LFE 401 OSCILLOSCOPE

Offers all these Important Features

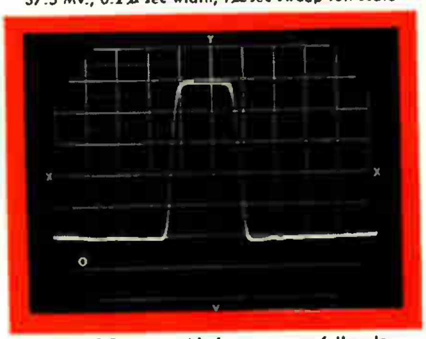


HIGH SENSITIVITY AND WIDE FREQUENCY RESPONSE OF Y-AXIS AMPLIFIER

The vertical amplifier of the 401 has been designed to provide uniform response and high sensitivity *from D-C*. The accompanying amplifier response curve shows the output down 3 db. at 10 Mc. and 12 db. at 20 Mc. Alignment of the amplifier is for best transient response, resulting in no overshoot for pulses of short duration and fast rise time. Coupled with this wide band characteristic is a high deflection sensitivity of 15 Mv./cm. peak to peak at *both D-C* and A-C.



37.5 Mv., 0.2 μ sec width, 1 μ sec sweep full scale



75 Mv., 0.2 μ sec width, 1 μ sec sweep full scale

LINEARITY OF VERTICAL DEFLECTION The vertical amplifier provides up to 2.5 inches positive or negative uni-polar deflection without serious compression; at 3 inches, the compression is approximately 15%. The accompanying photographs illustrate transient response and linearity of deflection.

SWEEP DELAY The accurately calibrated delay of the 401 provides means for measuring pulse widths, time intervals between pulses, accurately calibrating sweeps and other useful applications wherein accurate time measurements are required.

The absolute value of delay is accurate to within 1% of the full scale calibration. The incremental accuracy is good to within 0.1% of full scale calibration.

SPECIFICATIONS

Y-Axis

Deflection Sens.—15 Mv./cm, peak-to-peak.

Frequency Response—DC to 10 Mc

Signal Delay—0.25 μ sec

Input line terminations—52, 72 or 93 ohms, or no termination

Input Imp.—Direct—1 megohm, 30 μμf
Probe—10 megohms, 10 μμf

X-Axis

Sweep Range—0.01 sec/cm to 0.1 μ sec/cm

Delay Sweep Range—5-5000 μ sec in three adjustable ranges.

Triggers—Internal or External, + and −, trigger generator, or 60 cycles, undelayed or delayed triggers may be used.

Built-in trigger generator with repetition rate from 500-5000 cps.

General

Low Capacity probe

Functionally colored control knobs

Folding stand for better viewing

Adjustable scale lighting

Facilities for mounting cameras

Price: $895.00

Additional Features:

TRIGGER GENERATOR with variable repetition rate from 500 to 5000 cps.

POSITIVE & NEGATIVE UNDELAYED TRIGGERS and a **POSITIVE DELAYED TRIGGER** are externally available.

An **INPUT TERMINATION SWITCH** for terminating transmission lines at the oscilloscope.

A **FOLDING STAND** for convenient viewing.

FUNCTIONALLY COLORED KNOBS for easier location of controls.

Designed and built *for* electronic engineers, the 401, with its high gain and wide band characteristics, and its versatility, satisfies the ever-increasing requirements of the rapidly growing electronics industry for the ideal medium priced oscilloscope.

Write for Complete Information

LABORATORY for ELECTRONICS, INC.
75 PITTS STREET • BOSTON 14, MASS.

PRECISION ELECTRONIC EQUIPMENT • OSCILLOSCOPES • MAGNETOMETERS • COMPUTERS • MICROWAVE OSCILLATORS • MERCURY DELAY LINES

Industrial Engineering Notes

(Continued from page 74A)

Association of America, which asked the FCC to allocate a 420-mc band to theatre television, has filed a statement with the Commission outlining where this allocation might be made. At the time of the hearing, FCC had asked for such a statement. "In order to give notice of these proposals to all interested persons," the Commission has released proposals from the statement of the theatre interests. The first proposal, in summary form, is as follows: (a) Allocate the frequencies from 5,925 to 6,285 mc for the use of theatre television. (b) Provide a reasonable transition period within which the present occupants of 5,925 to 6,285 mc can move to frequencies between 6,285 and 6,425 mc. (c) Consideration be given to the possibility of using the frequencies between 3,500 to 3,700 mc for the purpose of common carrier fixed operations. (d) Examination be made as to whether the land mobile services in 6,425 to 6,575 mc can be used for theatre television mobile pick-up. Proposal number 2 would classify theatre television as an industrial radio service on a frequency sharing basis and expand the 6,575 to 6,875-mc band downward to include 6,425 to 6,575 mc for theatre television requirements. If theatre television must share frequencies below 7,125 mc with other services on a nonpriority basis, it will be necessary to use frequencies above 10,700 mc, in larger centers of population. If frequencies are allocated for theatre television in bands above 10,700 mc, they should begin at 10,700 mc and progress upward from that point. We have not planned to make further or different allocation proposal. . . . The FCC adopted **a Notice of Proposed Rule Making which would amend the auxiliary TV broadcast rules (Part 4) to accommodate the needs for TV pickup,** studio-transmitter link and intercity relay stations in the UHF band, through reapportionment of channels for these auxiliary services, and to make other changes not covered in the present rules. . . . The Commission **has postponed further the hearing on the allocations of frequencies for theatre television from January 12, 1953 to January 26,** due to the anticipated shortage of hotel facilities in Washington during the inaugural period. . . . **KDUB-TV, Lubbock, Tex., which was granted an STA in October, 1952, started commercial** operation on November 6, 1952, as the fourth new station to get on the air. . . . **At Austin, Tex.,** KTBC-TV, on channel 7, received an STA for interim operation with 2 kw visual and 1 kw aural output power for November 15, 1952. . . . **Hawaiian Broadcasting System** Ltd., permittee of KGMB-TV, Honolulu, was authorized and started commercial operation on channel 9 with output power of 500 w visual and 250 w aural, December 1, 1952.

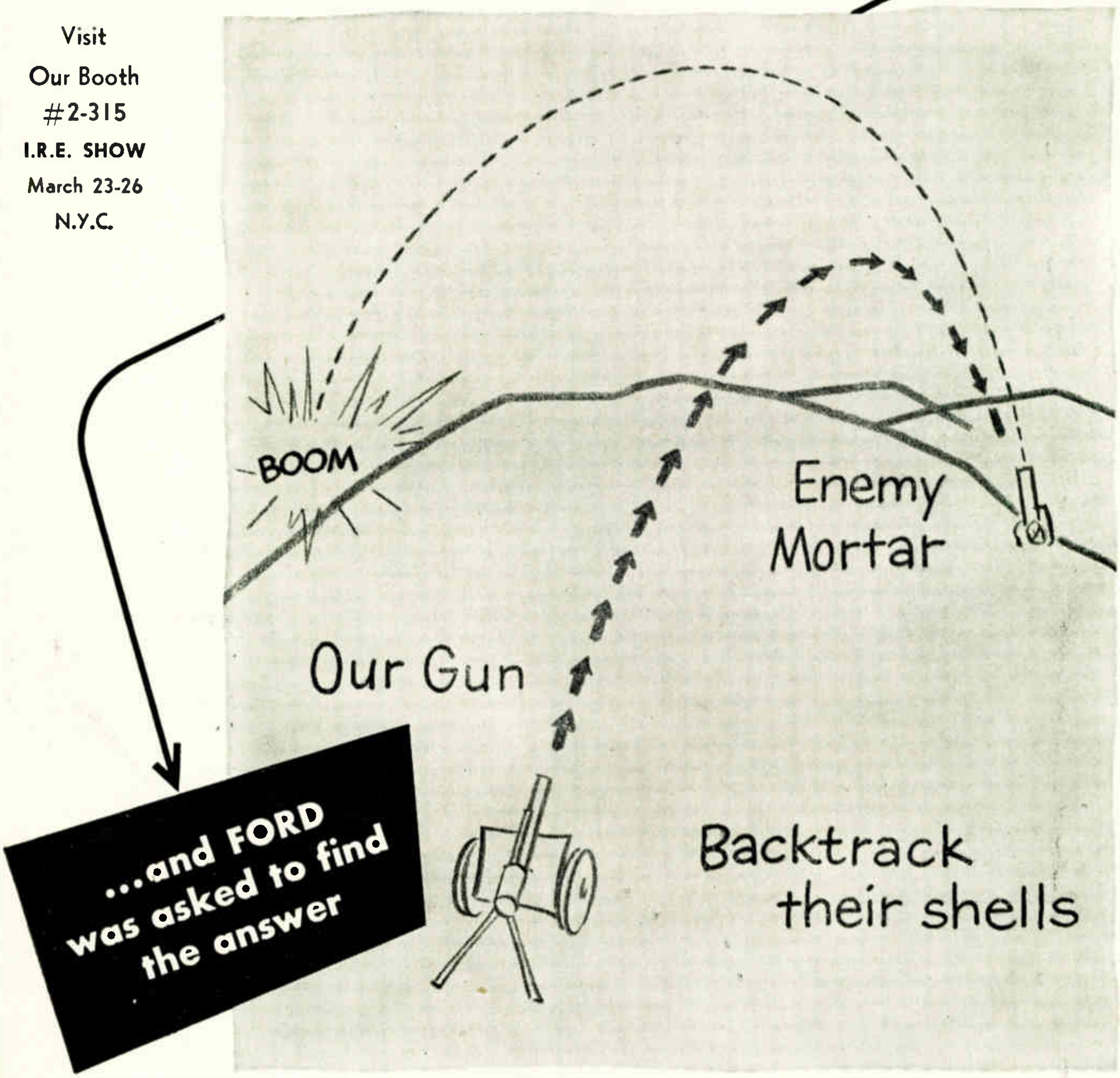
TV Station Grants

As of the end of November, 1952, The Federal Communications Commission had

(Continued on page 79A)

TO BACKTRACK SHELL TO GUN
and destroy same

Visit
Our Booth
#2-315
I.R.E. SHOW
March 23-26
N.Y.C.



Can projectiles be "seen" approaching and their flight back-tracked to locate the mortar or gun that fires them? This problem was simply reconciled with special computing equipment designed to be built right into the gun. The engineering of such a computer, the handling of such ballistic data, all falls into the pattern of previous Ford achievements.

This is typical of the problems that Ford has solved since 1915. For from the vast engineering and production facilities of the Ford Instrument Company, come the mechanical, hydraulic electro-mechanical, magnetic and electronic instruments that bring us our "tomorrow" today. Control problems of both Industry and the Military are Ford specialties.

6

You can see why a job with Ford Instrument Company offers a challenge to young engineers. If you qualify, there may be a spot for you in automatic control development at Ford. Write for illustrated brochure.

FORD

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

Filtered by Filtron


LOCKHEED F-94

GUARANTEES CONFORMANCE TO RADIO INTERFERENCE SPECIFICATION

MIL-I-6181

(0.15 TO 1000 MEGACYCLES)


BOEING B-47

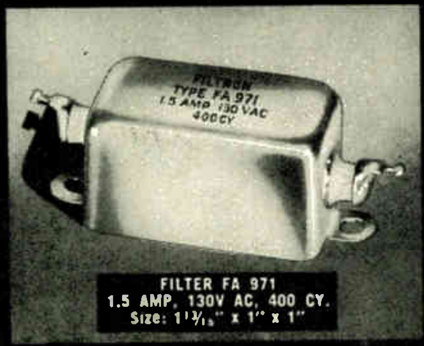
Filters by Filtron

FILTRON'S Engineering division, with its completely equipped screen room facilities, is always available to measure and recommend RF Interference Filters for your equipment, to meet and exceed the Radio Interference requirements of MIL-I-6181.

FILTRON'S production facilities are suppying more RF Interference Filters for use in military electronic equipment than ever before, to meet the nation's requirements.

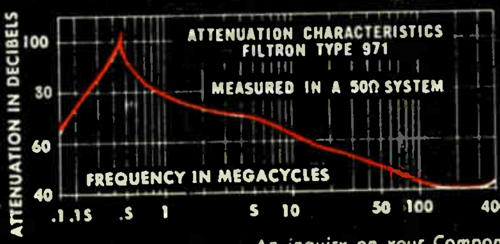
FILTRON... the LEADER IN RF INTERFERENCE FILTERS... has pioneered:

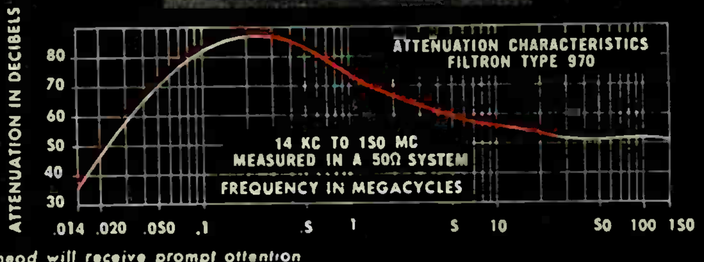
- Sub-miniature Filters
- High-temperature Filters
- RF Filters to withstand Shock and Vibration
- Wide band Multi-section Units
- RF Filters "Custom Designed" to meet YOUR requirements



FILTER FA 971
1.5 AMP, 130V AC, 400 CY.
Size: 1 13/16" x 1" x 1"

FILTER FA 970
155 MA, 130V AC-DC, 50-1000 CY.
Size: 1¾" x 1¼" x 1⅛"





An inquiry on your Company letterhead will receive prompt attention

THE **FILTRON** COMPANY INC., FLUSHING, LONG ISLAND, NEW YORK

LARGEST EXCLUSIVE MANUFACTURERS OF RF INTERFERENCE FILTERS

PRECISION 60-CYCLE POWER SUPPLY

Accurate 60-cycle frequency stabilization with up to 70 watts power output is furnished by the Ampex 375. To provide frequencies other than 60 cycles, the power amplifier section may be independently driven by an external signal generator instead of by the built-in tuning fork oscillator.

The 375 was originally designed to provide the precise 60-cycle power required by Ampex tape recorders. Hence it is ideally suited to any application where constant speed of electric motors is a prime requisite. Typical of these are precision electric motor drives for turntables, stroboscopic timing devices, time bases, timekeeping, high-speed cameras, chronographs, astronomical units, geophysical units and viscometers.

AMPEX MODEL 375

GENERAL PERFORMANCE CHARACTERISTICS & SPECIFICATIONS

OUTPUT POWER:	70 watts
OUTPUT FREQUENCY:	Precise 60 cycles using built-in tuning fork oscillator (temperature coefficient 5 parts per million per degree Centigrade) 50 to 400 cycles using external signal oscillator
OUTPUT VOLTAGE:	0 to 135 volts, continuously adjustable
INPUT FREQUENCY:	50 to 400 cycles
INPUT VOLTAGE:	115 to 125 volts
INPUT POWER:	275 watts
DIMENSION & WEIGHT:	Standard 19-inch rack mounting Panel Height: 12¼ inches Weight: 60 pounds

AMPEX ELECTRIC CORPORATION

Write Dept. G today for further information

AMPEX ELECTRIC CORPORATION
934 CHARTER STREET • REDWOOD CITY, CALIF.

What to see at the Radio Engineering Show

(Continued from page 12A)

Arco Electronics, Inc.
New York 13, N.Y.

Booth 4-308

Representing Electro-Motive Mfg. Co. ElMenco Capacitors.

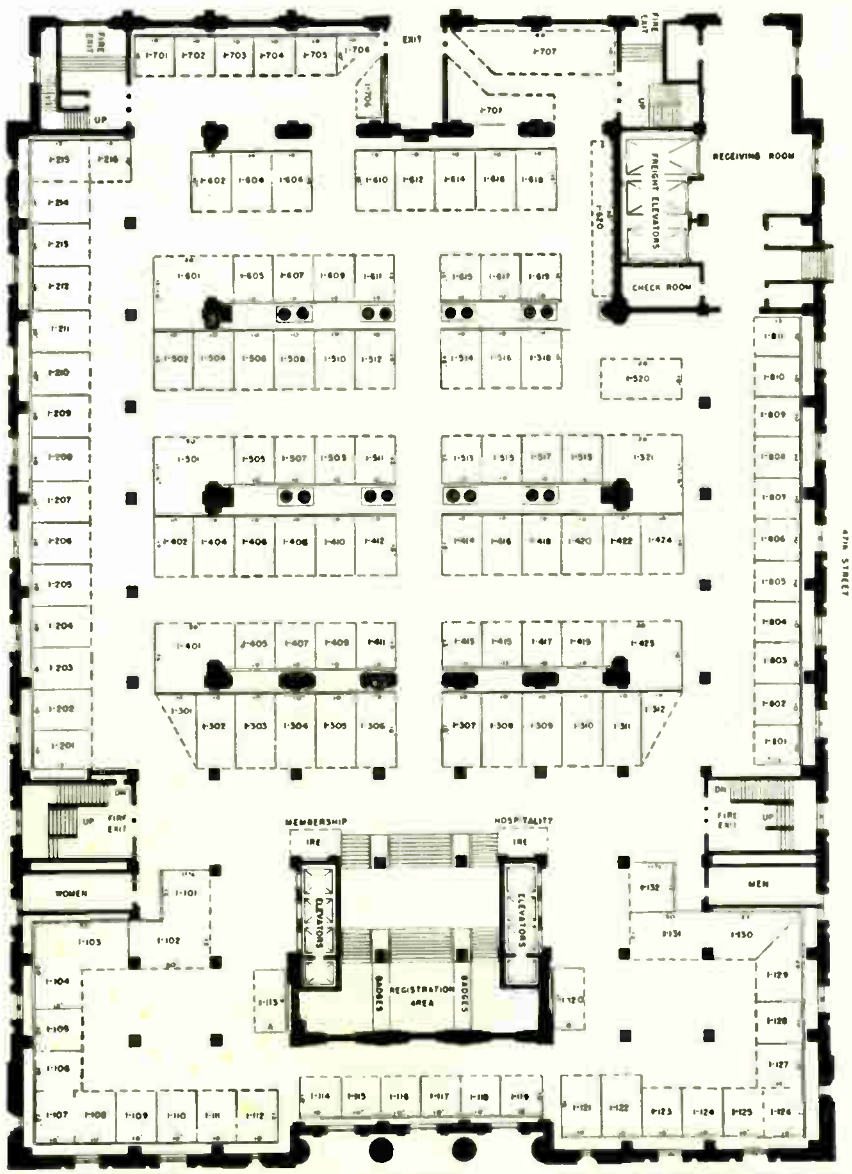
The Arnold Engineering Company
Subsidiary of Allegheny Ludlum Steel Corporation
Booth 1-406
Main Offices and Plant:
Marengo, Ill.

District Offices:
Empire State Building
New Lork City
3450 Wilshire Blvd.
Los Angeles, California

Arnold Engineering Co., Marengo, Ill. 1-406 & 408
Alnico Permanent Magnets (cast and sintered); Tape Wound Cores of High Permeability Alloys Including Silectron, Deltamax, Permalloy, and Supermalloy; C Cores of Silectron; Powdered Molybdenum Permalloy Cores; Vibralloy; Permendur; Precision Rolled Materials down to 1/10 Mil. (0.0001").

ASTRON CORPORATION
255 Grant Avenue
East Newark, N.J.
Booth 4-707
Metalite metallized paper capacitor Blue Point molded plastic tubular capacitors, Dry electrolytic capacitors, subminiature paper capacitors for 125°C operation; and standard and miniaturized RF Interference suppression filters for every radio, television and electronic use.

Atomic Instrument Co., Cambridge 39, Mass. 4-109 & 110
Power Supplies, Geophysical Apparatus. Medical Equipment, Audio Frequency. Test Equipment. Nuclear.



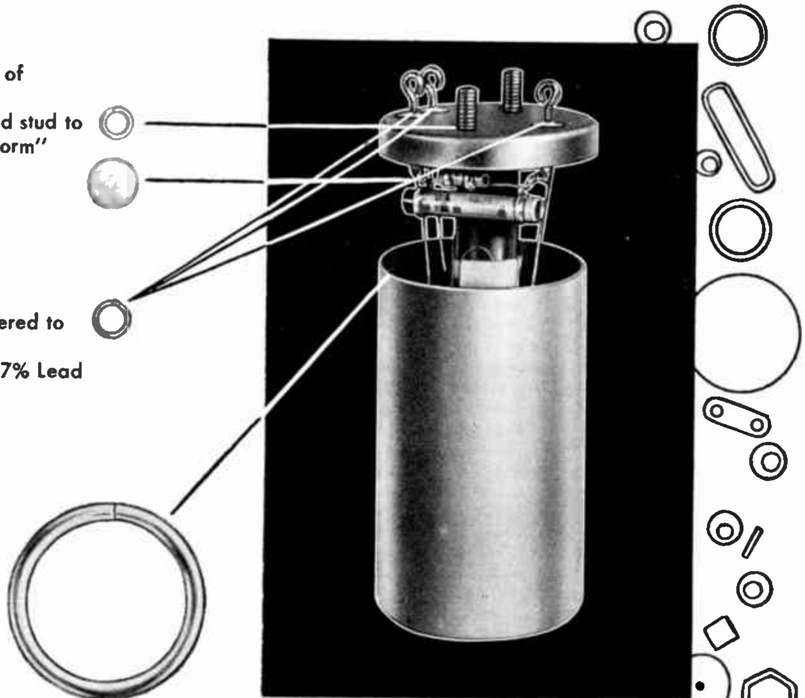
FIRST FLOOR

MAIN ENTRANCE LEXINGTON AVENUE

I R E RADIO ENGINEERING SHOW

(Continued on page 32A)

3 Soldering Operations in 1
Easy as ABC
with
KESTER® "SOLDERFORMS"



A First step in resistance soldering of this high-precision oscillator coil consisted of soldering screws and stud to can cover. Used Kester "Solderform" Disc and Rings composed of 5% Silver—95% Lead Alloy. Melting Point 680°F.

B Three glass terminals were soldered to cover with Kester "Solderform" Rings comprised of 63% Tin—37% Lead Alloy. Melting Point 361°F.

C Final operation, hermetically sealing cover on can, used Kester "Solderform" Ring 28.5% Bismuth—28.5% Tin —43% Lead Alloy. Softening Point 250°F.

MAKES MANY TOUGH JOBS SIMPLE

Tough jobs like this one can be made easy by Kester-engineered "Solderforms." Progressively lower melting temperatures at the various points of solder contact were mandatory, so as not to loosen each previous solder bond. And, typical of all Kester "Solderform" applications, the completely assembled coil successfully met all exacting tests, including 45 lbs. air pressure under alternate hot and cold water immersions.

KEY TO LOWERED PRODUCTION TIME

You'll find that Kester "Solderforms" are the definite answer to many severe production operations involving solder... speeding up production and lowering waste and rejects. Besides a wide variety of shapes and precise job-engineered composition, Kester "Solderforms" come to you dimensionally stable; every single Kester "Solderform" is guaranteed to be delivered in its exact pre-formed shape, ready for immediate use.

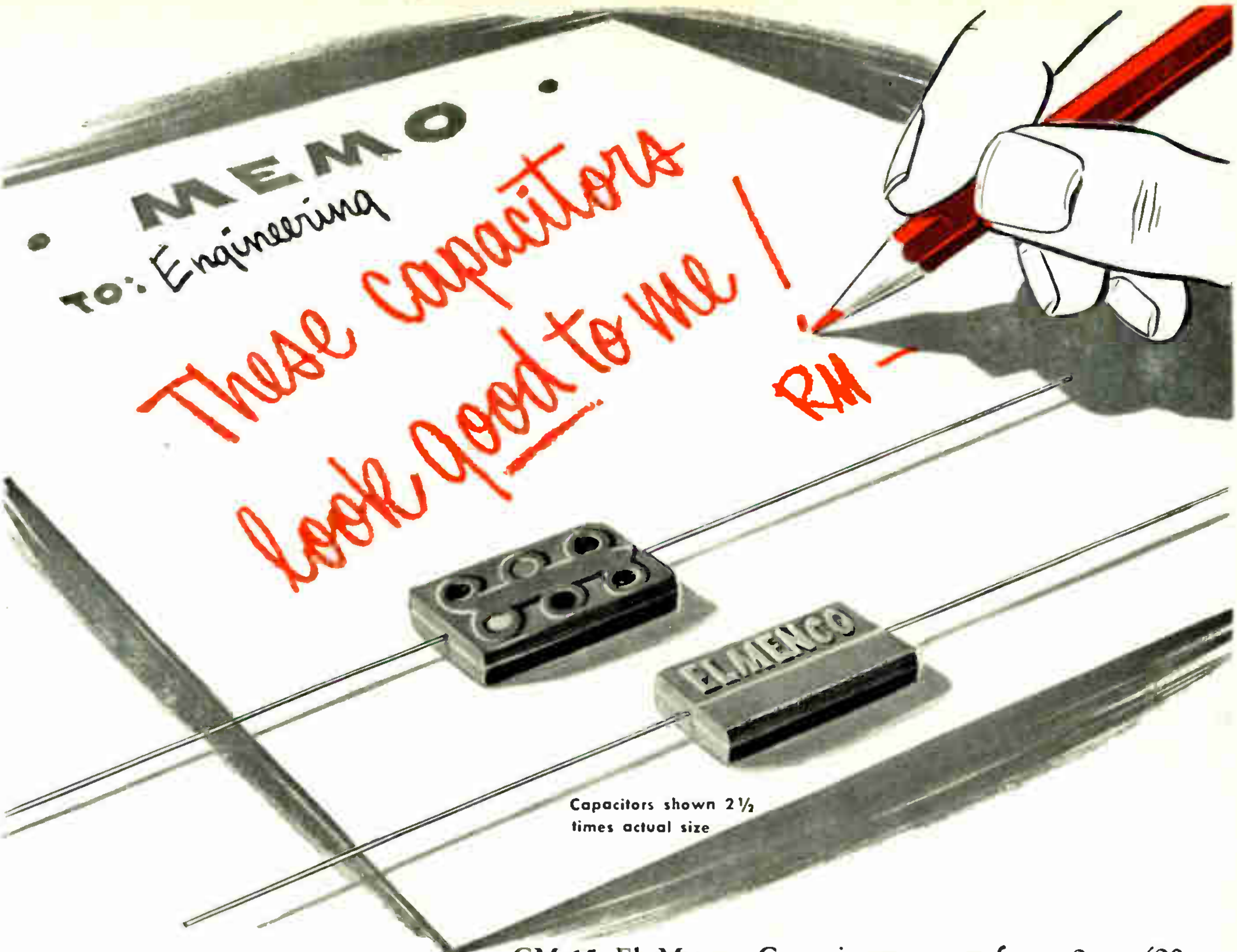
IF YOU MAKE Capacitors, Resistors, Switches, Transformers, Speaker Assemblies, Relays, Meters, Gauges, Fire Control Parts, Fuses, Badges & Emblems, Movements & Controls ... and many others ... you should INVESTIGATE KESTER "SOLDERFORMS"

WRITE TODAY for free samples and literature

KESTER
SOLDER COMPANY

4219 Wrightwood Avenue, Chicago 39, Illinois
Newark 5, New Jersey; Brantford, Canada

See "Solderforms" In Action Booth 2-411 I.R.E. Show



Capacitors shown 2½ times actual size

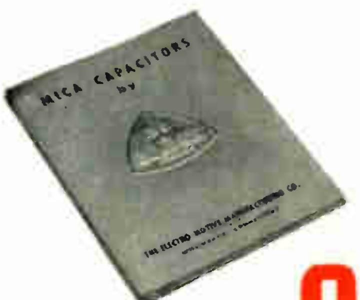
CM-15 El Menco Capacitors range from 2 to 420 mmf. at 500 vDCw . . . measure only 9/32″ x ½″ x 3/16″ . . . but they're

PRETESTED at 1000V!

ALL fixed mica El Menco Capacitors are *factory-tested at double their working voltage.* So, you can be sure they'll stand up. They also meet all significant JAN-C-81 specifications. This means that you can specify them with confidence for all military or civilian electronic applications.

Our Type CM-15 silvered mica capacitors reach 525 mmf. at 300 vDCw. Our other types — silvered and regular — provide capacities up to 10,000 mmf. Want samples for testing? *The Electro Motive Manufacturing Co., Inc., Willimantic, Conn.*

WRITE FOR FREE SAMPLES AND CATALOG ON YOUR FIRM'S LETTERHEAD



Jobbers and distributors are requested to write for information to Arco Electronics, Inc., 103 Lafayette St., New York, N. Y. — Sole Agent for Jobbers and Distributors in U. S. and Canada.

El-Menco

MOLDED MICA **MICA TRIMMER**

CAPACITORS

Foreign and Electronic Manufacturers Get Information Direct from our Export Dept. at Willimantic, Conn.

THE ELECTRO MOTIVE MFG. CO., INC. **WILLIMANTIC, CONNECTICUT**

At the Show, see—

HUDSON

—for a quick solution to all closure problems!

On Parade— HUDSON Standard Cases and Covers

Visit Booth 3-208 I.R.E. Electronics Show! See the standard cases and covers that solve special closure requirements, economically. Hudson stocks hundreds of types, sizes, shapes with dozens of optional features available. Precision drawn and thoroughly inspected to simplify the work of engineers, designers and purchasing officials. Ask for a copy of the Hudson Engineers Catalog File. 212 It's yours without obligation!

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PRECISION DRAWN CASES AND COVERS AND QUALITY METAL STAMPINGS FOR THE ELECTRONIC, NUCLEONIC AND ELECTRICAL INDUSTRIES

keeping communications ON THE BEAM

JK
PRODUCTS

the JK FD-12

FREQUENCY AND MONITOR MODULATION

Monitors any four frequencies anywhere between 25 mc and 175 mc, checking both frequency deviation and amount of modulation. Keeps the "Beam" on allocation: guarantees more solid coverage, too!

JK STABILIZED H-17 CRYSTAL

CRYSTALS FOR THE CRITICAL

The JK H-17 Crystal meets rigid airline requirements for compactness, light weight, rugged dependability. A Military type, it is hermetically sealed—dust and moisture proof —plated, quartz plate is shock mounted. One of many JK Crystals made to serve every need.

Ceiling Zero...Communications 100%

"Pea soup" over the field . . . and still the giants of air travel come in "on the beam". When visibility is poor, commercial pilots must rely on radio-radar equipment to bring their ship in safely. JK Crystals play an important role in this every day drama of keeping airlines communications "on the beam" in the air and on the ground.

THE JAMES KNIGHTS COMPANY
SANDWICH ILLINOIS

KROHN-HITE is Setting the Pace for Low Frequency Electronic Instrumentation

QUALITY INSTRUMENTS with PROVEN PERFORMANCE

moderately priced

★ Oscillators — .009 cps to 520 kc

Models 400-A, 420-A, 430-A
12" wide, 7" high

The Models 400-A, 420-A, and 430-A are compact RC Oscillators with outstanding performance, moderately priced. The Models 400-A and 420-A provide both sine and square wave output.

Models 410-A, 400-C, 420-C
19" wide, 8¾" high

The Models 410-A, 400-C, and 420-C are designed with sturdy steel cabinets for rack panel mounting. These units feature sine and square wave output. The Model 400-C provides either balanced or single ended output.

Model	Featuring	Frequency Range	Distortion	Output	Power Consumption	Price
400-A	Sine and Square Wave True RC Oscillator Compact Design	.009 cps to 1.1 kc	1%	25 mw/10 v	45 watts	$350.00
410-A	Sine and Square Wave Amplitude ±.25 db Low Distortion	.02 cps to 20 kc	1/4%	10 mw/5 v	150 watts	$950.00
420-A	Sine and Square Wave Audio and Sub-Audio Compact Design	.35 cps to 52 kc	1%	25 mw/10 v	45 watts	$290.00
430-A	Wide Range Compact Design Outstanding Value	5 cps to 520 kc	1%	50 mw/10 v	45 watts	$145.00
400-C	Sine and Square Wave Rock Panel Balanced Output	.009 cps to 1.1 kc	1%	100 mw/10 v	65 watts	$375.00
420-C	Sine and Square Wave Rack Panel Audio and Sub-Audio	.35 cps to 52 kc	1%	100 mw/10 v	65 watts	$325.00
440-A	Push-Button Controlled Excellent Resetability Low Distortion	.01 cps to 100 kc	1/10%	100 mw/10 v	120 watts	$450.00

★ Filters — .01 cps to 200 kc

Models 310-A and 360-A
12" wide, 7" high

The Models 310-A and 330-A are variable band-pass filters with unity pass band gain and 24 db/octave outside the pass band. Both high and low cut-off frequencies are independently adjustable over the entire frequency range.

The Models 350-A and 360-A are variable rejection filters which provide either a rejection band in which the gain falls at a rate of 24 db/octave or a sharp single frequency null. Both high and low frequencies are independently adjustable.

Models 330-A and 350-A
18" wide, 10" high

Model	Type	Featuring	Frequency Range	Noise & Hum	Power Consumption	Price
310-A	Band-Pass	Variable Band-Width Zero db Insertion Loss 24 db/octave Slope	20 cps to 200 kc	3 mv	40 watts	$275.00
330-A	Band-Pass	Low Internal Noise Zero db Insertion Loss 24 db/octave Slope	.02 cps to 2 kc	0.1 mv	50 watts	$450.00
	Band-Pass	Audio and Sub-Audio Range 24 db. octave Slope Variable Band-Width	0.2 cps to 20 kc	0.1 mv	50 watts	$450.00
340-A	Servo	Proportional-Plus-Derivative Proportional-Plus-Integral Servo-Design Filter	.01 cps to 100 cps	10 mv	40 watts	$350.00
350-A	Rejection	Low Internal Noise Rejection Band or Null 24 db/octave Slope	.02 cps to 2 kc	0.1 mv	50 watts	$450.00
360-A	Rejection	Variable Rejection Band Variable Null 24 db/octave Slope	20 cps to 200 kc	5 mv	40 watts	$275.00

ABOUT THESE INSTRUMENTS

The Oscillators and Filters described here are being effectively used in a growing number of interesting applications for engineering, research, and production.

WRITE FOR A FREE DESCRIPTIVE CATALOG

All instruments are fully guaranteed for one year against defective materials and workmanship.

Prices Net F.O.B. Cambridge

KROHN-HITE INSTRUMENT COMPANY
580 MASSACHUSETTS AVENUE
CAMBRIDGE 39, MASS., U.S.A.

ELECTRONIC TEST

New *Multi-purpose*

New!

-hp- 612A — VERSATILE, DIRECT READING. FOR UHF-TV, OTHER WORK 450 TO 1,200 mc

This master oscillator-power amplifier generator is especially designed for UHF-TV measurements including receiver and amplifier gain, selectivity, sensitivity and image rejection. It is also a convenient, direct-reading laboratory power source for driving bridges, slotted lines, antennas and filter networks. Both frequency and output are directly set on large, precisely calibrated dials. No charts or interpolation are required.

Model 612A has a maximum output of 0.5 volts into 50 ohms over its entire frequency range. The instrument also has low incidental fm and broad band modulation up to 5 mc. It may be modulated internally or externally, amplitude modulated, or pulse modulated (good rf pulses 0.2 μsec or longer). Pulse modulation may be applied to the amplifier; or direct to the oscillator when high on-off signal ratios are required.

BRIEF SPECIFICATIONS

Frequency Range: 450 to 1,200 mc, 1 band.

Accuracy: Calibration ±1%. Resettability better than 5 mc at high frequencies.

Output: 0.1 μv to 0.5 v continuously variable. Calibrated in volts and dbm. Impedance 50 ohms. Max. VSWR 1.2. Accuracy ±1 db entire range.

Modulation: Amplitude: From 0 to 90% indicated by panel meter.
Envelope Distortion: 2% at 30% modulation.
Internal: Fixed modulation frequencies, 400 and 1,000 cps.
External: Any frequency 20 cps to 5 mc.
Pulse Requirements, External Modulation:
Pulse to Amplifier: Good pulse shape at 0.2 μsec length.
Pulse to Oscillator: 1.0 μsec minimum.

Size: Cabinet 12" x 14" x 18" deep.

Price: $1,200.00

10 TO 500 mc

-hp- 608A VHF Signal Generator provides output ranging from 0.1 μv to 1.0 v into 50 ohms. Accuracy is ±1 db. Direct reading frequency and output calibration; no charts or interpolation required. Pulsed, cw or amplitude modulated output (50 cps to 1 mc). Resettability better than 1 mc. Has master oscillator-power amplifier for widest modulation capabilities. Constant internal impedance. Maximum VSWR 1.2. $850.00

800 TO 2,100 mc

-hp- 614A UHF Signal Generator provides output ranging from 0.1 μv to 0.223 v (1 mw) into 50 ohms. Accuracy ±1 db. Has single dial, direct reading frequency and output, no charts or interpolation. Offers cw, fm or pulsed output. Widely variable pulsing, synchronizing, delay and triggering features. Extremely fast rise/decay time of 0.1 μsec. Constant internal impedance. Maximum VSWR 1.6. $1,950.00

Complete Coverage HEWLETT-PACKARD

See us at the Radio Engineering Show

INSTRUMENTS

SIGNAL GENERATORS

New!

-hp- 618B — VARIED PULSING CAPABILITIES, DIRECT READING. RANGE 3,800 TO 7,600 mc

Model 618B offers faster, more accurate measurement of component performance in radar, radio relay and TV carrier systems and similar field and laboratory applications. Frequency is generated in a reflex klystron oscillator; accuracy and stability are high throughout the instrument's wide frequency range. Frequency and voltage are directly set and read. Dial tuning is tracked automatically, and no voltage adjustment is required during operation.

Extremely wide pulsing capabilities have been built into *-hp-* 618B. The instrument may be internally or externally pulse modulated, internally square wave modulated and frequency modulated. The repetition rate is continuously variable between 40 and 4,000 pps. Pulse width is variable 0.5 to 10 μsec. Sync-out signals are simultaneous with the rf pulse or in advance by any time-span from 3 to 300 μsec. The instrument also may be synchronized with an external sine wave, or with positive or negative pulse signals.

BRIEF SPECIFICATIONS

Frequency Range: 3,800 to 7,600 mc. 1 band.

Calibration: Direct. Accuracy better than 1%.

Stability: Frequency: less than 0.006% per °C change.
Line Variation: ± 10 v causes less than 0.01% frequency change.

Output: 1 mw 0.223 v to 0.1 μv into 52 ohms. (0 to –127 dbm).

Modulation: Internal or external pulse, fm, or internal square wave.

External Sync: (1) Sine wave 40 to 4,000 cps, 5 to 50 v rms.
(2) Pulse signals 40 to 4,000 pps, 5 to 50 v (pos. and neg.). Pulse width 0.5 to 5 μsec. Rise time 0.1 to 1.0 μsec.

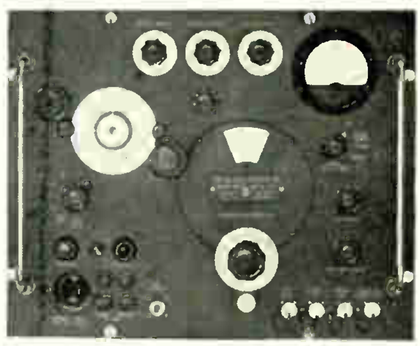
Size: Cabinet 16¾" x 13½" x 16" deep.

Price: $2,250.00

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

1,800 TO 4,000 mc

-hp- 616A UHF Signal Generator offers the same simple operation, wide pulsing capabilities, high stability and accuracy as *-hp-* 618B, but is designed for UHF frequencies. Output ranges from 0.1 μv to 0.223 v (1 mw) into a 50-ohm load. Accuracy is ±1 db. Output may be cw, fm or pulsed. Modulation and synchronizing features are similar with *-hp-* 618B. Oscillator section is a reflex klystron. Frequency changes are automatically tracked and no voltage adjustment is needed during operation. Frequency and output are directly set and read on large, carefully calibrated dials. No charts or interpolation are needed. $1,950.00



For complete details, see your -hp- field representative or write direct

HEWLETT-PACKARD COMPANY
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VACUUM ELECTRONIC COMPONENTS
VACUUM CAPACITORS
now available in such varieties of types, sizes, and electrical characteristics that you can design your next circuit around these units with ease. Our development laboratory is available to design and produce units for specialized application.
Voltages: Up to 65 KV
Currents: Up to 400 AMP
Capacities: Up to 2,500 MMFD
Ratio of change: Up to 180:1
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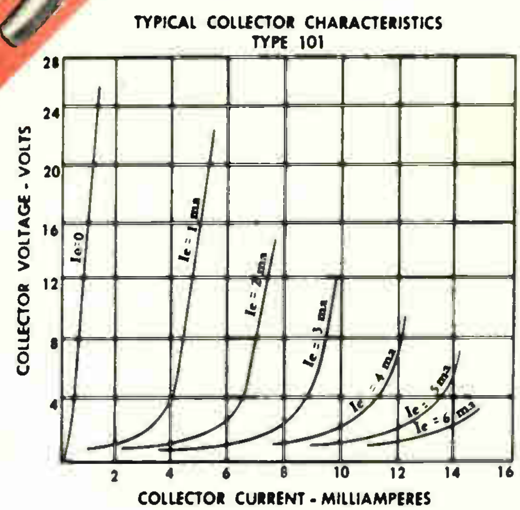
Texas Instruments'

POINT CONTACT

TRANSISTORS

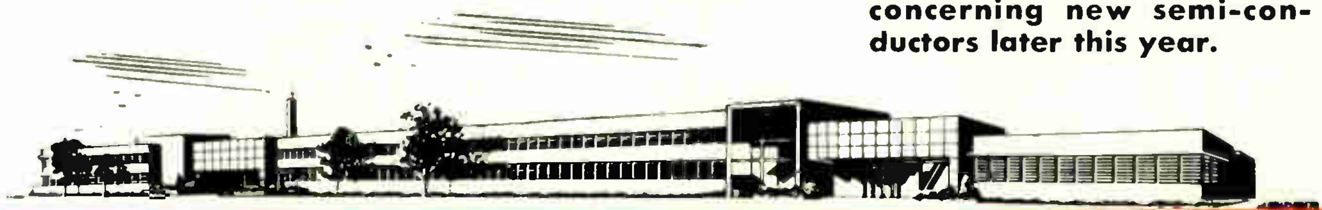
now available!

Texas Instruments makes available to industry Type 100 and 101 point contact transistors. Type 100 is designed for use in switching circuits. Type 101 is a high-efficiency, low-drain transistor for low frequency (below 1 mc) application. It is designed to operate at low voltage and power levels with a good, large signal performance. Both have the usual high temperature limitations of germanium semi-conductor devices. *Uniform characteristics are assured.* Write for bulletin with complete information.



★ **ACTUAL SIZE**

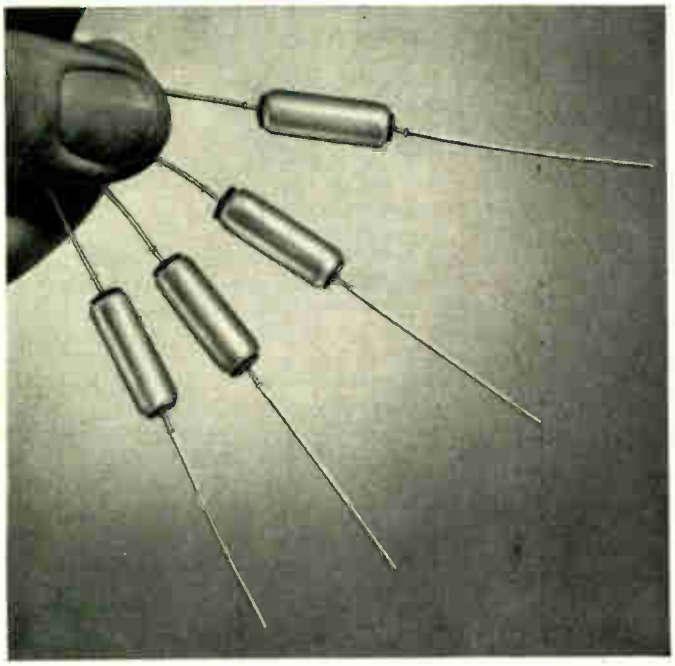
★ Point contact transistors Type 100 and 101 ready for immediate delivery. ★ Junction transistors will be available in developmental quantities in May. ★ Be sure to watch for announcement concerning new semi-conductors later this year.



TEXAS INSTRUMENTS

6000 LEMMON AVENUE INCORPORATED **DALLAS 9, TEXAS**

DESIGNER'S



Miniaturize your product with Tantalytic* capacitors

On low-voltage d-c applications, where your equipment miniaturization calls for both small size and superior performance, General Electric Tantalytic capacitors offer a host of advantages. These foil-type, tantalum-electrode, electrolytic capacitors have greater capacitance per unit volume and far longer shelf life than aluminum-electrolytic types. Long operating life, too, is provided by their inherently inert characteristics, and the use of non-corrosive, chemically neutral electrolyte. And leakage current is low—less than 10 microamps per microfarad.

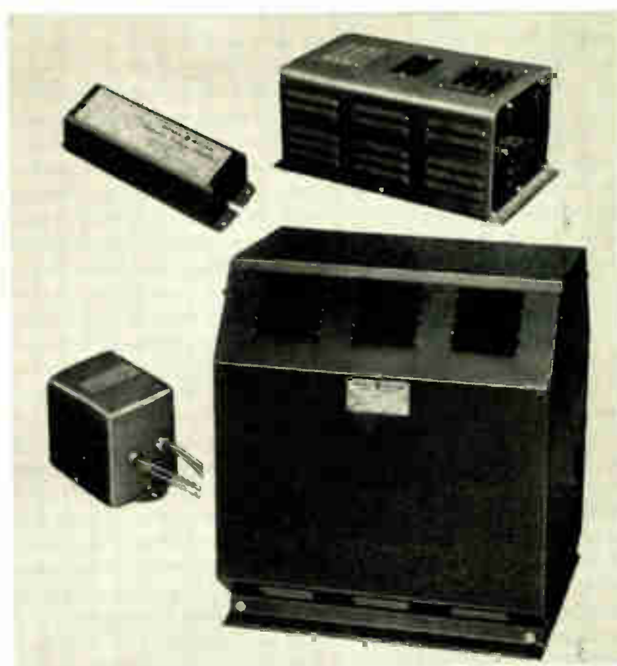
Built to withstand severe shock, these lightweight units operate over a wide temperature range (−55 C to +85 C and higher). Hermetic sealing protects them against leakage and contamination. Available in polar and non-polar construction, in ratings from 175 muf at 5 volts d-c to 12 muf at 150 volts d-c. For complete description of the line, plus application information, check Bulletins GEC-808 and GER-451 in the coupon on the next page.

*Trade-mark of General Electric Company.

Now—greater flexibility in voltage stabilizers

Fluctuating voltage is serious on sensitive electronic equipment designed for best performance at a specified voltage. Now, to help you get rid of voltage ups and downs, G.E. offers a new 15- to 5000-va line of automatic voltage stabilizers that gives you greater design flexibility at no increase in price, plus weight reduction in larger sizes. New output ratings of 1000, 2000, 3000, and 5000 volt-amperes—with 115 and 230 volts on both input and output—permit operation in any combination of these input and output voltages.

Fluctuations between 95 and 130 volts, or 190 and 260 volts, are corrected to a stable 115 or 230 volts within ±1 percent—and in less than two cycles. Single-core construction permits input circuit to be completely isolated from output circuit. Installation is easy: connect one set of terminals for supply and another set for the load. With no moving parts, maintenance is virtually eliminated. See Bulletin GEA-5754 for complete description.



GENERAL ELECTRIC

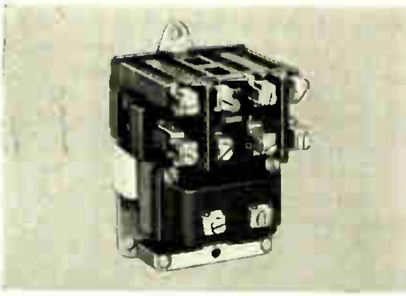
DIGEST

TIMELY HIGHLIGHTS ON G-E COMPONENTS

Prices reduced as much as 35% on light, flexible delay line

Increased use of delay line in special circuits for electronic equipment now enables General Electric to mass-produce it, at savings to you of up to 35 percent. Originally developed to provide delay with minimum distortion in radar equipment, G-E delay line now has many commercial uses such as color television and electronic calculators.

Bulk line is available in lengths of 100 feet or less to be cut as desired. Time delay is approximately ½ microsecond per foot for 1100-ohm line, ¼ microsecond per foot for 400-ohm line. Line is light in weight, ¼-inch in diameter, and easily bent into a 4-inch-diameter coil. Operates between −50 C and 100 C: Bulletin GEC-459.

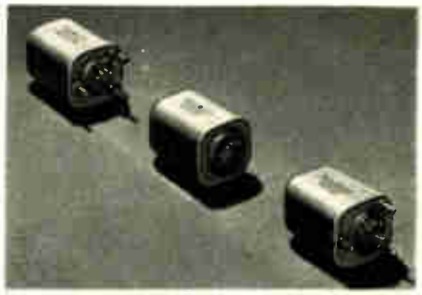


Size 00 relays cut inventories

Many of your control-circuit needs can be met with compact G-E size 00 contactors and relays—available in any combination of normally open and normally closed contacts from 2 to 8 poles. Since contact tips are easily changed from NO to NC without extra parts, your "specials" inventory is cut. Easily accessible terminals take up to 3 wires, speed connections. For complete details, see your General Electric apparatus sales representative.

Reliable d-c to a-c amplification

Designed mainly for 400-cycle excitation, the General Electric second-harmonic converter is a magnetic-amplifier type unit that converts low-level d-c error signals (such as thermocouple output) to 800-cycle a-c output. Static operation and hermetic sealing make it reliable under extreme conditions of acceleration, temperature, and pressure—important in aircraft applications. Length is $3\frac{1}{16}$ in., tube diameter 1¼ in., weight, 0.2 lb. See Bulletin GEC-832.



Now—sealed-relay line expanded

G-E hermetically sealed relays for 28-volt circuits are now available in these forms: DPDT, 3PDT, 4PDT, 6PNO—with coil ratings up to 10,000 ohms. Certain other configurations available on request. All have extra-high tip pressures, yet don't exceed Air Force-Navy size and weight specs. They withstand all outside atmospheric conditions, 50g operational shocks, and instantaneous voltage surges up to 1500 volts. Bulletin GEA-5729.

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Demagnetizers

*Reg. Trade-mark of General Electric Co.

General Electric Company, Section B 667-24
Schenectady 5, New York

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✓ for reference only
✗ for immediate project

☐ GEA-5729 Sealed Relays
☐ GEA-5754 Voltage Stabilizers
☐ GEC-459 Delay Line
☐ GEC-808 & GER-451 Tantalytic Capacitors
☐ GEC-832 2nd-Harmonic Converter

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Company ______________________

City ______________________ State ________

What to see at the Radio Engineering Show

(Continued from page 19A)

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Audiocom, Inc. Great Barrington, Mass. 3-310
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Automatic Electric Sales Corp., Chicago 7, Ill. 2-203
Telephone type relays and stepping switches, open and hermetically sealed, aircraft and AN types as well as regular. Design emphasis on ruggedness, reliability, small size and adaptability. Also a full line of push, turn, and lever keys and other allied items.

Avery Adhesive Label Corp., Monrovia, Calif. 4-817 & 819
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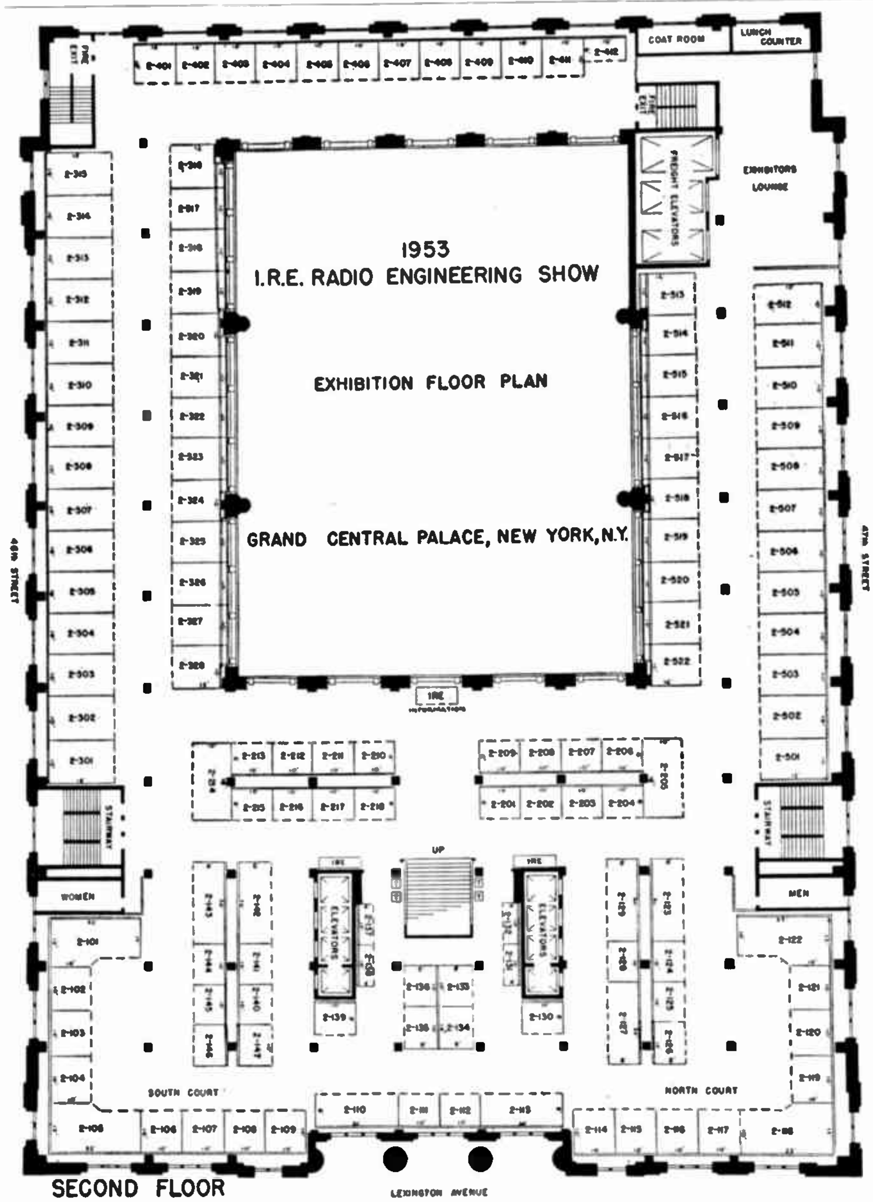
(Continued on page 64A)

Barker & Williamson, Inc., Upper Darby, Pa. 2-123
Coils, Capacitors, Components and Test Equipment.

Beam Instruments Corp., New York 1, N.Y. 2-117
Cossor Instruments, Oscillographs, etc., Wire and Cables, Tannoy Hi Fidelity Audio Products. Duode Hi Fidelity Audio Products, Acoustical Hi Fidelity Audio Products, Best Vacuo-Junctions.



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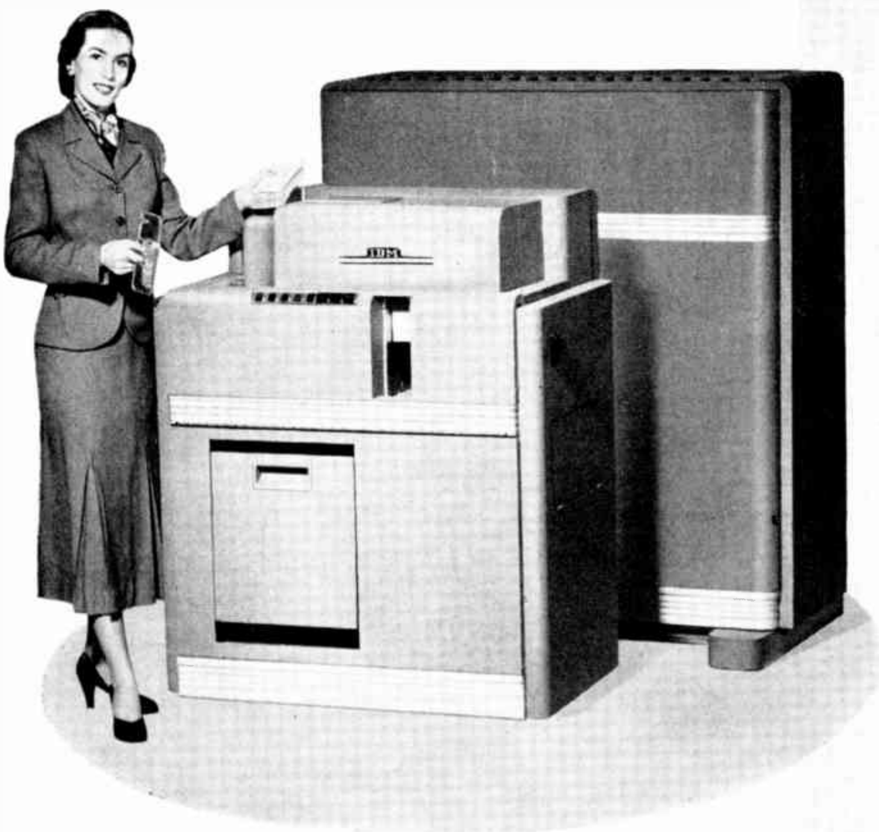

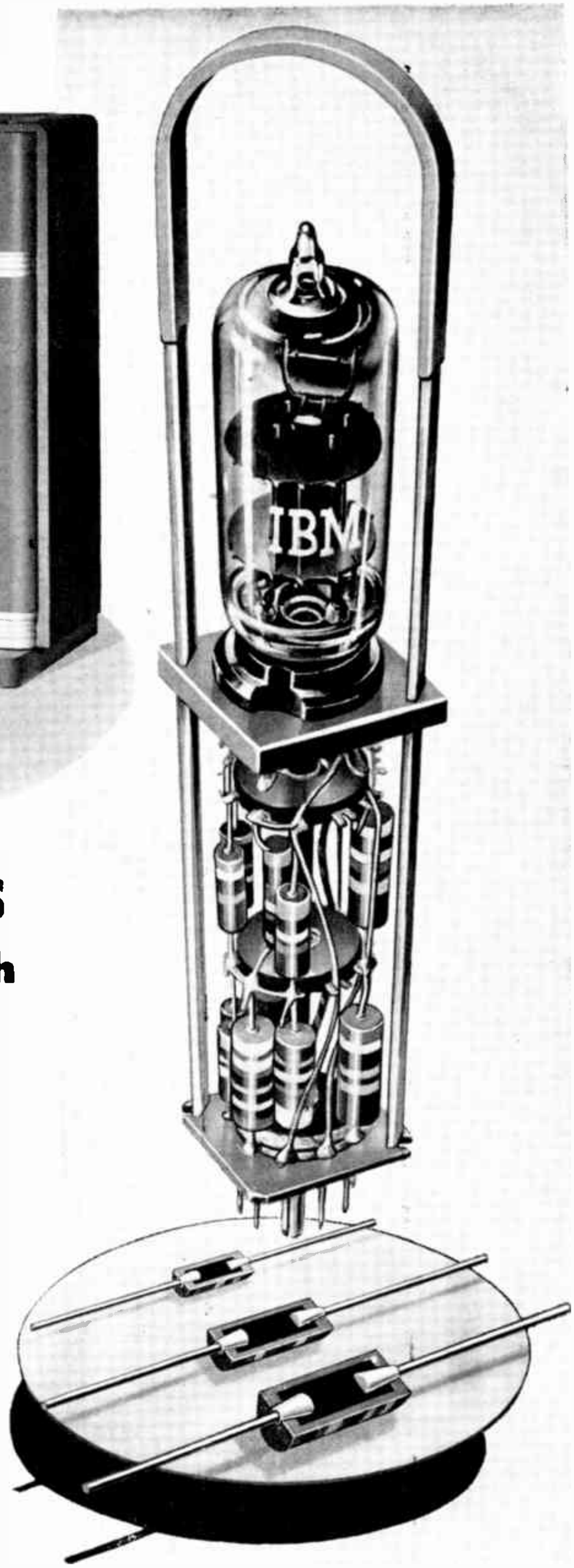

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The IBM Electronic Calculating Punch, shown above, will punch 6,000 cards per hour, performing up to 60 operating steps for each card.

The master key is the IBM Electronic Tube Assembly which comprises an electron tube and several resistors and capacitors. There are more than 1,200 of these pluggable units in each punch. With 8 or 9 Bradleyunits per assembly there are over 10,000 Bradleyunits per punch.

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Allen-Bradley Fixed Resistors are rated at 70C for high safety factor

Above is shown the internal construction of the ½, 1, and 2 watt Bradleyunits, all encased in hard plastic shells. Both leads are differentially tempered to prevent sharp bends near the resistor body.

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"camera work on the Waring Show is ... art photography"
JOHN CROSBY

and the cameras are GPL

Columnist John Crosby, discussing not electronics but end results on the screen, calls the Waring show on CBS Television "pure television." Such results come from three things: Waring imagination, CBS Television techniques, and GPL camera chains.

> *"The pictures move . . . are a combination of light and shadow, of form and substance that catch and hold the eye."*

A GPL extra in engineering accounts for much of this. Camera and operator may be moving on a boom in a 3-dimensional pattern. Yet the operator has only to concentrate on aim, while the director at the Camera Control Unit adjusts the iris for light and shadow.

> *"The cameras seem to roam at will on that show with a fluidity and grace almost never found in the movies."*

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Whatever your type of operation, whether you need one chain or six, investigate these cameras designed for *modern* television. Rugged but lightweight, they are easily interchangeable between studio and field. Circuit design guarantees consistent high quality.

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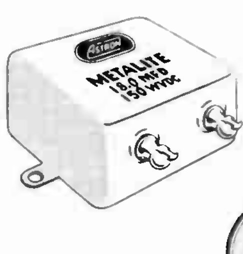
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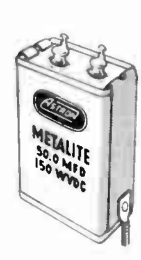
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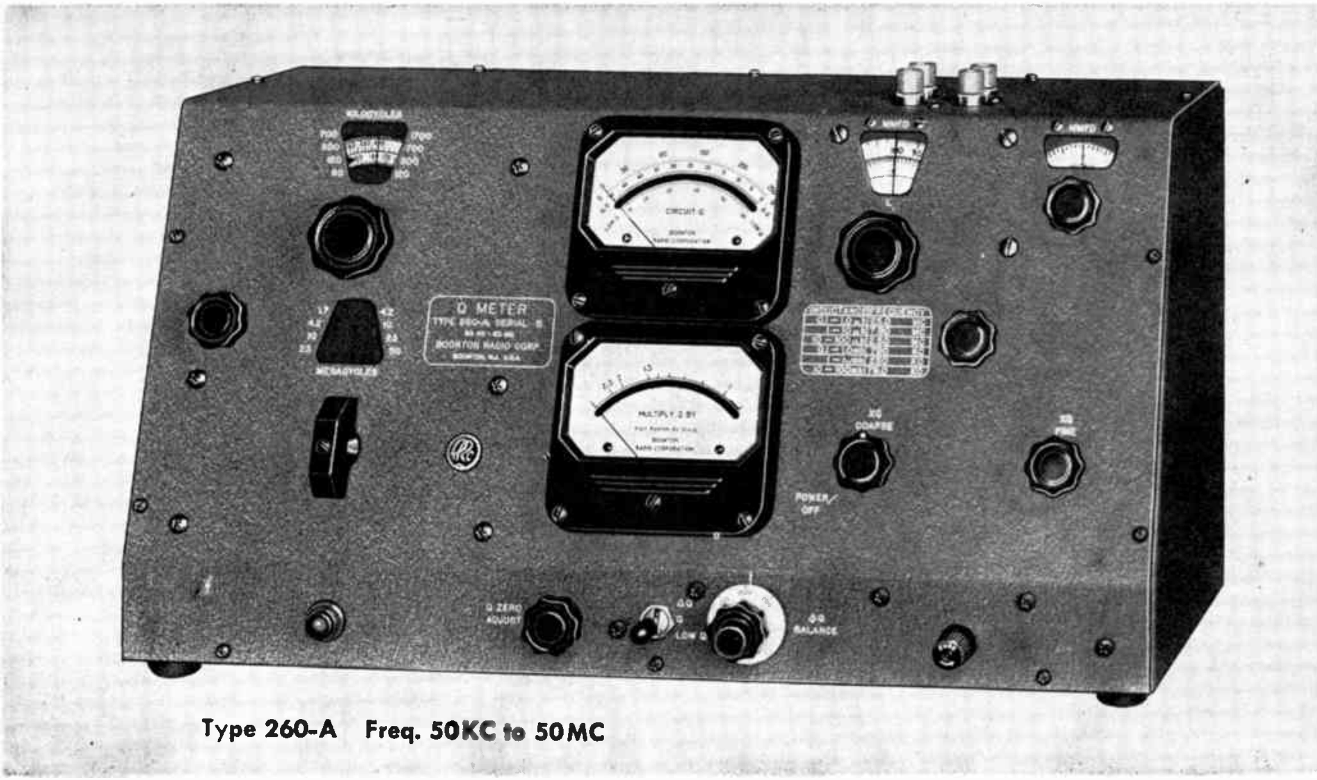

Type 260-A Freq. 50KC to 50MC

18 years of improvements are combined in this NEW Q Meter

NEW FEATURES

- **Lo Q Scale permits Q readings down to a value of 10.**
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- **Thermocouple for indicating current inserted into measuring circuit redesigned for high burnout point well above operating current.**
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SPECIFICATIONS:

FREQUENCY COVERAGE: 50 KC to 50 MC Continuously variable in eight ranges.

FREQUENCY ACCURACY: Approximately ±1%.

RANGE OF Q MEASUREMENTS: 10 to 625.

RANGE OF DIFFERENCE Q MEASUREMENTS: 0 to 125.

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Main Tuning Dial: 30 to 450 mmf (direct reading) calibrated in 1.0 mmf increments from 30 to 100 mmf: 5.0 mmf increments from 100 to 450 mmf.
Vernier: −3.0 to +3.0 mmf (direct reading) calibrated in 0.1 mmf increments.

ACCURACY OF RESONATING CAPACITOR:
Main Tuning Dial: Approximately ±1% or 1.0 mmf, whichever is the greater.
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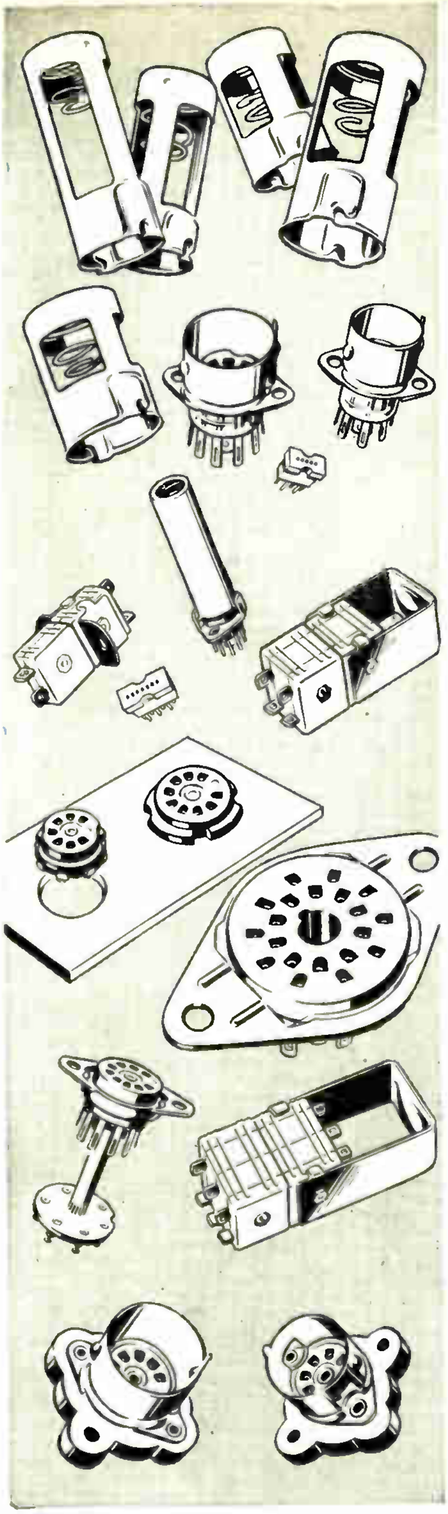

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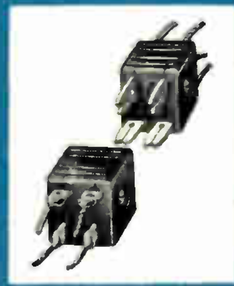

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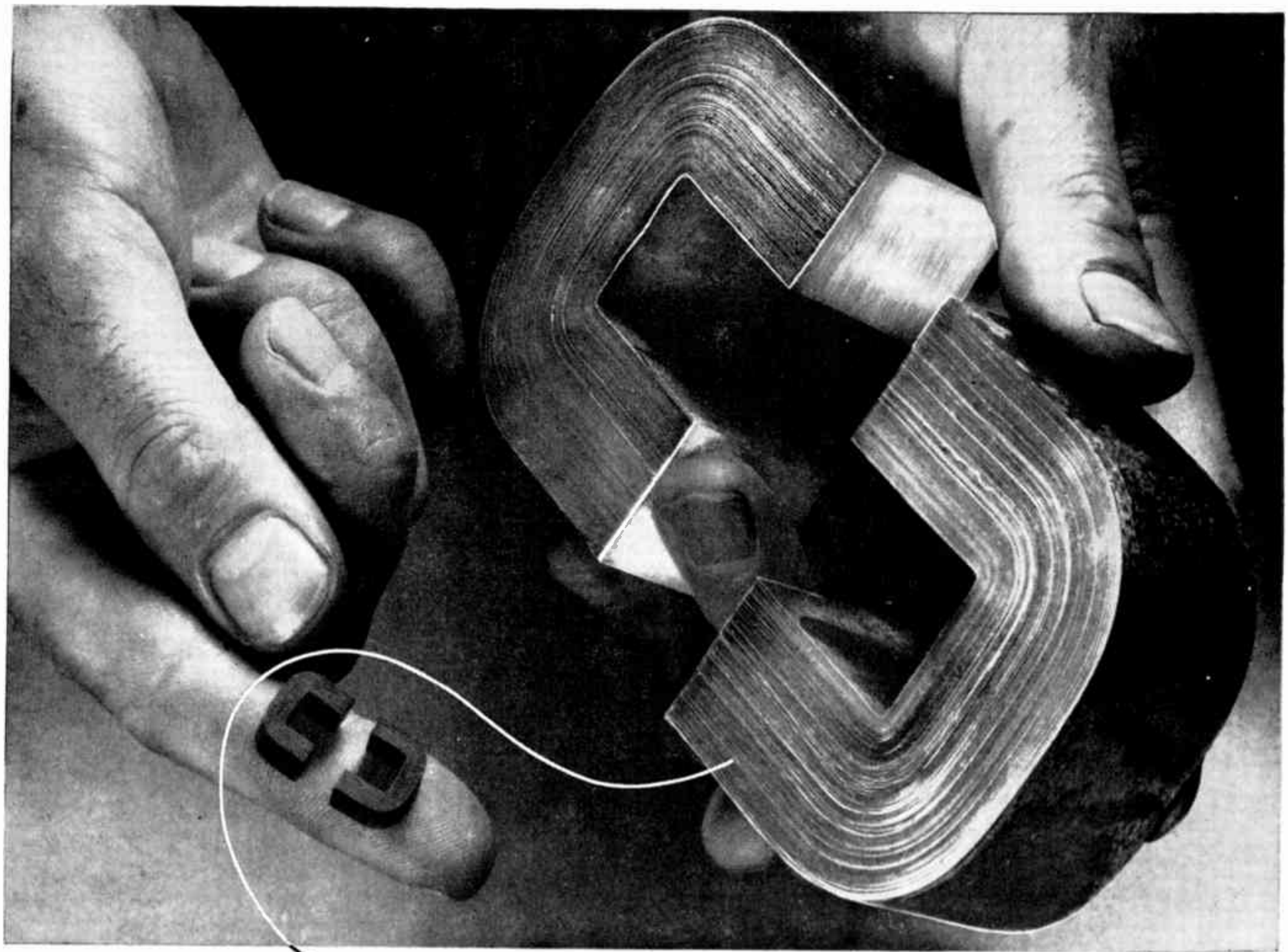

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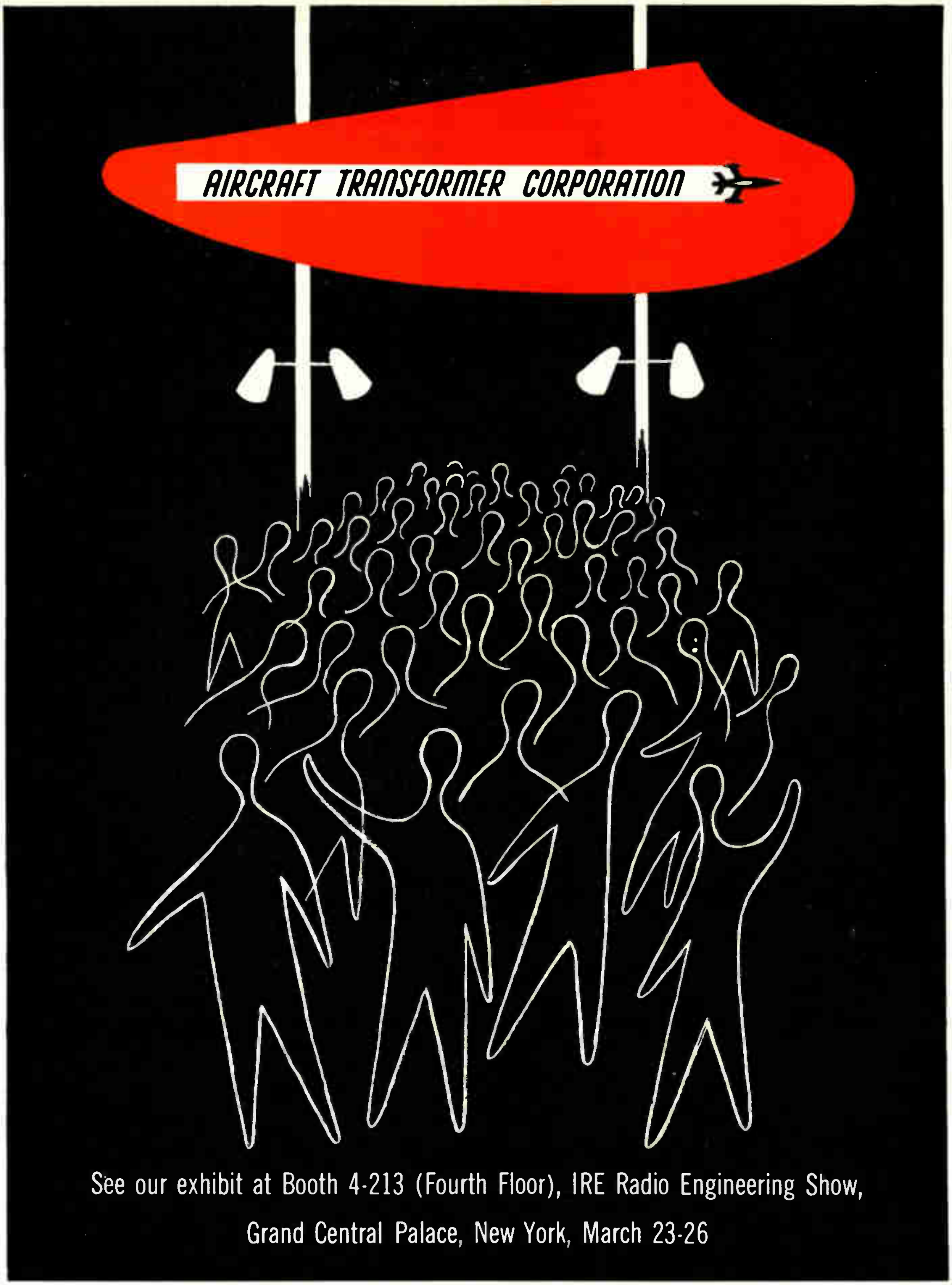
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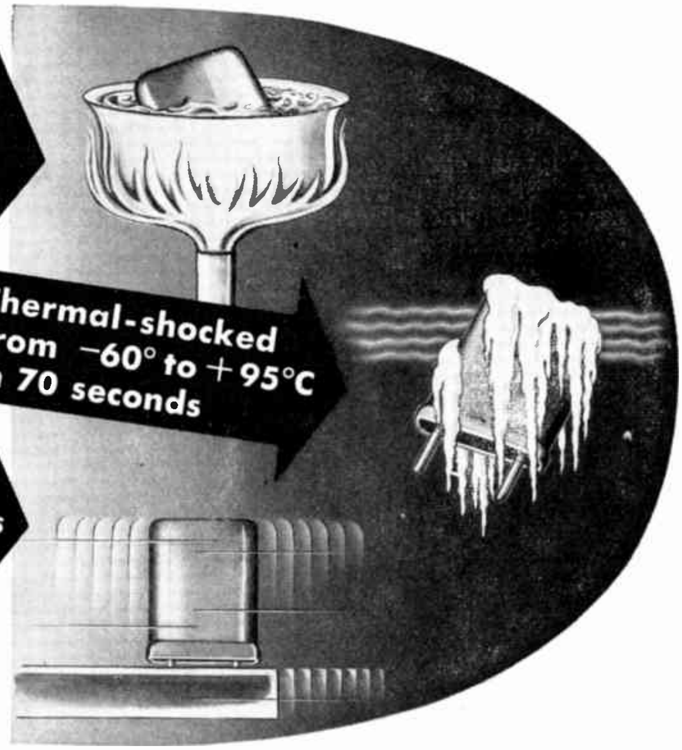

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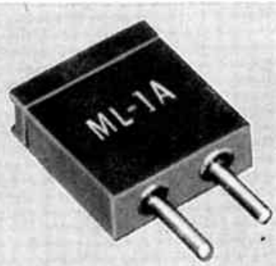
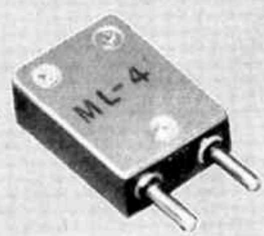


***TYPE ML-1A—RANGE:**
2.0—15.0 mc
Supplied per Mil type CR-1A when specified.



***TYPE ML-4—RANGE:**
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Yes, we get tough with our Midland crystals. You expect best performance, and we make sure you get it when you use Midland crystals for all your frequency control needs. The final test pictured above is just one of many quality checks we make at every step of Midland processing.

Midland Quality Control starts with the raw quartz. Using optical viewing equipment of high accuracy, we select only the "cream of the crystal crop." Then, as the crystal proceeds through the various steps of cutting, slicing, lapping, etching, plating, and sealing, it is checked repeatedly to turn up any defect that might develop.

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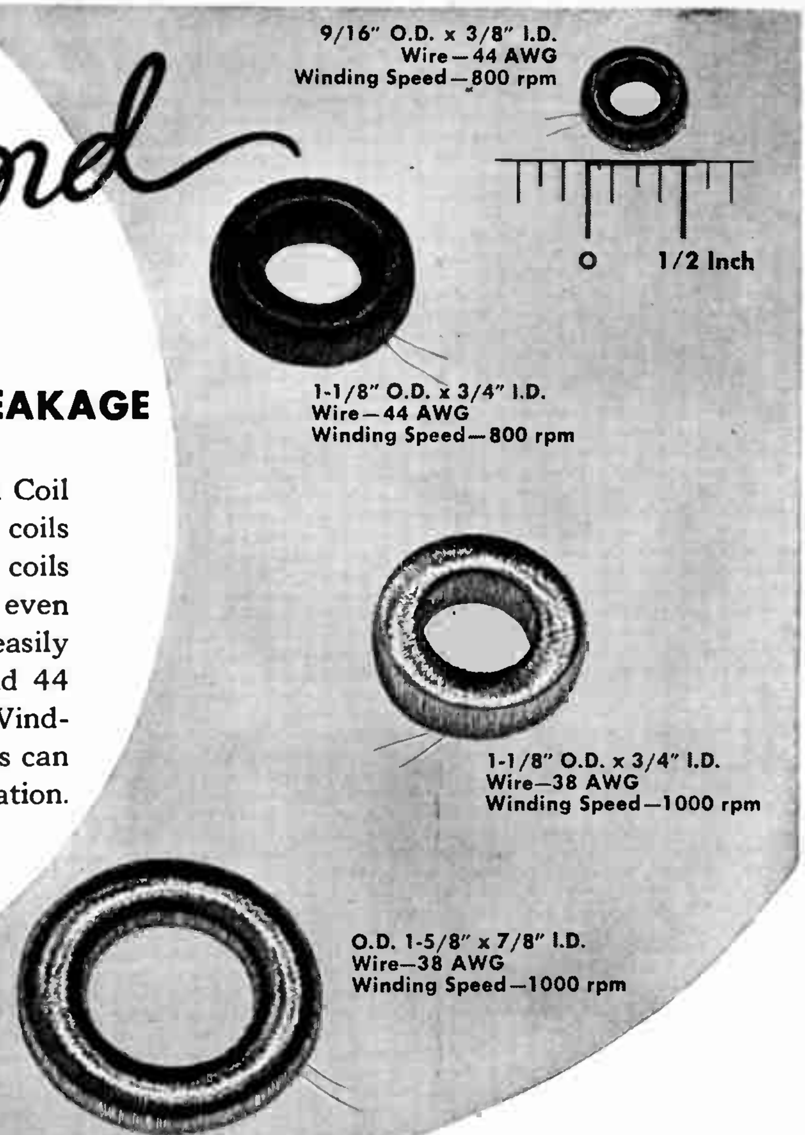
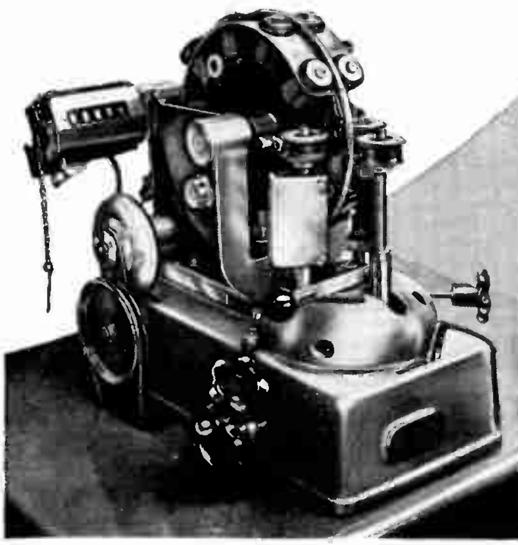


The MICAFIL Model RW-0 Toroidal Coil Winder automatically winds toroidal coils continuously around 360° and sector coils from 30° to 270°. To produce smooth, even layers of wire, the winder is adjusted easily to wind any wire size between 26 and 44 AWG and to obtain the proper pitch. Winding direction can be changed and feeds can be adjusted while machine is in operation.



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Coil Sizes
- Minimum finished I.D. . . . . ¼"
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Wire Sizes . . . . 26 to 44 AWG

Winding Speed—
- according to wire size. . up to 1000 rpm

Shuttle Capacity—
- according to wire size . . . 60 to 800 feet

MICAFIL Toroidal Coil Winders are made in three larger sizes for winding coils up to 8" O.D. and with 10 AWG Wire.

SPIRALING DEVICE—Device winds spirals for shuttle loads—in advance . . . Newly developed to permit continuous operation of Coil Winder . . . Winds to predetermined lengths.

SHUTTLES—Made in four different ring diameters to accommodate range of spiraled wire sizes . . . Larger wire capacities . . . *More than one coil can be wound with single loading* . . . Changed within 30 seconds . . . Loaded in less than a minute.

ACCURATE TURNS COUNTER—Preset for required number of turns . . . Automatically stops winder when turn count is reached.

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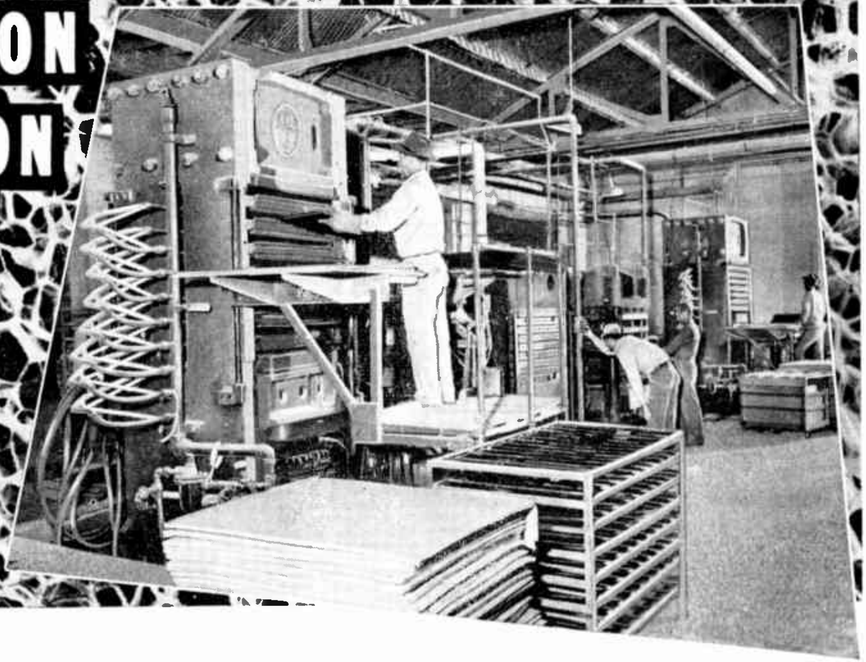

Battery of vulcanizing presses "bake" Rubatex to an optimum cure for product protection.

Closed cells are responsible for the structural strength and superior physical properties of Rubatex—not possessed by ordinary sponge rubber with open coarse cells which are wide open to oxygen and moisture.

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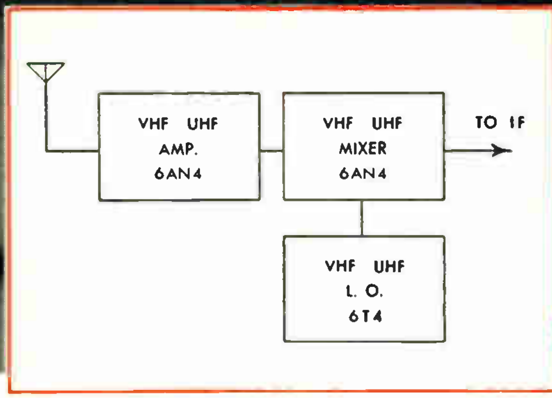
Use these two New Sylvania Tubes in tuners and converters



Representative block diagram of combination VHF-UHF tuner using the new Sylvania 6AN4 as rf amplifier and mixer, and the 6T4 as local oscillator.

Equipment Manufacturers! Simplify design of combination VHF-UHF tuners, UHF converters for TV! Two new Sylvania-developed tubes permit adaptation of conventional amplifier-mixer-local oscillator circuit to the new frequency bands—completely eliminate complicated switching arrangements or stage duplication. Leading Tuner Manufacturers have adopted these types for current tuner production.

- Short Bulb T-5½ 7-pin miniature construction
- Requires no special socketry
- Designed for use at frequencies up to 1000 mc
- Double plate and grid leads
- Uniformity at high frequency means lower cost and better availability

THE SYLVANIA 6T4 is designed for use as a local oscillator at frequencies up to 1000 mc. Used as the companion tube to the 6AN4, it makes possible the design of extremely simple combination tuners and UHF converters.

THE SYLVANIA 6AN4 can be used both as an rf amplifier and as a mixer. Its performance in the VHF band is equal to or better than previously existing types of tubes, and in UHF tuners it gives comparable performance to VHF tuners.

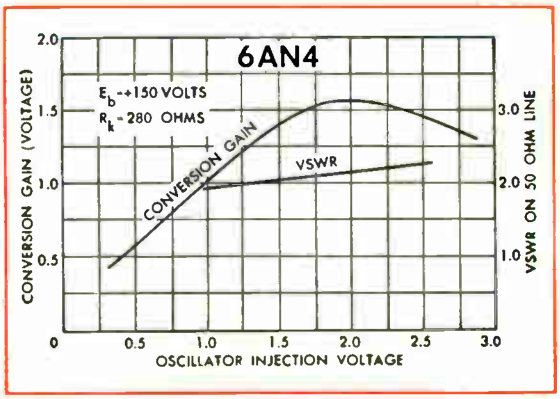
The 6AN4 is designed for both high g_m and high mu. Under representative operating conditions as a Class A amplifier, the transconductance is 10,000 micromhos and the amplification factor is 70.

When used as a mixer, the 6AN4 offers the advantages of a conversion gain and of relatively low oscillator drive requirements.

Complete technical information on operating characteristics, including performance curves, is included in the manual, "Sylvania's UHF Story." A copy is yours for the asking. Write to: Sylvania Electric Products Inc., Dept. 3R-4503, 1740 Broadway, New York 19, N. Y.

COMPARATIVE PERFORMANCE OF THE 6AN4 AT VHF AND UHF

CONDITIONS		VOLTAGE GAIN	NOISE FIGURE
Single tube in Channel 13 booster	VHF	5	9.2 db
Two tubes in cascode in Channel 13 booster	VHF	11.1	8 db
Single tube in open half-wave tuned amplifier at 450 mc.	UHF	12 db	13 db
Single tube in open half-wave tuned amplifier at 900 mc.	UHF	10 db	15 db



Curve shows representative relationships between conversion gain and input VSWR of the 6AN4 when used in mixer service, plotted against oscillator injection voltage.

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You're *safe* when you "batten down the hatches" against high humidity with Sprague Blue Jackets! They're rugged vitreous enamel power resistors *that can take abuse* . . . that eliminate electrolysis failure in the most humid atmospheres . . . that deliver top wattage ratings in every size . . . that assure unmatched stability and resistance to thermal shock. Yes, the Blue Jacket is outstanding even among the many noteworthy Sprague developments in the resistor art. ★ ★ ★ ★ ★ ★ ★

Blue Jacket resistors are made in types to meet the tough performance requirements of Military Specification JAN-R-26A, Characteristic "G". See Engineering Bulletin 110 for complete details. Blue Jackets are also available in commercial styles that excel in the most severe industrial electronic service. Engineering Bulletin 111 describes these superior units—*that* cost *no* more *than ordinary resistors!* Send for your copies to:

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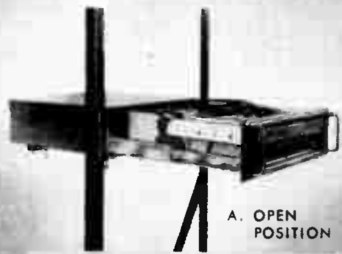
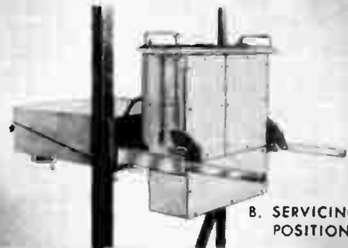
ELECTRONIC SLIDES



A. OPEN POSITION



B. SERVICING POSITION

A. Featuring Smooth continuous action. Closely fitted slide parts assure minimum of play. Locking device holds slide when fully extended, permitting easy access to all parts.

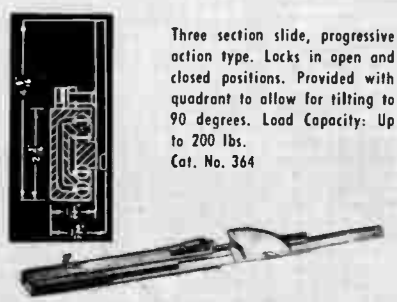
B. Quadrant for pivot support and tilting provision is equipped with simple tripping mechanism for servicing. Lever operated, it releases chassis and allows movement to open and closed positions.

Illustration shows an Automatic Transmission Measuring Set as developed by Bell Telephone Laboratories at Murray Hill, New Jersey.

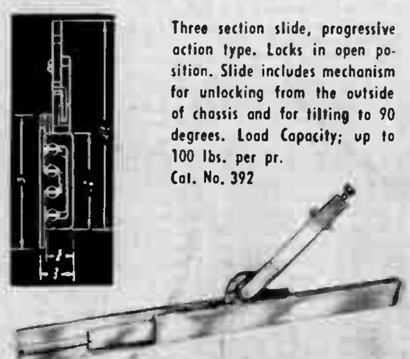
The receiving amplifier, modulator, amplifier modulator and recorder panels are suspended on *ball-bearing drawer slides* and are pivoted to permit the chassis to be inverted for servicing. The arrangement is such that all these panels can be kept in operation while so inverted.

Three section slide, progressive action type. Locks in extended position only. Tripping mechanism controls unlocking. Load capacity: Up to 200 lbs.
Cat. No. 375

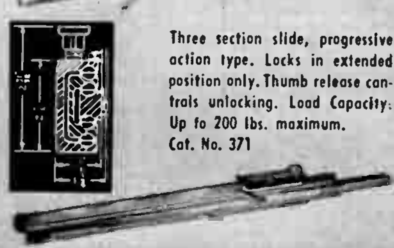
Three section slide, progressive action type. Load Capacity: Up to 50 lbs. per pair.
Cat. No. 350



Three section slide, progressive action type. Locks in open and closed positions. Provided with quadrant to allow for tilting to 90 degrees. Load Capacity: Up to 200 lbs.
Cat. No. 364



Three section slide, progressive action type. Locks in open position. Slide includes mechanism for unlocking from the outside of chassis and for tilting to 90 degrees. Load Capacity; up to 100 lbs. per pr.
Cat. No. 392



Three section slide, progressive action type. Locks in extended position only. Thumb release controls unlocking. Load Capacity: Up to 200 lbs. maximum.
Cat. No. 371

The present preparedness program requires that manufacturers be absolutely certain of the precision and dependability of all component parts. Over 50 years of dependability lie behind Grant Pulley & Hardware Co. Our extensive engineering and research department is constantly planning new and improved sliding devices. This department is available for consultation on individual specifications, and also provides engineering liaison from inception to conclusion of production. Chassis, Consoles, Racks, any device where access to parts or motion of equipment is desired should be equipped with Grant Slides. Wherever the installation, laboratory, tank, bomber, ship, mobile or stationary unit . . . you save time and manpower when you use Grant Sliding Devices.

Grant Slides are adaptable for many military uses, and Grant customers with Government contracts can rely upon the dependability of Grant cooperation and delivery.

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The Oscilloscope that portrays the Pulse by Waterman

Classic Examples of Precision Engineering...

Investigations of complex waves take great strides forward when either a Waterman SAR or LAB PULSESCOPE is employed. Their compactness, portability and precision have established a new high in pulse measurement instruments for all electronic work. Each PULSESCOPE has internally generated markers which are synchronized with the sweep with the basic difference that the sweep in the LAB PULSESCOPE initiates the markers while in the SAR PULSESCOPE it is the crystal controlled markers which initiate the sweep. Power supply requirements of 50 to 1000 c.p.s. at 115 Volts permits operation almost anywhere.

The SAR PULSESCOPE, model S-4-A, is characterized by a pulse rise time of 0.035 microseconds thru a video amplifier with a sensitivity of 0.5 Volts p to p/inch. A vertical delay of 0.55 microseconds is optional. A and S sweeps covering a continuous range from 1.2 to 12,000 microseconds are augmented by R sweeps, which in turn are variable from 2.4 to 24 microseconds. A directly calibrated dial permits R sweep delay readings from 3 to 10,000 microseconds.

The LAB PULSESCOPE, model S-5-A, has equivalent rise time of 0.035 microseconds, a fixed 0.55 microseconds vertical delay and 0.1 Volts p to p/inch sensitivity, so arranged as to assure portrayal of leading edges on displayed signals. A precision calibrated voltage is provided as well as an optional sweep expansion of 10 to 1. A built-in trigger generator voltage is available for synchronizing any associated test equipment.

WATERMAN RAYONIC® CATHODE RAY TUBE DEVELOPMENTS

Since the introduction of the Waterman RAYONIC 3MP1 for miniaturized oscilloscopes, scientists in our laboratories have diligently searched for more perfect answers to present day cathode ray tube problems. Such research led to the introduction of the revolutionary new 3SP and 3XP type cathode ray tubes. These tubes were designed with multi-trace oscilloscopy in mind. Every avenue of practical design was explored to produce tubes with bright, sharp traces and high deflection sensitivity at medium anode potentials.

TUBE	PHYSICAL DATA			TYPICAL VOLTAGES				DEFLECTION FACTOR V/IN.		MAX. VOLTS	
	Face	Length	Base	Anode #3	Anode #2	Anode #1	Grid #1	D1 to D2	D3 to D4	Anode #3	Anode #2
3JP	3 inch Round	10 inches	Medium Diheptal 12 Pin	3000	1500	300 to 515	—22.5 to —67.5	127 to 173	94 to 128	4000	2000
				4000	2000	400 to 690	—30 to—90	170 to 230	125 to 170		
3MP	3 inch Round	8 inches	Small Duodecal 12 Pin		1000	200 to 350	0 to —68	140 to 190	130 to 180		2500
					2000	400 to 700	0 to —126	280 to 380	260 to 360		
3SP	1½x3 inches	9.12 inches	Small Duodecal 12 Pin		1000	165 to 310	—28.5 to —67.5	73 to 99	52 to 70		2750
					2000	330 to 620	—58 to —135	146 to 198	104 to 140		
3XP	1½x3 inches	8.88 inches	Loctal		2000	400 to 690	—22.5 to —67.5	68 to 92	25 to 35		2750

Visit Our Booth 1-414, IRE SHOW, MARCH 23rd to 26th

POCKETSCOPE®

The Pocket Oscilloscope by Waterman

...light...compact...accurate...portable

The HIGH, WIDE and TWIN POCKETSCOPES have become the "triple threat" of the oscilloscope industry. Their small size, light weight and incredible performance, has skyrocketed this team of truly portable instruments into unparalleled prominence. Each oscilloscope features DC coupled amplifiers in both its vertical and horizontal channels. The HIGH GAIN, S-14-A POCKETSCOPE, has a vertical sensitivity of 10 millivolts rms/inch, and a frequency response within −2 db from DC to 200 KC, while the WIDE BAND S-14-B POCKETSCOPE is characterized by frequency response within −2 db from DC to 700 KC and a sensitivity of 50 millivolts rms/inch.

The TWIN POCKETSCOPE is essentially two HIGH GAIN POCKETSCOPES with individual cathode ray tubes, amplifiers, controls, but a common sweep generator. All these are endowed with many identical characteristics. Their sweep generators can be operated as triggered or repetitive over a frequency range from 0.5 cycles to 50 KC, with synchronization polarity optional. Return traces are blanked and provisions are made for modulating the intensity in each cathode ray tube.

Laboratory quality has not been sacrificed in order to accomplish portability and ruggedness. Investigate the many advantages of Waterman POCKETSCOPES.

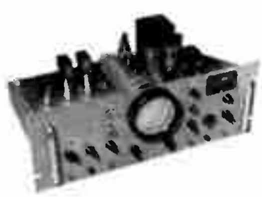
POCKETSCOPE

The INDUSTRIAL POCKETSCOPE, model S-11-A, has become America's most popular DC coupled oscilloscope because of its small size, light weight, and unique flexibility. This compact instrument has identical vertical and horizontal amplifiers which permit the observation of low frequency repetitive phenomena, while simultaneously eliminating undesirable trace bounce. Each amplifier sensitivity is 0.1 Volt rms/inch. The frequency responses are likewise identical, within −2 db from DC to 200 KC.

Discover for yourself the amazing utility of this tiny work-horse of industrial electronics.

S-11-A

RAKSCOPE®



S-12-B

The S-12-B RAKSCOPE is a rack mounted, JANized version of the famous Waterman S-11-A POCKETSCOPE, with the addition of a triggered sweep and a special calibrating circuit for rapid frequency comparisons. The entire oscilloscope is built to occupy but seven inches when mounted in a standard relay rack.

Because provisions are made for applying input signals from the rear, as well as the front, the S-12-B is the ideal combination, systems monitor and trouble-shooting oscilloscope. Investigate the multiple applications of this instrument as an integral part of your own rack mounted apparatus.

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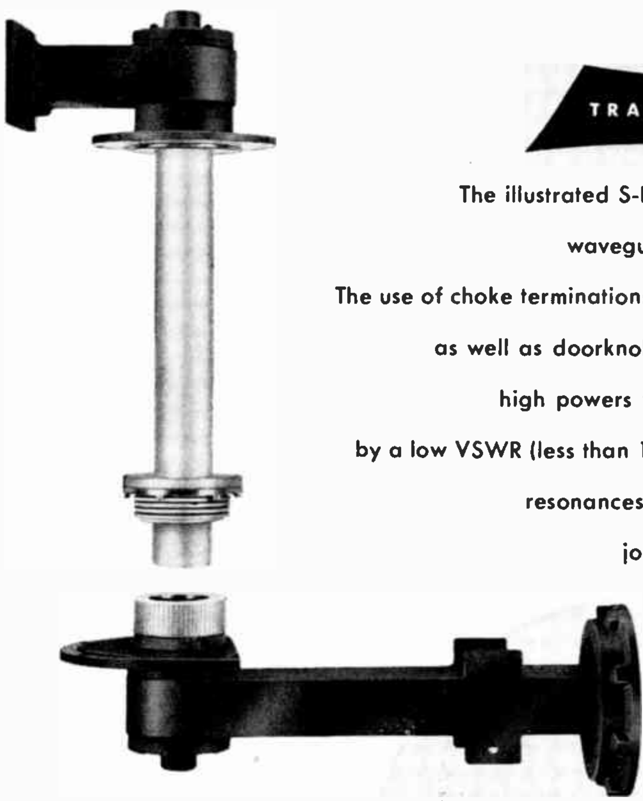

TRAIN ROTATING JOINT

The illustrated S-Band Rotary Joint is a waveguide to coaxial to waveguide structure employing doorknob transitions. The use of choke terminations for the inner conductor of the coaxial section, as well as doorknob transitions, ensures satisfactory operation at high powers without breakdown. This joint is characterized by a low VSWR (less than 1.04 over a 2% bandwidth) and freedom from resonances throughout its rotation of 360°. Similar rotary joints for elevation and cross-level purposes are available in various sizes of waveguide.

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I. R. E. Convention
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BOOTH 4-126

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BOGART manufacturing corporation
315 SIEGEL STREET BROOKLYN 6, NEW YORK

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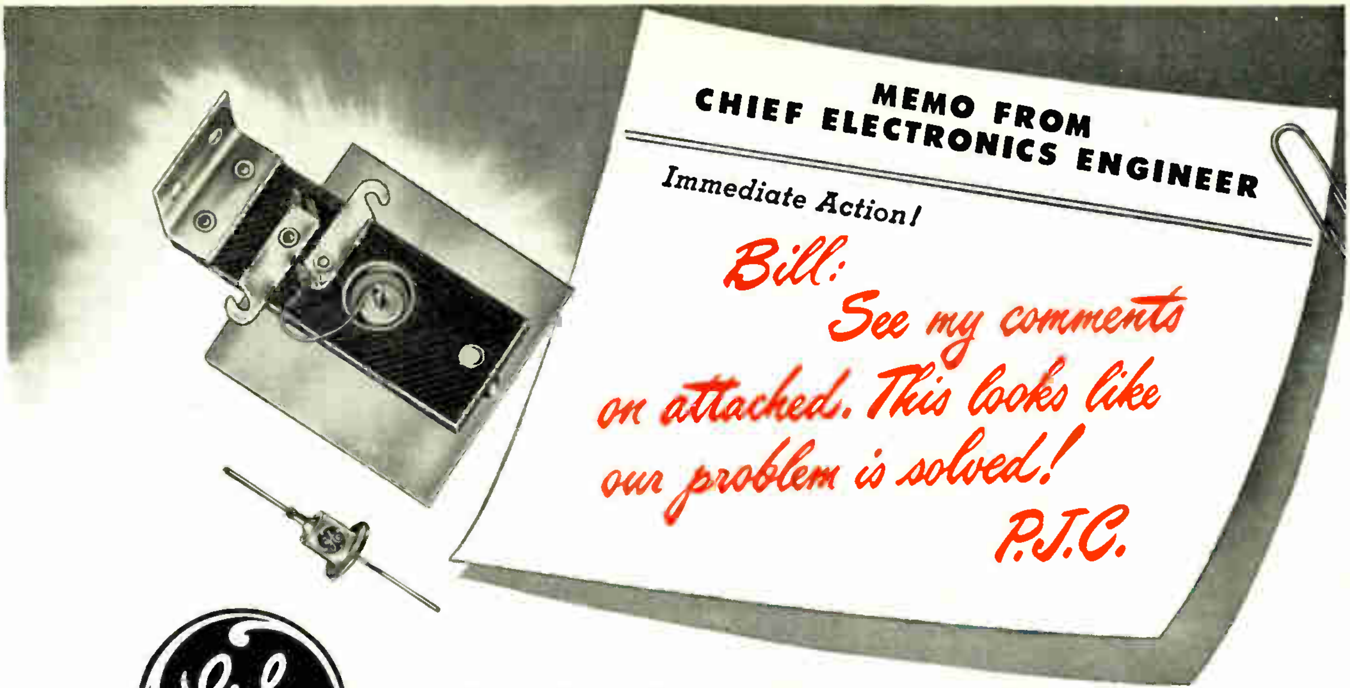


DIFFUSED JUNCTION GERMANIUM RECTIFIERS

ABSOLUTE MAXIMUM RATINGS • T-55°C • RESISTIVE LOAD				
DIFFUSED JUNCTION RECTIFIER	4JA1A1	4JA1A2	4JA1A3	4JA2A4
PEAK INVERSE VOLTAGE* (volts)	100	200	300	400
PEAK FORWARD CURRENT (amps)	0.47	0.31	0.25	1.57
D.C. OUTPUT CURRENT* (Ma)	150	100	75	500
D.C. SURGE CURRENT (amps)	25	25	25	25
FULL LOAD VOLTAGE DROP (volts peak)	0.5v	0.5v	0.5v	0.7v
FORWARD RESISTANCE AT FULL LOAD (ohms)	1.1	1.5	1.9	0.5
CONTINUOUS REVERSE WORKING VOLTAGE (volts D.C.)	30	65	100	185
FREQUENCY OF OPERATION (kc)	50	50	50	50
STORAGE TEMPERATURE (°C)	85	85	85	85

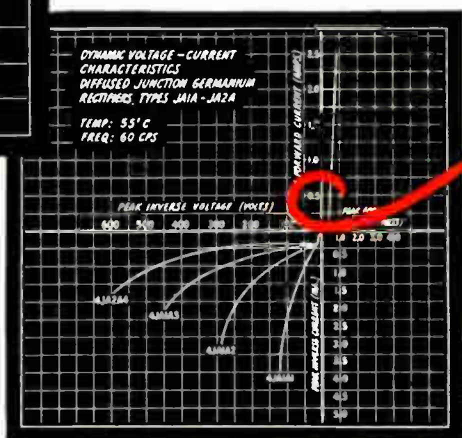
*Typical absolute maximum ratings. For other combinations refer to Fig. 1.

HERMETICALLY SEALED against deteriorating elements. Glass-to-metal seals throughout.

MINIATURE SIZE to facilitate use in all electronic equipments, yet heat losses are dissipated efficiently.

REDESIGNED to meet all military humidity tests and shock and vibration requirements.

HIGH OUTPUT VOLTAGE and improved back current characteristics.

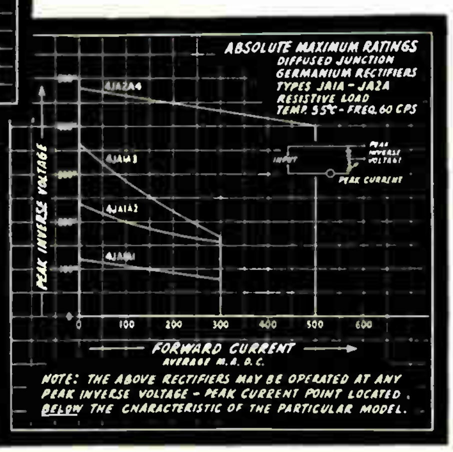


Note: This is only one ohm!

NEWS FROM OUR ADVANCED DEVELOPMENT LABORATORIES

Developmental germanium rectifiers for the KW range have been made so efficient that the copper lead connections must be larger in cross sectional area than the diffused junction itself.

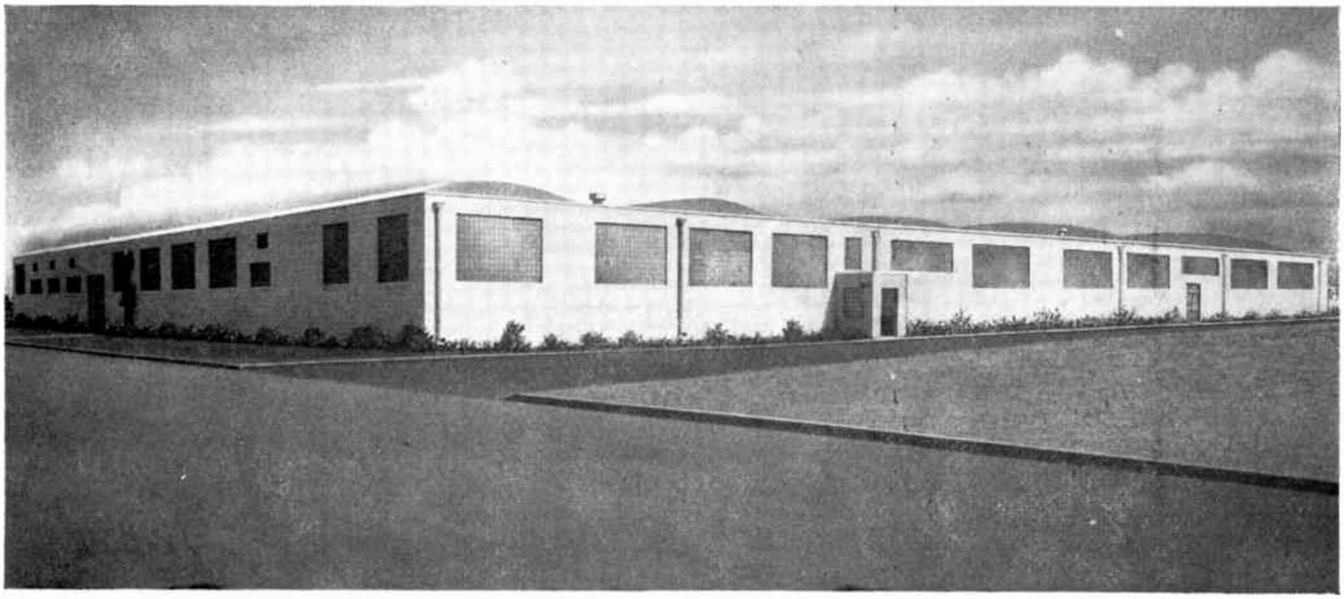
Send for complete G-E Diffused Junction Rectifier Information: General Electric Company, Section 5233 Electronics Park, Syracuse, New York.



1878 75 1953 YEARS OF ELECTRICAL PROGRESS

GENERAL ELECTRIC

LITTON INDUSTRIES NEWS

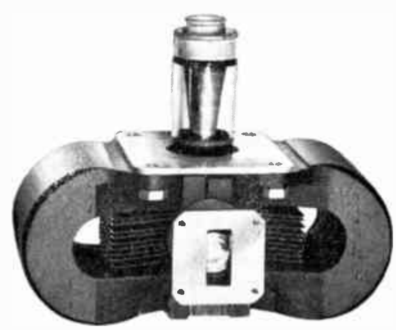


ANOTHER ADDITION TO LITTON PLANT TO HELP MEET YOUR TUBE DEVELOPMENT AND PRODUCTION NEEDS

Litton is now building a new addition to its vacuum tube plant at San Carlos, California. This expansion will approximately double tube development and manufacturing facilities and will allow expansion of our affiliate, Litton Engineering Laboratories, which has taken over the manufacture of glassworking lathes and other machine products. Like the plant completed last year, the new building has been designed specifically for vacuum tube manufacture; it has similar reinforced concrete block walls with large glass-block panels for diffused daytime illumination.

Included is complete environmental control of temperature, sound, light and air for optimum manufacturing conditions.

Increasing demand for Litton products has brought about this expansion, and we expect that the added capacity will provide greater volume and service to our friends in industry.



LITTON MAGNETRONS

Concurrent with plant expansion is a marked increase in the variety of pulse and CW magnetrons for radar, beacon and countermeasure equipment. It is quite possible that Litton Industries now has in production or development the specific tube to meet your needs.

Application of Litton design and processing criteria to all our tube types permits manufacture of tubes that require no aging racks in the plant or in the field and have long shelf life with snap-on operation to full rated power output immediately after completion of the cathode warm-up period.

2674

LITTON INDUSTRIES

Manufacturers of Vacuum Tubes and Accessory Equipment

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Engineering Leadership

IN PRECISION

HERMETICALLY SEALED TERMINALS

On Display **Hundreds of standard types — MULTIPLE HEADERS, OCTAL PLUG-INS, TERMINALS, COLOR CODED TERMINALS, END SEALS — for every electronic and electrical application.**

An Invitation! **A warm welcome awaits you at BOOTH 2-314, I.R.E. SHOW and SUITE 1010, ROGER SMITH HOTEL (Just across from Grand Central Palace) BE SURE TO VISIT BOTH E-I HEADQUARTERS!**

TEN YEARS of specialization in the manufacture of hermetically sealed terminals, including the solution of some of the most difficult of terminal sealing problems, is one part of the record of E-I engineers. The other is the development of hundreds of economical, standard components to provide a fast solution to unusual circuit requirements at a practical cost. For full information on the complete E-I line ask for the E-I File Folder including new Bulletin 960.

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DIVISION OF AMPEREX ELECTRONIC CORP.

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E-I

E-I . . . your Headquarters for Hermetically-Sealed Multiple Headers, Octal Plug-Ins, Terminals, Color Coded Terminals, End Seals, etc.

What to see at the Radio Engineering Show

(Continued from page 32A)

Firm — **Booth**

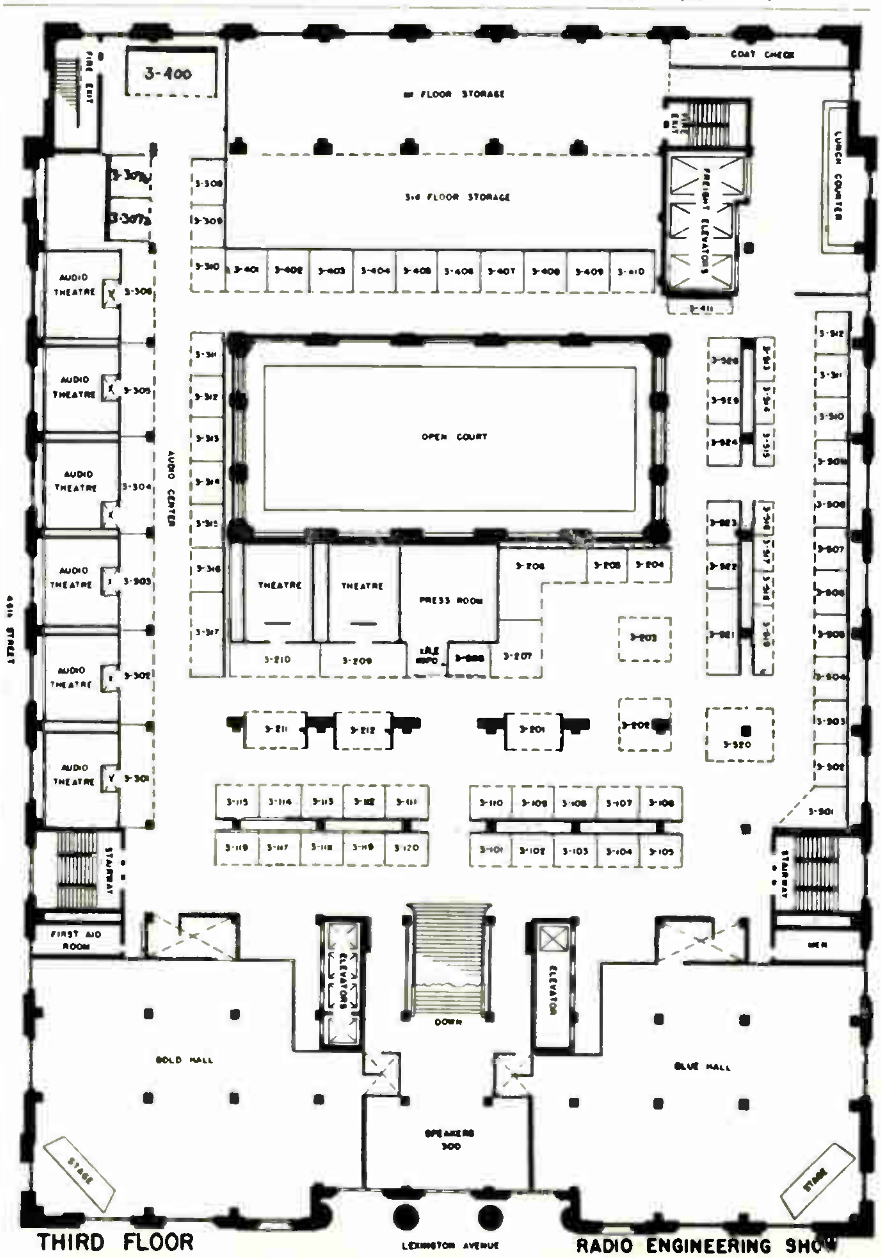
Berlant Associates, Los Angeles 16, Calif. — **Theatre 3-304A**
Magnetic Tape Recorders and Accessories "Concertone."

Beta Electric Corp., New York 29, N.Y. — **2-138**
High voltage power supplies, kilovolt meters, portable projection oscilloscopes, electronic microammeters.

Bird Electronic Corp., Cleveland 14, Ohio. — **2-410**
Termaline coaxial line instruments "RR" Wattmeters RF wattmeters—coaxial switches—RF filters.

Boesch Mfg. Co., Inc., Danbury, Conn. — **3-211**
High Speed Toroidal Coil Winding machines featuring many improvements particularly single and multiple predetermining electronic precision counters with direct count reading and remarkable winding speed and acceleration controls. Sub miniature Toroidal Coil Winding Machine. Tape Winding Machine for Toroidal Coils and Cores.

(Continued on page 124A)



New G-E Subminiature Metal-clad Capacitors with Permafil dielectric and silicone end seals provide exceptional ruggedness and service reliability.

G.E. ANNOUNCES a new line of subminiature metal-clad capacitors

with silicone end seals and a solid dielectric for operation from —55 C to +125 C without derating

This new line of General Electric subminiature metal-clad capacitors offers the designer and user of electronic equipment the utmost reliability under the severe operating conditions required of military equipment. G-E metal-clad capacitors are rugged units that provide the essential advantages of small size, no liquid leakage, and high insulation resistance. They also will withstand extreme temperature and humidity conditions.

While these capacitors have been designed for application in the temperature range from −55 C to +125 C *without derating*, they can, with proper derating, be operated up to +150 C.

G-E subminiature metal-clad capacitors offer two important, exclusive features that insure outstanding performance:

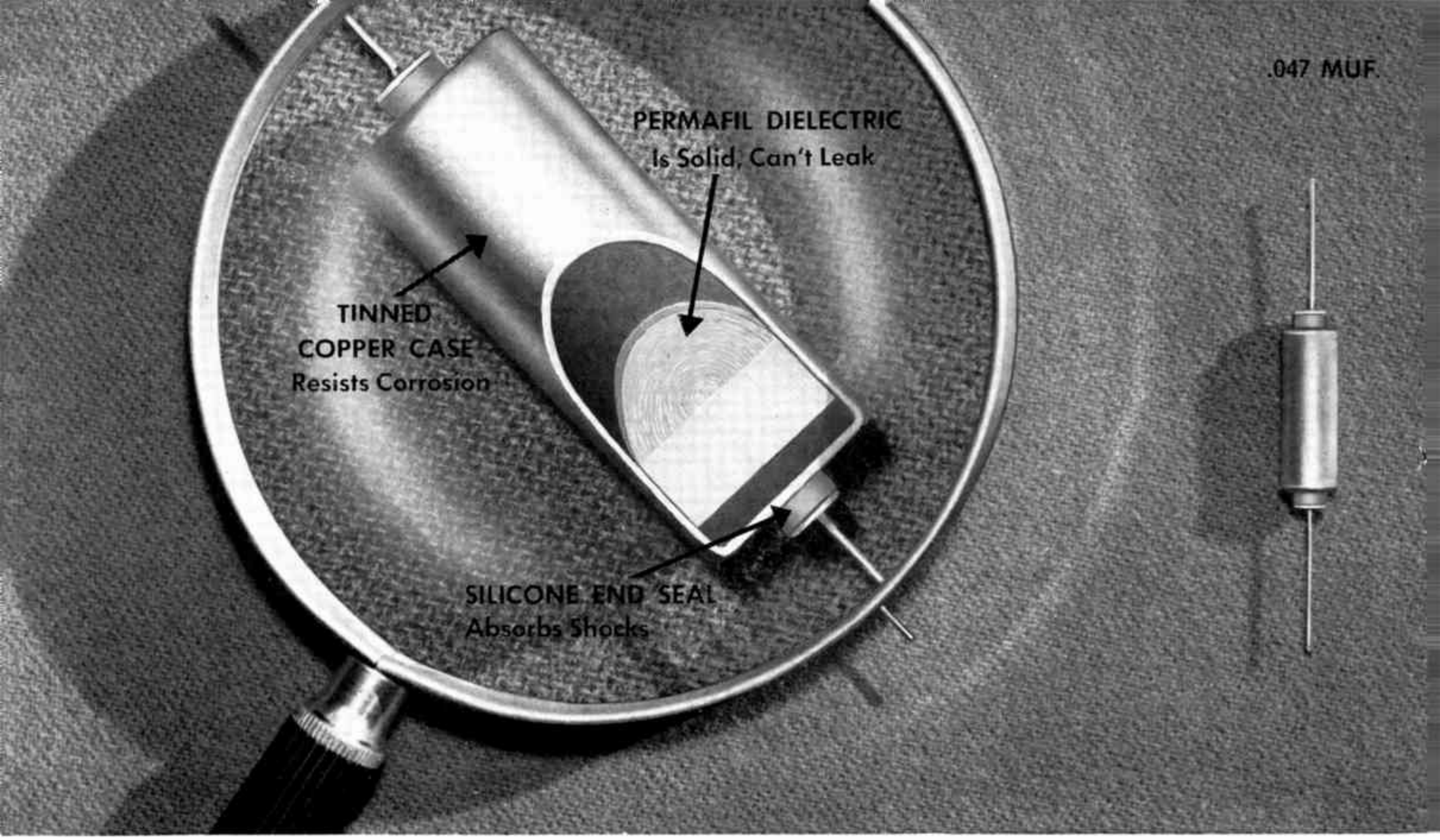
- **Solid dielectric**—G.E.'s Permafil—to provide excellent electrical characteristics and to eliminate the possibility of leakage.
- **Silicone end seal** for high shock resistance—both thermal and physical.

G-E subminiature metal-clad capacitors meet all requirements of JAN-C-25 and the proposed MIL-C-25. They can be supplied in both tab and exposed foil designs depending upon your application requirements.

Need Wax Replacement? If you are caught in the squeeze because of the recent elimination of characteristic J (wax) from the proposed MIL-C-25 specifications, you need not go to a larger capacitor (or continue to use an unacceptable product). See back page of this advertisement for information about a new line of G-E liquid-filled metal-clad capacitors. They're as small as the wax units, yet have superior life characteristics which make them a "natural" for military equipment.

GENERAL ELECTRIC

See next page for informative data on these new G-E capacitors



HERE'S WHY G-E SUBMINIATURE METAL-CLAD CAPACITORS GIVE SUPERIOR PERFORMANCE

G-E subminiature metal-clad capacitors, designed for operation at +125 C *without* derating, provide the highest degree of service reliability. The use of Permafil (solid) dielectric and silicone end seals—G-E exclusives—provide advantages of major importance.

For more than two years, Permafil has proved its reliability in G-E capacitors used in electronic equipment such as aircraft engine control, airborne radio and radar communication equipment, ground radio communication equipment, and in Thyratron controls for B-36 and B-47 gun control. During this period, there has been no reported service failure of any G-E Permafil capacitor.

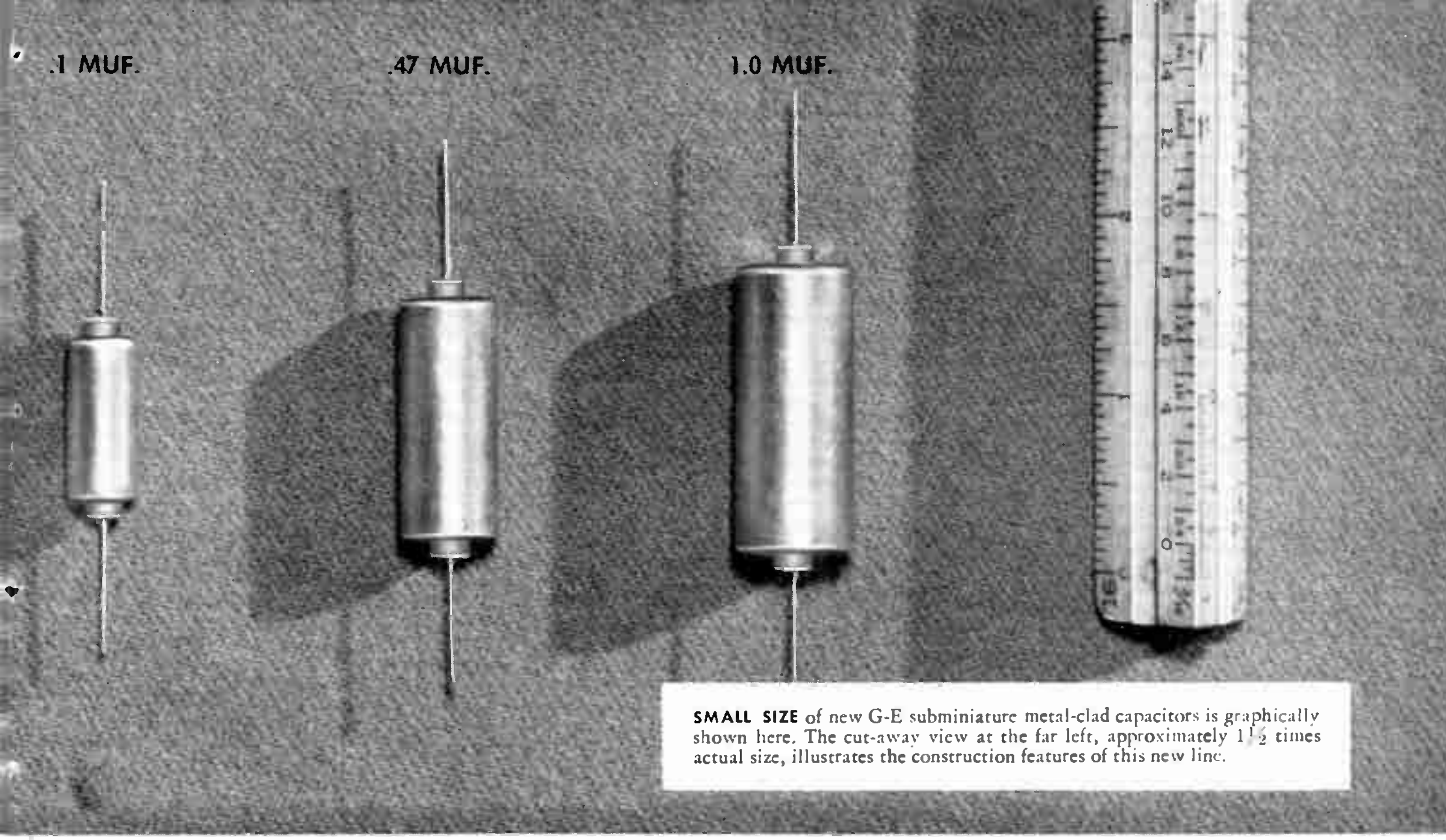
Since Permafil is a solid, it eliminates the possibility of leakage. Permafil also gives G-E metal-clad capacitors excellent electrical characteristics. Capacitance varies only 1 percent over the temperature range from 0 C to +125 C and only 7 percent over the entire range from −55 C to +125 C.

Silicone end seals provide exceptional resistance to both physical and thermal shocks. An added advantage is the fact that this seal will meet the moisture resistance tests of JAN-C-25 with d-c potential applied.

Muf ratings of these new G-E metal-clad capacitors range from .001 to 1.0 muf in voltage ratings of 100, 200, 400 and 600 volts d-c working. They can be operated at full voltage up to altitudes of 50,000 feet.

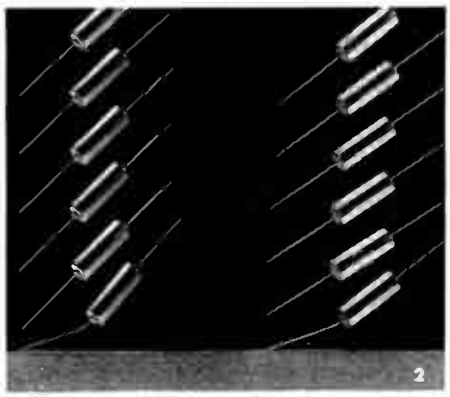
Case sizes range from .235 inches in diameter and $\frac{11}{16}$ inches in length to 1 inch diameter and $2\frac{5}{8}$ inches length.

GENERAL ELECTRIC

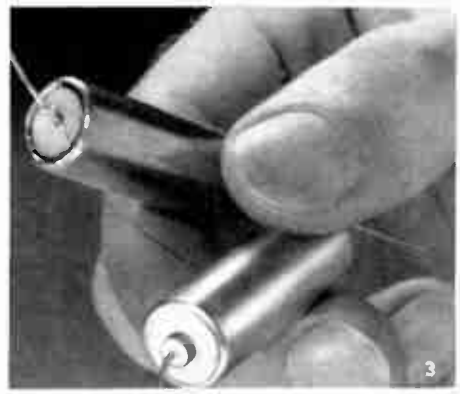


SMALL SIZE of new G-E subminiature metal-clad capacitors is graphically shown here. The cut-away view at the far left, approximately 1½ times actual size, illustrates the construction features of this new line.

1. Solder right up to the case with new G-E silicone end seal — no need to waste ¼ inch of valuable space because of danger of cracking glass.

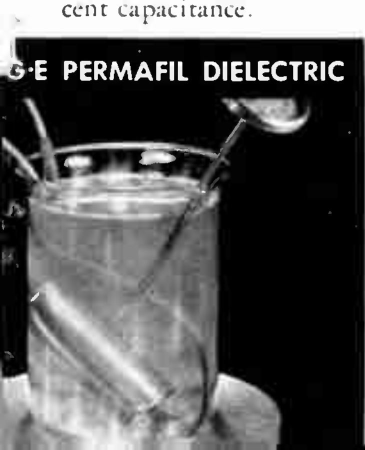


2. Withstands vibration and rough handling. This view shows a glass-bead-sealed capacitor and a silicone-sealed capacitor being dropped.



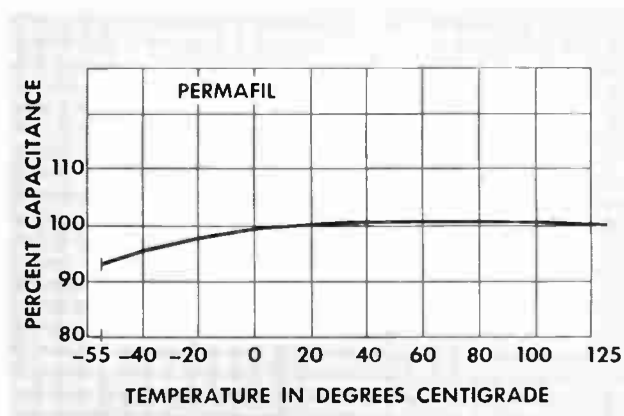
3. Undamaged by dropping, the two capacitors are shown here — note that there are no cracks in the G-E silicone-sealed unit.

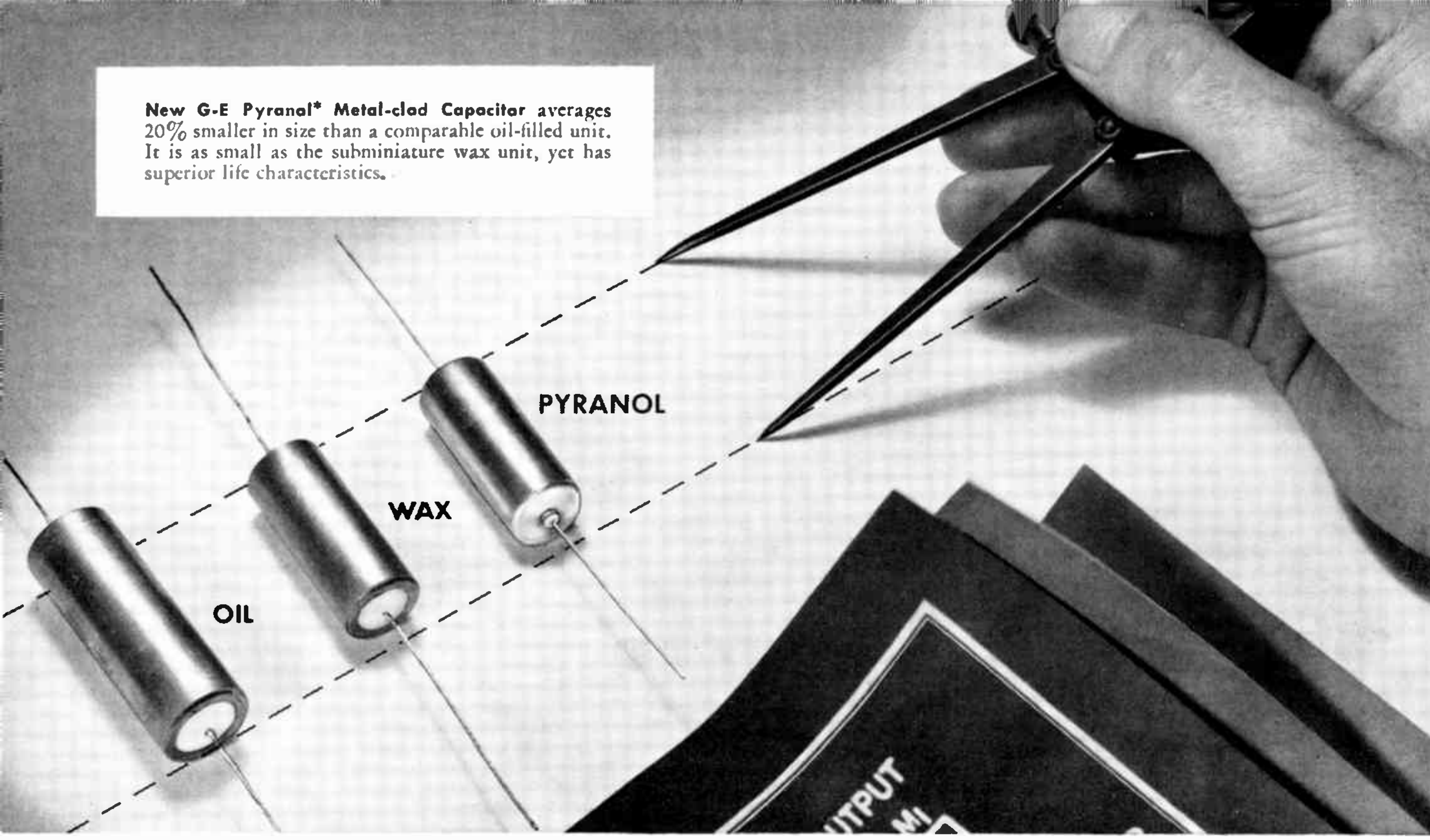
4. At +125 degrees centigrade, the capacitor consistently maintains 100 percent capacitance.



5. At −55 degrees centigrade, the subminiature G-E metal-clad capacitor with Permafil dielectric shows less than 7 percent loss in capacitance.

6. Capacitance vs. temperature is shown by this typical curve. G-E capacitors with Permafil dielectric have very little capacitance change throughout the entire range from −55 C to +125 C.





New G-E Pyranol* Metal-clad Capacitor averages 20% smaller in size than a comparable oil-filled unit. It is as small as the subminiature wax unit, yet has superior life characteristics.

ANNOUNCING also . . . a new line of G-E Pyranol liquid-filled metal-clad capacitors

subminiature in size—inexpensive—for operation to +85 C

This new line of G-E subminiature metal-clad capacitors with Pyranol dielectric equals its 125 C Permafil cousin for reliability and ruggedness. It is designed for operation from −55 C to +85 C *without derating.*

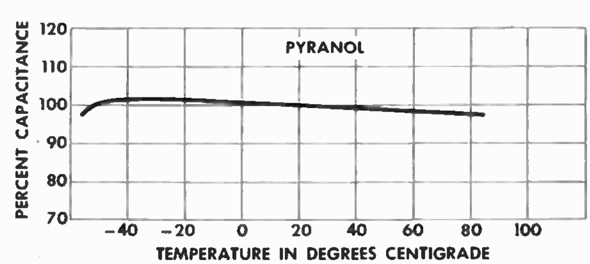
Pyranol, long noted for its high dielectric strength and exceptional stability, has been used in G-E capacitors for more than 20 years with excellent success. Now recently improved, Pyranol makes possible a small-size capacitor with extremely good life characteristics.

This G-E metal-clad line also incorporates the silicone end seal for maximum resistance to shocks—both thermal and physical—and thus permits soldering right up to the bushing without danger of damaging the seal.

G-E Pyranol metal-clad capacitors can be supplied in either tab or exposed foil designs in ratings from .001 to 1.0 muf in voltages of 100, 200, 400, and 600 volts d-c working.

Delivery of G-E Subminiature Capacitors. While many sizes and voltage ratings of both the 125 C Permafil and the 85 C Pyranol metal-clad capacitors are available for immediate shipment, not all muf and voltage ratings are in stock. However, the full line of each type of G-E metal-clad capacitor will be in "stock shipment" shortly. If your requirements demand the highest performance standards for subminiature capacitors, check with your nearest G-E Apparatus Sales Office for exact delivery information. Or write to Section 442-4, General Electric Company, Schenectady 5, New York.

*Reg. trademark of General Electric Company



Capacitance vs. Temperature is shown by this typical curve. G-E Pyranol subminiature metal-clad capacitors have only a small capacitance change through the entire range from −55 C to +85 C.

You can put your confidence in—

GENERAL ELECTRIC

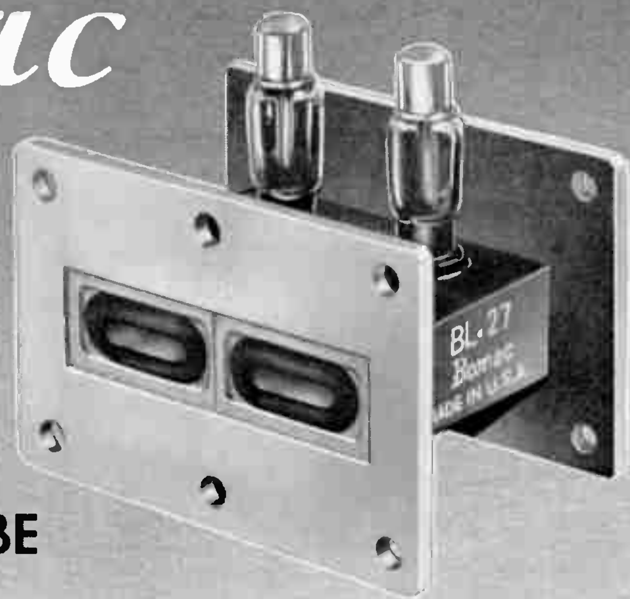
For a remarkable demonstration of the ruggedness and reliability of these new G-E capacitors,

Bomac

Announces

The BL27

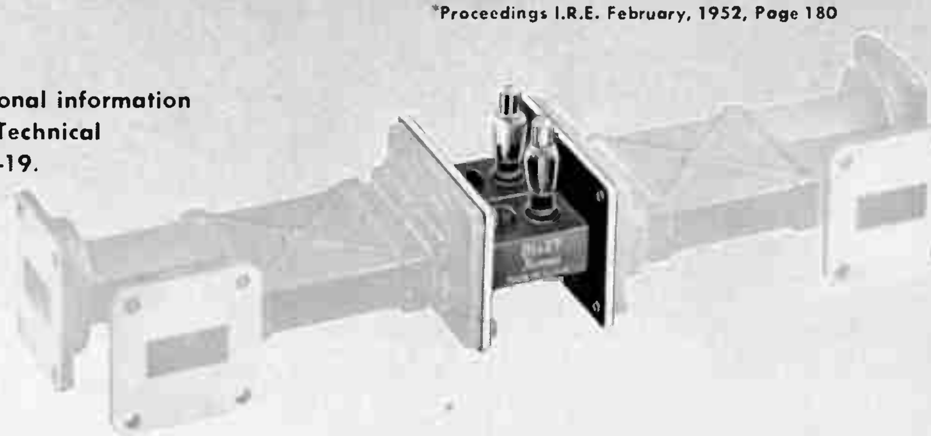
A DUAL TR TUBE



Each section of the BL27 is electrically similar to Type 1B63A. The two sections have a common wave guide wall and a common gas fill. Used with short-slot hybrids,* the BL27 provides a highly compact duplexer of utmost simplicity, with excellent performance over the band of 8500-9600 mc. with respect to both transmission and reception characteristics.

*Proceedings I.R.E. February, 1952, Page 180

For additional information write for Technical Bulletin T-19.



IT'S *Bomac* FOR GAS SWITCHING TUBES
TR, ATR, PRE-TR, HYDROGEN THYRATRONS
CRYSTALS AND MICROWAVE COMPONENTS

BOMAC LABORATORIES, INC. BEVERLY, MASS.

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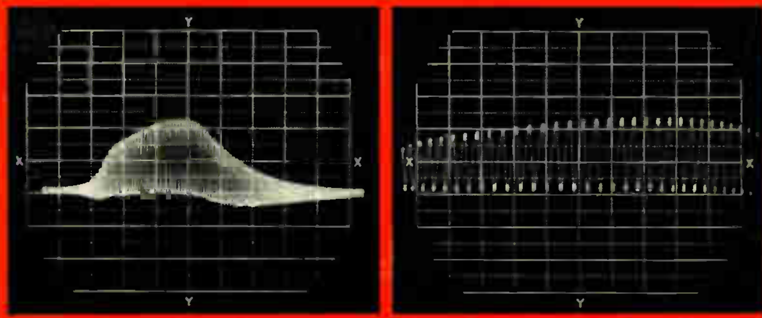
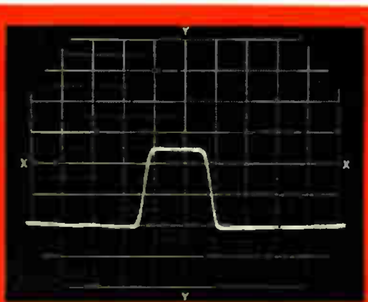
ONLY THE LFE 401 OSCILLOSCOPE

Offers all these Important Features

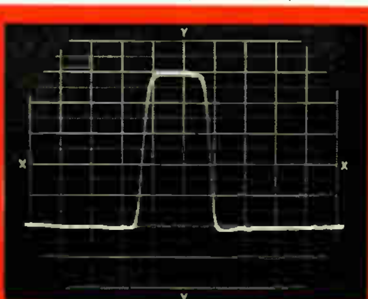


HIGH SENSITIVITY AND WIDE FREQUENCY RESPONSE OF Y-AXIS AMPLIFIER

The vertical amplifier of the 401 provides uniform frequency response and high sensitivity from D-C. Coupled with a sensitivity of 15 Mv./cm peak to peak at *both D-C* and A-C is a response characteristic which is 3 db. down at 10 Mc. and 12 db. at 20 Mc. Alignment of the amplifier is for best transient response, resulting in no overshoot for pulses of short duration and fast rise time. An example of the wide band response of the amplifier is shown in the accompanying photographs.



37.5 Mv., 0.2 μ sec width, 1 μ sec sweep full scale



75 Mv., 0.2 μ sec width, 1 μ sec sweep full scale

LINEARITY OF VERTICAL DEFLECTION The vertical amplifier provides up to 2.5 inches positive or negative uni-polar deflection without serious compression; at 3 inches, the compression is approximately 15%. The accompanying photographs illustrate transient response and linearity of deflection.

SWEEP DELAY The accurately calibrated delay of the 401 provides means for measuring pulse widths, time intervals between pulses, accurately calibrating sweeps and other useful applications wherein accurate time measurements are required.

The absolute value of delay is accurate to within 1% of the full scale calibration. The incremental accuracy is good to within 0.1% of full scale calibration.

SPECIFICATIONS

Y-Axis

Deflection Sens. — 15 Mv./cm, p-p
Frequency Response — DC to 10 Mc
Transient Response — Rise Time (10%-90%) 0.035 μ sec
Signal Delay — 0.25 μ sec
Input line terminations — 52, 72 or 93 ohms, or no termination
Input Imp. — Direct — 1 megohm, 30 μ μ f
Probe — 10 megohms, 10 μ μ f

X-Axis

Sweep Range — 0.01 sec/cm to 0.1 μ sec/cm
Delay Sweep Range — 5-5000 μ sec in three adjustable ranges.
Triggers — Internal or External, + and −, trigger generator, or 60 cycles, undelayed or delayed triggers may be used.
Built-in trigger generator with repetition rate from 500-5000 cps.

General

Low Capacity probe
Functionally colored control knobs
Folding stand for better viewing
Adjustable scale lighting
Facilities for mounting cameras

PRICE: $895.00

Additional Features:

TRIGGER GENERATOR with variable repetition rate from 500 to 5000 cps.

POSITIVE & NEGATIVE UNDELAYED TRIGGERS and a **POSITIVE DELAYED TRIGGER** are externally available.

An **INPUT TERMINATION SWITCH** for terminating transmission lines at the oscilloscope.

A **FOLDING STAND** for convenient viewing.

FUNCTIONALLY COLORED KNOBS for easier location of controls.

Designed and built *for* electronic engineers, the 401, with its high gain and wide band characteristics, and its versatility, satisfies the ever-increasing requirements of the rapidly growing electronics industry for the ideal medium priced oscilloscope.

Booth 4-105 New York IRE Show

L/E

LABORATORY for ELECTRONICS, INC.
75 PITTS STREET • BOSTON 14, MASS.

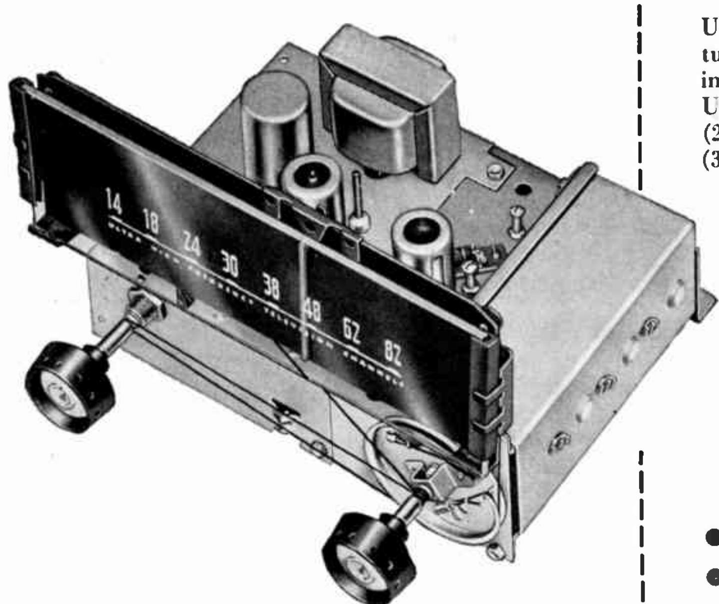
PRECISION ELECTRONIC EQUIPMENT • OSCILLOSCOPES • MAGNETOMETERS • COMPUTERS • MICROWAVE OSCILLATORS • MERCURY DELAY LINES

Why the Mallory UHF Tuner Should be Part of Your New TV Plans

The Mallory UHF Tuner can be the complete answer to your UHF tuning problems . . . whether you build converters, all-channel receivers, or both. It consists of three sections of variable inductance. It covers the range between 470 and 890 megacycles with approximately 2 mf of shunt capacity. Selectivity is excellent over the entire band.

No matter how you decide to handle the problem of UHF reception, it will pay you to investigate the various possibilities offered by the Mallory UHF Tuner. One of the following combinations is the answer to your requirements . . .

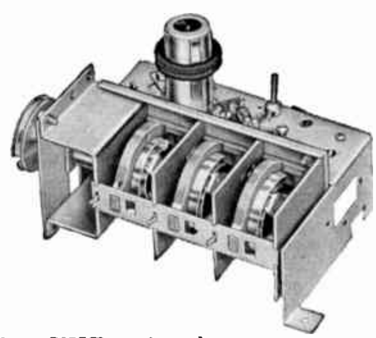
FOR CONVERTERS . . .



- Mallory UHF Tuning element for manufacturers building their own converters.
- Mallory UHF Converter chassis . . . ready to mount in your cabinet.
- Complete Mallory UHF Converter with your brand label.

FOR RECEIVERS . . .

UHF Tuners, for use in combination with VHF tuners, are available in 3 different designs . . . each in 3 different stages of assembly: (1) To convert UHF signals to 82 megacycles on channels 5 or 6. (2) To convert UHF signals to 130 megacycles. (3) For operation into a 41 megacycle IF amplifier.



- Mallory UHF tuning element.
- Mallory RF assemblies. This includes the tuner, oscillator, tube, crystal and associated circuitry.
- Mallory RF assemblies with an IF amplifier operating at conversion frequency.

Get in touch with us regarding the Mallory UHF Tuner. We will be glad to work with you . . . see how these various possibilities can be fitted into your plans for UHF television. Write today.

Television Tuners, Special Switches, Controls and Resistors

P.R. MALLORY & CO. Inc.
MALLORY

SERVING INDUSTRY WITH THESE PRODUCTS:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Dry Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

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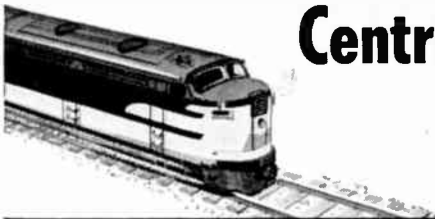
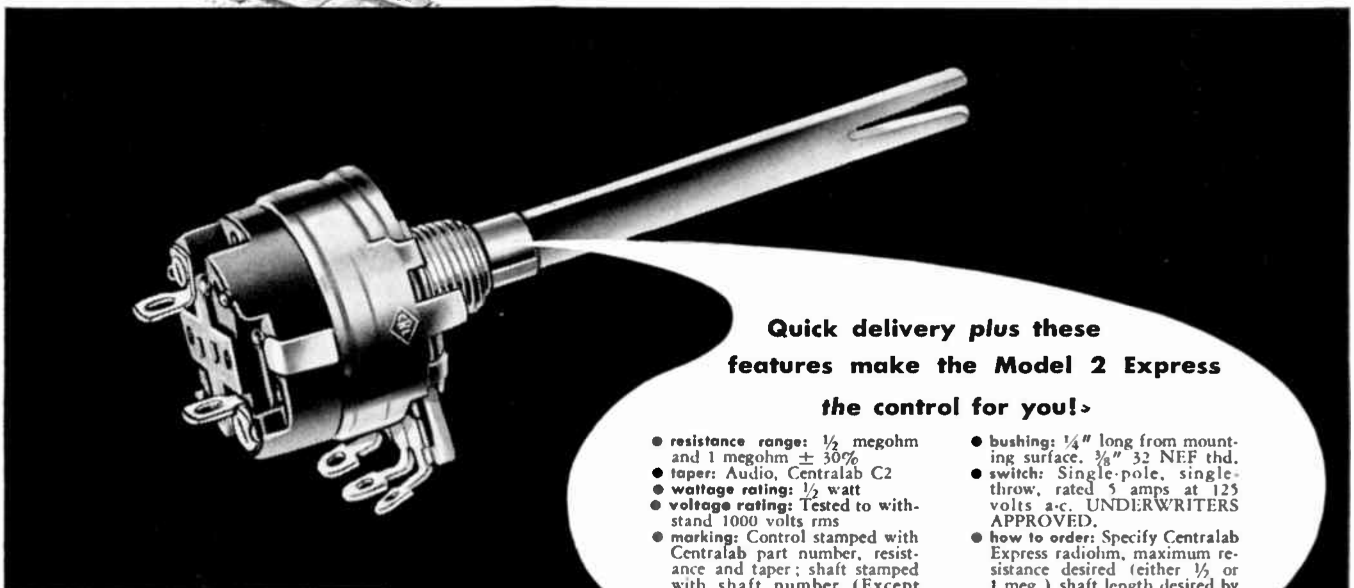
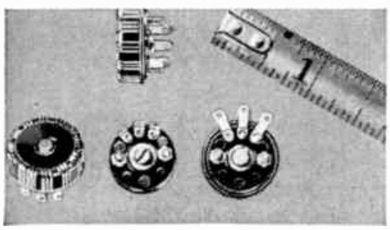


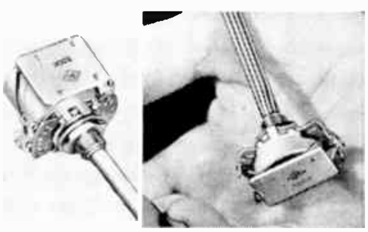
Centralab Model 2 EXPRESS keeps you ahead on AM-FM-TV



Typical Model 2 Radiohm control — only 15/16" dia., rated at ½ watt. Three basic switch ratings available 5, 8 and 1 amp, plus 8 switch combinations for real flexibility in application and design. Check No. 42-85 in coupon for more data.



Model 1 Radiohm miniature control, rated 1/10 watt — plain and switch types. World's smallest volume control! Ideal for hearing aids, other miniature uses. New high-torque control now available — stands vibration to 3.0 ounce-inches. Check No. 42-158.



Newly announced Compentrol combines volume control and Printed Electronic Circuit. Equalizes bass and treble response at low volume. Furnished in ½ or 1 meg—plain or switch types. Check No. 42-182 in coupon for more details.

You can always count on Centralab's wide variety of standard and custom controls to meet commercial and government requirements

CENTRALAB'S newest — the Model 2 Express — is ideal for the manufacturer needing controls on extremely short notice. Unique time-saving feature simplifies shaft assembly requirements — control shaft fits all standard RTMA split-knurled and certain spring-type push-in knobs.

Shafts and controls are carried in stock at our plant. When your order is received, desired shafts are staked directly to controls. Control assembly arrives in *your* plant in just a few days! To help you plan, Centralab will even tell you approximate delivery *time in hours,* from the date your order is received.

The new Express is available in two values: ½ megohm and 1 megohm, audio taper (C2) with SPST a-c line switch. These two values meet 75% of requirements for switch-type controls. Flat shafts are stocked separately in 14 lengths ranging from ⅞" from mounting surface to 2½" fms in increments of ⅛". For complete details check No. 42-163 in coupon.

Centralab CRL ®

A Division of Globe-Union Inc.
Milwaukee 1, Wis.
In Canada, 635 Queen Street East, Toronto, Ontario

Other famous Centralab plain or switch-type controls — standard or custom designs — with plain or dual concentric shafts are shown at left. They meet today's demand for smaller size, extra quality. Check coupon for more details. Manufacturer's samples on *all* controls on request.

MILITARY TYPES. If you use types RV2A or RV2B, Model 2 variable resistors on your next military order — there's no contractual approval or waiver required. They meet JAN-R-94, characteristic U requirements.

CENTRALAB Div. Globe-Union Inc.
920 East Keefe Avenue, Milwaukee 1, Wisconsin

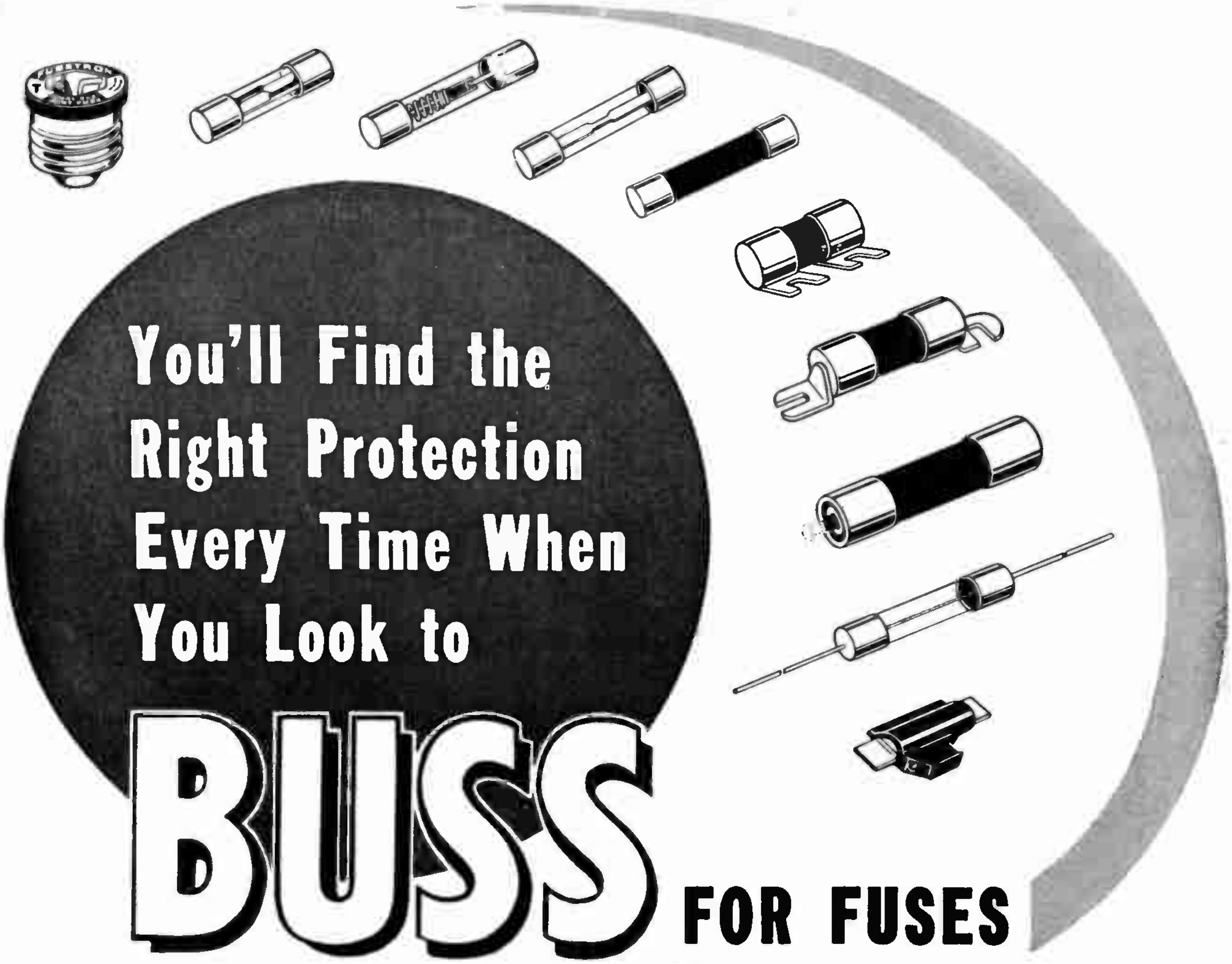
☐ No. 42-85; ☐ 42-158; ☐ 42-182; ☐ 42-163. Please send the bulletins I've checked. ☐ I'd also like a copy of Centralab's new Catalog No. 28, listing more than 470 *new* items for the fast-changing electronic field.

Name...Position..................................

Company..

Address..

City.......................................Zone............State.......................................



You'll Find the Right Protection Every Time When You Look to BUSS FOR FUSES

A COMPLETE LINE FOR TELEVISION · RADIO · RADAR · INSTRUMENTS · CONTROLS · AVIONICS

For almost four decades, BUSS has specialized in the production of fuses that are unexcelled for dependability and quality. Today, this experience and forward-looking BUSS research combine to give you the most complete line of fuses for modern needs.

Your added assurance of BUSS dependability is the rigid testing every fuse must undergo. Sensitive electronic testing devices check BUSS fuses for proper construction, correct calibration and accurate physical demensions.

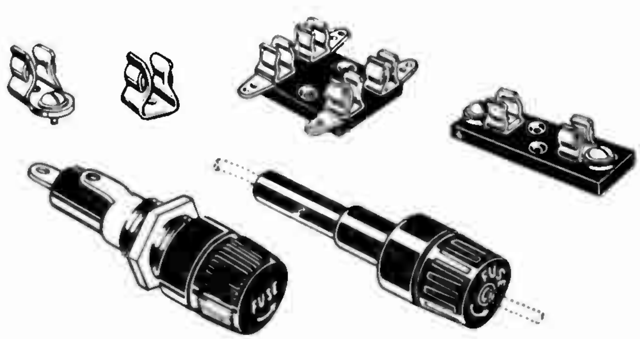
Turn To BUSS Engineers With Your Fuse Problems.

They will be glad to assist you in selecting the fuse to do the job best . . . and if possible a fuse that will be available from local wholesaler's stocks.

If your protection problem is still in the engineering state, tell us current, voltage, load characteristics etc.

BUSSMANN Mfg. CO., *Division McGraw Electric Company*
University at Jefferson, St. Louis 7, Missouri

and **A COMPLETE LINE OF FUSE CLIPS, BLOCKS AND HOLDERS**



BUSSMANN Mfg. Co. (Division of McGraw Electric Co.)
University at Jefferson, St. Louis 7, Mo.

Please send me bulletin SFB containing facts on BUSS small dimension fuses and fuse holders.

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The Most Complete Line of Ferrites

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TOROIDS
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"U" CORES
TV COMPONENTS
ANTENNA RODS

Ferramics offer many outstanding advantages. These widely adopted magnetic core materials have reduced assembly time by eliminating laminations in inductive components, cut costs and reduced space requirements by replacing tubes in digital computers, and revolutionized microwave transmission design by use of gyrator effect. Ferramics have improved designs in numerous other equipments, and have resulted in the development of basically new techniques in still others. Current research indicates still greater gains to come. The complete story on Ferramics is available without obligation.

—IF YOU NEED ENGINEERING ASSISTANCE ON SPECIFIC PROBLEMS

The General Ceramics technical staff will be happy to consult with you. Just call or write Sales Engineer, Ferramics Division.

TABLE OF MAGNETIC PROPERTIES OF FERRAMICS

PROPERTIES	UNIT	A-106	B-90	C-159	D-216	E-212	G-254	H-419	HI-1102	I-141	J-472
Initial Perm. at 1 mc/sec	—	20	95	250	410	750	410	850	550	900	330
*Max. Perm.	—	100	183	1100	1030	1710	3300	4300	3800	3000	750
*Sat. Flux Density	Gauss	1500	1900	4200	3100	3800	3200	3400	2800	2000	2900
*Residual Mag.	Gauss	1000	830	2700	1320	1950	1050	1470	1500	700	1600
*Coercive force	Oersted	5.0	3.0	2.1	1.0	.65	.25	.18	.35	.30	.80
Temp. Coef. of initial perm.	%/°C	.15	.04	.40	.30	.25	1.3	.66	.80	.30	.22
Curie Point	/°C	300	260	330	165	160	160	150	125	70	180
Vol. Resistivity	ohm-cm.	1×10^7	2×10^5	2×10^6	3×10^7	4×10^5	1.5×10^8	1×10^4	2×10^4	2×10^5	5×10^7
Loss Factor: At 1 mcs/sec	—	.0005	.00016	.00007	.00005	.00008	.00008	.00030	.0004	.0003	.000055
At 5 mcs/sec	—	.0007	.0011	.0008	.0012	.002	.00075	.00155	.001	.005	.0004

*Measurements made on D.C. Ballistic Galvanometer with Hmax = 25 oersteds. Above data based on nominal values

AT THE I.R.E. SHOW BOOTH #1-506

GENERAL CERAMICS AND STEATITE CORPORATION — STEATITE INSULATORS

General CERAMICS and STEATITE CORP.

Perth Amboy 4-5100

GENERAL OFFICES and PLANT: KEASBEY, NEW JERSEY

MAKERS OF STEATITE, TITANATES, ZIRCON PORCELAIN, FERRAMICS, LIGHT DUTY REFRACTORIES, CHEMICAL STONEWARE, IMPERVIOUS GRAPHITE AND FERRAMIC MAGNETIC CORES

COMPLETE KITS FOR TOWER LIGHTING

Backed by years of leadership, H & P lighting equipment is today the accepted standard throughout the world. Many exclusive features assure easy installation, low maintenance costs . . . dependable operation under all climatic conditions.

Everything Needed for any Tower, 150 to 900 feet!

H & P *Complete* Tower Lighting Kits include every item essential to the completed installation — every bolt and fitting . . . H & P Complete Lighting Kits, in today's critical market, will save you on purchasing, erection, and completion time . . . The H & P 300 MM Code Beacon (shown left) has 10 exclusive features, is CAA approved.

Single and double Obstruction Lights
below

Bases ruggedly constructed of heavy aluminum alloy castings. Precision machining insures proper light center when used with specified lamp. Prismatic globes meet CAA light specifications. Relamping accomplished without removing prismatic globes. Mounting base designed for standard A-21 traffic signal lamps.

above

"PECA" Series Photo-Electric Control

Factory-set to turn lights on at 35 f.c.; off at 58 f.c. as specified by CAA. Low-loss circuit insulation. High-wattage industrial type resistors. Tube ratings well over operational requirements. Fail-Safe: if any parts fail in service, lights automatically turn on. Models for all load capacities.

above **SF-30-E**

Mercury Code Flasher

Models available for any loads. Compact, spray-tight and drip-proof cast aluminum housing mountable on vertical OR horizontal member. Heavy-duty, self-starting, constant-speed synchronous timing motor is unaffected by extreme temperature and voltage ambients. Positive-acting ELECTRONIC fail-safe circuit guards against failure of ANY component.

Lighting for Airports, Bridges, Towers, Buildings and all obstructions hazardous to air commerce.

Sold only through jobbers and Tower Manufacturers.

Send for FREE Catalog

Write on your letterhead for new, detailed catalog. We will also send you the name of your nearest H & P distributor.

Complete Kits for CAA specifications A-1 to A-5 towers include every item essential for complete tower lighting installation.

HUGHEY & PHILLIPS

TOWER LIGHTING DIVISION

60 East 42nd Street • New York 17, N. Y.

Head Office • Encino, California

Another Machlett Contribution Toward Better, More Reliable Tubes for Industrial Service

ML-6257 is the latest addition to Machlett's line of tubes specially designed and processed for use in electronic heating equipment. It fulfills a long standing requirement for a long life tube which can safely provide 3 kw of heater output with reliability and economy.

ML-6257—with its companion tubes ML-6256 and ML-6258—makes available design and performance characteristics which provide a higher standard of value for all applications—including AM, FM & TV broadcasting.

ML-6257 is rated 5 kw plate dissipation with cooling provided through an integral anode water jacket. Type ML-6256 with the same ratings uses the Machlett automatic seal water jacket. Type ML-6258 designed for forced-air cooling is rated at 3 kw plate dissipation.

Phone, wire or write for more information—Machlett Field Engineers will be glad to assist in any tube application problem.

RATINGS AND CHARACTERISTICS

Electrical Data—General

Filament voltage	12.6 Volts
Filament current	27 Amps
Amplification Factor	21
Interelectrode Capacitances:	
Grid-Plate	20 uuf
Grid-Filament	22 uuf
Plate-Filament	0.7 uuf

Maximum Ratings—Class C Telegraphy
(Key down conditions per tube without modulation)

D-C Plate Voltage	5500 Volts
D-C Grid Voltage	—1500 Volts
D-C Plate Current	1.5 Amps
D-C Grid Current	.22 Amp
Plate Input	7 kW
Plate Dissipation	5 kW

Machlett Industrial and Broadcast Tubes will be exhibited at the 1953 I.R.E. Show, Booths 1-116 and 1-117

MACHLETT OVER 50 YEARS OF ELECTRON TUBE EXPERIENCE

MACHLETT LABORATORIES, INC., SPRINGDALE, CONNECTICUT

Industrial Engineering Notes[1]

British Radio Parts Show

The tenth annual private exhibition of British components, tubes, and test gear for the radio, electronic, and telecommunications industries is scheduled to be held in the Great Hall, Grosvenor House, Park Lane, London, on April 14–16, 1953. Over 100 firms will participate in the exhibition which is designed to acquaint manufacturers and engineers with the latest advances in the design and development of British radio, electronic and telecommunications components, tubes, and test instruments.

Audio Fair and Exhibition Slated

The Audio Fair in Chicago, Ill., will be combined with the 1953 International Sight and Sound Exposition to be held at the Palmer House, September 1–3, 1953.

The combined International Sight and Sound Exposition and Audio Fair, the only public high-fidelity audio-video show to be held in the midwest in 1953, is expected to attract more than 20,000 persons during its three-day public and trade display of leading American and foreign equipment.

Sprague Named Under Secretary

R. C. Sprague, formerly chairman of the board of directors and president of RTMA and long a leader in the electronics industry, has been chosen as Under Secretary of the Air Force in the Eisenhower Administration.

Mr. Sprague succeeds R. L. Gilpatric and will serve under Secretary of the Air Force, H. E. Talbott. Both appointments were subject to Senate confirmation.

As Under Secretary of the Air Force, Mr. Sprague is in a highly important position in the Department of Defense and is the outstanding authority on electronics production for the Armed Services among the top civilian administrators of the Defense Department.

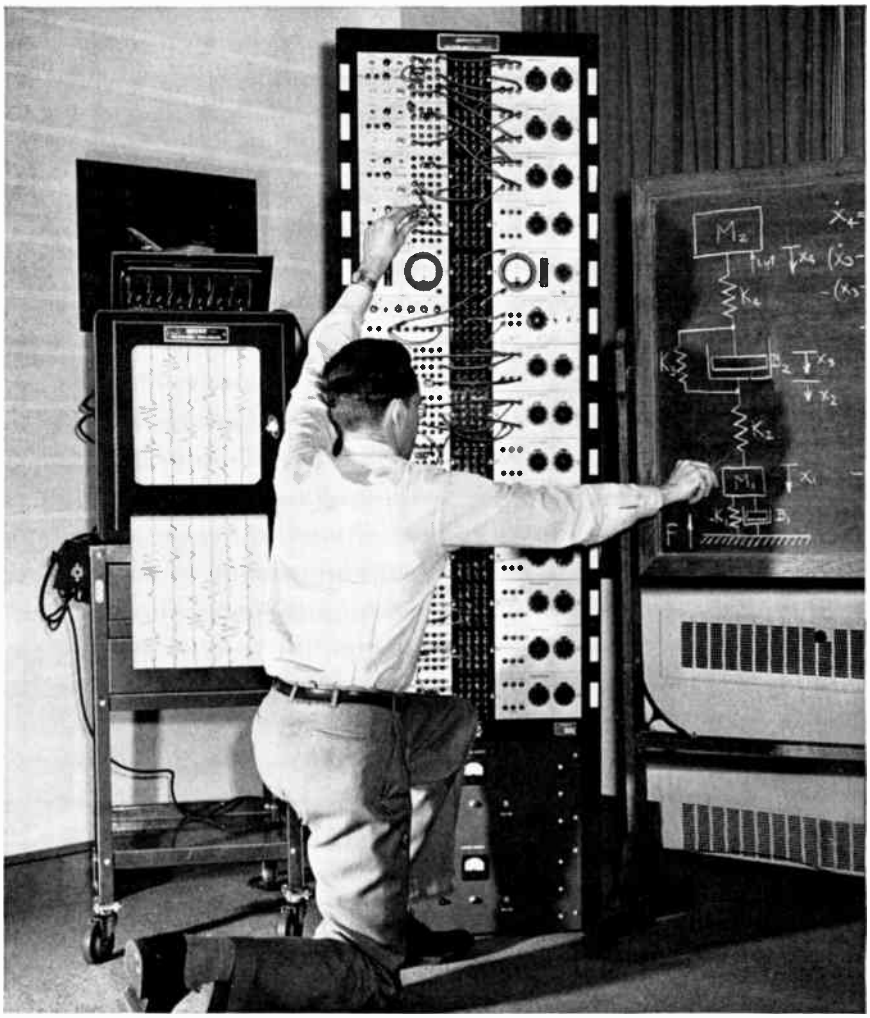
It is understood Mr. Sprague reorganized the Sprague Electric Company, of which he was founder and president, in order to accept the governmental appointment, and he has resigned as an RTMA director to free himself of all organized industry affiliations.

Technical and Research News

The Civil Aeronautics Administration has announced the release of a study on its newest air navigation device—the Distance Measuring Equipment (DME). The equipment works on principles somewhat similar to radar, and some 400 DME ground stations, called transponders, now are being installed by the CAA along the airways. The CAA study, called "DME at Work" is available from the CAA, and will be distributed to persons with a direct interest in the operational and engineering features of DME. The study de-

(Continued on page 78)

[1] The data on which these Notes are based were selected by permission from *Industry Reports*, issues of December 31, 1952, January 9, January 16, January 23, 1953, published by the Radio-Television Manufacturers Association, whose co-operation is gratefully acknowledged.



Industrial Engineering Notes

(Continued from page 77A)

scribes a series of flight tests and demonstrations which show the advantages DME offers to airline operators, military aviation, executive pilots and others. . . . **Increased accuracy in an analogue computer for the Laplacian equation has been produced by the National Bureau of Standards.** The electrolytic tank used in most analogue computers for the Laplacian equation, has been replaced in the NBS device by a fine network of resistors. Built under the direction of L. Marton of the NBS Electron Physics Laboratory, the new resistance analogue computer is patterned after a unit developed by G. Liebman, but the accuracy of the device reportedly has been increased by improvements and modifications of the original design. Details on the resistance network analogue computer appeared in the NBS Technical News Bulletin for February, 1953. . . . **An improved type of short-wave antenna is described in a government research report** made available by the Office of Technical Services, U. S. Department of Commerce. The new type antenna contains a coaxial cable in which the inside central rod is made to extend beyond the outside cylinder which forms an effective "sleeve." OTS says the antenna arrangement is simple and rugged and is structurally more desirable than the widely-used, conventional dipole arrangement. The report, PB 107274, "The Sleeve Antenna," is available from the Library of Congress on microfilm at $5.75 and photostat, $18.75. Orders should be addressed to Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C. . . . The OTS also has released a **research report on ways to build electronic aircraft equipment so as to eliminate operational disturbances.** The report is based on the findings of an Air Force survey of sources of interference and static and the techniques for suppressing these disturbances. It is designed as a guidebook, for both electronic equipment and aircraft builders. Copies of the report, PB 111051, "Design Techniques for Interference-Free Operation of Airborne Electronic Equipment," may be obtained in mimeograph for $11.50. Orders should be addressed to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

FCC Actions

The Federal Communications Commission has **finalized, with certain changes, its proposed rule making of April 17, 1952, with respect to Part 12, Rules Governing the Amateur Radio Service,** so as (1) to provide for use of radiotelephone emissions in the 72–7,300-kc segment of the 7-mc amateur frequency band, (2) to enable Novice Class amateur operators to use the 7,175–7,200-kc portion of the 7-mc amateur bands, (3) to establish standards for amateur radio teleprinter operation, (4) to open up the nonradiotelephone segments of the 3.5, 7, and 14-mc amateur bands to F-1 (frequency-shift telegraphy) emission

(Continued on page 79A)

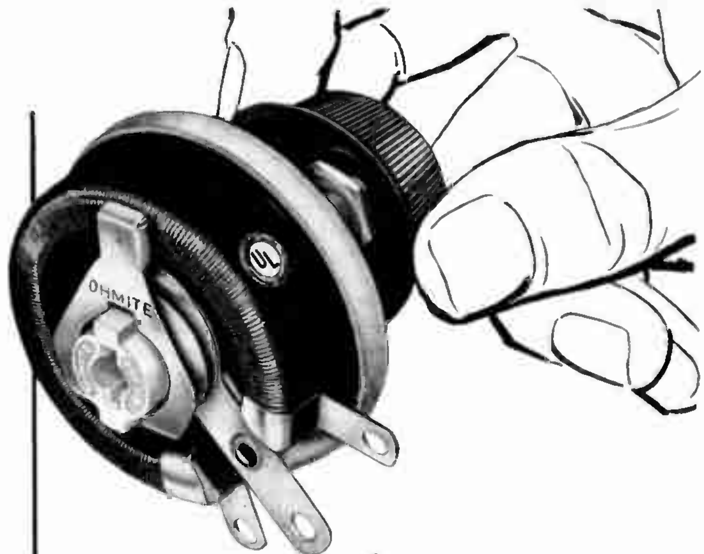
Industrial Engineering Notes

(Continued from page 78A)

and (5) to clarify requirements for the transmission of amateur call signs, including teleprinter operation. The changes were effective February 20, 1953. By separate Report and Order, the Commission finalized its proposal of April 17, 1952, amending Part 12 to permit the General and Conditional Class of amateur operators the use of the bands 3,800–4,000 kc and 14,200–14,300 kc for radiotelephone emissions, effective February 18, 1953. . . . **The FCC has amended Sections 8.104 and 8.105 of its rules regarding certain frequencies in the Maritime Mobile Service.** The amendments were effective February 16, 1953. The requirements of Section 8.104 concern the rapidity of changing from one operating channel to another during transmission or reception by ship stations using telegraphy in the band 2,065 to 2,107 kc, and on specific frequencies in the bands between 4,000 and 23,000 kc, authorized by international agreement. In addition, the FCC amended the section to indicate more precisely the band of frequencies affected by the rule. Copies of the amendments (Mimeograph No. 84766) may be obtained from the Office of Information, Federal Communications Commission, Washington 25, D. C. . . . The eighteenth **Annual Report of the Federal Communications Commission covering the fiscal year 1952, which ended June 30, shows that the number of radio authorizations issued passed the one million mark for the first time during the year.** The Annual Report was submitted to Congress by chairman P. A. Walker. The FCC report pointed out that there now are 45 times more nonbroadcast stations than there are broadcast stations. In other words, more than 200,000 radio authorizations are held by public agencies and by private industry and individuals as compared with less than 5,000 stations engaged in program broadcasting. The broadcast figure includes about 1,200 pickup and studio-transmitter links. The nonbroadcast figures, on the other hand, do not indicate the actual number of transmitters involved, since a single authorization—as in the case of a police or fire department, railroad, taxicab company, etc.—can cover many portable or mobile transmitters. Most of the nonbroadcast radio stations are grouped in the Safety and Special Radio Services. Their more than 212,000 authorizations represent the use of nearly 540,000 transmitters and constitute the largest number of radio stations licensed by the Commission. The safety group, with nearly 80,000 authorizations, covers the use of nearly 190,000 transmitters in the following fields: Aeronautical (42,000 transmitters), Marine (35,000), Police (81,000), Fire (11,000), Forestry-Conservation (14,000), Highway Maintenance (4,200), Special Emergency (1,900), and State Guard (140). The industrial group, with nearly 14,000 authorizations, covers the use of more than 90,000 transmitters by the Power (51,000),

(Continued on page 86A)

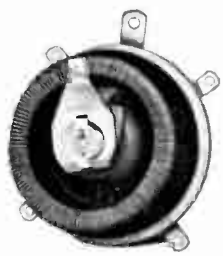
OHMITE® RHEOSTATS



WITH SPECIAL FEATURES . . .

BUSHINGS FOR SPECIAL PANEL THICKNESS

Extra-long bushings and shafts for mounting on panels up to 2" thick.



360° WINDING

Available with continuous circular core and endless winding.

SCREW DRIVER SLOT SHAFT

Shaft ends slotted for occasional adjustments with a screw driver.

SEALED, ENCLOSED CAGES

Compact, corrosion-resistant metal cages, sealed by a double seam.

SNAP-ACTION OFF POSITION

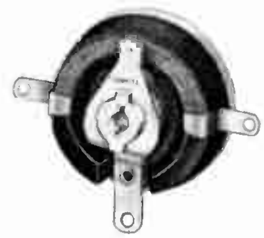
Opens at high or low resistance position. Notch provides indexing.

TANDEM ASSEMBLIES

Two or more rheostats in tandem for simultaneous operation.

TOGGLE SWITCH

Switch is operated with a positive snap by movement of the contact arm.



LESS THAN STANDARD ROTATION

Has winding space and angle of rotation less than standard.

• In addition to a complete line of standard rheostats, OHMITE manufactures a wide variety of rheostats with special features. All have the distinctive OHMITE design qualities: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel. Specify OHMITE for your special-feature rheostats, and know you'll get the best!

Write on Company Letterhead for Catalog and Engineering Manual No. 40.

OHMITE MANUFACTURING COMPANY
4862 Flournoy Street, Chicago 44, Illinois

OHMITE

first IN WIRE-WOUND RHEOSTATS AND RESISTORS

PRELIMINARY *

Announcement

SANBORN "150" SERIES OSCILLOGRAPH RECORDING SYSTEMS

(4-, 2-, and 1- channel)

THE MOST VERSATILE OSCILLOGRAPH RECORDERS ON THE MARKET

When the new Sanborn "150" Series is seen for the first time, all will agree that Sanborn engineers are really outdoing themselves in their *design for versatility.*

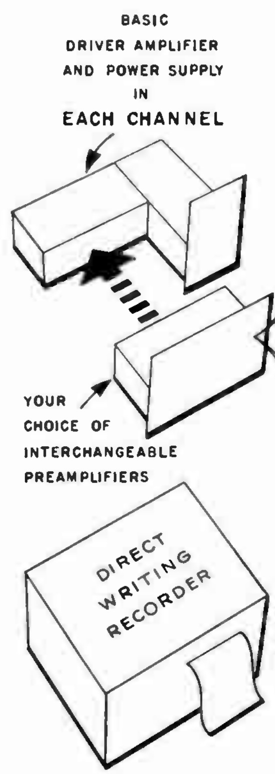
This increased versatility is being made possible by:

(1) the availability of a greater variety of newly designed *interchangeable* Sanborn amplifiers and preamplifiers which together encompass such a variety of uses that the recording possibilities of Sanborn Systems will include *almost every* phenomenon whose frequency spectrum covers the range from 0 to 100 cycles per second, and

(2) by an original design idea which makes such interchangeability *more practical.* Built into each System will be a *separate* DC driver amplifier and power supply for *each of the System's channels,* with provision for "plug in" connection to the driver amplifier (as shown in the diagram at right) of the *user's choice* of a preamplifier and control panel to complete the desired network for each channel.

IN ADDITION, the "150" series will include these Sanborn improvements:

- Increased frequency response
- Improved regulated power supply
- Individual stylus temperature control for each channel
- Improved, single control, paper speed selector. Nine speeds —.25 to 100 mm/sec
- Greater convenience and more area for immediate study of recorded events, and for notations on record
- Amplifier panels and Recorder panel all in one vertical plane on the 4-channel model. Complete system takes less floor space.



AC-DC PREAMPLIFIER
will produce 1 cm deflection for a 1 mv AC signal, and a 1 mm deflection for a 1 mv DC signal. Also provides for calibrated DC zero suppression (20X full scale). Balanced or single ended inputs.

CARRIER PREAMPLIFIER
permits a choice of three interchangeable oscillators — 400, 1000 and 2500 cycles. Each amplifier equipped with calibrated zero suppression network (20X full scale). Overall sensitivity 80 microvolts/cm deflection, or 40 microinches/inch/cm (one active arm; gage factor of 2). With commercial transducers, sensitivity usually sufficient for 20X full scale with maximum load on the transducer.

SERVO MONITOR PREAMPLIFIER — AC phase discriminating, with overall sensitivity of 10 mv/1 cm deflection. Provides DC outputs proportional to error signals from 60 to 10,000 cycles per second.

LOG-AUDIO PREAMPLIFIER
provides a 50 db dynamic range wtih resulting chart calibrated 1 db/mm. (At maximum sensitivity, bottom of chart equals 0.3 mv input, and top of chart 100 mv). 50 db (5 db steps) input audio attenuator. Input provision for either DC or audio signals. Audio range 20 cps to 20 kc. DC input range from 0.6 to 200 volts.

DC CONVERTER (Chopper Amp.)
for low level DC recording such as thermocouple output. Sensitivity 1 mv/cm deflection.

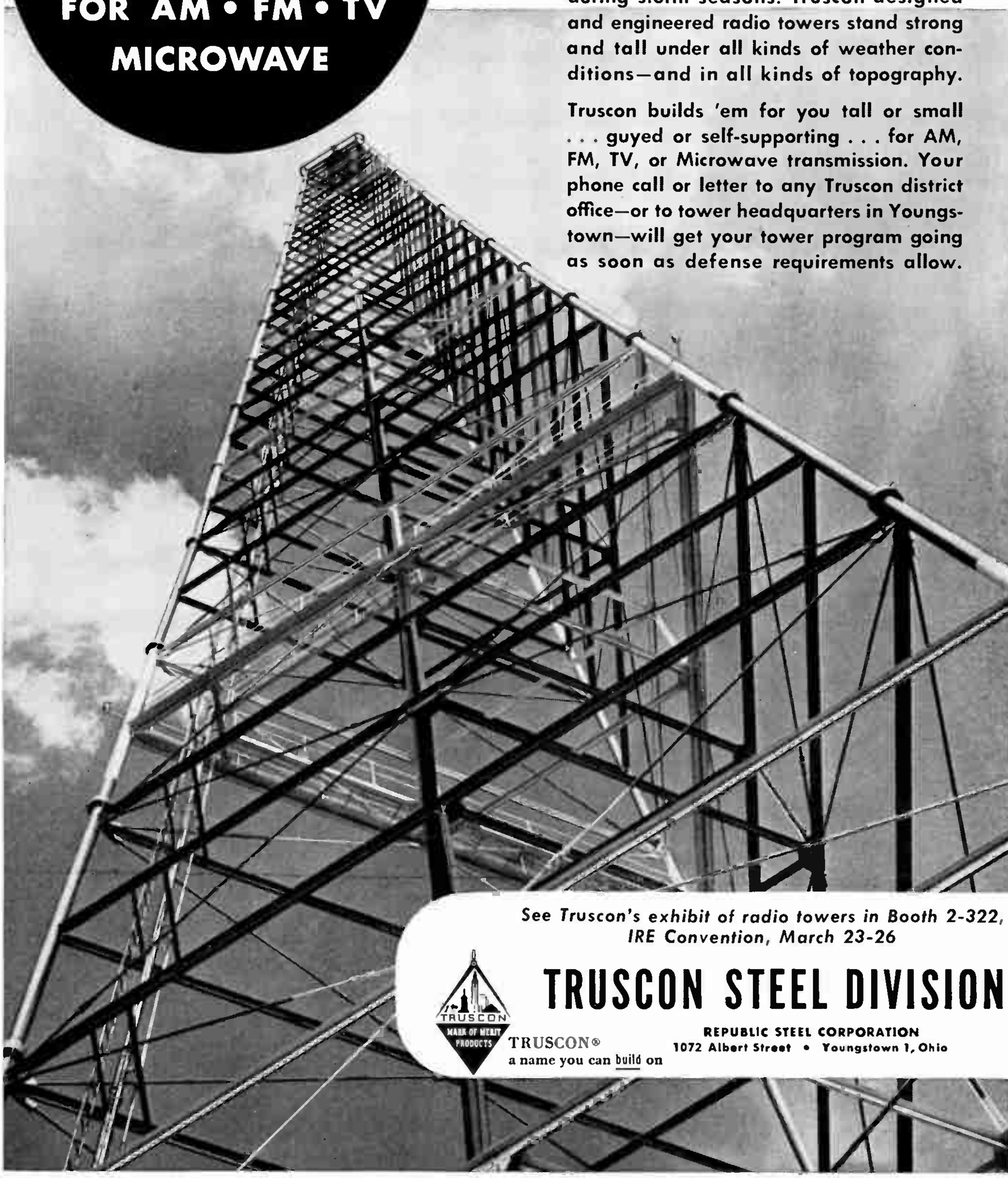
COUPLING PREAMPLIFIER
will take balanced or single ended inputs providing 50 mv/cm sensitivity.

* First showing of the new Sanborn "150" series will be at BOOTH 2-116, I.R.E. Convention, Grand Central Palace, New York City, March 23-26. Be sure to see it!

Sanborn Company

INDUSTRIAL DIVISION

Cambridge 39, Massachusetts



Specify "MAKEPEACE" *for*

PRECISION RINGS

DEMCO collector rings and ring assemblies give you these advantages . . .

ECONOMY . . . laminated construction provides contact metal where required . . . base metal for strength.

HIGH FINISH . . . on contact surface for long wear and noise-free operation.

PRECISION MADE . . . it is unnecessary to add further machine operations.

COMPLETE . . . rotor or pancake type multi-ring and ring-and-brush assemblies supplied.

PRECISION TUBING

PRECISION DRAWN . . . ID held as close as ±.001. Solid coin silver, brass or aluminum Rev. MIL-T-85.

LAMINATED SILVER . . . on ID for

- Low attenuation
- Corrosion resistance
- Highest mirror finish

Laminated silver ID and OD for round tuned lines.

PRECISION "KNOW-HOW"

With nearly sixty years of experience in the production of both laminated and solid precious metals, MAKEPEACE is today an accepted "headquarters" for the many special precious metal products and assemblies called for in the electronic field.

Our staff of thoroughly experienced design and production engineers and metallurgists . . . as well as our research and testing laboratory . . . are all at your service.

D. E. MAKEPEACE COMPANY

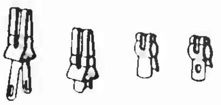
Laminated and Solid Precious Metals for Industrial Use • Fabricated Parts and Assemblies • Bar Contact Material • Precious Metal Solders

MAIN OFFICE AND PLANT, ATTLEBORO, MASSACHUSETTS
NEW YORK OFFICE, 30 CHURCH STREET
CHICAGO OFFICE, 55 EAST WASHINGTON STREET

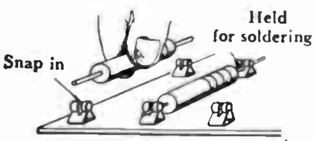
Here is Plug-in Unit Construction

Everything you need to mount, house, fasten, connect, monitor your equipment.

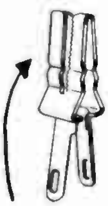
1st START WITH ALDEN MINIATURE TERMINALS



Here's a beautiful new little Terminal that really puts soldering on a production basis; taking a minimum of space and material. Ratchet holds leads firmly for soldering, no wrap-around or pliering necessary. Unique punch press configuration gives rapid heat transfer, taking less time and solder. Designed for Govt. Miniaturization contracts. Staked in Alden Prepunched Terminal Cards, allow patterns for any circuit.

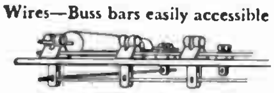


No pliers—No twisting



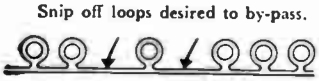
Ratchet holds leads firmly

Wires—Buss bars easily accessible



Both sides can be used

Snip off loops desired to by-pass.



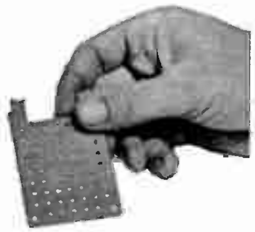
JUMPER STRIP

Stake under Terminals for common circuits. Loops match prepunched holes in Terminal Cards. Snip off loops desired to by-pass.

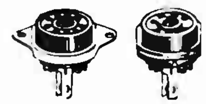
FOR YOUR SMALLER UNITS.

2nd
Take Pre-punched Terminal Mounting Card ready-cut to size you require. Stake in Alden Miniature Terminals to mount your circuitry.

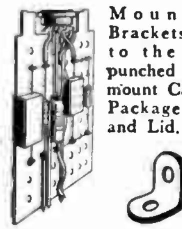
Prepunched Terminal Mounting Cards come in all sizes needed for Packages: miniature 7-pin and 9-pin units, or 11-pin and 20-pin plug-in units. Card is natural phenolic 1/16" thick prepunched on 1/4" centers with .101" holes for taking the Miniature Terminals.



3rd
Attach Miniature Terminals, Alden Card-mounting Tube Sockets and Mounting Brackets, which mount in the prepunched holes.



Alden Card - mounting Tube Sockets for miniature 7, miniature 9 and octal tubes, are complete with studs and eyelets for easy mounting on Prepunched Cards.



Mounting Brackets stake to the Prepunched Card, mount Card to Package Base and Lid.

FOR YOUR LARGER UNITS.

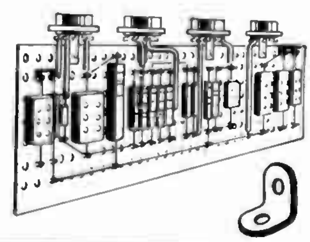
2nd
Lay out circuitry with Prepunched Terminal Mounting Card in lengths up to 3'.

READY MADE to fit various ready made Chassis sizes.

Organize circuitry in compact vertical planes. Use both sides of Prepunched Card to stake in Alden Miniature Terminals to your circuitry layout. Vertical position gives ready accessibility; there is no "underneath" in Alden design.

3rd
Attach Miniature Terminals, Card-mounting Tube Sockets and Mounting Brackets, which fit any of the prepunched holes.

Alden Card-mounting Tube Sockets, ready-made in variety of sizes, complete with studs and eyelets for easy mounting on Prepunched Cards.



TO OBTAIN COMPLETE DETAILS.

Tiny Sensing Elements specifically designed to spot trouble instantly in any unit.

Here are tiny components to isolate trouble instantly by providing visual tell-tales for each unit.

"PAN-i-LITE" MIN. INDICATOR LIGHT

So compact you can use it in places never before possible. Glows like a red-hot poker. Push-mounts in .348" drill hole. Bulbs replace from front. Tiny spares are unbreakable, easily kept available, taped in recess of equipment. Alden #86L, ruby, sapphire, pearl, emerald.

MINIATURE TEST POINT JACK

Here are tiny insulated Test Point Jacks that make possible checking critical plate or circuit voltages from the front of your equipment panel—without pulling out equipment or digging into the chassis. Takes a minimum of space, has low capacitance to ground, long life beryllium copper contacts. Available in black, red, blue, green, tan and brown phenolic conforming to MIL-P 14B- CGF; also nylon in black, red, orange, blue, yellow, white, green. Alden #110BCS.

ALDEN "FUSE-LITE"

Fuse Blows — Lite Glows.

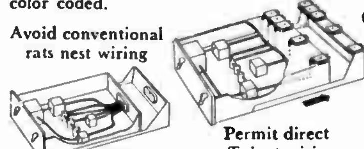
Signals immediately blown fuse. Lite visible from any angle. To replace fuse simply unscrew the 1-pc. Lite-lens unit. Mounts easily by standard production techniques, in absolute minimum of space. 110V Alden #440-4FH. 28V #440-6FH.

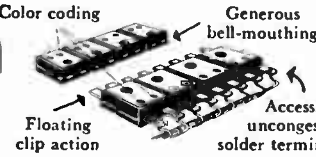
Free Samples Sent Upon Request

Get one point of check of all incoming and outgoing leads thru ALDEN BACK CONNECTORS

SINGLE CHECK POINT

Here for the first time is a slide-in connector that brings all incoming and outgoing leads to a central check point in orderly rows, every lead equally accessible and color coded.





STRAIGHT-THROUGH CIRCUITRY

Wiring is kept in orderly planes, avoiding rat's nest of conventional back plate wiring. Connections between Terminal Mounting Cards are through Back Connectors so that all circuitry is controlled at this central point. Incompatible voltages safely isolated and separated.

EASY INSERTION AND REMOVAL

Mating tolerances permit easy insertion and removal without demanding critical alignment tolerances. Assure proper contact, with safety shielding of dangerous voltages. Leads can be attached above, below or out of the back for most direct and efficient interconnects.

Ready-made Alden Back Connectors meet all conceivable needs, for slide-in chassis replaceable in 30 seconds with spare.

VISIT OUR COMPLETE DISPLAY AT THE I.R.E. SHOW

NA-ALN

ALDEN PRODUCTS COMPANY

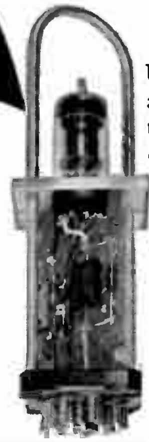
READY-MADE for your Electronic Equipment

All designed — all tooled — production immediately available — no procurement problems. ***Apply ALDEN Standards wholly or in part.***

ALDEN PLUG-IN PACKAGES

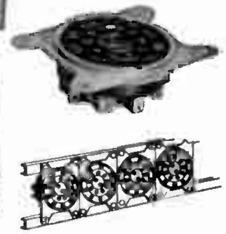
4th After mounting your circuits on Terminal Cards, use Alden Standard Plug-in Bases, Housings, Bails for packaging.

Min. 7 & 9-pin BASES available, also 11-pin & 20-pin. BAILS & HOUSINGS or LIDS to match.



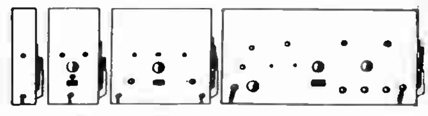
ALDEN PLUG-IN PACKAGES

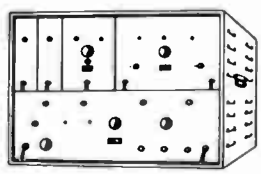
Using standard Alden Plug-in Packaging Components you can mount a tremendous variety of circuits on chassis or in racks.



Alden "20" Rack Mounting Socket with extended ears that mount side by side and in multiple rows on U-Channels that accommodate 50 Alden "20" Plug-in Units illustrated, in 10½ x 19" rack mounting panel.

HOUSE PLUG-IN UNITS IN ALDEN BASIC UNI-RACKS

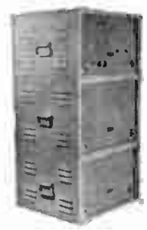




FOUR SIZES OF CHASSIS MOUNT IN ANY COMBINATION IN ALDEN UNI-RACKS

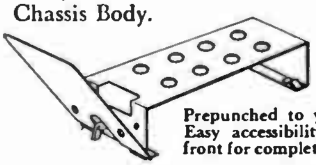
STACKED

Mounting all equipment in Alden Uni-Racks provides a uniform system easy to handle and ship. Can be installed and interconnected as fast as unloaded.



ALDEN BASIC CHASSIS

4th Fit Prepunched Cards carrying completed circuitry into Standard Alden Basic Chassis Body.



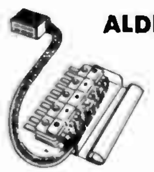
Prepunched to your specs. Easy accessibility at sides, front for completing wiring.

SERV-A-UNIT LOCK
pulls in or ejects chassis.

SLIDE-IN BACK CONNECTORS
See description on opposite page.

ALDEN BASIC CHASSIS
with spares provides 30-second servicing for your unitized circuitry.

ALDEN UNIT CABLE



interconnects between Uni-racks or other major circuitry divisions. Quick, sure, coded means of isolating and restoring (with spare) inter-division circuits.

SEND FOR FREE "ALDEN HANDBOOK"

Your design and production men have always wanted these advantages:

1. Experimental circuitry can be set up with production components, cutting down debugging time.
2. Allows technicians, rather than engineer, to debug, by taking out unit.
3. Given the circuitry, nothing further to design—make up from standard Alden components.
4. Optimum circuit layout using standard terminal card.
5. Absolute minimum requirements of labor, materials, space.
6. The various sub-assemblies can be built concurrently on separate assembly lines.
7. No tooling costs—no delays—no procurement headaches.
8. Fewer prints—smaller parts inventory.
9. Can subcontract assemblies.

Your customers and sales force will welcome these advantages:

The big objection to electronic equipment—from the user's point of view—is that if it goes out of order he feels helpless. But you have a perfect answer when your equipment is made to Alden Standards of Plug-in Unit Construction because they assure DEPENDABLE OPERATION, as follows—

30-SECOND REPLACEMENT OF INOPERATIVE UNITS by plugging in available coded spares.

TROUBLE INSTANTLY INDICATED AND LOCATED by monitoring elements assigned to each functional unit.

TECHNICAL PERSONNEL NOT REQUIRED to maintain in operation, due to obvious color coding and fool-proof non-interchangeability of mating components.

TOOLESS MAINTENANCE made possible by patented Alden fasteners and plug-in locking and ejecting devices.

AIRMAIL SERVICE—
Compact functional units practical to send airmail to factory for needed overhaul.

UNI-RACK FIELD HANDLING UNIT—groups functional units into stacking cabinets not exceeding one- or two-man handling capacity—go easily through windows, doors.

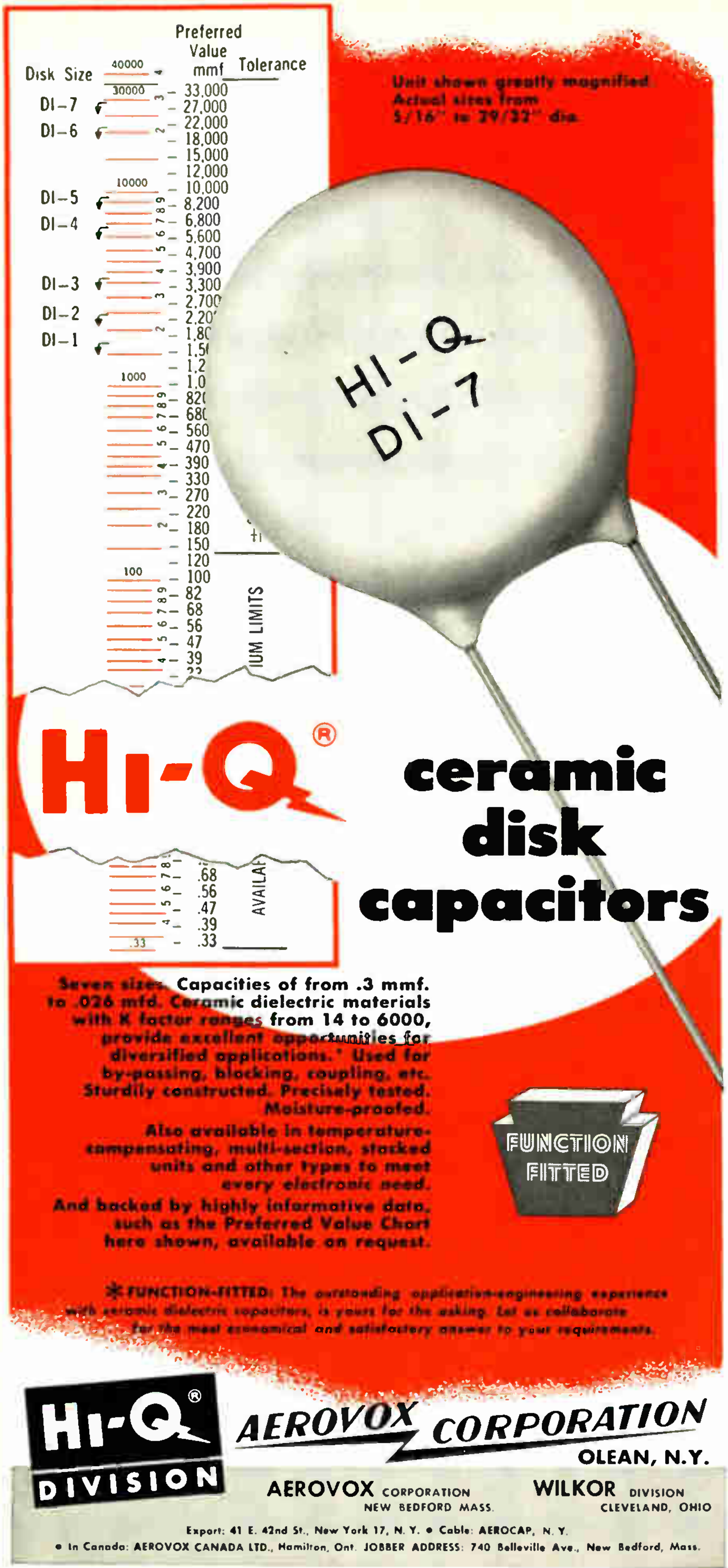
CONNECT AS FAST AS UNLOADED, by coded non-interchangeable unit cables plugged in between Uni-racks.

SEND FOR FREE 226-PAGE HANDBOOK

This 226-page Handbook describes fully the Alden System of Plug-in Unit Construction and the hundreds of components ready-made and completely tooled to meet your every requirement. It's a gold-mine for those designing electronic control equipment that is practical in manufacture; dependable in operation.

REQUEST YOUR COPY TODAY — SENT FREE!

121 North Main Street • Brockton 64 • Massachusetts



Industrial Engineering Notes

(Continued from page 79A)

Petroleum (15,000), Forest Products (5,200), Special Industrial (15,000), Low-Power Industrial (2,300), Relay Press (nearly 450), Motion Picture (nearly 200), Agriculture (10) and Radiolocation (11) Services. The land-transportation group, with nearly 6,500 authorizations, covers the use of nearly 145,000 transmitters in the field of Railroad (9,000), Urban Transit (1,700), Intercity Bus (400), Taxicab (125,000), Highway Truck (3,200), Automobile Emergency (1,500), and Citizens (3,000). The Amateur Radio Service, the FCC noted, has more than 113,000 authorizations covering about the same number of transmitters. The relatively new Disaster Communications Service has 69 authorizations but more than 400 transmitters. The close of the fiscal year saw 2,420 authorized commercial AM broadcast stations and 582 commercial FM stations. Copies of the FCC Annual Report may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 40 cents per copy.

RTMA Activities

Calling on all television manufacturers for co-operation, W. R. G. Baker, director of the RTMA engineering department, has presented **an RTMA plan for implementing and accelerating the reduction of spurious-oscillator radiation in TV transmission and reception,** at an all-industry engineering conference in the Biltmore Hotel, New York City. Dr. Baker appointed three task committees from the RTMA engineering department to carry out the plan in co-operation with the Joint Technical Advisory Committee and the Institute of Radio Engineers. A task committee on receivers, headed by J. A. Chittick, of RCA Division of RCA, will have responsibility for developing technical data on the limitation of oscillator radiation by television receivers and a time-table for carrying out the recommendations. A task committee, headed by J. E. Keister, of General Electric Company, will perform the same functions in the transmitter field. A third task committee, headed by D. G. Fink, of the Philco Corporation, will co-ordinate the work of the other two task committees with JTAC, IRE, and the Federal Communications Commission. This task committee also will have responsibility for disseminating full information on the developments to the industry. President A. D. Plamondon, Jr., and general counsel Glen McDaniel both stressed the importance of prompt industry action to reduce spurious-oscillator radiation and urged complete co-operation of the industry in making effective the plan proposed by Dr. Baker. . . . **Two promotions and a staff addition at RTMA headquarters have been announced by executive vice president J. D. Secrest.** P. H. Cousins, who has been information director of RTMA for several years, has been appointed special assistant to Mr. Secrest and staff

(Continued on page 87A)

Industrial Engineering Notes

(Continued from page 86A)

assistant to the technical products division. Tyler Nourse, who served as assistant information director under Mr. Cousins, has been promoted to the position of editorial director in charge of RTMA publications. H. F. Hodge, Jr., of Silver Spring, Md., formerly in government information service joined the RTMA headquarters staff on January 26, as an editorial assistant to Mr. Nourse. The staff reorganization was effected following the resignation of R. M. Haarlander, who has served as staff assistant to the technical products division for the past five years. Mr. Haarlander resigned to take a position in private industry. . . . Attorney General J. P. McGranery on his last day in office, January 19, **announced that he had revoked the grand jury authorization for a sweeping investigation of the electronics industry.** In January of last year the Department of Justice authorized a widespread probe of the industry, and RTMA and 17 or more radio and television set manufacturers were served subpoenas. "Most of the persons to whom subpoenas were directed have complied substantially with them," Mr. McGranery said. The Attorney General, in halting the inquiry, indicated that the removal of whatever restraints may exist in the industry should more properly be the subject of civil litigation than of criminal prosecution.

Mobilization News

The Federal Civil Defense Administration has announced that it is working with government experts and the radio manufacturing industry to develop **a small, low-cost, mass-produced radio which will receive civil defense and other emergency information under air-raid alert or bombing attack if the regular power supply fails.** The proposed radio receiver may be independently powered by batteries, or it may be a crystal set, FCDA said. While the emergency set is being developed, the public can rely for emergency information in case of home power failure, on the 27.5 million auto radios and 10 million portable battery sets now in operation. The agency is encouraging the development of a small, inexpensive portable standard "CD Alert" receiver capable of receiving the CONELRAD programs on 640 or 1240 kc. The CONELRAD Plan (Plan for CONtrol of ELectro-magnetic RADiation) permits AM broadcasting stations to remain on the air in civil defense emergencies. . . . **The radiation instrument industry, virtually nonexistent in 1946, had an annual business volume of approximately $20 million and employed more than 2,400 persons in 1952,** according to a survey conducted by the U. S. Atomic Energy Commission. Growth of the new industry has paralleled development of the nation's atomic energy program since early 1947, when the AEC adopted a policy of encouraging its operating contractors to procure radiation instruments from com-

(Continued on page 98A)

temperatures!
atmospheres!
pressures!

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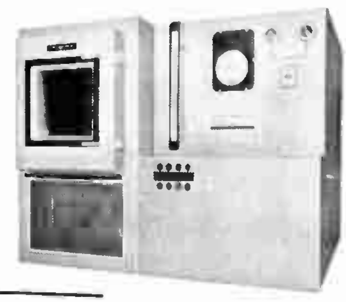

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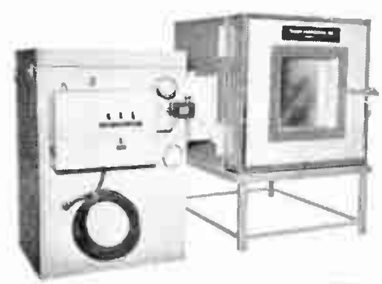

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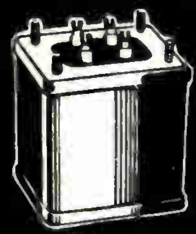

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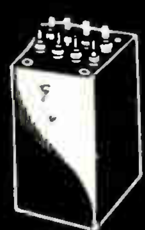

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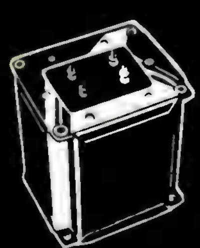

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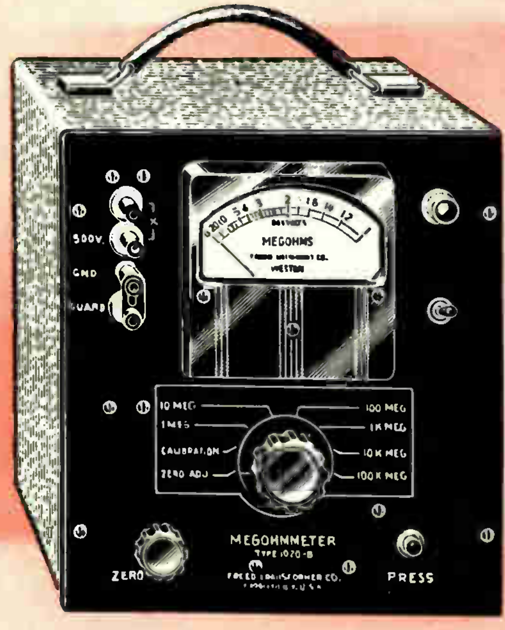

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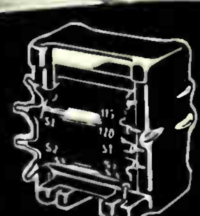

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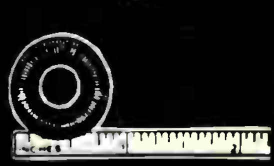

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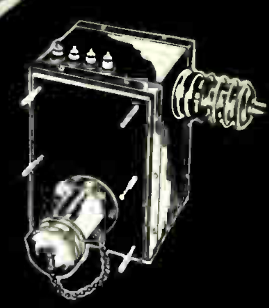

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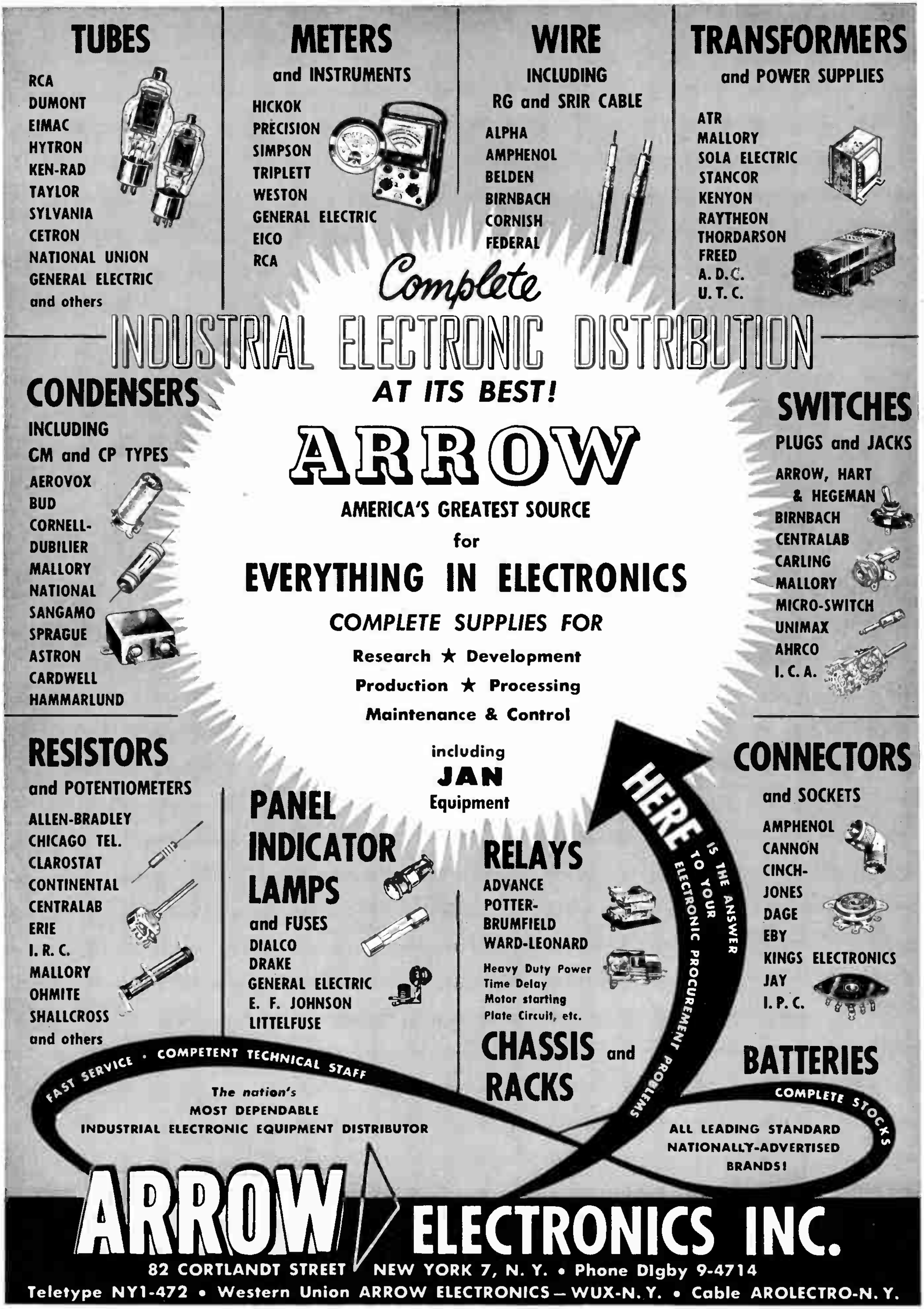

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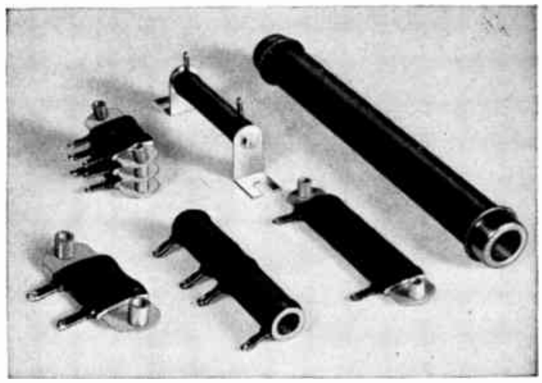

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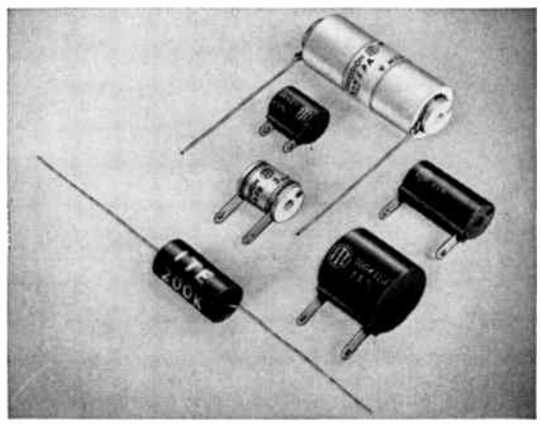

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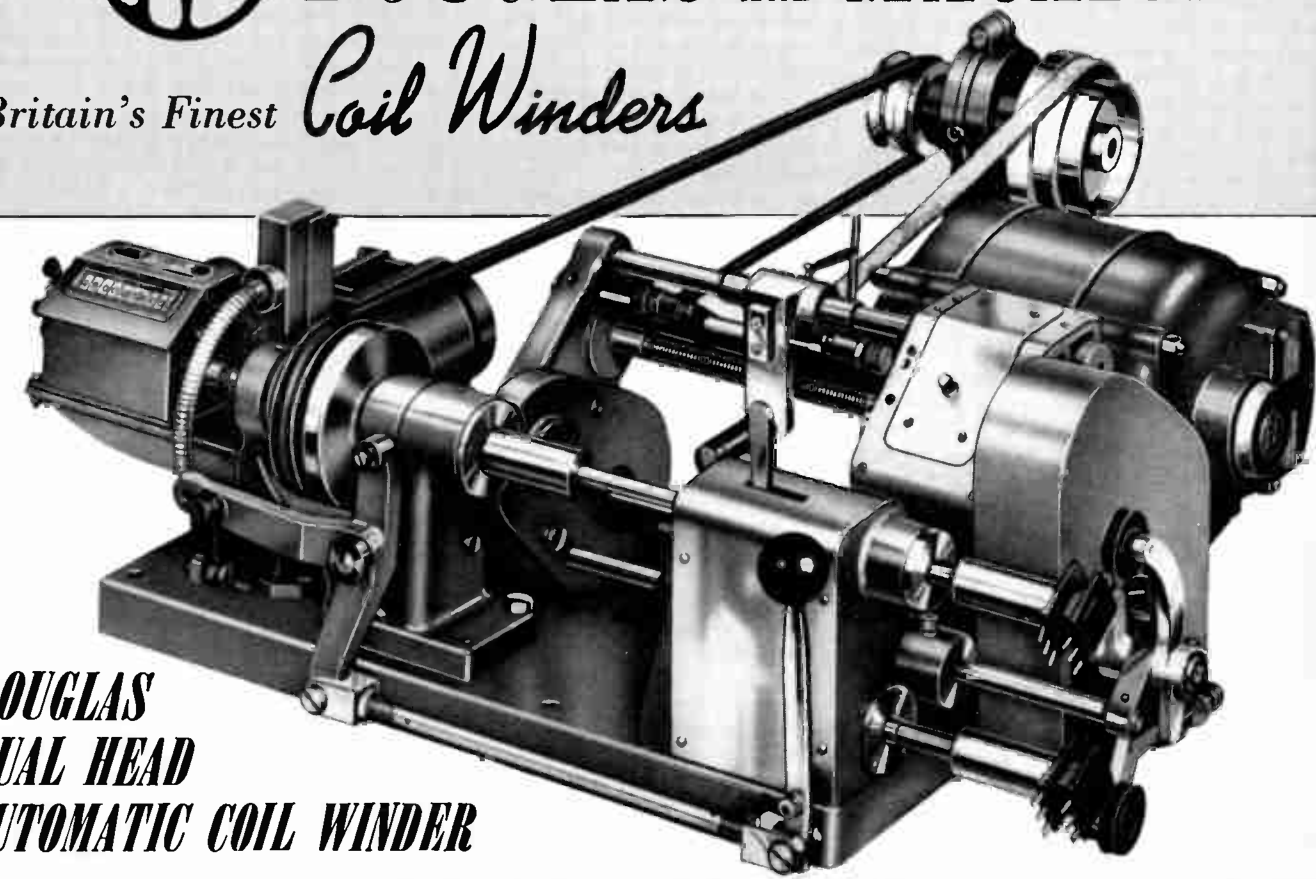

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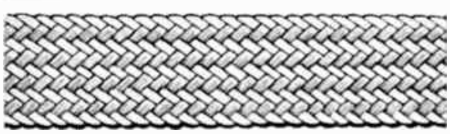

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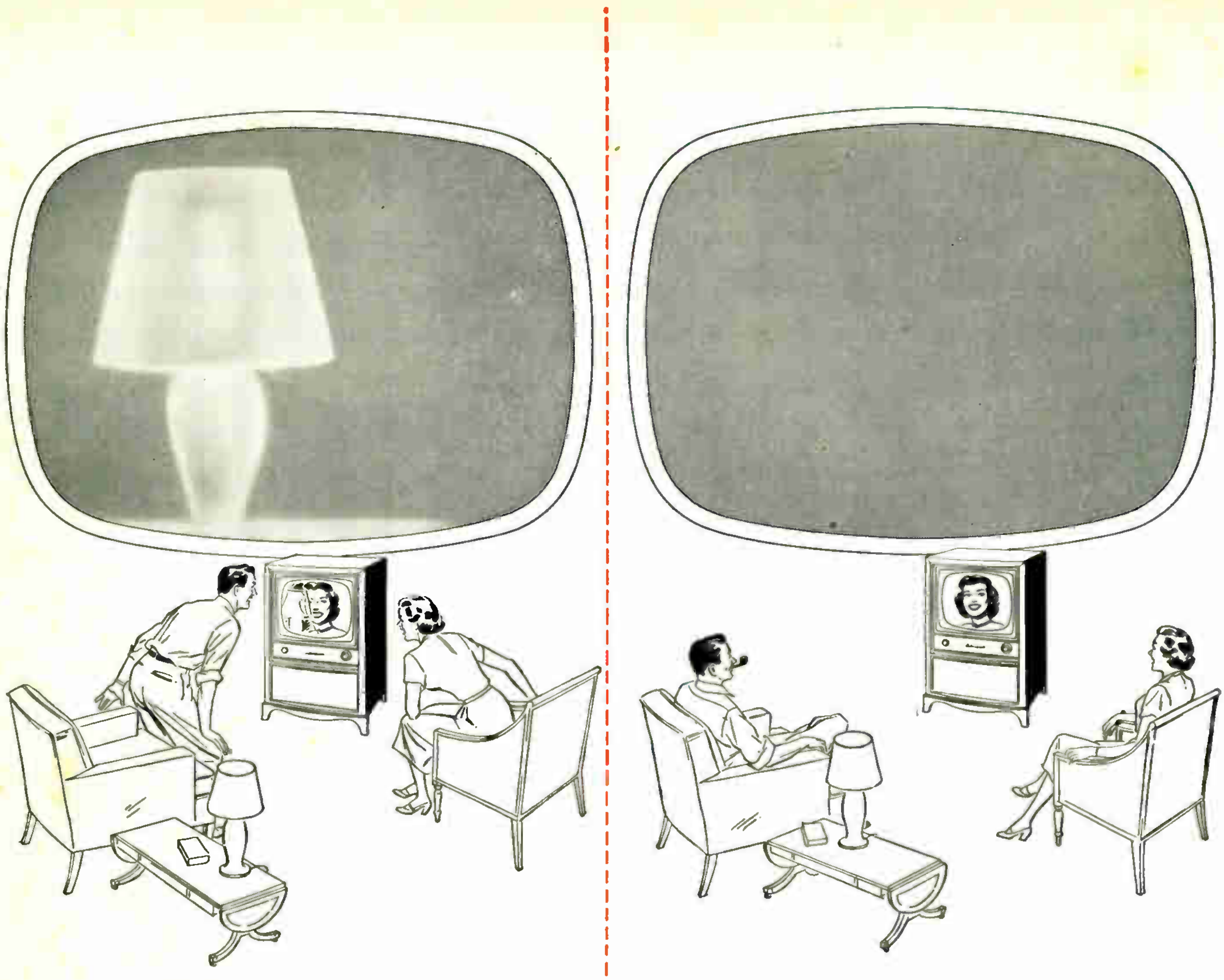

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Conan A. Priest

DIRECTOR, 1953–1954

Conan A. Priest, Regional Director of the East Central Region, was born in Solon, Maine, August 11, 1900. He received the B.S. degree in electrical engineering in 1922 from the University of Maine and was subsequently granted a professional E.E. degree from the university in 1925.

Upon graduation, Mr. Priest spent a year as a General Electric Company student in Schenectady, N. Y., and then joined the Company's transmitter engineering group. A year later he was appointed section leader of high-power transmitters. In this capacity, he served under W. R. G. Baker for the next three years during which a number of the new high-power transmitters were designed and shortwave (100 meters and below) broadcasting obtained its start.

In 1927, Mr. Priest was selected by General Electric and the Radio Corporation of America to make a survey of possible radio equipment sales in Japan, Formosa, Korea, and Manchuria. Upon his return in 1928 to General Electric, he was appointed assistant-in-charge of transmitters, and later in charge of transmitter engineering.

From 1930–1940, Mr. Priest's transmitter group carried out much pioneering in the television field, as well as experimentation with high-power AM broadcasting, single-sideband and carrier-suppressed transmissions.

During World War II, General Electric's transmitter work shifted to radar and airborne communications equipment at the Syracuse plants, which were managed by Mr. Priest. At the end of the war, he was made manager of the transmitter division of the, then, radio, television, and electronics department and later became manager of engineering for the commercial and government equipment division of the electronics department. With the reorganization of General Electric in 1951, he became assistant to the general manager of the commercial and government equipment department electronics division, his present position.

Mr. Priest became an IRE Associate in 1924, Member in 1938, and Senior Member in 1943. In 1947, he was made an IRE Fellow. He has served on a number of IRE technical committees and professional groups, and was instrumental in founding the Syracuse IRE Section, serving as its Chairman in 1947. He has been a member of the IRE Board of Editors since 1941.

Science and the Humanities

Frank A. Polkinghorn

In view of the grave consequences to humanity of the use of certain highly destructive devices produced by scientists, thoughtful engineers have been conscious of the need for more effective control or guidance of the employment of scientific products. Apparently the humanistic, sociologic, and political accomplishments of mankind have not kept pace with scientific achievements. This disparity is alarming.

In the following guest editorial by a member of the Bell Telephone Laboratories, Incorporated, who is as well a Fellow of the IRE, there are presented a thoughtful analysis and a definite proposal aimed ultimately to ameliorate the present dangerous situation.—*The Editor.*

In recent years scientists and engineers have been making new discoveries and developing new devices and processes so rapidly as to cause grave concern over the safety of our civilization. So many of these have been turned into instruments of destruction that it has been suggested scientists take a holiday to allow nonscientists to gain control of the situation.

There is no denying that the progress of science has been at a geometric rate in the past century, nor that scientific developments have posed some very real problems to civilization. Members of the Institute of Radio Engineers, composed of scientists and engineers engaged in a wide range of electronic activities, have had no small part in such developments during the past forty-one years.

When Marconi sent the first radio message across the Atlantic a half century ago, he began a new era in international communications that had vast potentialities for the improvement of international understanding. These communications aided also in reducing the dimensions of the world to the extent that heretofore far-off events cast an immediate shadow over the entire globe. Improved communications also have been used for unconscionable propaganda and have contributed to warfare destructiveness. In the past fifteen years many radio engineers have turned their talents away from communications toward developing radar, the proximity fuse, guided missiles, and other instruments of war.

No doubt many engineers entered the study of engineering because they found the laws of nature more satisfying to deal with than their fellow beings; nature is less capricious, her actions follow laws that appear to be understood, and there is none of the strife of human dealings. Perhaps for this reason the engineer has been content to place the responsibility for the conduct of human affairs upon his nontechnically trained colleague, even to determining uses of his developments.

There has been a long feud between those who advocate the study of the humanities and those who advocate the study of technical subjects. Likely, much of this is the rationalization of one's natural interests and approach. Fundamentally, the humanities are concerned with the experiences of mankind and lessons that history has taught. Surely these concern everyone.

Why is it that those who have studied the humanities are now crying that science should stop and wait for them to catch up? The humanities had been studied for centuries before science began its upward spiral. Is it that human relations are too complex to understand? Can it be that the student of the humanities has been content to stop at generalities and does not pursue details to the point of understanding? Does he fail to determine and relate cause and effect? Can it be that the lack of means for making measurements and the difficulty of stating results numerically is the reason why each generation seems to have to travel the same path as its predecessor? Perhaps what is needed is a more scientific approach to the humanities and perhaps the engineer and scientist can aid in this.

Whatever may be the answers, the fact that a person is trained as a scientist does not relieve him from a responsibility for the conduct of human affairs. This responsibility goes far beyond voting at the general elections and donating to the Community Chest. We should all ask ourselves if we are making our optimum contribution to society.

Multiple Television and Frequency-Modulation Transmitting Antenna Installation on the Empire State Building*

JOHN B. DEARING†, HERMAN E. GIHRING‡, SENIOR MEMBER, IRE, RAYMOND F. GUY§, FELLOW, IRE, AND FRANK G. KEAR¶, FELLOW, IRE

***Summary*—This paper describes the objectives, mechanical and electrical problems and solutions, and final performance of the multiple antenna system for television and FM broadcasting on the Empire State building in New York City. A specially built steel tower supports six individual antennas from which there are transmitted five picture carriers, five sound carriers, and three FM broadcasting carriers with completely satisfactory freedom from the effects of mutual coupling. The paper describes the planning, execution, and results of extensive preliminary field laboratory work during which much basic information on such systems was obtained through the use of full-scale model antennas.**

Part One

The Empire State Building has been linked closely with the development of television since 1931 when the National Broadcasting Company entered into a leasing arrangement to utilize space on and in this building for operational research in TV broadcasting, which would lead later to commercial TV service.

In 1928 NBC and RCA had built and placed in operation at 411 Fifth Avenue a 500-watt transmitter operating in the 2,000-kc region and utilizing mechanical scanning methods. This station was later moved to the Amsterdam Theatre Building. It quickly became apparent that the 2,000-kc region was unsatisfactory for high-quality television transmission and reception and that it would be necessary to utilize much higher frequencies which at that time represented a frontier requiring thorough exploration. It was also apparent that the height of the antenna above the earth would be an important factor in providing service on these frontier frequencies and that a transmitter location should be sought having that advantage. In 1931 NBC installed at the Empire State Building a TV station of about 1,000-watts power in the 40-mc region, incorporating picture and sound channels and utilizing individual sound and picture vertical dipoles. The station began regular operation on December 22, 1931, and the first large-scale demonstration of television there was given on January 11, 1932. The programs consisted of both film and live talent with make-up. Demonstrations and television field tests continued at frequent intervals, in one form or another throughout the following ten years of experimentation and operational research. In August, 1932 television radio relaying was demonstrated via Arneys Mountain, New Jersey, to Philadelphia.

The investigations of radio-wave propagation from the Empire State Building on the frequencies used and proposed, both by specific propagation measurement projects and field tests of transmission and reception, were of great value in establishing the suitability of the very high frequencies for television broadcasting. During the years these investigations were extended to 288, 510, and 910 mc.

The original transmitters and antennas and many others that replaced them were constantly modified as research and experimentation progressed through the years. On April 30, 1941, the FCC adopted commercial television standards and on July first this plant became the world's first commercial television station.

In the early post-World War II period the sharing of a building by two or more television stations presented a problem which had not been investigated. The successful post-war sharing of the Chicago Civic Opera Building by the National and the American Broadcasting Companies was undertaken with the conviction that problems of nearby antenna operation with the 150-foot separation involved there could be met by conventional means if corrective measures became necessary. The satisfactory operation in this case of two television and two frequency-modulation stations coupled with experience gained by adjacent operations on Mount Wilson, California, indicated the probability that in due course additional stations could share the use of the Empire State Building, and in 1949 a project began to take form which contemplated multiple station operation in New York.

Management Problems—The Primary Committee

In planning for multiple broadcasting from the Empire State Building, the need was recognized for a controlling organization which would co-ordinate the project and direct it from the preparation of specifications to the final testing of the completed structure. With this in mind, there was included in the first Lease Agreement to be signed, provision for such an organization. This same provision was included in each subsequent Lease Agreement.

The controlling engineering group thus provided for was composed of two bodies—the Primary Committee

* Decimal classification: R326.6. Original manuscript received by the Institute, April 22, 1952.
† RCA Service Co., Camden 2, N. J.
‡ RCA Victor Division, Radio Corporation of America, Camden 2, N. J.
§ National Broadcasting Co., RCA Building, New York 20, N. Y.
¶ Kear and Kennedy, Consulting Engineers, 1302 18 St., N. W., Washington 6, D. C.

and the Review Committee. The job assigned to the Primary Committee was that of formulating plans for the new structure, which would accommodate multiple television broadcasting, and of conducting any tests which this committee might deem necessary in order to establish satisfactory performance of the system as planned. The Primary Committee was restricted to two members, O. B. Hanson, representing the National Broadcasting Company, as the original licensee, and F. G. Kear, representing Empire State, Inc., and all other licensees. R. F. Guy was designated as an alternate for O. B. Hanson, and R. L. Kennedy as alternate for F. G. Kear.

In the event that the Primary Committee failed to reach an agreement or if the broadcast licensee principals did not agree with the decision of the Primary Committee, an appeal could be made to the Review Committee, which consisted of three independent electronic experts. The decision of this Review Committee was to have been final. However, during the operation of the Primary Committee there never was a time when agreement was not reached or when the broadcast licensees failed to approve the recommendations of the Primary Committee. Consequently, the Review Committee was never called into being.

Performance Specifications

In the design of an antenna system capable of multiple television operation, the number of variable factors increases almost by geometric progression as the number of stations increases. Furthermore, these factors are both mechanical and electrical. In order that some fixed frame of reference might be established upon which the electronic features could be based, the Primary Committee was authorized to consult with Shreve, Lamb, and Harmon, the architects of the Empire State Building; Edwards and Hjorth, the consulting structural engineers; and Starrett Brothers and Eken, general contractors, all of whom had been associated with the building since it was first built. It was determined that the present mooring mast, extending from the 90th floor to the 103rd floor, was so designed that with some reinforcing it could support a tower approximately 200 feet in height. Furthermore, the other dimensions of this proposed new tower were roughly established by the size of the top of the mooring mast and the fact that the tower would be required to taper from a maximum size of approximately 10 feet at the base to the minimum possible at the top.

With this basic information, the next question to be solved was the optimum number of stations that could be accommodated on such a tower. The official directions to the Primary Committee requested accommodations for seven television operations and three FM operations, if this was possible. It was immediately apparent that the number of stations to be accommodated was intimately associated with the amount of gain required in each antenna. If the required gain were low enough, there would be no problem in accommodating all of the stations, even with a much lower structure, because gain is roughly proportional to height for properly designed vertically stacked omnidirectional antennas.[1] Here reference was made to industry, from which it was learned that amplifiers of 25 to 50 kw might be available in the forseeable future, and to the desires of the individual licensees who, on their part, indicated that they desired the ability to radiate a minimum of 100 kw of effective power. This, of course, is much higher than was permitted at the time the specifications were drawn, but was believed to be desirable in order that the final design would not be too restrictive upon the future operations of the licensees. It appears at this time that a maximum erp of 100 kw may eventually be permitted on Channels 2 through 6 and approximately 316-kw erp on Channels 7 through 13. The new structure will accommodate these powers. An effective antenna gain of 5 was sought, but considering the number of stations involved, it was soon apparent that compromises would have to be reached. After several meetings with the then existing licensees, five in number, it was agreed that the optimum solution to this problem was to establish five independent television antenna systems and to so proportion them on the new structure that the effective gain of each installation would be substantially the same.

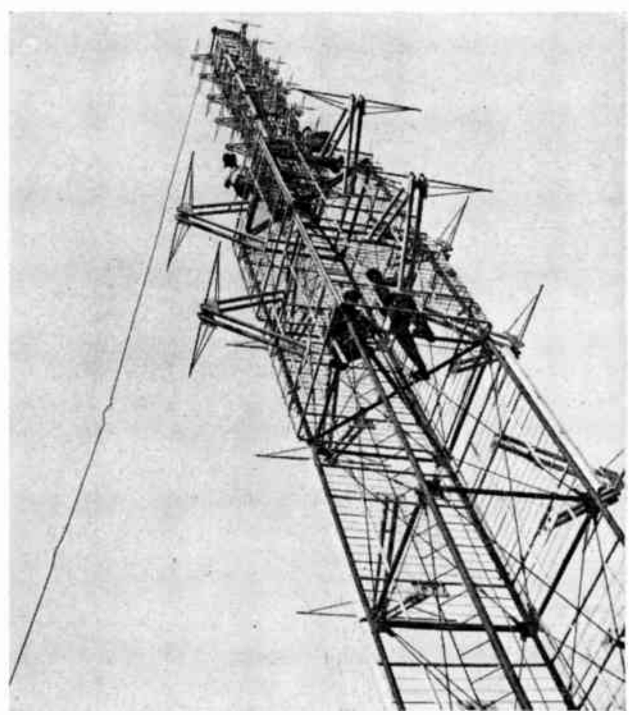

Fig. 1—View of supergain structure showing the channel 5-7 test tower.

Since time was an important consideration, it was desirable to use antennas on which basic development work was not required. The two commercial types of

[1] S. A. Schelkunoff, "Electromagnetic Waves," section 9.15, p. 352.

television antennas available were the superturnstile, utilizing the familiar batwing-shaped radiating elements, and the supergain, utilizing horizontal dipole elements with screen reflectors. The superturnstile antenna is widely used for single-station installations, but is not suited mechanically for stacking several antennas. However, the supergain antenna with its one-half wavelength square construction, shown in Fig. 1, offers suitable structural support for the antennas above, and also offers space within for the transmission lines, feed systems, junction boxes, power equalizers, sleet melting equipment, lighting circuits, and communication lines. The final structure which evolved from these tests and discussions consists of four supergain or ladder-type antennas and one superturnstile. One FM channel is triplexed with the superturnstile operation. The two remaining FM operations are diplexed on a single-layer supergain FM antenna, interleaved with the TV antenna at the lowest portion of the new structure.

Having reached this point, the problem was referred back to the mechanical engineers, who restudied the design from the mechanical standpoint, and finally completed the design of the supporting structure now a part of the Empire State Building. The completed structure is shown in Fig. 2.

Having decided upon this design, it was deemed advisable to have a test installation and measurements made thereon to determine the adequacy of the design from an electronic standpoint. This meant that certain target specifications had to be established. These included the following:

1. Circularity of pattern.
2. Gain.
3. Voltage standing-wave ratio.
4. Decoupling between any pair of antennas.
5. Power-handling capacity.

While items 1, 2, and 5 could be calculated, items 3 and 4 could only be determined by measurement. Following careful investigation, the following objectives were established:

1. Circularity—± 2 db, maximum departure.
2. Directive gain—5 for channels 7 and 11, and 4 for channels 2, 4, and 5 (relative to a thin half-wave dipole).
3. Voltage standing-wave ratio to be 1.1 or better throughout the visual portion of the band and 1.5 or better in the aural portion.
4. Decoupling. This latter was the most difficult figure to establish since by it would be determined the success or failure of the multiple operation. Obviously, the decoupling had to be sufficiently great so that no one transmitter would adversely affect the visual or aural transmissions from another station. At the same time, the figure had to be kept sufficiently low so as to avoid the unnecessary use of additional filter circuits. Measurements indicated that an isolation between transmitters, measured at their output terminals, of the magnitude of 20 db, would be adequate if the transmitters were of equal power. To allow for the possibility of a transmitter power differential of 4 to 1, an additional 6 db was added and the figure established at 26 db.
5. Power-handling capacity was determined primarily by the effective gain of the antenna, keeping in mind each licensee wished antenna to be capable of producing an effective radiated power of 100 kw.

Having reached agreement on the specifications, a contract was drawn up between the Primary Committee and the Radio Corporation of America so that the necessary tests to establish the feasibility of these target specifications could be carried out. The details of the work accomplished under this contract are covered in a following section. Fortunately, the preliminary tests under this contract were favorable enough so that it was possible to decide on tower-construction procedure prior to the final test results.

Interim Operation

Sharing of the Empire State Building for TV operation first took place in 1950 when the American Broadcasting Company joined the National Broadcasting Company there. The ABC TV antenna was erected immediately above the NBC antennas on the NBC supporting pole. Later, temporary expedients became necessary to make way for the new construction so that NBC and ABC operations could be conducted without interruption. A study of various methods of providing temporary antenna facilities led to the adoption of independent antennas by the two companies, the antennas being located on opposite sides of the building and projecting from what had formerly been the top of the building. These antennas consisted of conventional-type RCA superturnstile antenna elements on steel poles which tilted away from each other at 15 degrees from the vertical in each case. Preliminary tests confirmed estimates that this operation could be conducted without cross talk or other serious undesirable effects and with a minimum of interference to their patterns due to the new structure under construction. Operation with these temporary antennas was conducted for nearly a year while the new steel supporting system was under construction and new permanent antennas were being installed.

Mechanical Features

The five independent television antenna systems are stacked one above another in the vertical plane. With the exception of the topmost antenna, which is of the superturnstile type and mounted on a steel pole, all antennas consist of arrays of horizontal dipoles with re-

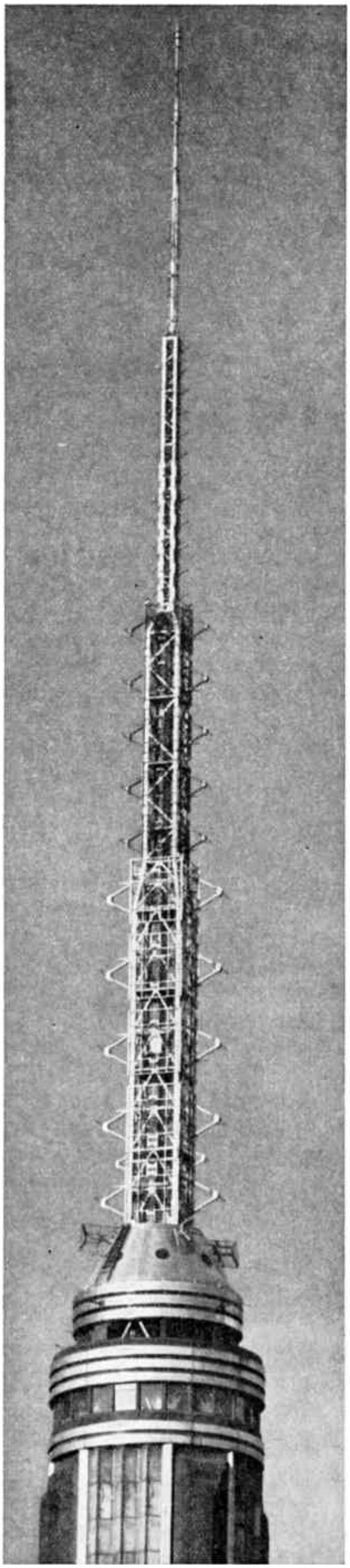

Fig. 2—Photograph of complete structure.

flecting screens mounted on the sides of a square steel supporting tower, as shown in Fig. 2. Fig. 3 depicts a typical dipole and screen. For each antenna system the dimensions of the tower faces conform with the optimum screen width for the frequency being used. Channel 2, requiring the greatest width, is first in upward progression. Channels 5, 7, and 11, requiring respectively narrower tower faces, follow in the upward progression. The channel 4 superturnstile, requiring only a steel pole, is at the uppermost point. By this configuration of the over-all structure it was possible to obtain the ideal mechanical design, in which the width is greatest where the moments are correspondingly greatest, at the bottom, and in which both taper progressively to a minimum at the top.

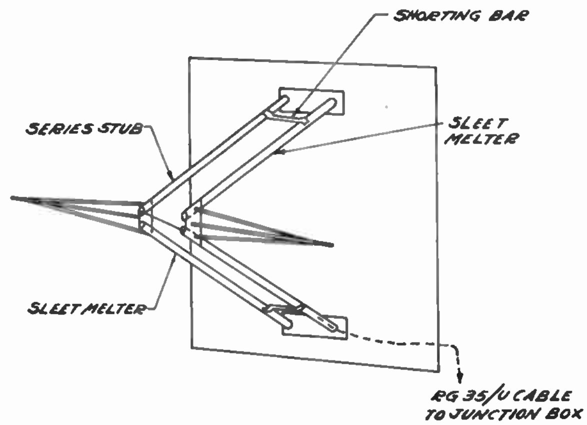

Fig. 3—Sketch of screen and dipoles.

Pertinent statistics of the structure are tabulated below:

	Channel				
	2	5	7	11	4
Face width dimension	9'1"	6'5$\frac{1}{2}$"	2'10"	2'6$\frac{3}{4}$"	batwings
Face height dimension	64'7"	46'3"	25'9"	22'9"	55'8"
Number of vertical groups	5	5	6	6	4
Center to center of dipoles	13'3$\frac{5}{8}$"	9'5$\frac{3}{16}$"	4'5$\frac{1}{4}$"	3'11"	14'

Over-all height of lightning rods above sidewalk, 1467'.
Over-all height of lightning rods above sea level, 1517'.
Height above sea level at base of radio tower, 1300'.
Over-all height of radio structure, top to bottom, 217'.
Wind loading designed for 50 pounds per square foot, including gust factors and shape factors of 1.3.
Velocity pressure designed for 30 pounds per square foot.
Wind velocity designed for 116 mph.
Maximum hurricane velocities recorded in area, 1938, 80 mph, 1950, 84 mph.

Computations by the mechanical engineers indicate that on the basis of statistical probability the center of the uppermost antenna pole will, under wind pressure, deviate from the vertical by the amounts shown at given intervals:

Deviation in degrees	*Frequency of occurrence*
1.5	18 times per year
2.33	12 times per year
3	6.5 times per year
3.5	2.5 times per year
4	once in 14 months
5	once in 18 months
6	once in 6 years
6.5	once in 37 years

Most of the deviation is produced in the pole and not in the steel tower which supports it. Because of the altitude and wind conditions in the New York area, this pole needs to be specially reinforced with a steel liner secured by plug welding.

Part Two

Development of the Antenna System

In the supergain type of antenna, shown in Figs. 1 and 3, the dipole is fed by a single RG-35/U cable (Fig. 3) which passes through one of the supporting legs. The outer conductor is connected to one side of the dipole and the inner conductor to the other side. The flare of the dipole is incorporated to obtain added bandwidth. While the flare for broad-band dipoles in free space is in the opposite direction, experiments have demonstrated that this is not true when a reflecting screen is used. The distance between the dipole and the reflecting screens is about 0.3 wavelengths for satisfactory bandwidth requirements. The reactance component of the antenna is balanced out by means of a series stub consisting of a short piece of solid dielectric cable which is placed in one of the other legs. The triangular supporting structure is electrically isolated from the dipole by means of a shorting bar placed approximately one-quarter wavelength from the dipole. The two other supporting legs have heating units mounted in them for de-icing. This deices the spaces between the dipoles where ice would have the maximum effect on impedance.

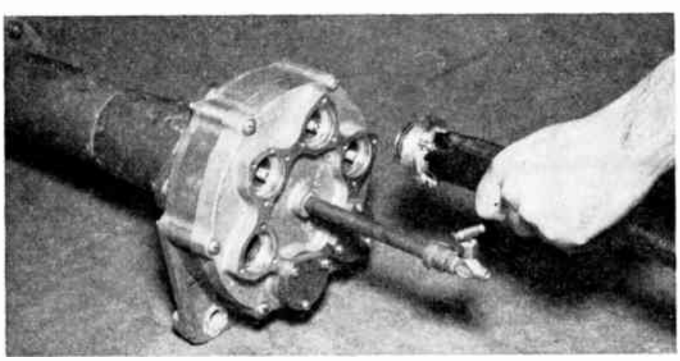

Fig. 4—One of the junction boxes and feed lines developed for the Empire State antenna.

Each dipole is fed by means of a cable which terminates in a common junction box (Fig. 4). The common impedance at the junction is $1/n$ of the dipole impedance if n is the number of dipoles. Immediately below the junction box, a two-stage transformer is used to match the common junction box impedance to the main transmission-line impedance of $51\frac{1}{2}$ ohms.

Because the number of elements used in the Empire State television antennas were less than those used in previous designs, and also because the feed cables used were larger because of power-handling requirements, it was necessary to develop special junction boxes. The problem of disconnecting the cables easily from the junction box, maintaining gas pressure and still maintaining excellent impedance characteristics, was a major development. Fig. 4 indicates the type of connection used.

A more detailed description of the supergain antenna has been given in a previous paper.[2]

Coupling

Possible coupling resulting in cross talk or other disturbances was one of the major considerations in the design of the antennas. Little previous experience was available, except the fact that some 80 superturnstile antenna installations had worked successfully without any trace of cross talk where the isolation between the visual and aural transmitters was of the order of 20 db. This was true of transmitters with both triode and tetrode tubes in the output circuit. In setting the 26-db specification, only coupling between antennas was considered since radiation from an antenna to another transmitter or interference between transmitters is a function of shielding and cannot be minimized by antenna design. Similarly, harmonics were not considered since these are generated in the transmitter and could be controlled at that point.

To check the impedance of each antenna and the coupling between them, it seemed desirable, at first, to duplicate the entire 217-foot structure at the test location. Because this was not feasible for a number of reasons, i.e., the difficulty of working on the structure and making tests, and so on, the next best procedure was adopted in which adjacent pairs of antennas were tested on four towers (Figs. 1 and 5). The highest tower using this method is of the order of 100 feet for the channel 2 and 5 combination.

However, such coupling tests could not be completed until the antennas were available and adjusted for impedance. Since the tower design for the Empire State Building had to proceed immediately, some assurance was necessary in advance of the final tests that the target specifications for coupling could be met. This was obtained by two approaches, namely, by calculation and by tests with single screens.

The method of calculation was arrived at by Masters.[3] The formula for coupling between antennas is as follows:

$$\frac{P_r}{P_t} \leqq \left(\frac{\lambda}{4\pi R}\right)^2 \frac{G_t G_r}{n_t n_r},$$

where equality under the assumptions obtains for $n_r = n_t = 1$.

[2] L. J. Wolf, "High gain and directional antennas for TV broadcasting," *Broadcast News*, vol. 58; March and April, 1950.

[3] With Ohio State University Research Foundation, engaged by RCA as consultant for this project.

P_t is the power applied to the transmitting antenna.
P_r is the power received by the receiving antenna.
R is the distance between the antennas.
G_r, G_t are the directive gains of the adjacent end bays of the neighboring antennas in each other's directions relative to an isotrope.
n_t is the number of bays of the transmitting antenna.
n_r is the number of bays of the receiving antenna.

A number of assumptions were necessary to arrive at this formula.

1. The field magnitude varies in proportion to inverse distance.
2. The major contribution to coupling comes from the two adjacent end bays.
3. The radiators are matched to the branch feed cables.
4. No coupling exists between the *N-S* and *E-W* elements of the antennas.

The coupling between the closest pair of half bays at the longer of the two wavelengths, namely, channels 5 and 7 at the channel 5 carrier under the above assumptions, was -17 db. However, since the power is not all concentrated in the adjacent bays but is fed equally to all bays, another 10 db can be easily obtained. Hence, from this viewpoint, the necessary decoupling could be achieved.

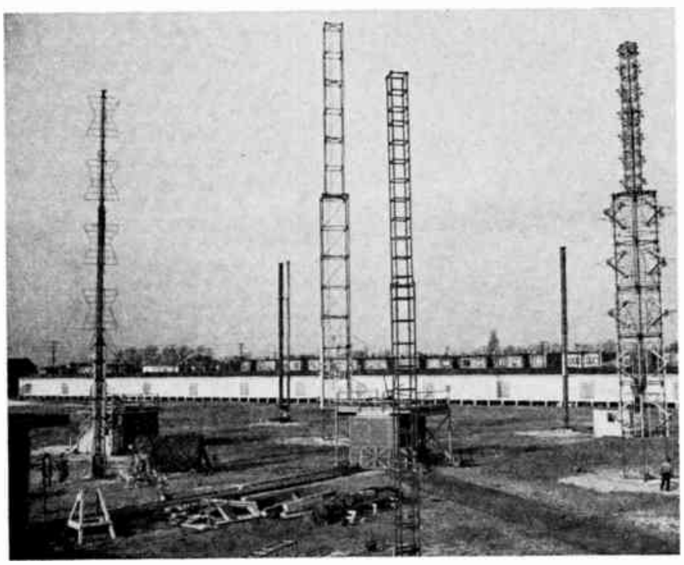

Fig. 5—General view of test towers used for Empire State antennas. Each tower accommodates two adjacent antennas.

As an additional check, combinations of single screens were tested with various separations. This experiment was performed in the same manner as the subsequent measurements on the complete antenna for which the following procedure was used:

An antenna was driven at a known level at its own frequency and the received power level in the adjacent antenna was measured. The mismatch in the antenna occupying the receiving position was often quite high because the frequency of the incoming signal was outside the design range of the antenna. By properly accounting for the additional power scattered by the receiving antenna as a result of an impedance mismatch

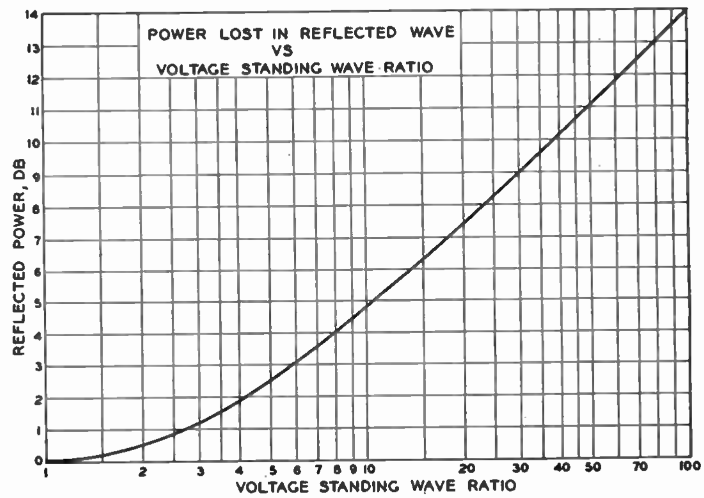

Fig. 6—Correction chart used in coupling tests.

between it and its transmission line, it was found that the measured cross-talk values could be adjusted to substantial equality for both directions of transmission. The adjustment amounted to the same thing as experimentally matching the receiving antenna to its line before measuring the cross talk. Fig. 6 gives the required correction as a function of voltage standing-wave ratio which the receiving antenna would set up on its line if used as a transmitter. The tests between single co-channel radiators spaced 0.65 wavelength apart indicated an isolation of about 18 db and greater values for dissimilar elements up to 40 db for channels 5 and 7 screens placed in close proximity.

Since agreement was obtained between calculated and measured results on single screens and since it appeared that an additional margin could be obtained when the power was divided into a complete antenna rather than into two adjacent bays, the tower design proceeded on the basis of the close spacing used in our experiments in order to obtain the maximum gain possible.

In the meantime, the antennas for channels 11, 7, 5, 4, and 2 were fabricated and placed on the towers and adjusted for impedance. Coupling tests were then made by the method outlined above. Typical results are shown in Tables I and II, shown on following page. In all cases, the specification of -26 db is well exceeded.

Gain

Gain was initially calculated by assuming a thin dipole, one-half wavelength long 0.3 wavelengths in front of an infinite screen. This resulted in an element pattern. The array factor for the number and spacing of elements decided upon was then determined and multiplied by the element pattern. The resulting pattern was then integrated over a sphere to obtain the gain of the configuration.

TABLE I

TYPICAL DECOUPLING DATA FOR CHANNELS 5 TO 7. FIELD ROTATION OF BOTH ANTENNAS IN SAME DIRECTION (NORMAL CONDITION)*

In	Channel 5 upper group	Channel 5 upper group	Channel 7 visual	Channel 7 aural
Out	Channel 7 visual	Channel 7 aural	Channel 5 upper group	Channel 5 upper group
Frequency				
77.25 mc	65.8 db	55.7 db		
79.0	54.1	50.7		
81.75	46.5	46.2		
175.25			51.2 db	51.2 db
177.0			52.6	52.6
179.75			51.3	50.2

* Data adjusted for mismatch loss. Quarter-wave phasing section in *E-W* halves.

This calculation makes a number of assumptions which gave a slightly optimistic result. Safety factors were allowed for these assumptions and the final measured gain checked quite closely. Subsequently, more precise methods were developed for the calculation of gain, especially for antennas using quadrature feed systems. These will be covered in future papers.

On the basis of the above calculations, it was determined that a directive gain with respect to a thin half-wave dipole of 4 could be achieved for channels 2, 4, and 5 and a gain of 5 for channels 7 and 11, respectively. These are the values specified as target gains.

The experimental determination of gain was made by measuring the principal plane pattern of the channel 7 antenna as shown on Fig. 7.

In this commonly accepted method, the antenna is mounted on its side and the dipoles radiating parallel to the ground are energized. For operating convenience, the antenna is used as a receiving antenna which will give correct results in accordance with the reciprocity theorem. The vertical pattern is obtained by rotating the antenna and recording the received signal. A great number of precautions were taken to assure correct results. Among these were the elimination of reflecting objects. The presence of reflections is evidenced by dissymmetry between the opposite sides of a received pattern. In a nearby building, electrical conduit had to be moved to the floor level and space cloth placed over other metallic objects. Brush and debris also had to be cleared. The distance from the transmitting to the receiving point was 2,400 feet, which is more than ade-

TABLE II

TYPICAL DECOUPLING DATA FOR CHANNELS 7–11. IN THE UPPER TABLE, FIELDS ARE ROTATING IN THE SAME DIRECTION FOR BOTH ANTENNAS. IN THE LOWER TABLE, FIELDS ARE IN OPPOSITE DIRECTION*

In	Chan 7 visual	Chan 7 visual	Chan 7 aural	Chan 7 aural	Chan 11 visual	Chan 11 visual	Chan 11 aural	Chan 11 aural
Out	Chan 11 visual	Chan 11 aural	Chan 11 visual	Chan 11 aural	Chan 7 visual	Chan 7 aural	Chan 7 visual	Chan 7 aural
Frequency 175.25 mc	48.9 db	36.9 db	36.9 db	48.9 db				
177.0	55.1	36.6	36.6	48.3				
179.75	59.3	36.8	35.5	51.9				
199.25					42.8 db	31.8 db	32.6 db	48.8 db
201.0					45.0	30.9	31.3	44.5
203.75					41.7	30.7	30.4	59.0

In	Chan 7 visual	Chan 7 visual	Chan 7 aural	Chan 7 aural	Chan 11 visual	Chan 11 visual	Chan 11 aural	Chan 11 aural
Out	Chan 11 visual	Chan 11 aural	Chan 11 visual	Chan 11 aural	Chan 7 visual	Chan 7 aural	Chan 7 visual	Chan 7 aural
Frequency 175.25 mc	36.9 db	52.4 db	40.2 db	36.4 db				
177.0	37.1	58.1	40.1	36.6				
179.75	36.3	51.3	41.1	35.3				
199.25					32.0 db	50.6 db	54.8 db	31.3 db
201.0					31.1	49.5	48.0	30.9
203.75					30.3	52.8	42.4	30.8

* Data adjusted for mismatch loss looking into the individual halves of antenna. Quarter-wave phasing section in *E-W* half of Channel VII and *N-S* of Channel XI antennas.

quate for the apertures involved. Both transmitting and receiving points were sufficiently above ground so that a uniform vertical field existed over the aperture of the antenna. The data obtained from the vertical pattern

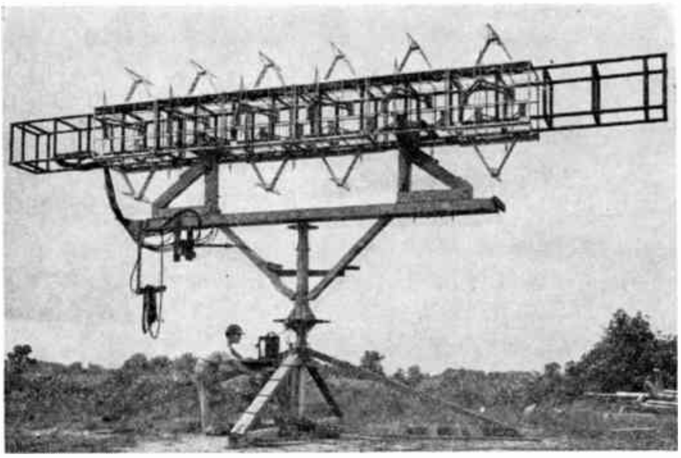

Fig. 7—Method of determining the vertical pattern.

measurements were then scaled to other channels. The exact procedure for determining gain is as follows:

1. Record the field pattern of the horizontally polarized field component in the principal vertical plane.
2. Square this pattern to obtain a power distribution and plot it against the cosine of the vertical angle, θ, (measured from the array axis) on rectangular co-ordinate paper.
3. By means of a planimeter, or other methods, find the area under the plotted power pattern and under the circumscribing rectangle which shares the same base line as the pattern plot.
4. The directive gain in the maximum direction relative to an isotropic radiator is the ratio of the rectangular area to the area under the pattern plot.
5. The gain thus found is divided by 1.641, which adjusts it to gain relative to a one-half wavelength thin dipole.

Gain measurements for a great number of conditions were necessary; for instance, the tower offset between channels 5 and 7 had to be simulated to determine its effect. The same was true of the tapered dome of the Empire State Building with respect to the channel 2 antenna. As pointed out later, the channel 2 and 5 antennas were split into two separate antennas of two and three bays each for the purpose of providing emergency antenna service. The gain for each of these conditions as well as the combined antenna had to be determined. During the investigation, the channel 7 antenna was rephased, at the request of the station, reducing the horizontal gain to obtain a higher field close to the antenna. Later, it was determined that the best method of providing FM service was to locate FM dipoles between the channel 2 dipoles. The effect of these dipoles on this antenna was also determined. While some of these changes resulted in a second-order effect, nevertheless, the problems merited investigation to insure no serious changes developing at a later date.

Table III gives the results of gain measurements for various conditions. The directive gain, as well as the net gain, is given. The net value takes into account losses in the RG-35/U feed cable between the junction box and the radiator and also in the power equalizer. The power equalizer and its function are more fully discussed in the next paragraph. The diplexer and the coaxial line ef-

TABLE III

Results of Gain Measurements for Various Conditions

	Television							
Channel	11		7		7		5	
			Equally phased		Rephased			
	Visual	Aural	Visual	Aural	Visual	Aural	Visual	Aural
Antenna directivity gain	5.40	5.55	5.59	5.74	3.94	4.04	4.17	4.50
Upper portion	—	—	—	—	—	—	1.45	1.57
Lower portion	—	—	—	—	—	—	2.52	2.72
Feed cable eff %	95.0	95.0	94.4	94.4	94.4	94.4	95.4	95.2
Power equalizer eff %	—	—	—	—	—	—	98.9	98.1
Net gain	5.12	5.28	5.28	5.42	3.72	3.80	3.93	4.21
	Television					FM		
Channel	4		4	2		97.1 mc	95.5 mc	101.1 mc
	Equally phased		Rephased					
	Visual	Aural	Visual	Visual	Aural			
Antenna directivity gain	4.48	4.79	3.95	4.00	4.43	6.24	0.707	0.707
Upper portion	—	—	—	2.49	2.75	—	—	—
Lower portion	—	—	—	1.61	1.78	—	—	—
Feed cable eff %	97.2	96.7	97.2	95.1	94.8	96.0	94.8	94.8
Power equalizer eff %	—	—	—	97.2	96.9	—	—	—
Net gain	4.36	4.63	3.85	3.71	4.06	6.00	0.67	0.67

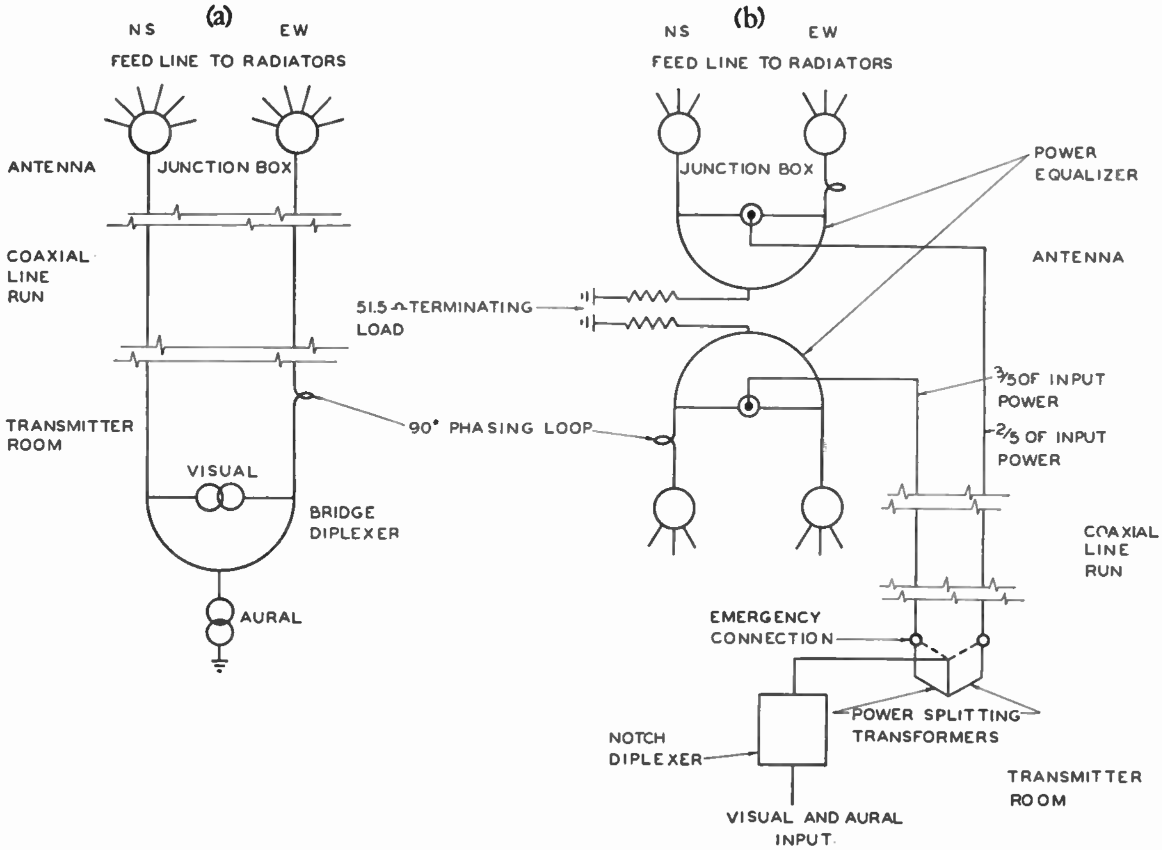

Fig. 8—Schematic portrayal of antenna system showing inner conductors only. (a) Bridge diplexer feed system chosen by stations on channels 4, 7, and 11. (b) Notch diplexer feed system with split antenna arrangement for emergency service chosen by stations on channels 2 and 5.

ficiencies are not charged to the net antenna gain. For most commercial antennas, the net gain is specified. For the Empire State antenna system, however, the directive gain was specified. It will be seen that the target values of directive gain were achieved in the apertures that were available.

Bandwidth

While previous experience with the supergain antenna indicated that the required bandwidth could be achieved, the problem was interrelated with effects due to the close proximity of the antennas, the necessity for different spacings between radiators to achieve the required gain, special junction boxes to handle the power, and a new type of feed cable. Since it was necessary to erect adjacent pairs of antennas on towers to determine the amount of coupling, as discussed earlier, the opportunity presented itself to make a thorough check of bandwidth under all of the special operating conditions required.

Since several possibilities presented themselves, the five stations were given a choice of feed systems. Stations on channels 4, 7, and 11 chose the bridge diplexing arrangement shown in Fig. 8(a), while stations on channels 2 and 5 chose the notch diplexing arrangement with the bridge power equalizer shown in Fig. 8(b). An additional variation offered was chosen by channels 2 and 5 in which the upper and lower portions of the antenna were treated as two separate antennas with separate feed systems, power equalizers, and coaxial lines. This permitted emergency operation with one portion of the antenna operating independently of the other.

VSWR

As a result of experience with many television installations, it was known that the voltage standing-wave ratio (vswr) over the visual band had to remain within the limits of 1.1 to 1 to obtain satisfactory operation. This value was indicated as one of the target specifications.

Inasmuch as the channel 4 superturnstile antenna and the channels 7 and 11 supergain antennas had broadband characteristics sufficient to achieve the necessary vswr over the band, the standard bridge diplexing method was used. The operation of the bridge diplexer is well known, having been described in a previous article.[2] For channels 2 and 5, power equalizing is desirable to achieve the required bandwidth since at the lower frequencies the percentage of bandwidth with respect to the transmitted frequency is greater. The power equalizer inherently improves the vswr over the band by trapping reflected energy from the antenna. Fig. 9 indicates an impedance chart plot of a portion of the channel 5 antenna before and after power equalizing. The

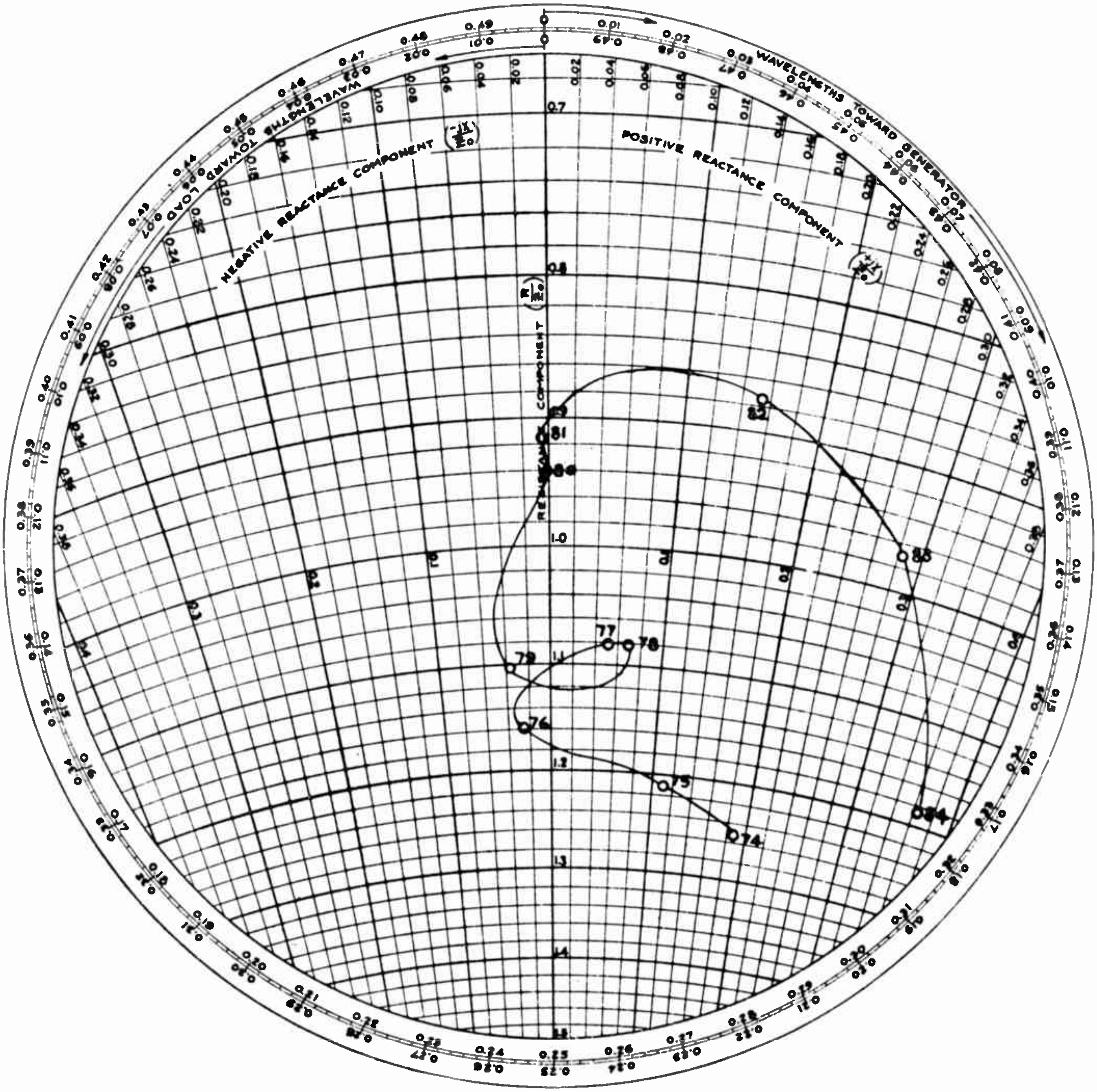

Fig. 9 (a)—Smith chart for channel 5 antenna before power equalizing.

improvement is quite obvious. A more detailed description of this device is given in a previous article.[4] The amount of energy absorbed for a reasonable vswr is negligible. For instance, if the vswr is 1.22, the reflection coefficient is 10 per cent, and only 1 per cent of the power is dissipated.

In the split-antenna arrangement, two coaxial lines are brought into the transmitter room where they are combined by a power-splitting transformer which, by transformation, splits the power from the transmitter to each portion of the antenna as required. The visual and aural signals are combined in a notch diplexer which is a frequency selective network permitting simultaneous operation, without interference, of visual and aural transmission into one antenna system.

The vswr over the band was measured for a number of conditions, including the *N-S* and *E-W* portions of each antenna before diplexing or power equalizing, and also the upper and lower portions of each antenna individually and combined by the power split transformer.

[4] R. W. Masters, "A power equalizing network for antennas," Proc. I.R.E., vol. 37, p. 735; July, 1949.

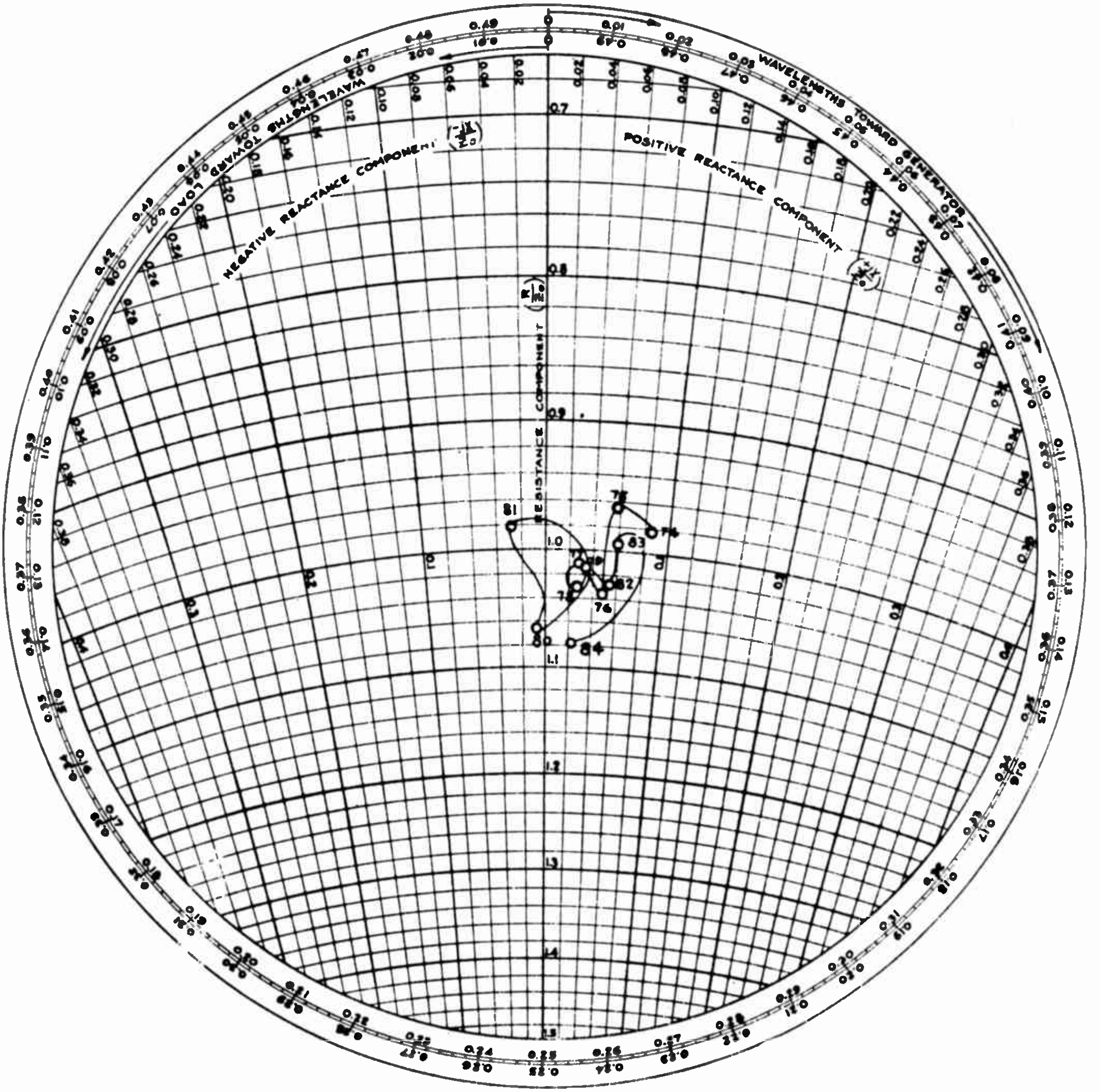

Fig. 9(b)—Smith chart for channel 5 antenna, indicating improvement after power equalizing.

A typical chart of vswr versus frequency for various conditions for channel 2 is shown in Fig. 10.

Power Handling

One of the requirements for the Empire State antenna was the ability to obtain an effective radiated power of 100 kw from the antenna. (This decision was made and the antenna substantially built before the later higher power proposals were made by the FCC.) Since there were relatively few elements (sixteen or twenty on the low band and twenty-four on the high band) and since the gain was proportionately low, each feed cable had to handle a relatively large power. Investigation revealed that RG-35/U cable was satisfactory for the purpose. Table IV indicates a typical calculation which establishes deratings for vswr and temperature above ambient for which the cable rating is made.

FM Considerations

Three frequency-modulation sound broadcasting services were desired, plus the five television services. Of these, the one for NBC, on 97.1 mc was triplexed on the channel 4 antenna by methods previously described.[5]

[5] L. J. Wolf, "Triplex antennas for television and FM," *Electronics*, vol. 20, p. 88; July, 1947.

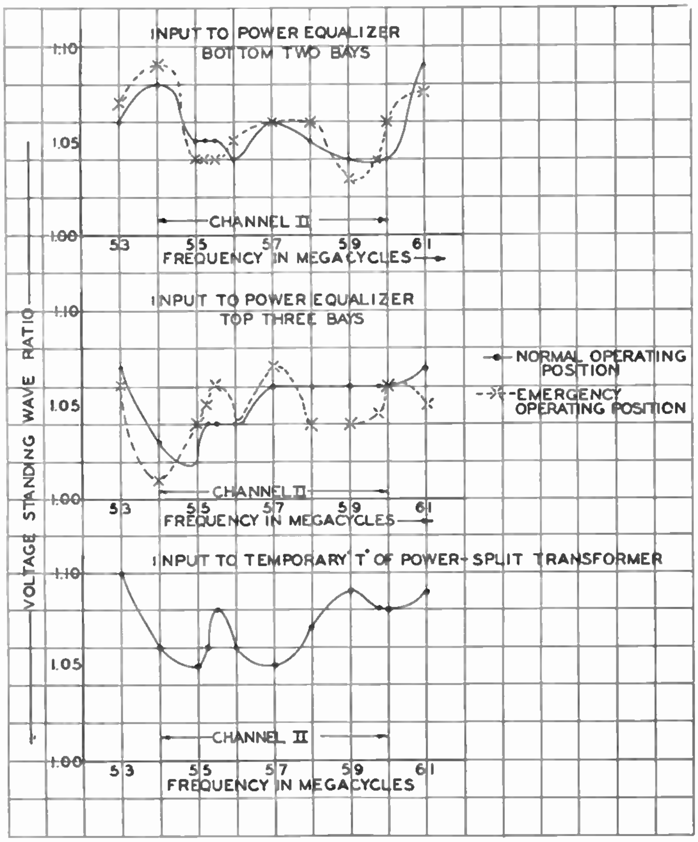

Fig. 10—Voltage standing-wave ratio curves versus frequency for channel 2.

Two other services for 95.5 mc and 101.1 mc were required. A number of experiments were made to find a location where the FM dipoles, which are similar to the supergain dipoles, could be located with negligible effect on the impedance and pattern characteristics of the television antenna. These experiments indicated that the best location was in the channel 2 array. The method employed is shown in Fig. 11. Both FM frequencies were diplexed into the single set of four radiators. A vswr of 1.03 was achieved for both frequencies, using a transformer designed for specific matching at the two carrier frequencies.

TABLE IV

Typical Calculations Establishing Power Rating of Feed Cable

Feed cable max vswr	1.20
Feed cable vswr derating factor	0.950
Feed cable temperature derating factor	0.788
Feed cable total derating factor	0.749
Feed cable power capacity before derating	1400 watts
Feed cable power rating after derating	1049 watts
Feed cable average power, visual for 100-kw erp	479 watts
Feed cable average power, aural, for 100-kw erp	396 watts
Power Carried / Rated power of feed cable for 100-kw erp	0.835
* Average power output of transmitter for 100-kw erp	24.8 kw
† Maximum erp possible within limit of feed cables	120 kw

* Assumes that diplexer handles 25 kw.
† Assumes that diplexer handles 30 kw.

Gain was measured by using a set of channel 7 screens to simulate the channel 2 antenna. The FM dipoles were then scaled to 320 mc. The gain, determined by the method previously described, taking into account the fact that the circularity was not optimum, for the FM frequency on the channel 2 tower was 0.707 over a half-wave dipole.

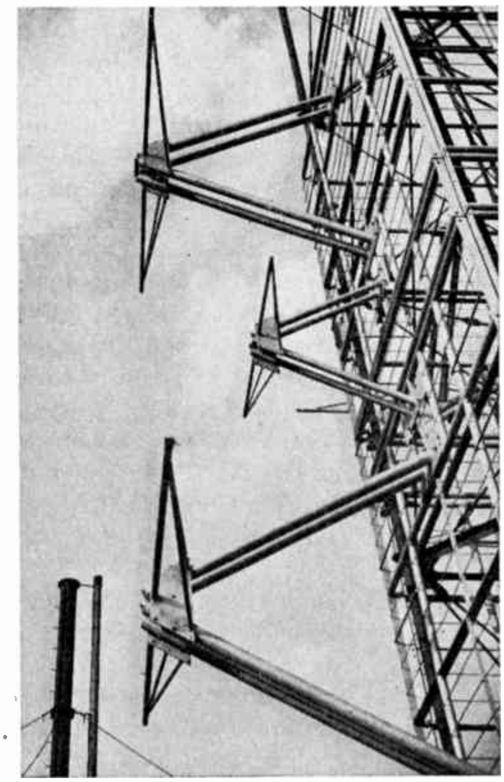

Fig. 11—FM dipole located in the channel 2 array.

Part Three

Installation and Operational Tests

In writing the installation specifications for the electrical contractor, emphasis was placed on obtaining a system which duplicated the engineering assembly which had been made at the field laboratory and provided, in addition, as much convenience and service ability as the structural limitations of space and wind loading would allow. The simultaneous outputs of 13 transmitters (3 FM, 5 TV picture and 5 TV sound) were provided for, and including emergency provisions, 8 separate antenna systems were installed.

Over 1,100 stainless-steel studs were required to insure adequate electrical and mechanical bonding of the screens to the corner members of the tower. A storage-battery-powered Nelson Stud gun was used to weld these studs in place and each one was tested and adjusted with a torque wrench.

Aside from the RF systems for the thirteen transmitters involved, provision had to be made for other essential services.

A system for sleet melting or de-icing the radiating elements was specified and installed. Calrod-type heaters located in the hollow legs of the dipole supports take a total of 75 kw when energized. Automatic control is provided for this system by a humidistat-thermostat adjusted to apply power when sleeting conditions exist, i.e., approximately 24 to 34° F and above 75-per cent humidity.

Provision was made for communication from each transmitter room to the tower base and to each station's antenna area as well as intercommunication between each transmitter room.

A safety-signal system was installed to provide a series of red and green lights at the antenna base and in the individual transmitter rooms to indicate when antennas are energized or whether or not work is being done on them.

Each station has a system of four polyethylene probe monitoring or measuring cables running from the transmitter room to the center of the respective antenna, with provision for patching into the system at their base of the tower. Many thousands of feet of standard solid dielectric coaxial cable were measured in an effort to find suitably flat lengths for this use. Present manufacturing tolerances are such that it is very difficult to find small cables in useful lengths with 1.1 or better swr in the range 50–200 mc.

In addition to the usual beacon and obstruction lighting, service receptacles and work lights were provided within each of the antenna arrays.

In order that the tower would not have to be climbed to purge the pressured co-ax systems and check them for dryness, return bleeder pipes were run from the top of each half of each antenna to the 104th floor where gauges and bleeder valves were provided.

Location of leaks in the breezy tower area was a difficult operation. Chemical and electronic halide detectors were used with some success with Freon gas as the sensitizer. The use of radioactive gas and Geiger counters was considered but abandoned because of the possible tendency to induce ionization when RF was applied. In the long run, old-fashioned soap suds were best, except that detergent and alcohol had to be used when the temperature was below freezing.

A centrally located video patch panel and distribution system was installed to provide for interchange of video information between stations. This is intended for trouble-shooting possible interference between stations or for emergency interchange of program material.

Like any tall structure, the building acts as a huge lightning rod. During dry weather there is an almost continuously audible discharge from the steel work apparent near the top. At times these effects were observed by workmen as a wavy ethereal blue glow coming from sharp points of steel and could be felt as a hair-raising, prickling sensation on the nose and ears. The lightning rod assembly is already pitted and fused at a hundred or more spots where lightning bolts have landed.

Although the system mockup and measurements made at Camden simulated as nearly as possible the conditions of the final installation, it was essential that the field installation be supervised carefully to insure the duplication of all factors and, furthermore, that measurements of the completed system be made to determine that target specifications had been met.

The isolation figures established at the field laboratory were measured looking directly into the antennas and using low-power signal generators. Although these measurements showed a good margin of safety, there could be no absolute certainty that objectionable forms of interference would not arise at the Empire State Building when all 13 transmitters were feeding full-modulated power to the completely assembled antenna systems through the relatively long transmission lines.

During the installation period as each system was completed preliminary isolation measurements and observations were made with a view to immediate correction or settlement of interference problems serious enough to cause operational difficulties.

When all the systems were finally completed, the laborious process of measuring some 400 combinations of carriers and antennas was carried out.

Five set-ups were made in which each station in turn was operated as a receiving point, with measurements made at the terminated end of all combinations of that station's antenna lines. The four transmitting stations then operated in turn their various combinations of transmitters and antennas at known average carrier powers with and without modulation.

As specified, all of the receiving station's lines were terminated while measurements were made on any one line.

Measurement of the received or interfering signal was made with a calibrated wattmeter load, 0–1 watts range, or when not measurable with the wattmeter, a calibrated diode and voltmeter were used.

As a further check of possible interference from sideband or heterodyne frequency combinations, careful observation for interference effects were made on the various station monitors and at various receiving points with various combinations of carriers and methods of modulation.

No evidence of cross modulation, beat-note, or other interference phenomena was observed. The isolation measured fell in no instance below the target specifications of -26 db, the poorest figure recorded being -40 db.

Recognizing that there could exist unpredictable "discrete" or sharply resonant conditions for interference in the broad TV pass bands and that these might be overlooked with observations made only at carrier and average modulation, an all-band high-power panoramic RF sweep was built to serve as a signal generator with enough power to override local noise and permit broad-band isolation measurements on the order of 40 db and greater.

Seventy-five to 100-watts output in the low bands and 50 to 75 watts in the high bands were obtained from this sweep which used two 826 tubes, a motor-driven capacitor, and 60-cycle blanking. The more closely coupled antennas were energized alternately and the isolation across their swept pass band was recorded from an oscilloscope trace produced by a diode pickup at the terminated input of the antenna to which the isolation was being measured. By reference to previously measured static isolation, a point of calibration was established on dynamic trace at carrier frequency.

Although the panoramic measurements demonstrated that the coupling between antennas made many gyrations, in no instance did it fall below the −26-db limit.

Over 5,000 feet of RF transmission line were required to couple the various transmitters, located on the 81st and 85th floors of the building, to their respective antenna systems mounted on the 220-foot tower which runs from the 105th floor up. In order to preclude the radiation of "built-in ghosts" due to reflections within the radiating systems, these lines were specified to have a vswr of 1.05 or better and the complete systems (lines and antennas) were to be held to 1.1 vswr.

Extreme care was used in the installation of the lines to make sure they were clean, tight, and free from dents or broken insulators. Periodic Hi-Pot, leakage, and vswr measurements were made and paired lines kept symmetrical as to lengths and fittings so that the cancellation of residual mismatches could be effected by bridge diplexing as described above.

The multitude of broad-band vswr measurements required on this project, together with the necessity for making them at many relatively inaccessible locations, made the cumbersome and time-consuming bridge and measuring line impractical. All vswr measurements were made by the "panoramic RF sweep and delay-line method," which has been used effectively for several years by one of the authors and his associates in the installation and adjustment of TV diplexers, triplexers, side-band filters, antennas, and other broad-band systems.

There is not room in this paper to discuss the "panoramic sweep system" in detail. However, some of the simple fundamentals on which the method is based merit reviewing.

Essentially, the system consists of an RF oscillator, frequency modulated over a relatively wide band (usually 6 to 8 mc), and a uniform coil of polyethlene delay line (approximately 325 feet long) of conventional impedance (either 51.5 ohm or 72 ohm) and having a delay or round-trip transmission time of about 1 μsec and loss in the neighborhood of 2 to 3 db per 100 feet.

A heterodyne diode detector applied at the input to the delay line combines the outgoing signal with any reflected signal which will be of different instantaneous frequency than the oscillator due to the "delay" or traverse time of the signal in the line. An oscilloscope connected to the diode output reproduces an audio-range beat signal, the amplitude and frequency of which are respectively proportional to the degree of reflection or mismatch and to the distance to the point of discontinuity.

In one major respect the slotted line and panoramic methods are similar. The slotted-line probe measures, on a meter, amplitudes and positions of "fixed standing waves" in a system at a single frequency. The panoramic method plots on an oscilloscope amplitudes and positions of "moving standing waves" existing at one point in the system as the frequency is varied over a spectrum. Thus slotted-line techniques are applicable in the determination of swr, or the familiar

$$\text{swr} = \frac{E_{max} + E_{min}}{E_{max} - E_{min}},$$

where E_{max} = peak-to-peak amplitude of the scope trace at 100-per cent mismatch (delay line open or shorted) and E_{min} = peak-to-peak amplitude of successive cycles (on either side of the frequency of measurements).

Location of abrupt or nondistributed discontinuities producing as little as 5-per cent mismatch can also be made within 10 or 15 feet in long transmission systems by this method.

This is done simply by determining the number of standing waves or scope trace cycles per megacycle swept and multiplying this by the velocity of propagation in the system, or

$dN/dF \times 984 \times K_p \times \frac{1}{2}$ = distance to point of reflection, where

dN = the number of cycles counted on the scope

dF = frequency width swept to produce this dN

984 = velocity of propagation in space

K_p = velocity constant of the line

$\frac{1}{2}$ = factor used for round-trip travel of signal to defect and back.

dN/dF will be recognized as being the signal traverse time in microseconds.

As of December 14, 1951 all stations were in commercial operation from the Empire State Building. The extension of reception, the clearing up of many ghosts and shadow problems, and the general improvement in receiving conditions realized throughout the service area has more than justified the considerable expense and risk involved.

Acknowledgment

The work described herein on the Empire State antennas is the work of many men. L. J. Wolf is responsible for much of the supervision and planning. R. W. Masters, formerly associated with RCA and presently engaged as a consultant to RCA for this project, is responsible for the basic theoretical work on superturnstile and supergain antennas. In addition, 14 other engineers were engaged on various parts of this project.

Generation of NTSC Color Signals*

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Summary—**The generation of compatible color signals according to NTSC specifications is covered in this paper. The equation for the composite signal is stated in terms of voltages existing in the red, green, and blue channels, and methods of calculating and measuring the composite video signal produced by a synthetic color bar chart generator are given. The development of the signal from the channel outputs of a color flying-spot scanner is illustrated with block diagrams, and the performance of a number of units in the chain is described. The signal specifications described in this article were used by the NTSC for field testing during the latter part of the year 1951 and also during the year 1952. On the basis of these tests certain modifications of signal specifications were made in January, 1953. These are listed at the conclusion.**

I. Introduction

The evaluation of the performance of a color system is determined both by measured data and subjective viewing; it is therefore essential that the conditions of transmission be accurately controlled. When specifications for a new system are being investigated, the generating equipment should be flexible enough to allow variation of certain operating parameters so their effect on over-all performance may be studied.

The color-signal generating equipment described in this article was designed and built in the Philco Research Laboratories in Philadelphia, and is currently being used to generate compatible color signals according to NTSC specifications. The signal is available as either a composite video signal or as a modulated signal on a standard television radio frequency carrier.

II. Composite NTSC Color Signal

Reference to Fig. 1(b) shows that the composite color signal consists of a wide-band luminance signal transmitted according to present F.C.C. standards for black and white television to which has been added a narrow-band color subcarrier. The color subcarrier, which has an equivalent video frequency of 3.89 mc, is an odd multiple of one-half horizontal deflection frequency, so the principal modulation components of monochrome and color are interleaved.[1] The combination of using a color carrier of high frequency related in this fashion to horizontal deflection frequency results in making the pattern of the subcarrier practically invisible in monochrome receivers. NTSC color signal may be received by present black-white television sets without any circuit or operating changes and produces a high-quality monochrome picture on these receivers.

Tests made at a number of laboratories have shown that in an additive color picture it is not necessary to devote full 4-mc bandwidth to each of the red, green, and blue signals if the luminance information is transmitted at full bandwidth.[2] The specification for the NTSC signal, as shown in Fig. 1(b), shows the color subcarrier sidebands extend to at least 1 mc below and 0.4 mc above the color subcarrier frequency as measured to the 6 db down points.

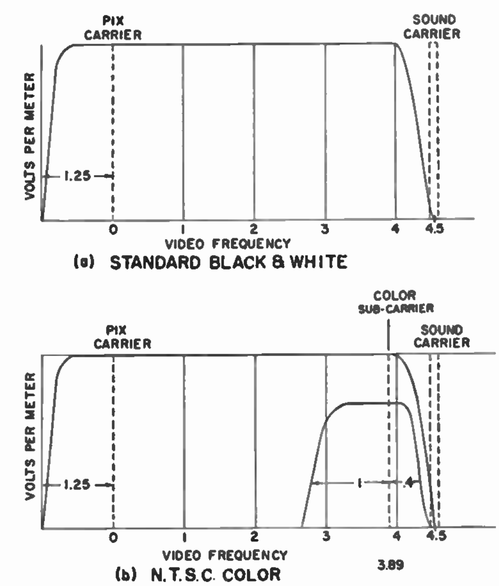

Fig. 1—Radiated signals (monochrome and NTSC color).

The NTSC color signal may be expressed by (1) of Fig. 2 which shows it to be made from a wide-band luminance signal (E'_Y) to which has been added the

$$E_m = E'_Y + \left[0.49(E'_B - E'_Y)\sin\omega t + 0.88(E'_R - E'_Y)\sin(\omega t \pm 90°)\right] \quad (1)$$

$$E_m = E'_Y + \overline{E_{SC}}\angle\alpha \quad (2)$$

$$\overline{E_{SC}} = \sqrt{\left[0.49(E'_B - E'_Y)\right]^2 + \left[0.88(E'_R - E'_Y)\right]^2} \quad (3)$$

$$\alpha = \tan^{-1}\left[\frac{0.88(E'_R - E'_Y)}{0.49(E'_B - E'_Y)}\right] \quad (4)$$

E'_R = VOLTAGE IN RED CHANNEL
E'_G = VOLTAGE IN GREEN CHANNEL
E'_B = VOLTAGE IN BLUE CHANNEL
$E'_Y = 0.59\,E'_G + 0.30\,E'_R + 0.11\,E'_B$

Fig. 2—Equation of NTSC composite color signal.

output of two balanced modulators operating in quadrature. One modulator has impressed on its input terminals the narrow-band color difference signal ($E'_B - E'_Y$), while the other modulator is driven by the color difference signal ($E'_R - E'_Y$). The output of either

* Decimal classification: R583. Original manuscript received by the Institute, July 8, 1952.

† Philco Research Division, Philadelphia, Pa. Paper presented at 1952 IRE National Convention, New York, N. Y.

[1] C. Hirsch, W. Bailey, and B. Loughlin, "Principles of NTSC compatible color television," *Electronics*, p. 88; February, 1952.

[2] M. W. Baldwin, "Subjective sharpness of additive color pictures," Proc. I.R.E., vol. 39, pp. 1173–1176; October, 1951.

modulator when transmitting a given color at a definite brightness is a 3.89-mc sine wave of constant phase having an instantaneous value directly proportional to the amplitude of the impressed color difference video signal. These signals are combined to form a color sub-

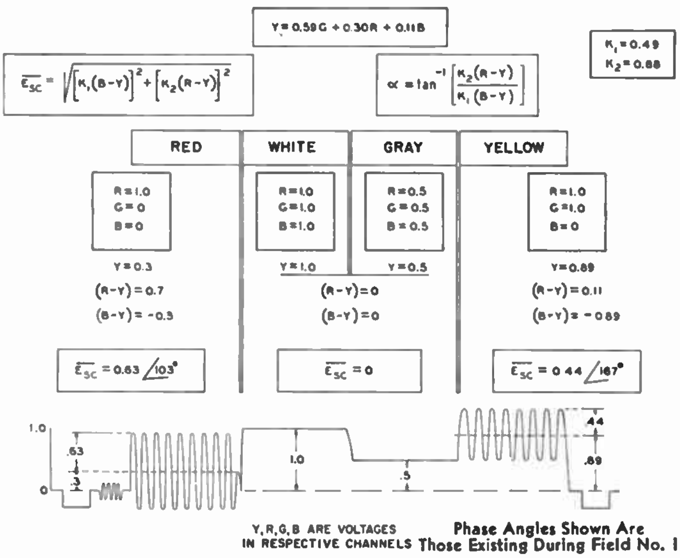

Fig. 3—Video signal (red, white, gray, and yellow) color bars.

carrier having an amplitude and phase which is the vector sum of the output of the two modulators. Color phase alternation, in which the phase of the $(E'_R - E'_Y)$ modulator output is shifted 180 degrees every successive field, is employed to reduce cross-talk developed in vestigial side-band handling of the color signal in the transmitter and receiver. It is often convenient to define the signal in polar form as shown in Fig. 2, (2). Peak value of the color subcarrier and its resultant phase can then be calculated directly by substitution of known voltages existing in the red, green, and blue channels.

Fig. 3 shows the video voltage generated when transmitting a scene consisting of four equal-width vertical bars of red, white, gray, and yellow. The waveform shown at the bottom is taken over a line period of 63.5 μsec. At the extreme left is the standard horizontal synchronizing pulse which is followed by a burst of 3.89 mc occurring during the back porch of the horizontal blanking period.[3] The burst signal is transmitted at a constant reference phase following each horizontal synchronizing pulse, and is used in the color receiver to accurately lock the 3.89-mc oscillator which feeds the synchronous demodulators. The first of the four vertical bar signals is a red stripe having a width of 13 μsec (one-fourth of picture width). During this time interval the average value, which is the (Y) or luminance signal, is 0.3 v above black level. The color subcarrier has a peak value of 0.63 v and a phase angle of 103 degrees relative to the output of the $(E'_B - E'_Y)$ modulator during field number one. The second stripe of Fig. 3 is a bright white vertical bar made from 1-v signals of red, green, and blue, while the third stripe is a gray bar made from ½-v levels of signals in the red, green, and blue channels. In these two cases, as can be seen from the equations in Fig. 3, the quantities $(E'_R - E'_Y)$ and $(E'_B - E'_Y)$ reduce to zero and there is no output from either of the two color modulators. In other words, the NTSC system only transmits color subcarrier during the time there is color information in the scene. If a scene should contain both color and black and white, no color subcarrier is radiated during the time the camera is scanning the monochrome picture elements. During this time interval the picture signal automatically becomes the same as that which would be radiated by a standard black and white transmitter. The fourth stripe is a yellow vertical bar which in an additive color system may be generated from 1-v signals in the red and green channels. The (E'_Y) signal has value of 0.89 v above black level, while color subcarrier has peak value of 0.44 v with phase angle relative to output of $(E'_B - E'_Y)$ modulator of 167° during field number one.

Referring to Fig. 3, it can be seen that during the time red and yellow information is being transmitted negative voltages exist in the $(E'_B - E'_Y)$ channel.

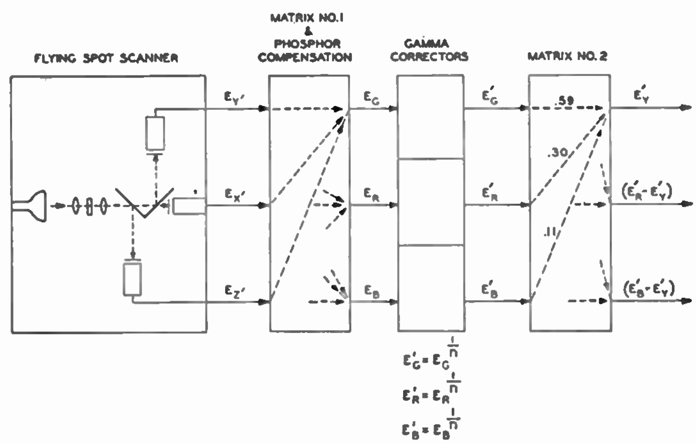

Fig. 4—Block diagram (scanner to matrix no. 2).

These negative voltages are real, and represent swings of video voltage below black level. The performance of either modulator is such that a constant phase output is maintained for all video voltages above black level, while for video voltages below black level the phase of the color subcarrier is shifted 180 degrees. The resultant color subcarrier, being the vector sum of the outputs of $(E'_B - E'_Y)$ and $(E'_R - E'_Y)$ modulators, can therefore take on any relative phase angle between 0 and 360°.

Shown in block form in Fig. 4 are the units to derive the video signals (E'_Y), $(E'_R - E'_Y)$ and $(E'_B - E'_Y)$. The first unit in the chain is a flying-spot scanner designed to operate with 35-mm double-frame transparent color slides. As described in a paper presented by Moore, Chatten, and Fisher,[4] the camera spectral characteristics have been adjusted to approximate closely the standard $\bar{x}$, $\bar{y}$, $\bar{z}$ mixture curves of the CIE system. The output

[3] R. B. Dome, "NTSC color-TV synchronizing signal," *Electronics*, vol. 25, p. 96; February, 1952.

[4] R. C. Moore, J. Chatten, and J. Fisher, "Measurement and Control of the Color Characteristics of a Flying Spot Scanner," presented before 1951 IRE National Convention, New York, N. Y.

voltage of a channel such as (Z) is therefore proportional to the product integral of the $\bar{z}$ curve and the spectral curve of the particular color being transmitted.

Since it is necessary to gamma correct the voltages in the red, green, and blue channels, a matrix unit is included to convert from E_Y', E_X', E_Z' to E_G, E_R, E_B. The three photomultiplier tubes used in the flying-spot scanner are linear devices (i.e., current output is directly proportional to incident illumination); therefore, the gamma-correcting circuits are designed to compensate for only the power law distortion of the picture tube used in a receiver. The gamma corrector employs a circuit described by Oliver[5] in which a nonlinear tube is used as the plate load of an otherwise linear amplifier. An analysis of the correction required to linearize the system was covered in a paper presented by Moore.[6] By means of linear adders and subtractors, brightness signal (E'_Y) and color difference signals ($E'_R-E'_Y$) and ($E'_B-E'_Y$) are derived in matrix unit no. 2.

Shown in the block diagram of Fig. 5 are the additional units in the complete chain. Two color difference signals are passed through filters having a frequency response flat to 1 mc and are down 6 db at 2 mc.

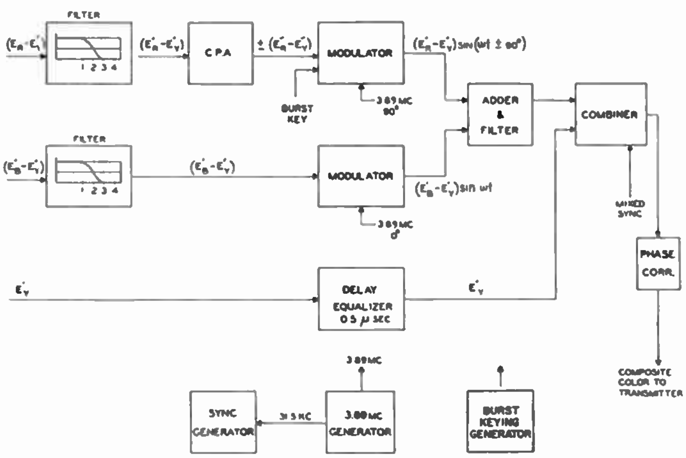

Fig. 5—Block diagram (filters to combiner).

Color-phase alternation is achieved by reversing the polarity of the applied video signal to the ($E'_R-E'_Y$) modulator at a sixty-cycle field rate. To insure that the burst signal is in phase with the output of the ($E'_R-E'_Y$) modulator during field number one, this modulator is unbalanced during the burst interval by a pulse signal from the burst keying generator.

The (E'_Y) signal is delayed $\frac{1}{2}$ μsec so that during transitions in picture information the luminance signal and envelope of the color subcarrier will be coincident in time at the output of the combiner unit. This delay network consists of a 10′ piece of RG 65/U, 950-ohm coaxial cable terminated with a constant resistance network. A circuit is also incorporated in this unt; thus an additional setup may be added to luminance signal.

[5] B. Oliver, "A rooter for video signals," Proc. I.R.E., vol. 38, pp. 1301–1305; November, 1950.

[6] R. C. Moore, "The specification and correction for non-linearity of cathode ray tubes," presented before 1952 IRE National Convention, New York, N. Y.

The luminance signal, color subcarrier, and synchronizing signals are added together in the combiner unit to form the composite NTSC color signal. Additional phase correction is employed to insure that the envelope of the color subcarrier and the luminance signal will be coincident in time at the output of the second detector of an average television receiver. Since receivers have an envelope delay of approximately 0.3 μsec for the higher modulation frequencies as compared to low frequencies, the correcting network produces an added delay for low-frequency components. The circuit employs a balanced lattice network described in an article by Kell and Fredendall.[7]

Phosphor Compensation and Matrix Unit

Transformation from voltages proportional to the tristimulus values X, Y, Z of the CIE system to voltages required in the red, green and blue channels is accomplished by a process of electronic addition and subtraction which is called matrixing.

The matrix equations to make these transformations for the Standard NTSC Panel 7 primaries are

$$E_R = 1.91E_X - 0.53E_Y - 0.29E_Z, \quad (5)$$

$$E_G = -0.98E_X + 2.00E_Y - 0.03E_Z, \quad (6)$$

$$E_B = 0.06E_X - 0.12E_Y + 0.90E_Z. \quad (7)$$

The channel output voltages from the flying-spot scanner, as indicated in Figs. 4 and 6, are designated $E_{X'}$, $E_{Y'}$, and $E_{Z'}$ because the lower wavelength lobe of the $\bar{x}$ curve is not included in the pickup spectral characteristic. Furthermore, the realized $\bar{y}'$ pickup spectral characteristic rolls off short of the $\bar{y}$ curve on the high wavelength end of the visible spectrum. However, both the $\bar{x}'$ and $\bar{y}'$ pickup spectral characteristics are linear combinations of $\bar{x}$ and $\bar{y}$ and therefore do not limit the color fidelity that is realized in the scanner. Output voltages from scanner may be expressed by following:

$$E_{X'} = (1.2E_X - 0.2E_Z) \quad (8)$$

$$E_X = (0.83E_{X'} + 0.166E_Z). \quad (9)$$

The latter equation is justified on the basis that the shape of the lower lobe of the $\bar{x}$ curve closely approximates the shape of the $\bar{z}$ curve, and has an area equal to 17 per cent of the $\bar{z}$ curve.

$$E_{Y'} = (1.4E_Y - 0.4E_{X'}), \quad (10)$$

$$E_Y = (0.7E_{Y'} + 0.286E_{X'}), \text{ and} \quad (11)$$

$$E_Z = E_{Z'}.$$

Substitution of (9) and (11) in (5), (6), and (7) gives the red, green, and blue channel voltages in terms of the output voltages from the flying spot scanner.

$$E_R = 1.43E_{X'} - 0.37E_{Y'} + 0.03E_{Z'} \quad (12)$$

$$E_G = -0.24E_{X'} + 1.4\ E_{Y'} - 0.19E_{Z'} \quad (13)$$

$$E_B = 0.02E_{X'} - 0.08E_{Y'} + 0.9\ E_{Z'}. \quad (14)$$

[7] R. D. Kell and G. L. Fredendall, "Standardization of the transient response of television transmitters," *RCA Rev.;* March, 1949.

Fig. 6 is a circuit diagram of the matrix unit and phosphor compensation amplifier used to obtain the red channel voltage (E_R). Similar amplifiers with appropriate matrixing are used in the green and blue channels.

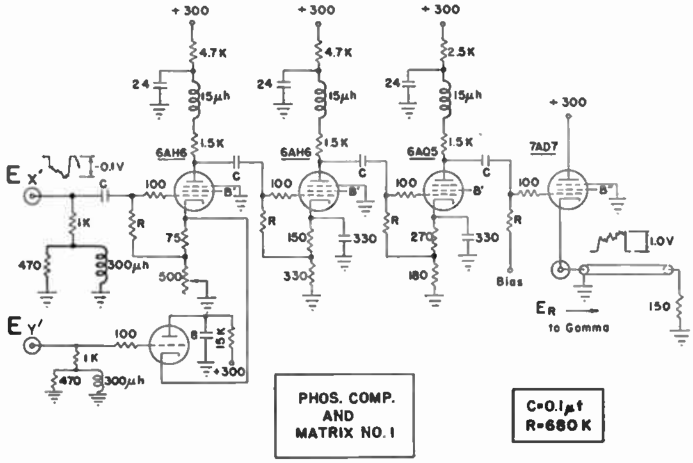

Fig. 6—Matrix no. 1 and phosphor compensation circuit diagram.

The current outputs of the photomultiplier tubes used in the scanner are connected by means of low capacity cable to the inputs marked ($E_{X'}$) and ($E_{Y'}$). The signal across the input impedance has a peak-to-peak amplitude of 0.1 v with black level positive. The amplifier uses three gain stages and a cathode follower to produce an output signal of 1.0-v peak-to-peak amplitude with black level negative. Matrixing is done at low level to insure good linearity, and the proper proportioning of the signals ($E_{X'}$) and ($E_{Y'}$) is controlled by adjustment of the common cathode resistor in the first stage.

The generation of video signals by a flying-spot scanner requires the use of compensation networks to correct for the light decay characteristic of the phosphor used in the flying-spot cathode ray tube. Equalization requires a network which has a flat frequency response from 60 cps to approximately 25 kc and then a gradually rising characteristic to 4 mc. The elimination of smear is accomplished by the network consisting of the 1,000-ohm input resistor in series with a 300-microhenry coil shunted by a 470-ohm resistor. The high-frequency response is corrected by two stages of cathode peaking. Since the noise output of a photomultiplier is relatively flat and wide band, the result of high-frequency peaking is to decrease the signal-to-noise ratio for high-frequency video signals. The two equalizing networks are independent, and by this means the smear can be removed first and then the cathode peaking adjusted to produce a high-definition picture consistent with a satisfactory signal-to-noise ratio.

Color Modulator

Shown in Fig. 7 is a simplified circuit diagram of the ($E'_R-E'_Y$) modulator. The input signal for purpose of illustration is depicted as a 4-step staircase signal occurring at a 15.75-kc repetition rate. A positive pulse from the burst keying generator, which produces the reference burst signal, is added to the video signal in the common plate load of the first two stages. Continuous sine waves having a frequency of 3.89 mc are applied 180° out of phase to the grids of the 6BE6 tubes. The keyed clamps are adjusted so that during black level the resultant ac voltage across the filter impedance is zero. During field number one, for the staircase signal shown, the ac plate current of tube T1 is greater than tube T2, and the output subcarrier has a constant reference phase of 90° and an amplitude which is directly proportional to the level of the impressed video voltage. The CPA unit reverses the polarity of the impressed video signal every successive field, and during field number two the polarity of the staircase voltage applied to tube T1 is negative. This results in a 180° phase shift of the color subcarrier for field number two; however, the phase of the reference burst signal is unaltered since the burst keying pulse is added following the CPA unit. The 90° phase difference between the 3.89 mc signals applied to the two modulators is obtained from a constant resistance phase shifter incorporated in this unit. It should be emphasized again

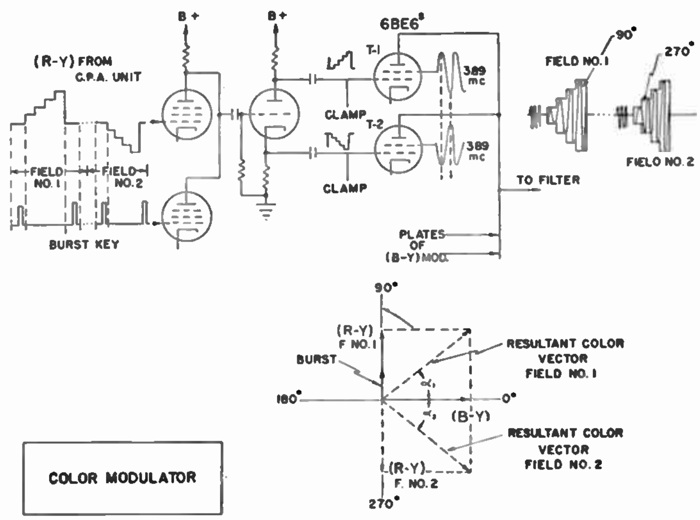

Fig. 7—Modulator circuit diagram.

that both the ($E'_R-E'_Y$) and ($E'_B-E'_Y$) signals may have either negative or positive polarity depending upon the color being transmitted at a given time. Whenever there is a color transition causing video signal impressed on either modulator to swing from above black level to below black level or vice versa, the color subcarrier phase at output of that modulator is shifted 180°.

For the modulator shown in Fig. 8:

Tube 1	Video signal	$E_{dc} + E_1 \cos \omega_v t,$	(18)
	Subcarrier	$E_2 \cos \omega_c t;$	(19)
Tube 2	Video signal	$-(E_{dc} + E_1 \cos \omega_v t),$	(20)
	Subcarrier	$E_2 \cos (\omega_c t + 180°).$	(21)

In each tube the subcarrier is multiplied by the impressed signal and the output of the two tubes are added in a common load impedance so that

$$E_0 = (E_{dc} + E_1 \cos \omega_v t)(E_2 \cos \omega_c t)$$

$$+ [-(E_{dc} + E_1 \cos \omega_v t)(E_2 \cos (\omega_c t + 180°))], \quad (22)$$

$$E_0 = 2E_{dc}E_2 \cos \omega_c t + 2E_1E_2(\cos \omega_v t)(\cos \omega_c t), \quad (23)$$

$$E_0 = 2E_2\, E_{dc} \cos \omega_c t + E_1\, E_2 \cos (\omega_c t + \omega_v t) + E_1\, E_2 \cos (\omega_c t - \omega_v t). \quad (24)$$

The resultant output from one modulator such as the $(E'_R - E'_Y)$ unit includes a color subcarrier term which is directly proportional to the dc component of the impressed color difference signal. In addition, an upper and lower sideband signal is also generated.

Combiner Unit

The circuit diagram of the combiner unit is shown in Fig. 8. In this unit the various signals required to form the NTSC composite color signal are added together in proper proportion. Ample gain is provided in both the luminance and chroma channels so that either of these quantities may be varied experimentally, to determine the effect of over-all performance. The attenuator shown in the input to the chroma channel terminates the interconnecting 150-ohm coaxial cable and has provision for changing the amplitude of the color subcarrier in 3 db steps from +3 db to −9 db.

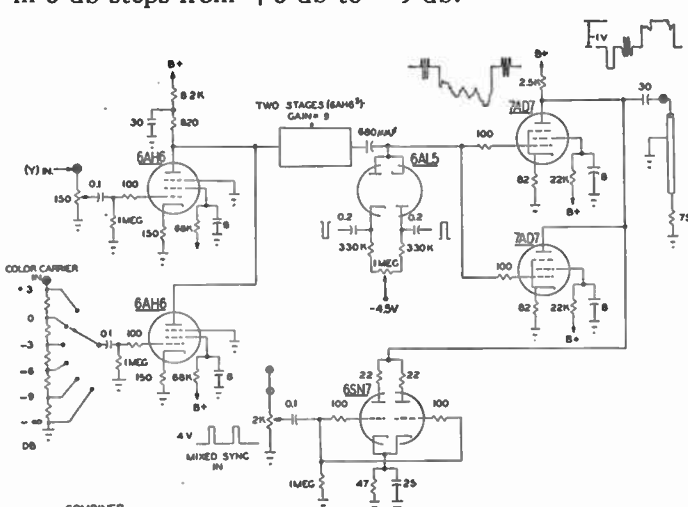

Fig. 8—Combiner circuit diagram.

The chroma and luminance information are combined in a common plate load, amplified, and then coupled to the output stage. A fast-acting keyed clamp is used on the grids of the 7AD7 output tubes to insure good low-frequency response. Standard synchronizing signal is coupled directly into 75-ohm output line to reduce signal level that must be handled by prior stages.

Burst Keying Generator

Shown in Fig. 9 is the circuit diagram of the burst keying generator. The duration of the pulse produced by this generator controls the number of cycles of the 3.89-mc reference phase that are transmitted during the burst interval. For a burst of 8 cycles the pulse duration would be 2.06 μsec.

The input signal to the burst keying generator is a short-duration spike pulse coincident in time with the leading edge of horizontal blanking and occurring at a repetition rate of 15.75 kc. A negative, nine-line pulse occurring at a 60-cycle rate, which is obtained from the synchronizing generator, is connected to the suppressor grid of the 6AS6 gate tube to key out the input pulses

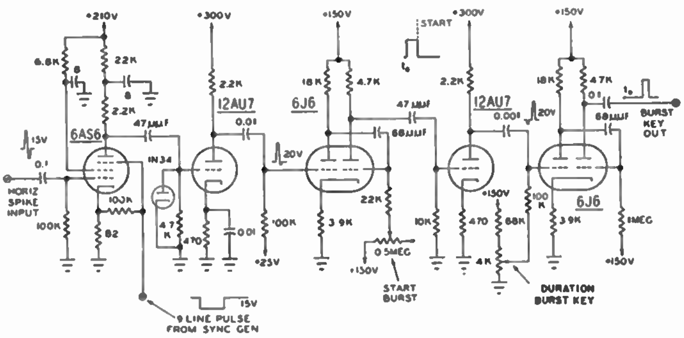

Fig. 9—Burst-keying-generator circuit diagram.

during this time interval. By this means the burst signal is keyed out during the time the equalizing pulses and the serrated vertical synchronizing pulse are transmitted. The resultant pulse train is amplified and applied as a 20-v positive trigger pulse to the first multivibrator. The duration of the pulse produced by this multivibrator controls the time at which the burst signal starts. For a gap of 0.57 μsec between the trailing edge of the horizontal synchronizing pulse and the start of the burst signal the multivibrator would be adjusted to have a duration of 6.6 μsec. After differentiation and inversion by the 12AU7 tube, the trailing edge of this pulse is used as a positive trigger for the second multivibrator. The duration of the pulse produced by the second multivibrator is controlled by a vernier control located in the grid circuit.

The time duration of the various signals occurring during the horizontal blanking period, such as the front porch interval, and the gap between the trailing edge of the horizontal synchronizing pulse and the start of the burst signal, may be accurately measured and adjusted by an oscilloscope having provision for intensity modulation of trace by a cohered oscillator.[8]

Timing Unit

The subcarrier frequency is chosen to be an odd multiple of one-half horizontal deflection frequency, therefore the unit generating the 3.89-mc signal and the synchronizing generator must be locked together. The method used to insure this tie-in is illustrated in Fig. 10. The master oscillator in the synchronizing generator operates at a frequency of 31.5 kc, which is four times fh/2, and for stable synchronizing between the two units it is necessary to lock this oscillator with a 31.5 kc pulse derived from the timing unit. The odd number 495 is factorable into 5, 9, and 11, which determines the dividing ratio of the counters used. Using only dividers in the chain requires the master crystal oscillator to operate at a frequency of 15.592 mc, which is four times

[8] J. F. Fisher, "Television picture line selector," *Electronics;* 1952.

the color subcarrier frequency. A gated oscillator operating at a 4 to 1 division ratio produces the 3.89 mc signal directly. The 5 to 1, and 9 to 1 counters are gated oscillators, while the final 11 to 1 divider employs a staircase type counter with special linearizing networks.

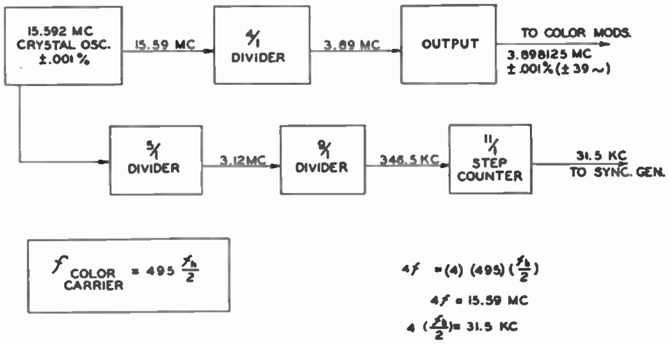

Fig. 10—Timing-unit block diagram of 3.89 mc generator.

Fig. 11 is a circuit diagram of 9 to 1 divider which counts from a frequency of 3.12 mc to one of 346.5 kc. Similar circuits with different values of capacity and inductance are used in other gated oscillator counters.

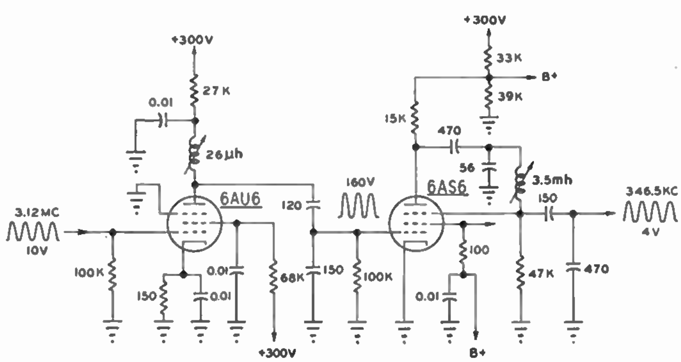

Fig. 11—Circuit diagram of 9/1 counter, 3.1185 mc to 346.5 kc.

Operating Procedure and Calibration

The scanner is adjusted for white balance by setting the voltages E_R, E_G, E_B equal when a black and white test slide is used. This is accomplished by means of individual controls, connected between dynodes 5 and 7 of the Z' and Y' photomultiplier tubes.

The three gamma correctors are most easily adjusted by impressing a 1-v, 10-step linear staircase signal, operating at a 15.75 kc repetition rate, to the input terminals. The operating controls are adjusted so the various steps, measured at the output of the corrector, coincide with calibration lines on an oscilloscope. This results in a 3 to 1 ratio of gain between step one, which is nearest black level, and step ten.

The calibration of the second matrixer, color modulators, and combiner units is most easily done by means of a synthetic color bar chart generator[9] connected to the inputs of matrix unit no. 2. A wideband oscilloscope is used to check the proper levels of the signals as tabulated in Fig. 12. Switches are provided so that the output of either color modulator as well as the luminance channel may be measured individually to insure the accuracy of that particular part of the system. The phase of the reference burst signal and the output of

Color	Signal from Bar Chart Generator Volts (Peak to Peak)			Matrix No. 2 Output Volts (P. to P.)		System Output Volts (Peak to Peak)				Phase Angle in Degrees Relative to Output of $(E'_B-E'_Y)$ Mod.	
	E'_R	E'_G	E'_B	$E'_R-E'_Y$	$E'_B-E'_Y$	$E'_R-E'_Y$ Mod. only	$E'_B-E'_Y$ Mod. only	E'_Y	Color Sub-carrier	ϕ Field 1	ϕ Field 2
Red	1.0	0	0	0.70	-0.30	1.23	0.30	0.30	1.26	103.4°	256.6°
Yellow	1.0	1.0	0	0.11	-0.89	0.19	0.88	0.89	0.90	167°	193.0°
Green	0	1.0	0	-0.59	-0.59	1.04	0.58	0.59	1.18	240.7°	119.3°
Cyan	0	1.0	1.0	-0.70	0.30	1.23	0.30	0.70	1.26	283.4°	76.6°
Blue	0	0	1.0	-0.11	0.89	0.19	0.88	0.11	0.90	347°	13°
Magenta	1.0	0	1.0	0.59	0.59	1.04	0.58	0.41	1.18	60.7°	299.3°
White	1.0	1.0	1.0	0	0	0	0	1.0	0	—	—

Fig. 12—Calibration chart.

the $(E'_R - E'_Y)$ modulator are in phase coincidence because of the method used to generate the burst signal. Phase-measuring equipment may be used to check the relative phase of the color subcarrier for various colors produced by the synthetic color bar generator. The relative phase of the color subcarrier for a number of colors is tabulated in Fig. 12.

New Specifications

As mentioned in the summary, certain signal modifications were made in January 1953. (1) Spacing between sound and picture carriers, (4.5 mc ±1000 cycles). (2) Sound transmitter power, (50–70% of peak picture power). (3) Color subcarrier frequency reduced to 3.579545 mc ±0.0003%, and color phase alternation eliminated. (4) New color subcarrier specifications in which the color difference signals applied to the modulators are E'_I and E'_Q, where

$$E'_I = 0.74\,(E'_R - E'_Y) - 0.27\,(E'_B - E'_Y)$$

$$E'_Q = 0.48\,(E'_R - E'_Y) + 0.41\,(E'_B - E'_Y).$$

Sidebands of E'_Q information are limited to ±600 kc while those of E'_I information extend to ±1.2 mc. Two signals are in quadrature with E'_I leading E'_Q, and burst signal leading E'_I by 57°.

For color difference signals having frequencies below 500 kc this is identical to a signal generated by the methods given in this article, in which $(E'_R - E'_Y)$ leads $(E'_B - E'_Y)$ by 90°. The amplitude and phase of the color subcarrier for color difference video signals below 500 kc and the value of the luminance signal are therefore exactly as tabulated in Fig. 12, the phase of the subcarrier being that shown for (ϕ Field One).

The specifications of the signal are such that the pair of vectors E'_I and E'_Q, which are in quadrature, lead the pair of vectors $(E'_R - E'_Y)$ and $(E'_B - E'_Y)$ by 33°. The burst signal leads E'_I by 57° and leads $(E'_R - E'_Y)$ by 90°.

[9] R. P. Burr, W. R. Stone, and R. O. Noyer, "Picture generator for color television," *Electronics*, vol. 24, p. 116; August, 1951.

Standards on Television: Definitions of Color Terms, Part I, 1953*

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I. Introduction

Many of the terms defined here are of long standing in colorimetry and photometry. Already available definitions for them have been accepted by the Institute wherever possible. We have drawn freely on material developed by the American Standards Association, by the Illuminating Engineering Society, by the International Commission on Illumination, and by the Optical Society of America. Our indebtedness to these organizations is hereby acknowledged.

The definitions which follow lie in a field that may be novel to radio engineers. These definitions involve subjective as well as objective considerations. In consequence, we draw your attention to the desirability of acquiring background knowledge from other sources, such as:

1. Optical Society of America, Committee on Colorimetry, "Science of Color," Thomas Y. Crowell Co., New York, N. Y.; 1953.
2. Deane B. Judd, "Colorimetry," National Bureau of Standards Circular 478, Washington, D. C.; March 1, 1950.

II. Definitions

Achromatic Locus (Achromatic Region). Chromaticities which may be acceptable reference standards under circumstances of common occurrence are represented in a chromaticity diagram by points in a region which may be called the "achromatic locus."

Note—The boundaries of the achromatic locus are indefinite, depending on the tolerances in any specific application. Acceptable reference standards of illumination (commonly referred to as "white light") are usually represented by points close to the locus of Planckian radiators having temperatures higher than about 2,000°K. While any point in the achromatic locus may be chosen as the reference point for the determination of dominant wavelength, complementary wavelength, and purity for specification of object colors, it is usually

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advisable to adopt the point representing the chromaticity of the luminator. Mixed qualities of illumination, and luminators with chromaticities represented very far from the Planckian locus, require special consideration. Having selected a suitable reference point, dominant wavelength may be determined by noting the wavelength corresponding to the intersection of the spectrum locus with the straight line drawn from the reference point through the point representing the sample. When the reference point lies between the sample point and the intersection, the intersection indicates the complementary wavelength. Any point within the achromatic locus, chosen as a reference point, may be called an "achromatic point." Such points have also been called "white points."

Brightness. The attribute of visual perception in accordance with which an area appears to emit more or less light.

Note—Luminance is recommended for the photometric quantity, which has been called "brightness." Luminance is a purely photometric quantity. Use of this name permits "brightness" to be used entirely with reference to the sensory response. The photometric quantity has been often confused with the sensation merely because of the use of one name for two distinct ideas. Brightness will continue to be used, properly, in nonquantitative statements, especially with reference to sensations and perceptions of light. Thus, it is correct to refer to a brightness match, even in the field of a photometer, because the sensations are matched and only by inference are the photometric quantities (luminances) equal. Likewise, a photometer in which such matches are made will continue to be called an "equality-of-brightness" photometer.

A photo-electric instrument, calibrated in foot-lamberts, should not be called a "brightness meter." If correctly calibrated, it is a "luminance meter." A troublesome paradox is eliminated by the proposed distinction of nomenclature. The luminance of a surface may be doubled, yet it will be permissible to say that the brightness is not doubled, since the sensation which is called "brightness" is generally judged to be not doubled.

Candle. The unit of luminous intensity. One candle is defined as the luminous intensity of 1/60th square centimeter of a blackbody radiator operating at the temperature of solidification of platinum. Values for standards having other spectral distributions are derived by the use of accepted luminosity factors.

Candlepower. Luminous intensity expressed in candles.

Chroma (Munsell Chroma). The dimension of the Munsell system of color which corresponds most closely to **saturation.**

Note—**Chroma** is frequently used, particularly in English works, as the equivalent of **saturation** (*q.v.*).

Chromaticity. The color quality of light definable by its chromaticity co-ordinates, or by its dominant (or complementary) wavelength and its purity taken together.

Chromaticity Co-ordinate. The ratio of any one of the tristimulus values of a sample to the sum of the three tristimulus values.

Chromaticity Diagram. A plane diagram formed by plotting one of the three chromaticity co-ordinates against another.

Note—The most common **Chromaticity Diagram** at present is the CIE (x, y) diagram plotted in rectangular co-ordinates (see Fig. 1).

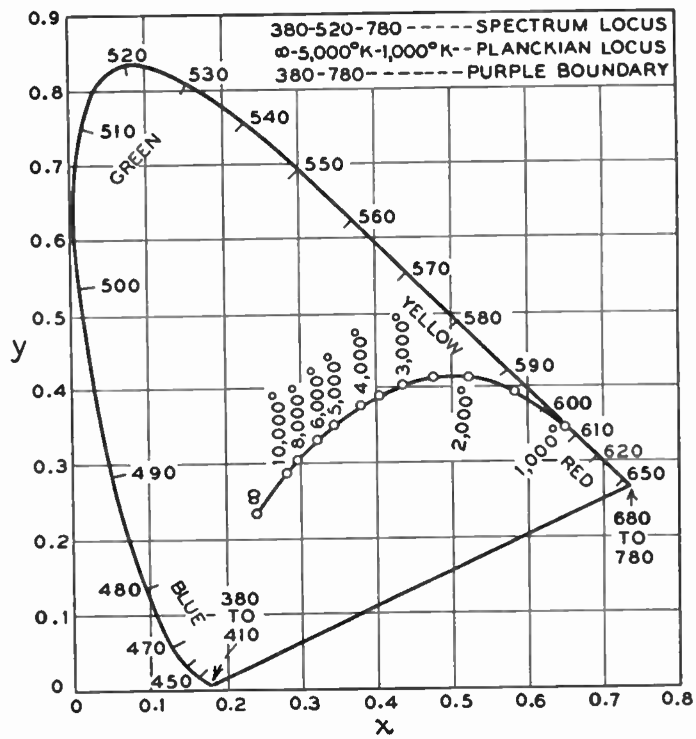

Fig. 1—Chromaticity Diagram.

CIE. Abbreviation for "Commission Internationale de l'Eclairage."

Note—These are the initials of the official French name of the "International Commission on Illumination." This translated name is approved for usage in English-speaking countries, but at its 1951 meeting the Commission recommended that only the initials of the French name be used. The initials "ICI" which have been used commonly in this country are deprecated because they conflict with an important trademark registered in England and because the initials of the name translated into other languages are different.

Color. The characteristics of light other than spatial and temporal inhomogeneities.

Note 1—The measure of color is three dimensional. One of the many ways of measuring color is in terms of luminance, dominant wavelength, and purity.

Note 2—Inhomogeneities, for example, particular distributions and variations of light, and characteristics of objects which are revealed by variations such as gloss, lustre, sheen, texture, sparkle, opalescence, and transparency, are not included among the color characteristics of objects.

Color-Mixture Data. See **Tristimulus Values,** the preferred term.

Complementary Wavelength. The wavelength of light of a single frequency, which matches the reference standard light when combined with a sample color in suitable proportions.

Note 1—The wide variety of purples which have no dominant wavelengths, including nonspectral violet, purple, magenta, and nonspectral red colors, are specified by use of their complementary wavelengths.

Note 2—Refer to **Dominant Wavelength.**

Dominant Wavelength. The wavelength of light of a single frequency, which matches a color when combined in suitable proportions with a reference standard light.

Note—Light of a single frequency is approximated in practice by the use of a range of wavelengths within which there is no noticeable difference of color. Although this practice is ambiguous in principle, the dominant wavelength is usually taken as the average wavelength of the band used in the mixture with the reference standard matching the sample. Many different qualities of light are used as reference standards under various circumstances. Usually the quality of the prevailing illumination is acceptable as the reference standard in the determination of the dominant wavelength of the colors of objects.

Equal-Energy Source. A light source for which the time rate of emission of energy per unit of wavelength is constant throughout the visible spectrum.

Excitation Purity (Purity). The ratio of the distance from the reference point to the point representing the sample, to the distance along the same straight line from the reference point to the spectrum locus or to the purple boundary, both distances being measured (in the same direction from the reference point) on the CIE chromaticity diagram.

Note—The reference point is the point in the chromaticity diagram which represents the reference standard light mentioned in the definition of **Dominant Wavelength.**

Footcandle. A unit of illuminance when the foot is taken as the unit of length. It is the illuminance on a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illuminance at a surface all points of which are at a distance of one foot from a uniform source of one candle.

Footlambert. A unit of luminance equal to $1/\pi$ candle per square foot, or to the uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square foot.

Note—A footcandle is a unit of incident light and a footlambert is a unit of emitted or reflected light. For a perfectly reflecting and perfectly diffusing surface, the number of footcandles is equal to the number of footlamberts.

Hue. The attribute of color perception that determines whether it is red, yellow, green, blue, purple, or the like.

Note 1—This is a subjective term corresponding to the psychophysical term **Dominant** (or **Complementary**) **Wavelength.**

Note 2—White, black, and gray are not considered as being hues.

ICI. Superseded by "**CIE.**"

Illuminance (Illumination). The density of the luminous flux on a surface; it is the quotient of the flux by the area of the surface when the latter is uniformly illuminated.

Lambert. A unit of luminance equal to $1/\pi$ candle per square centimeter, and, therefore, equal to the uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square centimeter.

Light. The aspect of radiant energy of which a human observer is aware through the visual sensations that arise from the stimulation of the retina of the eye. For the purposes of engineering, light is visually evaluated radiant energy.

Note 1—Light is psychophysical, neither purely physical nor purely psychological. Light is not synonymous with radiant energy, however restricted, nor is it merely sensation.

Note 2—The present basis for the engineering evaluation of light consists of the color-mixture data $\bar{x}$, $\bar{y}$, $\bar{z}$ adopted in 1931 by the International Commission on Illumination.

Lumen. The unit of luminous flux. It is equal to the flux through a unit solid angle (steradian) from a uniform point source of one candle, or to the flux on a unit surface all points of which are at unit distance from a uniform point source of one candle.

Luminance. The luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed from that direction.

Note—See Note under the term **Brightness.**

Luminosity. Ratio of luminous flux to the corresponding radiant flux at a particular wavelength. It is expressed in lumens per watt.

Luminosity Coefficients. The constant multipliers for the respective tristimulus values of any color, such that the sum of the three products is the luminance of the color.

Luminous Efficiency. The ratio of the luminous flux to the radiant flux.

Note—Luminous efficiency is usually expressed in lumens per watt of radiant flux. It should not be confused with the term "efficiency" as applied to a practical source of light, since the latter is based upon the power supplied to the source instead of the radiant flux from the source. For energy radiated at a single wavelength, luminous efficiency is synonymous with luminosity.

Luminous Flux. The time rate of flow of light.

Luminous Intensity (in any direction). The ratio of the luminous flux emitted by a source or by an element of a source, in an infinitesimal solid angle containing this direction, to the solid angle.

Note—Mathematically, a solid angle must have a point at its apex; the definition of **Luminous Intensity,** therefore, applies strictly only to a point source. In practice, however, light emanating from a source whose dimensions are negligible in comparison with the distance from which it is observed may be considered as coming from a point.

Planckian Locus. The locus of chromaticities of Planckian (blackbody) radiators having various temperatures (see Fig. 1).

Primaries. The colors of constant chromaticity and variable luminance, which, when mixed in proper proportions, are used to produce or specify other colors.

Note—Primaries need not be physically realizable.

Purity (Excitation Purity). The ratio of the distance from the reference point to the point representing the sample, to the distance along the same straight line from the reference point to the spectrum locus or to the purple boundary, both distances being measured (in the same direction from the reference point) on the CIE chromaticity diagram.

Note—The reference point is the point in the chromaticity diagram which represents the reference standard light mentioned in the definition of **Dominant Wavelength.**

Purple Boundary. The straight line drawn between the ends of the spectrum locus (see Fig. 1).

Radiance. The radiant flux per unit solid angle per unit of projected area of the source.

Note—The usual unit is the watt per steradian per square meter. This is the radiant analog of luminance.

Radiant Flux. The time rate of flow of radiant energy.

Radiant Intensity. The energy emitted per unit time, per unit solid angle about the direction considered; for example, watts per steradian.

Receiver Primaries. The colors of constant chromaticity and variable luminance produced by the receiver which, when mixed in proper proportions, are used to produce other colors.

Note—Usually three primaries are used: red, green, and blue.

Relative Luminosity. The ratio of the value of the luminosity at a particular wavelength to the value at the wavelength of maximum luminosity.

Saturation. The attribute of any color perception possessing a hue that determines the degree of its difference from the achromatic color perception most resembling it.

Note 1—This is a subjective term corresponding to the psychophysical term **Purity.**

Note 2—The description of saturation is not commonly undertaken beyond the use of rather vague terms, such as vivid, strong, and weak. The terms brilliant, pastel, pale, and deep, which are sometimes used as descriptive of saturation, have connotations descriptive also of brightness.

Spectrum Locus. The locus of points representing the chromaticities of spectrally pure stimuli in a chromaticity diagram (see Fig. 1).

Tristimulus Values. The amounts of the primaries that must be combined to establish a match with the sample.

White.

Note—In color television, the term **White** is used most commonly in the nontechnical sense. More specific usage is covered by the term **Achromatic Locus,** and this usage is explained in the Note under the term **Achromatic Locus.**

White Object. An object which reflects all wavelengths of light with substantially equal high efficiencies and with considerable diffusion.

Low-Loss Waveguide Transmission*

S. E. MILLER†, MEMBER, IRE AND A. C. BECK†, SENIOR MEMBER, IRE

Summary—**The circular electric mode in round metallic tubing becomes increasingly more attractive than the dominant mode from the standpoint of minimizing the waveguide size at frequencies above about 10,000 mc for the loss criterion of 0.25 db/100 feet.**

The circular electric (TE_{01}) mode also makes available a theoretical heat loss of 2 db/mile in waveguides less than 6 inches in diameter at frequencies higher than about 5,500 mc. Increased transmission bandwidth, reduced delay distortion, and reduced waveguide size are factors favoring use of the highest practical frequency of operation. An increased number of freely propagating modes and smaller mechanical tolerances are the associated penalties.

Experimental work has been carried out in the 9,000-mc region using the TE_{01} mode in a pipe about 5 inches in diameter. Transmission of 0.1-μsec pulses has been observed over a distance of 40 miles. Mode conversion and surface roughness of the tubing walls result in observed losses which average about 50 per cent higher than the theoretical values for geometrically perfect, smooth-walled tubing.

There is included a brief discussion of several problems unique to transmission in a multimode medium, including pure mode generation, mode filtering, the bend problem, and the effects of mode conversion on transmission loss and signal fidelity.

Introduction

THIS PAPER presents some results of an investigation carried on at Holmdel to evaluate the possibility of using waveguide as a low-loss transmission medium. The Bell System is interested in knowing whether waveguide can be used as a long-distance communication medium in the manner in which coaxial cable or the radio-relay system is now employed.

Our interest in long-distance waveguides is due in part to the fact that radio-wave propagation through the atmosphere becomes progressively more severely handicapped by oxygen, rain, and water-vapor absorptions at frequencies above 12,000 mc. Use of the spectrum above this frequency seems to require a sheltered transmission medium.

We also employ waveguide for subsidiary connecting links in other systems, for example, between the antenna and the transmitter or receiver in a radio-relay system, and we are interested in the general factors governing such waveguide use.

The loss requirements for these two general applications are of course different. For long-distance transmission it would be desirable to have losses as low as 1 to 4 db per mile. For the subsidiary connecting-link application, a loss on the order of ¼ db per 100 feet, that is, about 13 db per mile, is an attractively low loss. Other characteristics of these two waveguide uses are also quite different. For the subsidiary connecting link, the frequency of operation, the type of signal modulation to be used, and numerous space requirements are frequently dictated by the remainder of the system. For long-distance application, on the other hand, the kind of waveguide, the mode to be used, the frequency of operation, and the type of signal modulation employed are all at the disposal of the system designer for use in achieving the most efficient transmission of intelligence. In this case the equipment associated with the waveguide is in a sense subordinate to the characteristics of the waveguide. The associated equipment will be designed to take advantage of the medium's desirable characteristics and to avoid the medium's undesirable characteristics. These detailed systems considerations will not be discussed in this paper, but the systems point of view should be kept in mind when assessing the observations to be reported.

Theoretical Considerations Governing Waveguide Use

Fig. 1 shows the loss characteristics of dominant-mode rectangular waveguide. The ordinate is the mid-band theoretical attenuation for a rectangular waveguide designed to be in the center of its region of

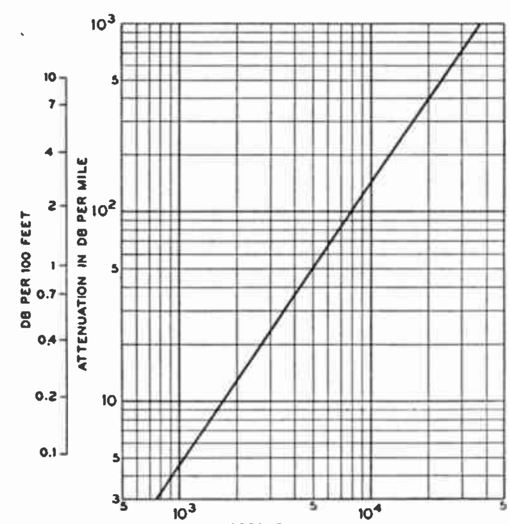

Fig. 1—Attenuation versus frequency for dominant-mode rectangular hollow copper waveguides in the center of their region of single-mode operation.

single-mode operation at the abscissa frequency. At 5,000 mc the loss is around 1 db per 100 feet, at 10,000 mc the loss is around 3 db per 100 feet, and at 30,000 mc the loss is in excess of 10 db per 100 feet. Thus above 5,000 mc the dominant-wave rectangular guide loss becomes undesirably high even for subsidiary connecting-link applications.

* Decimal classification: R118.2. Original manuscript received by the Institute, September 9, 1952. Presented orally at the March, 1951 IRE National Convention in New York, N. Y.

† Bell Telephone Laboratories, Box 107, Red Bank, N. J.

For long-distance applications and transmission losses under 5 db per mile, a midband frequency below 1,000 mc is necessary with dominant-mode rectangular waveguide. This corresponds to a waveguide approximately one foot in width, which is undesirable from the standpoint of size and cost. Furthermore, delay-distortion requirements would necessitate the use of such a waveguide in baseband channels only a few megacycles wide. The total RF band available is less than 500 mc for single-mode operation. We conclude that a more attractive design for long-distance application would be very desirable.

The situation just described for single-mode rectangular waveguide would be broadly the same for other shapes of single-mode hollow-conductor waveguide.

It is well known that the loss of any hollow conductor waveguide can be reduced in theory to any desired extent by increasing the cross-sectional area a suitable amount. The resulting penalty is that the medium is capable of supporting more than one mode. There seem to be no advantages of rectangular waveguide when operated in the multimode region. As a result this discussion will now be confined to ***round*** waveguides which are attractive for mechanical reasons.

The difficulties associated with the transmission line increase as the number of freely propagating modes increases. Furthermore, the cost of the line increases as the size is increased. Thus, convenient criteria for choosing the mode of transmission are the ***required waveguide size*** and the ***number of freely propagating modes.*** To this should be added the criterion ***delay distortion*** for it will become evident that the various modes differ in this respect also.

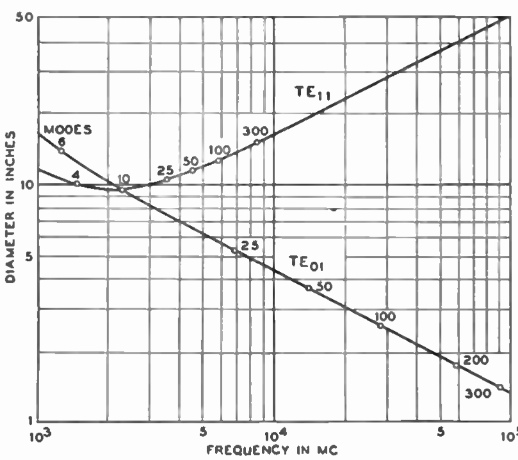

Fig. 2—Round-guide diameter versus frequency for the fixed attenuation of 2 db/mile.

Fig. 2 shows the waveguide diameter required at any given frequency to achieve a theoretical loss of 2 db per mile. Below 2,500 mc use of TE_{11}, the dominant wave, results in the smallest waveguide size. Above 2,500 mc the circular electric mode provides the smallest waveguide diameter at the required 2 db per mile loss. For a frequency of operation near 50,000 mc, the diameter required is about 2 inches.

Fig. 3 shows similar data for the condition where the loss is held constant at 0.25 db per hundred feet. Under these conditions use of the dominant wave TE_{11} results in smaller waveguide diameters for midband frequencies up to 8,000 mc. At midband frequencies above 8,000 mc use of the circular electric wave TE_{01} provides a medium with 0.25 db/100-foot loss in the smallest waveguide diameter. From Figs. 2 and 3 one may draw the general conclusion that for frequencies up to 5,000 or 10,000 mc, depending upon the exact loss tolerated, dominant-wave transmission results in the smallest waveguide size, and appears attractive. At midband frequencies higher than 10,000 mc the circular electric wave will provide the desired magnitude of transmission loss in a smaller waveguide diameter than that required by any other wave.

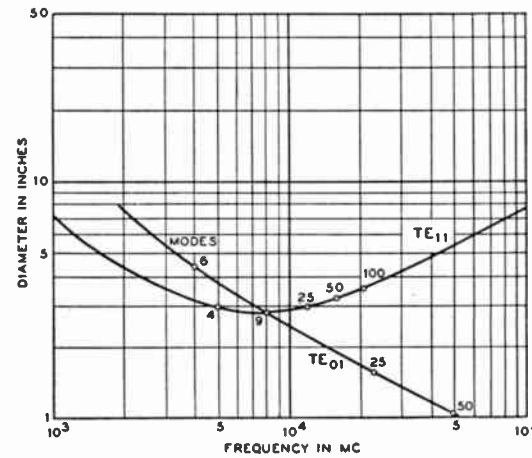

Fig. 3—Round-guide diameter versus frequency for the fixed attenuation of 0.25 db/100 feet and 13.2 db per mile.

The number of freely propagating modes is also shown on Figs. 2 and 3 by the circles and numerals at points along the curves. For the 2 db/mile condition, Fig. 2 indicates that 25 to 50 modes will propagate in a line designed to operate near 10,000 mc. This corresponds to a condition which has been studied experimentally, as reported in succeeding sections of this paper. In order to reduce the waveguide to about 2 inches in diameter, an interesting region for long-distance communication, a carrier frequency of about 50,000 mc is required and about 175 modes can propagate.

For the short connecting-link application, Fig. 3 shows that about 10 modes will propagate in a line designed to operate near 10,000 mc, and even at 4,000 mc 2 or 3 modes must be tolerated. For a line designed to operate at 25,000 mc the circular electric wave is clearly indicated and about 25 modes must be accepted to reach the condition of 0.25 db/100 foot theoretical loss.

Delay distortion is another parameter governing waveguide uses. In Fig. 4 the ordinate is the ratio of group velocity to the velocity in free space, and the abscissa is the operating frequency. For any smooth-walled hollow conductor waveguide the group velocity is zero below the cutoff frequency and approaches the free-space velocity asymptotically above the cutoff frequency. To establish quantitatively the magnitude of delay distortion, we assume a carrier shown on the

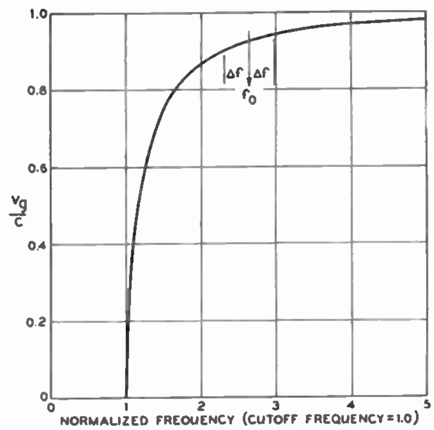

Fig. 4—Group velocity (relative to an unbounded medium) versus frequency for hollow conductor waveguides.

chart as f_0, with two sidebands separated from the carrier by Δf. For a certain magnitude of delay distortion there will be a 180° phase difference between the components at plus and minus Δf, a condition of severe distortion using any of the ordinary modulation methods. The bandwidth associated with this amount of delay distortion is an upper limit on the usable bandwidth,[1] and we shall use it as a quantitative indication of the quality of the medium. In order to simplify the presentation we shall assume one mile of waveguide length in all cases. It may be shown that the allowable base bandwidth varies inversely as the square root of the length of waveguide.

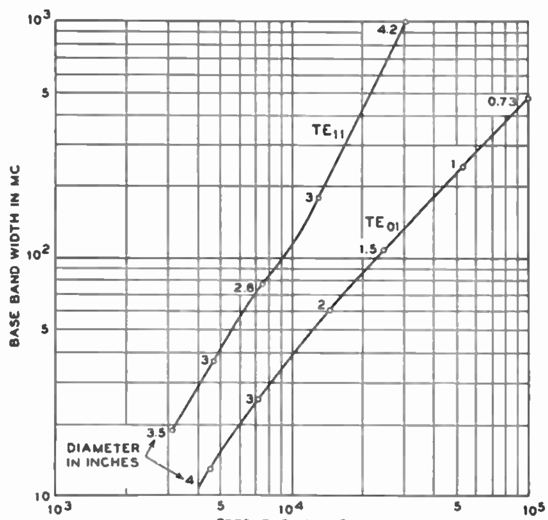

Fig. 5—Base bandwidth per channel vs. frequency for one-mile waveguide length, loss fixed at 0.25 db/100 feet and 13.2 db per mile.

Fig. 5 shows on the ordinate the base bandwidth allowable for a one-mile waveguide length and on the abscissa the midband operating frequency. The waveguide diameter shown by circles along the curve has been varied to hold the loss constant at 0.25 db per hundred feet, making these curves comparable to those of Fig. 3. Note that for midband frequencies below 10,000 mc the allowable channel bandwidths are less than 100 mc for a one-mile waveguide length. Shorter waveguide runs allow the use of wider bands. Fig. 6 shows similar information where the waveguide loss has been held constant at 2 db per mile, the same condition held in Fig. 2. Below 3,000 mc the TE_{11} wave is more attractive since it provides more bandwidth and requires about the same diameter as the circular electric wave. Above 3,000 mc, also, the TE_{11} wave provides more bandwidth under the conditions plotted. However, note that the waveguide diameter required in this region is larger for the TE_{11} wave. Hence, if more bandwidth than provided for the TE_{01} wave is required, one would probably enlarge the waveguide to get the prescribed bandwidth in the circular electric wave, or as an alternative, go to a higher frequency where the circular wave provides the same loss in a smaller waveguide and at the same time makes available more bandwidth per channel. In the vicinity of 50,000 mc for the 2 db/mile condition, a bandwidth per channel on the order of 500 mc is the maximum that is available. Of course, the useful bandwidth of the waveguide is much greater than this since many such channels can be multiplexed by frequency division.

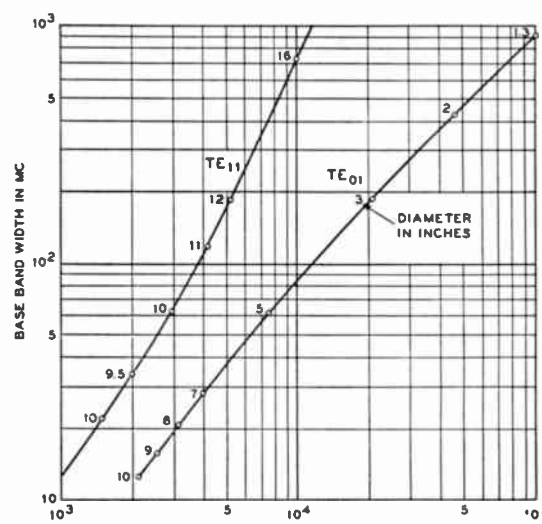

Fig. 6—Same as Fig. 5 except loss fixed at 2 db/mile.

In view of the general trend toward wider bandwidth systems and toward higher midband frequencies of operation it would appear likely that hollow conductor waveguides operated in the multimode region will find application if their theoretically available transmission capabilities can be realized in practice.

Report on Experiments Concerning Circular Electric Wave Transmission[2]

Some over-all transmission experiments were conducted on a low-loss waveguide line, approximately 500

[1] This conclusion is based on some unpublished analyses made by D. H. Ring and S. Darlington of Bell Telephone Laboratories.

[2] A report on some dominant-wave experimental work in multimode round waveguides was given by A. P. King, "Dominant-wave transmission characteristics of a multimode round waveguide," Proc. I.R.E., vol. 40, pp. 966–969; August, 1952.

feet long. Fig. 7 shows the waveguide installation. The supports for the line were set in concrete and optically aligned so as to provide a waveguide straight within about ⅛ inch over its entire length. The philosophy behind this installation was the familiar one of providing, for experimental purposes, as close to the ideal line as possible so that deviations could be created in a controlled manner. The inside diameter was about 4¾ inches, chosen to obtain the desired theoretical loss of about 2 db per mile at 9,000 mc, where measuring equipment was readily available. Higher frequencies in smaller waveguides would of course be more attractive for commercial use, but this must await the development of suitable electron tubes.

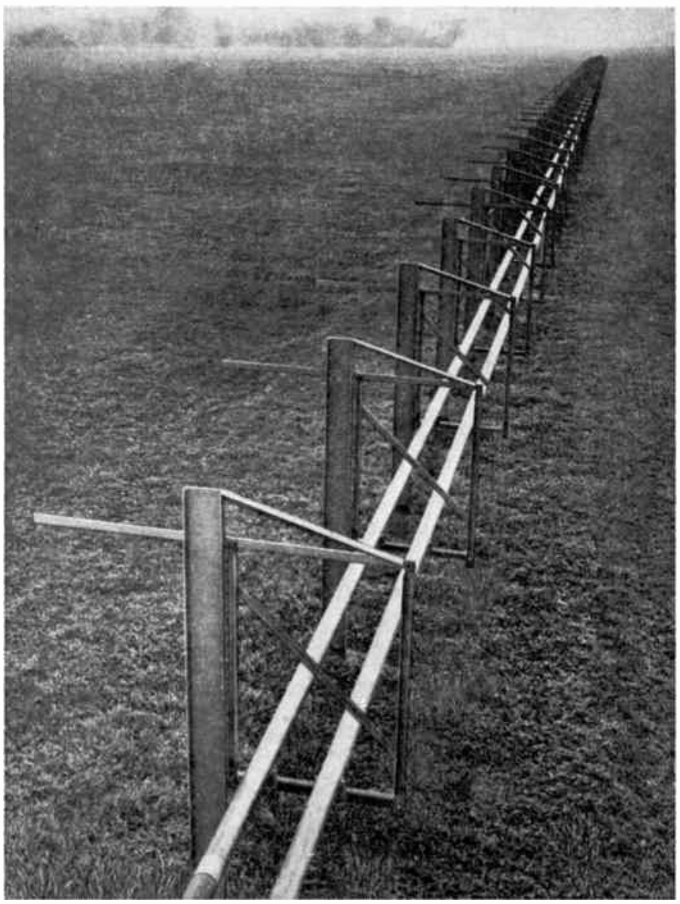

Fig. 7—Installation of 5-inch diameter waveguide line.

The copper tubing employed was produced by a commercial supplier using the manufacturing techniques now standard for precision waveguide.

Fig. 8 shows the layout of equipment used for one type of test conducted on the line. In this test, short bursts of RF energy, approximately 0.1 μsec in duration, were injected into the line at intervals of 300 μsec. Except for two small holes through which to couple to the transmitter and receiver, the waveguide line was short-circuited at both ends. The injected 0.1-μsec pulse occupied at any instant a space interval of 100 feet; therefore, as the pulse traveled from one end to the other between the short circuits, it produced at the receiver coupling hole spurts of energy at the instants when the pulse was passing the sending end. Each time the pulse passed the input end a small amount was

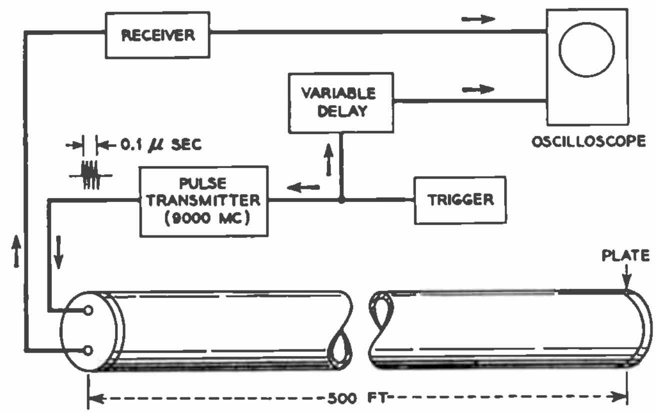

Fig. 8—Diagram of equipment used for pulse transmission tests.

sent to the receiver, amplified, detected, and placed as a vertical deflection on the oscilloscope. The horizontal deflection on the oscilloscope was a linear time base having a duration of a few microseconds. In order to look at the received pulse after a selected number of trips back and forth down the line, a variable delay was placed between the trigger and the oscilloscope's

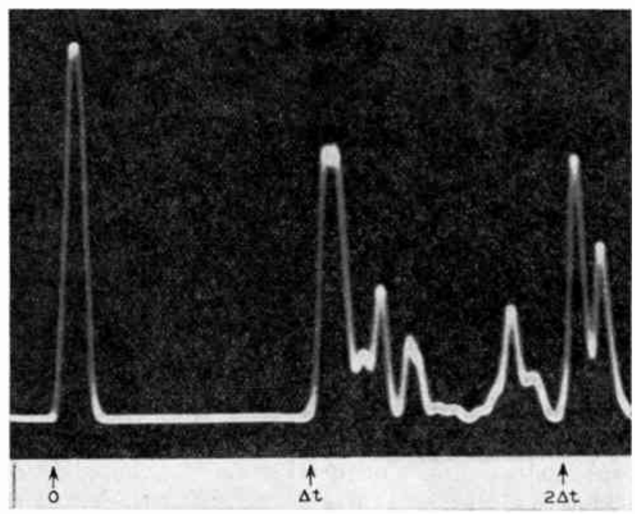

Fig. 9—Photograph of cathode-ray tube presentation during the time interval immediately following the transmitted pulse.

horizontal deflection circuits. Figs. 9–12 show photographs of the oscilloscope under different conditions. It should be noted that the pulse transmitted through the small orifice in the end plate of the waveguide excited a large number of modes. There are, at 9,000 mc, approximately 40 modes which can propagate in this waveguide. It also is known that the coupling through the end-plate holes was so weak and the energy lost due to dissipation in the shorting plates was so small as to represent an attenuation which was negligible compared to the theoretical wall loss in the 500-foot long line. Therefore, as the pulse bounced back and forth in the line, it decayed just as though it had traveled on a straight long section of waveguide made up of 500-foot

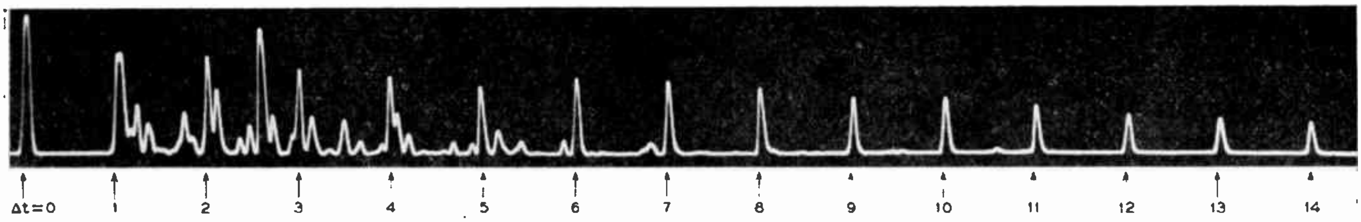

Fig. 10—Same as Fig. 9, except that a longer time interval is shown.

long segments identical to the single 500-foot section actually constructed.

Fig. 9 shows a photograph of the oscilloscope displaying the time interval immediately following the transmitted pulse. The pulse at the extreme left represents the transmitted pulse which passed directly from the transmitter orifice to the receiver orifice on the end plate of the waveguide. The blank time interval immediately following the transmitted pulse is about 1 μsec long and represents the time of travel of energy down to the far end of the 500-foot line and back to the sending end. During this interval no pulses were received because the joints in the line produce little reflection. The first pulse after the transmitted pulse represents energy in the mode which has the highest group velocity. Pulses immediately following this first received pulse represent energy which traveled in other modes whose velocities were lower and which therefore required more time for the one round trip of travel. Beginning at the time $2\Delta t$, there appear received pulses which represent energy which made two round trips in the line. If the transmitted pulse width were short enough, one could theoretically identify the mode in which the energy traveled by observing the time of arrival, since the velocities of propagation and the distance are known parameters. The 0.1-μsec pulse used in these experiments was not short enough to allow this kind of resolution on an individual mode basis. Something on the order of five or six modes had velocities so nearly the same that they could not be resolved on a time basis with the 0.1 μsec pulse and the 500 foot line.

In Fig. 10 the scale of the abscissa was changed so as to show the interval 0 to 14 Δt instead of the interval 0 to $2\Delta t$. Observe that fewer pulses were received in a time interval Δt for increased time delay relative to the transmitted pulse. This is a consequence of the fact that energy traveling in some modes was attenuated more rapidly than that in other modes. For time delays greater than $10\Delta t$ the received pulses appeared at regular intervals and with smoothly decaying amplitude. This behavior indicated that the major portion of the energy in the line was traveling in a single mode, and we deduced that this mode was TE_{01} as follows: We identified the mode as one near the TE_{01} mode in velocity of propagation by measuring the absolute time between pulses (averaged over many round trips) and finding that this period corresponds to the theoretical time of energy travel for one round trip of TE_{01} in the 500-foot line. This excluded all but a few modes whose velocities are nearly that of TE_{01}. Measurements of transmission loss were made by observing the rate of decay of the received pulses averaged over 10 round trips or more. It was found that the loss was about 3 db per mile compared to a theoretical value of approximately 2 db per mile for TE_{01} propagation. This confirmed that propagation was actually taking place in the TE_{01} mode, for all other modes near TE_{01} in velocity have theoretical losses well in excess of the observed value.

In summary of the effects illustrated in Fig. 10, a great many modes including TE_{01} were launched by exciting the waveguide through a small aperture in the end plate. All these modes propagated back and forth in the line for a while, but due to the fact that TE_{01} has appreciably less loss than the other modes the energy which remained in the line after a suitable time delay was substantially all in the TE_{01} mode. This permitted measuring the TE_{01} loss over a distance of many miles by allowing the energy to traverse the 500-foot line many times.

The theoretical loss of the experimental line was about 2 db/mile, and the average observed value was about 50 per cent higher than this. Some of the excess above theoretical was due to roughness of the copper surface on the inner wall of the pipe. Measurements made on a sample of the same waveguide by Tyrrell, and measurements made by Beck and Dawson on wire samples,[8] both show that the surface roughness effects account for ohmic losses 15 to 20 per cent above theoretical. The remainder of the excess above theoretical would therefore appear to be due to mode conversion from TE_{01} to other modes, which is really an energy transformation phenomenon rather than a dissipative phenomenon. Direct measurements to confirm this supposition are described in a later section of this paper.

Questions naturally come to mind in connection with long waveguide propagation possibilities: Will circular electric wave propagation be limited by mode-conversion effects and, if so, at what distance? Will mode conversion cause the shape of a pulse to be distorted beyond recognition? Fig. 11 gives a partial answer to these questions. In Fig. 11 there are shown several successive pulses which traveled up and down the 500-foot waveguide for a total distance of 40 miles. The pulse shape

[8] A. C. Beck and R. W. Dawson, "Conductivity measurements at microwave frequencies," Proc. I.R.E., vol. 38, pp. 1181–1189; October, 1950.

after 40 miles was essentially the same as the transmitted pulse, although thermal noise was clearly visible. One certainly can conclude from this observation that circular electric wave transmission over great distances is possible.

The long waveguide line and associated pulse transmitting and receiving equipment also provided a very convenient way of demonstrating additional mode transmission effects. For example, in a multimode medium

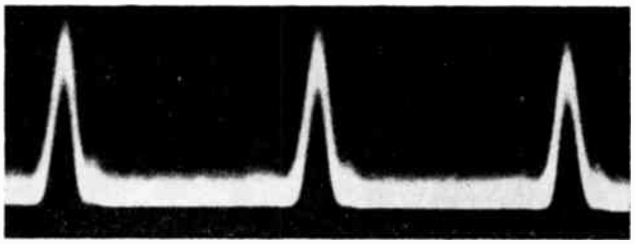

Fig. 11—Record of pulses after 40 miles of repeated traversal over the 500-foot line.

one may use mode filters. One such filter may have a very low loss for the circular electric waves but very high loss to other waves. Such mode filters have been built and Fig. 12 shows the transmission changes which resulted when one was introduced into the experimental line. The upper half of Fig. 12 shows the time interval 0 to 11Δt with no mode filter in the line. When the mode filter was introduced into the waveguide, the received signal changed to that shown in the lower half of Fig. 12. The energy in the undesired modes largely disappeared; it was absorbed by the mode filter.

There are a few small pulses in the lower half of Fig. 12 which cannot be in the TE_{01} mode because of their time position. Starting at time 1.15Δt there is a series of regularly spaced pulses in Fig. 12 labeled TE_{02}, and a single small pulse labeled TE_{03}. The geometric placement of resistive material in the mode filter used lead us to anticipate low losses for the entire circular electric (TE_{0n}) family of modes, and, therefore, the extra pulses were suspected of being in higher-order circular electric modes. The TE_{03} pulse was tentatively identified by noting that its group velocity was 55 to 60 per cent of that of the TE_{01} pulses. High attenuation in the TE_{03} mode prevented additional TE_{03} pulses from being observed.

In the case of the TE_{02} series of pulses, it was possible to get a fairly accurate measure of relative group velocity, confirming the identification as TE_{02}. Note that the seventh TE_{01} pulse coincides with the sixth TE_{02} pulse, and that the pulse at 7Δt shows on the TE_{01} train as being too large in amplitude.

For the lower half of Fig. 12 with the mode filter in the waveguide, the TE_{01} train shows a smoothly decaying amplitude characteristic in the region 0 to 10Δt (with the exception of the situation at 7Δt as already described); whereas, in the upper half of Fig. 12 for which no mode filter was used, the series of TE_{01} pulses show rather marked deviations from a smoothly decaying wave in the 0 to 10Δt time interval. The latter is due of course to the presence of energy in the line in undesired modes.

Mode Filters and Transducers

Filters which selectively attenuate certain modes while passing others, as just described, are expected to be an essential part of a circular electric wave transmission system. Fig. 13 is a photograph of some of the circular electric mode filters[4] used in the work being described in this paper. A series of resistive sheets, located radially in the waveguide, formed a resistance path perpendicular to the electric field of the TE_{01} wave. Any wave except TE_{0n} had an electric field along the resistance path and was attenuated. At 9,000 mc, this fil-

[4] Mode filters of the type shown were first made by A. P. King of the Bell Telephone Laboratories, Inc.

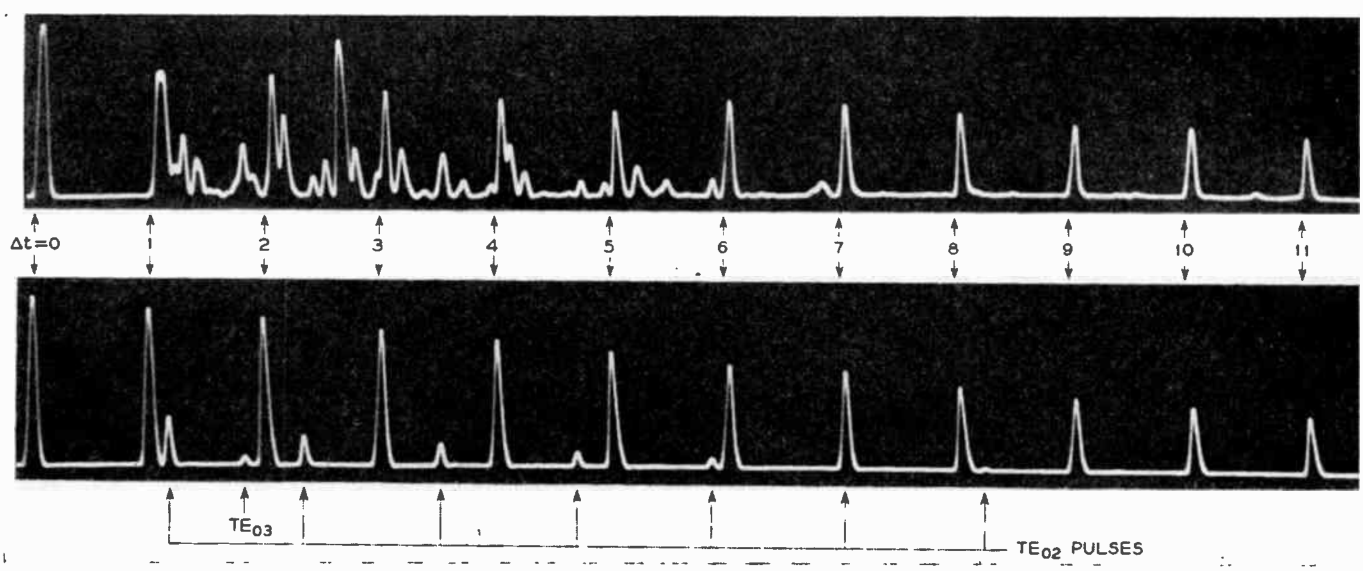

Fig. 12—The effect of a mode filter on transmission in the 500-foot line. The unlabeled pulses in the lower part are in the TE_{01} mode.

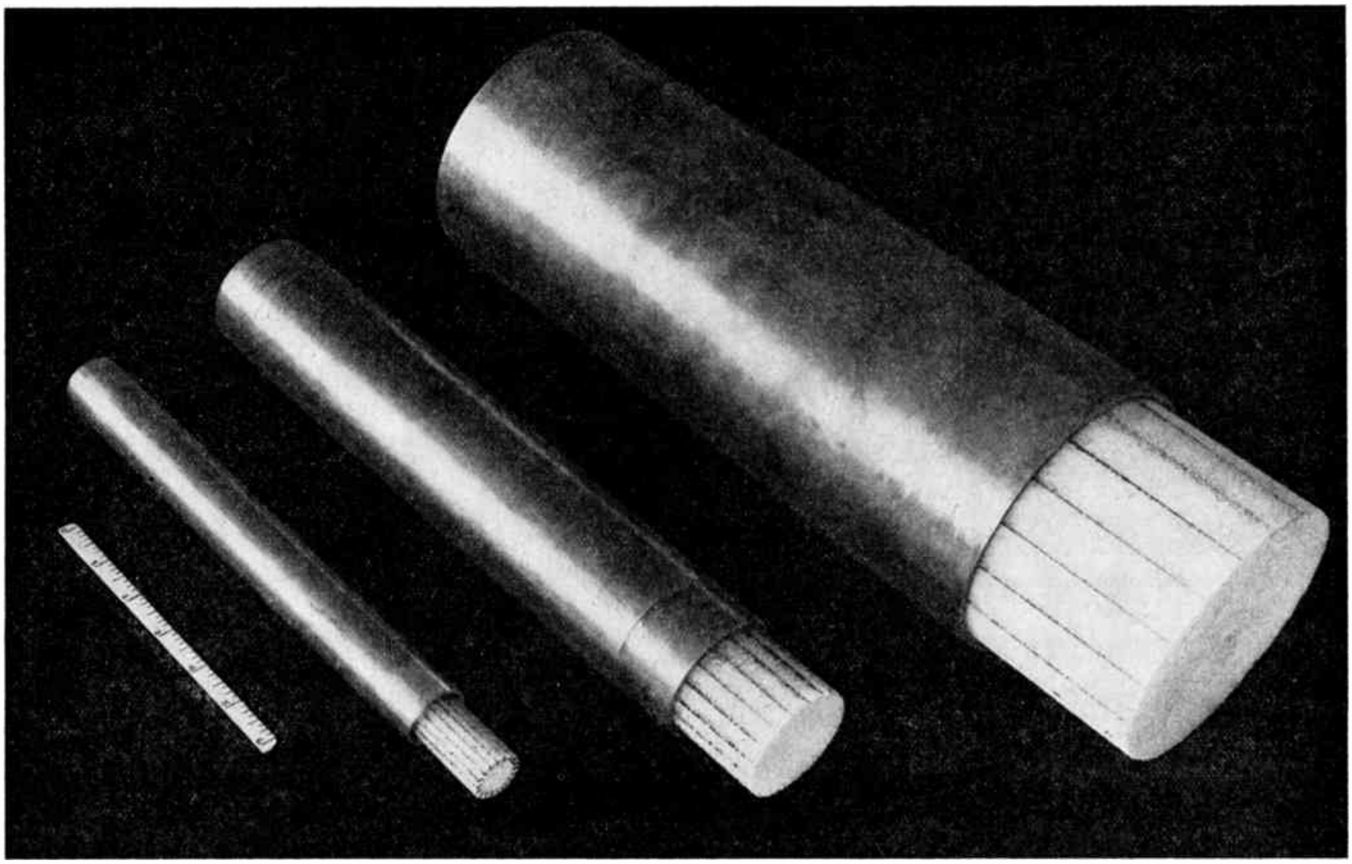

Fig. 13—Mode filters which pass only circular electric waves.

ter presented a loss to the TE_{01} wave of less than 0.05 db and losses to some of the other waves in excess of 20 db.

A circular electric wave transducer having high efficiency is very important in the use of circular electric waves for communication purposes, and is extremely useful in making certain measurements on the line. Fig. 14 shows one way of producing the TE_{01} wave over a very broad band.[6] The input to the transducer is on one rectangular single-mode guide. The internal cross section of the rectangular guide is first flared to a triangle, then the triangle is gradually opened to form the circle. The combination of the transducer of Fig. 14 and mode filters of Fig. 13 has produced the circular electric wave with undesired mode components at least 40 db down, and with an over-all transfer loss of less than 0.5 db.

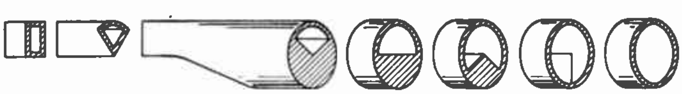

Fig. 14—Circular electric wave transducer. $TE_{1,0}\square - TE_{01}\bigcirc$ transducer.

It is important to be able to transform energy from a dominant mode rectangular guide to any *one* of the modes of the multimode guide without appreciable coupling to the other modes. Fig. 15 illustrates a very versatile means for accomplishing such mode transformations. Two parallel transmission lines are coupled together over a length interval which typically could be 0.5 to 20 wavelengths long. The phase constant of the dominant mode rectangular line is made equal to the phase constant of the desired mode of the multimode line. Under

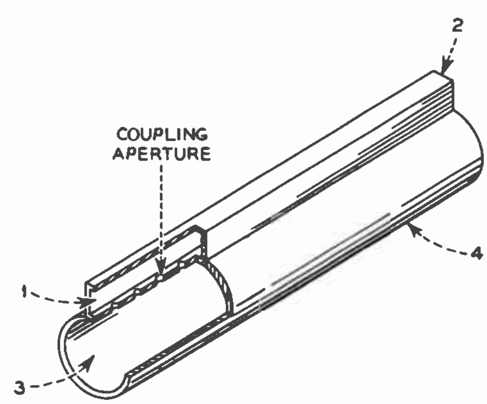

Fig. 15—Coupled wave transducer.

these circumstances the over-all power transfer which takes place is predominantly in the single mode of the multimode line whose phase constant is matched by that of the dominant mode line. Energy in other modes of the multimode line passes by the coupling array without appreciable effect. In the single mode selected, the device may also be made directional, with significant

[6] A. P. King was responsible for the first transducer of this kind in these Laboratories. Later we learned of a similar device described by Jean Ortusi, "Les Conditions de Propagation de L'onde H_0 et ses Applications," *Ann. Radioelect.*, pp. 95–116; April, 1949.

energy transfer occurring only between terminals 1 and 4 or 2 and 3. Devices of this form, called "coupled-wave transducers," were built as loose coupling devices or as high-efficiency transducers (having transfer losses in the 0.2- to 0.75-db region) for a variety of modes including TE_{01}, TM_{11}, and TE_{11} of round waveguide.[6]

Some Effects of Taper Transitions

The 500-foot line, in combination with the equipment layout sketched in Fig. 16, has been used to demonstrate some higher-order mode effects associated with taper transitions. It was convenient to generate the circular electric wave in a waveguide which can support a relatively small number of modes, that is, a round waveguide smaller than that used for transmission purposes.

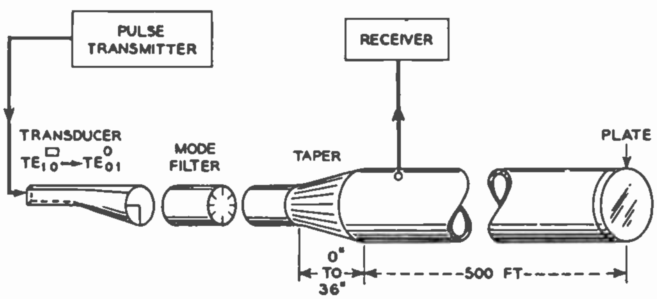

Fig. 16—Equipment layout for pulse measurement of mode conversion in a taper.

This is illustrated on the left side of Fig. 16. The taper transition from the small to the larger round guide must be designed with regard to both reflection effects and mode-conversion effects. With pure TE_{01} excitation, the taper introduces higher-order circular modes. To demonstrate this effect, a pure TE_{01} wave was propagated into the taper and the resultant wave traveled down the 500-foot line and back to the receiver. The energy which converted from the TE_{01} wave to the TE_{02} or TE_{03} wave in the taper traveled at a lower velocity than the energy in the TE_{01} wave. Therefore, after reflection from the far end of the line the energy present in TE_{02} and TE_{03} waves arrived back at the receiver later than the energy which traveled in the TE_{01} mode. Thus it was possible to observe the mode-conversion effects due to the taper.

Fig. 17 illustrates these effects. The top left trace shows the received signal when no taper was used; the second trace on the left shows the received signal when a 6-inch taper was used, and so forth. The first pulse after the transmitted pulse represents energy in the TE_{01} mode, and the next one energy in the TE_{02} mode, as marked. The receiver pick up was not equally sensitive to TE_{01} and TE_{02}, and, therefore, the relative pulse magnitudes shown are not true comparisons of powers in the two modes. However, the receiver sensitivity was maintained constant as the taper length was changed, so the changes in relative pulse magnitudes for different taper lengths directly indicate the changes in mode conversion. Fig. 17 demonstrates that an increase of taper length decreased the amount of mode conversion, and that even with a 24-inch taper the conversion to TE_{02} is not negligible.

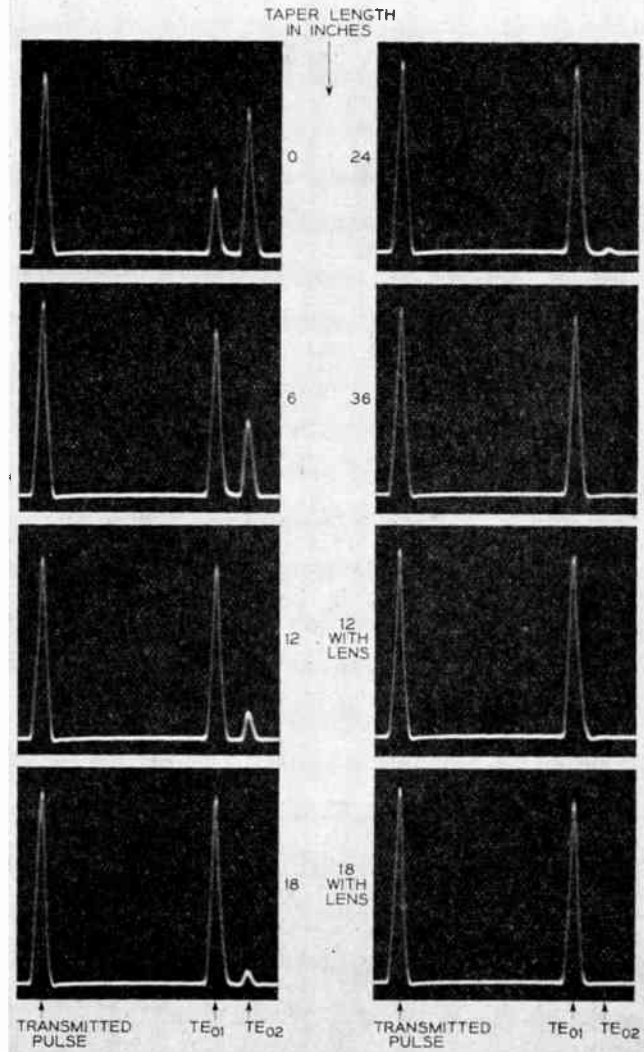

Fig. 17—Photographs showing observed effects of mode conversion in a taper, and the improvement when using a suitable lens.

Mode conversion in a taper can be made tolerably small by using a long taper or, instead, a short taper may be corrected by means of a lens. The latter approach has also been used successfully, as illustrated in Fig. 17. The lower two traces on the right show the received signal when lenses constructed from a design worked out by Morgan were added to the same tapers which, when used without correcting lenses, gave the corresponding left-hand traces. Reduction in TE_{02} conversion obtained by using such lenses is very evident when comparing the lower left-hand and right-hand traces in Fig. 17.

CW Loss Measurements

Loss measurements were made on the 500-foot line using cw instead of a pulsed source, in this case exciting the line alternately with the dominant wave (TE_{11}) or

[6] S. E. Miller, "Some Coupled Wave Theory and Application to Waveguides," to be submitted to Proc. I.R.E.

with the circular electric wave. This type of measurement was not as accurate as the pulse measurement because the round-trip loss of the 500-foot line is on the order of ½ db and small errors cause appreciable percentage deviations. In the measurements, the cw power input to the line was used as a reference by closing the shorting switch (Fig. 18) and the magnitude of the wave

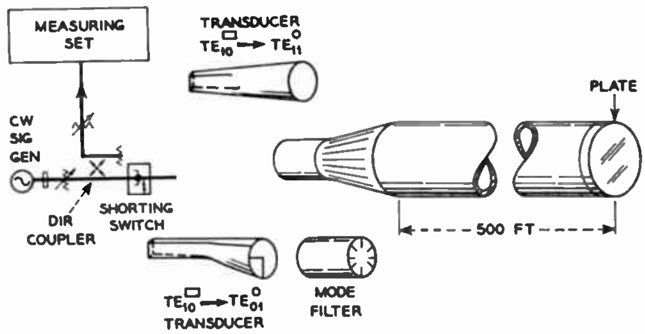

Fig. 18—Equipment layout for cw measurement of transmission loss.

reflected back to the measuring set was observed. Then the shorting switch was opened, and the energy allowed to propagate through the transducer down to the end of the line, back through the transducer again, and thence to the measuring set. The difference between these readings was twice the sum of transducer plus line loss, and by making a separate measurement of transducer loss the line loss was determined. The results of measuring the line in this manner are shown in Fig. 19.

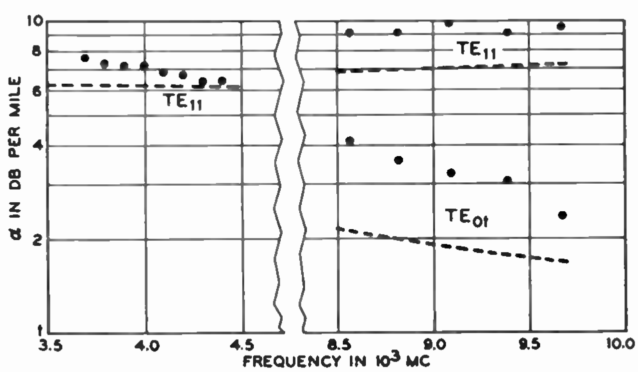

Fig. 19—Theoretical and cw observations of loss for the 500-foot waveguide.

The theoretical loss for the dominant wave TE_{11} and for the circular electric wave TE_{01} are shown by the broken lines. The observations are represented by plotted points. Comparison of the theoretical and observed losses indicates that the excess above theoretical is on the order of 25 to 80 per cent in the 9,000-mc region, and somewhat less in the 4,000-mc region. The work of Tyrrell, Beck, and Dawson leads one to expect losses on the order of 15 or 20 per cent above theoretical due to surface roughness in the 9,000-mc region, thus suggesting that the remainder may be due to mode conversion. Furthermore, the observed variation in circular electric wave loss versus frequency is also larger than the theoretical variation as a consequence of a mode-conversion phenomena. It is important to indicate the mechanism involved in this effect.

Fig. 20 shows a hypothetical piece of waveguide containing two similar small deformities. A pure circular electric wave is assumed propagated toward the first deformity, beyond which there will be some energy present in some other mode, designated as TX_1 in Fig. 20. When this complex wave strikes the second deformity, another conversion takes place and the output will now be a large TE_{01} wave component, the two smaller components in the undesired mode, TX_1 and TX_2, and a still smaller circular electric wave component, TE_{01}', which is due to reconversion of the energy from TX_1 to the circular electric wave in traversing the second deformity. This latter reconversion occurs with very significant results. It can be shown that for the proper distance between two *identical* symmetrical deformities the wave coming out is *entirely* pure circular electric. Another separation between the deformities will result in a maximum energy transfer from circular electric to the other mode. Therefore, any mechanism which varies the effective spacing between conversion points will produce

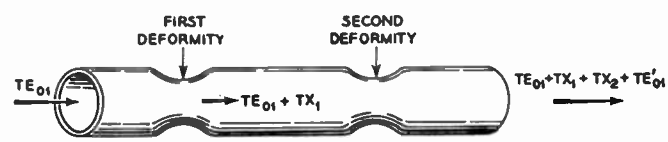

Fig. 20—A hypothetical distorted waveguide and the associated mode-conversion, signal-loss effects.

a TE_{01} insertion-loss variation. This effect was observed on the 500-foot line (1) by varying frequency and (2) by varying the physical length of the line in the pulse-type loss measurement.

It is important to note that if a mode filter is placed between the two deformities of Fig. 20, the component TX_1 will be removed and therefore the component TE_{01}' at the output of the second deformity must be zero. For this idealized case of a mode filter between each deformity there is no effect due to the phasing of the deformities. We would expect, therefore, in a practical line, that if we observed the loss variation as we changed the electrical spacing between the conversion points, then the variation in loss should be smaller with a mode

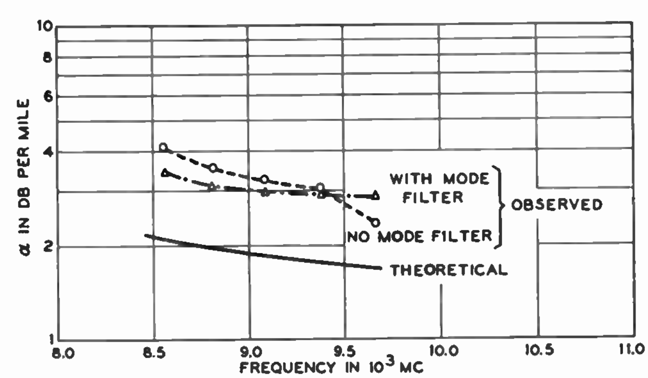

Fig. 21—The effect of a mode filter on the observed cw TE_{01} loss versus frequency characteristic.

filter than without it because the mode filter would absorb some of the unwanted wave components before they could be reconverted into the circular electric wave. This experiment was done with the results as follows:

Fig. 21 shows the results of measuring the TE_{01} loss by the cw method in the 9,000-mc region with and without the mode filter. No correction was made for the mode filter loss; it was included in the plotted values. This shows quite clearly that the mode filter can reduce the circular electric wave loss and also that it has the effect of smoothing out the variation in loss which, in this case, is shown as a function of frequency.

The Effect of Mode Conversion in Producing Signal Distortion

Mode-conversion phenomena can also produce a signal-interference effect. Fig. 22 shows another hypothetical waveguide containing two deformations, but in this case the distance between the deformations may be

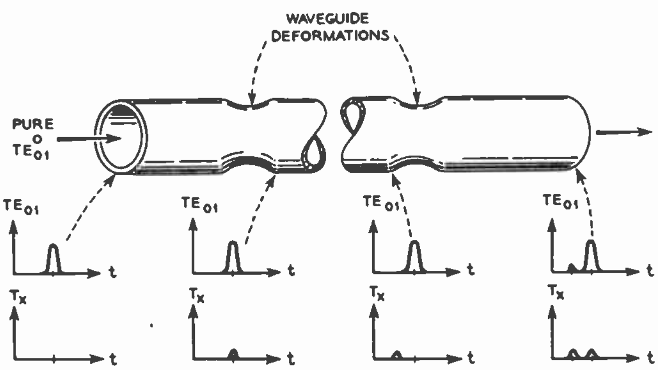

Fig. 22—Signal interference effects due to mode conversion and reconversion.

great, perhaps hundreds of feet. A pure TE_{01} wave is assumed propagated into the line, and on striking the first deformity, a small component is produced in some undesired mode designated T_x. In the waveguide adjacent to the first deformity the TE_{01} pulse and the T_x pulse appear at the same instant of time since the latter was derived from the former. This situation is sketched in the second pair of amplitude-time diagrams of Fig. 22. These two wave components are now allowed to propagate for some distance, and because of a difference between their velocities of propagation they will arrive at the second deformity at different times. This situation is illustrated in the third pair of amplitude-time diagrams of Fig. 22. Now, on passing through the second deformity, the reconversion which takes place from the undesired wave back to the circular electric wave produces a signal in the circular electric wave which occurs at a different time than the signal which came straight through without conversion. Because there are some modes with a velocity faster than that of the circular electric wave, these interference pulses may precede the signal pulse itself, as well as lag it. When the distance between deformities is too short for the pulses to be resolved at the second deformation, the result will be a distortion of the wave, of course, rather than separate pulses. The general subject of signal distortion due to mode conversion in a multimode medium is an interesting one on which considerable work has already been done.

Direct Measurement of Mode Conversion

Mode conversion effects in the line have also been measured directly.[7] Fig. 23 shows the general arrangement. A pure circular electric wave was introduced at

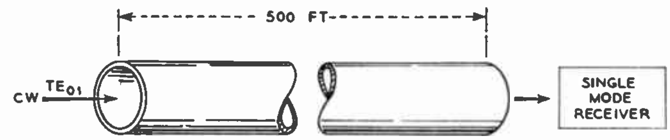

Fig. 23—Equipment layout for the direct measurement of mode conversion.

one end of the line and at the far end of the line a single-mode receiver was arranged to accept one mode at a time from the output. Coupled wave transducers of the general type shown in Fig. 15 were very useful in this measurement. A reference reading of the TE_{01} output of the line was taken. The power received in other modes was recorded relative to the TE_{01} output. Since the loss in the line was a small fraction of a db for the circular electric wave and only a few db for the other modes, the comparison of the TE_{01} output with other mode outputs yields a good order of magnitude indication of the mode conversion effects. The results of the measurement are shown in Fig. 24. The ordinate in this chart is the absolute magnitude of the undesired mode power at the

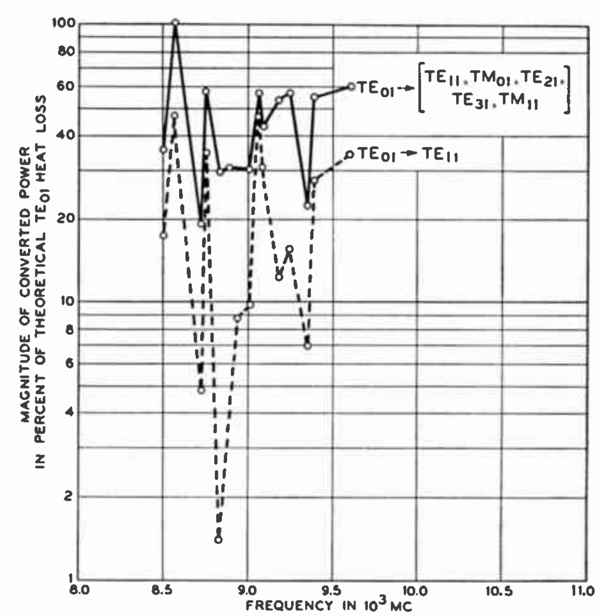

Fig. 24—Observed mode conversion in the 500-foot line.

[7] This work was carried out jointly by A. C. Beck and M. Aronoff of Bell Telephone Laboratories.

end of the line, expressed as a percentage of the theoretical heat loss power of the TE_{01} wave for the 500 feet. That is, a reading of 100 per cent means that the power converted from TE_{01} to the given mode is exactly equal to the power theoretically lost by the TE_{01} wave in traveling through a geometrically perfect, smooth-walled 500-foot section of line. This scale provides a direct indication of the significance of the mode conversion as influencing transmission loss. Measurements were made to evaluate conversion to the TE_{11}, TM_{01}, TE_{21}, TM_{11}, and TE_{31} modes. The dotted curve of Fig. 24 represents a typical individual mode conversion measurement, in this case TE_{01} to TE_{11}. The solid curve is the sum of the individual measurements of conversion from TE_{01} to the modes listed. The variation in magnitude (see Fig. 24) is due to phasing of the conversions from a number of points. Very small indicated percentages of mode output for these modes at certain frequencies probably does not mean lack of mode conversion, but rather a partial cancellation of the multiplicity of conversions in that mode.

Using the probe technique of evaluating mode conversion effects, as reported previously,[8] Aronoff determined that the modes represented in Fig. 24 are probably the principal ones in which significant mode conversion takes place. More precisely, the probe measurements indicate that conversion from TE_{01} to the TE_{mn} and TM_{mn} modes is confined to those modes of index m between one and four.

The Bend Problem

It is familiar to those who have thought about using the circular electric wave that there is a problem associated with transmitting this wave around bends.[9,10,11] The problem stems from the fact that there is a degeneracy between the TE_{01} and TM_{11} modes in straight round waveguide. A deviation from straightness, as in a bend, causes mode conversion no matter how gradually the bend takes place.

A detailed discussion of some solutions to this problem is given in another paper.[12] It is noted that the form of the waveguide may be altered so as to remove the degeneracy between TE_{01} and TM_{11}. An alternative is to convert the circular electric wave into a normal mode of the bent round guide at both ends of the bend. Finally, dissipation in the unwanted modes may be used to inhibit the mode conversion tendency and thereby avoid loss in the bend. Experimental work has been carried out on several of these band solutions, by King at 9,000 mc and by Fox at 48,000 mc, with the conclusion that circular electric waves can be transmitted around arbitrary bends with very low losses.

Experimental work has also been carried out, by Beck on the 500-foot line and by King on a smaller diameter line, to test the theoretical predictions of TE_{01} behavior in bent round waveguide. This work may be reported in later papers. Broadly, the experimental results were in good agreement with theory.

Conclusion

In order to reduce the theoretical heat losses of hollow metallic waveguides to 0.25 db/100 feet at frequencies above about 2,000 mc, it is necessary to use the guide as a multimode medium. At frequencies above about 10,000 mc the circular electric mode in round metallic tubing becomes more attractive than the dominant mode because it provides a medium with the 0.25 db/100 feet loss in a smaller space.

Using the circular electric wave, theoretical heat losses of 2 db/mile are associated with tubing diameter of 2 to 6 inches and carrier frequencies between 50,000 and 5,500 mc, respectively. Increased transmission bandwidth, reduced delay distortion, and reduced waveguide size are factors favoring use of the highest practical frequency of operation. The number of freely propagating modes lies in the range 175 to 20 for the 2- to 6-inch diameter region.

Experimental work has been carried out at 9,000 mc on a waveguide having a theoretical loss of 2 db per mile for the TE_{01} wave. Transmission losses on the order of 3 db per mile over distances as great as 40 miles, with tolerable signal distortion of a 0.1-μsec pulse, have been observed on a well-constructed line. Techniques for mode filtering and pure mode generation were described and some performance characteristics given.

The problem of transmitting the circular electric wave around bends may be solved by altering the form of the wave in the bend region or by altering the waveguide itself. Experimental work has demonstrated the feasibility of transmitting the TE_{01} wave around bends.

Mode conversion tends to degrade signal fidelity as well as increase the transmission loss. Mode filtering can be used to reduce signal distortion due to mode conversion and to smooth out the loss variations due to mode conversion.

Acknowledgment

The authors are indebted to many of their co-workers at Holmdel for suggestions, for stimulating discussions, and in addition, for numerous new components as already noted. The foresight and encouragement of Ralph Bown and Harald T. Friis is gratefully acknowledged.

[8] M. Aronoff, "Radial probe measurements of mode conversion in large round waveguide with TE_{01} mode excitation," submitted to Proc. I.R.E.

[9] M. Jouguet, "Effects of the curvature on the propagation of electromagnetic waves in guides of circular cross-section," *Cables and Trans.* (Paris), vol. 1, no. 2, pp. 133–153; July, 1947.

[10] W. J. Albersheim, "Propagation of TE_{01} Waves in Curved Waveguides," *Bell Sys. Tech. Jour.*, vol. 28, January, 1949.

[11] M. Jouguet, "Wave Propagation in Nearly Circular Waveguides: Transmission-Over-Bends Devices for H_0 Waves," *Cables and Trans.* (Paris), vol. 2, no. 4, pp. 257–284; October, 1948.

[12] S. E. Miller, "Notes on methods of transmitting the circular electric wave around bends," Proc. I.R.E., vol. 40, pp. 1104–1113; September, 1952.

Analysis of Measurements on Magnetic Ferrites*

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***Summary*—The unconventional behavior of permeability and core loss in the magnetic ferrites as compared to metals has led to a study of core-loss measurements. The relationships between the magnetic quality factor μQ and the characteristics of coils and transformers are developed, and the advantages of μQ as a parameter for the study and application of ferrites are discussed. A selected bibliography is given.**

Introduction

During the past few years, a new and important family of engineering materials known as magnetic ferrites has been developed and made available for design applications. These ferrites combine magnetic, electric, and dielectric properties never before realized in one material. For this reason new criteria for evaluating their properties and performance are needed. The purpose of this paper is to review the characteristics of the ferrites which distinguish them from other magnetic materials, to point out resonance-type phenomena associated with frequency and dimensions which affect their practical operation, to indicate the effects of the different properties on measurement techniques, and to show the advantages of expressing the magnetic data in the form of the μQ product for the engineer designing telephone-carrier or radio-frequency coils and transformers.

General Properties and Uses of Ferrites

Chemically, the magnetic ferrites are a modern derivation of magnetite, the oldest magnetic material known; they are achieved when certain iron atoms in the cubic crystal of magnetite (ferrous ferrite) are replaced by other metal atoms, such as Mn and Zn to form manganese zinc ferrite, or by Ni and Zn to form nickel zinc ferrite.[1] They resemble ceramic materials in production processes and physical properties. Ferrite cores are manufactured in many simple geometric forms, some of which are shown in Fig. 1. The dc resistivities correspond to those of semiconductors, being at least a million times those of metals. The magnetic permeabilities up to over 4,000 formerly were realized only in metallic cores. In addition, some ferrites exhibit apparent dielectric constants in excess of 100,000. The Curie point, or temperature above which a material is nonmagnetic, is in the range of 100 to 300 degrees C in most of the commercial ferrites. The saturation flux densities also are comparatively low, usually under 4,000 gausses (see Fig. 2).

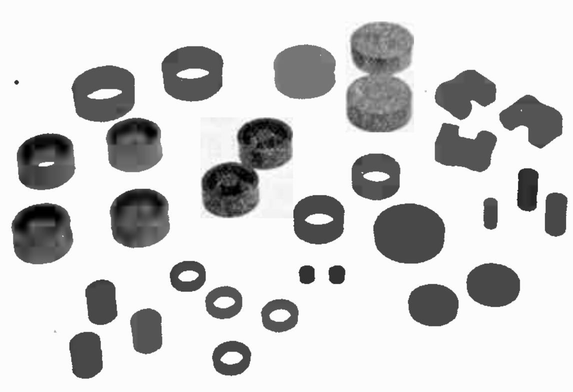

Fig. 1—Core parts of manganese zinc ferrite produced at Bell Telephone Laboratories for experimental apparatus design studies.

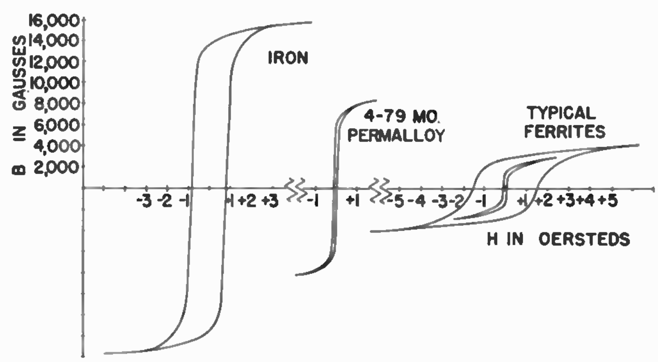

Fig. 2—Hysteresis loops of iron, Permalloy, and typical ferrites. The thin ferrite loop was taken on a MnZn ferrite while the other represents a NiZn ferrite.

The present magnetic ferrites, principally MnZn and NiZn types, provide design advantages over metal sheet and powder for such uses as filter coils at 50 to 200 kc, broad-band-carrier transformers operating up to a few megacycles, TV deflection transformers and yokes, and antenna rods for radio reception. There are many potential applications, some of which are pulse and high-frequency transformers, magnetic amplifiers, delay lines, miniature components, and waveguide elements at microwave frequencies, including the gyrator[2] recently announced.

Role of Magnetic Measurements

Coil design engineers make use of the permeability of a magnetic material to provide a positive reactance in a winding on a core. The magnetic material, however, extracts a toll for this service in the nature of an energy loss, which can be represented as a core-loss resistance in series with the reactance. The ratio of the reactance

* Decimal classification: R282.3. Original manuscript received by the Institute, March 18, 1952; revised manuscript received August 29, 1952. This paper was presented at the 1952 IRE National Convention.
† Bell Telephone Laboratories, Inc., Murray Hill, N. J.

[1] J. L. Snoek, "Nonmetallic magnetic materials for high frequencies," *Philips Tech. Rev.*, vol. 8, pp. 353–360; December, 1946.

[2] C. L. Hogan, "The ferromagnetic Faraday effect at microwave frequencies and its applications—the microwave gyrator," *Bell Sys. Tech. Jour.*, vol. 31, pp. 1–31; January, 1952.

to the magnetic core-loss resistance is a figure of merit, conveniently called material Q. The engineer desires high permeability, high material Q and high stability of these properties with temperature, frequency, flux density, superposed dc fields, and time. Since optimum values of all of these properties do not occur together, he needs to know their values and interrelationships. It is important for manufacturers and design engineers alike that there be standard measuring techniques and methods of expressing magnetic-loss data.

As iron, silicon iron, nickel-iron, and other alloys in sheet and powdered forms, and now ferrites have become available, design applications have multiplied and progressively moved toward higher frequencies; magnetic measurements have become more complex in technique and interpretation, and a more comprehensive theory of the mechanisms of magnetism has been evolved. Table I outlines some of the interrelated developments in regard to core-loss measurements. The

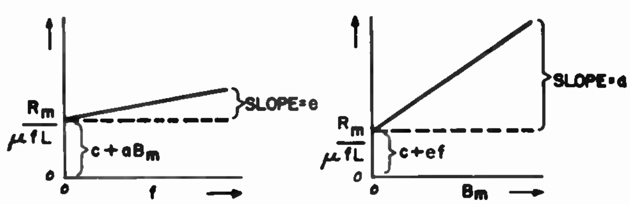

Fig. 3—Graphical separation of core-loss coefficients.

development of lower loss materials and improvements in ac impedance bridges enabled Jordan[3] (in 1924) and others to measure a "Nachwirkung" or "residual" loss in magnetic materials after eddy current and hysteresis losses were carefully accounted for. These three magnetic losses are combined as an equivalent series resistance by the well-known Legg equation,[4]

$$R_m = e\mu f^2 L + a\mu B_m fL + c\mu fL. \quad (1)$$

Core loss (ohms) = eddy current + hysteresis + residual losses.

Coefficients e, a, and c can be determined graphically (see Fig. 3). Comparative values for the coefficients and losses of several materials are shown in Fig. 4.

MATERIAL	SIZE	μ	$e\times10^9$	$a\times10^6$	$c\times10^6$
1. MO. PERMALLOY POWDER	120 MESH	125	19.	1.6	30
2. MO. PERMALLOY POWDER	400 MESH	14	7.	11.	140
3. CARBONYL IRON POWDER	5 MICRON	13	1.	5.	60
4. Mn Zn FERRITE		1500	.3	1.6	48 (100 KC) 550 (1000 KC)
5. Ni Zn FERRITE (REF. 5)		280	.3	50.	115 (UP TO (APPROX. 1000 KC)
6. 4-79 MO. PERMALLOY	1 MIL SHEET	13000	10.	.2	NEGLIGIBLE

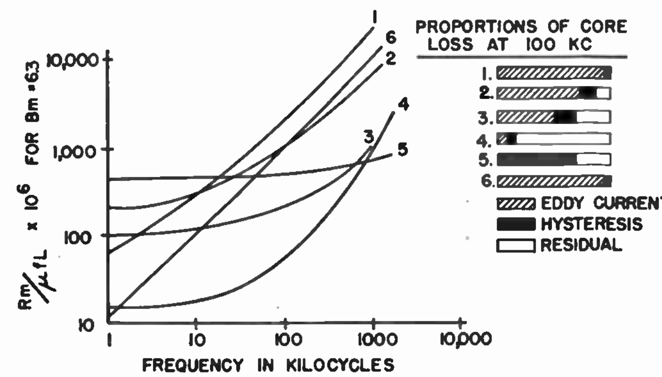

Fig. 4—Comparison of core-loss characteristics of several magnetic materials. Note log scales not suitable for core-loss separation.

When the magnetic losses in ferrites are analyzed (see (1)), it is found that the loss per cycle increases with ascending frequencies at a more rapid rate than indicated from eddy current calculations based on dc resistivity. The plot of $R_m/\mu fL$ versus frequency (see Fig. 3) is not straight, but curves upward at a rate

TABLE I

Outline Illustrating Related Development Progress in Magnetic Materials, Applications, Techniques of Core Loss Measurements, and Theory of Mechanisms Involved

Typical Material	*Typical Application*	*Factors in Magnetic Loss*	*Units*	*Typical Frequency (cps)*	*Measurement Method*	*Core Loss Equation*
Iron	relays	hysteresis	ergs/cm³ per cycle	dc	ballistic galvanometer	$W_h = \frac{1}{4\pi}\oint Hdb$ per cycle
Silicon iron sheet	transformers	eddy current + hysteresis	watts/lb.	60	wattmeter	$W = \eta v f B^w + \gamma v f^2 B^2$
Iron powder	loading coils	eddy current + hysteresis	ohms	1,000	impedance bridge	$\frac{R_t}{fL} = 8\pi\mu(\eta B^{z-2} + \gamma f)$
Permalloy & fine iron powders	filter coils loading coils tuning coils	eddy current + hysteresis + residual	ohms	500 to 500,000	impedence bridge Q-meter	$\frac{R_m}{fL} = \mu(ef + aB_m + c)$
Ferrite	filter coils transformers	eddy current +hysteresis +domain wall relaxation +domain wall resonance +dimensional resonance +ferromagnetic resonance		10^3 to 10^7	impedance bridge LC circuits Q-meter coaxial line waveguide	μQ (See text)

[3] H. Jordan, "Ferromagnetic constants for weak fields," *Elek. Nach. Tech.*, vol. 1, pp. 7–29; July, 1950.

[4] V. E. Legg, "Magnetic measurements at low flux densities using the ac bridge," *Bell Sys. Tech. Jour.*, vol. 15, pp. 39–62; 1936.

[5] R. L. Harvey, I. J. Hegyi, and H. W. Leverenz, "Ferromagnetic spinels for radio frequencies," *RCA Rev.*, vol. 11, pp. 321–363; September, 1950.

which increases rapidly with frequency and depends somewhat on the type and size of sample. Thus, the "residual" loss appears to predominate at high frequencies and the coefficient c is dependent upon frequency. In design work, it becomes necessary to confirm computations based on (1) with actual measurements of core losses, particularly at higher frequencies.

The rapid rise in core loss in the ferrites is also associated with a rapid decline in permeability. These behaviors in the ferrites have stimulated many studies to explain the mechanisms involved, and to derive practical expressions for permeability and core loss.

Mechanisms of Magnetism Contributing to Core Loss

Ferromagnetic Resonance

Snoek,[6] Kittel,[7] and others advanced an explanation that the occurrence of ferromagnetic resonance, well known at microwave frequencies, could account for the behavior observed in ferrites at lower frequencies, even at 1 mc or less. This resonance phenomenon is associated with the precession of magnetic dipoles about a self-contained crystal field when an ac field of appropriate frequency is applied. Kittel has derived a theoretical relationship

$$f_0 \approx \frac{2Bs}{\mu_{rf} - 1} mc, \quad (2)$$

which expresses the "maximum usable frequency" f_0 as proportional to the saturation-flux density and inversely related to the effective high-frequency permeability μ_{rf}. Here, μ_{rf} is assumed to be due to the rotation of magnetization within the domains only, and does not include contributions to permeability from displacements of domain boundaries, which will be discussed later.

The inverse frequency permeability relationship of (2) has been borne out generally by measurements. For manganese zinc ferrite with a measured permeability of 1,500 at 1 mc and a saturation value of about 2,500 gausses, the theoretical limit is approximately 3 mc while the working limit in most practical designs is somewhat lower.

Domain Wall Motion

The domain theory of magnetism ascribes the principal source of initial permeability in metals to the movement of domain walls to enlarge favorably oriented domains. In ferrites, the wall motion may be restricted severely by impurities, voids, and crystal imperfections including grain boundaries. However, where wall motion exists, it may be described by the equations of a damped simple harmonic oscillator with mass, stiffness, and viscous damping. Depending on the values of these coefficients, the wall motion may "relax" above a certain frequency, producing a decrease in permeability and an increase in core loss. On the other hand, under proper conditions the wall could show resonance like an RLC circuit, resulting in anomalous behavior of the magnetic properties.

Dimensional Resonance

Measurements on ferrite also have revealed that the dimensions of the sample can have a marked effect on permeability and core loss, unpredicted from usual eddy current computations. Brockman, Dowling, and Steneck,[8] observing such effects on bricks of manganese zinc ferrite, proposed an explanation based on dimensional resonance associated with standing electromagnetic waves supported by high permeability and the high dielectric constant of the material.

Combined Effects

In developing theoretical curves of permeability and associated magnetic losses over a wide frequency range, Galt[9] has pictured the components of domain-wall relaxation and resonance, ferromagnetic resonance, and dimensional resonance as occurring at separated frequencies for purposes of clarity. In practice, these effects may overlap and combine in various combinations, even at low frequencies, complicating the efforts to express the magnetic data into simple material constants of more than restricted use.

μQ as a Useful Design Parameter

While the core loss (1) can be modified to fit the data measured on a particular core by using additional terms in higher powers of frequency, it becomes cumbersome for general use. As mentioned before, it is preferable generally to resort to confirmatory measurements at frequencies where (1) is no longer reliable. In fact, experience in the design of coils and transformers for use up to a few megacycles, as well as development studies in ferrites, has indicated that the measurement of permeability and total losses over a suitable range of frequencies, temperatures, flux densities, and dimensions provides the most reliable basic data.

The product $\mu_m Q_m$ has advantages as a parameter for evaluating ferrites for design application. Here, Q_m is the quality factor of the material and μ_m is the permeability measured on a closed ferrite core. With air gaps in the core, new values of effective permeability μ_e and Q_e will be obtained, but the product $\mu_e Q_e$ will remain equal to $\mu_m Q_m$. Hence, intrinsic properties may be measured on a closed core sample and applied to a core of the same material assembled with air gaps. This assumes the same average values of flux density, without excessive leakage. For convenience, in the fol-

[6] J. L. Snoek, "Dispersion and absorption in magnetic ferrites at frequencies above one mc/s," *Physica*, vol. 14, pp. 207–222; May, 1948.

[7] C. Kittel, "Ferromagnetic resonance," *Jour. Phys. Radium*, vol. 12, pp. 291–302; March, 1951.

[8] F. G. Brockman, P. H. Dowling, and W. G. Steneck, "Dimensional effects resulting from a high dielectric constant found in ferromagnetic ferrite," *Phys. Rev.*, vol. 7, pp. 85–93; January 1, 1950.

[9] J. K. Galt, "Initial Permeability and Related Losses in Ferrites," presented symposium on ferrites at Rutgers University; October, 1951.

lowing discussion, the expression μQ is written without subscripts when no specific values of μ_e and Q_e are indicated. Measured values of μQ at 100 kc for a small ferrite test ring with several different air gaps are shown in Fig. 5, illustrating the relationship discussed above.

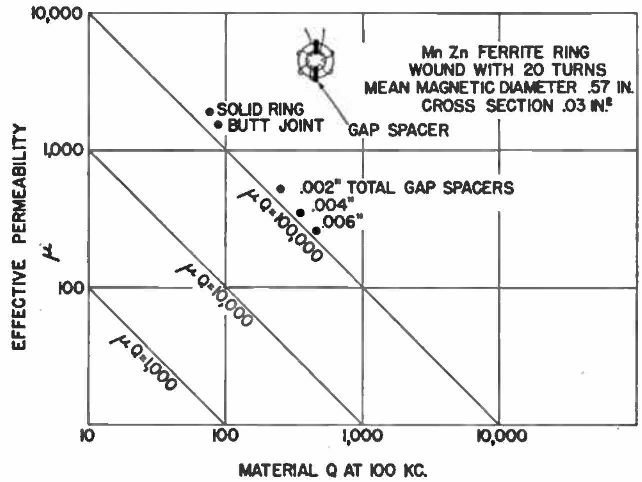

Fig. 5—Effect of air gap on μ and Q of a MnZn ferrite ring core, showing invariance of μQ.

An air gap usually is required in the magnetic core of an inductance coil to produce high coil Q and good stability of inductance. If the air gap alone is varied, the effective permeability of the core and the inductance of the coil will change, while the Q of the coil will pass through a peak at a certain optimum value of effective permeability. The peak Q of the coil thus obtained and the corresponding optimum value of effective permeability both will be directly proportional to $\sqrt{\mu Q}$ of the ferrite material used in the core, as developed mathematically in the Appendix. Experimental data illustrating these relationships are given in Fig. 6. The same experimental winding was used on two different assemblies of U-shaped core parts, which were similar except that the μQ product of one core assembly was slightly over three times that of the other. The ratio between the values of $\sqrt{\mu Q}$ for the two core assemblies was 1.76. The air gap of each core was varied to determine the peak coil Q at 100 kc, as shown in Fig. 6(A). Fig. 6(B) shows the change of coils Q's with frequency for the optimum air gap adjustments at 100 kc. The ratio of optimum effective permeabilities, determined from the measured inductance values, was almost exactly the theoretical value of 1.76. The ratio of coil Q values was a little lower, about 1.65. The difference probably is due to distributed capacitance and leakage, which are always present to some degree, but which were not determined on these samples.

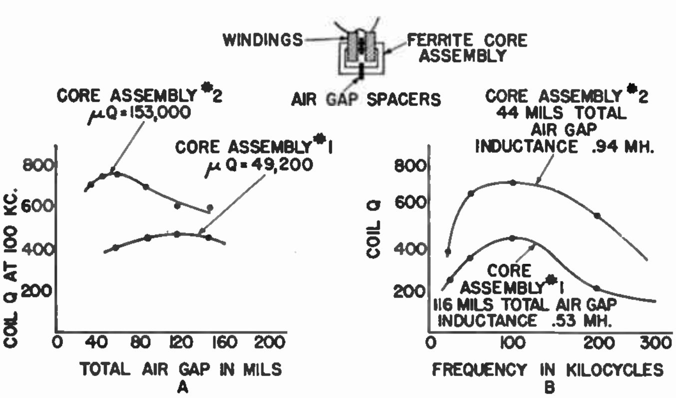

Fig. 6—Effect of μQ of core material on coil Q for (A) different air gaps and (B) different frequencies.

It is convenient to represent the loss in a transformer core as a shunt resistance R_p across the line or circuit. The value of this resistance is directly proportional to the product μQ of the core material.

These important relationships of μQ, derived in the Appendix, are summarized thus:

$$\mu_{\text{opt}} \propto \sqrt{\mu Q} \quad (3)$$

$$Q_{\text{opt}} \propto \sqrt{\mu Q} \quad (4)$$

$$R_p \propto \mu Q. \quad (5)$$

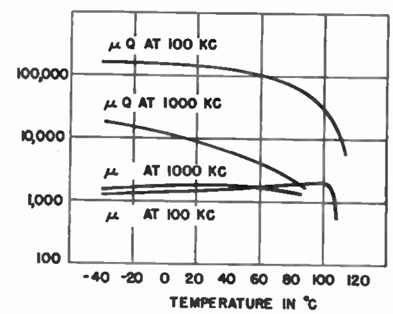

Fig. 7—Variation of μ and μQ with frequency and temperature for experimental MnZn ferrite.

A higher value of μQ in a core material can be utilized to obtain a coil of equivalent Q in smaller volume.

Typical variations of permeability and μQ with frequency, temperature, and flux density are shown in Figs. 7 and 8 for experimental samples of manganese zinc ferrite produced in the Bell Telephone Laboratories

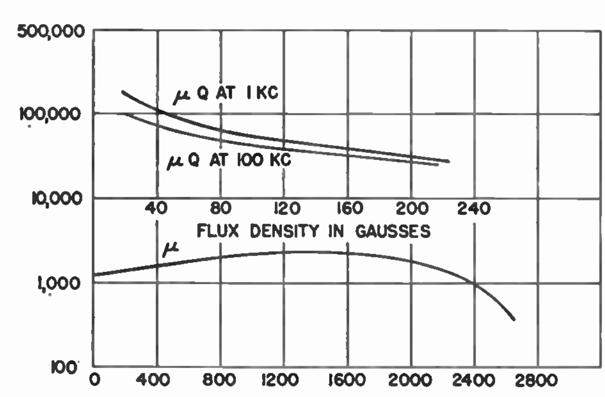

Fig. 8—Variation of μ and μQ with flux density for experimental MnZn ferrite.

The effects of the comparatively low Curie points and saturation-flux densities are important for design considerations. Fig. 9 compares the values of permeability and μQ for different values of frequency for ferrite samples, magnetic powders, and 0.001-inch thick

Permalloy. These data indicate the superior design advantages of ferrites from the standpoint of μQ for certain frequency ranges.

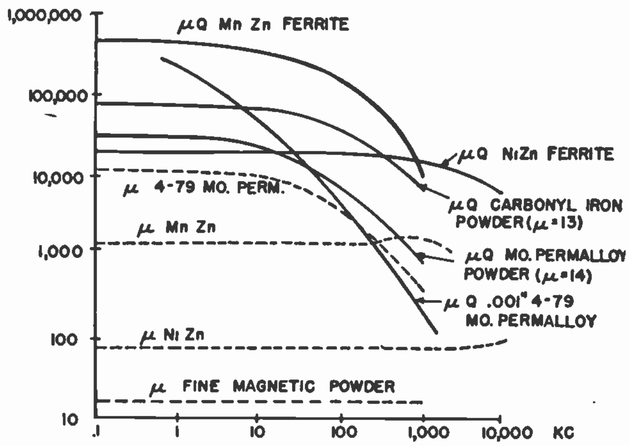

Fig. 9—Comparison of μ and μQ for typical ferrites and other materials for different values of frequency.

Notes on Measurements

Toroidal test samples 0.6 inch in mean diameter with a cross section approximately 0.15 inch square have been used for measurement up to a few megacycles on MnZn and NiZn ferrites. A direct-reading Maxwell bridge built to measure inductances below 1,000 microhenries and resistances below 10,000 ohms from 15 kc to 2 mc has been found very stable and convenient for this purpose. Series resonance bridges have been used for inductance and core-loss measurements at frequencies from 2 to 20 mc, and higher.

The dielectric characteristics were explored on some of the same samples used for inductance measurements, with silver or evaporated gold on the flat surfaces for contact. The resistivity and negative reactance measured on MnZn ferrite samples have been found to decrease appreciably with frequency. At 100 kc, the "apparent" dielectric constant computed from the reactance measurement usually has been found to fall within a range of 20,000 to something over 100,000 with a dielectric Q well below unity. Good contact to the ferrite is essential for satisfactory measurements. Otherwise, for the more conducting ferrites, such as the high-permeability MnZn type, the resistivity of the contacts may predominate the measurements and lead to grossly inaccurate determinations. Methods of checking the contact resistances include measuring the constancy of the dc resistance with reversed polarity, the use of a potentiometer probe method, or comparing measurements on a sample which is successively shortened and replated.

Dimensional resonance should be avoided, or taken into account, when the fundamental properties of a ferrite material are being measured, or when ferrite is being used in apparatus. The dimensional effect is to be expected when a dimension of the core across the flux path is of the order of a half wavelength, or more, for the frequency of application, as computed from the permeability and dielectric constant of the material. A precise calculation of this effect is made difficult by the variation of the magnetic and dielectric properties with frequency,[10] the boundary conditions, and an incomplete understanding at this time of the nature of the dielectric properties of ferrite.

Permeability and dielectric measurements on ferrites from a few megacycles up through microwave frequencies are useful in the study of the fundamental properties of the material as well as its potential uses as waveguide elements. It is quite common for investigators to express the permeability and the dielectric constant as complex quantities

$$\text{complex } \mu = \mu' - j\mu'' \tag{6}$$

$$\text{complex } \epsilon = \epsilon' - j\epsilon''. \tag{7}$$

In this representation, μ' corresponds to the permeability and μ'' is a measure of the loss per cycle. The Q and μQ of the magnetic material are expressed then as

$$Q_m = \mu'/\mu'' \tag{8}$$

$$\mu Q = (\mu')^2/\mu''. \tag{9}$$

As will be obvious from the previous discussion, the values of μ', μ'', ϵ', and ϵ'' are dependent upon frequency, vary with temperature, and may be affected by dimensions. Such data must be used with appropriate discretion.

Acknowledgments

The author is indebted to many associates. Experimental ferrite parts were provided by a metallurgical research group under the supervision of Mr. J. H. Scaff. Messrs. A. G. Ganz, V. E. Legg, and J. K. Galt have provided helpful guidance and comments on the manuscript, and Mrs. C. E. Hedden and Mr. R. C. Conway have assisted in magnetic measurements.

Appendix

Formulas Involving Material Q

Core loss may be represented as a resistance R_s in series with the inductance L_s, or as a resistance R_p in parallel with the inductance L_p of a winding on the core. Then, by definition,

$$\text{material } Q = \frac{\omega L_s}{R_s} = \frac{R_p}{\omega L_p}.$$

A. For a core without air gap with intrinsic permeability μ_m, writing L_m for L_s and R_m for R_s,

$$\text{material } Q = Q_m = \frac{\omega L_m}{R_m} = \frac{R_p}{\omega L_p}. \tag{10}$$

Parallel Resistance R_p. From a treatment of equivalent circuits, it can be shown,

$$R_p = R_m(Q_m^2 + 1) = \frac{\omega L_m}{Q_m}(Q_m^2 + 1). \tag{11}$$

[10] D. Polder, "Ferrite materials," *Proc. IEE* (London), vol. 97, part II, pp. 246–256; April, 1950.

Since

$$L_m = \frac{4\pi N^2 A \mu_m}{l} 10^{-9},$$

$$R_p = \frac{K\mu_m}{Q_m}(Q_m^2 + 1). \tag{12}$$

If $Q_m \gg 1$,

$$R_p \propto \mu_m Q_m. \tag{13}$$

Expression for Coil Q. Let R_c be the resistance of the winding.

$$\text{Coil } Q = \frac{\omega L_m}{R_c + R_m} = \frac{1}{\dfrac{R_c}{\omega L_m} + \dfrac{R_m}{\omega L_m}} = \frac{1}{\dfrac{1}{Q_{cm}} + \dfrac{1}{Q_m}},$$

or

$$Q = \frac{Q_{cm} Q_m}{Q_{cm} + Q_m}. \tag{14}$$

By inspection of (14), it is evident that the coil Q cannot exceed Q_{cm} or Q_m, whichever is lower.

B. For a core with an air gap and effective permeability μ_e (flux leakage and capacitance effects neglected).

Optimum Coil Q.

$$Q_c = \frac{\omega L_e}{R_c} = \frac{2\pi f}{R_c}\left[\frac{4\pi N^2 A \mu_e}{l}\right] 10^{-9} \tag{15}$$

$$Q_e = \frac{\omega L_e}{R_m} = \frac{2\pi f L_e}{\mu_e f L_e (c + aB_m + ef + kf^2 + \cdots)}. \tag{16}$$

For a given winding and core, and a fixed value of frequency and flux density,

$$Q_c \propto \mu_e \tag{17}$$

$$Q_e \propto \frac{1}{\mu_e}. \tag{18}$$

$$\therefore \quad Q_c Q_e = \text{constant}. \tag{19}$$

$$\text{Coil } Q = \frac{\omega L_e}{R_c + R_m} = \frac{1}{\dfrac{R_c}{\omega L_e} + \dfrac{R_m}{\omega L_e}} = \frac{1}{\dfrac{1}{Q_c} + \dfrac{1}{Q_e}},$$

or

$$Q = \frac{Q_c Q_e}{Q_c + Q_e}. \tag{20}$$

Consider that all other conditions remain unchanged except that the air gap is varied to change μ_e. From (19) and (20), the condition for a maximum value of coil Q is found to be ($\widehat{\ }$ indicates values at optimum condition),

$$\widehat{Q}_c = \widehat{Q}_e, \tag{21}$$

corresponding to an optimum value of permeability $\widehat{\mu}_e$.

$$\therefore \quad \widehat{Q} = 1/2\widehat{Q}_c = 1/2\widehat{Q}_e = 1/2\sqrt{\widehat{Q}_c\widehat{Q}_e}. \tag{22}$$

Also from (15),

$$\frac{\widehat{Q}_c}{\widehat{\mu}_e} = \frac{Q_c}{\mu_e} = \frac{Q_{cm}}{\mu_m}, \tag{23}$$

and from (16),

$$\widehat{\mu}_e \widehat{Q}_e = \mu_e Q_e = \mu_m Q_m. \tag{24}$$

Hence

$$\widehat{Q}_e = \frac{\mu_m Q_m}{\widehat{\mu}_e} \quad \text{and} \quad \widehat{Q}_c = \frac{\widehat{\mu}_e Q_c}{\mu_e}, \tag{25}$$

which, when substituted in (22), gives

$$\widehat{Q} = 1/2\sqrt{\frac{Q_c}{\mu_e}\mu_m Q_m}, \tag{26}$$

or

$$\widehat{Q} \propto \sqrt{\mu_m Q_m}. \tag{27}$$

Optimum Effective Permeability for Maximum Coil Q. From (22) and (25),

$$\widehat{\mu}_e = \sqrt{\frac{\mu_e}{Q_c}\mu_m Q_m}, \tag{28}$$

or

$$\widehat{\mu}_e \propto \sqrt{\mu_m Q_m}. \tag{29}$$

Parallel Resistance R_p. If the equivalent parallel resistance is expressed in terms of effective permeability μ_e and effective material Q_e instead of the intrinsic values of μ_m and Q_m in (10) to (13), it will be found that

$$R_p = \frac{K\mu_e}{Q_e}(Q_e^2 + 1). \tag{30}$$

Since $\mu_e Q_e = \mu_m Q_m$, the value of R_p is seen to be unaffected by the air gap.

SYMBOLS

a = hysteresis coefficient, ohms/henry/cycle/gauss /μ.
A = effective area of flux path, cm^2.
B = instantaneous flux density, gausses.
B_m = maximum flux density due to ac field, gausses.
B_s = saturation-flux density.
c = residual-loss coefficient, ohms/henry/cycle/μ.
γ = eddy-current coefficient.
e = eddy-current coefficient, ohms/henry/cycle^2/μ
ϵ' = real part of complex dielectric constant.
ϵ'' = imaginary part of complex dielectric constant.
f = frequency, cps.
f_0 = frequency of ferromagnetic resonance.
H = magnetizing force, oersteds per cm.
η = Steinmetz hysteresis coefficient.
K = constant.
L = inductance of coil, henrys.
L_m = series inductance for permeability μ_m.
l = mean length of flux path, cm.

L_p = equivalent parallel inductance of coil, henrys.
L_s = series inductance for permeability μ_e.
N = number of turns in winding.
Q = ratio of reactance to resistance.
$Q_c = \omega L_s / R_c$.
$Q_{cm} = \omega L_m / R_c$.
$Q_e = \omega L_s / R_m$.
$Q_m = \omega L_m / R_m$.
R_c = dc resistance of copper winding.
R_m, R_t = equivalent series resistance due to core loss, ohms.
R_p = equivalent parallel resistance due to core loss, ohms.
ρ = resistivity, ohm-cm.
μ, μ_e = effective permeability of core.
μ_m = permeability of magnetic core without air gap.
μ_{rf} = permeability at high frequencies.
μ' = real component of complex permeability.
μ'' = imaginary component of complex permeability.
w, w_h = power loss, ergs per second, or watts.
x = hysteresis exponent.

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The Effect of Impurity Migrations on Thermionic Emission from Oxide Cathodes*

IRVING E. LEVY†

Summary—**A comparison of thermionic emission from oxide cathodes with different base alloys showed the dependence of the work function on migrating impurities from tube parts other than the cathode.**

The effect of the base metal alone could be evaluated properly only by the use of a special diode structure which did not contribute any impurities toward the reduction of the oxide-coating.

In the test method used, saturated emission was measured but the anode voltage was kept below the decomposition energies of most of the compounds apt to be found on the plate.

Introduction

WORK DONE over the past several years has resulted in the conclusion that pure nickel is incapable of reducing an oxide-coated cathode. White[1] presented the thermodynamic data to substantiate this. Results reported on experimental diodes by Nottingham, Cardell, and Levy[2] in this country and by Violet and Riethmuller[3] in France showed the importance of the base-metal impurities in influencing thermionic emission.

Recent concepts dealing with the mechanism of getting thermionic emission treat the oxide-coated cathode as an excess impurity semiconductor.[4,5] According to

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[1] A. H. White, "Applications of thermodynamics to chemical problems involving the oxide cathode," *Jour. Appl. Phys.*, vol. 20, pp. 856–60; September, 1949.

[2] W. B. Nottingham, J. Cardell, and I. E. Levy, Summary Report for O. N. R. Contract N8onr-389, Raytheon Mfg. Co., Newton, Mass.; July, 1950.

[3] F. Violet and J. Riethmuller, "Contribution to the study of oxide cathodes" (in French), *Ann. Radioelect.*, vol. 4, pp. 148–215; 1949.

[4] A. S. Eisenstein, "Advances in Electronics," vol. 1, pp. 1–64, Academic Press, New York, N. Y.; 1948.

[5] W. E. Danforth, "Elements of thermionics," Proc. I.R.E., vol. 39, pp. 485–499; May, 1951.

these ideas a cathode base metal free of reducing impurities would be incapable of producing the stoichrometric excess barium needed for good thermionic emission. It was an apparent experimental contradiction to this belief which led to the present work.

The Tube Structure

The tube structure used in this work is similar in design to the A.S.T.M. standard diode.[6] This is a cylindrical diode with a conventional radio-tube oxide-coated cathode. Actually, in this study, two structures were compared to determine the effect of migratory impurities. One structure will be called the "Standard" Diode, the other structure will be called the "Purified" Diode. The difference in the parts is shown in Table I. The

TABLE I

Comparison Between "Standard" and "Purified" Diode

Part	Standard Diode	Purified Diode
Getter	KIC getter-heavy iron with Si, Mg, Al, Ba, Cu present	batalum contains Mo, Be, Ba, Ti, trace of Si and Fe
Cathode tab	silicon nickel (2.8–3.2% Si) other constituents the same as "A" nickel	499 alloy nickel (high purity)
Plate	grade "A" ni-max. limits in per cent: C 0.20, Cu 0.25, Fe 0.30, Mn 0.35, S 0.008, Si 0.20, Mg 0.04	499 alloy nickel (high purity) limits in per cent: C 0.10, Cu 0.04, Fe 0.05, Mn 0.02, S 0.005, Si 0.01, Mg $-\neq 0$
Mica	selected class 1	fair stained or better
Plate supports and welds	grade "A" nickel	499 alloy nickel
Stops and connetors	grade "A" nickel	499 alloy nickel

heaters which were conventional aluminum oxide-coated tungsten were the same for both structures. The bulb in both lots was standard lime glass.

Table I shows that the "standard" diode consisted of parts commonly used in commercial radio tubes. The "purified" diode parts, on the other hand, were fabricated out of the purest available materials.

Method of Evaluating Thermionic Emission

To evaluate thermionic emission correctly it is necessary to have some means of observing the total emission current not limited by space charge. At the usual operating cathode temperatures (720 degrees C–800 degrees C), this saturation emission measurement involves the use of pulse techniques in order to keep the plate dissipation down to a practical maximum. However, there are several disadvantages to pulse testing. There is some experience to indicate that the drawing of current under pulse conditions changes the state of the cathode. It is also known that bombardment of the anode with high-energy electrons will bring about decomposition of oxides, chlorides, and other compounds likely to be found there, and cause a significant reduction in electron emission. Metson,[7] and Metson and Holmes[8] have studied this phenomenon and have reached the conclusion that decomposition of anode impurities will occur even at electron energies as low as 6 volts.

Consequently, a test was established here which arbitrarily used 4 volts applied potential between anode and cathode. In order to insure temperature-limited emission, at this plate voltage it was necessary to drop the heater voltage to 1.75 volts (335 degrees C). This is true temperature as measured with a thermocouple.

This low field test was adopted as the standard method of evaluating thermionic emission in the experiments described below. In addition, from 1947 to date, several thousand diodes have been tested under ONR sponsored research with this low field technique,[9] and it has proven itself to be a simple, satisfactory method which should have general utility and value.

Tests Conducted on Standard Diode

For the first test lot six "standard" diodes were assembled and given optimum processing, three with vacuum-melted "D" cathodes and three with regular 220 alloy cathodes—melt 66. A comparison between the chemical analysis of these two cathode melts is made below in Table II.

TABLE II

Comparison Between Vacuum Melt "D" and Melt 66 Cathodes as Received Before Assembly

Melt No.	% Si	% Fe	% Mn	% Mg	% Cu	% Ti
"D"	0.009	0.046	0.024	0.005	0.017	0.008
66	0.024	0.096	0.095	0.035	0.023	0.035

It was anticipated that the decreased availability of silicon, magnesum, and titanium in the vacuum-melted nickel cathodes would significantly reduce the thermionic emission from diodes made with these cathode sleeves. The surprising results are shown in Fig. 1, where the low field emission for each tube is plotted against life. The life-test conditions were as follows: Ef = 6.3 volts, Ep = 40 volts, Ip = 100 ma/sq cm. It is apparent from the results that there is no significant difference in emission between the normal alloy cathodes—melt 66, and the exceptionally pure nickel cathodes—vacuum melt D, both initially as well as during life. The cathodes were taken from these tubes after 500 hours' life and analyzed spectrochemically.[10] The results of the analysis follow in Table III:

[6] R. L. McCormack, "A standard diode for electron tube oxide-coated cathode core material approval tests," Proc. I.R.E., vol. 37, pp. 683–687; June, 1949.

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[8] G. H. Metson and W. B. Holmes, "Poisoning in high-vacuum oxide-cathode valves," *Nature*, vol. 163, p. 61; June, 1949.

[9] W. B. Nottingham, J. Cardell, and I. E. Levy, Summary Report of O.N.R. Contract N7onr-389, Raytheon Mfg. Co., Newton, Mass.; July, 1950.

[10] Although the cathodes were 27 mm long, only the center portion, 12 mm long, which contained the coating, was taken for analysis

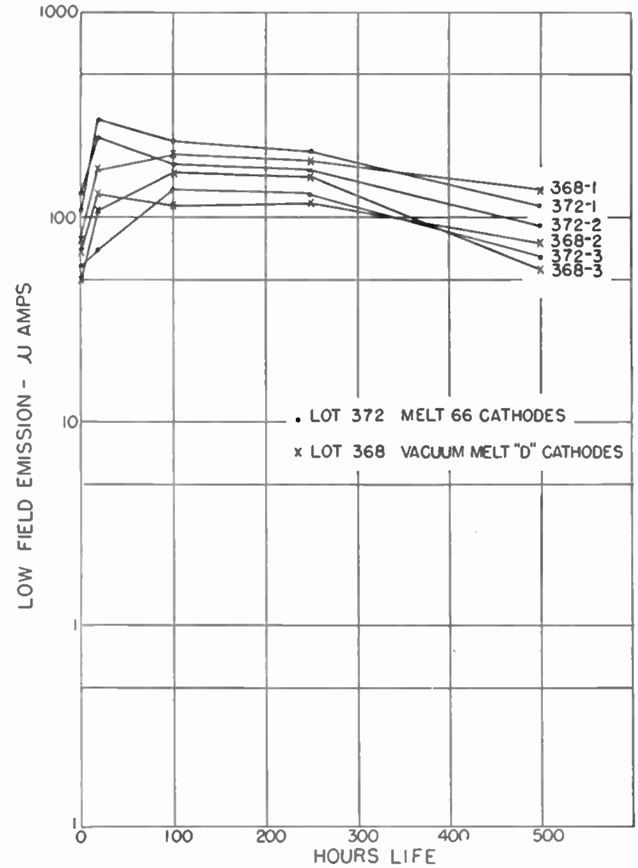

Fig. 1—Vacuum melt "D" cathodes versus melt 66 cathodes in the "standard" diode.

Comparison of the analyses of the cathode melts as received (Table II) with Table III on concentrations clearly shows that migrations of impurities, especially silicon, iron, and magnesium do occur, and that these impurities are in evidence beyond the concentrations that were originally contained in the cathodes under test.

TABLE III

SPECTROCHEMICAL ANALYSIS OF COATED CATHODES REMOVED FROM STANDARD DIODES AFTER 500 HOURS LIFE

Melt No.	% Si	% Fe	% Mn	% Mg	% Cu	% Ti
"D"	0.04	0.06	0.02	0.01	0.02	0.01
66	0.04	0.12	0.08	0.03	0.02	0.04

It was concluded that with reference to the standard diode structure used the results were not a true indication of cathode-emitting properties. It was rather felt that the emission current measured especially in the case of vacuum melt "D" was largely a function of migrating reducing impurities which become available to the cathode during processing and life.

TESTS CONDUCTED ON PURIFIED DIODE

To separate the true cathode thermionic emission from the influence of migrating impurities as much as possible, six tubes were made up as before except that the purified diode structure was used (see Table I). The

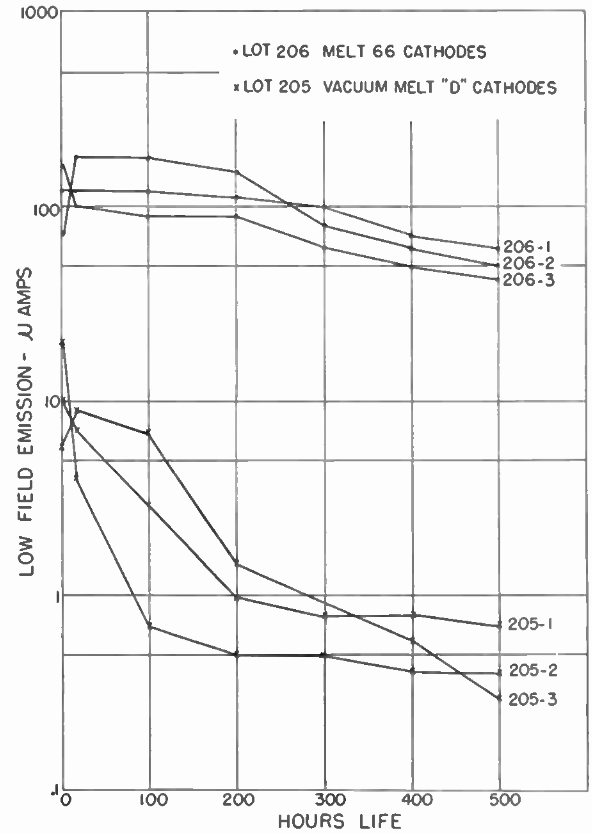

Fig. 2—Vacuum melt "D" cathodes versus melt 66 cathodes in "purified" diode.

results are shown in Fig. 2. This conclusively shows that vacuum melt "D" cathodes do result in exceptionally low emission when the effect of migrating impurities, as far as possible, is eliminated.

At the end of 500 hours' life the cathodes were removed from these tubes and spectroscopically analyzed as before. The results are shown in Table IV.

TABLE IV

SPECTROCHEMICAL ANALYSIS OF COATED CATHODES REMOVED FROM "PURIFIED" DIODES AFTER 500 HOURS LIFE

Melt	% Si	% Fe	% Mn	% Mg	% Cu	% Ti
"D"	0.01	0.038	Tr	0.006	0.008	Tr
66	0.027	0.090	0.075	0.022	0.01	Tr

These results show no significant increase in cathode reducing impurities over the original concentrations shown in Table II.

One can conclude from these data that the use of "purified" structures similar to the one used in these experiments is essential in order to minimize impurity migration and to properly evaluate the emission properties of cathodes.[11]

[11] Although this report deals with only a small quantity of tubes, the same consistent data was obtained from several hundred tubes run over a period of years. Details are reported by W. B. Nottingham, J. Cardell, and I. E. Levy, "Summary Report for O.N.R. Contract N7onr-379," July, 1950.

The Effect on the Work Function

The ratio of emission in the "purified" structure to emission in the "standard" structure at 605°K is seen to be about 1:100 at the end of life for the case of melt "D" cathodes. It is interesting to apply Richardson's equation to these results.

If we call Is_1 the emission density from melt "D" cathodes in the purified diode, and Is_2 the emission density from melt "D" cathodes in the standard diode, then

$$Is_1 = AT^2\epsilon^{-\epsilon\phi_1/KT}, \quad (1)$$

$$Is_2 = AT^2\epsilon^{-\epsilon\phi_2/KT} \quad (2)$$

where

A = Richardson's constant

ϕ = the Richardson work function in volts

T = temperature in degrees K

ϵ = electron charge 1.6×10^{-19} coulombs

K = Boltzman's constant 1.38×10^{-23} joules per degree,

and

$$\frac{Is_2}{Is_1} = 100 = \epsilon^{-\epsilon(\phi_2-\phi_1)/KT}. \quad (3)$$

From (3) the difference in work function is

$$\phi_1 - \phi_2 = 0.24 \text{ volt}.$$

This work function difference, however, is due to nothing more than the migrating impurities resulting from the "standard" structure. This indicates that extreme caution is advised in oxide-coated cathode research and production to insure that the cathode itself and not migrating impurities are being evaluated.

Acknowledgment

The author wishes to express his gratitude to Dr. W. B. Nottingham of Massachusetts Institute of Technology for his interest and guidance in this work, and to J. Cardell, Chief Investigator in this research project, under whose administration this work was carried out.

Electrically Tuned RC Oscillator or Amplifier*

OSWALD G. VILLARD, JR.†, SENIOR MEMBER, IRE AND FRANK S. HOLMAN‡, STUDENT, IRE

Summary—**Two RC circuits based upon all-pass phase-shift networks are described. They are useful as electronically tunable audio oscillators, selective amplifiers, or bridges. Change of resonant frequency is accomplished by varying amplitude of transmission in one or more circuit branches by means of vacuum-tube modulators.**

In theory, both circuits may be electronically tuned from zero to infinite frequency, and their feedback-loop gain at resonance should be independent of the frequency to which they are tuned. However, the frequency ratio conveniently obtainable in practice, before appreciable changes in gain occur, is about four to one. This limitation is in part a consequence of the decrease in effective *Q* of the frequency-controlling portion of the circuit when they are tuned far from center frequency.

Introduction

Many applications exist for electronically tunable oscillators and amplifiers capable of operation at the lower audio frequencies where RC circuits become preferable to LC. The best oscillator circuits disclosed so far appear to be those of McGuaghan and Leslie,[1] Ames,[2] and Anderson.[3] Electronically tuned amplifiers do not seem to have received much attention.

There will be described two circuits which have an interesting property, that in theory it should be possible to tune their frequency of resonance, electronically, from zero to infinite frequency. Furthermore, the magnitude of their positive feedback voltage should be independent of the frequency of resonance. However, the effective Q of the feedback loop falls off when the deviation from center frequency becomes large, so that the practical operating frequency ratio is about four to one. Over this range the feedback loop transmission at resonance is found to be constant enough to make the circuits useful as electronically tuned selective amplifiers.

The curve of frequency versus modulating voltage has a point of inflection; therefore, modulation about this point is highly linear. Furthermore, the nature of the curve is such that if a maximum departure from linearity of the order of five per cent is permissible, a frequency ratio of the order of two to one may be obtained.

Tuning is accomplished by variation of voltage amplitude in a vacuum-tube modulator rather than by variation of an effective circuit impedance. The desired performance is obtained when the transfer characteristic of the modulator is linear. In one of the circuits the modulator is of the conventional balanced type, whose transfer-characteristic linearity is inherently high.

There is a resemblance to the phase-shifter approach of De Lange[4] to the extent that frequency modulation may be considered obtainable in these circuits by variation of transmission. Other differences are considerable.

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‡ Electronics Research Laboratory, Stanford University, Stanford, Calif.

[1] H. S. McGuaghan and C. B. Leslie, "A resistance-tuned frequency-modulated oscillator for audio frequency applications," Proc. I.R.E., vol. 35, pp. 974–978; September, 1947.

[2] M. E. Ames, "Wide range deviable oscillator," *Electronics*, pp. 96–100; May, 1949.

[3] F. B. Anderson, "Seven league oscillator," Proc. I.R.E., vol. 39, pp. 881–890; August, 1951.

[4] O. E. DeLange, "A variable phase-shift frequency-modulated oscillator," Proc. I.R.E., vol. 37, pp. 1328–1330; November, 1949.

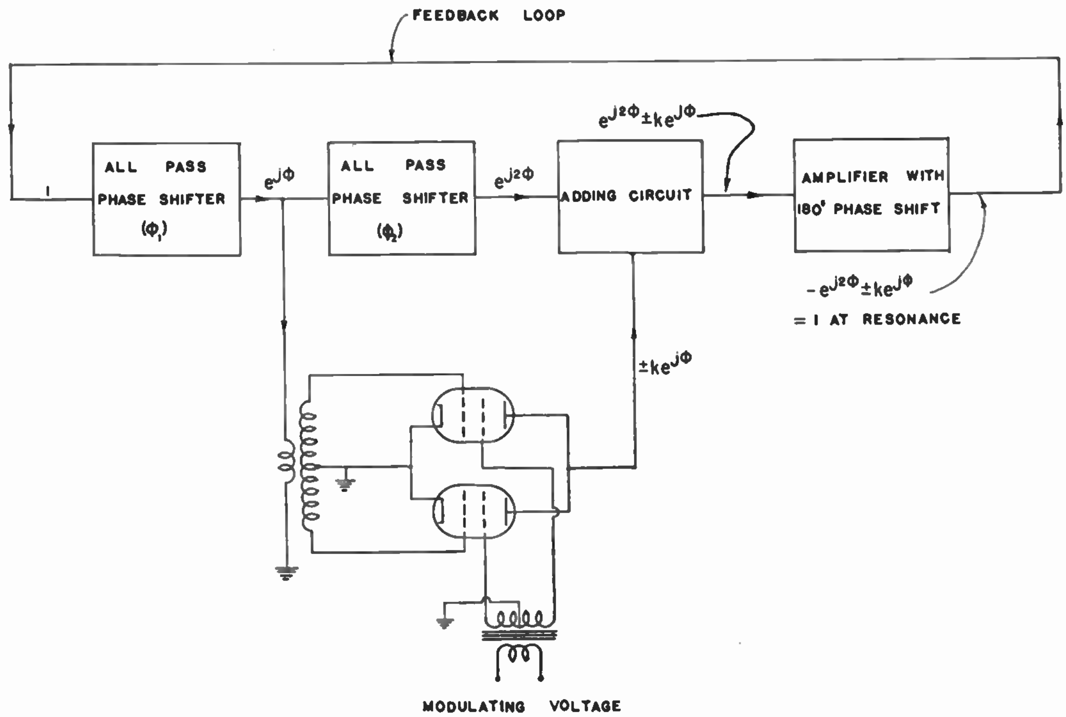

Fig. 1—Block diagram of series circuit.

There is also a resemblance to the "reactance-tube-modulated" phase-shift oscillators of Dennis and Felch.[5] In the present case, however, a different analytical approach is used; a different phase-shift circuit is considered, and the resulting possibilities in regard to tuning range, feedback constancy, and modulation linearity are pointed out.

Description

The first circuit will be called the "series" circuit, and the second the "sum" circuit, after the way in which the phase-shifted voltages are disposed. Both incorporate an all-pass half-lattice RC phase-shifting network, which is conveniently driven by a vacuum-tube phase inverter.[6,7]

A block diagram of the series connection is shown in Fig. 1. Vector diagrams illustrating operation will be found in Fig. 2. The time constants of the two phase shifters are made equal, so that both shift by an equal number of degrees ϕ. Electronic tuning is accomplished by adding variable amounts of the output of the first phase shifter to the output of the second. Assuming the gain of the phase shifters and of the amplifier to be unity and using exponential notation, expressions for the voltages in the various parts of the circuit at any resonant frequency (ω_r) are shown in the figure. A modulation constant k establishes the amount of first-phase-shifter output voltage added for frequency-shifting purposes. Since it is proportional to the instantaneous amplitude of the modulating voltage, its sign may be

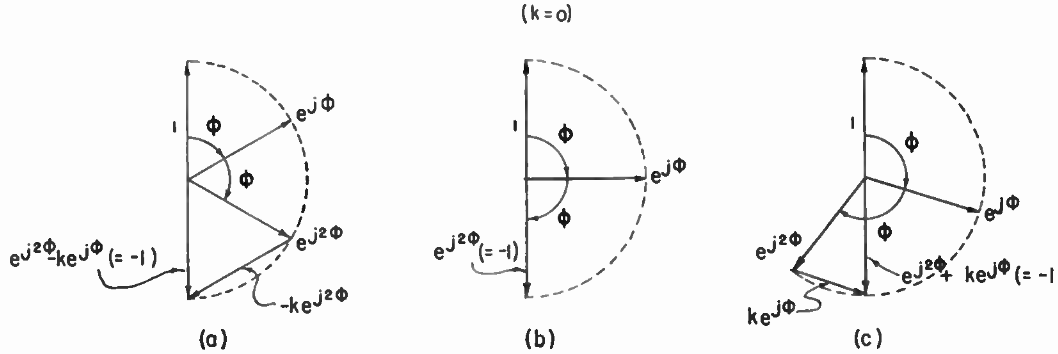

Fig. 2—Vector diagrams, series circuit. (a) Resonance shifted to lower frequency, (b) at center frequency, (c) to higher frequency.

positive or negative. At the center resonant frequency (ω_0), illustrated in Fig. 2(b), $k=0$ and resonance (that is, exactly positive feedback) occurs at the frequency at which $2\phi = 180$ degrees, or $e^{j2\phi} = -1$. This is also the frequency at which $\omega R_1 C_1 = 1$. To shift the resonant fre-

[5] F. R. Dennis and E. P. Felch, "Reactance-tube modulation of phase-shift oscillators," *Bell Sys. Tech. Jour.*, vol. 28, no. 4, pp. 601–607; October, 1949.

[6] R. B. Dome, "Wideband audio phase-shift networks," *Electronics*, pp. 112–115; December, 1946.

[7] O. G. Villard, Jr., "Tunable A-F amplifier," *Electronics*, pp. 77–79; July, 1949.

quency higher, k must be positive, as in Fig. 2(c). For a given k, frequency will increase until the vectors $e^{j\phi}$ and $e^{j2\phi}$ arrive at the correct phase position to make $e^{j2\phi}+ke^{j\phi}$ equal to -1. Similarly, reversing the phase of the shifting voltage $ke^{j\phi}$ will cause the frequency of resonance to become lower, as in Fig. 2(a). The equation $e^{j2\phi}\pm ke^{j\phi}=-1$ is satisfied for any value of ϕ provided that $k=\pm 2\cos\phi$. Since ϕ equals $2\tan^{-1}\omega R_1C_1$, it follows that ratio ω_r/ω_0 may be expressed as follows:

$$\left(\frac{\omega_r}{\omega_0}\right)^2=\frac{2+k}{2-k} \quad \text{where} \quad -2 \leqq k \leqq 2. \tag{1}$$

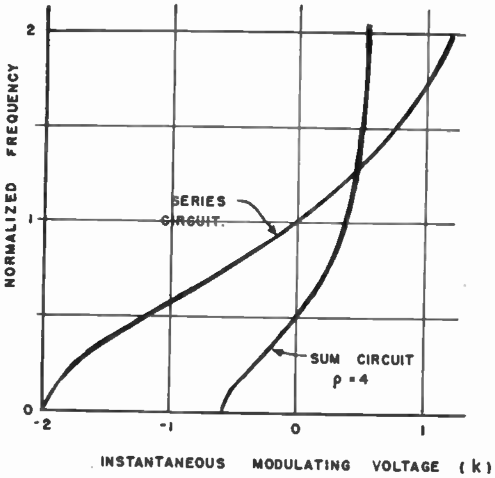

Fig. 3—Resonant frequency versus instantaneous modulating voltage (k), series and sum circuits.

Fig. 3 shows relationship between ω_r/ω_0 and k for series circuit. A point of inflection occurs when k equals -1 and $\omega_r/\omega_0=0.57$. Small frequency excursions about this point may be expected to be highly linear.

Block and vector diagrams illustrating operation of the sum circuit are shown in Figs. 4 and 5. Here the two phase shifters have differing time constants; the ratio of the time constant of the second phase shifter to that of the first (a number greater than unity) will be called ρ. The outputs of the phase shifters are acted upon by two modulators, having modulation indices k_1 and k_2, whose sum must be a constant. After modulation, the two outputs are combined and fed back to the input through a zero-phase-shift amplifier or attenuator. At the center resonant frequency, when k_1 and k_2 may be considered to be equal to unity, the vectors arrange themselves as in Fig. 5(b), that is, resonance occurs when the frequency becomes that at which the resultant of the two phase-shifted vectors is in phase with the input or reference voltage. Variation of k_1 and k_2 changes

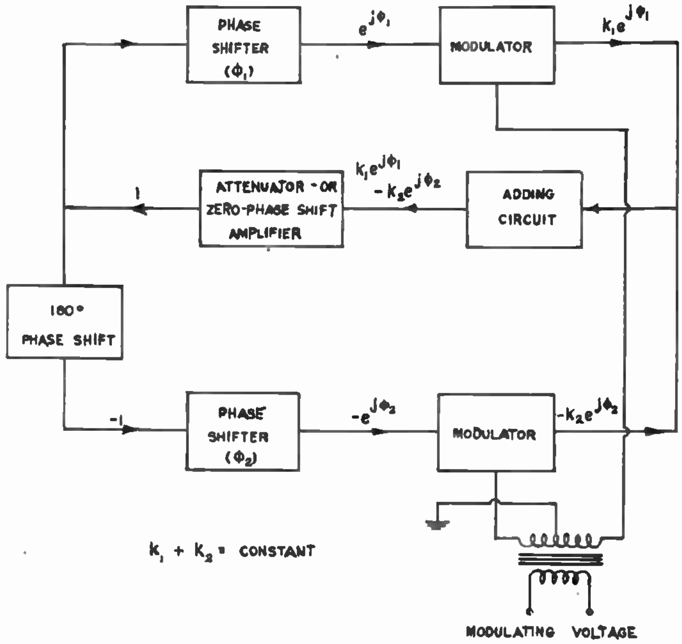

Fig. 4—Block diagram, sum circuit.

the resonant frequency and the vector positions as shown in Fig. 5(a) and (c).

An analysis of this circuit analogous to that previously given results in the following expression for the ratio ω_r/ω_t, where ω_t is the value of ω equal to $1/R_1C_1$:

$$\left(\frac{\omega_r}{\omega_t}\right)^2=\frac{1}{\rho}\left[\frac{\dfrac{\rho-1}{\rho+1}+k}{\dfrac{\rho-1}{\rho+1}-k}\right] \tag{2}$$

$$\text{where } -\left(\frac{\rho-1}{\rho+1}\right)\leqq k \leqq \left(\frac{\rho-1}{\rho+1}\right). \tag{3}$$

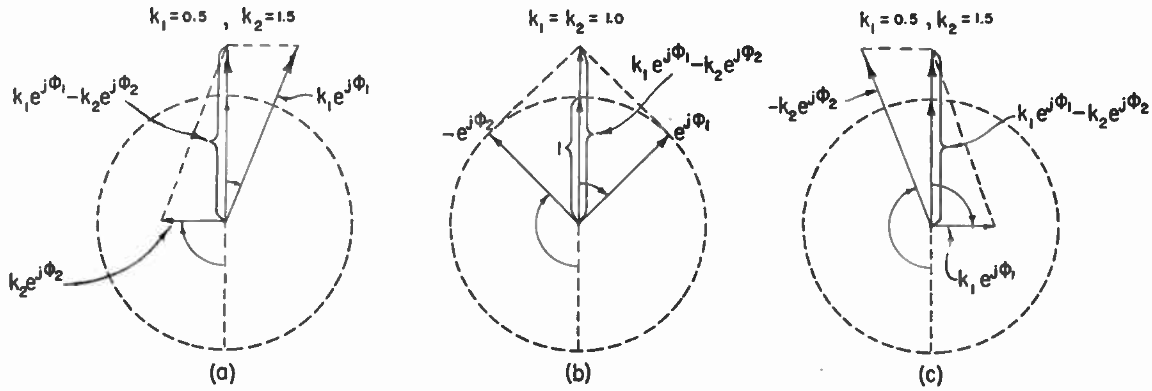

Fig. 5—Vector diagram, sum circuit. (a) Resonance shifted to lower frequency, (b) at center frequency, (c) to higher frequency.

In this expression the factor k is so defined that $(1-k)=k_1$, and $(1+k)=k_2$. When $k=0$, ω_r equals the center resonant frequency ω_0 and $\omega_0=\omega_i\rho^{-1/2}$. A plot of (2), when $\rho=4$, is included in Fig. 3.

It may be shown that the magnitude of the feedback voltage in the sum circuit is also independent of ω_r.

Variation in Stability with Electronic Tuning

The effective Q of the feedback loop may be expected to decrease when the frequency of resonance is electronically tuned to either side of center. Behavior of both circuits is very similar in this respect. As a means of estimating this decrease, the rate of change of phase

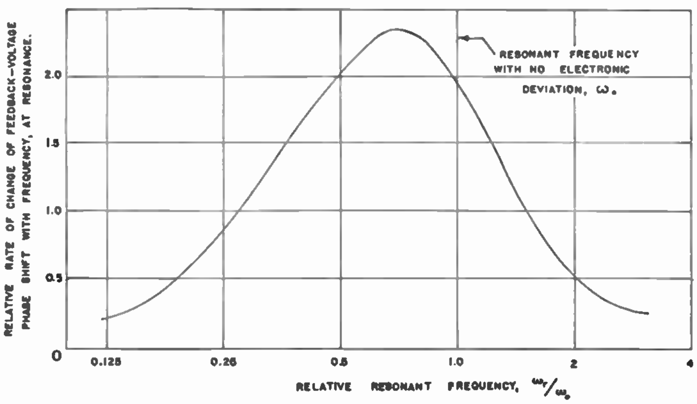

Fig. 6—Rate of change of feedback-loop phase shift with frequency at resonance, for various amounts of electronic deviation.

shift with frequency at resonance, for the series circuit has been plotted as a function of ω_r/ω_0 in Fig. 6.

A further idea may be gained from Fig. 7, which shows the phase shift and amplitude of transmission for a typical sum circuit, when ω_r is equal to ω_0, 0.33 ω_0, and 3.3 ω_0. The falling off in feedback-loop Q not only causes the bandwidth of these circuits, when used as selective amplifiers, to become larger, but also places a limitation on the frequency ratio obtainable when they are employed as oscillators. It will be found that residual phase shifts introduced by coupling circuits have appropriate sign, when ω_r is shifted far from ω_0 in either direction, to cause feedback voltage and oscillation amplitude to increase.

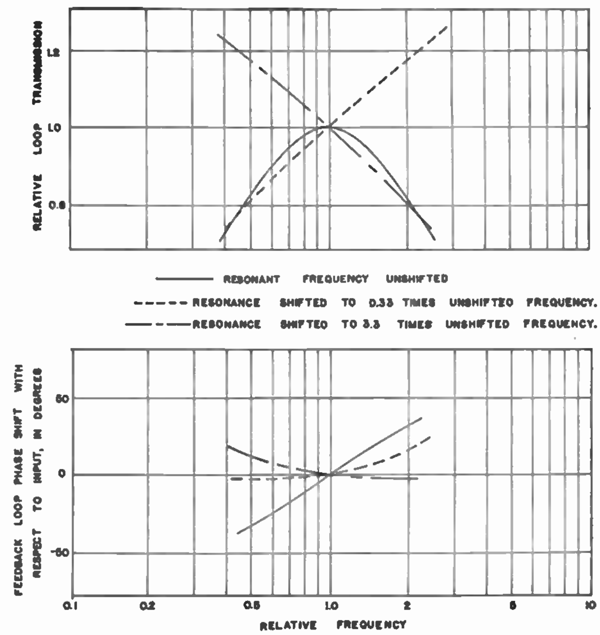

Fig. 7—Characteristics of the feedback loop at different resonant frequencies. Sum circuit, $\rho=4$. Calculated values.

Experimental Arrangements

Figs. 8 and 9 are schematics of experimental series- and sum-type circuits. A balanced modulator may be substituted for the frequency-control potentiometer of Fig. 8, as in Fig. 1.

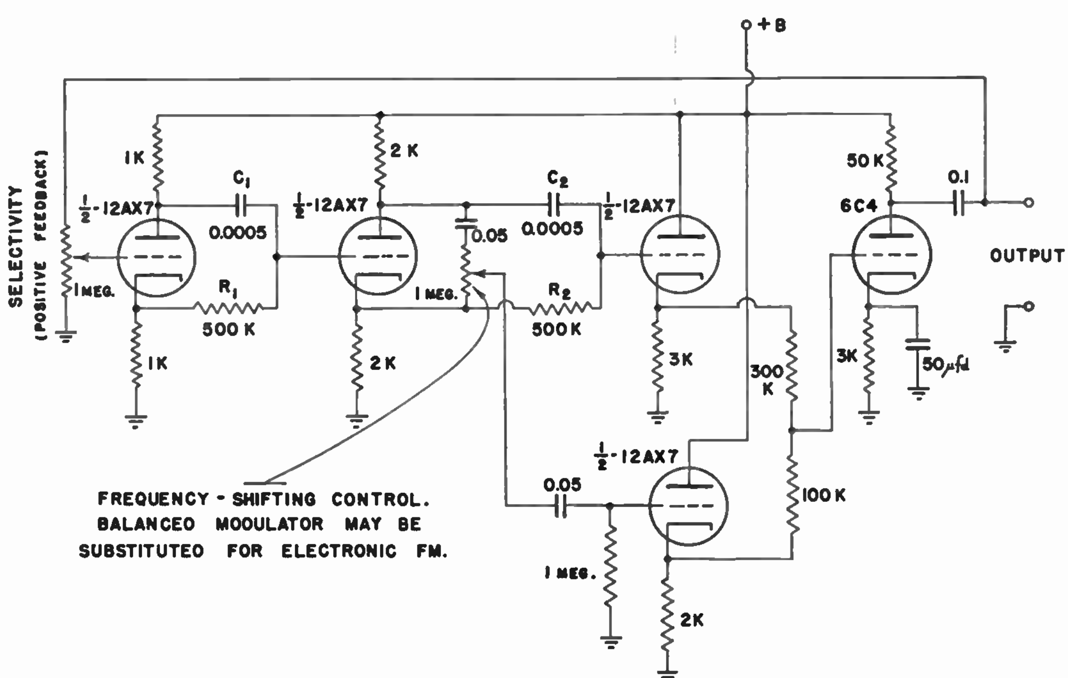

Fig. 8—Schematic diagram of series circuit.

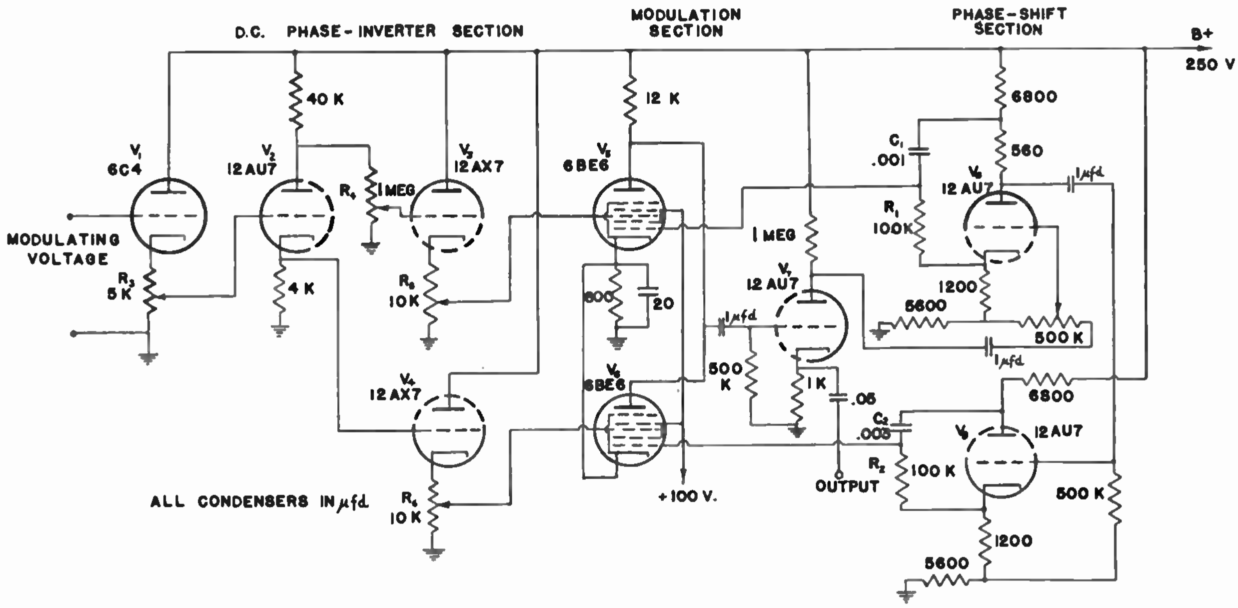

Fig. 9—Schematic of sum circuit.

The sum circuit is perhaps the more difficult to realize in practice, since constancy of the feedback voltage requires that the gain of the modulator tubes vary by exactly equal amounts in opposite directions. Second-order distortion of their transfer characteristic must accordingly be small. The series circuit requires careful matching of the two time constants, but nonlinearity of its modulator characteristic results only in a departure from the predicted curve of resonant frequency versus modulating voltage. The photograph of Fig. 10 shows use of the sum circuit as a simple audio-frequency spectrum analyzer. The modulating voltage applied to the electronically tunable amplifier is merely a portion of the sawtooth sweep voltage of a standard oscilloscope. Its lowest sweep rate was slightly too rapid in view of the Q of the tuned amplifier, and some ringing is observed on the response curve obtained with a sine-wave input signal.

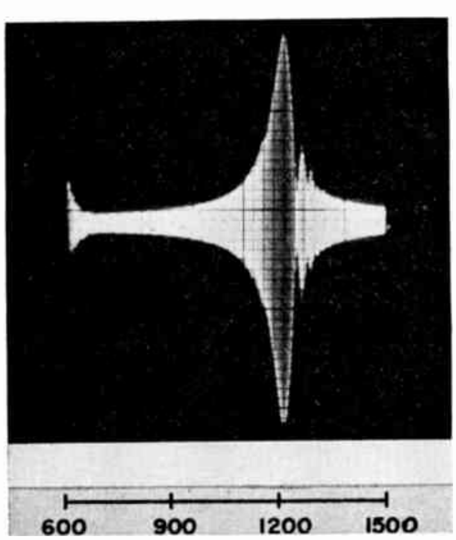

Fig. 10—Electronically tuned amplifier as spectrum analyzer. Response to single input frequency. 10-cps sawtooth sweep. Sum circuit.

It is evident that these circuits may be used as electronically tunable frequency-rejection bridges, since the feedback voltage at resonance passes through zero or 180 degrees at unity magnitude and, accordingly, may be balanced against a voltage derived from the input to give a zero resultant.

Conclusions

The two circuits described appear to be useful in view of the relatively wide frequency range over which they may be electronically tuned, the constancy of feedback voltage over this range, and the predictability (and relative linearity) of their frequency-versus-modulating-voltage characteristic.

Acknowledgment

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The Principle of a Servo-Type Mechanism Requiring Variable Elements*

R. DRENICK†, SENIOR MEMBER, IRE

Summary—**The subject of this article is the theoretical synthesis of a mechanism which has some essential features in common with conventional servomechanisms and some with analog computers. It operates on a feedback principle; that is, at one point of the system an input is compared with a signal fed back from the outputs of the device, and an error signal is derived from this comparison. The basic distinction lies in the fact that this one error signal is used in this mechanism to control two outputs which are subject to a constraint. This is accomplished by a suitable variation in the gains of the system.**

Introduction

THE PRESENT ARTICLE is concerned with the theoretical characteristics of a type of mechanism which operates on the feedback principle and performs certain computational functions. As will be seen, some of its characteristics are quite similar to those of conventional servomechanisms and analog computers, while others differ considerably. The main difference lies apparently in the fact that suitable stability features can be achieved only by employing specific types of time-variable, and often even nonlinear, elements. In return for this, however, the mechanism under discussion will, in general, control from one error signal, two outputs which are connected by one constraint.

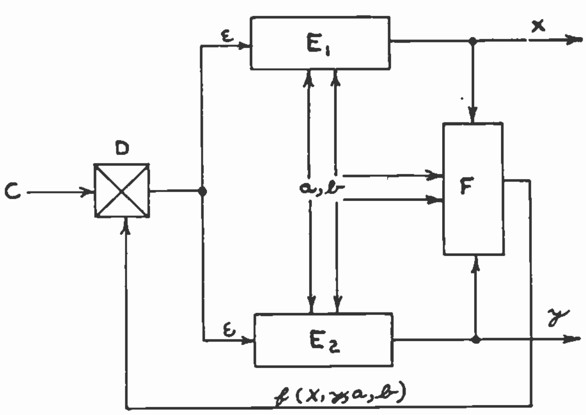

Fig. 1—Block diagram of mechanism.

The principle of operation can be explained by reference to Fig. 1. The two outputs of the mechanism are denoted there with x and y. Let the constraint be written generally as

$$f(x, y; a, b) = c, \tag{1}$$

where a, b, and often also c, are parameters which vary with time. The block marked F in Fig. 1 represents a computing element which forms $f(x, y; a, b)$. The differential D subtracts c from it and derives an error signal ϵ which indicates the failure of the mechanism to satisfy (1). The error signal is fed through the units E_1 and E_2, which act here somewhat like equalizing filters in conventional servos[1] and produce the outputs x and y.

Now, if the units E_1 and E_2 are properly designed, outputs x and y will exhibit various specifiable stability characteristics. Thus, one can specify that a certain mechanism of this type should be free from position errors.[2] By this it would be meant that the actual outputs x and y should, over a sufficiently long period of time, approach the desired ones infinitely closely, providing the desired outputs are constants $\bar{x}$ and $\bar{y}$ (or, more precisely, step-functions) connected by the constraint (1). One can, in principle, specify also that a certain mechanism should be free of velocity errors.[3] In such a case, the actual outputs should approach the desired ones infinitely closely if the latter are linear in time (or, more precisely, ramp functions) and connected by the constraint (1), and so on. In each case, a design exists for E_1 and E_2, which will satisfy such specifications. As a rule, it will be necessary to prescribe time-variable elements to accomplish this. These elements must be continuously adjusted in accordance with the variation of a and b in (1). In many cases, depending usually on the function $f(x, y; a, b)$, they will have to be nonlinear also.

The mechanism under discussion may seem a rather artificial concept at this point. In order to remove some of that impression, an assumed application will be presented in the next two sections to illustrate the idea. It is one in which the particular mechanism will be required to be free of velocity errors, as defined above, and in which $f(x, y; a, b)$ will be quadratic in x and y.

In two later sections, another case will be quantitatively discussed, namely, that in which the function $f(x, y; a, b)$ is linear in x and y and in which the mechanism is to be free only of position errors. It may be worth pointing out that, even in this special case, the mechanism does not degenerate into a conventional servomechanism, but retains the requirement for time variable gains in order to be stable.

Illustrative Example

In order to explain the idea of the mechanism under discussion, let the following hypothetical situation be visualized: Assume that, similar to Loran navigation,

* Decimal classification: 621.375.13. Original manuscript received by the Institute, December 20, 1951; revised manuscript received June 19, 1951.

† RCA Victor Div., Radio Corporation of America, Camden, N. J.

[1] H. M. James, N. B. Nichols, and R. S. Phillips, "Theory of Servomechanisms," McGraw-Hill Book Co., Inc., New York, N. Y., p. 196; 1947.

[2] *Ibid.*, p. 138.

[3] *Ibid.*, p. 145.

an aircraft receives signals which have been transmitted from several ground stations at exactly the same time.[4] Assume, furthermore, that the aircraft is capable of measuring accurately the time intervals between the arrivals of these signals.

Loran-type navigation requires two pairs, that is, at least three such ground stations. The reason for this is the following: One pair will produce in the aircraft equipment one time differential. This time differential is proportional to the difference in the distances between aircraft and the two ground stations. The navigator in the aircraft will, accordingly, be able to conclude that he is located somewhere along a curve which is characterized by that difference in the distances. Such a curve is, by definition, a hyperbola.

In order to determine his location completely, a second pair of ground stations is supplied in Loran navigation, which delivers to the navigator a second hyperbola. He then establishes as his position the point of intersection of the two curves.

Now, it can be argued that, in principle, one pair of ground stations should often be enough rather than the two used in Loran navigation. It is true that one pair can provide the aircraft with only one time differential and, hence, only one hyperbola. But, as will be explained immediately, if it is *also* known that the aircraft is flying for sufficiently long periods of time with constant speed and along a straight line course, its position and, incidentally, its velocity can be ascertained.

That this must be possible, at least in principle, can be seen from the following consideration: Assume that the navigator measures the one time differential available to him under the present arrangement at four successive occasions: t_0, $t_0+\Delta t$, $t_0+2\Delta t$, and $t_0+3\Delta t$. Each observation will then allow him to write down the equation of a hyperbola on which he must be located at that time. For example,

$$\begin{aligned} x^2/a_0^2 - y^2/b_0^2 &= 1 \quad \text{at} \quad t = t_0, \\ x^2/a_1^2 - y^2/b_1^2 &= 1 \quad \text{at} \quad t = t_0 + \Delta t, \\ x^2/a_2^2 - y^2/b_2^2 &= 1 \quad \text{at} \quad t = t_0 + 2\Delta t, \\ x^2/a_3^2 - y^2/b_3^2 &= 1 \quad \text{at} \quad t = t_0 + 3\Delta t. \end{aligned} \tag{2}$$

Now, it is true, he will not know his location at t_0, for example (x_0, y_0), nor his velocity (v_x, v_y) during the period of observation. But he will know that he must have been at the points

$$\begin{aligned} &(x_0, y_0) && \text{at} \quad t = t_0, \\ &(x_0 + v_x\Delta t, y_0 + v_y\Delta t) && \text{at} \quad t = t_0 + \Delta t, \\ &(x_0 + 2v_x\Delta t, y_0 + 2v_y\Delta t) && \text{at} \quad t = t_0 + 2\Delta t, \\ &(x_0 + 3v_x\Delta t, y_0 + 3v_y\Delta t) && \text{at} \quad t = t_0 + 3\Delta t. \end{aligned}$$

These points must be, respectively, on the hyperbolas (2). If they are substituted into their equations, one obtains four simultaneous equations for the four unknowns x_0, y_0, v_x, v_y, and can (in general) solve for them. The solutions are the initial location and velocity components of the aircraft.

The mechanism whose discussion is the topic of this article can, in principle, solve problems of this type. It does not, however, rely on discrete sampling of data, as has been so far used in the present example, but accepts data continuously. The function unit F in Fig. 1 would, in this application, generate the quantity

$$f(x, y; a, b) = x^2/a^2 - y^2/b^2.$$

The parameters a and b are characteristic of the hyperbola along which the aircraft is located in each instant, and they vary as the aircraft moves. The quantity c in (1) is unity here. The outputs x and y of the mechanism could, at the start of the operation, be arbitrary. Hence, as a rule, a discrepancy will exist between $f(x, y; a, b)$ and c, and an error signal will be developed at D (Fig. 1). The error signal will drive x and y, and, if the "equalizing" units E_1 and E_2 are properly designed, the outputs will approach the aircraft co-ordinates; that is, the discrepancies

$$[x_0 + v_x(t - t_0)] - x \quad \text{and} \quad [y_0 + v_y(t - t_0)] - y$$

between desired and actual outputs will asymptotically approach zero.

Reduction to a Linear Case

The critical item in what has just been called a proper design is the units E_1 and E_2. They would certainly have to be made time-variable, that is, their gains would have to be continuously adjusted in accordance with the instantaneous values, and the rates, of a and b. In this particular application, they would also have to be nonlinear. This circumstance makes the analysis and synthesis of many mechanisms of this sort quite involved mathematically and often rather unmanageable.

One can, however, introduce some assumptions, not altogether implausible, which allow the present problem to be formulated as a linear one. Moreover, they permit the stability specifications of the mechanism to be relaxed. Thus, one needs to require only that it be free of position errors, rather than of velocity errors as before.

The assumptions which lead to these simplifications are the following:

Let it be assumed that, in solving the hypothetical navigation problem, use could be made of additional information. Assume, first of all, that the aircraft has accurate means of measuring its velocity. Assume, furthermore, that there is always good reason to believe that it will depart only a little from some standard route, even if it did not employ the hypothetical navigation system. In such a case, one could state that, at any time t, its actual location would be

$$\begin{aligned} x_0^* + \delta x_0 + v_x(t - t_0) &= x^* + \delta x_0, \\ y_0^* + \delta y_0 + v_y(t - t_0) &= y^* + \delta y_0. \end{aligned} \tag{2a}$$

Here the subscripts zero refer to the time at which the mechanism is turned on. Asterisks denote the locations of the aircraft along the standard route which it would

[4] J. A. Pierce, A. A. McKenzie, and R. H. Woodward, "Loran," McGraw-Hill Book Co., Inc., New York, N. Y., p. 10; 1948.

follow only under ideal circumstances. The departures from this route under actual conditions are δx and δy. They are assumed small.

Now, the hyperbola which is set up at the time t by the navigation system is the locus of all possible aircraft locations at that time and, hence, must be satisfied by the co-ordinates of the aircraft $\bar{x}$ and $\bar{y}$. That is, one must have

$$\bar{x}^2/a^2 - \bar{y}^2/b^2 = 1$$

at any time t or, since δx_0 and δy_0 are small,

$$x^*\delta x_0/a^2 - y^*\delta y_0/b^2 = 1 - (x^{*2}/a^2 - y^{*2}/b^2). \quad (3)$$

In this equation x^*, y^*, a, b are known functions of time. The values of the deviations δx_0 and δy_0 are unknown. It is known, however, that they are constants. When they are established, they will determine the actual position of the aircraft at the time t_0, and hence, using (2a), at any time thereafter.

The mechanism which solves the problem of obtaining δx_0 and δy_0 could be one of the type discussed in this article. Its function unit F (Fig. 1) would combine the outputs x and y and form

$$f(x, y) = (x^*/a^2)x - (y^*/b^2)y.$$

The quantities (x^*/a^2) and (y^*/b^2) would act as the time-variable parameters which are denoted with a and b in Fig. 1. The input c shows that there will now be

$$c = 1 - (x^{*2}/a^2 - y^{*2}/b^2).$$

Any error signal derived from a discrepancy between f and c would drive x and y through the elements E_1 and E_2. If these are properly designed, the outputs x and y will stabilize on the unknown constants δx_0 and δy_0, and thus determine the initial displacements of the aircraft from its desired path. Some fairly general methods by which the elements E_1 and E_2 can be designed will now be derived.

Formulation of the Linear Problem in General

The example just given is a special case of a more general problem which is characterized by the fact that the desired outputs of the mechanism under discussion are two constants, $\bar{x}$ and $\bar{y}$ for example, which are at all times connected by a linear constraint

$$f(\bar{x}, \bar{y}; A, B) = A\bar{x} + B\bar{y} = C, \quad (4)$$

where A, B, and C are time-variable parameters. (Capital letters are used to distinguish the linear case from the general one, discussed in the Introduction.) The problem is that of designing a mechanism of the type under consideration whose outputs x and y would approach $\bar{x}$ and $\bar{y}$ infinitely closely as the time $t \to \infty$.

The mechanism would form in its function unit F (Fig. 1), the quantity

$$f(x, y; A, B) = Ax + By$$

which would be fed back and compared with the input c. The error signal

$$\epsilon = Ax + By - C = A(x - \bar{x}) + B(y - \bar{y}) \quad (5)$$

would drive the outputs x and y through the "equalizing" units E_1 and E_2. The problem of designing this mechanism is, accordingly, synonymous with that of establishing suitable performance equations for E_1 and E_2.

To do this, let it be first assumed that

$$A^2 + B^2 = 1.$$

This is no restriction to the generality of the solution, yet it simplifies the formulas which follow. Next, assume that the units E_1 and E_2 operate on their input ϵ according to the performance equations

$$\begin{aligned} x &= \xi_1\epsilon + \int_0^t \xi_2\epsilon dl \\ y &= \eta_1\epsilon + \int_0^t \eta_2\epsilon dl, \end{aligned} \quad (6)$$

where ξ_1, η_1, ξ_2, and η_2 are time-variable gains to be determined. The proof of this assumption lies chiefly in its success. It will be seen that the performance equations of E_1 and E_2 certainly need to be no more complicated than these. It is also easy to convince oneself that ξ_2 and η_2 must not be identically zero. Whether or not ξ_1 and η_1 can be omitted without sacrifice in the generality of the solution is not known. The derivations which follow are predicated on their presence.

It will be convenient in what follows to introduce two quantities x', y':

$$\begin{aligned} x' &= A(x - \bar{x}) + B(y - \bar{y}), \\ y' &= -B(x - \bar{x}) + A(y - \bar{y}). \end{aligned}$$

They render the formulas below more symmetrical. It should also be observed that, to make x approach $\bar{x}$, and y approach $\bar{y}$, it will be necessary to make x' and y' approach zero.

If these expressions are introduced into (6), one gets, after some simple manipulations, equations of the form

$$\dot{x}'\Delta = \alpha x' + \delta y', \qquad \dot{y}' = \beta x' + \gamma y', \quad (7)$$

where Δ, α, β, γ, δ, have been written for

$$\begin{aligned} \Delta &= 1 - A\xi_1 - B\eta_1, & \gamma &= \delta(A\eta_1 - B\xi_1), \\ \alpha &= A(\dot{\xi}_1 + \xi_2) + B(\dot{\eta}_1 + \eta_2), & \delta &= A\dot{B} - \dot{A}B. \quad (8) \\ \beta &= (A - \xi_1)(\dot{\eta}_1 + \eta_2) - (B - \eta_1)(\dot{\xi}_1 + \xi_2) - \delta\Delta, \end{aligned}$$

Of these coefficients, δ does not depend on the gains of the system but only on the inputs A and B. As will be seen, this circumstance often assigns to δ a fairly important role in determining the behavior of the mechanism.

Equations (7) describe the performance of the mechanism. The problem now is that of determining the gains of the system, ξ_1, η_1, ξ_2, and η_2 in such a way that the solutions x' and y' of (7) approach zero as $t \to \infty$. This problem has many solutions; that is to say, there exist many sets of gains which assure such solutions. One set leading to an especially simple one will now be suggested and will be shown to possess a potentially undesirable feature which has no parallel in conventional servotheory.

Reduction of Constant Coefficients

It is possible, in principle, to choose the gains ξ_1, η_1, ξ_2, and η_2, in such a way that (7) has constant coefficients, regardless of what the variation of A, B, and C is. Inspection of the first (7) shows that, to achieve this, one must have

$$\alpha = \lambda_1\delta, \qquad \Delta = \mu_1\delta, \tag{9a}$$

where λ_1 and μ_1 are suitable constants. This choice implies for the second equation

$$\beta = \lambda_2\delta, \qquad \gamma = \mu_2\delta. \tag{9b}$$

This leads to the system equations

$$\mu_1\dot{x}' = \lambda_1 x' + y', \qquad \mu_1\dot{y}' = \lambda_2 x' + \mu_2 y', \tag{10}$$

with the characteristic equation

$$\mu_1^2 p^2 - \mu_1(\lambda_1 + \mu_2)p + (\lambda_1\mu_2 - \lambda_2) = 0.$$

For solutions which approach zero as $t \to \infty$, one must have

$$\mu_1(\lambda_1 + \mu_2) < 0, \quad (\lambda_1\mu_2 - \lambda_2) > 0, \quad \lambda_1 \neq 0, \mu_1 \neq 0.$$

That is, the constants λ and μ can be chosen freely, providing only they satisfy these conditions. The gains which lead to the system (10) follow from (8) and (9). They are

$$\begin{aligned} \xi_1 &= A - \mu_2 B - \mu_1\dot{B}, \\ \eta_1 &= B + \mu_2 A + \mu_1\dot{A}, \\ \xi_2 &= (\lambda_1\mu_2 - \lambda_2)B/\mu_1 + (\lambda_1 + \mu_2)\dot{B} + \ddot{B}, \\ \eta_2 &= (\lambda_1\mu_2 - \lambda_2)A/\mu_1 + (\lambda_1 + \mu_2)\dot{A} + \ddot{A}. \end{aligned} \tag{11}$$

This shows that mechanisms of the type under discussion exist. Moreover, they can be designed to perform, in principle, like systems with constant gains. Their behavior is essentially like that of a servosystem with two inputs and two outputs, that is, a very simple version of a system described recently in the literature.[5] An assumption has, however, been tacitly made in this derivation which can lead to difficulties: To establish (10), both sides were divided by δ, a practice which is permissible only when $\delta \neq 0$.

It is, on the other hand, quite possible that δ should go through zero at times. Equations (10) would possess singularities at all these points. This means that a mechanism built with the gains (11) would become highly unreliable near such points, and small disturbances in the input could lead to unpredictably large errors at the outputs. To alleviate this situation, one would have to make arrangements which could render the servo very sluggish whenever δ became rather small and allow it to recover its sensitivity as each critical point was passed. Arrangements of this sort can actually be made by suitable redefinition of the gains ξ_1, η_1, ξ_2, and η_2, as will be illustrated in the next example.

Servo with Variable Sensitivity

It will now be shown that a mechanism with the following, rather simple, gain formulas,

$$\xi_1 = \mu A, \eta_1 = \mu B; \xi_2 = -2\mu\ddot{A}, \eta_2 = -2\mu\ddot{B} \; (\mu < 0), \tag{12}$$

exhibits the desired characteristic of variable sensitivity under rather general conditions.

In this example, one condition will be imposed on the coefficients A and B in (4). It is not very restrictive, and if it should be so in some specific case, it can be replaced with others. This condition is that

$$\int_0^\infty |\dot{\delta} - \mu\delta^3| \, dt < \infty. \tag{13}$$

Qualitatively, this means that $\dot{A}$, $\dot{B}$, $\ddot{A}$, and $\ddot{B}$ should go to zero reasonably rapidly, as $t \to \infty$. The condition will insure proper behavior for the present mechanism.

If the gains (12) are substituted into (7) and (8), one obtains

$$\dot{x}' = \mu\delta^2 x' + \delta y', \qquad \dot{y}' = \beta x' + \mu\delta^2 y', \tag{14}$$

with

$$\beta = -\delta - \mu\dot{\delta} + \mu^2\delta^3.$$

These equations can be simplified by substituting for x', y' the variables u, v

$$u = x' \exp\left[-\mu\int_0^t \delta^2 dt\right]$$

$$v = y' \exp\left[-\mu\int_0^t \delta^2 dt\right].$$

They reduce (14) to

$$\dot{u} = \delta v, \qquad \dot{v} = \beta u.$$

The solutions of this system are bounded when condition (13) is fulfilled.[6] This means that, under the same condition, the system responses

$$x' = u \exp\left[\mu\int_0^t \delta^2 dt\right],$$

$$y' = v \exp\left[\mu\int_0^t \delta^2 dt\right] \qquad (\mu < 0)$$

approach zero as $t \to \infty$. This is assured by the fact that the exponent is never positive. Moreover, these responses exhibit the desired characteristics of variable sluggishness: Whenever δ becomes small, the rates at which x' and y' approach zero become small, too. If δ should go to zero at any time, their approach is arrested altogether.

[5] M. Colomb and E. Usdin, "A theory of multidimensional servo systems," *Jour. Frank. Inst.*, vol. 253, pp. 29–59; 1952.

[6] A. Rosenblatt, "On the growth of the solutions of ordinary differential equations," *Bull. Am. Math. Soc.*, vol. 51, p. 723; 1945.

It might be repeated here that condition (13) is by no means the only one, nor perhaps even the simplest one which will insure the desired system behavior. The state of the art in the solution of linear differential equations, however, makes it difficult to derive conditions which are simple, yet sufficiently general to encompass most practical cases.

Conclusion

It has been demonstrated that, at least in principle, certain simple versions of the mechanism described in this article are realizable. The illustrative example given may hold a broad clue to their possible usefulness. It was shown, using a Loran-type navigation system as an illustration, that one can theoretically dispense with one piece of direct input information (namely, one time differential in the navigation system and, hence, at least one ground station) if one has sufficient *a-priori* knowledge of the characteristics of the desired outputs (the linearity of the variation of the aircraft co-ordinates).

In practice, as in the case of Loran navigation, there frequently exist no very pressing reasons why one should make use of any such *a-priori* knowledge even if it were sufficiently reliable to do so. It would probably not be even an economical procedure. Thus, it would presumably not be economically wise to decide on saving one ground station at the expense of putting mechanisms of the type described here into all aircraft using the navigation system.

One can conceive of situations, however, in which the opposite is true; that is, it may be either uneconomical, or even operationally impossible, to obtain complete input information, or to obtain it with the desired accuracy. In cases like these, it may be necessary to utilize any available *a-priori* knowledge concerning the anticipated outputs. When such knowledge exists, mechanisms of the type described here could fulfill rather useful functions.

Filter Transfer Function Synthesis*

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Summary—**In this paper we shall discuss a method for the synthesis of transfer functions which have one or more steady-state frequency bands throughout which a constant-amplitude level is approximated. Filters and amplifiers are familiar examples of circuits which commonly use transfer functions of this kind. The salient points of this method as applied to some low-pass filter examples will be considered herein.**

The Electrostatic Potential Analogy

LET US CONSIDER the transfer function

$$T(p) = \frac{E_1}{E_2} = K\frac{(p-p_1)(p-p_3)\cdots}{(p-p_2)(p-p_4)\cdots}, \quad (1)$$

where p is the complex frequency variable $p=\sigma+j\omega$; E_1 and E_2 are the input and output voltages, respectively; K is a real constant; $p_1, p_3, \cdots$ are the points of infinite gain; and $p_2, p_4, \cdots$ are the points of infinite loss. This attenuation ratio may be expressed as

$$e^{\alpha+j\beta} = T(p), \quad (2)$$

where α is the attenuation in nepers and β is the phase in radians. Equation (2) may also be written in the form

$$\alpha = \ln K + \ln|p-p_1| + \ln|p-p_3| + \cdots, \\ -\ln|p-p_2| - \ln|p-p_4| - \cdots, \quad (3a)$$

$$\beta = \arg(p-p_1) + \arg(p-p_3) + \cdots \\ - \arg(p-p_2) - \arg(p-p_4) - \cdots. \quad (3b)$$

As bibliographical references 1, 2, and 3 show,[1] if we place infinitely long parallel filaments having one unit of positive charge per unit of length so that they pierce the p-plane vertically at the poles $p_2, p_4, \cdots$ and similar filaments of negative charge at zeros $p_1, p_3, \cdots$, then α in (3a) is analogous to the potential between the filaments and β in (3b) is analogous to the flux. This analogy gives us a powerful tool for mathematical reasoning.

The LC Filter

Let us now discuss the use of this analogy for synthesizing a low-pass filter whose steady-state transfer characteristic $T(j\omega)$ has an equal-ripple pass and stop band similar to the characteristic shown in Fig. 1.

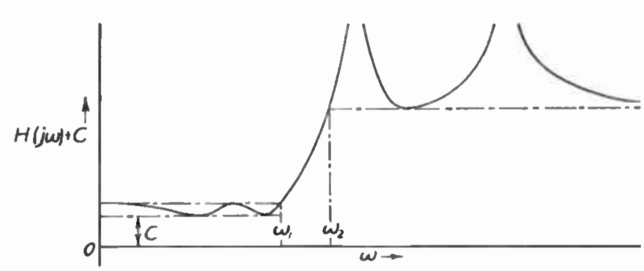

Fig. 1—The function $H(p)+C$ along $j\omega$ axis.

Furthermore, let us assume that this filter transfer function is to be realizable in a passive LC network.[2] This can be accomplished by a transfer function having four poles and zeros. The steps in the synthesis procedure are as follows:

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[1] This research makes use of the viewpoint presented by Klinkhamer in bibliographical reference 1.

[2] The network can be obtained by Darlington's procedure (see bibliographical reference 4).

Step 1

An electrostatic problem is set up by mathematically placing charged conducting plates in the regions of the p-plane where equal-ripple bands are desired. Thus, as is shown in Fig. 2, a conducting plate with eight units of negative charge is placed between $-j\omega_1$ and $j\omega_1$ where an equal-ripple pass band is desired, and plates are placed in the "equal-ripple" stop-band regions from $-j\infty$ to $-j\omega_2$ and from $j\omega^2$ to $j\infty$, each plate having four units of positive charge. Observe that this gives a potential variation along the $j\omega$ axis similar to the desired low-pass filter transfer characteristic.

Step 2

The distributed charge on the conducting plates is "quantized" into filaments of charge so that the complex potential may be expressed as the logarithm of a rational function. To accomplish this quantization, we must first find the charge distribution on the plates.

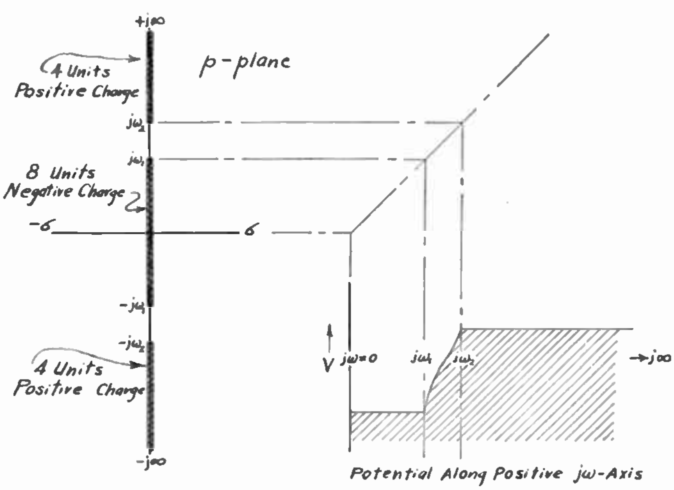

Fig. 2—Four-pole LC filter potential problem.

Since the flux emerges from or is terminated by charge, the charge distributions on the plates are known if the flux distributions at the surfaces of the plates are known. In many cases this flux distribution may be determined easily by use of a conformal mapping. For this particular problem the elliptic tangent function mapping makes the solution quite simple.[3]

Knowing the flux distributions at the surfaces, we may quantize the distributed charge into filaments having either unit charges, or double charges (per unit length). In this case the double-charge procedure will be used. Fig. 3 shows the flux about the pass-band plate. Two units of negative charge will terminate 4π lines of flux, hence the region between points a and b must contain two units of charge. Note that the point at which the π and 7π flux lines come together will divide this region into two parts, each of which has one unit of charge, i.e., the junction of the π and 7π flux lines divides the charge of the region a-b in half. This midpoint of the charge is the point at which the charge of the region a-b should be quantized. The positive charge on the stop-band plates is quantized in the same manner

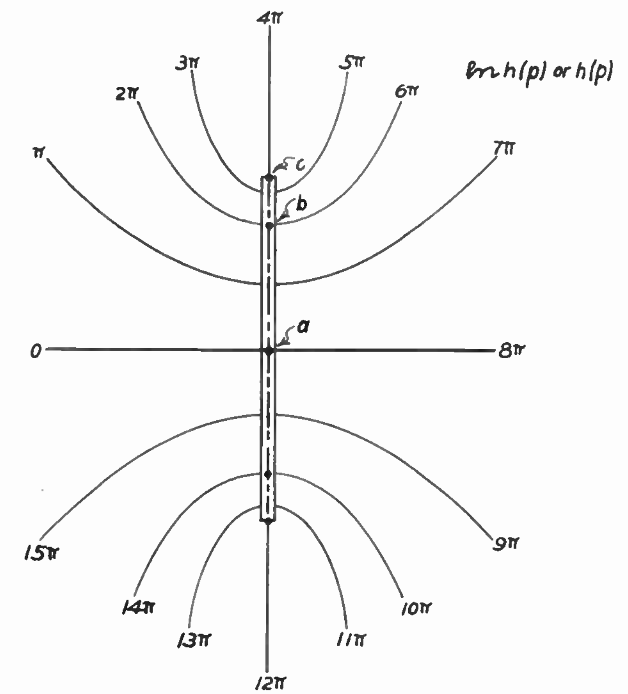

Fig. 3—Conducting plate with 8 units of negative charge.

and the results are pictured in Fig. 4. It can be shown that, in this case, quantizing the distributed charge this way will result in perfectly equal-ripple bands of potential where the plates were, as is indicated in Fig. 4.[4]

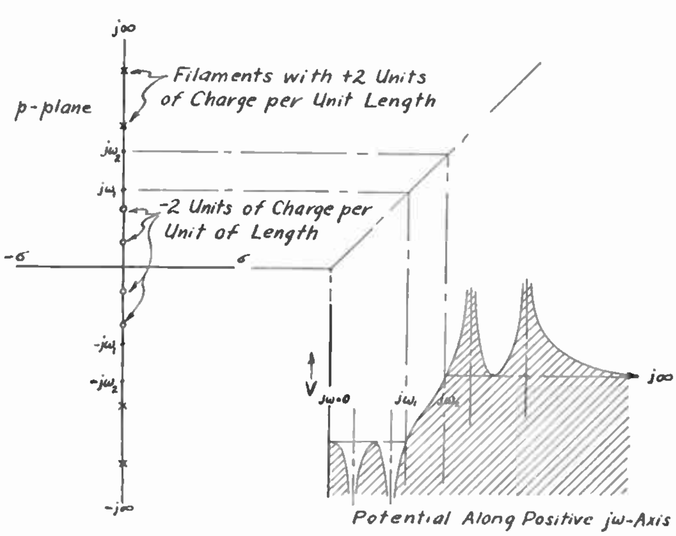

Fig. 4—Results of charge quantization.

The complex potential about the charge filaments in Fig. 4 may be expressed in the form

$$V + j\phi = \ln H(p), \tag{4}$$

[3] See bibliographical reference 3, pp. 23–27 and 81–82. The writer intends to offer a paper at a later date which will discuss the use of the elliptic tangent and other mappings for solution of the charge distribution problem.

[4] See bibliographical reference 3, chapter III. This proof also shows that the above quantization technique will not give *perfectly* equal-ripple bands for all cases. The cases where the method is not exact will be discussed later.

where V is the ordinary scalar potential, ϕ is the flux, and $H(p)$ is a rational function having double poles and zeros at the locations of the doubly charged positive and negative filaments, respectively. The constant multiplier of $H(p)$ is arbitrary, and it can easily be shown that if the multiplier is chosen to be real (1, for example), then $H(p)$ will be entirely real along the $j\omega$

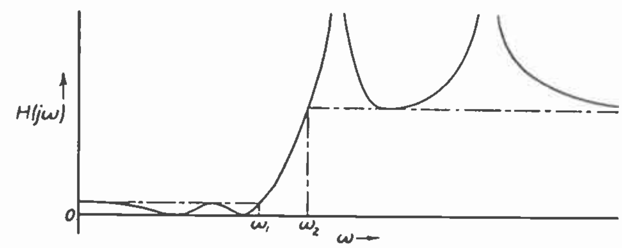

Fig. 5—The function $H(p)$ along $j\omega$ axis.

axis. Furthermore, in this case if we give the multiplier the proper sign, $H(p)$ will be entirely positive along the $j\omega$ axis, as shown in Fig. 5.[5] Observe that $H(j\omega)$ also has equal-ripple bands. We shall now manipulate $H(p)$ to obtain the desired transfer function.

Step 3

An appropriate real constant is added to the rational function $H(p)$. The addition of this constant causes the amplitude along the $j\omega$ axis to be of a low-pass filter form, as shown in Fig. 1. The size of the constant is determined by the attenuation ratio desired between the frequencies ω_1 and ω_2. Fig. 6 shows that the addition of the constant causes the double zeros on the $j\omega$ axis to move out onto the complex part of the plane in

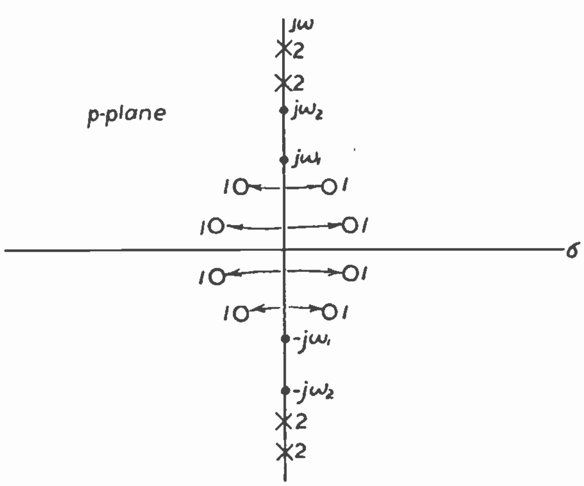

Fig. 6—$H(p)+C=T(p)T(-p)$.

a symmetrical manner. From this it is clear that the function $H(p)+C$ is not suitable as a transfer function because it would have points of infinite gain (natural modes) in the right half plane.

[5] This is due to the double poles and zeros on the $j\omega$ axis. If they were single, the function would have alternately positive and negative real regions along this axis.

Step 4

Half of each pole on the $j\omega$ axis and all poles and zeros in the right-half plane are discarded. This is why we started out with eight units each of positive and negative charge instead of only four, as might seem logical for the synthesis of a four-pole function.[6] This step leaves us with the desired transfer function $T(p)$ having four poles on the $j\omega$ axis and four complex zeros (see Fig. 7). It is readily seen that $H(p)+C=T(p)T(-p)$ and $|T(j\omega)|=\sqrt{H(j\omega)+C}$. Therefore the amplitude of $T(p)$ for steady-state frequencies will vary as the square root of the amplitude in Fig. 1.

The RC Filter

The transfer function shown in Fig. 7 can be realized in an LC network terminated in a resistance load. In

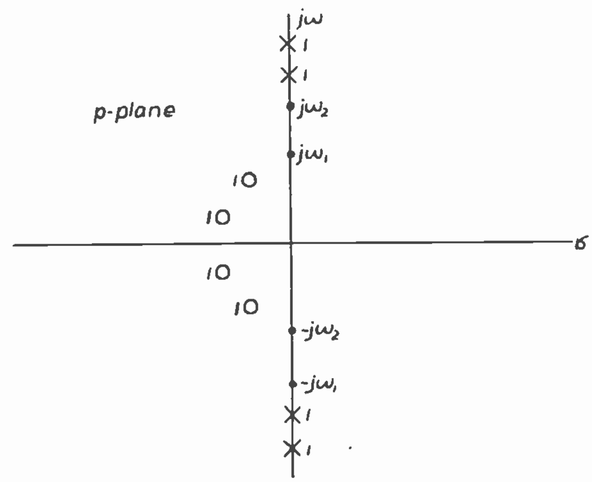

Fig. 7—$T(p)$. Low-pass transfer function.

most cases an LC filter is preferable, but now suppose a similar low-pass characteristic is required for an extremely low-frequency application. Then the size of coils in an LC filter would become impractical and an RC filter becomes desirable. As bibliographical reference 5 shows, for $T(p)$ to be realizable in a passive RC network all of its zeros (points of infinite gain) must lie on the negative real axis, and they must be simple. Since the zeros in the transfer function shown in Fig. 7 occur at complex frequencies, this transfer function cannot be realized in a passive RC network.

To see how an RC realizable low-pass filter transfer function can be obtained with an equal-ripple pass and stop band, let us go back to the $H(p)$ function related to Fig. 4 and the $H(p)+C$ function of Fig. 6. Observe that when a positive real constant is added to $H(p)$, the new zero locations will occur at points where $H(p)$ is real and negative. A little reflection on the matter reveals that when a real, positive constant is added to $H(p)$, the zeros move out along the lines of odd multiples of π

[6] An alternate procedure would be to start out using only four units of positive and negative charge and then quantize to give singly charged filaments and a rational function $H_z(p)$ with simple poles and zeros. Next, our previous function $H(p)$ could be obtained by simply squaring $H_z(p)$ to double the poles and zeros.

phase, and as larger and larger constants are added to $H(p)$, the zeros progress towards the poles.[7] Therefore, we may say that the poles have the effect of "attracting" the zeros when a constant is added to $H(p)$. This gives us the key to our problem. It is evident that if we are to prevent the zeros of $H(p)+C$ from locating themselves out on the complex part of the plane, as they did in Fig. 6, there must be additional poles on or near the real axis in order to "attract" the zeros in that direction. Consequently, the potential problem set up in Step 1 will be somewhat different for RC filter synthesis than it was for LC synthesis. In this case only part of the positive and negative charge will be distributed on conducting plates, the rest being in filaments on or near the real axis.

The question immediately arises, "How much charge should be used in filaments and how much should be on plates in the potential problem?" To answer this we may list several different cases:

Case A

If n is to be the number of poles and zeros in the transfer function and z is the number of positive (and also negative) charges in the potential problem, we may use $z=2n$ if n is an odd number.

Case B

If n equals two times an odd number, then we may use $z=n$.

Case C

If n is neither an odd number nor two times an odd number, we may use $z=n$.

For both Cases A and B, best "efficiency" will be obtained if

$$m = z/2 - 1 \tag{5}$$

and

$$x = z/2 + 1, \tag{6}$$

where m is the number of both positive and negative charges in filaments on or near the real axis and x is the number distributed on conducting plates. For Case C

$$m = z/2 \tag{7}$$

and

$$x = z/2. \tag{8}$$

The potential problem for synthesis of a 6-pole (Case B) RC filter is shown in Fig. 8. In accordance with (5) and (6), the stop-band plates have two units of positive charge each while the pass-band plate has four units of negative charge. There are also two units of positive and negative charge in filaments on the real axis. These filaments must be located so as to give a maximum number of saddle points on the real axis since when a constant is added to the rational function to move the $j\omega$-axis zeros to the real axis the zeros can enter the real axis only at saddle points.

This time we shall quantize the distributed charge into singly charged filaments, thus yielding $H_1(p)$ with simple poles and zeros. Briefly, the remainder of the synthesis may go as follows: All zeros of $H_1(p)$ are moved to the real axis by the addition of a constant C_1. Since $H_1(p)$ is alternately positive and negative real along the $j\omega$ axis (recall footnote 5), $|H_1(p)+C_1|$ will no longer have equal-ripple character in the stop band. This is corrected by forming the function

$$\frac{1}{H_2(p)} = \frac{1}{H_1(p) + C_1} + C_2,$$

where C_2 is a constant used to readjust the level of the $j\omega$-axis stop-band region ripples of $1/[H_1(p)+C_1]$ so that

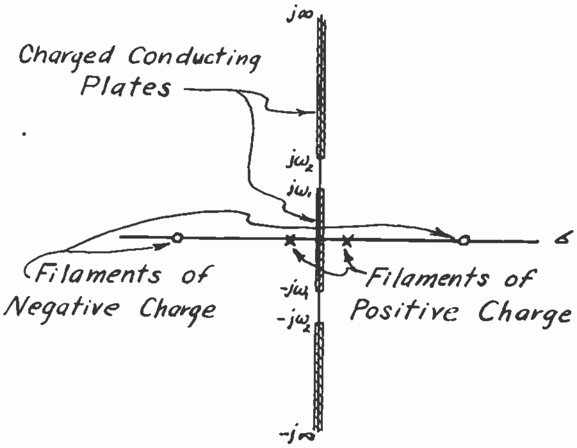

Fig. 8—Six-pole RC filter potential problem.

they extend equally above and below zero. The corrected function $H_2(p)$ is then squared (as was done in footnote 6). This gives double poles and zeros. If no buffer amplifier is to be used, we must have simple zeros on the real axis and a small real constant is subtracted from $H_2(p)$ to separate the zeros.[8] Then the right half plane poles and zeros are discarded, as in the LC case, and our 6-pole RC filter transfer function is shown in Fig. 9.

Observe that though the double pole on the real axis of Fig. 9 is necessary for RC realizability, it tends to decrease rather than increase the attenuation ratio of the filter. For this reason, it can easily be shown that the attenuation of the 6-pole RC function in Fig. 9 must be less than that of the 4-pole LC function of Fig. 7, assuming both to have the same per cent ripple in the pass band and the same ratio ω_1/ω_2. From (5), (6), (7), and (8), it is evident that transfer functions having an odd number or two times an odd number of poles (and zeros) will give the best attenuation ratios. However, even in those cases, as the number of poles is in-

[7] As an aid for visualizing the pattern of the odd multiple of π phase lines, recall that they have the same contours as the odd multiple of π flux lines in the electrostatic analogy.

[8] As bibliographical reference 5 points out, if a buffer amplifier is used, double zeros are permissible. This step is then unnecessary.

creased, the situation is rapidly approached where only half of the poles are contributing to the attenuating ability of the filter.

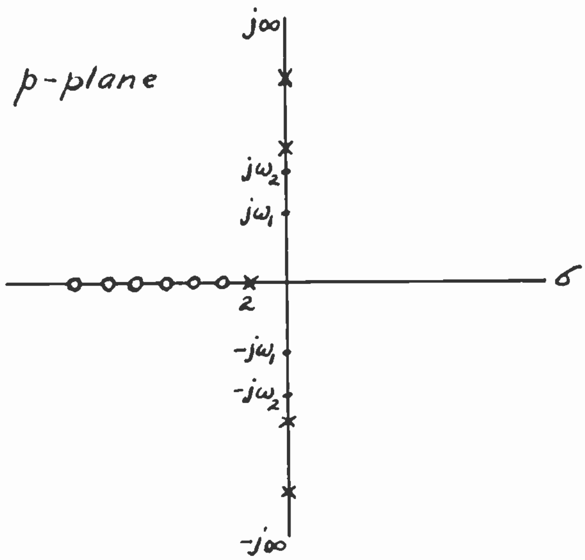

Fig. 9—Poles and zeros of 6-pole RC filter transfer function.

The RC, LC Filter

In spite of the relatively low "efficiency" of RC filter transfer functions, for extremely low-frequency applications, they are often desirable because of the saving in space and weight which RC networks can afford. For some moderately low-frequency applications it is likely that a compromise between the weight and space saving virtues of RC networks and the efficiency of LC networks is desirable.[9] Such compromises can be achieved by use of transfer functions of the variety shown in Fig. 10. In this case only enough poles are used on the real axis to locate 6 of the 10 zeros there. The 6 zeros and the 6 poles which occur at lower frequencies can be realized in an RC network, while the outer 4 poles and zeros may be realized in an LC network. Since the LC network poles and zeros occur at higher frequencies, their coils may not be of unreasonable size. The attenuation ratio of this 10-pole "compromise" filter with equal-ripple pass and stop bands would be superior to that of an analogous 14-pole, purely RC filter, and most likely the compromise filter attenuation ratio would be considerably superior.

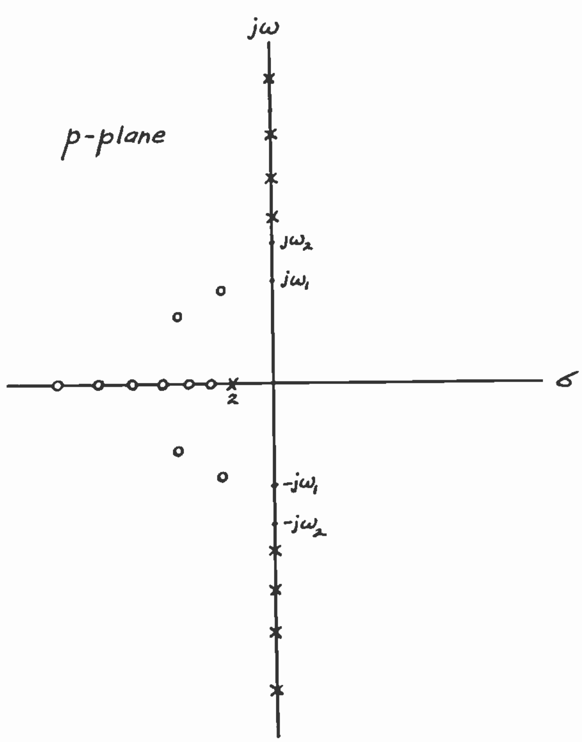

Fig. 10—Ten-pole, LC, RC compromise filter transfer function.

General Application of These Principles

In the preceding discussion, techniques have been pointed out for synthesis of three distinctly different transfer functions for low-pass filters with equal-ripple pass and stop bands. For practical purposes, this method of attack can be used to synthesize almost any transfer function having equal-ripple or maximally flat bands. It provides a means for meeting special pole and zero location limitations imposed by circuit requirements.

It is of at least theoretical interest to point out that this procedure will not always give *perfectly* equal-ripple bands. Whether or not perfectly equal-ripple bands character is obtained depends on the nature of the initial potential problem. To give perfectly equal-ripple results by use of this procedure, the potential problem must have all of the charge of a given sign distributed on conducting plates if any of the charge of that sign is distributed. The potential problem of Fig. 2 meets this requirement. A potential problem with, for example, all of the negative charge on conducting plates and all of the positive charge already quantized into filaments would also give perfectly equal-ripple results.

The cases which generally give only approximately equal-ripple bands are those where part of the charge of a given sign is distributed and part of the charge of that sign is already quantized. The problem shown in Fig. 8 is of this type.

Though when synthesizing RC filters having equal-ripple pass and stop bands this method does not give perfectly equal-ripple bands, the approximation appears to be so good that this is of little consequence. For instance, in the numerical examples that the author computed, deviations from perfectly equal-ripple character in the "equal-ripple" bands of the $H_1(p)$ function did not appear until the third or fourth significant figure. After a constant was added to $H_1(p)$, this small deviation became so minute as compared with the total amplitude of the function that the error became entirely negligible. The author also found that if a single rather than double-charge quantization procedure is used, the error will be less.

[9] Besides the low "efficiency" of the transfer function, RC filters have the additional disadvantage of introducing a constant loss due to the resistors. This is usually compensated for by an amplifier.

ACKNOWLEDGMENT

In conclusion, the author would like to acknowledge many helpful suggestions received from Professor D. F. Tuttle, Jr. of Stanford University during the course of this research.

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Stabilization of Nonlinear Feedback Control Systems*

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Summary—**Conventional methods for linear systems may be used for determining the operating characteristics of a nonlinear device near equilibrium, provided the differential equations expressing its operation can be expanded in a Taylor series about the equilibrium point. These methods are justified only for variations about equilibrium sufficiently small that all second and higher power terms of the expansions can be neglected, thereby reducing the expansions to linear equations. In linear feedback systems the response is independent of the equilibrium point. If a system is inherently nonlinear, it generally will not have this characteristic. It is shown that these systems can be modified so that the response of the output will also be independent of the equilibrium point, except for an amplitude scale factor, for a given incremental input variation from equilibrium.**

STABILIZATION OF NONLINEAR FEEDBACK CONTROL SYSTEMS

DURING THE PAST YEARS a large amount of material has been presented concerning feedback devices. The most exact mathematical treatment has been developed for systems characterized by linear differential equations with constant coefficients. Fortunately, many systems may be considered nearly linear and calculations of performance characteristics do not deviate greatly from those of the physical device.

Nonlinear systems have been studied for as long a period as linear systems, and a number of approaches have been developed; however, these approaches are not too flexible and general criteria cannot be obtained easily. Although nonlinear devices are in common use (such as switches, tubes, and innumerable others), it is felt that these mathematical difficulties still restrict the development of other useful devices. Nonlinear feedback systems can produce a multitude of effects that cannot be produced by linear systems. For example, a device of this type can generate an output which is a function such as the logarithm of the input. Unfortunately, no single stability criterion is available for the design of such systems. In this paper a criterion is obtained which causes a system to have a uniform response about any equilibrium point.

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Equilibrium Conditions

A system will be considered in equilibrium when the input to and output from the system are both constant. (The equilibrium condition may be either stable or unstable.) For such a system, the equilibrium output E_{00} may be plotted as a function of a constant input E_{ii} (see Fig. 1).

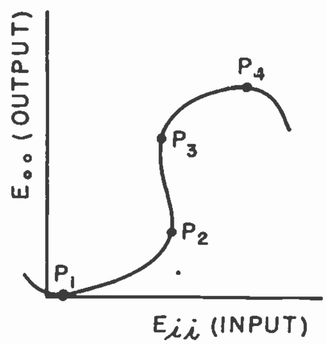

Fig. 1—Possible form of equilibrium condition.

The points P_1, P_2, P_3, P_4, where the slope of the static or equilibrium curve changes sign, are of special interest since they divide the static curve into regions for which there is one-to-one correspondence between input and output. For the present the discussion will be limited to one of these intervals between two consecutive special points.

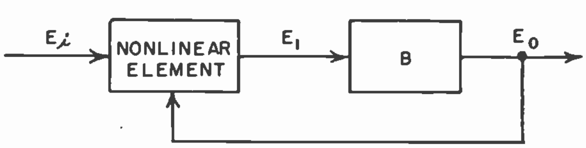

Fig. 2—Block diagram of nonlinear closed-loop system.

The nonlinear system will be considered to consist of a linear section and a nonlinear section (see Fig. 2).

Here the nonlinear section performs an operation upon the input E_i and output E_0, and produces an output E_1. The output E_1 excites the linear section B whose output is E_0.

If Y_B is the transfer function of block B, then the relationship between E_1 and E_0 is

$$E_0 = Y_B E_1. \tag{1}$$

Generally, Y_B will be a function of the differential time operator p.[1] The output E_1 of the nonlinear device is a function of E_i, E_0 and the derivatives of E_i and E_0 with respect to time, that is,

$$E_1 = f(E_i, E_0; \dot{E}_i, \dot{E}_0; \ddot{E}_i, \ddot{E}_0; \cdots). \tag{2}$$

At equilibrium, E_i and E_0 are represented by E_{ii} and E_{00}, as before; and all the derivatives of E_{ii} and E_{00} have a value of zero. The relationship shown in Fig. 1 is then the solution of the equation

$$E_{00} = Y_B f(E_{ii}, E_{00}), \tag{3}$$

which is obtained from (1) and (2).

Equation (2) may be expanded in a Taylor's series about the equilibrium condition. First, E_i and E_0 will be defined in terms of the equilibrium values and variations about the equilibrium values

$$\begin{aligned} E_0 &= E_{00} + \Delta_0 \\ E_i &= E_{ii} + \Delta_i. \end{aligned} \tag{4}$$

Then, if Δ_i, Δ_0 and all of their derivatives approach zero, E_1 reduces in this limit to

$$E_1 = f(E_{ii}, E_{00}) + \sum_{n=0} a_n p^n \Delta_i + \sum_{n=0} b_n p^n \Delta_0, \tag{5}$$

where

$$a_n = \frac{\partial f}{\partial\left(\dfrac{d^n E_i}{dt^n}\right)}$$

$$b_n = \frac{\partial f}{\partial\left(\dfrac{d^n E_0}{dt^n}\right)}, \tag{6}$$

both evaluated at the equilibrium condition.[2,3] Substituting (5) into (1) and subtracting the equilibrium relationship given by (3), a linear relationship between Δ_i and Δ_0 is obtained.

$$\Delta_0 = Y_B\left(\sum_{n=0} a_n p^n \Delta_i + \sum_{n=0} b_n p^n \Delta_0\right). \tag{7}$$

If the inverse of Y_B is Y_B^{-1}, then the transfer function of the nonlinear system for small variations of Δ_i and Δ_0 about equilibrium is given by

$$\frac{\Delta_0}{\Delta_i} = \frac{\sum_{n=0} a_n p^n}{Y_B^{-1} - \sum_{n=0} b_n p^n}. \tag{8}$$

The stability of the equilibrium may now be investigated by using Nyquist's[4,5] or Routh's[6] criterion. However, the a's and b's used in (8) are not constants as in the case of a linear system, but are functions of the equilibrium condition, and for this reason the transient response about equilibrium is determined by the equilibrium position. For example, the system may be unstable about one equilibrium point and be very sluggish about another equilibrium point.

If the a's and b's are constants independent of the equilibrium condition, the system will have a uniform response about any equilibrium condition. In fact, if the b's are constants and a_n/a_0's are constants, then the system will have a uniform response about any equilibrium point, with only the amplitude of the response changing. The last condition must be accepted as an optimum condition if the desired equilibrium is of a nonlinear nature.[7] The process of obtaining this latter condition will be called "first-order linearization."

First-Order Linearization

Linearization about an equilibrium point may be accomplished by several methods. Consider an amplifier whose gain is controlled by E_0. This unit amplifies E_1 and drives block B as shown in Fig. 3.

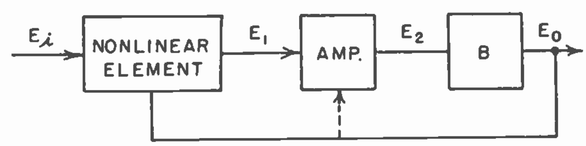

Fig. 3—Block diagram of system with first-order linearization.

If the gain of the amplifier is denoted by G, the value of E_2 becomes

$$E_2 = f(E_i, E_0; \dot{E}_i, \dot{E}_0; \cdots)G. \tag{9}$$

The value of E_2 may be expanded in the same manner as given for E_1, giving

$$E_2 = f(E_{ii}, E_{00})G + G\left\{\sum a_n p^n \Delta_i + \sum b_n p^n \Delta_0\right\} + \frac{\partial G}{\partial E_0} f(E_{ii}, E_{00})\Delta_0. \tag{10}$$

Since the equilibrium condition is now

$$Y_B^{-1} E_{00} = f(E_{ii}, E_{00})G, \tag{11}$$

the relationship between Δ_0 and Δ_i becomes

$$\frac{\Delta_0}{\Delta_i} = \frac{G\sum a_n p^n}{Y_B^{-1} - G\sum b_n p^n - f(E_{ii}, E_{00})\dfrac{\partial G}{\partial E_0}}. \tag{12}$$

[1] E. L. Ince, "Ordinary Differential Equations," Dover Publications, New York, N. Y., pp. 114, 115; 1944.

[2] A. A. Andronow and C. E. Chaikin, "Theory of Oscillations," (English Language Edition) Princeton University Press, Princeton, N. J., pp. 197–199; 1949.

[3] N. Minorsky, "Non-Linear Mechanics," J. W. Edwards, Inc., Ann Arbor, Mich., pp. 48–55; 1947.

[4] G. S. Brown and D. P. Campbell, "Principals of Servomechanisms," John Wiley and Sons, New York, N. Y., pp. 166–175; 1948.

[5] H. W. Bode, "Network Analysis and Feedback Amplifier Design," D. Van Nostrand Co., New York, N. Y., pp. 137–169; 1945.

[6] M. F. Gardner and J. L. Barnes, "Transients in Linear Systems," John Wiley and Sons, New York, N. Y., pp. 197–201; 1942.

[7] It is possible to require that only the b's be constant, but in this case the shape of the transient solution will not be uniform about all equilibrium points.

Now, if G satisfies

$$G\frac{\partial f}{\partial E_0}+f\frac{\partial G}{\partial E_0}=-K, \tag{13}$$

where K is a constant, then (12) becomes

$$\frac{\Delta_i}{\Delta_0}=\frac{Ga_0\left(1+\sum_{n=1}^{\infty}\frac{a_n}{a_0}p^n\right)}{Y_B^{-1}+K-\sum_{n=1}^{\infty}b_np^n}. \tag{14}$$

If f is a function of only E_i and E_0, (14) indicates that the system will have a uniform transient response, since all b's and a_n/a_0's in (14) are then zero.

Example

The block diagram of a servo square-root system to be examined is shown in Fig. 4.

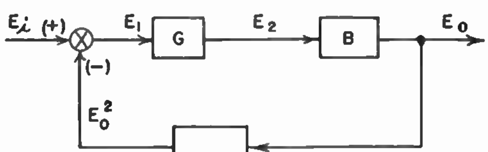

Fig. 4—Block diagram of square-root generator.

If G is a constant and Y_B^{-1} is of the form $p(p+d)$, then (12) becomes

$$\frac{\Delta_0}{\Delta_i}=\frac{G}{Y_B^{-1}+2GE_0}. \tag{15}$$

And if G is not constant but is a solution of (13), then

$$\frac{\Delta_0}{\Delta_i}=\frac{\dfrac{K}{2E_{00}}}{Y_B^{-1}+K}. \tag{16}$$

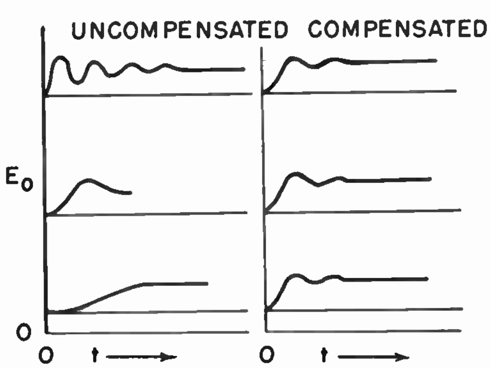

Fig. 5—Step function response of square-root generators.

The transient value of Δ_0 is uniform in the second case while the response given by (15) changes with E_0. The responses of the two are shown in Fig. 5. The equilibrium conditions are shown as straight lines while the transient responses are the small deviations from these straight lines. Equation (13) may often reduce to

$$G=\frac{K}{\partial f/\partial E_0} \tag{17}$$

exactly, if Y_p^{-1} is the form $p(a_0+a_1p+a_2p^2+\cdots)$, and approximately, if the gains of G and Y are sufficiently large to cause E_2 to approach zero.

In our general case f was considered to be a function not only of E_i and E_0 but also of the derivatives. At times it is possible to allow G to be a function of these derivatives as well as E_0, in which case (10) can be written as

$$E_2=f(E_{ii},E_{00})G+G\left\{\sum a_np^n\Delta_i+\sum b_np^n\Delta_0\right\}$$
$$+f(E_{ii},E_{00})\left\{\sum_{n=1}^{\infty}A_np^n\Delta_i+\sum_{n=1}^{\infty}B_np^n\Delta_0\right\}. \tag{18}$$

Here A_n and B_n are

$$A_n=\frac{\partial G}{\partial\left(\dfrac{d^nE_i}{dt^n}\right)} \tag{19}$$

$$B_n=\frac{\partial G}{\partial\left(\dfrac{d^nE_0}{dt^n}\right)}. \tag{20}$$

In this case the linearization may be accomplished by requiring that

$$b_n+B_n=\text{constant}\quad n=0,1,2,\cdots \tag{21}$$

$$\frac{a_n+A_n}{a_0}=\text{constant}\quad n=1,2,3,\cdots. \tag{22}$$

Special Points[8]

Operation near the special points must be carefully considered. Observe P_2 in Fig. 6. If the system is in

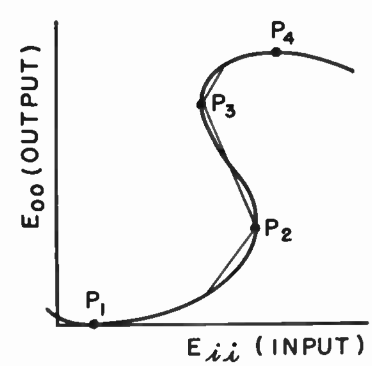

Fig. 6—Modification of equilibrium conditions.

equilibrium at point P_2 and an incremental change is made in E_{ii}, then ideally E_{00} must change to a new value. If the incremental gain of the system is defined

[8] A. A. Andronow and C. E. Chaikin, *op. cit.*, p. 198.

as dE_{00}/dE_{ii}, it will be noted that the system would have infinite incremental gain. Likewise, (13) designating G would be found to be infinite. Obviously, both of these conditions are impossible. It has been found to be practical in the case of function generators to alter the function at points of infinite slope so that the slope on both sides of the special point is finite and is undetermined at the point itself as shown in Fig. 6.

Acknowledgments

The author wishes to express his appreciation for the assistance and guidance given him in the development of this material and its preparation by the members of the Antenna Laboratory and Electrical Engineering Department of the Ohio State University. In particular, he wants to thank C. E. Warren, V. H. Rumsey, R. A. Fouty, and Jack Bacon.

Nomograms for the Computation of Tropospheric Refractive Index*

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Summary—**Three sets of nomograms permitting calculation of tropospheric refractive index, refractive index discontinuity, and vertical refractive index gradient are presented. So far as is known, no similar charts have been made for discontinuity and gradient calculations. All three have been designed about the standard radiosonde transmission, which gives temperature, dew-point temperature, and pressure at points where discontinuities occur in the vertical gradients of temperature or dew-point temperature. These nomograms are valid for all wavelengths greater than 1.5 cm.**

Introduction

Although several nomograms, charts, and tables for the computation of the atmospheric refractive index have been prepared by others,[1,2,3,4] these are not well-adapted to the evaluation of tropospheric refractive index from the standard meteorological radiosonde reports. The nomograms presented below for the computation of tropospheric refractive index, its gradients and discontinuities, are designed around the standard radiosonde transmission, utilizing temperature, dew-point temperature, and pressure. For the calculation of refractive index gradients in the vertical, the hydrostatic equation has been incorporated in the calculation of the nomogram, thus eliminating the need for subsequent height calculations.

The standard transmissions give temperature, dew-point temperature, and pressure at "critical" points where the vertical gradients of either temperature or dew-point temperature change "significantly." As transmitted, the curves of temperature and dew-point temperature versus height are continuous broken-line-segment curves.

For the sake of completeness, values of dielectric constant have been included where appropriate, while modified refractive index values are easily obtained by addition of the height term.

The Refractive Index of Air

Following an extensive search of the literature, the following equation was taken as best representing the variation of tropospheric refractive index with temperature (T, °K), total pressure (p, mb), and water-vapor pressure (e, mb):[2,5–15]

$$(n-1)\cdot 10^6 = \frac{74.4}{T}\left(p + \frac{4973e}{T}\right). \qquad (1)$$

Conversion to dew-point temperature (T_D, °K) is made by

$$e = 6.105 \exp 5369\left(\frac{1}{273} - \frac{1}{T_D}\right), \qquad (2)$$

* Decimal classification: R082×R112.21. Original manuscript received by the Institute May 24, 1950; revised manuscript received August 25, 1952.

† Signal Corps Engineering Laboratories, Fort Monmouth, N. J.

[1] A. W. Friend, "Charts of dielectric constant or refractive index of the troposphere," Technical Report No. 34, Cruft Laboratory, Harvard University, Cambridge, Mass.; 1948.

[2] A. W. Friend, *op. cit.*, *Bull. Amer. Met. Soc.*, vol. 29, pp. 500–509; December, 1948.

[3] R. H. Burgoyne, "Nomograms for computation of modified index of refraction," M.I.T. Radiation Laboratory Rept. No. 551, M.I.T., Cambridge, Mass.; April 6, 1946.

[4] H. G. Booker, "Some problems in radio meteorology," *Quart. Jour. Roy. Met. Soc.*, vol. 74, pp. 277–315; July–October, 1948.

[5] C. M. Crain, "The dielectric constant of several gases at a wavelength of 3.2 centimeters," *Phys. Rev.*, vol. 74, pp. 691–693; September, 1948.

[6] L. G. Hector and D. L. Woernley, "The dielectric constants of eight gases," *Phys. Rev.*, vol. 69, pp. 101–105; February 15, 1946.

[7] Landolt-Börnstein, *Physikalisch-Chemische Tabellen*, Fünfte Auflage, J. Springer, Berlin; 1923–1936

[8] R. Sänger, "Bestimmung des elektrischen momentes eines moleküls aus dem temperaturverhalten der dielektrizitätskonstanten," *Phys. Zeit.*, vol. 31, pp. 306–315; April 1, 1930.

[9] J. D. Stranathan, "Dielectric constant of water vapor," *Phys. Rev.*, vol. 48, pp. 538–544; September, 1935.

[10] A. C. Tregidga, "The dielectric constant of water vapor at a frequency of 42 megacycles," *Phys. Rev.*, vol. 57, pp. 294–297; February, 1940.

[11] H. E. Watson, G. G. Rao, and K. C. Ramaswamy, "Dielectric coefficients of gases: Part II," *Proc. Roy. Soc. A.*, vol. 143, pp. 558–588; February, 1934.

[12] C. R. Englund, A. B. Crawford, and W. W. Mumford, "Further studies of ultra-short-wave transmission phenomena," *Bell Sys. Tech. Jour.*, vol. 14, pp. 369–387; July, 1935.

[13] J. A. Saxton, "Dielectric properties of water vapour at very high frequencies," *Meteorological Factors in Radio-Wave Propagation Phys. Soc.*, London, pp. 215–238; 1946.

[14] F. J. Kerr, "Refractive indexes of gases at high radio frequencies," *Nature*, London, vol. 148, p. 752; December, 1941.

[15] It will be noted that this differs slightly from the widely used formula [12,16,17]

$$(n-1)\cdot 10^6 = \frac{79}{T}\left(p + \frac{4800e}{T}\right). \qquad (1a)$$

[16] "Meteorological factors in radio-wave propagation," *Phys. Soc.* London; 1946.

[17] S. S. Attwood, ed., "Radio Wave Propagation," Academic Press, New York, N. Y.; 1949.

which gives a good fit over the range −20 to +40 degrees C.[18,19] The resulting formula for the refractive index may then be evaluated by use of Figs. 1(a) and (b) below. For small discontinuities of temperature and dew-point temperature Figs. 2(a), (b), and (c) may be utilized, while the following formula is obtained for a temperature of 10 degrees C, dew-point temperature 0 degrees C, and pressure of 880 millibars.

$$\Delta n \cdot 10^6 = 2\Delta T_D - \Delta T. \tag{3}$$

Incorporating the hydrostatic relation

$$\frac{dp}{dz} = -g\rho \tag{4}$$

leads to an equation for the vertical gradient of refractive index evaluated by use of Figs. 3(a) to (e);

$$\frac{dn}{dz} = -2.54 \cdot 10^{-8} \frac{p}{T^2} - \frac{dT_D}{dp}\left[4.142 \frac{p}{T^3 T_D^2} \exp 5369\left(\frac{1}{273} - \frac{1}{T_D}\right)\right] + \frac{dT}{dp}\left[2.54 \cdot 10^{-8} \frac{p^2}{T^3} + 1.543 \cdot 10^{-3} \frac{p}{T^4} \exp 5369\left(\frac{1}{273} - \frac{1}{T_D}\right)\right]. \tag{5}$$

Use of Nomograms for Index Calculations

Figs. 1(a) and (b) indicate the contributions of the density of atmospheric gases and of water vapor present to the index of refraction. Fig. 1(a) is entered with temperature and pressure. A straight edge connecting these gives that part of $(n-1)$ due to density of the gas. Fig. 1(b) is entered with temperature and dew-point temperature. A straight edge connecting these gives that part of $(n-1)$ due to the presence of water vapor. These two contributions are added to obtain the total index of refraction. Dielectric constant values have also been plotted for convenience.

Figs. 2(a), (b), and (c) permit calculation of refractive index or dielectric constant discontinuities due to rapid changes of temperature and dew-point temperature with height. Fig. 2(a) is entered with temperature and dew-point temperature to give the differential coefficient, D_D, multiplying the change in dew-point temperature. Fig. 2(b) is entered on the left with temperature and pressure to obtain one of the differential coefficients D_{T1} of the dry-bulb temperature change, while it is entered on the right with temperature and dew-point temperature to give the other coefficient, D_{T2}. These dry-bulb-temperature multipliers are added. Fig. 2(c) is entered with the change of temperature, dew-point or dry-bulb, and with the proper differential coefficient. A straight edge gives the product. Care must be exercised to keep the signs straight. The actual value of the change of index is given by the change due to dew-point temperature change *minus* that due to dry-bulb temperature change. Dielectric-constant values are also included for convenience in Fig. 2(c).

Figs. 3(a) to (e) are used to calculate the refractive-index gradient. They are entered with pressure, temperature, dew-point temperature, $\Delta T/\Delta p$ and $\Delta T_D/\Delta p$ at each "significant" level of the radiosonde report. For the difference of index gradients, the differences of temperature gradient and of dew-point gradient above and below the significant levels are used in place of $\Delta T/\Delta p$ and $\Delta T_D/\Delta p$, respectively. Fig. 3(a) is entered with temperature and pressure to give the contribution to index gradient due to the change of pressure with height, dn_p/dz. Fig. 3(b) is entered with temperature and pressure to give the point on the center scale. Then it is entered with dew-point temperature in the right-hand scale to give the derivative-coefficient for the dew-point-temperature gradient with pressure, G_D. Fig. 3(c) is entered with temperature and pressure to give the first derivative-coefficient for the dry-bulb-temperature gradient, G_{T1}. Fig. 3(d) is entered with temperature and pressure on the left to give the point on the center scale. Then it is entered with dew-point temperature to give the second derivative-coefficient for the dry-bulb-temperature gradient, G_{T2}. The two gradients, G_{T1} and G_{T2}, are added. Finally, Fig. 3(e) is entered with the temperature gradients and their respective derivative-coefficients to give their contributions to the refractive-index gradient. Care must be taken here to preserve the signs in multiplication. Contributions due to dew-point-temperature gradient and vertical-pressure gradient are subtracted from that due to dry-bulb-temperature gradient to obtain actual value of index gradient. Dielectric-gradient values are included.[20]

For some purposes difference of refractive-index gradient above and below the "significant" level is needed. This can be calculated directly by entering Fig. 3(e) with difference of temperature (or dew-point-temperature) gradients above and below "significant" level.

For convenience in picking data off plotted adiabatic diagrams, the temperature and dew-point-temperature gradients in Fig. 3(e) are labeled with temperature-difference per ten millibars.

Acknowledgment

The research reported in this article was made possible through support extended Cruft Laboratory, Harvard University, jointly by the Navy Department (Office of Naval Research), the Signal Corps of the U. S. Army, and the U. S. Air Force, under ONR Contract N5ori-76, T.O. 28.

[18] J. H. Keenan and G. K. Keyes, "Thermodynamic Properties of Steam," John Wiley and Sons, New York, N. Y.; 1936.

[19] P. J. Kiefer, "The thermodynamic properties of water and water vapor," *Mon. Weath. Rev.*, vol. 69, pp. 329–331; November, 1941.

[20] If M-gradient values are desired, one need merely add $\partial M/\partial h$ to the result.

$$M = (n-1)\cdot 10^6 + \frac{h}{a}\cdot 10^6 \tag{6}$$

$$\frac{\partial M}{\partial h} = \frac{10^6}{a} = .157\ m^{-1}, \tag{7}$$

where a is the radius of the earth ($a = 6.371 \cdot 10^6$m).

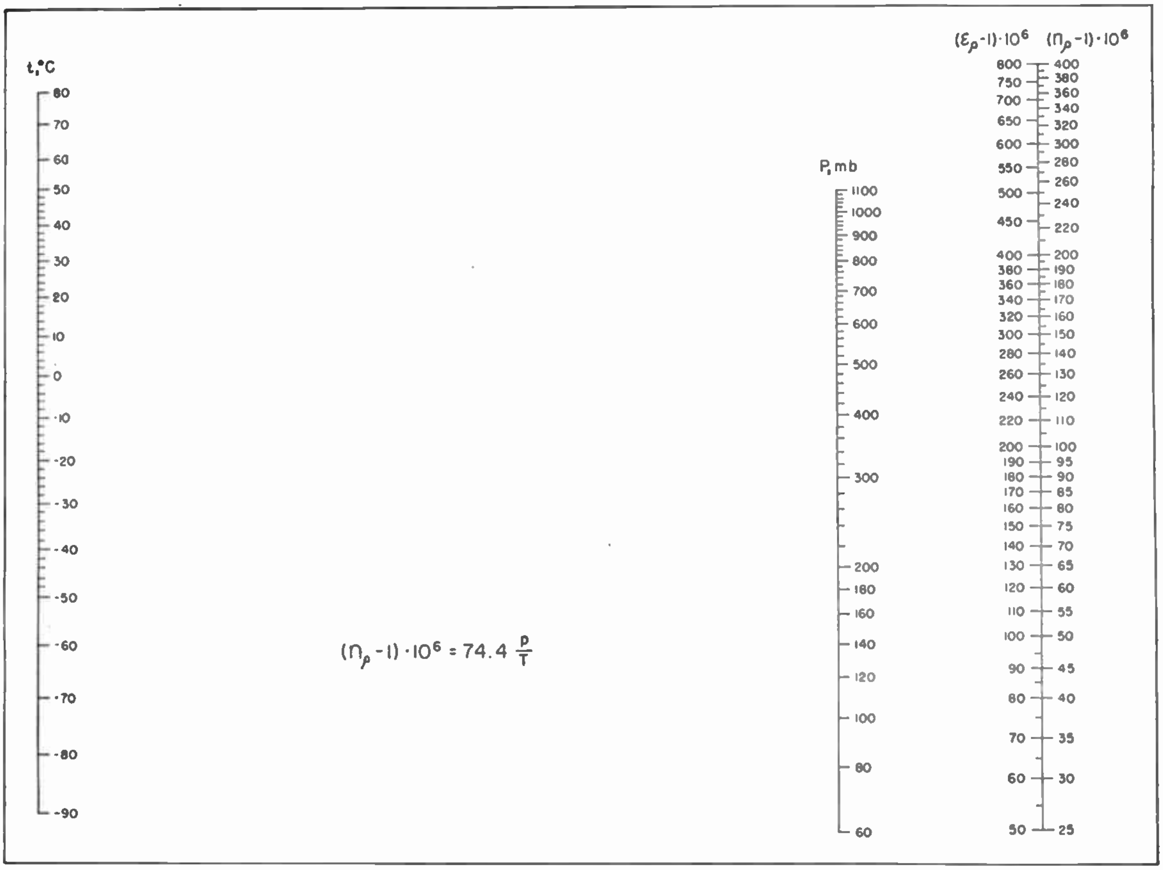

Fig. 1(a)—Contribution to refractive index due to density of atmospheric gases.

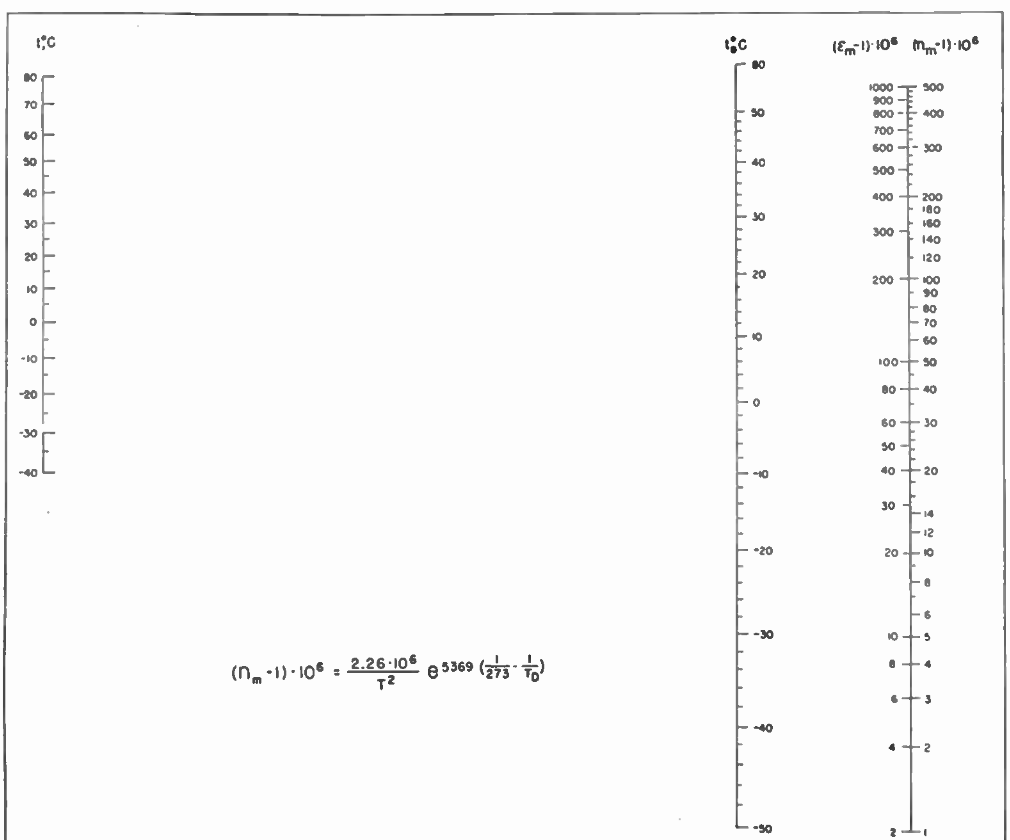

Fig. 1(b)—Contribution to refractive index due to presence of water vapor.

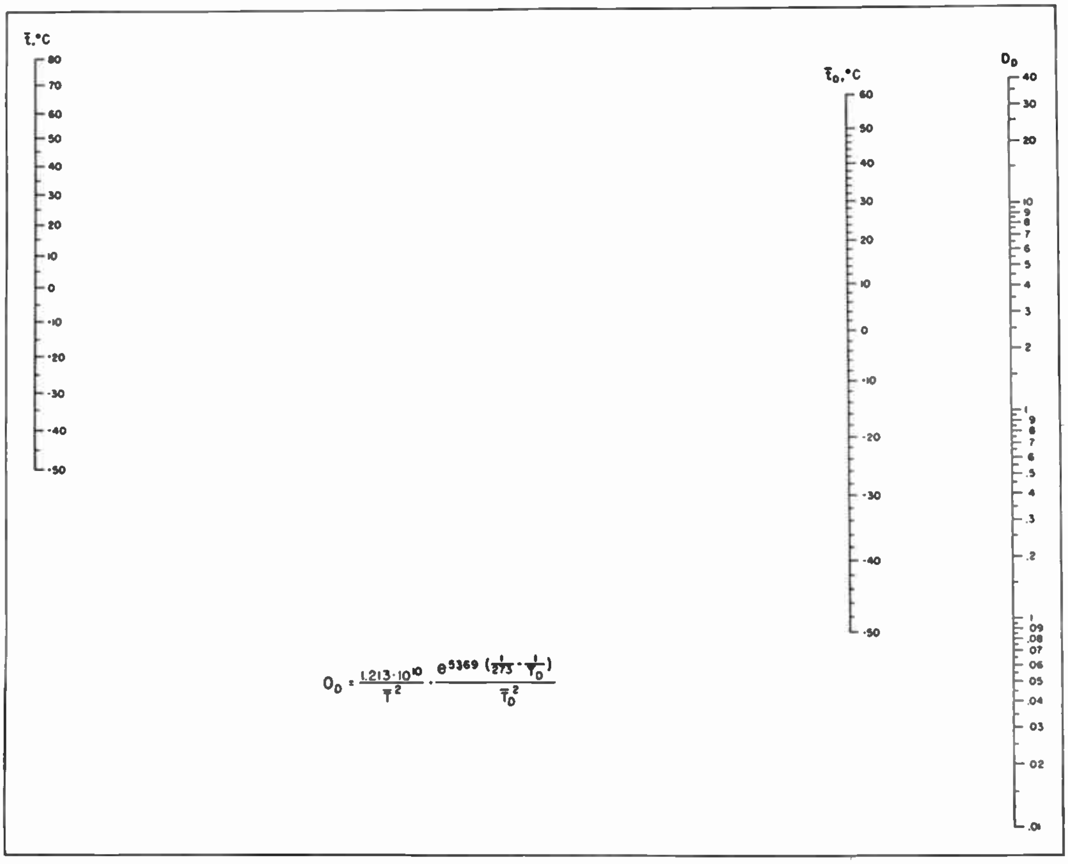

Fig. 2(a)—Differential coefficient D_D of dew-point temperature change, ΔT_D.

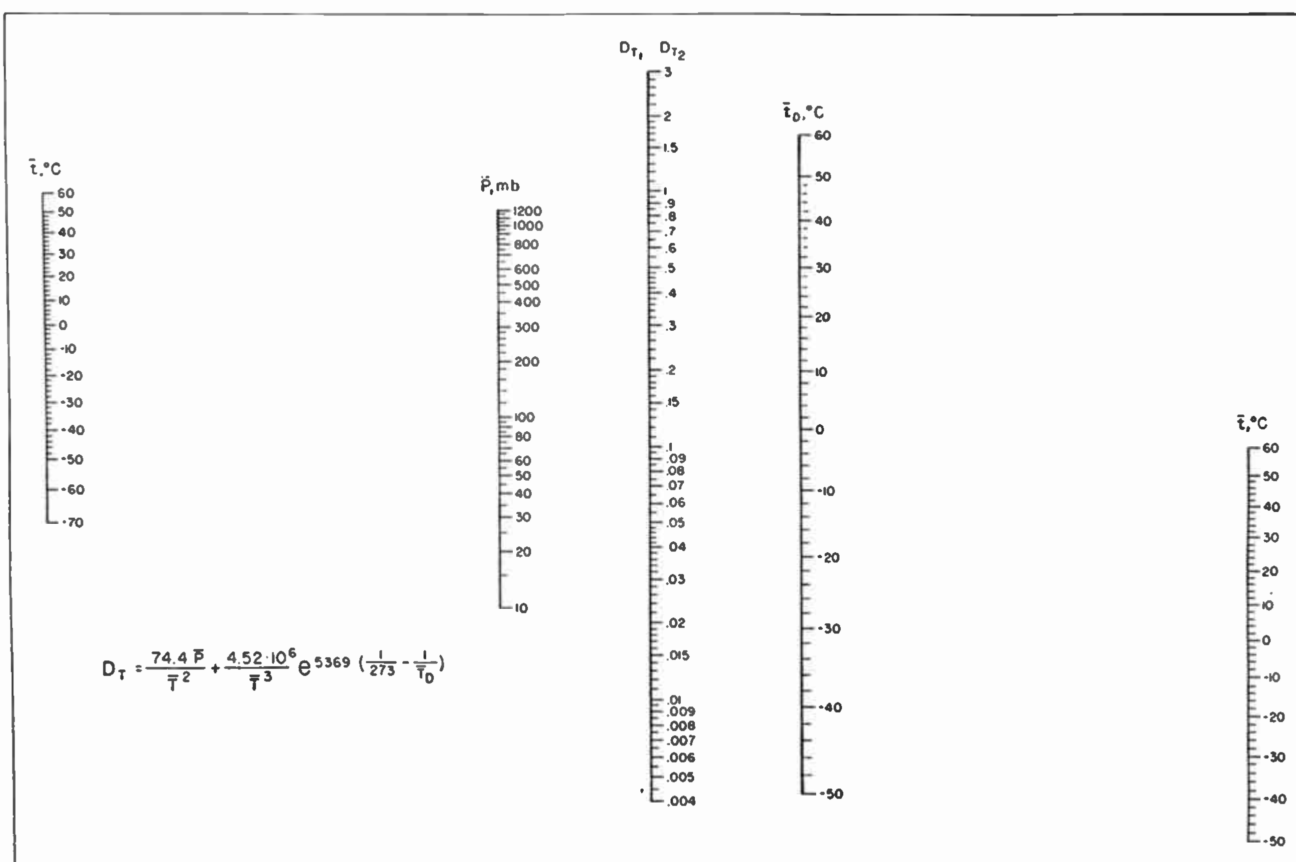

Fig. 2(b)—Differential coefficient D_T of dry-bulb temperature change, ΔT.

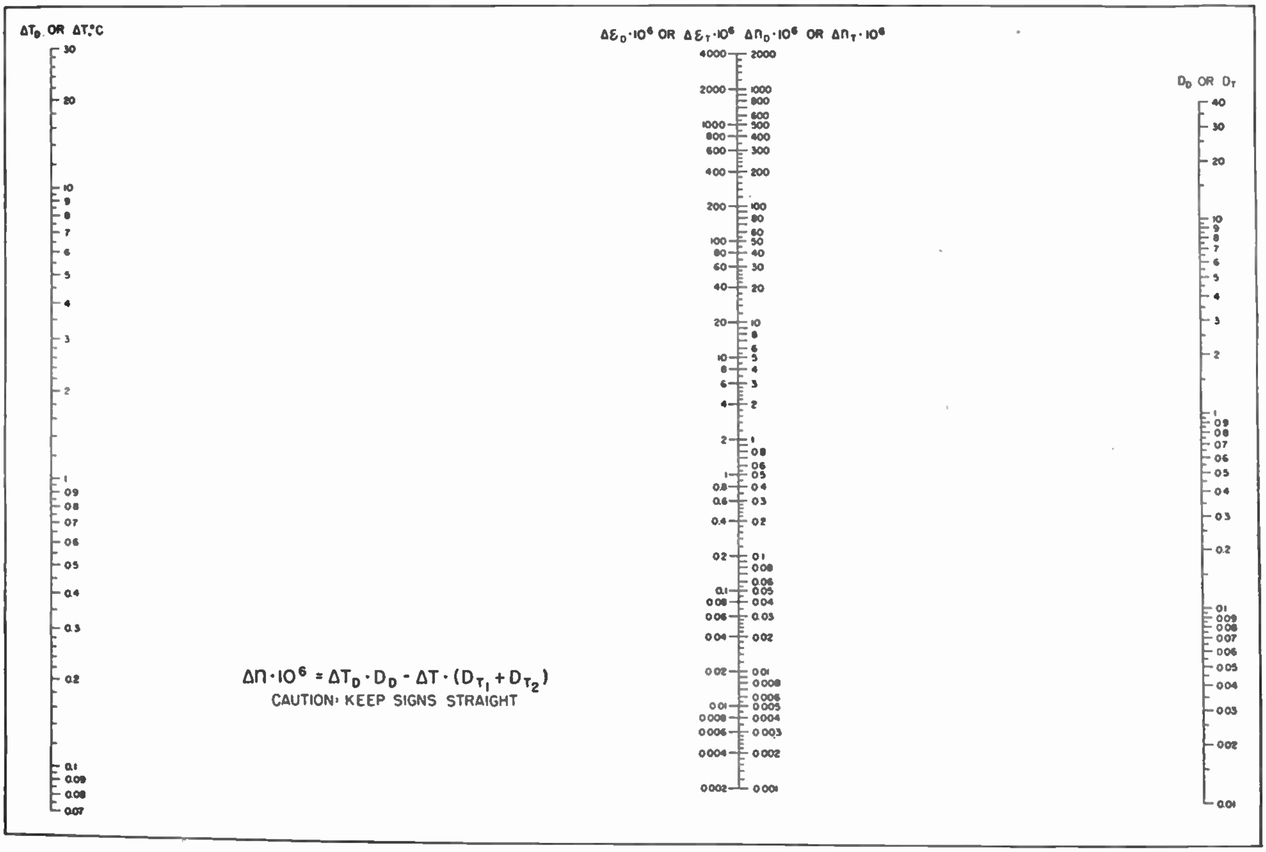

Fig. 2(c)—Index change Δn due to change ΔT_D in dew-point temperature or ΔT in temperature.

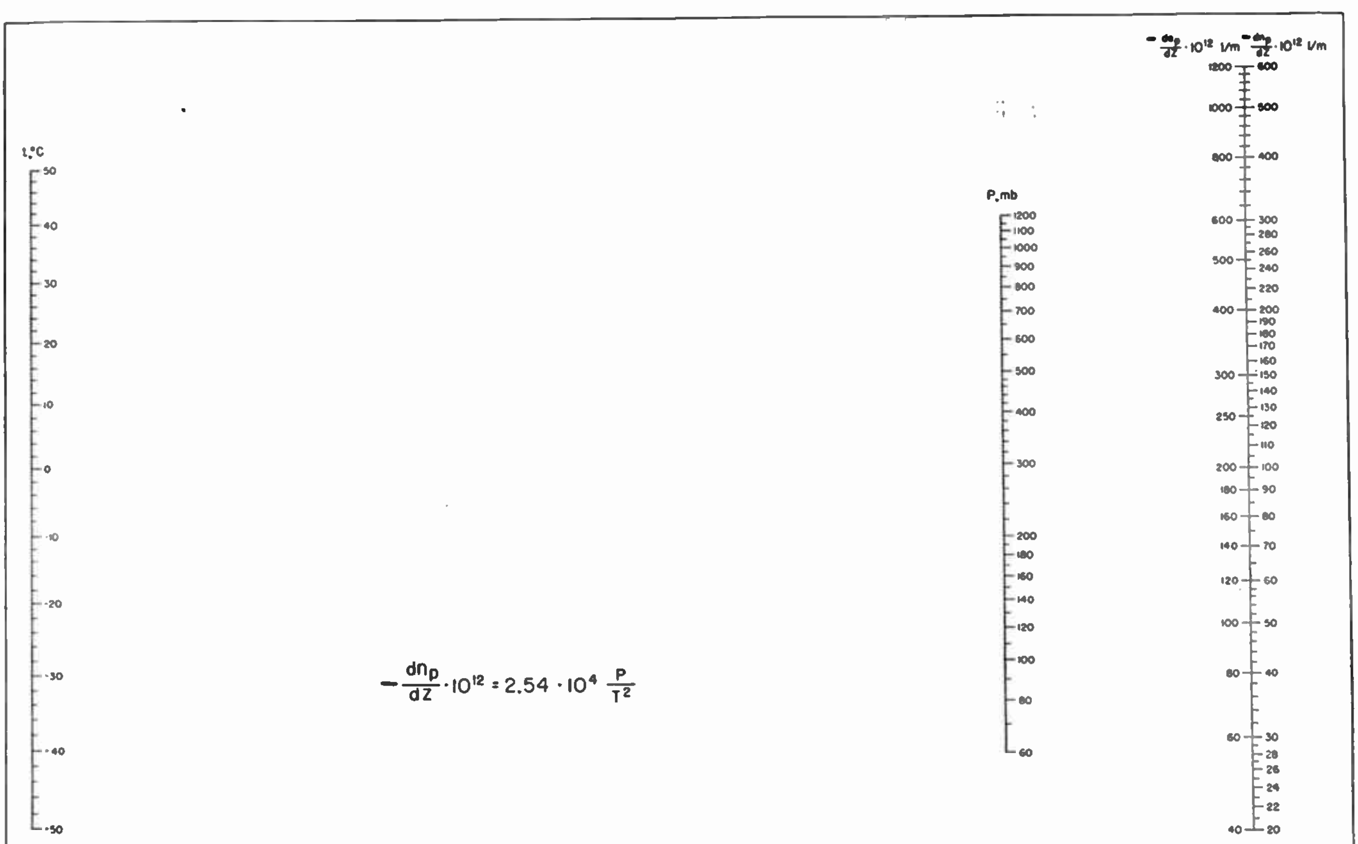

Fig. 3(a)—Refractive index gradient in an isothermal atmosphere.

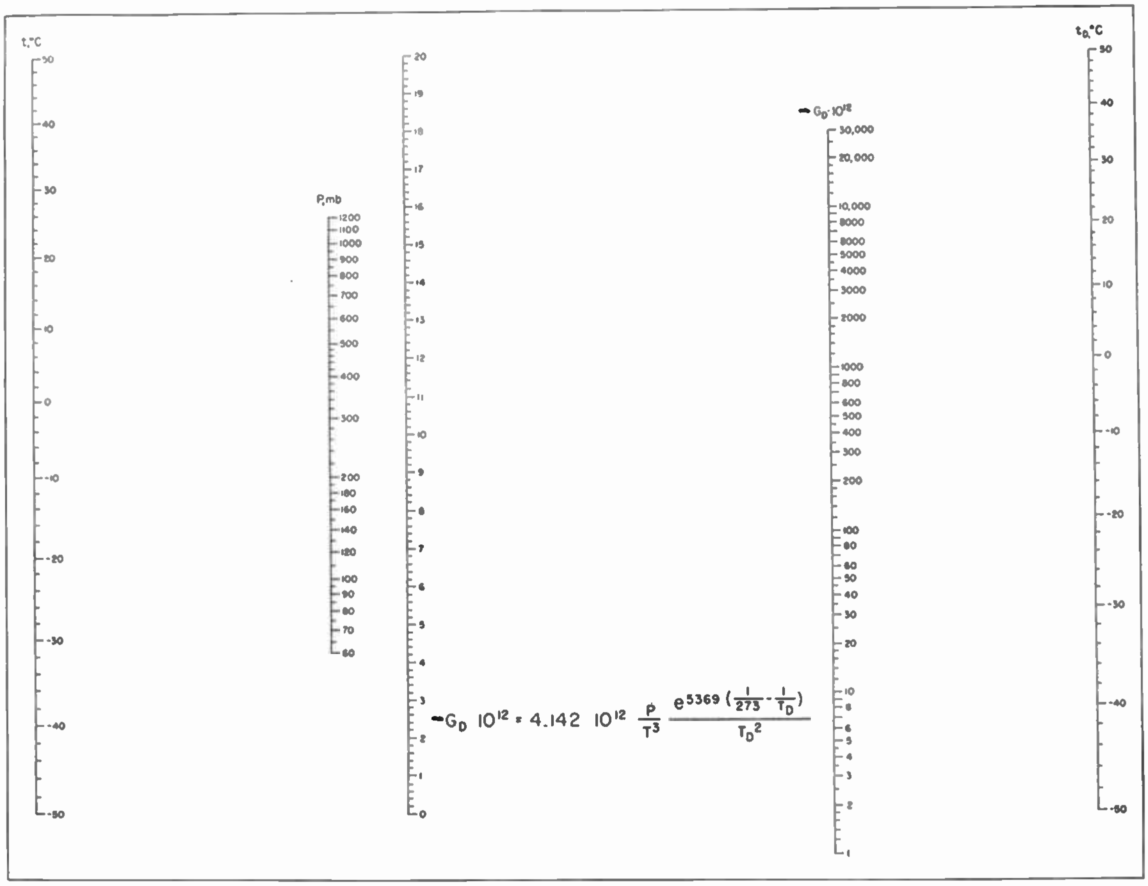

Fig. 3(b)—Calculation of dew-point gradient coefficient, G_D.

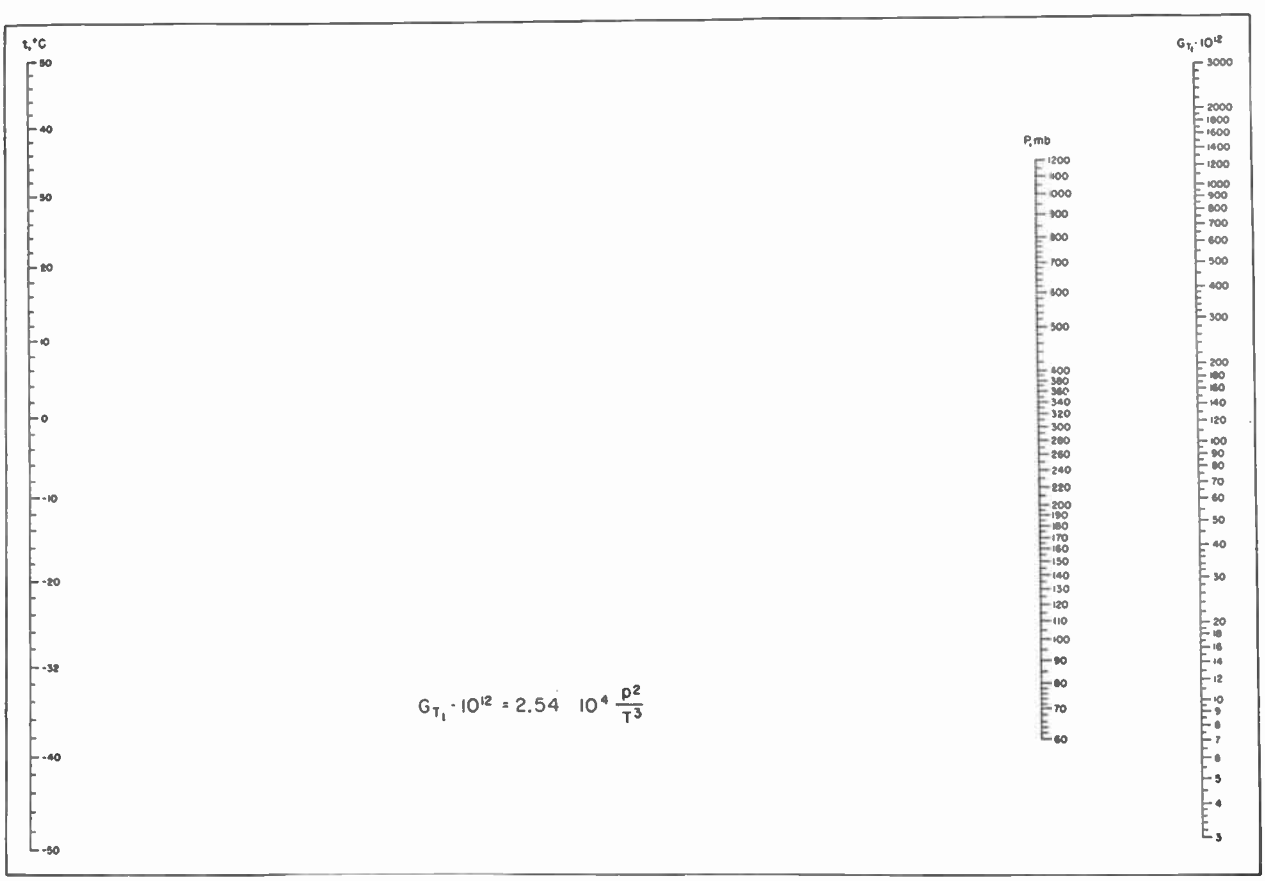

Fig. 3(c)—Calculation of temperature gradient coefficient, G_{T_1}.

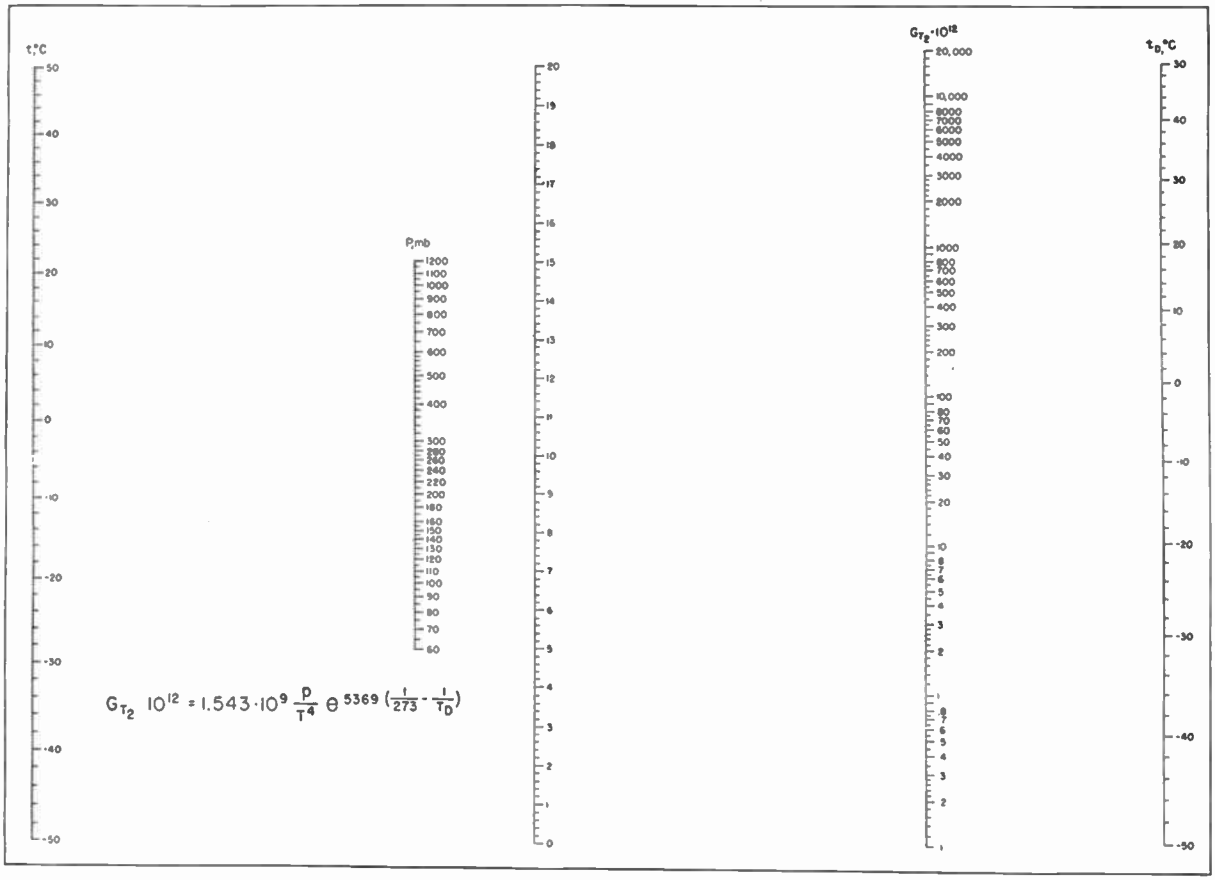

Fig. 3(d)—Calculation of temperature gradient coefficient, G_{T_2}.

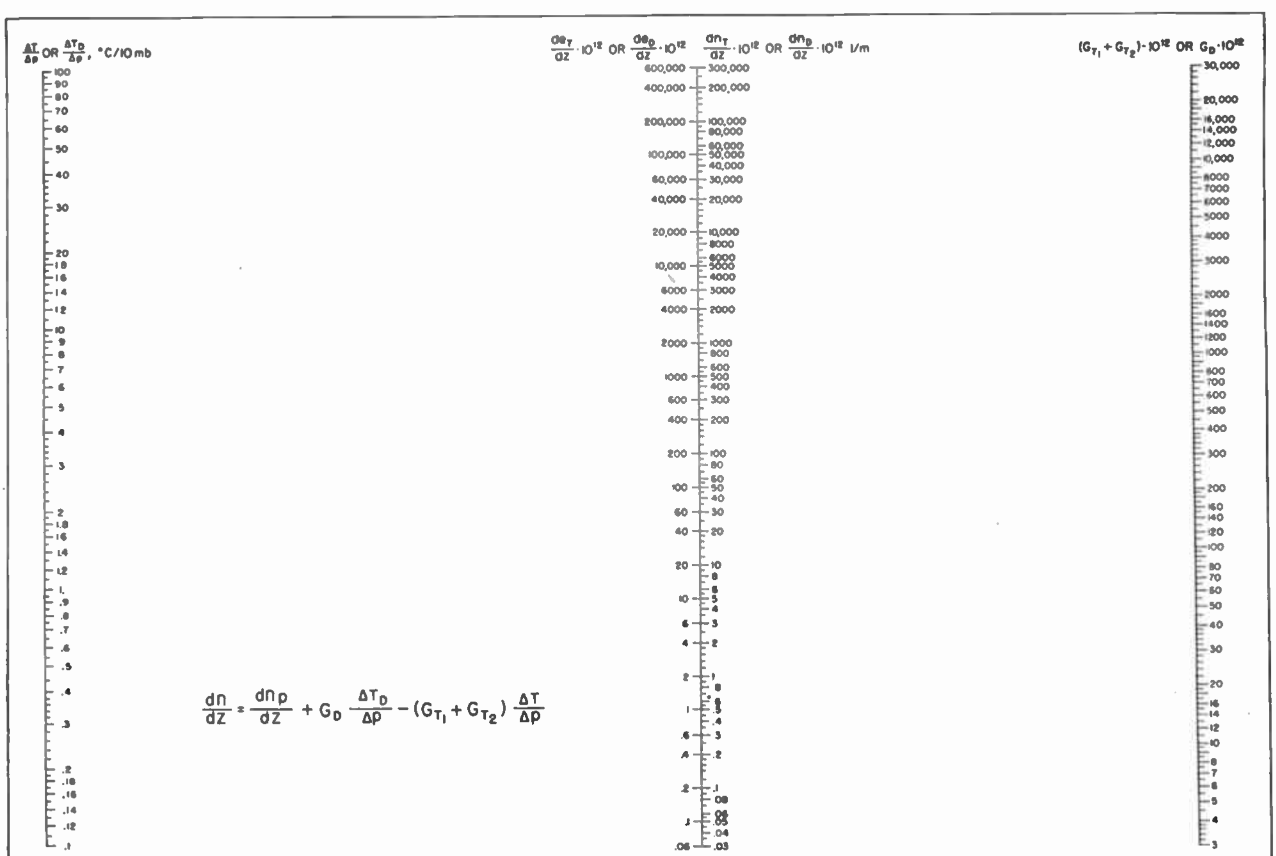

Fig. 3(e)—Refractive index gradient due to temperature gradient $\Delta T/\Delta p$ or dew-point temperature gradient $\Delta T_p/\Delta p$.

The Maximum Gain of an RC Network*

A. D. FIALKOW† AND IRVING GERST‡

Summary—**It is shown that voltage gains of any preassigned magnitude may be achieved at a real frequency by means of physical RC two terminal-pair networks, either grounded or ungrounded. However, the maximum gain possible by means of any RC network having a transfer function of fixed degree is bounded and the relationship between the maximum gain and the degree is determined. The results are illustrated by several examples.**

I. Introduction

It is commonplace knowledge that any two terminal-pair inductance-capacitance network is resonant at some real frequency. On the other hand, there appears to be a widespread feeling among engineers, probably based on energy or other physical considerations, that the voltage gain of a resistance-capacitance network can never exceed unity. However, even superficial examination of the energy argument for this belief throws the conclusion in doubt since the conservation law applies to energy not to voltage.

Indeed, two papers[1] [1, 3] have appeared recently which indicate how certain special RC networks may be devised to produce voltage gains between 1 and 2. This disposes of the above-mentioned belief. Nevertheless, the results found thus far in the problem of the gain attainable with an RC network may best be described as sporadic. This may be due in part to the fact that the discussion in these earlier papers depends mainly on special RC networks and consequently does not reveal the deeper properties which may be characteristic of more general RC networks.

In the present paper, we do not restrict ourselves to networks of any special internal structure, but treat the general grounded two terminal-pair (three external terminals) and also the general two terminal-pair (four external terminals) RC networks (abbreviated 3 T.N., 4 T.N., respectively).

We are here concerned with the voltage gains which may be obtained with these networks. Contrary to a conjecture made in [1], any desired gain may be achieved at a given real frequency by means of networks of sufficient complexity. This is readily seen by considering the cascaded iteration of one of the special networks mentioned above with suitable impedance level separation. Our aim is to give a systematic and quantitative form to the relation between gain and network complexity.

To accomplish this, criteria are required by which one may recognize a rational function as being the transfer function of a 3 T.N. or 4 T.N. Such criteria have been obtained by us in a recent paper [2]. These conditions are summarized in Section II. As a consequence of them, the transfer function of any 3 T.N. or 4 T.N. may be written in the form (1) or (2), respectively. Conversely, any rational function of the form (1) or (2) may be realized as the transfer function of a real 3 T.N. or 4 T.N., respectively. The degree m which appears in these expressions is, in a sense, a measure of the complexity of the network which realizes the transfer function.

For all 3 T.N. or 4 T.N. whose transfer functions (1) or (2) are of a fixed degree m, the maximum gain is described. The synthesis of physical networks realizing the possible gains then follows using the method of [2]. We note some of our results. It is found that the voltage gain of any 4 T.N. corresponding to a transfer function (2) of degree m can never equal or exceed $2^{(m-1)/2}$, but that such 4 T.N.'s do exist whose voltage gain is as close as desired to the above limit. Thus the maximum possible voltage gain of such a 4 T.N. is equal to $2^{(m-1)/2}$. In the case of a 3 T.N. corresponding to a transfer function (1) of degree m, the maximum possible gain is asymptotically equal to $2^{(m-3)/2}$; that is, the ratio of the maximum possible voltage gain to $2^{(m-3)/2}$ tends towards unity as m becomes large.

II. The Transfer Function of a 3 T.N. and 4 T.N.

Let the real rational function $A(p)$ be given by $A(p)=N/D$ where N and D are polynomials having no common zeros and where the leading coefficient of D is positive. Then it is shown in [2] that necessary and sufficient conditions for $A(p)$ to be the transfer function of a 3 T.N. may be stated as follows:

(i) The zeros of D are negative real and distinct.
(ii) Degree of $N \leqq$ Degree of D.
(iii) The leading coefficients of N and of $D-N$ are positive.
(iv) The zeros of N and $D-N$ may not be positive real.

Except for the restrictions imposed by these conditions the zeros of N may be arbitrary.

In the case of the 4 T.N. conditions (i) and (ii) are the same, (iii) and (iv) are thus replaced:

(iii′) The leading coefficients of $D+N$ and of $D-N$ are positive.
(iv′) The zeros of $D+N$ and $D-N$ may not be positive real.

It is further shown in [2] that every real rational function $A(p)$ satisfying the first set of conditions may be written in the form

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‡ Control Instrument Co., Brooklyn, N. Y.
[1] Numbers in brackets refer to the bibliography at end of paper.

$$A(p) = \frac{a_m p^m + a_{m-1}p^{m-1} + \cdots + a_0}{b_m p^m + b_{m-1}p^{m-1} + \cdots + b_0},$$
$$0 \leqq a_i \leqq b_i \ (i = 0, 1, \cdots, m), \quad (1)$$

where $b_m = 1$ and where the zeros of the denominator are negative real and distinct.

Similarly, if $A(p)$ satisfies the second set of conditions, it may be written in the form

$$A(p) = \frac{a_m p^m + a_{m-1}p^{m-1} + \cdots + a_0}{b_m p^m + b_{m-1}p^{m-1} + \cdots + b_0},$$
$$0 \leqq |a_i| \leqq b_i \ (i = 0, 1, \cdots, m), \quad (2)$$

where again $b_m = 1$ and the zeros of the denominator are negative real and distinct. It is clear that conversely functions $A(p)$ of the forms (1) or (2) satisfy the first or second set of conditions given above respectively. The conversion to these forms may possibly introduce common factors in the numerator and denominator of $A(p)$. We note that the degree m which figures in our results is the degree which appears in (1) or (2) rather than the degree of the reduced transfer functions from which common factors have been deleted.

III. Maximum Gain of a 4 T.N.

We shall begin by an investigation of the 4 T.N. where the discussion is simpler technically. In equation (2) keeping m fixed, we wish to determine the coefficients a_i and b_i so that $|A(p)|$ shall be a maximum at some particular real frequency $p = j\omega_0$. This maximum value of $|A(p)|$ does not depend upon the choice of ω_0, so that, without loss of generality, we may select ω_0 to be 1.

Let the zeros of the denominator in (2) be $-\gamma_1, -\gamma_2, \cdots, -\gamma_m$ where the γ's are positive and distinct. Of course,

$$\sum_{k=0}^{m} b_k p^k = \prod_{k=1}^{m} (p + \gamma_k). \quad (3)$$

Then, from (2),

$$|A|^2_{p=j} = \frac{(a_m - a_{m-2} + \cdots)^2 + (a_{m-1} - a_{m-3} + \cdots)^2}{\prod_{k=1}^{m} (1 + \gamma_k^2)}. \quad (4)$$

In virtue of the inequalities (2), for a fixed denominator, the numerator in (4) is maximized when $a_m = \pm b_m$, $a_{m-2} = \mp b_{m-2}, \cdots$, and independently of this sign choice $a_{m-1} = \pm b_{m-1}$, $a_{m-3} = \mp b_{m-3}, \cdots$. In each of these four cases $|A|^2_{p=j}$ becomes

$$|A'|^2 = \frac{(b_m + b_{m-2} + \cdots)^2 + (b_{m-1} + b_{m-3} + \cdots)^2}{\prod_{k=1}^{m} (1 + \gamma_k^2)}.$$

The expression $|A'|$ then represents the maximum value at $p = j$ of all transfer functions (2) having the same denominator.

We now determine the optimum choice for the denominator. As may be seen from calculations based on (3), $|A'|^2$ can be written as

$$|A'|^2 = \frac{1}{2} \frac{\left\{\prod_{k=1}^{m} (1 + \gamma_k)^2 + \prod_{k=1}^{m} (-1 + \gamma_k)^2\right\}}{\prod_{k=1}^{m} (1 + \gamma_k)^2}.$$

Since the bracket in the numerator of this fraction is subject to the inequality

$$\{\ \} \leqq \prod_{k=1}^{m} [(1 + \gamma_k)^2 + (-1 + \gamma_k)^2]$$
$$= 2^m \prod_{k=1}^{m} (1 + \gamma_k^2), \quad (5)$$

it follows that

$$|A'|^2 \leqq 2^{m-1}. \quad (6)$$

If $m > 1$, it is clear that the equality sign obtains in (6) if and only if each $\gamma_k = 1$.[2] Of course this choice of the γ's does not correspond to a physical 4 T.N. Thus (6) implies that the maximum gain of a 4 T.N. having a transfer function (2) of degree m cannot equal or exceed $2^{(m-1)/2}$. But, by choosing γ_k close to 1 and distinct, and by choosing the a_i as above, real 4 T.N.'s corresponding to transfer functions of degree m can be obtained whose gains at $p = j$ are as close to $2^{(m-1)/2}$ as desired.

IV. Maximum Gain of a 3 T.N.

The procedure here parallels that of the preceding section. We may start with (4), where now the a_i is subject to the inequalities (1). In view of the latter, for a fixed denominator, the numerator will be a maximum for at least one of the following four combinations of the a_i: either $a_m = b_m$, $a_{m-2} = 0$, $a_{m-4} = b_{m-4}, \cdots$ or $a_m = 0$, $a_{m-2} = b_{m-2}$, $a_{m-4} = 0, \cdots$; and also independently of this choice, either $a_{m-1} = b_{m-1}$, $a_{m-3} = 0$, $a_{m-5} = b_{m-5}$, or $a_{m-1} = 0$, $a_{m-3} = b_{m-3}$, $a_{m-5} = 0, \cdots$. Let $B_k = b_k + b_{k+4} + b_{k+8} + \cdots$ $(k = 0, 1, 2, 3)$. Then with the above choices of the a_i, $|A|^2_{p=j}$ goes over into four functions $|A'|^2_{st}$ given by

$$|A'|^2_{st} = (B_s^2 + B_t^2) \Big/ \prod_{k=1}^{m} (1 + \gamma_k^2)$$
$$(s = 0, 2;\ t = 1, 3). \quad (7)$$

We now obtain an upper bound for each $|A'|^2_{st}$. Write $f(p) = \prod_{k=1}^{m}(p + \gamma_k)$. Then using (3), we find after some calculation that

[2] The case $m = 1$ is trivial for here $|A'|^2 = 1$ for any permissible denominator, the corresponding four transfer functions being $(\pm p \pm \gamma_1)/(p + \gamma_1)$.

$$B_k = \frac{1}{4}\sum_{n=0}^{3}(-j)^{kn}f(j^n) \quad (k = 0, 1, 2, 3).$$

Inserting these expressions into (7) and writing $R=f^2(1)+f^2(-1)$, $L=f(1)+f(-1)$, $M=f(1)-f(-1)$, $P=f(j)+f(-j)$, $Q=f(j)-f(-j)$, $S=\Pi^m_{k=1}(1+\gamma_k^2)=f(j)f(-j)$, we get, after simplification,

$$|A'|^2_{st} = \frac{1}{8}\left[\frac{R+j^sLP-j^tMQ+2S}{S}\right]. \quad (8)$$

Since j^sP and $-j^tQ$ are both real, we may use the inequality[3]

$$|j^sLP - j^tMQ| \leq \{[L^2+M^2][(j^sP)^2+(-j^tQ)^2]\}^{1/2} = (2R\cdot 4S)^{1/2}.$$

This result together with the inequality $R \leq 2^mS$ given by (5), when used in (8), implies that

$$|A'|^2_{st} \leq g(m) \quad (9)$$

where $g(m)=2^{m-3}+2^{(m-3)/2}+1/4$. Thus $g(m)$ is a common upper bound for each $|A'|^2_{st}$. We now inquire as to whether $g(m)$ is ever actually attained by any $|A'|^2_{st}$. If this were so, the equality sign would hold in (9) for at least one choice of γ_k, s and t. Supposing $m>1$,[4] we see by referring to (5) that this is possible only if each $\gamma_k=1$. Hence making this (nonrealizable) choice in (8), we find that (8) may be transformed into

$$[|A'|^2_{st}]_{\gamma_k=1} = 2^{m-3} + 2^{(m-4)/2}[j^s \cos(m\pi/4) - j^{t+1}\sin(m\pi/4)] + 1/4. \quad (10)$$

The discussion now divides into two subcases, depending on whether m is odd or even. First suppose m is odd and write it in the form $8l+\alpha$ where l is an integer and α is one of numbers 1, 3, 5, or 7. Then it may be verified that (10) actually equals $g(m)$ when s and t are chosen as follows, corresponding to a given value of α: $\alpha=1$, $s=0$, $t=1$; $\alpha=3$, $s=2$, $t=1$; $\alpha=5$, $s=2$, $t=3$; $\alpha=7$, $s=0$, $t=3$. We have thus proved in this case that the maximum gain of the 3 T.N. cannot equal or exceed $2^{(m-3)/2}+\frac{1}{2}$. However, by taking γ_k close to 1 and distinct and by choosing the a_i in accordance with the above values of s and t, we can obtain physical 3 T.N.'s whose gain at $p=j$ is as close as desired to this value. Hence the maximum gain for m odd is $2^{(m-3)/2}+1/2$.

If m is even, the situation is different. For it may be shown that with suitable s and t depending on the value of m, the greatest value yielded by (10) is $g_1(m)=2^{m-3}+2^{(m-4)/2}+1/4$, which is less than $g(m)$. Nevertheless this implies the existence of physical transfer functions $A(p)$ for which

$$g_1(m) - \epsilon < |A|^2_{p=j} < g(m),$$

where ϵ is any arbitrarily chosen small positive number. Dividing through by 2^{m-3} and letting $m\to\infty$, the statement in the introduction concerning the asymptotic behavior of the maximum gain may be proved.

In the case where m is even, there still remains the determination of the actual maximum gain. Denote the square of the latter by $g_2(m)$. We do not have an explicit formula for $g_2(m)$ analogous to that for $g(m)$ which holds in the case where m is odd. However, for each value of m, $g_2(m)$ may be computed as follows. It can be shown that each of the functions $|A'|^2_{st}$ attains its maximum when all the γ_k are equal to each other. Hence with $\gamma_k=\gamma$, for example, each $|A'|^2_{st}$ now becomes a function of one variable γ whose maximum value may be determined in the usual way by means of differential calculus. The greatest of these maxima is then $g_2(m)$. In this way we find $g_2(2)=4/3$, $g_2(4)=432/125$.

V. Examples

We restrict our examples to grounded networks. The simplest transfer functions yielding voltage gains greater than unity are quadratic. The preceding theory shows that the maximum gain of a 3 T.N. having such a transfer function is $(4/3)^{1/2}=1.155$. Thus, for example, the realizable transfer function $A(p)=(3p+2)/(p^2+3p+2)$ has a gain of $(1.3)^{1/2}=1.140$ at $p=j$. Our synthesis procedure leads to the bridged T network of Fig. 1 which is analogous to that given in [3]. In Fig. 1, λ is an arbitrary positive impedance level constant.

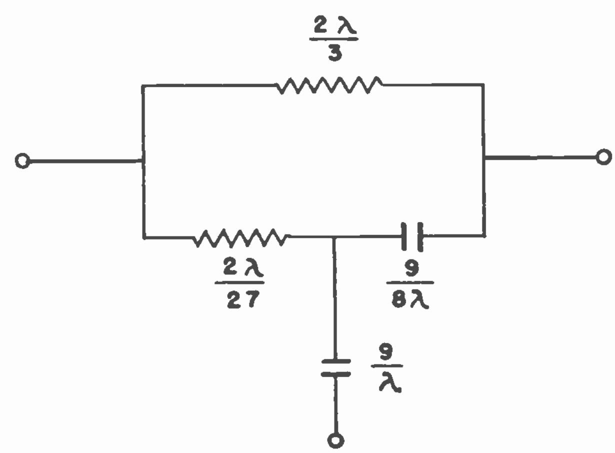

Fig. 1—Network realizing gain of 1.14.

The next case in order of complexity is one in which the transfer function is cubic. To get transfer functions whose gain at $p=j$ shall be close to the maximum gain possible for that degree, we proceed as follows:

First determine the denominator of the transfer function by choosing its three zeros as distinct negative numbers close to -1, e.g., $\gamma_1=3/4$, $\gamma_2=1$, $\gamma_3=5/4$. Thus the denominator here is $(p+3/4)(p+1)(p+5/4)=p^3+3p^2+47p/16+15/16$. Now since the α of §IV is 3 in this case, we have $s=2$, $t=1$, and the numerator of the transfer function is obtained by taking those terms of the denominator corresponding to these values of s and t.

We arrive at the transfer function

[3] This is merely a paraphrase of the inequality $(c_1c_2+d_1d_2)^2 \leq (c_1^2+c_2^2)(d_1^2+d_2^2)$, where c_1, c_2, d_1, d_2 are real quantities.

[4] The case $m=1$ is again trivial, for here the maximum gain of $A(p)$ for any denominator is readily found to be 1.

$$A(p) = \frac{3p^2 + 47p/16}{p^3 + 3p^2 + 47p/16 + 15/16}. \qquad (11)$$

Calculation shows the gain at $p=j$ to be 1.484 as compared to the theoretical maximum gain of $2^{(3-3)/2}+1/2 = 1.5$. Better approximations to the maxima gain may be obtained by taking the γ's still closer to 1. Realization of the transfer function (11) using the synthesis method given in [2] leads to the network shown in Fig. 2 with λ as before. The circuit in Fig. 2 consists of the parallel connection of two bridged-T networks similar to that of Fig. 1, each of which has been terminated by an appropriate element.

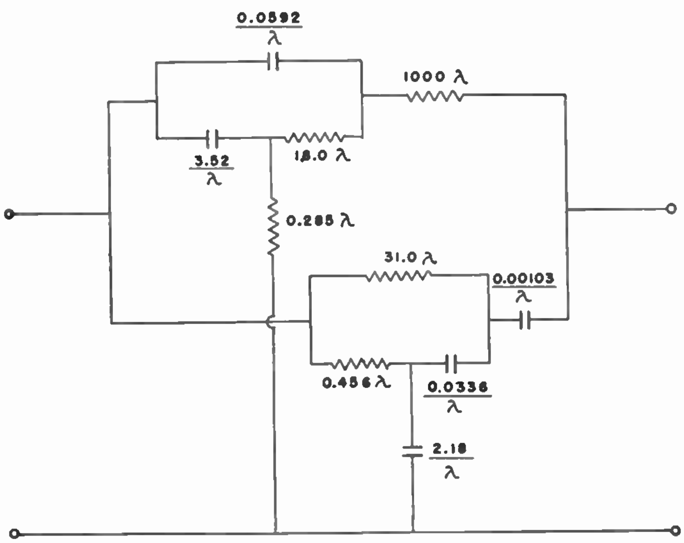

Fig. 2—Network realizing gain of 1.48.

If a 3 T.N. is required whose gain is greater than 2, then, by our results, the degree m of its transfer function in (1) must be at least 5. Such transfer functions may be constructed by the method used in the previous example. An illustration with $m=5$ is

$$A(p) = \frac{155p^3 + 145p^2}{16(p+1/2)(p+3/4)(p+1)(p+5/4)(p+3/2)},$$

whose gain at $p=j$ is 2.326 (as compared to the theoretical maximum of $2^{(5-3)/2}+1/2=2.5$). The synthesis of this function results in a network of 46 elements which is the parallel combination of two circuits, each of which is itself the parallel combination of two networks analogous to that of Fig. 2, each network being suitably terminated before connection. The same type of network, namely, the iterated parallel connection of networks realizing transfer functions of lower degree, will also result in the general case. Of course, the number of elements required in the realization will increase with increasing m.

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"Extension of the Planar Diode Transit-Time Solution"*

NICHOLAS A. BEGOVICH

Discussion on

W. E. Benham:[1] With reference to Section IV of his paper, Dr. Begovich apparently misunderstood parts of my paper,[2] and I regret if I did not make things sufficiently clear.

First, the conservation-of-charge method is very well tried as against other methods, and cannot be held responsible for the omission of terms in the theory of the space-charge diode. If I understand Dr. Begovich correctly, the terms which he considers I have missed are those corresponding to the two blanks in his table. Now the missing terms will in fact be found included in my work; witness the asterisk at (97), explained at the foot of p. 1147. The blanks are thus filled in by my $\overline{\Upsilon}_{17}$ from (138), corresponding to his Υ_{31}, and $\overline{\Upsilon}_{15}$ from my (137), corresponding to his Λ_{31}. The relevant equations in his paper for comparison with my (138) and (137), respectively, are 10f and (21) a and b. Note that the table in my paper is scheduled as Appendix III, Appendix IV following, and also that $\overline{\Upsilon}_{17}$ is the same as $|\Upsilon_{14}|\Upsilon_7$.

The interpretation of (91a), p. 1146 of my paper, is also, of course, subject to similar considerations, and Appendices II and IV should have been invoked for the full interpretation. I regret this was not done until p. 1147, as it may have led to difficulty.

Regarding the absolute bars, the complex conjugate has certainly to be taken for δi_0. This is done in (95b). I think, however, Dr. Begovich demands their inclusion about Υ_6^2 in (95a), and could not agree to this without discussion. As an indication of what may be expected, one may revert to the low-frequency expressions for triode currents on p. 1109. The third of (15) shows $(r+z_1)^2$ in the denominator. Only when taking δi_0 does the insertion of absolute bars become indicated.

* A. N. Begovich, "Extension of the planar diode transit-time solution," Proc. I.R.E., vol. 37, pp. 1340–1344; November, 1949.
[1] Holt's Crest, Fordcombe, Tunbridge Wells, England.
[2] W. E. Benham, "A contribution to tube and amplifier theory," Proc. I.R.E., vol. 26, pp. 1093–1170; September, 1938.

The form of (15) is such that they have been arranged to exclude explicit appearance of μ. This means that with simple changes they may be applied to a diode. The following expressions then result (after introducing the appropriate transit angle functions, using p. 1147 and Appendices as guides):

Fundamental (including third-order contribution thereto)

$$\text{(real part of)}e^{j\omega t}\left[\frac{3}{2}\frac{i_0}{v_0}v_1\frac{r_p}{(r_p\Upsilon_6(\alpha)+Z_1)}-\frac{3i_0v_1^3r_p^4\{(4\bar{\Upsilon}_{17}-2\bar{\Upsilon}_{11}\Upsilon_{15})(r_p\Upsilon_6(2\alpha)+Z_2)-r_p\Upsilon_{11}\Upsilon_{15}\}}{64v_0^3(r_p\Upsilon_6(2\alpha)+Z_2)(r_p\Upsilon_6(\alpha)+Z_1)^2|r_p\Upsilon_6(\alpha)+Z_1|^2}\right].$$

Second harmonic and rectified current (excluding fourth order)

$$\frac{3}{16}\frac{i_0v_1^2r_p^3}{v_0^2}\left[\frac{\Upsilon_{11}e^{2j\omega t}}{(r_p\Upsilon_6(2\alpha)+Z_2)(r_p\Upsilon_6(\alpha)+Z_1)^2}+\frac{\bar{\Upsilon}_{11}}{(r_p+r)|r_p\Upsilon(6\alpha)+Z_1|^2}\right].$$

Third harmonic (excluding higher-order contributions)

$$-\frac{i_0v_1^3r_p^4\{4\Upsilon_{17}(r_p\Upsilon_6(2\alpha)+Z_2)-3r_p\Upsilon_{11}\Upsilon_{15}\}e^{3j\omega t}}{64v_0^3(r_p\Upsilon_6(2\alpha)+Z_2)(r_p\Upsilon_6(3\alpha)+Z_3)(r_p\Upsilon_6(\alpha)+Z_1)^3}.$$

The functions appearing in these expressions are all listed in Appendix III of my paper. Note that in the expression for the detected current the resistance r is the resistive component of the external impedance z, and is is important to note that v_1 is the signal voltage applied in series with z and the diode, but that v_0 is the dc voltage actually at the diode terminals.

Dr. Begovich's correction that v_0 should be v_0^2 in (95b) is, of course, accepted, and I regret the presence of too many errors of this kind. I have just noticed that there should be a factor 3/2 multiplying the dc quantity i_0 in (78), (79), and (91), subsequent work being unaffected thereby. A list of errors was included in the December, 1938 issue (p. 1429), but it appears that a supplement to this should be issued.

Correspondence

The Use of an Ellipsoidal Permanent Magnet for a Collimating Field*

The advent of electron devices, such as the traveling-wave tube, has brought up the desirability of having an economical source of collimating magnetic field. In order to avoid the power requirements, a permanent magnet would be desirable.

Usually this magnetic field is required to be uniform over a cylindrical volume whose length is much greater than its diameter. Consequently, if the field is derived from a conventional horn gap, the total field volume is necessarily much larger than that actually required since for uniformity of field the gap length cannot be made greater then the pole diameter.

Another way of obtaining the field is to make a hole in the length of a bar of magnetic material, such as one of the alnicos which is magnetized parallel to the hole. Since the hole is long compared to its cross section, it may be considered to be a thin slit, where the field in the hole is then axial, and equal to the magnetization in the alnico. It is well known that the only simple shape that has a uniform magnetization is an ellipsoid of revolution. Demagnetization factors for this shape have been calculated.[1] These are combined with the known characteristics of two alnicos to give Fig. 1.

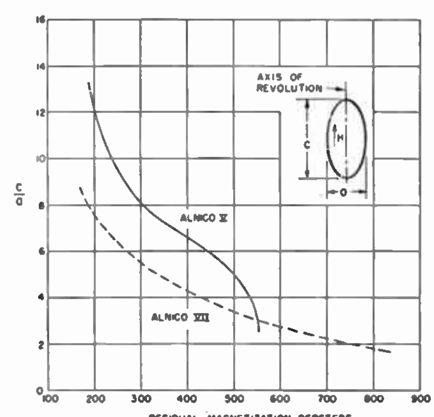

Fig. 1—Slimness of alnico ellipsoid for given magnetization.

If the required ellipsoid for a given magnetization is not too slender, a hole can be cored into it without upsetting the fields greatly. We have been successful in using this type of approach as a starting point in proportioning solenoids with a hole that is as large as 15 per cent of the magnetic material area. A sketch of one approximation to an ellipsoid and the resulting field is shown in Fig. 2.

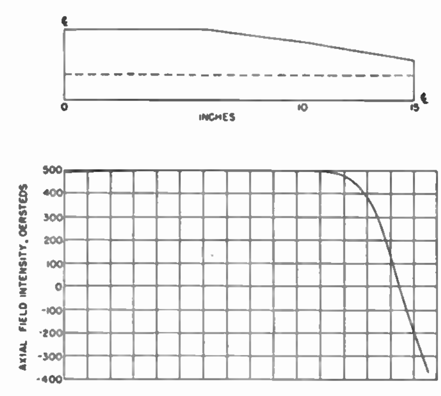

Fig. 2—Proposed permanent magnet and field distribution

The field obtained in such a manner equals the magnetization in the alnico only

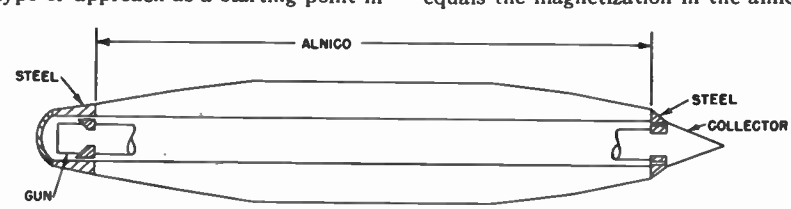

Fig. 3—Proposed design of magnet for tube with built-in pole pieces.

* Received by the Institute, November 14, 1951.

[1] J. A. Osborn, "Demagnetizing factors of the general ellipsoid," *Phys. Rev.*, vol. 67; June, 1945.

Correspondence

when the end effects are small. Outside the magnet the field is much greater and in the opposite direction. Consequently, the axial field undergoes a reversal just inside the magnet. It is difficult to get an electron beam through this reversal and still be sure of its behavior. We have avoided this by using a steel shield attached to the end of the magnet as in Fig. 3. A typical flux distribution is shown in Fig. 4. Here the enclosed volume having a very low field is large enough to contain a Pierce gun for starting the beam. The field inside the shield may be reduced to a much lower value by suitably arranged mu-metal cylinders inside the steel shown.

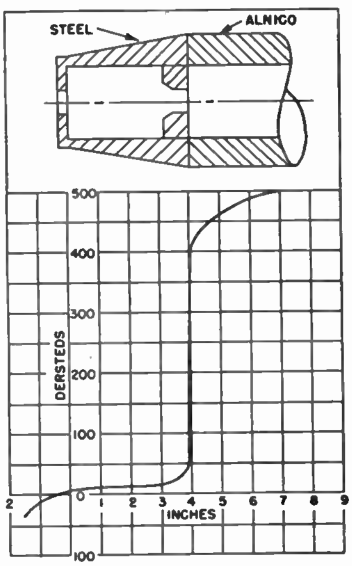

Fig. 4—Axial field intensity.

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Reduction of FM Interference*

The problem of separating two or more FM signals close in amplitude is important in many applications, but particularly in the reduction of selective fading in long distance communication on short waves. At present there seems to be two solutions to the problem, (1) the wide-band discriminator principle described by Arguimbau[1] and (2) the feedback system recently put forward by Wilmotte.[2]

Considering the importance of and general interest in the problem, I would like to mention briefly the results of work done along these lines, hoping that other investigators will be induced to report their findings.

The narrow-band feedback system described by Wilmotte is attractive indeed, in that a simple receiver would result if the principle could be applied successfully in practice. Wilmotte states that "if a feedback circuit is inserted around the limiter and that circuit contains a bandpass filter wide enough to carry the intelligence contained in signal A, but not much more . . . ." However, without knowing the exact circuitry used by Wilmotte, it is hard to reconcile this statement with feedback amplifier theory where a safety margin of 30 degrees and 15 db loss around the feedback loop must be allowed to maintain stability. Differently expressed, this means that the cutoff rate of the bandpass filter-amplifier combination cannot exceed 10 db per octave. Therefore, in applying the feedback system, one is interested in how much feedback to apply and in the cutoff characteristics of the bandpass filters.

Nevertheless, the feedback system was investigated at ultrasonic frequencies, using a counter type discriminator preceded by an effective, nonresonant type limiter. Inverse feedback was applied across the limiter through a bandpass filter as suggested. But the amount of feedback had to be reduced and the cutoff characteristics of the filter modified in order to achieve stability. Then the two-signal test was applied, but no improvement was noticed in discriminating against the interfering signal.

On the other hand, with the wide-band discriminator system described by Arguimbau it was actually possible to separate two signals differing as little as 1 db in amplitude. In general, the results were in agreement with the theoretical relation $(1+a/1-a)$, where (a) is the amplitude factor.[1]

Therefore, in order to fully exploit possibilities of the feedback system, it is desirable to have more information and circuit details; particularly in the application of feed back.

Kerim Onder
Research and Development Engineer
Panoramic Radio Products, Inc.
Mount Vernon, New York

* Received by the Institute, October 14, 1952.

[1] L. B. Arguimbau and J. Granlund, "The possibility of transatlantic communication by means of frequency modulation," Proc. *NEC* (Chicago), vol. 3, pp. 644–653; Nov. 3–5, 1947.

[2] R. M. Wilmotte, "Reduction of interference in FM receiver by feedback across the limiter," Proc. I.R.E., pp. 34–36; January, 1952.

Calculation of the Radiation Pattern of an Array on an Arc*

In connection with the publication of Walsh's paper on the radiation patterns of arrays on a reflecting cylinder[1] it may be interesting to state a calculation of an antenna array distributed on an arc segment of a circle, which was executed some time ago.

For a limited number of antennas the radiation pattern can be derived by assembling into pairs and adding vectorially the absolute values and phases. The calculation is simplified when the antennas are placed symmetrically, since in this case pairs with equal amplitudes and phases, but each having an individual pattern, can be formed.

* Received by the Institute, January 14, 1952.

[1] J. E. Walsh, "Radiation patterns of arrays on a reflecting cylinder," Proc. I.R.E., vol. 39, pp. 1074–1081; September, 1951.

1. General Methods of Calculation

The field strength at great distance R for each radiator pair: $(1, 2, 3, \cdots, k)$ (Fig. 1) with amplitudes $A_1, A_2, A_3, \cdots, A_k$, normalized individual patterns, $c_1, c_1', c_2, c_2', c_3, c_3' \cdots c_k, c_k'$, (functions of the angle α), and distances $a_1, a_2, a_3 \cdots a_k$ is equal to, in the radiator's plane,

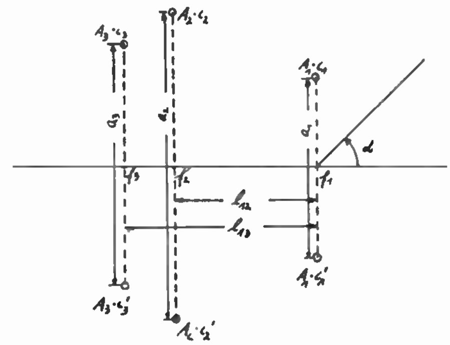

Fig. 1

$$E_n = \frac{f_n}{R} e^{j(\omega t - 2\pi R/\lambda)} \tag{1}$$

with

$$f_n = A_n \cdot c_n e^{j\cdot\phi_n/2} + A_n \cdot c_n' \cdot e^{-j\cdot\phi_n/2}, \tag{2}$$

and

$$\phi_n = \frac{2\pi}{\lambda} \cdot a_n \cdot \sin\alpha. \tag{3}$$

Transformed, is for the absolute value and phase of

$$\begin{aligned} f_n &= |f_n| \cdot e^{j\cdot\psi_n} \\ &= A_n\sqrt{c_n^2 + c_n'^2 + 2c_n\cdot c_n'\cdot\cos\phi_n} \\ &\quad \cdot e^{j\cdot\mathrm{arc\,tg}\,[(c_n - c_n')/(c_n+c_n')\cdot\mathrm{tg}\,\phi_n/2]}. \end{aligned} \tag{4}$$

If the pairs are joint with consideration of their center of gravity distances, then the relative field strength of the complete arrangement will be given by

$$F = \sum_{n=1}^{n=k} |f_n| \cdot e^{j\psi_n} \cdot e^{j(\Phi_{1n} - \Theta_{1n})}. \tag{5}$$

The geometrical differences of phases, in relation to the distances of the radiator pairs are

$$\Theta_{1n} = \frac{2\pi}{\lambda} \cdot l_{1n} \cdot \cos\alpha, \tag{6}$$

and Φ_{1n} represents possible additional assistant-phases between the pairs 1 and 2, 1 and 3, $\cdots$, 1 and k, depending on their connections. The absolute value of (5) may be evaluated from case to case and indicates the relative amplitude of the electric-field strength (far-zone field), therefore the radiation pattern. For three pairs of radiators it is, for example,

$$\begin{aligned} |F| = [\,&|f_1|^2 + |f_2|^2 + |f_3|^2 \\ &+ 2\cdot|f_1|\cdot|f_2| \\ &\cdot\cos(\psi_1 - \psi_2 + \Theta_{12} - \Phi_{12}) \\ &+ 2\cdot|f_1|\cdot|f_3| \\ &\cdot\cos(\psi_1 - \psi_3 + \Theta_{13} - \Phi_{13}) \end{aligned}$$

Correspondence

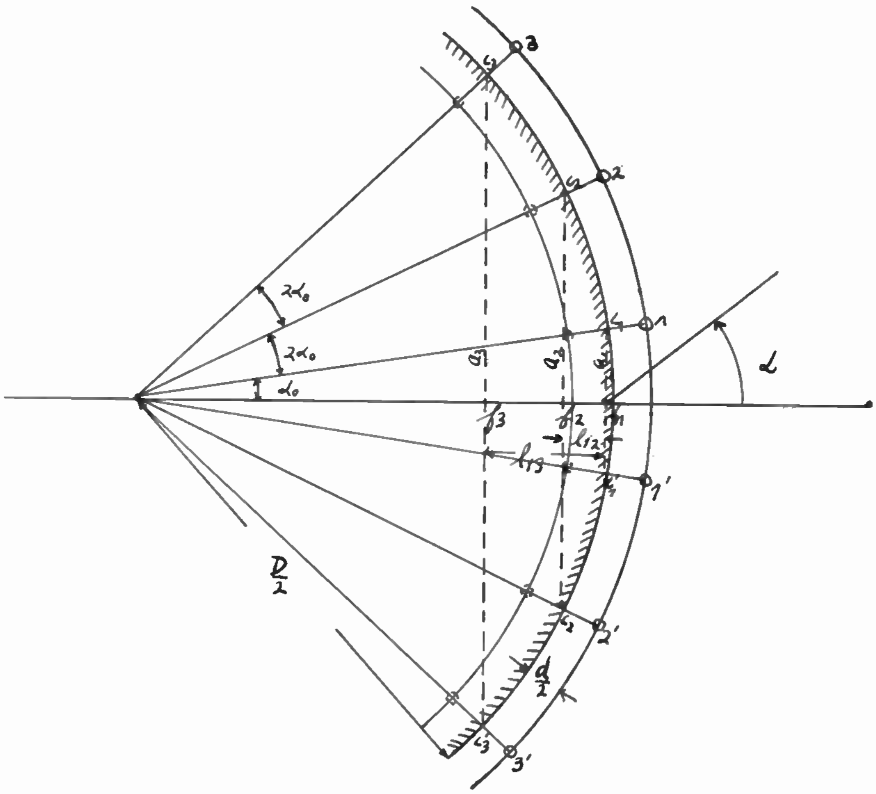

Fig. 2

$$\times 2 \cdot |f_2| \cdot |f_3| \cdot \cos(\psi_2 - \psi_3 + \Theta_{13} - \Theta_{12} + \Phi_{13} - \Phi_{12})]^{1/2}. \quad (7)$$

2. Array on an Arc Sector with Reflector

When calculating the radiation pattern of an antenna array, arranged on an arc of a circle, and backed by a reflecting cylinder, a counterphased image (180 degrees out of phase) can be associated to each antenna. This approximation improves, the greater the circle diameter and the smaller the distance from the antenna to the reflecting cylinder.

The normalized individual patterns of the different radiators with reflecting cylinder will be given, referring to Fig. 2, without the negative value, by

$$c_n = \sin\left[\frac{\pi d}{\lambda} \cdot \cos(\alpha - (2n-1) \cdot \alpha_0)\right]$$

and (8)

$$c_n' = \sin\left[\frac{\pi d}{\lambda} \cdot \cos(\alpha + (2n-1) \cdot \alpha_0)\right]$$

The distances of the radiators are

$$a_n = D \cdot \sin((2n-1) \cdot \alpha_0). \quad (9)$$

The distances of the radiator pairs 2, 3, $\cdots$, k from the first pair are

$$l_{1n} = \frac{D}{2} \cdot (\cos \alpha_0 - \cos(2n-1) \cdot \alpha_0). \quad (10)$$

For maximum radiation in the direction of the symmetrical line ($\alpha = 0°$) the assistant-phases must also have, by (6), the value

$$\Phi_{1n} = \frac{2\pi}{\lambda} \cdot l_{1n}. \quad (11)$$

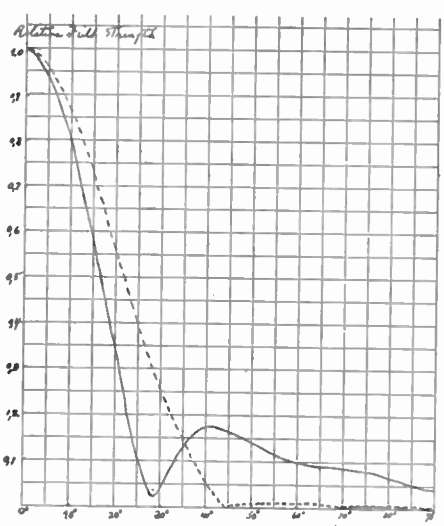

Fig. 3

3. Example

In the course of experiments with direction finders executed during World War II by the "Entwicklungsinstitut für Nachrichtenmittel Konstanz," a circular array was examined consisting of 24 antennas, with a circle diameter of 3, 20 meters, and a wavelength of $\lambda = 80$ cm; also a circular array consisting of 36 antennas with a diameter of 90 meters for a band of $\lambda = 15$–25 meters.

For the second case the horizontal radiation pattern was calculated, by means of the equations stated above, for a segment of 6 vertical antennas separated by $d/2 = 3.75$ m from the reflector, whose diameter was $D = 82.5$ m. At $\alpha_0 = 5$ degrees the results by (9) are $a_1 = 7.2$ m; $a_2 = 21.36$ m; $a_3 = 34.84$ m, and by (10) $l_{12} = 1.25$ m; $l_{13} = 3.71$ m and the assistant-phases are for compensation in the direction $\alpha = 0$ degrees on account of (11), $\Phi_{12} = 22.5$ degrees; $\Phi_{13} = 66.8$ degrees. For equal amplitudes $A_1 = A_2 = A_3$, and for a medium wavelength $\lambda = 20$ meters, the compensated radiation pattern in relative field strength values is stated in Fig. 3 (drawn line). The intensity is obtained by squaring the values. The half power beam width is 24 degrees and the first side lobe is 15.3 db down from the peak.

If a greater beam width and lower gain is permitted, then the side lobes may be limited to approximately 30 db down from the peak. In Fig. 3 (dotted line) the relative field strength of an array, with a relation of the amplitudes $A_1 : A_2 : A_3 = 4:3:1$ is indicated. The half power beam width has increased to 32 degrees, consequently the side lobes have almost disappeared.

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Note of Acknowledgment on "A Broad-Band Interdigital Circuit for Use in Traveling-Wave Type Amplifiers"*

It has been brought to my attention that the possibility that interdigital circuits might be made with a constant phase velocity over a broad band of frequencies had been pointed out independently by Warnecke, Doehler, and Guenard,[1] using an equivalent lumped-circuit model. Warnecke, in a recent private communication, says that operating traveling-wave magnetron amplifiers have been built using such circuits and that these tubes, as anticipated, did exhibit a broad bandwidth and high-impedance parameter. Operating at a center frequency of 1500 mc they were observed to have a power output within 3 db of maximum over a frequency band of 150 mc with an over-all efficiency of about 40 per cent and an over-all gain of 13 db.

R. C. Fletcher
Bell Telephone Laboratories, Inc.
Murray Hill, N. J.

* Received by the Institute, October 15, 1952. R. C. Fletcher, Proc. I.R.E., vol. 40, pp. 951–958; August, 1952.

[1] R. Warnecke, O. Doehler, and P. Guénard, "Sur les lignes à retard en forme de peigne ou de circuit interdigital et sur leur schéme équivalent," *Comptes-rendus*, vol. 231, pp. 1220–1221; November 1950.

Contributors to Proceedings of the I.R.E.

Alfred C. Beck (A'30–SM'46) was born on July 26, 1905 at Granville, N. Y. He received the E.E. degree from Rensselaer Polytechnic Institute in 1927. After two summers in the test department of the New York Edison Company and a year as instructor in mathematics at Rensselaer, he became a member of the technical staff of Bell Telephone Laboratories, Inc., in 1928. Since then he has been in the radio research department, working on antennas, waveguides, and various shortwave, radar, and microwave projects.

A. C. Beck

He is a New York State licensed professional engineer and a member of Sigma Xi.

❖

Robert L. Cosgriff (S'47–A'49) was born on February 27, 1923, near Big Timber, Mont. After attending Montana State College for two years he served three years in the U. S. Army. In 1947, he received a B.E.E. degree from the Ohio State University.

R. L. Cosgriff

From 1947 to 1950 Mr. Cosgriff was a research engineer at the Airplane Division of the Curtiss Wright Corporation. While in this capacity, he attended twilight courses at the Ohio State University and obtained his M.S. degree in 1949. Since 1950 he has been investigating nonlinear phenomena in the field of servomechanisms at the Ohio State University Antenna Laboratory.

Mr. Cosgriff is a member of the American IEE, Tau Beta Pi, Sigma Xi, Sigma Pi Sigma, and Pi Mu Epsilon.

❖

J. B. Dearing, born August 9, 1905 in Jamestown, N.Y., studied mechanical engineering at Carnegie Institute of Technology from 1924 to 1929. He joined the Hochstetter Research Labs in Pittsburgh as chief engineer in 1929. In 1931 he joined RCA Photophone and was active during the early installation of sound movies.

J. B. Dearing

After two years with the Engineering Products Sales Section, Mr. Dearing joined the RCA Service Company and has remained there to date. His activity has involved the installation supervision of the Company's equipment lines, chiefly Television. His present assignment is Television Field Supervisor in the Broadcast Communications Service Section.

❖

Rudolf F. Drenick (SM'52) was born in Vienna, Austria, on August 14, 1914. He attended the University of Vienna, where he received the Ph.D. degree in theoretical physics in 1939. He was on the staff of Villanova College from 1939 to 1944, as assistant professor for mathematics and physics in the School of Engineering. He served in the U. S. Army from then until 1946 and participated there in the evaluation of captured technical documents.

R F. Drenick

From 1946 until 1949, Dr. Drenick was with the Aeronautics and Ordnance Division at the General Electric Co., and worked in the field of flight mechanics of guided missiles. Since 1949, he has been with the RCA Victor Division. He is now head of the Analytical Group in Advanced Development.

Dr. Drenick is a member of the American Mathematical Society.

❖

Aaron D. Fialkow was born in New York, N. Y., on August 9, 1911. He received the B.S. and M.S. degrees from the College of the City of New York in 1931 and the Ph.D. degree in mathematics from Columbia University in 1936. During 1936–1937, he was National Research Fellow at Princeton University and the Institute for Advanced Study. He taught mathematics at Brooklyn College and Columbia University from 1937–1945. Subsequently, he was a research engineer with Federal Telephone and Radio Laboratories, New York, N. Y., and then research mathematician and head of the Mathematics Section at Control Instrument Company, Brooklyn, N. Y. Since 1946 he has also been associated with the Mathematics Department of Brooklyn Polytechnic Institute where he is now a professor.

A. D. Fialkow

Dr. Fialkow is a member of the American Mathematical Society, Phi Beta Kappa and Sigma Xi.

Joseph F. Fisher (SM'48) was born on February 28, 1911 in Philadelphia, Pa. He attended the Drexel Institute of Technology from 1929 to 1933, graduating in 1936 from the evening school. His co-operative periods while attending Drexel were with the Philco Corporation, with whom he has been employed for eighteen years.

J. F. Fisher

After several years work in quality control Mr. Fisher joined the Research Division. Projects he has worked on in a supervisory capacity include apparatus for measurement of long persistence cr tubes, propagation studies at vhf and uhf, instrumentation for transient analysis of television receivers and systems, and design of color television terminal equipment. At present he is a project engineer on color television systems.

Mr. Fisher is the author of several articles in trade journals.

❖

Irving Gerst was born in New York, N. Y., on May 30, 1912. He received the B.S. degree from the College of the City of New York in 1931 and the M.A. and Ph.D. degrees in mathematics from Columbia University in 1932 and 1947. He taught mathematics in the New York City school system from 1937–1942. Subsequently, he was an instructor at the Air Force Technical School, Biloxi, Miss. and became a technical consultant for the Transportation Corps of the Army Service Forces. Since 1946, he has been research mathematician at the Control Instrument Company, Brooklyn, N. Y.

Irving Gerst

Dr. Gerst is a member of the American Mathematical Society, the Mathematical Association of America, Phi Beta Kappa and Sigma Xi.

❖

Herman E. Gihring (A'29–SM'49) was born on October 2, 1904, in St. Louis, Mo. He received the B.S. degree in electrical engineering from Washington University in 1926. He then served as an electrical assistant in the Signal Corps for three years.

Mr. Gihring joined the Technical and Test Department of RCA in 1929. He transferred to the newly formed Broadcast

Transmitter Section in Camden, and for the next five years did propagation and antenna work. In 1936 he worked on the Empire State television transmitter installation, and from 1937 to 1940 engaged in television transmitter development. In 1940 he supervised the Television Transmitter Group, which expanded into radar activities until 1944. He has since worked on television and antennas in a supervisory capacity.

H. E. Gihring

❖

Raymond F. Guy (A'25–M'31–F'39) was born in Hartford, Conn., on July 4, 1898. He joined the Marconi Wireless Company in 1916. During World War I he served overseas with the Signal Corps. Upon discharge, he entered Pratt Institute, from which he graduated with an electrical engineering degree in 1921.

Raymond F. Guy

In the same year Mr. Guy was engaged as a broadcast engineer for WJZ. From 1924 to 1929 he was head of the Broadcast Engineering Section of the RCA Research Laboratories, where he supervised the development and building of broadcasting equipment and systems, network and international broadcasting, and television.

In 1929 Mr. Guy transferred to the National Broadcasting Company to direct its frequency allocations engineering and the planning, design, and construction of all NBC transmitting facilities. His present responsibilities encompass all phases of FM, TV, standard and international broadcasting, plant engineering design and construction, and frequency allocations engineering.

Mr. Guy has been very active in Institute affairs for many years, having been Treasurer, Director, and, in 1950, President.

❖

Frank S. Holman (S'48) was born on December 12, 1924, in Great Falls, Mont. He received the B.S. degree in radio technology from Utah State College in 1949, and the M.S. and E.E. degrees in electrical engineering from Stanford University, in 1950 and 1951, respectively.

F. S. Holman

At present, Mr. Holman is a research associate at the Electronics Research Laboratory, Stanford, Calif., and is continuing his graduate study at the university.

Frank G. Kear (A'24–M'31–SM'43–F'53) was born in Minersville, Pa., on October 18, 1903. He received the E.E. degree (cum laude) from Lehigh University in 1926 and the S.M. degree in E.E. in 1928 and Sc.D. degree in E.E. in 1933, from the Massachusetts Institute of Technology.

Frank G. Kear

Dr. Kear was associated with development of the product integraph and the differential analyzer. From 1928 to 1933 he was a physicist in the Aeronautical Radio Group at the National Bureau of Standards. For the next eight years he was Chief Engineer of the Washington Institute of Technology, in charge of development of radio aids to air navigation. Since 1941 he has been a Senior Partner in the consulting engineering firm of Kear and Kennedy. During 1941–1945 he headed the Radio Section, Electronics Division, Bureau of Aeronautics, U. S. Navy.

Dr. Kear is a member of the Society of Motion Picture and Television Engineers, the Association of Federal Communications Consulting Engineers, Eta Kappa Nu, Tau Beta Pi, Phi Beta Kappa, and Sigma Xi.

❖

For a photograph and biography of Irving E. Levy see page 607 of the May, 1952, issue of the Proceedings of the I.R.E.

❖

George L. Matthaei (S'49–A'52) was born in Tacoma, Wash., on August 28, 1923. He entered the University of Washington in 1941, but left during the period 1943 to 1946 for Army service in the U. S. and the Pacific Theater. He returned to Washington and received his B.S. degree in electrical engineering in 1948. He then received his M.S. at Stanford University in 1949, the degree of Engineer in 1951, and the Ph.D. degree in 1952.

G. L. Matthaei

Since September of 1951 Mr. Matthaei has been an instructor in the Division of Electrical Engineering of the University of California at Berkeley. He is a member of Tau Beta Pi and Sigma Xi.

❖

For a photograph and biography of Stewart E. Miller, see page 1128 of the September, 1952 issue of the Proceedings of the I.R.E.

❖

Mr. C. Dale Owens was born May 15, 1906, near Wadesville, Indiana. After graduating from Indiana University in 1928, where he received his A.B. in physics, he joined Bell Telephone Laboratories. For about two years Mr. Owens was assigned to the design and development of condensers. He then moved to development work on molybdenum permalloy powder cores and other magnetic materials, with particular emphasis on their applications to retardation and loading coils. Meanwhile, conducting graduate study at Columbia University, he was awarded an M.A. degree in physics in 1936.

C. Dale Owens

From 1940 through 1945 Mr. Owens designed, developed, and tested coil components for high-powered radar. Since World War II he has studied the characteristics of new magnetic materials and their applications, particularly the ferrites or ferromagnetic nonmetals.

Mr. Owens is a member of Phi Beta Kappa and the American Physical Society, as well as a Fellow of the American Association for the Advancement of Science. Also, he is chairman of I.R.E.'s Subcommittee on Magnetic Measurements.

❖

Donald M. Swingle (A'45–M'48) was born in Washington, D. C. on September 1, 1922. He received the B.S. degree in mathematics and education in 1943 from Wilson Teachers College. He completed the meteorological program at New York University in 1944, and the training programs in radio and radar engineering at Harvard University and M.I.T. Radar School in 1944. He received the M.S. degree in meteorology from New York University in 1947. While at Harvard he earned the A.M. degree in 1948, the M.Eng.Sci. degree in 1949, and the Ph.D. degree in 1950, with research on the tropospheric reflections of electromagnetic waves.

D. M. Swingle

Dr. Swingle entered the U. S. Army in 1943, serving as a radar engineer and weather radar research scientist at the Signal Corps Engineering Laboratories, Fort Monmouth N. J. until 1946, and radar development engineer until 1947. In 1950 Dr. Swingle returned to the Laboratories, and is now engaged in research in radar storm and cloud detection and related problems in weather electronics.

Dr. Swingle is a member of the American Meteorological Society, the American Geophysical Union, and the American Association for the Advancement of Science, and an associate member of A.I.E.E.

❖

For a photograph and biography of Oswald G. Villard, Jr., see page 360 of the March, 1952 issue of the Proceedings of the I.R.E.

1953 IRE National Convention Program

WALDORF-ASTORIA HOTEL and GRAND CENTRAL PALACE—MARCH 23–26 NEW YORK CITY

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Registration

Members and visitors may register at either the Waldorf-Astoria Hotel or Grand Central Palace at the following hours:

	Waldorf-Astoria	*Grand Central Palace*
Mon.	9 A.M.–5:30 P.M.	10:30 A.M.–9 P.M.
Tue.	9 A.M.–8 P.M.	9 A.M.–9 P.M.
Wed.	9 A.M.–6 P.M.	9 A.M.–6 P.M.
Thur.	9 A.M.–2:30 P.M.	9 A.M.–9 P.M.

Technical Sessions

Over 200 technical papers will be presented in 43 sessions. A schedule of sessions is listed on the following page. A listing of papers, authors, and 100-word summaries is given in the following pages.

Technical sessions will be held at the Grand Central Palace, 47th Street and Lexington Ave.; the Waldorf-Astoria Hotel, 49th Street and Lexington Ave.; and the Belmont Plaza Hotel, across the street from the Waldorf-Astoria.

Exhibits

The Radio Engineering Show, featuring 405 exhibits of the most recent advances in the radio-electronic field, will occupy four floors of Grand Central Palace. A list of exhibitors and their products starts on page 1A of this issue. Exhibits will be open during the following hours:

Monday: 11:00 A.M.–9:00 P.M.
Tuesday: 9:30 A.M.–9:00 P.M.
Wednesday: 9:30 A.M.–6:00 P.M.
Thursday: 9:30 A.M.–9:00 P.M.

Annual Meeting

IRE members will be particularly interested in the opening meeting of the convention, the Annual Meeting of the Institute, to be held in the Grand Ballroom of the Waldorf-Astoria at 10:30 A.M. on Monday, March 23. The principal speaker will be William R. Hewlett, IRE director and vice-president of the Hewlett Packard Co. Added features of the meeting will be the presentation of the gavel of office to the incoming IRE president, James W. McRae, by his predecessor, Donald B. Sinclair, and the presentation of special pins to nine Charter Members of the I.R.E.

(Continued on the following page)

(Convention Program, cont'd)

Convention Record

Papers presented at the convention will be published in a new publication, the CONVENTION RECORD OF THE I.R.E., which will be available about two months after the convention. The CONVENTION RECORD will be issued in ten parts, with each part containing papers relating to one general field.

Every member of an IRE Professional Group who has paid the Group assessment fee by April 30, 1953, will automatically receive, free of charge, that part of the CONVENTION RECORD which contains papers relating to the field of interest of his Group. Information on how to join a Professional Group may be obtained by writing to the Institute of Radio Engineers, Inc., 1 East 79 Street, New York 21, N. Y., or by inquiring at the Professional Groups desk at the convention.

Full details concerning the contents and prices of CONVENTION RECORD parts will be published in the April issue of the PROCEEDINGS. Delivery cannot be guaranteed on orders received after April 30, 1953.

Social Events

A "get together" **Cocktail Party** will be held on the first evening of the convention, March 23, from 5:30 to 7:30 P.M. in the spacious Grand Ballroom of the Waldorf-Astoria. Tickets may be purchased from Institute headquarters at $4.00 each. Tickets will be on sale also at the convention.

The **Annual Banquet,** to be held in the Grand Ballroom on Wednesday, March 25, at 6:45 P.M., will feature an address by General David Sarnoff, chairman of the board of RCA and first recipient of the newly established IRE Founders Award. His speech promises to be of great interest, not only to professional engineers, but to the entire electronics industry. Dr. A. M. Zarem, director of the Los Angeles division of Stanford Research Institute, will serve as toastmaster. President J. W. McRae will bestow the annual IRE awards to their recipients.

Ticket orders will be honored in the order received. To ensure reservations, members are urged to write now to Institute headquarters. Tickets are available at $13.75 each.

Women's Program

An attractive program of sightseeing and tours has been arranged for wives of IRE members and immediate members of their families. Among the events planned will be a "get acquainted" party, a tour of the United Nations and Lever Brother's buildings, luncheon and fashion show, and a matinee of the "King and I" or "Wish You Were Here."

Note

Convention papers will be published about two months after the convention in the CONVENTION RECORD OF THE I.R.E. Each paid member of an IRE Professional Group (as of April 30, 1953) will receive, free of charge, that part of the CONVENTION RECORD containing papers of interest to his group. Full details on prices will appear in the April issue of the PROCEEDINGS.

SCHEDULE OF TECHNICAL SESSIONS

	BELMONT-PLAZA	WALDORF-ASTORIA			GRAND CENTRAL PALACE	
	Moderne Room	*Grand Ballroom*	*Astor Gallery*	*Jade Room*	*Gold Hall*	*Blue Hall*
Mon. P.M. 2:30	Session 1 Antennas I—General	Session 2 Television I	Session 3 Circuits I—Network Theory	Session 4 Electronic Computers I	Session 5 Symposium: Instrumentation I—Automatic	Session 6 Radio Location, Navigation and Airborne Electronics
Tues. A.M. 10:00	Session 7 Antennas II—Microwave	Session 8 Television II	Session 9 Circuits II—Symposium: Panel Discussion on Wide-band Amplifiers	Session 10 Electronic Computers II	Session 11 Instrumentation II—Symposium: Transistor Measurements	Session 12 Significant Trends in Airborne Equipment
Tues. P.M. 2:30	Session 13 Antennas III—Propagation	Session 14 Symposium: Diagnostic Programs and Marginal Checking for Large Scale Digital Computers	Session 15 Circuits III—Time Domain Networks—Delay Lines	Session 16 Electron Devices I—Transistors	Session 17 Instrumentation III—Electronics	Session 18 Symposium: Trends in Mobile Communications
Tues. 8:30		Session 19 Symposium: Electronics in Flight				
Wed. A.M. 10:00	Session 20 Electron Devices II—Electron Tubes	Session 21 Circuits IV—Active Networks—Transistors	Session 22 Noise and Modulation	Session 23 Symposium: Television Broadcasting	Session 24 Quality Control Methods Applied to Electron Tube and Electronic Equipment Design	Session 25 Seminar: Acoustics for the Radio Engineer—I
Wed. P.M. 2:30	Session 26 Electron Devices III—Microwave Tubes	Session 27 Information Theory I—Recent Advances	Session 28 Communications Systems	Session 29 Symposium: Television Broadcasting and UHF	Session 30 Microwaves I—Symposium: Manufacture of Microwave Equipment	Session 31 Seminar: Acoustics for the Radio Engineer II
			Starlight Roof	**Sert Room**		
Thurs. A.M. 10:00	Session 32 Symposium: Nucleonics	Session 33 Information Theory II—Theoretical	Session 34 Medical Electronics	Session 35 Broadcast and Television Receivers—I	Session 36 Microwaves II—Discontinuities and Transitions	Session 37 Radio Telemetry
Thurs. P.M. 2:30	Session 38 Audio	Session 39 Engineering Management	Session 40 Information Theory III—Coding	Session 41 Broadcast and Television Receivers—II	Session 42 Microwaves III—Ferrites and Detectors	Session 43 Remote Control Systems

SUMMARIES OF TECHNICAL PAPERS

Session 1

Antennas I—General

(Organized by the Professional Group on Antennas and Propagation)

Chairman, D. C. Ports

(Jansky and Bailey, Washington, D. C.)

1.1. THE MEASUREMENT OF HIGHLY DIRECTIVE ANTENNA PATTERNS AND OVER-ALL SENSITIVITY OF A RECEIVING SYSTEM BY SOLAR AND COSMIC NOISE

Jules Aaron

(Air Force Cambridge Research Center, Cambridge, Mass).

Utilizing the 100 narrow sources of radio frequency energy and known data about the effective diameter of the sun at various ranges of radio frequencies, a technique for plotting the directional characteristics of large antennas is outlined. Over-all system sensitivies (receiver, antenna, and transmission lines) are checked by using values already obtained for sky contours. The general receiver characteristics necessary for such measurements are outlined. Patterns of the sun and cosmic sources are illustrated and their analysis evaluated.

1.2. RADIATION PATTERNS FOR APERTURE ANTENNAS WITH NONLINEAR PHASE DISTRIBUTIONS

C. C. Allen

(General Electric Co., Schenectady, N. Y.)

A method of antenna pattern calculation employing automatic punch-card machines to perform numerical integrations has been used to obtain sets of patterns for several nonlinear phase distributions. These results extend previous work to the cases of quadratic and cubic phase distributions combined in various proportions together with uniform, tapered, and cosine amplitude distributions. The magnitude patterns include the first two or three side lobes, and phase patterns are given for the main beams. The sets of patterns are arranged to permit interpolation which makes them useful in semiquantitative pattern synthesis of which an example is given. The need for arbitrary criteria used heretofore in determining the suitability of aperture distributions is thus eliminated.

1.3. FACTORS AFFECTING RADIATION PATTERNS OF CORRUGATED SURFACE ANTENNAS

M. Ehrlich and L. Newkirk

(Hughes Aircraft Co., Culver City, Calif.)

The radiation patterns of corrugated metal-surface antennas have been computed in the past by an integration of tangential electric field over the surface of the antenna. Measured radiation patterns of these antennas when fed by a horn, slot, or wire feed exhibit characteristic perturbations from the computed theoretical value. These perturbations are a reduced beam width, a minimum at the theoretical half-power point, and extremely high first-side lobes. It is conclusively shown in the present study that the total pattern is a combination of the radiation pattern of the feed and metal surface configuration. The perturbations can be reduced to any desired degree by means of a long transition section between feed and corrugated surface array in which the feed mode is almost wholly transformed to the surface mode; this has been demonstrated for a wide variety of aperture sizes and array lengths. Independent control of the relative phase of the two fields can be achieved by altering the length of the corrugated surface array. Variation of the ratio of the relative amplitudes can be achieved over a wide range by changing the length of the transition section used to accomplish the mode transformation from feed to array mode. Thus a practical flush-type feed producing negligible pattern perturbations is now possible for corrugated surface or dielectric slab antennas.

1.4. A MICROWAVE ANECHOIC CHAMBER MAKING USE OF A NEW BROAD-BAND ABSORBING MATERIAL

A. J. Simmons and W. H. Emerson

(Naval Research Laboratory, Washington, D. C.)

A room lined with a broadband microwave absorbing material has been built in which radiation patterns of small antennas may be measured at frequencies higher than 1,000 mc. The material, developed at the Naval Research Laboratory, is made by applying graphite in neoprene to a mat of loosely spun animal hair to create a lossy low-dielectric constant medium.

The reflective properties of this material and the evaluation of the room as an antenna test site are presented.

1.5. WIDE-FREQUENCY-RANGE TUNED CIRCUITS AND ANTENNAS

A. G. Kandoian and William Sichak

(Federal Telecommunication Laboratories, Nutley, N. J.)

Helical circuit elements, with or without coaxial outer conductors, have important network and antenna applications. As resonant circuits, they are as useful at hf and vhf as conventional coaxial lines at uhf. Among their important characteristics are ability to tune over an extremely large frequency range and achieve high unloaded Q in a limited space.

In antenna applications, it will be shown that a resonant multiturn helix has more radiation resistance and considerable less loss than conventional small dipoles with equivalent apertures.

The discussion will include theory, fundamental properties, useful applications, and experimental data to bear out the theoretical conclusions.

Session 2

Television I

Chairman, I. J. Kaar

(General Electric Co., Syracuse, N. Y.)

2.1. THEORY OF SYNCHRONIZATION, APPLIED TO NTSC COLOR TELEVISION

Donald Richman

(Hazeltine Corporation, Little Neck, L. I., N. Y.)

This paper presents the results of an analytical evaluation of the performance capabilities of the system used in NTSC color television to synchronize the color-carrier reference signal. The color sync burst appears to contain far more timing and synchronizing information than is required, although previously used sync systems have been inefficient in using the information.

Analysis begins with determination of the amount of integration required for phase stability. The properties and limitations of "standard" passive and locked (APC) integrators are discussed. Integration requirements limit pull-in performance.

The basic principle for overcoming previous limitations and obtaining the upper limit of performance is explained, leading to a determination of the ultimate capabilities permitted by the NTSC color sync signals.

Simple techniques and new sync systems for approaching this limit are presented, and discussed.

The physical principles apply to synchronizing systems, generally.

2.2. COLOR SYNCHRONIZATION IN THE NTSC COLOR TELEVISION RECEIVER BY MEANS OF THE CRYSTAL FILTER

W. E. Good

(General Electric Co., Syracuse, N. Y.)

The problem of color synchronization in the NTSC color television receiver means generating a continuous-wave signal which is in phase with the transmitted color burst. This 3.9-mc reference signal is then used to switch the color samplers or demodulators. Of the various methods proposed for color synchronization, the automatic frequency controlled oscillator and the quartz-crystal filter have worked out well in practice.

The crystal filter or ringing circuit is supplied with a gated-burst driving signal and the resultant in-phase damped wave is amplitude-limited and used for the reference signal. The circuit is passive in its operation and has given satisfactory performance during the color field tests. The design characteristics of the filter will be discussed as will the various sources of phase errors. The effect of spurious modes in the crystal will be pointed out. It will be compared with the AFC type of circuit.

2.3. APC COLOR SYNC FOR NTSC COLOR TELEVISION

Donald Richman

(Hazeltine Corporation, Little Neck, L. I., N. Y.)

This paper presents a description of the characteristics and capabilities of a "standard" automatic-phase-control system applied to NTSC color-carrier reference-phase synchronization.

Following a discussion of in-sync performance characteristics, a physical description of the mechanism by which the system pulls into sync provides a background for the relations between frequency pull-in range and time, and the in-sync characteristics such as noise bandwidth. The system includes a nonlinear (sinusoidal) phase detector. An explanation of results of a mathematical analysis, presented graphically, emphasizes the upper limits of performance and how they may be obtained. A numerical evaluation for NTSC color sync indicates over-all satisfactory performance with this APC system.

2.4. TRANSIENT RESPONSE IN A COLOR CARRIER CHANNEL WITH VSB TRANSMISSION

J. S. S. Kerr
(General Electric Co., Syracuse, N. Y.)

Two independent signals used to modulate a carrier in quadrature can be detected without crosstalk only if the transfer characteristic of the network through which the modulation passes fulfills certain conditions of symmetry. For vestigial sideband transmission—as proposed for the transmission of chrominance information by the National Television Systems Committee—these conditions may not be fully met. In systems being considered by the NTSC, residual crosstalk is eliminated either by CPA or by video filtering.

Several types of vestigial-sideband transfer characteristics which are used in the transmission of chrominance information are analyzed and compared, both for minimum phase and linear phase. Their video inphase and quadrature transfer characteristics are shown along with the transients which arise from a step input.

2.5. TRANSIENTS IN COLOR TELEVISION

P. W. Howells
(General Electric Co., Syracuse, N. Y.)

A color television system transmits three independent signals, each of which specifies one of the three co-ordinates that determine the location of the reproduced color in a three-dimensional color space. When a color transient occurs, each of these signals responds in a different manner determined by the characteristics of its own channel. The system response may be characterized by the resulting path along which the reproduced color point moves through the color space from its initial to its final location. The shape of such color transient paths as determined by the individual transient responses of the three channels is analysed, and the subjective appearance of different transient-path shapes is discussed. Various modifications of the NTSC proposals are compared by these methods.

Session 3

Circuits I—Network Theory

(Organized by Professional Group on Circuit Theory)

Chairman, S. Darlington
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

3.1. A GENERAL RLC SYNTHESIS PROCEDURE

Louis Weinberg
(Hughes Aircraft Co., Culver City, Calif.)

Any physically realizable transfer function (impedance, admittance, or dimensionless ratio) can be realized within a multiplicative constant by the new synthesis procedure presented in this paper. The form of network achieved is a lattice with the following significant features: (1) The lattice may have any desirable termination. (2) The lattice contains no mutual inductance. (3) Every inductance in the network appears with an associated series resistance so that, in building the network, low-Q coils may be used.

In addition, the lattice arms relative to each other are of so simple a form as to render many of the achieved lattices amenable to reduction to an unbalanced network. For the case of a transfer admittance, moreover, reduction *always* can be achieved with, at most, the use of real transformers, that is, transformers with winding resistance, finite magnetizing inductance, and a coupling coefficient smaller than one.

3.2. A GENERAL THEORY OF WIDE-BAND MATCHING

H. J. Carlin and Richard LaRosa
(Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

A general treatment is given for the design of wide-band matching networks which may contain dissipation. Loss is intentionally introduced to permit a degree of match unobtainable with lossless matching networks. For any prescribed input reflection magnitude including zero (that is, perfect match) the method allows the most efficient network configuration to be determined.

From scattering considerations, simple, easily interpreted relations are presented which predict the theoretical limitations on the two quantities of engineering interest: the magnitude of input reflection coefficient, and the power which reaches the load. The best two-terminal pair network from the standpoint of minimum insertion loss (normalized to available generator power) is shown to contain no more than one resistor.

3.3. SYNTHESIS OF ELECTRIC FILTERS WITH ARBITRARY PHASE CHARACTERISTICS

B. J. Bennett
(Stanford Research Institute, Stanford, Calif.)

Conventional synthesis methods for design of electric filters generally follow the pattern of approximating a desired attenuation characteristic using a minimum-phase network, and then if the phase characteristic is undesirable, a phase-corrective all-pass network is connected in tandem. In contrast, the design theory introduced in this paper deals directly with the over-all insertion-transfer function, in general, a nonminimum-phase function, which approximates, at once, the attenuation and phase characteristics desired. The network is then realized as a unit on an insertion-loss basis.

For a nonminimum-phase function, attenuation and phase characteristics are, to a large extent, independent of each other, and Lee's and Bode's relations between real and imaginary components of network functions are not violated. It is shown that if the prescribed phase characteristic is attainable by an all-pass transfer function, it may be realized exactly in a network which also possesses an attenuation characteristic which is a close approximation to a prescribed filter attenuation characteristic.

3.4. WIDE-BAND FILTER AMPLIFIERS AT ULTRA-HIGH FREQUENCIES

W. A. Christopherson
(IBM Corp., San Jose, Calif.)
D. O. Pederson and J. M. Pettit
(Stanford University, Stanford, Calif.)

This paper describes the development of a stagger-tuned, band-pass amplifier at ultra-high-frequency using grounded-grid triodes and having a prescribed gain magnitude response. For the first time, the concepts of stagger tuning have been extended to grounded-grid cascades so that triodes designed for uhf operation can be effectively utilized to obtain amplifiers having large gain-bandwidth products and low-noise figures.

The amplifier described uses high performance. disc-seal triodes with special four-terminal interstages. The special interstages accomplish the impedance transformation needed for grounded-grid amplifiers and in addition have a frequency characteristic which is approximately that of a single-tuned circuit. Because of this frequency characteristic, stagger-tuning is employed to conserve gain-bandwidth product; however, the nature of the characteristic requires the use of novel low-pass to band-pass transformations to determine the correct interstage tunings for a "maximally-flat" type of response. The feedback effects occurring between adjacent interstages are incorporated in the tuning procedure.

The design and performance of an amplifier having a gain of 50 db, a bandwidth of 50 mc, and a maximally-flat gain characteristic will be presented.

3.5. NETWORK ANALYSIS WITH THE AID OF GENERATING POLYNOMIALS

Herbert Kurss
(Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

The technique emphasized here is the representation of a finite matrix by a polynomial whose coefficients are the various minors of the matrix. This "generating polynomial," determined by a vanishing determinant, effectively defines a network in terms of its input-output relations. Two networks are then equivalent with respect to a specified class of terminations if the respective generating polynomials have proportional coefficients. For simplicity, this is illustrated for microwave networks where the relevant form of the Jacobi ratio theorem, the Campbell formula (for the "elimination of concealed circuits"), and a compound network theorem are all simply derived.

3.6. TWO NEW EQUATIONS FOR THE DESIGN OF FILTERS

M. Dishal
(Federal Telecommunication Laboratories, Inc., Nutley, N. J.)

Two basic problems in filter design have been the finding of element values in ladder networks of inverse arms (or equivalent structures) to produce Chebishev response for two terminal conditions: (a) loading on both ends of the network, (b) loading on only one end of the network.

These problems have now been solved for the general case of any number of elements for both the Chebishev response and its limiting case of the Butterworth response.

The complete design information is contained in two simple equations that can replace those of classical filter theory. These equations and their derivations are presented.

Session 4

Electronic Computers I

(Organized by Professional Group on Electronic Computers)

Chairman, J. H. Felker

(Bell Telephone Laboratories, Whippany, N. J.)

4.1. MULTICHANNEL ANALOG INPUT-OUTPUT CONVERSION SYSTEM FOR DIGITAL COMPUTER

P. A. Adamson and M. L. MacKnight

(Hughes Aircraft Co., Culver City, Calif.)

The conversion of dc voltages to binary numbers, and vice versa, is performed independently of computer operation, the magnetic drum serving as storage for the most recently sampled data. Input voltages are compared by a multiar-type comparator with an accurately linear saw-tooth waveform, gated once per revolution of the drum to successive inputs. Clock pulses are counted from the start of the ramp until comparison is reached and the resulting binary number is shifted to the memory. The ramp slope is calibrated once per cycle of inputs, making the scale factor virtually independent of drum speed, temperature, and supply-voltage changes.

Output voltages are derived from a filtered rectangular waveform whose symmetry is made proportional to the output binary number. One cycle of the waveform is recorded on a drum channel during an output sample period, and the waveform is continuously read to a regulated current switch tube and filter every revolution. Several outputs may be time shared on a single-drum channel. Input and output conversions have an accuracy of about ±0.1 per cent full scale.

4.2. AN ANALOG TO DIGITAL CONVERTER WITH AN IMPROVED LINEAR SWEEP GENERATOR

D. W. Slaughter

(California Institute of Technology, Pasadena, Calif.)

This paper describes an analog-to-digital converter with 1 part in 5,000 (.02 per cent) accuracy and excellent long-time stability. Sampling speeds of up to 100 per second at high accuracy are readily obtainable. This converter utilizes the familiar circuitry in which an analog voltage is represented by a train of pulses initiated at the start of a linear sweep and ending when the magnitude of the sweep and the analog voltage coincide. The heart of the high-accuracy sweep generator is an electronically gated operational amplifier. Optional automatic self calibrating can provide exceptional long-time stability. A stable circuit for detecting the magnitude coincidence is also presented.

4.3. DYNAMIC BINARY COUNTER WITH ANALOG READ-OUT

Leroy Packer

(Columbia University, New York, N. Y.)

A binary counter using circulating pulse techniques is described. The counting rate is one mc and the carry time per stage is approximately 0.02 μs. Information can be read out of the counter every μs since the counter is not stopped when a sampling pulse appears. The read-out mechanism consists of a parallel register, associated relays, and an ac feedback amplifier which provide both parallel binary and analog outputs equal to the time between the start of the counting cycle and the appearance of a sampling pulse.

4.4. LIFE AND RELIABILITY EXPERIENCE WITH TRANSISTORS IN A HIGH SPEED DIGITAL COMPUTER

J. J. Scanlon

(Bell Telephone Laboratories, Whippany, N. J.)

This experience is based on the use of approximately 500 semiconductor diodes as logic elements and 78 transistors as the only active elements in a binary multiplier. The machine operates at a pulse repetition rate of one megacycle and can multiply two 16 digit binary numbers in 272 μsec. The maximum potential used is 8 volts with a resultant total battery drain of less than 5 watts. Approximately the same amount of master clock power is also required.

Approximately 3,000 hours of continuous operation (234,000 transistor hours) have been logged with only one transistor failure at 1,430 hours.

Freedom from random error has been demonstrated by circulating binary information, without error, in closed loops within the machine for hundreds of hours. In one case a 700 hour run was terminated by accidental power failure. For each hour of operation each transistor must make 3.6×109 successful discriminations.

Periodic voltage margin checks have disclosed no aging effects.

4.5. ENGINEERING EXPERIENCE IN THE DESIGN AND OPERATION OF A LARGE SCALE ELECTROSTATIC MEMORY

J. Logue, A. Brennemann, and A. Koelsch

(IBM Engineering Laboratory, Poughkeepsie, N. Y.)

The IBM Type-701 Electronic Data Processing Machine uses an electrostatic storage unit. This paper will describe the engineering considerations encountered in the design and operation of the circuits involved. The video amplifier will be described and factors involved in setting the amplitude-discriminating level of the video amplifier will be treated in some detail. The deflection circuits will be discussed, together with the special requirements of electrostatic storage and how these requirements were met. The problems encountered when a read-around ratio of 200 to 1, or larger is required, will be included in the discussion.

Session 5: Symposium

Instrumentation I—Automatic

(Organized by Professional Group on Instrumentation)

Chairman, Ernst Weber

(Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

5.1. A NEW METHOD FOR MEASURING NOISE FIGURE AND GAIN OF A RADAR RECEIVER

R. J. Parent and V. C. Rideout

(University of Wisconsin, Madison, Wis.)

A new method has been developed for the measurement of the gain-and-noise figure of a radar receiver. In this method a pulsed gas-discharge noise source at the input and a coherent detector at the output are used. The use of a gas-discharge noise source has the usual advantages over a small monochromatic-signal source that output level and frequency need not be adjusted. The sensitivity of the coherent detector overcomes the difficulty ordinarily encountered with the low-output level of this noise source. The use of the coherent detector requires that the noise source be pulsed, which in turn gives other advantages.

The scheme described is adaptable to either quantitative measurement or a go-no-go indication based on some set limits.

An adaptation of this method to the measurement of noise figure and gain of a radar receiver while the radar is in normal operation has also had successful preliminary tests.

5.2. AUTOMATIC INSTRUMENTATION FOR CONTINUOUS MONITORING OF SYSTEMS PERFORMANCE

M. V. Ratynski, Milton Kant, and Haywood Webb

(Rome Air Development Center, Rome, N. Y.)

The utilization of automatic instrumentation to facilitate the measurement of performance parameters of electronic systems is discussed. A comparison is made between existing measurement methods and recently developed techniques.

Techniques are described for continuous and automatic measurement of (1) receiver noise figure and gain-bandwidth product, (2) transmitter power output, (3) constant velocity servosystem performance, (4) transmission line vswr. These measurements are made while the system whose performance is being monitored is in operation, and advantages of incorporating these items in typical systems are demonstrated.

5.3. AUTOMATIC ONE-SHOT METHODS FOR BANDWIDTH MEASUREMENT

J. B. Woodford, Jr., and E. M. Williams

(Carnegie Institute of Technology, Pittsburgh, Pa.)

The problem of determining a simple bandwidth acceptability criterion which can be reduced to a number or set of numbers which adequately emphasizing band width-related performance, is surveyed. Typical one-shot measurement systems for go-no-go indication are summarized; results of experimental tests on prototype and operating radar and communication systems are described.

5.4. MICROWAVE POWER METER WITH AUTOMATIC ZERO SETTING AND TELEMETERING

L. A. Rosenthal and G. M. Badoyannis
(Rutgers University, New Brunswick, N. J.)

An improved self-balancing bridge type of microwave-power meter capable of automatically setting its zero, to compensate for temperature variations, and telemetering the measured power is described. Automatic zeroing is accomplished by shutting off the RF power for a regular short interval during which time a servomechanism adjusts the power level so that the meter reads zero. Frequency-modulation telemetering provides a direct power indication at a removed position. The system will allow for the remote monitoring and recording of power level in a microwave installation.

Operating principles and design of individual units are described and performance data for the complete system presented.

5.5. MONITORING OF ERRORS IN SYNCHRO SERVO SYSTEMS

Giorgio Quazza
(Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

In synchro-servo systems transmitting positional information at constant or slowly varying speed of the input member, the control transformer-output voltage depends on the speed, and therefore is not a direct measure of the system positional error. Different passive networks, to be inserted in series with the ct stator windings, are proposed to compensate for the system output voltage variations due to speed and permit monitoring of the system error by direct measurement of the ct output voltage. Formulas for their design are derived and analytical and experimental results given, to describe their relative merits and the effect of temperature variations on their performance.

Session 6

Radio Location, Navigation and Airborne Electronics

(Organized by Professional Group on Airborne Electronics)

Chairman, P. C. Sandretto
(Federal Telecommunications Laboratories, New York, N. Y.)

6.1. THE TECHNIQUE OF MONOPULSE RADAR

W. Hausz
(General Electric Co., Syracuse, N. Y.)

The monopulse technique in radar consists in deriving sufficient information on a single pulse by multiple simultaneously acting receiving channels to determine completely both the angular position and the range of a target or targets. Two commonly used variants are phase comparison and amplitude comparison. The informational aspects of both of these, and of monopulse more generally compared with scanning techniques for angular determination, is given.

6.2. REDUCING SKY WAVE ERRORS IN CW TRACKING SYSTEMS

M. S. Friedland
(Air Force Missile Test Center, Patrick Air Force Base, Fla.)
Nathan Marchand
(Electronics Laboratory, Greenwich, Conn.)

A cw tracking system is very susceptible to sky-wave interference and errors. Once a received cw signal is contaminated by sky wave, it is impossible to separate out the error. When the possibility of contamination exists, it is felt that the system should be modified, and the basic theory underlying a modification by pulsing the transmitted frequency is given. In a system employed at the Air Force Missile Test Center, the transmitter is airborne. The necessary pulse lengths and repetition rates, as well as other design data, are determined by the ranges to be covered, frequencies to be employed, and the ionospheric layer heights. The interdependence of these factors are detailed, modifications applied to a Raydist system, and discussed.

6.3. AN APPLICATION OF INTEGRATOR TYPE SIGNAL ENHANCER TO DIRECTION FINDING EQUIPMENTS

C. A. Strom and J. A. Fantoni
(Rome Air Development Center, Rome, N. Y.)

This paper summarizes the results obtained in applying integrating type of signal enhancers to certain radio direction-finding equipments and to other repetitive type signals such as may be displayed on an "A" scope. The integrators used include systems employing magnetic storage units such as a tape recorder, delay lines techniques such as magnesium delay lines, and capacitor storage elements. The paper shows that improvements in signal-to-noise ratio of 12 db is easily obtained and that improvements up to 20 db or more are obtainable by use of positive feedback around the integrator.

6.4. A THEORY OF TARGET GLINT OR ANGULAR SCINTILLATION IN RADAR TRACKING

R. H. Delano
(Hughes Aircraft Co., Culver City, Calif.)

A theory is presented to describe the statistical aspects of tracking a complex isolated structure, such as an aircraft or naval vessel, by radar. The results are expressible in simplest form when the target subtends an angle small compared with the beamwidth. When the angle subtended by the target is small, a single description applies to all radar tracking systems. An instantaneous and an effective target displacement from the mean are defined and their statistical properties derived. Special treatment is given to additional noise arising in conical scanning due to amplitude fluctuations as such. The theory provides information relating to the spectra as well as to the probability densities and rms values of the pertinent quantities.

6.5. AUTOMATIC DEAD RECKONING NAVIGATION COMPUTERS FOR AIRCRAFT

J. L. Dennis
(Wright Air Development Center, Dayton, Ohio)

Two airborne navigation computers based on the principles of dead reckoning are described. The first, the Type A-1 Ground Position Indicator, is a computer which operates from inputs of true airspeed and magnetic heading. Wind can be inserted manually in the form of magnitude and direction. Position in latitude and longitude can be set initially or reset upon sighting a check point, but is maintained current except for the errors in input data.

The second computer, Ground Position Computer AN/APA-58, has additional features. A set of counters are provided for destination latitude and longitude. Furthermore, a range and azimuth mark generator based on signals from the difference in latitude and longitude of the present position and destination are provided to a search radar set, such as the AN/APS-42. These cross hairs appear on the radar indicator. If present position is correct the cross hairs will be in coincidence with the position of the radar target representing the destination.

Session 7

Antennas II—Microwave

(Organized by Professional Group on Antennas and Propagation)

Chairman, L. C. Van Atta
(Hughes Aircraft Co., Culver City, Calif.)

7.1. ARRAYS OF FLUSH MOUNTED TRAVELING WAVE ANTENNAS

J. N. Hines, V. H. Rumsey and T. E. Tice
(Ohio State University, Columbus, Ohio)

The object of this paper is to present and discuss the results of an investigation of problems that arise in the design of arrays of tapered-depth traveling-wave slot antennas.

Past experience with arrays of slots shows that the conventional method of array design has sometimes failed to predict the pattern of the array with sufficient accuracy for practical purposes. An absolutely correct but more complicated design technique based on the principle of superposition has been developed and tested.

The results of experimental measurements showing the effect of coupling between adjacent elements are presented and array patterns based on both design procedures are compared.

7.2. TRANSIENT BUILD-UP OF THE ANTENNA PATTERN IN END-FED LINEAR ARRAYS

N. H. Enenstein
(Hughes Aircraft Co., Culver City, Calif.)

In linear antenna arrays that are fed from one end, there is a finite transit time for the wave group traveling from the first radiator to the last radiator of the array. As a result the transient antenna pattern may be distorted from the pattern determined on a continuous-wave basis. If the array is used in a communication system, this distortion becomes appreciable when the reciprocal of the signal bandwidth and the transit time are comparable. If it is used in a radar system, the effect on the pattern is appreciable when the system pulse length and array transit time are comparable. Approaches to the problem in the time and frequency domains are developed in this paper. Examples of the effect on angular discrimination of radar systems due to this phenomena are given.

7.3. A NEW MICROWAVE REFLECTOR

K. S. Kelleher
(Naval Research Laboratory, Washington, D. C.)

A reflecting surface is discussed which is formed by the rotation of an arc of a parabola about a line parallel to the latus rectum. It is shown to be superior to the paraboloidal and spherical reflector for applications where plane motion of feed horn is desired.

Besides the obvious application of this reflector as a scanning antenna, it is shown to be useful as a "beam bender" in a microwave-relay link. Other possible applications include its use in marine radar for reduction in vertical-antenna beamwidth and consequently in transmitted power.

7.4. CROSSTALK IN RADIO RELAY SYSTEMS CAUSED BY FOREGROUND REFLECTIONS

H. W. Evans
(Bell Telephone Laboratories, Inc., New York, N. Y.)

Measurement of 19 horn-lens antennas of the New York-Chicago TD-2 radio relay system indicated that the rms front-to-back ratio was 10 db poorer than that of a prototype antenna previously measured. Radar-type measurements showed these degradations were caused by reflections from trees, buildings and hills, to a degree which had not been anticipated. Geographical studies confirmed the reflecting media. These results set a limit to transmission improvement from higher power and lower noise figure in systems using two-frequency allocations, and raise new limitations on the selection of radio relay repeater sites.

7.5. LOW SIDE LOBES IN PENCIL-BEAM ANTENNAS

E. M. T. Jones
(Stanford Research Institute, Stanford, Calif.)

A theoretical and experimental investigation has been performed on the paraboloid-reflector antenna and the isotropic-dielectric hyperboloid-lens antenna to determine the depth of principal-polarization side lobes and the depth of cross-polarized lobes that can be obtained in practice. The analysis determines the aperture fields of these two aplanatic devices when they are excited at their foci by short electric dipoles, short magnetic dipoles and plane-wave sources. It is found that no cross-polarized aperture fields are obtained for the reflector when it is excited by a plane-wave source, and none are obtained for the lens when it is excited by a short electric dipole. The experimental results show that a reduction of at least 10 db in cross-polarized radiation field of the paraboloid reflector can be obtained when it is excited by a horn, which approximates a plane-wave source, instead of by a Cutler feed, which approximates an array of magnetic dipoles. Principal-plane side lobes of −39 db and cross-polarized lobes of −28 db have been obtained with the hyperboloid-lens antenna.

Session 8
Television II

Chairman, A. V. Loughren
(Hazeltine Electronics Corporation, Little Neck, N. Y.)

8.1. PROBABILITY DISTRIBUTION MEASUREMENTS OF TELEVISION SIGNALS

W. F. Schreiber
(Harvard University, Cambridge, Mass.)

A device was constructed which, in effect, produces two video signals from a picture in a flying-spot scanner, the two signals being derived from points separated an arbitrary amount in any direction. Another device was constructed which displays the joint-amplitude probability density of the two signals as a two-dimensional brightness pattern on a cathode-ray tube. Qualitative effects can be studied by direct observation or photography of this pattern. Quantitative results, which include a computation of the second-order approximation to the entropy of the television signal, have been made by measuring the brightness pattern with a scanning photometer.

8.2. A PRECISION LINE SELECTOR FOR TELEVISION USE

I. C. Abrahams and R. C. Thor
(General Electric Co., Syracuse, N. Y.)

This paper describes the design and operation of a versatile measuring instrument for use in television laboratories and stations. This precision-line selector has numerable useful purposes which are described.

The instrument consists of a precision-phase shifter, operating at ten times the standard television line-repetition frequency, that is, 157.5 kc. This is then divided down to 30 cycles. Hence, variable phase shift or delay is obtained at 30 cycles, having the absolute accuracy and stability of that obtained at 157.5 kc.

By proper use of the phase shifter alone, the instrument may also be used to measure time delays to accuracies of ±0.001 h. In addition, the frequency divider chain has many uses, and descriptions of their application will be given.

8.3. COLORIMETRIC PROPERTIES OF GAMMA-CORRECTED COLOR TELEVISION SYSTEMS

D. C. Livingston
(Sylvania Electric Products Inc., Bayside, N. Y.)

Through the use of a set of system parameters which measure individual properties of a color television system as a function of the chromaticity of the color viewed by the camera, there will be presented analyses of the performance of the NTSC color television system in its present form and in several related forms. Particular attention will be given to color fidelity and adherence to the constant-luminance principle, including susceptibility of the displayed luminance on a color kinescope to spurious signals in the chrominance channel. These analyses will take into account several recently proposed system modifications.

8.4. PHASE MEASUREMENTS AT SUBCARRIER FREQUENCY IN COLOR TELEVISION

A. P. Stern
(General Electric Co., Syracuse, N. Y.)

For reliable adjustment and checking of the transmitter and receiver in the NTSC color television system, the possibility of accurate phase measurements at subcarrier frequency is of primary importance. This paper describes the principles and operation of phase measuring equipment recently built in the electronics laboratory of the electronics division of the General Electric Company.

Very accurate measurements can be obtained by phase shifting at low frequency and heterodyning to subcarrier frequency. The accuracy is essentially limited by instabilities in the equipment. The over-all error is estimated to be less than 1.0°.

Some methods employed in using the instrument to measure subcarrier-phase accuracy of a color signal generator are described.

8.5. A MONITORING SYSTEM FOR NTSC COLOR TELEVISION SIGNALS

C. E. Page
(Hazeltine Corporation, Little Neck, N. Y.)

The advent of the NTSC color television signal on a commercial basis will introduce a new problem in signal monitoring. The normal television monitor which displays signal amplitude versus time provides only a fraction of the information required for checking the chrominance portion of the signal. This paper describes an equipment which displays on a cathode-ray oscilloscope the phasor diagram of the chrominance component of NTSC color television signal. This type of display permits rapid visual checking of the chrominance portion of the signal and is equally suitable for signal monitoring service at the transmitter, studio, or color receiver production line. In addition the visual display greatly facilitates the correct alignment of NTSC encoding equipments.

The equipment consists basically of a pair of quadrature demodulators whose outputs are fed respectively to the horizontal and vertical plates of an oscilloscope. The equipment described in this paper includes refinements which make it largely self-checking and facilitate rapid operation.

Session 9: Symposium
Circuits II—Panel Discussion on Wide-Band Amplifiers

(Organized by Professional Group on Circuit Theory)

Chairman, H. A. Wheeler
(Wheeler Laboratories, Inc., Great Neck, N. Y.)

9.1. CONVENTIONAL WIDE-BAND AMPLIFIERS

W. E. Bradley
(Philco Corporation, Philadelphia, Pa.)

Progress in the design of conventional wide-band amplifiers has continued along three principal lines: (1) Tubes are now available with improved figure of merit, internal shielding and reliability; (2) Using new components, layouts are available combining mechanical ruggedness and reproducibility with clean electrical characteristics; (3) Extensive development and widespread use of complex-frequency plane-design methods has led to high performance and design flexibility combined with circuit simplicity.

9.2. BROAD-BAND FEEDBACK AMPLIFIERS

H. N. Beveridge
(Raytheon Manufacturing Co., Newton, Mass.)

Broad-band video and IF amplifiers using conventional tubes and employing resistive feedback from plate to grid will be considered.

A qualitative analysis of the broad-banding effects of this type of feedback will be presented. The simplest case, a two-tube feedback pair, will be considered first, and the discussion extended to feedback triples, infinite chain, and double tuned. Practical problems in the feedback path due to capacity and effective transit angle will be discussed.

The results of measurements of gain bandwidth product will be presented and compared with other types of amplifiers.

9.3. TRANSISTOR AMPLIFIERS

R. L. Wallace, Jr.
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

Mr. Wallace will discuss some of the properties of transistors which result in limitation of bandwidth and will indicate the order of performance which has been achieved.

9.4. WIDE-BAND DISTRIBUTED AMPLIFIERS

W. G. Tuller and E. H. Bradley
(Melpar, Inc., Alexandria, Va.)

Distributed amplifiers using available multigrid tubes are limited to operation below approximately 400 mc. However, distributed amplifiers containing triode pairs have been developed having a 3-db bandwidth of approximately 1,000 mc. The "paraphase" distributed amplifier, as the new triode circuit is called, utilizes the improved high-frequency characteristics of triodes.

This paper discusses the achievable gain and bandwidth characteristics for both types of amplifier. The limitations encountered in the development of these distributed systems are described and evaluated. The future trend in the development of distributed amplifiers also is considered.

9.5. TRAVELING-WAVE AND RELATED TUBES

L. M. Field
(Stanford University, Stanford, Calif.)

Circuit, electronic, and matching limitations on the wide-band amplifying properties of helix-type tubes in the range of frequencies from 50 mc through the microwave range will be reviewed. Bandwidths of from one to several octaves in this range have been obtained and typical examples and design criteria will be given. Bandwidth and bandtuning of several related types of microwave tubes using other than a helix for wave propagation or nonpropagating structures will also be discussed.

Session 10

Electronic Computers II

(Organized by Professional Group on Electronic Computers)

Chairman, J. R. Weiner
(Eckert-Mauchly Computer Co., Philadelphia, Pa.)

10.1. ANALOG COMPUTING WITH MAGNETIC AMPLIFIERS USING MULTIPHASE AC VOLTAGES

J. E. Richardson
(Hughes Aircraft Co., Culver City, Calif.)

By the use of multiphase-ac voltages, simple methods are explained by which arithmetic operations, such as multiplication and division, are achieved. Also many algebraic and transcendental functions, such as the general second-degree equation and trigonometric, hyperbolic, and exponential functions, are generated. The general problem of two-dimensional co-ordinates is treated with relation to transfer and rotation of co-ordinate axes, as well as the resolution of an arbitrary vector with respect to a selected co-ordinate system. The instrumentation involves two basic computing units which contain no vacuum tubes, being instrumented with magnetic-core components.

10.2. SOME RECENT DEVELOPMENTS IN LOGICAL "OR-AND-OR" PYRAMIDS FOR DIGITAL COMPUTERS

Cornelius Leondes
(Moore School of Electrical Engineering, Philadelphia, Pa.)
and
Morris Rubinoff
(University of Pennsylvania, Philadelphia, Pa.)

This paper first reviews, briefly, the design methods commonly employed in logical "or-and-or" pyramids for digital computers. It then describes some recent developments in the design of these circuits.

The following important advantages are then seen to result from the new design techniques. (1) Fewer Germanium diodes are needed. (2) The largest voltages needed may be reduced by factors of as much as two. (3) The power needed in the pyramid may be reduced as much as one-half or less. As a direct result the sizes of the resistors needed are also reduced. (4) The resulting rise-and-fall times are speeded up by an appreciable factor. (5) The impedance levels at the various inputs to the pyramid go up in some cases by factors of as much as two or more. This makes it possible to drive more circuits with any given pulse power amplifier. (6) The clock pulse power needed to drive any input may be reduced as much as one-half or less. The paper concludes with an illustrative example.

10.3. MAGNETIC CORE SWITCHES AS LOGICAL ELEMENTS IN COMPUTERS

E. A. Sands
(Magnetics Research Co., Chappaqua, N. Y.)

The use of rectangular hysteresis-loop magnetic cores as general purpose logical elements in computers will be discussed. Advantage is taken of the amplitude limiting properties of the magnetic hysteresis loop to make operation of the cores extremely uncritical with respect to variations in input currents and voltages. Several alternative ways of generating logical "or" (mixer) and "and" (gating) functions will be shown. Methods of designing cores to operate at a given speed and into a given load will be pointed out. An all magnetic computer using drums for low-speed storage, magnetic memory elements for high-speed storage, magnetic shift registers for input-output buffer storage, and magnetic core switches for arithmetic and selection units is a realizable possibility.

10.4. MAGNETIC-SHIFT REGISTER USING ONE CORE PER BIT

S. Ruhman, W. D. Woo, and R. D. Kodis
(Raytheon Manufacturing Co., Waltham, Mass.)

Conventional magnetic-shift registers use two cores and two to four diodes per bit, and require two-shift pulse sources displaced in time. A new circuit utilizing a condenser for temporary energy storage between cores permits the use of a single core, and a single diode per binary digit requires only one-shift pulse source, and provides greater stability of operation. The principle of operation is described, an approximate analysis of the circuit is given, and experimental results are presented.

10.5. A SIMPLE COMPUTER FOR AUTOMATICALLY PLOTTING CORRELATION FUNCTIONS

A. H. Schooley
(Naval Research Laboratory, Washington, D. C.)

A simple analog computer is described which has proved useful as a research tool in evaluating the autocorrelation and cross-correlation functions of various analytical and experimental time functions. The input functions to be correlated are fed into the computer as two loops made from 35-mm. motion-picture film. Provision is made for automatically varying the delay of one loop with respect to the other. The output correlation function is automatically plotted on a commercial paper recorder. Correlation functions for several analytical and experimental functions are given.

Session 11: Symposium

Instrumentation—Transistor Measurements

(Organized by Professional Group on Instrumentation)

Chairman, G. M. Rose, Jr.
(Radio Corporation of America, Harrison, N. J.)

11.1. TRANSISTOR METROLOGY

D. A. Alsberg
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

Existing transistor test methods, conditions, accuracies, and apparatus will be reviewed. These will be evaluated in terms of the needs of the transistor measurement clientele. Principles will be indicated which may lead to the reduction of the present great variety of methods and apparatus, by stressing absolute measurement and those parameters and methods which best satisfy the practical needs of the vast majority.

11.2. MEASUREMENT OF TRANSISTOR PARAMETERS BY CRO AND OTHER METHODS

W. E. Morrow, Jr.
(Massachusetts Institute of Technology, Cambridge, Mass.)

Equipment has been designed for the presentation of large signal transistor characteristics. The collector (Z_{22}) and base (Z_{12}) characteristics are automatically plotted on the face of a cathode-ray oscilloscope. A device for the measurement of the small signal parameters has also been completed. The device measures a, $1-a$, r_c, r_b, and r_e directly on a meter. The equipment has been designed to operate with both point-contact and junction transistors.

11.3. TRANSISTOR STATIC CHARACTERISTICS OBTAINED BY PULSE TECHNIQUES

D. R. Fewer
(Bell Telephone Laboratories, Inc. Murray Hill, N. J.)

It is desirable to know the static characteristics of transistors in the region where electrode dissipations exceed safe values. These characteristics are impossible to obtain by direct-current methods without damage to the transistor. Under these conditions it is necessary to employ pulse methods in which the transistor passes current for short intervals of such duration and recurrence rate that the unit is not damaged.

Point contact transistors have been examined by pulse methods in regions greatly in excess of rated dissipations. The static characteristics in these regions are discussed and the effects of various pulse shapes and widths are examined.

11.4. BRIDGES FOR MEASURING JUNCTION TRANSISTOR ADMITTANCE PARAMETERS

L. J. Giacoletto
(RCA Laboratories, Princeton, N. J.)

The small signal operation of a transistor is accurately specified by means of our complex parameters having both a real and reactive component. Therefore, eight quantities must be measured, and since these quantities in a fixed environment are potentially a function of operating voltage, current, and frequency, the measurement equipment must have considerable flexibility. This talk will consider in detail the design, construction, and operation of special equipments operating on the bridge principle for measuring admittance parameters of junction transistors. These bridge equipments operate in the frequency range of approximately 1 kc to 1 mc, although by suitable modifications, the operating frequency range can be extended.

An important feature of the operation of these bridge equipments is the use of a multifrequency-test signal such as a square wave, pulse, or swept-frequency-test signal. With this mode of operation, multi-element equivalent-circuit representations can be obtained which are valid over a wide range of frequencies so that a relatively complex measurement task is considerably simplified.

11.5. A TRANSISTOR ALPHA SWEEPER

H. G. Follingstad
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

A new measuring tool has been designed for exploring the alpha variation of transistors with emitter current. The new instrument, which displays the alpha-versus-emitter current characteristic on an oscilloscope, has an alpha measuring range of 0 to 100, and an emitter current range of 0 to 10,000 μa in both polarities. By varying the collector voltage in discrete steps, complete families of characteristics can be photographically recorded. When utilizing the resolution obtainable from a commercial oscilloscope the measurement accuracy is ± 5 per cent.

11.6. RAPID TRACING OF TRANSISTOR CHARACTERISTICS BY OSCILLOGRAPHIC METHODS

Vernon Mathis and J. S. Schaffner
(General Electric Co., Syracuse, N. Y.)

An instrument is described that permits a rapid evaluation of junction transistors. It will give the peak-inverse voltage and approximate values for "a," r_e, and I_{co} as a function of collector voltage and hence permit selection of a desirable operating point.

Session 12
Significant Trends in Airborne Equipment

(Organized by Professional Group on Airborne Electronics)

Chairman, J. A. Marsh
(North American Aviation, Inc., Downey, Calif.)

12.1. SOME SYSTEMS CONSIDERATIONS IN FLIGHT CONTROL SERVOMECHANISM DESIGN

R. J. Bibbero and R. Grandgent
(Republic Aviation Corporation, New York, N. Y.)

Flight control servomechanisms are defined as the power amplifying link between the steering intelligence and the stabilizing or directional aerodynamic controls. To overcome aerodynamic forces, hydraulic, pneumatic, or electrical machines must be coupled to the stabilizing and sensing electronics. The electronics engineer engaged in autopilot design must have knowledge of the aircraft transfer function (that is, its aerodynamic parameters under a given set of flight conditions), together with the transfer functions of the mechanical elements of the servo to produce an optimum systems design. This paper considers the specification of servo requirements through steering-loop analysis, the control-power requirements, linearization of hydraulic elements, and approaches to servosystems synthesis.

12.2. FAIRED-IN ADF ANTENNAS

L. E. Raburn
(Electronics Research, Inc., Evansville, Ind.)

A preliminary study was made of the ADF bearing errors encountered at different locations along the center line of an SNB-2 and an R4D aircraft. It was found that the bearing errors were greater, and the dispersal of the individual error curves with frequency became greater as the loop was moved farther back from the nose of the aircraft. When an installation was made in the top of the SNB-2, a form of electrical compensation was discovered which employs inductive loops. Optimum-inductor compensation was obtained at a single frequency by adjusting the size and location of the inductor elements.

A novel ring-type sense antenna was evolved which can be adapted for many flush installations. It is as effective as the conventional sense stubs and plates, is light in weight, and can be installed in the same opening necessary for the flush-mounted loop without interfering with the loop.

The results show that it is not necessary to sacrifice electrical performance by any appreciable amount to achieve a zero-drag installation in the case of (top, nose, or belly) locations near the center line of the aircraft. In some cases, however, it is necessary to employ electrical compensation. Furthermore, it may not always be possible to achieve good sense-antenna performance at a nose location unless the sense antenna can be placed a sufficient distance above or below the electrical field neutral plane of the aircraft to prevent phase reversals.

12.3. MAGNETIC AMPLIFIERS FOR AIRBORNE APPLICATIONS

J. K. McKendry
(General Precision Laboratory, Inc., Pleasantville, N. Y.)

In the present state of magnetic-amplifier development one of the most attractive applications is in the output stages of instrument servo-amplifiers, particularly for use in airborne equipments. This paper discusses two such applications, a position servo and a rate servo, with particular attention to the influence of the magnetic-amplifier characteristics on the obtainable performance.

The possibilities of improvement in magnetic-servo-amplifier performance by utilization of more recent magnetic-amplifier developments are considered, together with some of the principal problems foreseeable.

12.4. AIRCRAFT ELECTRICAL POWER

J. C. Dieffenderfer and G. W. Sherman
(Wright Air Development Center, Dayton, Ohio)

Complex aircraft electrical and electronic systems demand that an engineer associated with either system have a working knowledge of the other if the over-all weapons system is to perform its mission effectively. No longer can the electrical power engineer assume that his job is completed when he simply energizes the airplane bus, nor can the electronic engineer assume that he need only to connect the equipment to the bus for satisfactory operation. The power generation and control system in military aircraft is not an infinite source of power nor is it practical to provide the power to classical textbook limits on voltage and frequency regulation, waveform, or harmonic content. It is possible, however, that a fully integrated electrical and electronic system permitting optimum operation of electronic equipment and without unduly compromising either system may be realized if the electronic and electrical engineers approach their problems from the broad-systems concept.

12.5. THE EFFECTS OF ELECTRONIC EQUIPMENT STANDARDIZATION ON AIRCRAFT PERFORMANCE

G. C. Sumner
(Consolidated Vultee Aircraft Corporation, Ft. Worth, Tex.)

The increasing amount of airborne-electronic equipment on modern aircraft and increasing performance requirements on the aircraft make it mandatory that the aircraft performance cost of carrying electronic equipment be minimized. This seems inconsistent with electronic equipment standardization. Present concepts of standardization regarding environmental conditioning are examined. It is shown that if conditioning is provided as a part of the particular airframe rather than as an integral part of the equipment, greater efficiency can be obtained. In this way equipments can be standardized and performance cost to the aircraft be reduced to a minimum.

Session 13

Antennas III—Propagation

(Organized by Professional Group on Antennas and Propagation)

Chairman, Newbern Smith
(National Bureau of Standards, Washington, D. C.)

13.1. NOTES ON PROPAGATION

L. A. Byam, Jr.
(Western Union Telegraph Co., New York, N. Y.)

A summary is given of results obtained from a microwave propagation experiment involving an overland path 42 miles long. A cw type magnetron, operated at 4,000 mc and 10 watts output power, was used. Spaced diversity reception was employed. As a much higher carrier-to-noise ratio was obtained, compared with an earlier similar test, fades of greater depth were recorded. Results are depicted graphically by distribution curves and graphs, followed by a brief discussion of diversity action. These results generally support and also supplement to some extent information contained in an earlier paper.

13.2. TROPOSPHERIC PROPAGATION IN HORIZONTALLY STRATIFIED MEDIA OVER ROUGH TERRAIN

H. M. Swarm, R. N. Ghose, and G. H. Keitel
(University of Washington, Seattle, Wash.)

Rough terrain along the propagation path introduces considerable difficulty in computing the field intensity at the diffraction zone for vhf and uhf waves. In this paper, the probable field intensities in the diffraction zone are calculated for various types of atmospheric structures. The fields are calculated from a solution of the Hertzian-vector wave equation with suitable boundary conditions to account for the rough terrain along the propagation path. Numerical computations are made to study the effect of different types of atmospheric structures for various transmitter heights and distances.

13.3. RADIO WAVE SCATTERING IN TROPOSPHERIC PROPAGATION

J. W. Herbstreit, K. A. Norton, P. L. Rice, and G. E. Schafer
(National Bureau of Standards, Boulder, Colo.)

The scattering theory of Booker and Gordon has been developed, assuming the correlation function $C(r)=C(O)\exp(-r/l)$, so as to be suitable for easy numerical calculation of the transmission loss expected with this mode of transmission; $C(O)$ denotes the variance with time of the refractive index of the atmosphere and l denotes the scale of turbulence. In this development the parameter, $[C(O)/l]$, emerges as a direct measure of the radio-wave power transmitted by this mode of propagation. Assuming our theory to be valid, the use of extensive radio transmission-loss measurements on 100 mc for transmission paths throughout the United States yields an estimate of the variation of $[C(O)/l]$ as a function of height above the surface of the earth. This estimate is found to be in qualitative agreement with the rather meager meteorological data which are now available for estimating this parameter. The validity of the scattering theory is further established by using it, in conjunction with an extrapolation of our radio estimate of $[C(O)/l]$, to predict the transmission loss to be expected on the transmission paths involved in the National Bureau of Standards' Cheyenne Mountain experiment which cover the transmitting antenna-height range from 30 to 7,800 feet, distance range 223 to 628 miles, and frequency range 100–1,046 mc.

The results obtained in this paper apparently provide a useful means for explaining and extrapolating the results of tropospheric-propagation transmission-loss measurements, in particular their dependence on distance, antenna height, antenna gain (the theory predicts a loss of free-space gain at large distances), and radio frequency.

It is believed that the component of signal power received via the scattered mode of transmission is the principal component at large distances beyond the horizon and is responsible for the short-period fading observed in tropospheric propagation at all distances.

13.4. EXTENDED-RANGE RADIO TRANSMISSION BY OBLIQUE REFLECTION FROM METEORIC IONIZATION

O. G. Villard, Jr., A. M. Peterson, L. A. Manning and V. R. Eshleman
(Stanford University, Stanford, Calif.)

It has been found that radio communication between relatively low-power stations operating at 14 mc and separated by distances of roughly 1,200 km may be maintained at times when no layer transmission to any point on the earth's surface can be demonstrated to be present. The signal obtained is subject to considerable fading, but some signal is nearly always detectable. The contribution of overlapping oblique-incidence meteor reflections to the observed signal is considered in the light of some preliminary theoretical and experimental findings. It is clearly important to assess the meteoric contribution with care, since the possibility that meteoric reflections alone could account for the signal does not seem unreasonable. Suggestions for further investigation are given.

13.5. AN INTERPRETATION OF VERTICAL INCIDENCE EQUIVALENT IGHT VERSUS TIME RECORDINGS ON 150 KC

Rune Lindquist
(Pennsylvania State College, State College, Pa.)

Results of virtual height versus time vertical-incidence pulse recordings, obtained on 150 kc, are presented and discussed. Monthly median values of the reflection heights are shown in a series of graphs. The coupling echo, predicted by current-wave theory, is definitely shown to exist. The results of measurements during undisturbed and disturbed days are discussed. It is concluded that one form of echo regularly noticed during magnetically disturbed nights must be due to one type of sporadic *E*. Recorded group and phase heights are compared and the differences checked against those predicted theoretically. Finally, the results are given of a preliminary investigation of the effects of solar flares.

Session 14: Symposium

Diagnostic Programs and Marginal Checking for Large Scale Digital Computers

(Organized by Professional Group on Electronic Computers)

Chairman, Nathaniel Rochester
(IBM Corporation, Poughkeepsie, N. Y.)

14.1. DIAGNOSTIC PROGRAMS AND MARGINAL CHECKING IN THE WHIRLWIND I COMPUTER

N. L. Daggett and E. S. Rich
(Massachusetts Institute of Technology, Cambridge, Mass.)

In the Whirlwind I computer, constructed at MIT under Office of Naval Research sponsorship and presently operated under Joint Services support, it has been found that marginal checking vastly reduces the machine failure rate. A series of test programs each of which thoroughly exercises a different section of the machine is used in the marginal checking procedure. Marginal checking cannot prevent intermittent and total failures caused by shorts and opens. These are isolated by methods combining built-in checking features, diagnostic

programming, signal tracing, and operator experience and ingenuity. These methods are greatly facilitated by a special program control which allows a periodically repeated test program to be stopped at an arbitrary point to study indicator lights and signal waveforms.

14.2. RELIABILITY AND DIAGNOSTIC PROGRAM TECHNIQUES FOR THE IBM TYPE 701 EDPM

L. R. Walters

(IBM Corporation, Poughkeepsie, N. Y.)

Reliability of a complex machine is attained by replacing components before they wear out. A calculator, such as the 701, executing diagnostic programs under nonstandard supply-voltage conditions is capable of aiding the engineer in this preventive maintenance.

A large-scale calculator can perform a diagnosis on itself faster and more thoroughly than the most capable engineer. Diagnostic programs replace expensive test equipment and provide greater versatility.

High-speed printing is the method by which results of a diagnosis are presented to the engineer. By this means, data can be compiled concerning even highly intermittent failures.

A severe spill test for the 701's electrostatic memory is given as an example of diagnostic programming in current use.

14.3. DIAGNOSIS AND PREDICTION OF MALFUNCTIONS IN THE COMPUTING MACHINE AT THE INSTITUTE FOR ADVANCED STUDY

G. Estrin

(Institute for Advanced Study, Princeton, N. J.)

The original design of the Institute machine sought to minimize the need for diagnosis of malfunctions and to permit variation of parameters common to the group of elements taking part in any parallel machine operation.

A routine maintenance program uses limit test techniques to observe the execution of basic machine processes and to predict malfunction of machine elements.

In the event of malfunction a set of diagnostic codes carry out much of the logical partitioning necessary to the discovery of a single faulty element.

Experiences during a year of operation will be evaluated and other possible means of increasing error-free running time of this type of machine will be projected.

14.4. CHECKING CIRCUITS AND DIAGNOSTIC ROUTINES

J. P. Eckert, Jr.

(Remington Rand, Inc., Philadelphia, Pa.)

The design of the UNIVAC System is based upon the use of checking circuits as a means for minimizing the need for diagnostic routines. In a complex system such as UNIVAC the principal requirement of trouble-shooting is to isolate the offending elements. Coupled with the very-high speeds of operation, an error producing element can in a matter of split seconds propagate an error throughout a major part of the computer unless error or checking circuits, operating in synchronism with the internal computing operations, can detect the erroneous operation during the cycle in which it occurs and stop further operation.

UNIVAC operation depends primarily upon checking circuits but also uses two principal programmed routines for checking purposes. One of these routines causes the computer to perform nearly every available operation while the other routine primarily tests the correct operation of the input-output system, each by means of programmed comparisons. However, in each case dependence is placed upon the checking circuits to help isolate faulty elements during the performance of the routines if they should occur.

Finally, routine scheduled engineering maintained procedures are regulated so as to minimize the unscheduled maintenance time. Although diagnostic routines may eliminate the cost of built-in checking circuits, computer time today and for some years to come is of sufficient value that time spent performing diagnostic routines may in the long run cost as much as, or more than, the checking circuits would have cost.

14.5. EXPERIENCE WITH MARGINAL CHECKING AND AUTOMATIC ROUTINING OF THE EDSAC

M. V. Wilkes

(University of Cambridge, Cambridge, England)

The paper will describe a system of marginal checking depending on the use of pulse attenuators which has been fitted to the Edsac, and also a routining device which puts the machine through a prescribed series of tests automatically. An account will be given of the experience which has been obtained up to date, and of the tentative conclusions which have been drawn about the principles on which marginal checking should be applied to an existing machine and to a new machine.

Session 15

Circuits III—Time Domain Networks—Delay Lines

(Organized by Professional Group on Circuit Theory)

Chairman, J. G. Brainerd

(Moore School of Electrical Engineering, Philadelphia, Pa.)

15.1. CONTINUOUSLY VARIABLE DELAY LINE

Carl Berkley

(Allen B. DuMont Laboratories, Inc., Clifton, N. J.)

A need exists for a continuously-variable method of delaying pulses or signals while still retaining their waveshapes. This has been previously accomplished with tapped delay lines with sliding contactors. These suffer from the usual deficiencies of sliding contacts and the discontinuities due to commutation. A method is proposed and will be demonstrated which uses a continuously wound delay line similar to standard lines but with a magnetic core intended to increase the delay per unit length. Saturation of a portion of the core with an external magnetic field changes the characteristic impedance in the saturated region and results in reflections or changes in delay which can be continuously adjusted either mechanically or electrically. The specialized requirements for the core material are considered and a number of possible applications described, including: (1) a linear delay, (2) an oscillator with linear-frequency calibration, (3) doppler-effect-pulse stretcher, (4) pt modulation, (5) transient synthesizer.

15.2. GENERAL TRANSMISSION THEORY OF DISTRIBUTED HELICAL DELAY LINES WITH BRIDGING CAPACITANCE

M. J. Di Toro

(Allen B. DuMont Laboratories, Inc., Passaic, N. J.)

Helical delay lines are dispersive transmission systems because their group velocity of propagation increases with increasing frequency. The use of bridging capacitance to reduce this dispersion is known, but no general analysis has been presented previously for distributed (that is, nonlumped) lines. This paper derives the general equations for the propagation constant and the impedance of such distributed helical delay lines with bridging capacitance. The problem requires the solution of integral equations, which is effected using Fourier transforms. The general conditions for linear phase propagation are derived, and design data are given for the bridging capacitance geometry, along with other delay-line parameters as delay, usable bandwidth, length, diameter, and the line's impulse response overshoot or echo

15.3. DISTRIBUTED CONSTANT DELAY LINES WITH CHARACTERISTIC IMPEDANCES HIGHER THAN 5000 OHMS

W. S. Carley

(Naval Ordnance Laboratory, Silver Spring, Md.)

Artificial delay lines with characteristic impedances of greater than 5,000 ohms have been developed for use with fractional microsecond pulses. These lines have delays greater than 0.35 μs per axial inch. The attenuation of a 1 μs pulse may be as low as 0.3 db/μs of delay. Comparison of rise times, attenuations, time delays, and characteristic impedances for various formex insulated wire sizes will be given. A comparison will be made between lines wound with A.W.G. #46 formex insulated wire and teflon insulated wire. Photographs of the pulse response of these lines to 0.2, 0.3, 0.5, and 1 μs will be shown.

15.4. HELICAL WINDING EXPONENTIAL-LINE PULSE TRANSFORMERS FOR MILLIMICROSECOND SERVICE

J. Kukel and E. M. Williams

(Carnegie Institute of Technology, Pittsburgh, Pa.)

The slow-wave transmission structure comprising a helical inside winding and shielding outer cylindrical shell has higher impedance level and more compact physical dimensions for a given electrical length than linear transmission-line sections.

Design of millimicrosecond-pulse transformers using helical slow-wave structures is described and illustrated with a typical transformer. This transformer, designed for ten millimicrosecond pulses and suitable for magnetron pulsing service has a physical length 8 per cent of that required with earlier linear types. Methods of calculating performance are described in detail.

15.5. TIME DOMAIN APPROXIMATION BY USE OF PADÉ APPROXIMANTS

R. D. Teasdale
(Radio Corporation of America, Camden, N. J.)

It is often desired to approximate a complicated transfer function as a ratio of rational polynomials in such a way that the original function can be physically realized with a network of lumped elements by Brune's method or otherwise. It is further desired that the approximation be effected in such a way that the error in the time domain is small and predictable.

Such a desired method of approximation was first developed by Padé and has since been extended by others. It is a useful feature of Padé's method that one can specify in advance the relative degree of the numerator and denominator of the rational fraction which is the approximant.

In this paper the basic theory is presented and is then used to develop successive Padé approximants for several functions useful in network theory, such as e^x and $J_1(x)/x$. The results are summarized in tables, and the accuracy of approximation is illustrated by plots. The corresponding error in the time domain is computed.

The necessity for further work is emphasized.

15.6. FREQUENCY TRANSIENTS IN IDEALIZED LINEAR SYSTEMS

Ben Gold
(Hughes Aircraft Co., Culver City, Calif.)

The work of Salinger on FM transients is extended by considering (a) more complex networks, (b) more complicated modulation wave forms. A general technique is presented for finding the response of more complicated networks when the response to the simple rectangular filter is known. This method is applied to problems involving frequency transients. Response to a frequency pulse is also examined and the effect of the nonlinear element (the limiter) on resulting transient response discussed.

Session 16

Electron Devices I—Transistors

(Organized by Professional Group on Electron Devices)

Chairman, H. L. Owens
(Evans Signal Laboratories, Belmar, N. J.)

16.1. THE NEGATIVE RESISTANCE DIODE

I. A. Lesk and V. P. Mathis
(General Electric Co., Syracuse, N. Y.)

By properly biasing a *p-n* junction, a large negative-resistance region may be made to appear in the $V-I$ characteristic of the junction. This negative-resistance characteristic may be utilized in various oscillator and multivibrator circuits. A sawtooth oscillator circuit using the device is presented, also calculations of frequency and linearity. Linearity of the sawtooth waveform over a large percentage of the operating cycle suggests linear sweep applications.

16.2. RELIABILITY OF CURRENT TRANSISTORS

R. M. Ryder and W. R. Sittner
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

Under ordinary conditions of operation, transistors encased in protective waxes and plastics will give long service. However, under conditions of combined high temperature and humidity or under some types of shelf aging there may be deterioration. Recent test results will be described.

16.3. CHARACTERISTICS OF M-1768 TRANSISTOR

L. B. Valdes
(Bell Telephone Laboratories, Inc. , Murray Hill, N. J.)

Intended for economical operation in remote service, the M-1768 is a point-contact transistor which attains about 30 per cent efficiency at 6 volts with only 30 mw input, with some sacrifice in frequency response. Its properties are described in some detail.

16.4. A DEVELOPMENTAL GERMANIUM *N-P-N* ALLOY-JUNCTION TRANSISTOR

D. A. Jenny
(RCA Laboratories Division, Princeton, N. J.)

The problems encountered in the development of a germanium *n-p-n* alloy-junction transistor are discussed and the results are compared with a *p-n-p* alloy-junction transistor. The most serious problem arises from the differential expansion strains between the donor impurity element and the germanium which are introduced during the cooling and solidification process due to the relatively high melting points and the lack of ductility of many bulk impurity elements. One method of overcoming these strains is to use a ductile low melting point alloy containing the impurity element as one component. This technique has been used to produce transistors with essentially planar junctions with power gains of over 50 db and "alpha" over 0.999. High "alpha" is maintained up to very high current densities, which is at least partially due to the parallelism of the junctions.

16.5. BEHAVIOR OF GERMANIUM JUNCTION TRANSISTORS AT ELEVATED TEMPERATURE AND POWER TRANSISTOR DESIGN

L. D. Armstrong
(Radio Corporation of America, Princeton, N. J.)

The behavior of germanium junction transistors at elevated temperatures is examined with regard to the performance of low-power devices in high-ambient temperatures and the capabilities of power transistors with various means of cooling. In the case of low-power devices, values of various prameters of developmental germanium junction transistors are given as a function of ambient temperature. In the case of power transistors, the design and operation characteristics of laboratory units capable of several watts dissipation are described.

Session 17

Instrumentation III—Electronics

(Organized by Professional Group on on Instrumentation)

Chairman, I. G. Easton
(General Radio Co., Cambridge, Mass.)

17.1. THE RESPONSE OF A PANORAMIC RECEIVER TO CW AND PULSE SIGNALS

H. W. Batten, R. A. Jorgensen, A. B. Macnee, and W. W. Peterson
(University of Michigan, Ann Arbor, Mich.)

The results of an analysis of the response of a panoramic receiver to cw and pulse signals are given. The receiver's response is studied quantitatively as a function of the parameters: signal pulse length and frequency, receiver bandwidth, sweep rate, and type of IF amplifier. The effect of these parameters on the relative output amplitude, output pulse width, and apparent bandwidth is emphasized. Two specific cases are considered. Theoretically the response of a receiver with a Gaussian-shaped IF passband to pulses having Gaussian envelopes is derived. This answer is given in closed form. The response of a receiver with a single-tuned IF amplifier to pulses having rectangular envelopes has been studied with an electronic differential analyzer. The agreement between these two cases justifies application of the Gaussian case to most practical design problems.

17.2. A VHF IMPEDANCE METER

J. H. Mennie
(Boonton Radio Corporation, Boonton, N. J.)

A self-contained impedance measuring instrument that operates from 0.5 to 250 mc will be described. The wide-frequency range is the result of a recent development that greatly simplifies the problem of connecting oscillator and detector to the corners of a bridge network. The application of this principle to a Schering Bridge has resulted in a wide range instrument that will measure resistance directly from 15 ohms to 100,000 ohms over its entire frequency range. Equivalent parallel reactance or susceptance is measured in micro-microfarads by a capacitance substitution method. Special techniques enable low inductance values to be measured directly with a readability of 0.0001 μh.

17.3. SIMPLIFIED MEASUREMENT OF INCREMENTAL PULSE TIME JITTER

W. T. Pope
(Griffiss Air Force Base, Rome, N. Y.)

A method of measuring incremental time jitter such as may be introduced on a train of pulses passing through a stage or a series of stages is described. A measurement of this type may be required for testing of modulators and other equipment using hydrogen thyratrons. Measurement of incremental jitter to 0.001 μs is shown to be practical. The measurement is made by observing a cathode-ray oscilloscope screen. Excessive sweep speeds or unusually wide-band video circuits are not required. The circuits used are described and some of the difficulties encountered are discussed. Typical measurements are also tabulated.

17.4. WIDE-BAND WAVE ANALYZER

O. Kummer
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

This paper describes a wave analyzer covering the frequency range of 100 kc to 20 mc. The analyzer indicates directly, the level of any signal in the range −130 dbm to +30 dbm, and the frequency of the signal with an accuracy of +2 kc. The analyzer is flat over the entire spectrum to within +0.5 db. The effective bandwidth is constant at 2 kc. Measurements in the presence of other signals as much as 80 db higher than the desired signal do not produce detectable errors in the measurement.

17.5. ULTRA-LOW-FREQUENCY, THREE-PHASE OSCILLATOR

Gilbert Smiley
(General Radio Co., Cambridge, Mass.)

This paper describes the development of a resistance-capacity oscillator using "Miller effect" multiplication of capacity values to achieve very-low frequencies with practical values of capacitors and resistance. Because three resistance-capacity networks are used to secure a one hundred-eighty degree phase shift, each network is assigned its own "Miller effect" amplifier, which, in practice, results in a three-phase network, wye connected to the power supply. This, in turn, results in an oscillator that is relatively independent of disturbances in the common neutral supply. Furthermore, the three-phase output furnishes, by suitable connections, a source voltage adjustable as to phase and magnitude, independent of frequency. The theory by which unwanted residuals are exactly offset over a wide operating range is also expounded.

Session 18: Symposium

Trends in Mobile Communications

(Organized by Professional Group on Vehicular Communications)

Chairman, A. B. Buchanan
(Detroit Edison Co., Detroit, Mich.)

18.1. THE EFFECTS OF SELECTIVITY, SENSITIVITY, AND LINEARITY IN RADIO CIRCUITS ON COMMUNICATIONS RELIABILITY AND COVERAGE

J. G. Schermerhorn
(Rome Air Development Center, Rome, N. Y.)

A general representation of the multi-frequency, mobile receiver and transmitter-broadcast coverage problem common to civilian and military applications is given, and the communications reliability and coverage is estimated from the isolation to interference obtainable with various radio circuit designs. The selectivity, linearity, and sensitivity of receiver RF circuits are examined in particular, and an analysis demonstrates the effects of such equipment design parameters on interference isolation. Charts of useable service areas provide a physical picture of circuit-design results. Design information is furnished that relate the above parameters to recommendations for optimum sensitivity, frequency allocation, and power requirements.

18.2. SINGLE SIDEBAND FOR MOBILE COMMUNICATIONS

Adamant Brown and R. H. Levine
(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

The problems encountered in the use of single-sideband communication in mobile installations where size, weight, and simplicity of operation are of prime importance are discussed. A review of progress to date towards such operation is made. A comparison is made of the advantages or disadvantages arising in the generation of a single-sideband signal at high level or low level, and at the operating frequency or at a fixed low frequency. Methods of providing suitable automatic-frequency control of the received signal, during push-to-talk operation as necessary in mobile communications, are discussed. Photographs of the spectrum of the single-sideband signal resulting from various systems are shown.

18.3. MAJOR FACTORS IN MOBILE EQUIPMENT DESIGN WITH EMPHASIS ON 460 MC MOBILE EQUIPMENT CHARACTERISTICS

J. F. Byrne and A. A. Macdonald
(Motorola, Inc., Chicago, Ill.)

This paper will review the design considerations pertinent to the development of mobile equipment for operation in the 450–470-mc band. Receiving system requirements will be outlined and the means selected for achieving these requirements will be described. Similarly the evolution of the transmitting component and its specifications will be shown, and finally the complete system performance as a mobile package, operationally consistent with lower-frequency systems will be presented.

18.4. FIELD EXPERIMENTS WITH 450 MC MOBILE SYSTEMS

P. H. Bellingham and J. Q. Montress
(Bell-Mont Communications Service Corporation, Englewood, N. J.)

Information will be presented relative to comparison tests between 150-mc and 450-mc equipment in various cities of different typographical situations along with a description using slides and maps of two existing proven 450-mc mobile systems. Experiences encountered with various antennas available to the authors will also be described.

A brief summary of the maintenance techniques utilized in these new frequencies will be outlined.

Session 19: Symposium

Electronics in Flight

Chairman, C. S. Draper
(Massachusetts Institute of Technology, Cambridge, Mass.)

A discussion by a panel of distinguished authorities.

Session 20

Electron Devices II—Electron Tubes

(Organized by Professional Group on Electron Devices)

Chairman, G. R. Kilgore
(Evans Signal Laboratories, Belmar, N. J.)

20.1. GAS PRESSURE EFFECTS ON IONIZATION PHENOMENA IN HIGH-SPEED HYDROGEN THYRATRONS

W. C. Dean
(Gulf Research and Development Co., Pittsburgh, Pa.)
G. W. Penny and J. B. Woodford, Jr.
(Carnegie Institute of Technology, Pittsburgh, Pa.)

Initiation of conduction and rise of anode current in highly shielded hydrogen thyratrons involve a markedly different process from the ion migration phenomenon occurring in conventional "line of sight" thyratron structures. A simplified ionization model for well-shielded thyratrons is given for analysis of pressure effects on both the trigger delay and the anode-current commutation intervals and an optimum pressure is described. Analytical and experimental results are given.

20.2. LOW NOISE, HOT CATHODE, GAS TUBES

E. O. Johnson, W. M. Webster, and J. B. Zirker
(RCA Laboratories, Princeton, N. J.)

For many purposes, gas tubes are more attractive than vacuum tubes because their much lower tube drop permits high-circuit efficiency. However, gas tubes used in or near sensitive equipment require extensive shielding and filtering because of the noise they generate. Such noise consists of fluctuations in the tube drop during conduction having, frequently, an amplitude of many volts. Different types of noise having different origins and frequency bands have been observed. For example, a low-frequency relaxation oscillation, usually quite incoherent, often occurs which is caused by an instability of the region within which ionization is taking place. At much higher frequencies (50–500 mc), noise has been detected from tubes which have a negative-resistance characteristic. In the neighborhood of 500 kc, still another type of noise has been observed when the tube current approaches half the saturated cathode emission.

20.3. NEW DISPENSER TYPE THERMIONIC CATHODE

R. Levi
(Philips Laboratories, Inc., Irvington-on-Hudson, N. Y.)

In recent years dispenser type cathode known as the "L cathode" was developed in

Holland. Work undertaken at Philips Laboratories, Inc., Irvington, N. Y., for the purpose of improving fabrication techniques has resulted in a variant of the L cathode, which is being called the Philips' "impregnated" cathode. Interest in this new cathode has developed to such a degree that it appears desirable to present details about its structure and some of its inherent advantages.

In the new cathode, the alkaline earth material is dispersed within the pores of the tungsten body thus eliminating the need for a large reservoir cavity. This has resulted in a radical simplification in cathode construction and has made possible fabrication of cathodes of practically any shape and dimension within extremely close tolerance. This has been brought about by a special technique also developed by the author which makes possible the machining of tungsten. Among the advantages of this new cathode derived from the elimination of the large cavity are a more homogeneous temperature distribution across the emitting area, an improved thermal efficiency, and additional heater space which permits the use of larger heaters.

20.4. MULTI OUTPUT BEAM SWITCHING TUBES FOR COMPUTERS AND GENERAL PURPOSE USE

S. Kuchinsky

(Burroughs Adding Machine Co., Philadelphia, Pa.)

The prototype development of two unique tube types has opened up a new field in reliable high-speed switching. One type is a small coaxial "coding tube," using crossed electric and magnetic fields, with ten stable beam positions and four parallel binary coded outputs. The second type is a complementary ribbon-beam cathode-ray "selector tube" with deflection-plate inputs and ten individual outputs. Details of design, construction, and operational characteristics are given. Versatility of these tubes has been experimentally verified as a decimal to binary converter, a high-speed reversible binary counter, a binary adder, and a coding system for PCM. Further designs and applications are predicted.

20.5. AN EQUIVALENCE PRINCIPLE IN HIGH FREQUENCY TUBES

R. Adler

(Zenith Radio Corporation, Chicago, Ill.)

A close analogy exists between beam-deflection tubes and velocity-modulation devices such as klystrons or traveling-wave tubes. For beam-deflection tubes in which an inductive pick-up system is used instead of the usual intercepting anodes, the equivalence is rather complete. Qualitative similarities between the two types of tubes are developed, and quantitative differences, as well as characteristic advantages and disadvantages of each, are discussed and explained in some detail. The analogy permits a transfer of experience between the two fields, and several applications are discussed which may be valuable in the uhf range.

20.6 THE INTERNAL MAGNETIC FOCUS TUBE, ITS THEORY, PERFORMANCE AND APPLICATION

R. B. Gethmann and L. E. Huyler

(General Electric Co., Syracuse, N. Y.)

The "Internal Magnetic Focus Tube" (IMF) is described and its attractive features are pointed out. The basic elements involved, the focus lens structure, and the ion trap are discussed in detail together with the electron optics of the combined unit. The magnetization procedure is described and the performance characteristics of the tube are discussed.

This high quality permanent-magnet focus lens, with trimmer-shunt adjustment, and a preset ion trap combine to provide an unusually attractive picture-focus system for all television sets.

Session 21

Circuits IV—Active Networks-Transistors

(Organized by Professional Group on Circuit Theory)

Chairman, R. F. Shea

(General Electric Co., Syracuse, N. Y.)

21.1. TRANSIENT ANALYSIS OF JUNCTION TRANSISTOR AMPLIFIERS

W. F. Chow and J. J. Suran

(General Electric Co., Syracuse, N. Y.)

In the calculation of transient response problems involving junction transistors it is desirable to use an equivalent circuit that can be handled readily with standard circuit techniques. Transient analysis based upon the diffusion equation gives results which are mathematically unwieldy and which are not explicitly related to the parameters of the low-frequency equivalent circuit.

An approximate equivalent circuit is developed which exhibits both a frequency and transient voltage transform in good agreement with experimental results. The transform of the equivalent circuit is comparatively simple and thus provides a rapid means of calculating transient response of transistor circuits.

21.2. THE GROUNDED-COLLECTOR TRANSISTOR AMPLIFIER AT CARRIER FREQUENCIES

F. R. Stansel

(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

Expressions are derived for input resistance, output resistance, and ratio of input-to-output voltage and current at low frequencies for transmission in both the base-to-emitter and the emitter-to-base directions. These expressions are extended to the carrier-frequency range (up to approximately twice the alpha cutoff frequency) by considering the effect of the variation of alpha with frequency, of collector capacitance and of load capacitance. Experimental evidence is presented which verifies the equations obtained and indicates that the method of computing the effect of frequency may be applied to other transistor circuits.

21.3. SYMMETRICAL PROPERTIES OF TRANSISTORS AND THEIR APPLICATION

G. C. Sziklai

(RCA Laboratories Division, Princeton, N. J.)

There are certain transistor characteristics which are not present in vacuum tubes. Some of these characteristics may be best classified as symmetrical properties. The first kind of symmetry may be found in the complementary characteristics of the *n-p-n* and *p-n-p* junction transistors. Circuits using both kind of transistors in combination provide advantages in efficiency, reduction of components, and other circuit simplifications.

A second kind of symmetry is displayed by specially-constructed single units in which the emitter and collector may be interchanged. This symmetry permits a current flow of either direction controlled alike by the base current. This basic property is useful in switching circuits for clamping, phase and frequency comparison, modulation, etc. A high-efficiency deflection-current circuit for television was developed using this principle.

21.4. A STUDY OF TRANSISTOR CIRCUITS FOR TELEVISION

G. C. Sziklai, R. D. Lohman, and G. B. Herzog

(RCA Laboratories Division, Princeton, N. J.)

A study was made to cover the various portions of a television receiver to explore the possibility of using transistors. The paper will be presented in two parts: Part 1—the signal channel and Part 2—the scanning channel.

21.5. CONDUCTANCE CURVE DESIGN OF RELAXATION CIRCUITS

K. A. Pullen

(Ballistic Research Labs., Aberdeen Proving Ground, Md.)

Design of nonlinear repetitive circuits using electron tubes requires data not readily available on static-tube-characteristic curves. A technique for use of the recently developed conductance curves to this design problem has been developed.

The application of the technique to the design of multivibrators and blocking oscillators requires knowledge of the dynamic-loop gain, the plate-voltage swings, the dynamic-tube conductances, and the static-circuit characteristics. Determination of the switching time and the initiation bias are considered. The effect of the conductance of the positive grid and the effects of the tube conductances are studied.

Several examples of multivibrator and blocking oscillator designs illustrating use of the method are presented. Experimental confirming data are included. The agreement with the theory is examined.

21.6. TRANSISTOR RELAXATION OSCILLATORS

S. I. Kramer

(Fairchild Guided Missiles Division, Wyandanch, N. Y.)

Several novel relaxation oscillators have been developed using point-contact transistors. One of these generates a rectangular waveform but minus the rather drastic slope of the more conventional version. The other is a triggered- or free-running pulse generator using capacitive feedback which can supply a fast, high-energy, 1-μs pulse with virtually no overshoot. Schematics and waveforms are supplied together with an explanation of the operation and design criteria. Some data on reproducibility is also included.

These circuits provide some of the fundamental building blocks for the transistorization of electronic equipment. Two versions of the rectangular-wave generator have been used. Both of these make use of resistance in series with the timing capacitor. One is a grounded-collector circuit with the output taken from the base and the other uses a collector load to provide two out-of-phase waveforms. The pulse generator provides a 1-μs pulse with a rise and fall time of 0.1 to 0.2 μs. While such a waveform is obtainable with a blocking oscillator, this circuit has the advantage of using only capacitive coupling. Quantitative data for 19 transistors is given.

SESSION 22

Noise and Modulation

(Organized by Professional Group on Information Theory)

Chairman, J. B. WIESNER

(Massachusetts Institute of Technology, Cambridge, Mass.)

22.1. NOISE PROBLEMS OF THEORETICAL AND PRACTICAL INTEREST

G. O. YOUNG AND BERNARD GOLD

(Hughes Aircraft Co., Culver City, Calif.)

The effect of a communications receiver on a signal which has unwanted noise added is a problem which is far from having been completely solved. This paper touches upon some problems of interest, indicates and discusses the solutions to the solved problems, and points out some of the difficulties and suggests possible approaches to the unsolved problems.

The questions dealt with are: (1) functional representations of noise, (2) categorization of noise, (3) noise in linear systems (solved problems), (4) noise in linear systems (unsolved problems), (5) noise transients.

22.2. A NOTE ON RECEIVERS FOR USE IN STUDIES OF SIGNAL STATISTICS

RALPH DEUTSCH AND H. V. HANCE

(Hughes Aircraft Co., Culver City, Calif.)

The characteristics of linear, lin-log, and logarithmic receivers are described and the effect of their transfer response on random signals is obtained. The limited dynamic range of an amplifier system is shown to produce calculable errors in the measurement of signal statistics. Curves have been derived which relate the agc circuits to a predetermined measurement error.

22.3. AMPLITUDE MODULATION BY PLATE MODULATION OF CW MAGNETRONS

J. S. DONAL, JR. AND K. K. N. CHANG

(RCA Laboratories Division, Princeton, N. J.)

Using a plate-modulated cw magnetron, means have been devised for the obtaining of high system efficiency, combined with good performance as regards linearity, depth of modulation, and bandwidth. Magnetron pushing has been studied as a function of modulation frequency and loading. The modulation impedance of the magnetron has been correlated with pushing and envelope amplitude. The performance of phase-locking systems can be predicted if the characteristics of the magnetron are known. Phase locking, used primarily to overcome pushing, may in turn alter the linearity, depth of modulation, and bandwidth of a system.

22.4. COMPARISON OF MODULATION METHODS

R. M. PAGE

(Naval Research Laboratory, Washington D. C.)

The statistical theory of communication is interpreted in familiar radio-engineering terms. Tuller's and Shannon's equations are compared, and reasons are given for choosing Shannon's equation. The information transformer concept is exploited, with input-output relationships expressed in terms of the fundamental information equation, taking into account the relationship between noise and bandwidth. A distinction is made between coding and modulation. Reduction of equivocation by ideal coding and by power margin are compared quantitatively. Using Shannon's definition of an ideal system as a reference standard, a quantitative comparison is made between single- and double-sideband amplitude modulation, standard broadcast frequency modulation, and binary pulse code modulation for moderately high-quality audio, 32-level teletype, and a generalized bilevel function. A summary of the best types of modulation for each of several different conditions of operation is followed by an evaluation of the impact of the statistical approach to communication theory on radio methods of communication. The paper is predominantly tutorial in nature, although significant material is included which has not previously been published.

22.5. A TECHNIQUE OF INTERMODULATION INTERFERENCE DETERMINATION

A. J. BEAUCHAMP

(Rome Air Development Center, Rome, N. Y.)

The increased use of multifrequency communications equipment in both civilian and military applications has aggravated the severity of intermodulation interference between radio circuits. As a result, there is a need for a tool as an aid in the sorting process in determining potential intermodulation-interference products that may result from spurious radiations of transmitters and spurious responses of receivers. This paper describes such a tool that has been developed. Determination of the frequency components of odd-order intermodulation products for any number of frequencies is shown, with particular emphasis placed on third-order products, by a graphical technique that reduces this determination to a mechanical level. A method of quickly determining interference frequencies for any given number of frequencies is also indicated.

SESSION 23: SYMPOSIUM

Television Broadcasting

(Organized by Professional Group on Broadcast Transmission Systems)

Chairman, E. M. JOHNSON

(Mutual Broadcasting Co., New York, N. Y.)

23.1. THE DESIGN OF SPEECH INPUT CONSOLES FOR TELEVISION

R. H. TANNER

(Northern Electric Co., Ltd., Belleville, Canada)

This paper describes two types of TV audio consoles both specifically designed for the particular requirements of the Canadian Radio and TV setup. The first type is intended for large studio installations, and is used in the Montreal and Toronto TV studios of the Canadian Broadcasting Corporation. It possesses certain unique features which facilitate the production of a sound component well matched to the picture.

The second design is suitable for smaller centers, either in its basic form, or with two similar units integrated mechanically and electrically to form a highly flexible, yet compact, double-channel console.

In the interests of standardization, both designs are also eminently suitable for high-grade sound broadcasting use.

23.2. BUILDING TV BROADCAST FACILITIES FOR GROWTH, FLEXIBILITY AND ECONOMY

A. R. KRAMER AND E. R. KRAMER

(Kramer, Winner and Kramer, New York, N. Y.)

A demonstration of the techniques which can be used to insure the organized growth of TV broadcasting stations, utilizing thorough planning and unique structural design.

A basic unit designed for network relay, film, and a minimum of live broadcasting is analyzed and used as a first-stage prototype. Growth is charted with plans and diagrams as the basic units expand to house-production studios, control rooms, offices, public spaces, and related facilities. Building problems encountered at each stage are described and solutions presented.

The planning and construction principles proposed provide not only efficient growth but a construction system flexible enough to allow plan changes and adjustments to new developments other than additions.

Practical construction details necessary to achieve expansion and flexibility with economy are illustrated.

23.3. FASHIONS IN TV TRANSMITTING ANTENNAS

F. G. Kear
(Kear and Kennedy, Washington, D. C.)
and
J. G. Preston
(American Broadcasting Co.,
New York, N. Y.)

23.4. HIGH GAIN AMPLIFIERS FOR HIGH POWER TELEVISION TRANSMITTERS

John Ruston
(Allen B. Du Mont Laboratories, Inc.,
Clifton, N. J.)

It is shown that the availability of suitable high-power tetrode tubes has made possible unusually high-power gain in the final broadband linear amplifier of a high-power vhf television transmitter. For a specific 20-kw tetrode, a power gain exceeding 100 is computed at a power-output level of 30 kw and a bandwidth of 5 mc. Some sacrifices of power gain enables the "lower-sideband reinsertion" inherent in such an amplifier to be reduced enough to permit the inclusion of the vestigial-sideband filter in the low-power driver stage.

A practical application is illustrated by a brief description of a commercial 25-kw low-band amplifier having a power gain of 50.

23.5. OPTIMUM UTILIZATION OF THE RADIO FREQUENCY CHANNEL FOR COLOR TV

R. D. Kell and A. C. Schroeder
(RCA Laboratories, Princeton, N. J.)

To produce a simultaneous television image in color, three communication channels must be available. The first of these may be used to transmit the scene brightness, the second the degree of color saturation, and the third the hue or color. For compatibility the brightness is transmitted as amplitude modulation in the usual way. A subcarrier is introduced to carry the other two pieces of information as amplitude and phase modulations. The optimum loading of these two auxiliary communication channels is the major consideration of this paper.

Session 24

Quality Control Methods Applied to Electron Tube and Electronic Equipment Design

(Organized by Professional Group on Quality Control)

Chairman J. R. Steen
(Sylvania Electric Products Inc.,
New York, N. Y.)

24.1. USE OF STATISTICAL TOLERANCES TO OBTAIN WIDER LIMITS ON TUBE COMPONENT DIMENSIONS

E. V. Space
Radio Corporation of America,
Harrison, N. J.

A statistical quality-control technique is used to determine the tolerances required on tube components in order to maintain plate-current within functionally imposed limits. Production tolerances of the component dimensions are evaluated consistent with the absolute and natural tolerances of the cathode-plate spacing. A comparison of the predicted values of the mean and standard deviation of the cathode-plate spacing with actual data shows close agreement.

24.2. TOLERANCE CONSIDERATIONS IN ELECTRONIC PRODUCT DESIGN

R. C. Miles
(Airborne Instruments Laboratory, Inc.,
Mineola, N. Y.)

Casual selection of electronic-component tolerances may result in a design which is unnecessarily expensive to manufacture or which lacks the necessary reproducible performance. Elementary probability theory can provide a partial solution to the problem since many components have either a rectangular or modified normal distribution. The probability concept can be extended to the problem of cumulative tolerances in such a manner as to improve the quality of electronic-product designs.

24.3. DISTRIBUTION PATTERNS FOR THE ATTRIBUTES OF ELECTRONIC CIRCUITRY

R. F. Rollman and E. D. Karmiol
(Allen B. DuMont Laboratories, Inc.,
East Paterson, N. J.)

This paper presents the findings of extensive studies into the distribution patterns of the major attributes for varied types of electronic circuitry. It is shown that these patterns can be readily computed from data obtained by conventional production measuring techniques on small quantities in the order of fifty units. Very marked correlation was found between parameter tolerances, production techniques, and the distribution patterns. It was concluded that parameter tolerances and production techniques must be given major consideration by the electronics engineers if engineering design efforts are to be successful.

24.4. THE APPLICATION OF STATISTICS TO FIELD SURVEILLANCE OF PRODUCT PERFORMANCE

R. Herd
(Aeronautical Radio Inc., Washington, D. C.)

This paper presents some of the statistical techniques applicable to field surveillance of the performance and operation of any selected product. A planned experiment, utilized by AR Inc. in its surveillance activities to compare tube types, standard tubes versus their improved versions, manufacturers, etc., is described, and methods of analyzing the experiment are investigated. The problems involved in planning an experiment, including the definition of terms, the purpose of the experiment, and field operations are discussed.

24.5. RELIABILITY OF ELECTRON TUBES IN MILITARY APPLICATIONS

E. F. Jahr
(Aeronautical Radio Inc., Washington, D. C.)

This paper is based upon the AR Inc military tube project and discusses electron-tube reliability. Findings are analyzed by tube type, time and nature of failures, and environmental conditions. Specific causes of failures are noted as well as required improvements and expected gains.

The problem of predicting reliability and a suggested approach to this problem are discussed together with an analysis of the present status of electron-tube reliability and a projected goal.

24.6. DYNAMIC ENVIRONMENT TESTING

D. T. Geiser
(Boeing Airplane Co., Wichita, Kan.)

Investigation by analogy showed equipment failure was caused not only by environment, but also by the rate of change of environment. Tests verified the usefulness of this concept as a design tool, thus furnishing a concise method of comparing airplane and equipment in the planning and design stage.

A proposal is advanced for a universal method of component and equipment environment specification. Examples are given of the use of both the experimental and Maxwellian analysis in air frame and missile work.

Session 25: Seminar

Acoustics for the Radio Engineer—I

(Organized by the Professional Group on Audio)

Chairman, J. J. Baruch
(Massachusetts Institute of Technology,
Cambridge, Mass.)

25.1. FUNDAMENTAL THEORY

L. L. Beranek
(Massachusetts Institute of Technology,
Cambridge, Mass.)

25.2. MICROPHONE

H. F. Olson
(Radio Corporation of America,
Princeton, N. J.)

25.3. LOUDSPEAKERS

H. S. Knowles
(Industrial Research Products, Inc.,
Franklin Park, Ill.)

This seminar will present the engineering aspects of the science of acoustics and those fundamental principles which have a direct bearing on acoustical engineering in terms which the Radio Engineer can understand, and which will assist him in his daily work. Leading experts in the field will discuss fundamental theory with emphasis on equivalent electrical circuits, the engineering use of microphones, loudspeakers, and the characteristics which are of importance to their users.

Session 26

Electron Devices III—Microwave Tubes

(Organized by Professional Group on Electron Devices)

Chairman, J. H. Bryant
(Federal Telecommunication Laboratories, Inc., Nutley, N. J.)

26.1. HIGH-POWER TRAVELING-WAVE-TUBE AMPLIFIERS

M. Ettenberg
(Sperry Gyroscope Co., Great Neck, N. Y.)

Recent experimental work has shown that the traveling-wave tube may be used successfully for high-power amplification over a large bandwidth. Efficiency and gain are comparable with good klystron amplifier performance and the bandwidth is inherently much larger. The magnetic focusing and the beam-dissipation requirements are similar in both types.

This paper will present the design and performance parameters of high-power traveling-wave amplifiers. The construction and performance of several experimental tubes both pulsed and cw will be described.

26.2. OPERATION OF THE TRAVELING-WAVE TUBE IN THE DISPERSIVE REGION

L. A. Roberts and S. F. Kaisel
(Stanford University, Stanford, Calif.)

The majority of the published information on the traveling-wave tube has been concerned with operation of the tube as a wide-band amplifier, in a frequency range where the helix is a nondispersive structure. In many applications where very wide bandwidth is not required, the traveling-wave tube amplifier still offers attractive advantages over other types of amplifiers as regards gain, bandwidth, and simplicity of operation. Where great bandwidth is not required, operation in a region where the helix is a dispersive transmission line can be considered. This paper will present a comparison of tube characteristics in the dispersive and nondispersive regions and the effects on gain and bandwidth of this choice. Experimental results will be presented for tubes built for operation in the dispersive region.

26.3. A TRAVELING-WAVE ELECTRON BUNCHER

R. B. Neal
(Stanford University, Stanford, Calif.)

This device supplies axially bunched electrons to the Stanford Mark III linear accelerator. The buncher consists of a disc-loaded circular wave-guide structure, 32 inches long, tapered so that the phase velocity increases from 0.5 to 1 times the velocity of light in its length, while the axial field strength increases 10 times. Electrons, injected at 80 kv, emerge with energies of 4 mev, bunched within 20° in each cycle. Peak currents up to 170 ma are obtained. RF power is supplied by a 10.5-cm, 10-mw klystron amplifier delivering 1.4 μs, pulses at 60 cps.

26.4. SOME PROPERTIES OF PERIODICALLY LOADED STRUCTURES SUITABLE FOR PULSED TRAVELING-WAVE TUBE OPERATION

M. Chodorow and E. J. Nalos
(Stanford University, Stanford, Calif.)

This paper describes some of the factors involved in the selection of structures suitable for high-power pulsed traveling-wave tubes, and the experimental evaluation of their properties, such as bandwidth, gain parameter, and space-harmonic content. The properties of periodically loaded structures can be determined by measurements on a capped-off section comprising only a few periods. From such measurements, the bandwidth, group, and phase velocities can be deduced. By perturbation methods, at a given resonance of such a cavity, the ratio of field strength to energy storage can be made, which is essentially R_{shunt}/Q of this cavity. From bead measurements along the path of the electron beam, the relative spatial dependence of the electric field can be obtained by measuring the variation of cavity resonance as a function of bead position. From this, Pierce's gain parameter for the structure, as well as the space-harmonic components can be determined experimentally. The above experiments bear out the usefulness of lumped-equivalent circuits in predicting qualitative behavior of such structures.

26.5. EXPERIMENTS ON MILLIMETER WAVE AND LIGHT GENERATION

H. Motz, W. Thon, and R. N. Whitehurst
(Stanford University, Stanford, Calif.)

It can be shown that electromagnetic radiation of very short wavelength may be obtained from electron beams accelerated to relativistic velocities passing through suitable magnetic-field configuration. Experiments with electrons passing through arrangement of magnetic fields which we call an *undulator* were carried out at the microwave laboratory at Stanford University. For the first experiments, a 100-mev beam from the Mark III linear accelerator was used to generate visible light. In other experiments a beam of 3-mev electrons, obtained from a small accelerator with good bunching action, was used to generate radiation in a band of about one-millimeter wavelength at a peak power level of approximately one watt.

Session 27

Information Theory I—Recent Advances

(Organized by Professional Group on Information Theory)

Chairman, L. A. De Rosa
(Federal Telecommunications Laboratories, Inc., Nutley, N. J.)

27.1. RECENT ADVANCES IN INFORMATION THEORY

L. A. De Rosa
(Federal Telecommunications Laboratories, Inc.)

27.2. RADAR PROBLEMS AND INFORMATION THEORY

Harry Davis
(Rome Air Development Center, Rome, N. Y.)

A short review of the application of information theory to radar problems, as carried out by North, Van Vleck and Middleton, Woodward, Leifer, and others is presented. A comparison of several methods of detecting radar signals in noise is made, relating these methods to the theoretical analyses and showing similarities in end result. Finally, the use of the foregoing material to a practical designer is outlined, considering the signal-to-noise enhancement and clutter rejection problems.

27.3. ANALYSIS OF MULTIPLEXING AND SIGNAL DETECTION BY FUNCTION THEORY

Nathan Marchand
(Marchand Electronic Laboratories, Greenwich, Conn.)

A general signal, which may be any time-varying function, is analyzed in multidimensional space where instants in time are the co-ordinates. It is shown how it is possible to take any signal in a limited-time interval and obtain a multiplexing set by multidimensional-vector transformation. The properties of the set are discussed and related to the bandwidth and noise. The detection and contamination of any signal in the presence of other signals and noise is shown to depend upon the orthogonality of the functions representing the signals. Linear and the so-called asynchronous multiplexing are shown to be similar and to fall within the same mathematical analysis. Matrix transformations and their use in signal detection are illustrated. Circuit equivalents of function operation for the detection of signals are shown in block diagram form. Correlation analysis is found to be a special case of function-theory analysis. It is shown that analysis by correlation techniques only gives limited results in most practical cases.

27.4. OPTIMUM NONLINEAR FILTERS FOR THE EXTRACTION AND DETECTION OF SIGNALS

L. A. Zadeh
(Columbia University, New York, N. Y.)

A system of classes of nonlinear filters designated as $F_1, F_2, F_3, \cdots$, is considered. The system is such that F_{n-1} is a subclass of F_n, and the class of linear filters is a subclass of F_1. The input-output relationship for a filter in class F_n has the form of an n-fold integral of a function which depends on n-age variables, $\tau_1, \tau_2, \cdots, \tau_n$, and the values of the input at the instants $t-\tau_1, t-\tau_2, \cdots, t-\tau_n$. The optimization (in the least squares sense) of a filter in class F_n requires the knowledge of $2n$th order probability density functions for the signal and noise, and reduces to the solution of a linear integral equation of $2n$th order. The optimization of filters of class F_1 and their realization is considered in detail.

27.5. DETECTION OF INFORMATION BY MOMENTS

J. J. Slade, Jr., S. Fich and D. A. Molony
(Rutgers University, New Brunswick, N. J.)

Theoretical and practical considerations point to the importance of time moments in representing and detecting information. A time-limited function can be represented in terms of Gaussians by the canonical form of the Gram-Charlier series in which the leading term has the same area, mean, and spread as the given function. These three parameters which are determined by the first three time moments can be made to convey information. In practice, any pulse-modulation sequence can also be identified by moments. These moments can be computed by conventional integrators without the use of multipliers. The required circuitry and the effects of network distortion and noise will be discussed.

Session 28

Communications Systems

(Organized by Professional Group on Communications Systems)

Chairman, G. T. Royden

(Mackay Radio and Telegraph Co., New York, N. Y.)

28.1. AUTOMATIC-TUNING COMMUNICATIONS TRANSMITTER

M. C. Dettman

(Federal Telecommunication Laboratories, Nutley, N. J.)

This paper describes a 100/500-watt transmitter that was developed to fill the need for a modern medium- and high-frequency shipboard transmitter. Automatic tuning to any frequency within this frequency range without need for a multiplicity of preset controls is featured. Total tune-up time under normal conditions is about 30 seconds. Facilities for high-speed keying, facsimile, and frequency-shift operation are provided. The equipment also includes facilities for the usual types of emission encountered in this operating-frequency range. Considerable flexibility of installation is provided by the grouping arrangement. The equipment and individual chassis are described.

28.2. DOUBLING TRAFFIC CAPACITY OF SINGLE-SIDEBAND SYSTEMS

C. D. May, Jr.

(Office of the Chief Signal Officer, Washington, D. C.)

Radioteletypewriter service is the primary means of radio communications between the United States and Overseas Army Commands. At the present time single-sideband radio circuits with a capability of six sixty-word per minute teletypewriter circuits are in use. Several of these circuits have reached their traffic capacity due to increased requirements for Overseas Army communications. This necessitated the development of a means of expanding the capacity of these multichannel circuits. The purpose of this paper is to discuss a method used to derive additional traffic channels from the existing single-sideband systems.

The system presently used maintains circuit reliability by transmitting duplicate traffic simultaneously on separate tones to overcome the effects of selective fading. This frequency-division arrangement requires double the bandwidth that is actually required to transmit the traffic. By eliminating the frequency-diversity scheme and developing a space-diversity arrangement the band formerly occupied by the frequency-diversity tone can be used to transmit the traffic from a second set of six-channel terminal equipment.

With the addition of necessary frequency conversion equipment the traffic from the two sets of six-channel terminal equipment can be converted in frequency to permit tones from the normal receiver to be channeled through the normal circuits of the unmodified terminal equipment and the tones from the diversity receiver to be channeled through the diversity circuits of the unmodified terminal equipment. Actual physical and electrical changes to the equipment are minor and can be accomplished on a patch basis with minor modification.

Operational experience on a twelve-channel single-sideband radio circuit indicates that a degree of reliability at least as good as the original six-channel circuit can be expected.

28.3. PERFORMANCE OF SPACE AND FREQUENCY DIVERSITY RECEIVING SYSTEMS

M. Acker and R. E. Lacy

(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

and

J. L. Glaser

(Bell Telephone Laboratories, Inc., New York, N. Y.)

Information is provided concerning the physical installation of antennas for space diversity systems, and the frequency spacing in frequency diversity systems in order to increase the communication performance of a radio system operating in the high-frequency range over ionospheric paths. Means are provided for utilizing most economically the area that may be available for antenna installations. Charts are included from which can be predicted the increase in communication performance that may be achieved through the installation of diversity systems in any particular communication circuit. This information is the result of a joint investigation for over four years by the Signal Corps and Washington University.

28.4. EFFECT OF HITS IN TELEPHOTOGRAPHY

P. Mertz and K. W. Pfleger

(Bell Telephone Laboratories, Inc., New York, N. Y.)

Brief variations in attenuation or gain of communications links known as "hits" may cause objectionable marks in received pictures unless the circuits are engineered to limit hit intensity and duration sufficiently. This study includes judging the objectionableness of about 200 individual hits on a total of 16 positive prints of received pictures by ten observers, and measuring the hit intensities and durations. The paper contains graphs of these two variables for various degrees of picture impairment. A smoothed summary curve indicates tentative limits of hit intensity tolerance as a function of hit duration, for individual hits.

28.5. RELIABILITY OF MILITARY ELECTRONIC EQUIPMENT AND OUR ABILITY TO MAINTAIN IT FOR WAR

A. S. Brown

(Stanford Research Institute, Stanford, Calif.)

This paper discusses the increased emphasis being placed upon improved reliability by all concerned with the development and production of military electronic equipment. The author points out that there has been very little reduction in the number of types and makes of equipment for similar uses. Under the free enterprise system of our country, which we would not want otherwise, we produce as many different makes of television equipments as business finds profitable. For military use the Armed Forces are following a similar pattern with Army, Navy, and Air Force going their separate ways in many cases to come up with individual designs by different manufacturers. Recommendations are made for far-reaching standardization which would increase the feasibility of high-quality, high-speed production, and simplify the maintenance problem.

Session 29: Symposium

Television Broadcasting and UHF

(Organized by Professional Group on Broadcast Transmission Systems)

Chairman, George Sterling

(Federal Communication Commission, Washington, D. C.)

29.1. A FLEXIBLE TV STUDIO INTERCOMMUNICATION SYSTEM

R. D. Chipp and R. F. Bigwood

(DuMont Television Network, New York, N. Y.)

The manifold requirements of a television studio intercommunication system will be discussed, with emphasis on the need for speed of communication and complete flexibility of interconnection between the many locations involved. Various systems used in the past will be described, followed by detailed consideration of a modern system based on the use of "cross-bar" techniques. With this type of equipment, appropriate members of the production and engineering team can select direct circuits to other locations, or can tie various groups together on a common circuit. Interlocks and light signals are incorporated to minimize operational difficulties.

29.2. CBS-TELEVISION'S HOLLYWOOD TELEVISION CITY: VIDEO, AUDIO AND COMMUNICATION FACILITIES

Richard O'Brien, Robert Monroe and Price Fish

(Columbia Broadcasting System, New York, N. Y.)

CBS-Television recently inaugurated television service from its new Hollywood Television City headquarters. Located on a 25-acre site adjacent to the famous Farmer's Market, Television City is constructed from a flexible and expansible master plan that permits ultimate expansion to 24 studio units.

The initial construction phase now completed provides two audience and two nonaudience studios, each exceeding one-fourth acre in area, together with the necessary technical, production, scenery construction, and office facilities to support completely CBS-Hollywood television operations.

This paper describes the philosophy underlying the design of the video, audio, and communication facilities for this project. Emphasis is placed on description of methods and features that are new or novel.

29.3. AN EXPERIMENTAL STUDY OF WAVE PROPAGATION AT 850 MC

JESS EPSTEIN AND D. W. PETERSON
(RCA Laboratories Division, Princeton, N. J.)

In establishing a TV broadcasting station the prediction of the service area is of vital importance. This involves a knowledge of the mechanism of radio propagation which is made exceedingly complex because of its dependence on numerous physical phenomena. In general, this would involve an evaluation of such well-known factors as wave refraction, reflection, diffraction, absorption, and scattering as a function of frequency and time.

This paper offers a study of propagation characteristics at the upper edge of the ultra-high TV band. A further simplification of the problem is made by limiting it to measurements of wave propagation out to distances of 30–40 miles which would be the approximate optical horizon of most transmitting-antenna heights likely to be used. This limitation permits the variation of field strengths with time to be ignored since past experience has shown that this functional dependence is relatively unimportant within the optical horizon.

Theoretical prediction of wave propagation for even highly idealized conditions of the various parameters is difficult and is exceedingly complicated in actual practice by extreme deviations from the idealized form. The ultimate goal of these investigations is to formulate procedures which will permit the prediction of median field strengths throughout typical broadcast service areas. The achievement of such a goal will greatly depend upon the accumulation of experimental data against which the theoretical formulations can be checked.

The purpose of this paper is to describe an experimental project conducted at 850 mc and aimed at obtaining some of this needed information. Since the properties of propagation at these frequencies are related to both the height of the transmitting and receiving antennas, arrangements were made so that these factors could be varied. At the transmitter site, antennas were installed at four different heights on the WOR 760-foot tower. The effective radiated power was obtained by use of high-gain nondirectional antennas with a narrow, vertical, and broad horizontal beam. By employing a narrow elevation beam and making the antennas tiltable it was possible to direct the full effective radiated power at any receiving site. Provisions were also made so that measurements would be along two typical radials, one smooth and the other relatively hilly. The data thus obtained have been analyzed statistically to obtain the trends of the median field strengths, for a variety of typical receiving locations. An effort has been made to separate and measure the losses introduced by houses and trees as compared to that which is attributable to hills. A knowledge of the magnitude of these two effects under known experimental conditions is an essential prerequisite in attempting to formulate a theoretical basis for the calculation of wave propagation for a known topography.

29.4. UHF POWER TUBES IN TV APPLICATIONS

D. H. PREIST
(Eitel-McCullough, Inc., San Bruno, Calif.)

29.5. HIGH-POWER UHF KLYSTRON APPLICATION

A. E. RANKIN
(General Electric Co., Schenectady, N. Y.)

This paper discusses the application of a family of six 15-kw, three-resonator klystrons as radio-frequency amplifiers with particular emphasis on their performance in aural and visual television service in the ultra-high frequency band.

Features, designed with the equipment designer and station operator in mind, and which facilitate handling and installation, are reviewed.

Tube ratings and characteristics are described as they relate to and govern performance.

The effect of stagger tuning the three resonators to obtain the bandwidth response needed for visual television is described.

Equipment design considerations, including power-supply requirements, radio-frequency circuit requirements, and tube-protective devices are discussed.

29.6. HIGH-POWER UHF KLYSTRON AMPLIFIER DESIGN

N. P. HIESTAND
(Varian Associates, San Carlos, Calif.)

Latest developments in the design of multiple-resonator high-power klystron amplifiers that cover the uhf band from 400 to 1,000 mc are described. 15-kw, 3-resonator tubes are now in production which will provide a narrow-band power gain of over 33 db with an efficiency of almost 40 per cent at saturation level. Tunable over an 11 per cent frequency range, these integral cavity tubes provide full-power output over the entire band.

Advanced design work has been completed on a 75-kw, 4-resonator amplifier and progress on this development is described in some detail. Both tubes are particularly suitable for use in uhf television transmitters.

29.7. HIGH-POWER UHF TELEVISION BROADCASTING SYSTEMS

H. M. CROSBY
(General Electric Co., Syracuse, N. Y.)

Up to 300-kw ERP may be obtained in the uhf-television band by using a 12-kw transmitter and a five-bay helical antenna.

The General Electric 12-kw uhf-television transmitter is made up of a complete 100-watt transmitter and separate high-power klystron amplifiers for the visual and aural signals.

The 100-watt transmitter features a frequency-control circuit which effectively locks together the aural and visual carriers with a fixed separation of 4.5 mc. Power amplification is obtained by tetrodes which plug in to cavity-type circuits.

The 12-kw amplifier with its associated rectifier and control equipment is built in four cubicles. The klystron used in this amplifier has many advantages over conventional tubes for power amplification at uhf.

The helical antenna offers high gain per bay, a minimum of feed points, and the possibility of null "fill-in" adjustment in the field.

Operating and propagation tests have now been made at the first two high-power uhf installations.

SESSION 30: SYMPOSIUM

Microwaves I—Manufacture of Microwave Equipment

(Organized by Professional Group on Microwave Theory and Technique)

Chairman, HARALD SCHUTZ
(The Glen L. Martin Co., Baltimore, Md.)

30.1. HOW TO DESIGN MICROWAVE COMPONENTS FOR EASE OF ASSEMBLING

FRANK NEUKIRCH
(NRK Manufacturing and Engineering Co., Chicago, Ill.)

Microwave components have become standardized to a considerable extent. Electrical requirements necessitate manufacturing to a high degree of accuracy and put them into the instrument class.

Engineers starting out to design the complex microwave circuits required in present-day radars and guided-missile programs should try to avoid close tolerances where possible.

Methods developed in order to simplify manufacture are: *a.* precision casting, *b.* merco-cast process, *c.* electroforming, *d.* tube bending, *e.* dip brazing and other brazing methods, *f.* fabricating.

If the above methods are applied intelligently and if the important point of keeping tolerance requirements as loose as possible is followed, the average machine shop will be able to produce delicate components without too much difficulty.

30.2. THE DESIGN OF MICROWAVE COMPONENTS FOR PRODUCTION

H. J. RIBLET
(Microwave Development Labs., Inc., Waltham, Mass.)

This paper discusses some of the problems of fabricating microwave components as they affect initial design and developmental effort. The special advantages of lost-wax casting broaching, forging, and form-tool cutting are reviewed. Alternate procedures for fabricating two waveguide-to-coaxial transitions are discussed by way of examples. The importance of maintaining close liaison between engineering and manufacturing is emphasized.

30.3. FABRICATION OF MICROWAVE COMPONENTS EMPLOYING THE DIP BRAZING PROCESS

W. J. Rudolph
(The Glenn L. Martin Co., Baltimore, Md.)

A short discussion on aluminum brazing methods, the materials and alloys employed will be used as an introduction. Problems of joint design and proper fixturing of assemblies will be surveyed, along with various means of solving these problems. Filler sizes will be discussed along with the methods used to hold close tolerances. The preparation of the base materials prior to brazing is one of the most important factors in producing a satisfactory brazed joint; therefore, precleaning, deburring, etc. will be used as another topic. Then, flux-removal procedures and other items will be presented.

In closing, a brief summary will be given.

30.4. ELECTROFORMING WITH COPPER AND NICKEL AND OTHER METALS

C. L. Duncan
(C. L. Duncan Co., Chamblee, Ga.)

1. Purpose of Electroforming: To produce internal surfaces of various shapes to close tolerances and fine surface finish.
2. Scope of Electroforming: Electroforming is a specific field and does not compete with die casting, stamping, drawing, etc. It is not a cheap method of manufacture.
3. Research and Development Compared to Production: Relation of assembly and fabrication of intricate shapes to electroforming in compounded sections and the elimination of joining.
4. Some Qualities of Electroformed Nickel and Copper: Experiences in machining, soft and hard soldering.
5. Electroforming with Aluminum, Silver, Gold, and Iron: Experiences with electroforming these metals.
6. Open Discussion for Question and Answer Period: Practical problems and methods.

30.5. MANUFACTURING OF "MICROSTRIP" PRINTED CIRCUITS COMPONENTS

H. F. Engelmann
(Federal Telecommunication Laboratories, Nutley, N. J.)

The manufacture of components utilizing the "microstrip" transmission system may be achieved by mass production techniques.

Among the applicable methods are the photo-engraving, silk-screen, and vacuum-metal deposition processes. A further simplification in the manufacture of complete microwave systems is possible since the above processes are also suited to printed-circuit and printed wiring techniques. Thus it is quite practical to simultaneously "print" microwave and low-frequency circuits and circuit elements.

A general discussion of various manufacturing techniques, with a detailed description of the manufacture of a complete microwave receiver utilizing the photo-engraving process, will be included.

Session 31: Seminar

Acoustics for the Radio Engineering—II

(Organized by Professional Group on Audio)

Chairman, J. J. Baruch
(Massachusetts Institute of Technology, Cambridge, Mass.)

31.1. PHONOGRAPH REPRODUCERS

B. B. Bauer
(Shure Brothers, Inc., Chicago, Ill.)

31.2. TAPE RECORDING

Marvin Camras
(Armour Research Foundation, Chicago, Ill.)

31.3. STUDIO ACOUSTICS

H. J. Sabine
(Celotex Co., Chicago, Ill.)

The discussion will centralize around broadcasting studios, and the engineering use of phonograph reproducers and magnetic recording.

Continual interplay among the members of the panel and between the panel and the audience will assure the focusing of attention on the aspects of acoustics which are of interest and intense importance to the radio engineer.

Session 32: Symposium

Nucleonics

(Organized by Professional Group on Nuclear Science)

Chairman, L. V. Berkner
(Associated Universities, Inc., New York, N. Y.)

32.1. SERVOS FOR REMOTE MANIPULATORS

R. C. Goertz and F. Bevilacqua
(Argonne National Laboratory, Lemont, Ill.)
J. R. Burnett
(Purdue University, W. Lafayette, Ind.)

Master-slave manipulators have become quite popular for nonroutine general purpose handling and manipulations involving radioactive materials.

Servomechanisms which reproduce mechanical position and reflect the load are being developed to replace the mechanical connections used in most of the present master-slave manipulators. These servos must maintain proportional position and force correspondence between the input (masterhandle) and output (slave tongs or tool) for all velocities, forces, and inertia loads from zero to the maximum capabilities of the manipulator. Several schematic arrangements will be discussed which fulfill the requirement for positional correspondence, force reflection, and bilateral action of the servos. Analysis by impedance concept quickly leads to some basic requirements of the system. Possibilities for incorporating these devices into robots will be discussed briefly.

32.2. TWO NEW PHOTOMULTIPLIERS FOR SCINTILLATION COUNTING

M. H. Greenblatt, M. W. Green, P. W. Davison, and G. A. Morton
(RCA Laboratories Division, Princeton, N. J.)

The present paper describes two new developmental multiplier phototubes which are designed to meet some of the recent needs of scintillation counting. These are developmental numbers H-5037 and H-4646.

A large phosphor crystal is desirable for gamma-ray spectroscopy and for obtaining complete absorption of high energy particles. A photomultiplier with a large photocathode is necessary in order to realize the full advantage of a large crystal. Developmental No. H-5037 was developed for use with large scintillation crystals.

It is also desirable to have a photomultiplier with a gain high enough to eliminate the need for pulse amplifiers with their necessarily limited frequency response. Such a tube is very useful for studying very fast phenomena, for portable survey instruments and for use in cases where the photomultiplier is necessarily in a remote location. Developmental No. H-4646 is suitable for such applications.

Some characteristics of these two tubes are given in Table I.

TABLE I

Multiplier Type:	*H-5037*	*H-4646*
Dimensions:		
diameter	4 inches	1 5/8 inches
length	7 inches	7 1/2 inches
Cathode:		
dimensions	3 1/2 inches dia.	1/2 inch×1 inch
sensitivity	30–50 ua/l	30–50 ua/l
spectral type	s-9	s-9
collection eff.	high	high
Gain:		
number dynodes	10	16
gain	10^6	10^9
overall voltage	1,000	2,000

The H-5037 uses a cylindrical electrostatic lens to focus electrons from the photocathode onto the first stage of the multiplier. The multiplier structure is similar to the RCA 931-A. The collection efficiency of the electron optical system used is quite good. Preliminary tests indicate that results consistent with the larger photocathode area are obtainable.

The H-4646 has a much smaller photocathode area but has, in addition to excellent collection efficiency, a strong electrostatic collecting field in the vicinity of the cathode. This decreases the transit time spread and also makes the tube less susceptible to interference from external magnetic fields. The very high gain of the tube introduces a number of space charge problems. These are met by a special 16th dynode-anode structure. The output is through a 125 ohm coaxial transmission line system. Saturation output current is about 300 ma.

32.3. BILLION-ELECTRON-VOLT ACCELERATORS

G. K. Green
(Brookhaven National Laboratory, Upton, Long Island, N. Y.)

Accelerators producing particles with energies of millions of electron volts to hundreds of million electron volts have been used to explore the properties of the atomic nucleus. However these machines are not adequate for detailed examination of the particles of the nucleus. Four machines for at least one billion electron volts are now being built and a fifth—the Brookhaven Cosmotron—is giving proton energies above two billion electron volts. The Cosmotron synchronizes a changing radio frequency with an increasing magnetic field to accelerate protons for a path length of some 150,000 miles. New theoretical discoveries indicate that a one hundred billion ev machine is an engineering and economic possibility.

32.5. INSTRUMENTATION DEVELOPMENTS IN FAST NEUTRON DOSIMETRY

G. S. Hurst
(Oak Ridge National Laboratory, Oak Ridge, Tenn.)

Fast neutrons are more harmful to many biological systems than is an equal amount of gamma radiation; thus fast neutron dosimeters should be gamma insensitive. Two such dosimeters have been developed. The first type uses a proportional counter whose count rate response versus energy is the same as the first collision tissue dose curve. This detector is simple and adapts itself to portable instruments, of which a commercial model is now available. The counter has a dependence on the direction of the neutrons, which is advantageous in some cases.

The second type uses a proportional counter which is designed in accordance with the Bragg-Gray principle and hence is nondirectional. Dose is determined by adding pulse heights which may be done by a simple pulse integrator which uses two ordinary binary scaling units.

Session 33

Information Theory II—Theoretical

(Organized by Professional Group on Information Theory)

Chairman, W. G. Tuller
(Melpar Inc., Alexandria, Va.)

33.1. ERROR PROBABILITIES OF BINARY DATA TRANSMISSION SYSTEMS IN THE PRESENCE OF RANDOM NOISE

S. H. Reiger
(Air Force Cambridge Research Center, Cambridge, Mass.)

In a binary data transmission system, the error probability depends on the transmitter power, receiver sensitivity, pulse shape, modulation method, and detection characteristics; however, the output S/N ratio of the optimum receiver is dependent only on the signal energy of the pulse and the noise power per unit bandwidth. In practice, for large S/N, the ideal case may be approached very closely with simple filters. For small S/N this may be done if the transmission, is coherent.

Minimum error probabilities on the basis of an "ideal observer" have been computed numerically for the following systems: a. carrier keying (non-coherent), b. carrier keying (coherent), c. frequency shift keying, d. rf phase shift keying.

The average information value of each pulse has been computed for the four systems as a function of the S/N ratio and they are compared with Shannon's formula.

33.2. THE STATISTICAL PROPERTIES OF THE OUTPUT OF CERTAIN FREQUENCY SENSITIVE DEVICES

G. R. Arthur
(Sperry Gyroscope Co., Great Neck, N. Y.)

Frequently it is desirable to know the statistical properties of the output of frequency sensitive devices when some type of random signal is impressed. This problem is essentially one of the statistics of the difference of two dependent random quantities and the statistics of a filtered signal.

The problem of finding the probability density of the difference of two dependent random variables has not been solved in any general way. This paper gives the solution of this problem for the case of a frequency discriminator excited by a narrow-band spectrum. It is solved by expressing the output of the device as the difference of two independent random variables which allows the use of the characteristic function method. The problem of passing a non-Gaussian random signal through a low-pass filter is then solved by obtaining the predominant moments of the density at the filter output. This method clearly demonstrates the approach of that density to a Gaussian as the filter band is made narrow.

33.3. CROSS-CORRELATION APPLIED TO AUTOMATIC FREQUENCY CONTROL

M. J. Stateman
(Sylvania Electric Products, Inc., Bayside, N. Y.)

Automatic frequency control requires that an error signal be obtained as a function of the slaved and controlling voltages. This error signal is used in a feedback loop to minimize the difference in phase between the two voltages. Such an error voltage must indicate both the direction and the magnitude of the existing difference to be effective in obtaining and maintaining the locked condition in the presence of noise. Using examples of AFC from television circuitry, standard graphical analyses are followed by correlation techniques which present a new viewpoint concerning the criteria of waveforms suitable for AFC.

33.4. APPROXIMATE PROBABILITY DENSITY FUNCTION OF FIRST LEVEL CROSSING FOR LINEARLY INCREASING SIGNAL PLUS NOISE

G. Preston and R. Gardner
(Philco Corporation, Philadelphia, Pa.)

The solution of many timing and synchronizing problems depends upon having a device that registers the time a signal first crosses a given cutoff level. Often the signal can be considered to be a linearly increasing function of time with a superimposed random noise. The noise introduces a variation in the time the composite signal first crosses the cutoff level causing jitter in the output signal. This effect is described by the probability density function for the first cutoff-level crossing. In this paper an approximate expression for the probability density function is obtained for the case of normal noise.

The conditional probability-density function is obtained by linear extrapolation of the composite signal from some convenient point. By successive application of this probability-density function, the desired density function can be plotted. The resultant distribution has many of the characteristics of a normal distribution whose rms deviation depends upon the ratio of the signal slope to the rms value of the noise.

By reference to work in the literature, the assumption of normal noise can be verified for a receiver with a wideband IF and a narrow-band video. One possible application, satisfying these requirements, is in the television synchronization problem. Graphs are shown of the probability-density function with values typical of such an application. One result is that less jitter is obtained as the video bandwidth is extended although this action decreases the conventional signal-to-noise ratio.

33.5. OPTIMUM DEMODULATION

F. W. Lehan and R. J. Parks
(California Institute of Technology, Pasadena, Calif.)

The problem of demodulation of a signal, modulated in a general way, is studied using the statistical technique of curve fitting. This technique attempts to make the best possible fit to an incoming noisy signal with a locally generated signal by proper choice of certain parameters of the local signal. The best fit is defined to be that which maximizes the likelihood of the noise function which is defined as the difference between the incoming signal and the locally generated signal. A priori assumptions concerning the modulation are introduced implicitly by the choice of form of the locally generated signal. Other assumptions may be introduced explicitly by means of Bayes Theorem. Various types of modulated signals are considered and under certain simplifying assumptions the method is found to lead to correlation detection, local-carrier insertion, and other so-called ideal detection techniques.

Session 34

Medical Electronics

(Organized by Professional Group on Medical Electronics)

Chairman, L. H. Montgomery, Jr.
(Metal Products Co., Nashville, Tenn.)

34.1. ELECTRIC PHOTOGRAPHY

K. S. Lion
(Massachusetts Institute of Technology, Cambridge, Mass.)

A great number of problems, particularly in the fields of medicine and biology, require the use of photographic methods of extreme sensitivity. Such problems arise, for instance, in medical radiography, in X-ray diffraction pattern technique, or in low-level spectroscopy, where even the use of the most sensitive photographic emulsion is not satisfactory or leads to an overdose of radiation, and intensifier screens must be employed.

The new photographic method presented in this paper combines the advantages of the photographic method (simultaneous two-dimensional, pictorial presentation, and integration) with the sensitivity of the Geiger counter. The sensitivity of this method is several orders of magnitude higher than that obtained with ordinary photographic methods. It may be called electronic photography, although the application of this method far exceeds the field of photography.

The method consists in a parallel-plate Geiger counter whereby a photographic emulsion, on a carrier, is brought into the counting volume. The counter is filled with an appropriate gas and quenching agent, and a voltage source is applied. Under appropriate operating conditions a radiation entering the counter will trigger a discharge which does not spread throughout the counter but which is strictly localized and which locally exposes the photographic plate. Theoretical considerations show a possible increase of sensitivity of a photographic emulsion by a factor of 1,000. Actual tests so far have resulted in an increase of sensitivity by a factor of 100, with a resolving power acceptable for a great number of applications.

Experimental results and applications of this method in the field of photography and in other fields will be discussed.

34.2. CONCERNING THE USE OF HIGH ENERGY PARTICLES AND QUANTA IN THE DETERMINATION OF THE STRUCTURE OF LIVING ORGANISMS

R. J. Moon
(University of Chicago, Chicago, Ill.)

The important basic principles for the determination of the structure of living organisms by means of high-energy quanta and particles are developed. Primary emphasis is put upon obtaining the information relative to structure of the organisms with a minimum amount of damage to it and a maximization of the amount of information derived. Several instruments are considered with reference to their ability to fulfil these conditions. Systems which employ "thick detectors" and derive their information in serial-time sequence seem to fulfil these conditions best. Experimental work with a scanning X-ray system performed with regard to these principles is described.

34.3. POSSIBLE MEDICAL AND INDUSTRIAL APPLICATION OF LINEAR ELECTRON ACCELERATORS

W. C. Barber, A. L. Eldredge, and E. L. Ginzton
(Stanford University, Stanford, Calif.)

A linear-electron accelerator has many possible applications since it provides a simple means of obtaining intense electron beams in the multimillion volt-energy region. Uses to be considered are the direct employment of the electron beam for sterilization of biological materials or for cancer therapy. Alternatively, the electron beam can be converted to high-energy X-rays which can be used for cancer therapy or radiography of thick sections.

Analysis and experience suggests that linear accelerators are practical for any of these applications, and as an introductory venture in this field the Microwave Laboratory is constructing a 6-mev accelerator to produce X-rays for cancer therapy.

34.4. CAPACITY AND CONDUCTIVITY OF BODY TISSUES AT ULTRA-HIGH FREQUENCIES

H. P. Schwan and Kam Li
(University of Pennsylvania, Philadelphia, Pa.)

It has been recognized recently that electromagnetic-radiation operating in the frequency range from 300 to 600 mc is much more suitable for diathermy than radiation operating above 1,000 mc. However, no detailed data of the dielectric properties of various body tissues within the range from 100 to 1,000 mc are available at present. Such data are desirable in view of the fact that they permit more quantitative determination of such data as depth of penetration, reflection energy at tissue interfaces, and so on. Dielectric constant and conductivity of various body tissues have been measured, therefore, in the range from 200 to 900 mc and are presented in this paper. The significance of this data with respect to problems of diathermy is discussed.

34.5. THE PROBLEM OF THE APPLICATION OF ELECTRONICS TO MEDICINE

R. S. Schwab
(General Hospital, Boston, Mass.)

The task of the physician is the prompt recognition of bodily dysfunction (pathology), its identification and location (diagnosis), and later correction or elimination (therapy).

He is handicapped in this task by inaccessibility of many structures, their delicacy, the presence of pain, extreme variations from mean values and relationships, and urgency.

Alone with his eyes—and ears—and the touch of his hands, the physician is limited in dealing with the many complicated variables he knows exist, and which are early and clear signs of the puzzle he must solve.

For better, more exact, more comprehensive measurement of countless parameters, he turns to electronics for help.

Some basic difficulties in the liaison between medicine and electronics are: (1) Most physicians have very little idea of limits of the measurements they want to obtain. A great many doctors have no idea of the meaning of significant figures. (2) On the other hand, most electronic engineers have little experience with the uncertainty of medical knowledge, of the immense number of variables, many that are not known even to the well-trained specialist in his particular branch of medicine. They have little idea of just how their services can be used, or what is really wanted by the physician, and particularly why it is wanted.

We need, first of all, a book on electronics for the doctor and a book on medicine for the electrical engineer.

Five principal applications of electronics and fifteen examples of existing electronic devices that are in use in medical problems are described.

Some future challenges to spark further developments along these lines are mentioned.

34.6. PROGRESS REPORT ON ELECTRONIC MAPPING OF THE ELECTRICAL ACTIVITY OF THE HEART

Stanford Goldman, D. W. Spence, Mary Rizika, and Silvan Lidovitch
(Syracuse University, East Syracuse, N. Y.)

Electronic mapping (or area display) is a method of investigating the electrical activity of the heart. Many common diseases of the heart can be recognized and distinguished by slow-motion pictures of their area displays. These include left and right ventricular hypertrophy, left and right bundle-branch block, posterior and anterior and anterolateral infarction, and auricular fibrillation. The movies give an informative picture of the pathological physiology.

Moving pictures will be shown illustrating normal and abnormal types. The relation between electronic mapping and vector cardiography will be discussed.

Session 35

Broadcast and Television Receivers—I

(Organized by Professional Group on Broadcast and Television Receivers)

Chairman, G. L. Beers
(RCA Victor Division, Camden, N. J.)

35.1. GAIN STABLE MIXERS AND AMPLIFIERS WITH CURRENT FEEDBACK

G. E. Boggs
(National Bureau of Standards, Washington, D. C.)

Narrow-band radio-frequency amplifiers and mixers may be stabilized by negative feedback without increasing the bandwidth excessively. A couple of this type using current feedback is described. This couple requires only a simple resistive beta circuit and may be designed such that the bandpass characteristic is largely independent of the feedback. Consideration is also given to the problem of input impedance. Amplifier couples of this type with 20 db of feedback have been operated at 15 mc and can probably be used at higher frequencies. Current feedback mixer couples have been used satisfactorily at frequencies as high as 50 mc.

35.2. VIDEO AMPLIFERS WITH INSTANTANEOUS AUTOMATIC GAIN CONTROL

W. E. Ayer
(Stanford University, Stanford, Calif.)

Circuits are described which allow essentially complete control of the output-input amplitude characteristic of multistage video amplifiers for both positive and negative input signals. The incremental gain of each stage is determined instantaneously by the signal current through the tube, diodes being employed to introduce degeneration for signals above a certain amplitude. The gain reduction achieved in this manner lasts only as long as a strong signal is present so that recovery time is not adversely affected.

As a typical practical example, these circuits may be readily utilized to provide a "logarithmic" amplifier, the output voltage being proportional to the logarithm of the input voltage.

35.3. AN AUTOMATIC LEVEL-SETTING SYNC AND AGC SYSTEM

E. O. Keizer
(RCA Laboratories, Princeton, N. J.)
and M. G. Kroger
(Motorola, Inc., Chicago, Ill.)

The failure of many commercial television receivers to remain in stable synchronism in the presence of high-energy types of interference is often due to charging up during the noise pulses of capacitors in the sync separator and agc circuits of the receiver. A system has been developed which largely overcomes this failure. In this system, the agc is derived following a dc-coupled-sync separator in such a manner that any departure from the correct operating level for the sync separator is counteracted by a change in agc voltage and sync-separator bias. Three tube functions are required for the system. Both polarities of sync output are provided.

35.4. PACKAGED ADJACENT CHANNEL ATTENUATION

J. P. Van Duyne
(Allen B. Du Mont Laboratories, Inc., Clifton, N. J.)

The problem of adjacent-channel attenuation is discussed in its relation to the allocation problem, the economics of receiver design, and the ultimate cost to the consumer. It is pointed out that the design of a television receiver for excellent adjacent-channel rejection is not compatible with economical design for operation in the usual service area.

A solution to this dilemma, in the form of a plug-in adjacent-channel rejection filter, is proposed. The results achieved with the filter described, indicate that the limitation to interference-free reception in an adjacent-channel area is the nonlinearity of the RF tuner.

The design of a filter for such service imposes several practical limitations on the designer. These limitations, and their influence on the design problem, are discussed.

35.5. METHODS OF MATRIXING IN AN NTSC COLOR TELEVISION RECEIVER

W. M. Quinn
(General Electric Co., Syracuse, N. Y.)

In order to obtain the required Red, Blue, and Green signals in an NTSC color television receiver, it is necessary to combine or matrix the brightness signal with the two detected components of the chrominance signal.

Several methods have been employed to accomplish this matrixing. One method consists of applying the *Y* or brightness signal to the three grids of a tri-color kinescope and then applying the three-color difference signals (*R-Y*, *B-Y*, *G-Y*) to the individual cathodes. This particular method utilizes the kinescope itself as an adder. Other methods are resistive matrixing, summing amplifiers, and the feedback summing amplifier. All of these methods will be discussed with the most emphasis being given to the feedback summing amplifier. Consideration will be given to linearity, phase distortion, bandwidth, and general performance.

Session 36

Microwaves II—Discontinuities and Transitions

(Organized by Professional Group on Microwave Theory and Techniques)

Chairman, G. A. Deschamps

(Federal Telecommunications Laboratories, Inc., Nutley, N. J.)

36.1. RF MEASUREMENTS ON METALLIC DELAY MEDIA

S. B. Cohn
(Sperry Gyroscope Co., Great Neck, N. Y.)

This paper presents RF index-of-refraction data for metallic delay-line media containing square and circular obstacles, and compares data for strip obstacles with theoretical values. The measuring equipment used is described, and the necessary correction formulas are given. The test specimens consisted of alternate layers of polyfoam spacers and thin polystyrene sheets imprinted with conducting obstacles. The RF data was correlated with the static data from electrolytic-tank measurements, in order to obtain graphs of index of refraction versus frequency suitable for design purposes. As shown in this paper, the data may be extended readily to other techniques of fabrication. A practical and economical method of construction will also be described.

36.2. IMPEDANCE MEASUREMENTS IN A CIRCULAR WAVEGUIDE WITH TE_{01} EXCITATION

L. S. Sheingold
(Sylvania Electric Products Inc., Boston, Mass.)

A unique method of measuring impedance in a circular waveguide supporting only the dominant circular-electric wave is described. Results are given of precise impedance measurements made on circular obstacles, circumferential gaps, radiating guides, and sharp axial bends. The experimental results are compared with theoretical values and are found to be in excellent agreement. It is demonstrated that application of Deschamps' graphical method in the experimental determination of the scattering parameters of a circumferential-gap junction results in a rapid determination of the pertinent quantities; for example, the power reflected by, power transmitted through, and power dissipated in the junction.

36.3. EXPERIMENTAL DETERMINATION OF THE PROPERTIES OF MICROSTRIP COMPONENTS

M. Arditi
(Federal Telecommunications Laboratories, Inc., Nutley, N. J.)

Transmission properties of microstrip components are readily obtainable experimentally due to the case of manipulation of the line element. The properties of a wide-band transition for connecting coaxial lines to microstrip systems are given. The scattering matrix coefficients and equivalent circuits are presented for a right-angle bend, offset junction, step discontinuity, parallel-coupled junction, and for transverse posts, gaps, or slots in the strip conductor. These data facilitate the design of resonant sections that include such obstacles. Measurements have verified the predicted performance of these components when assembled into a microwave receiver.

36.4. A WIDE-BAND TRANSITION BETWEEN WAVEGUIDE AND COAXIAL LINE

N. A. Spencer and H. A. Wheeler
(Wheeler Laboratories, Great Neck, N. Y.)

In an unusual type of transition, two parallel paths are inserted between a rectangular waveguide and a coaxial line. These two paths are the two halves of an H-plane waveguide ring, series connected at the guide junction and parallel connected at the line junction. The coaxial line has the maximum diameter consistent with single-mode propagation and maximum pulse-power capacity. The two-sided junction with the line is conducive to wideband-impedance matching. The entire transition has been matched within 0.3 db swr over a 10 per cent frequency bandwidth.

Session 37

Radio Telemetry

(Organized by Professional Group on Radio Telemetry and Remote Control)

Chairman, M. V. Kiebert

(Bendix Aviation Corporation, Teterboro, N. J.)

37.1. TELEMETERING REQUIREMENTS FOR UPPER AIR ROCKET RESEARCH EXPERIMENTS

Marcus O'Day
(Air Force Cambridge Research Center, Cambridge, Mass.)

Rocket-borne experiments which require telemetering, as well as other experiments which, although proposed, are restricted by data transmission systems currently in use, will be described in this paper. The requirements of a high-sampling rate will be contrasted with that of high-time resolution, and some of the experiments which illustrate the difference will be discussed. The requirement of high accuracy for certain projects, for example, the determination of the solar constant at high altitudes, will be analyzed and possible solutions proposed. In addition, the speaker will discuss certain operation restrictions, such as the inability to change batteries after the rocket is fueled, as well as limitations imposed by the parachute-recovery system.

37.2. TELEMETERING—BROAD BAND ON SHORT ORDER

T. F. Jones, Jr.
(General Electronic Laboratories, Inc., Boston, Mass.)

The Navy required the delivery, in four months' time, of a telemetering system having eight channels, each having a signal bandwidth of zero to ten kc. The specification on operating range dictated the use of an airplane-relay station. The requirement of side-by-side operation of similar systems on adjacent channels imposed stringent conditions on carrier stability and receiver stability.

The need was met within the time limit by the development of an AM-AM system with the aid of experimental telemeter element designs supplied by NRL. Problems such as calibration, deviation limiting, subcarrier stability, subcarrier interaction, sonic shielding, carrier stability, receiver stability, automatic control of relay-signal levels, and subcarrier separation were adequately solved.

The basic design can meet effectively the needs of other telemetering applications.

37.3. FLUTTER COMPENSATION FOR FM-FM TELEMETERING RECORDER

J. T. Mullin
(Bing Crosby Enterprises, Inc., Los Angeles, Calif.)

Records of FM-FM telemetering information reproduced from magnetic tape are restricted in the accuracy with which information may be read because of flutter and dc drift in the tape-transport mechanism. A method is described wherein the effects are reduced by electronic compensation during playback. A high-frequency pilot tone is added to the FM-FM signals as they are recorded. During playback all channels are modulated by a high-frequency carrier. The resulting side bands are demodulated separately for each channel by a carrier whose frequency is controlled in an absolute manner by information derived from the pilot tone. Demodulation thereby restores the channel frequencies to their correct values with variations due to flutter and dc drift greatly reduced.

37.4. A MAGNETIC TAPE RECORDING SYSTEM FOR PRECISION DATA

L. L. Fisher
(Ampex Electric Corporation, Redwood City, Calif.)

A new magnetic recording system has been developed which makes it possible to accurately record and reproduce all forms of data from the range of 0 to 5,000 cycles. Employing an FM carrier technique, this new system overcomes the deficiencies of conventional magnetic recorders, allowing response to dc with very-low phase shift, excellent transient response, and complete freedom from the coating deficiencies and the nonhomogeneity of the magnetic medium. Special packaging arrangements have been worked out to allow assembly of the equipment for any number of recording tracks up to 14 on 1" wide tape. Operation at a great variety of speeds makes possible frequency expansion, frequency contraction, and other tricks which allow complete flexibility in analysis of recorded data. Use of such techniques on the "live" data signal allow the ultimate amount of information to be derived from the original recorded signal.

37.5. AN IMPROVED FM-FM DECOMMUTATOR GROUND STATION

F. N. Reynolds
(The Ralph M. Parsons Co., Pasadena, Calif.)

A new and straightforward approach to the extraction of intelligence from variable amplitude data pulses is carried out in the system described herein. Theoretically, if a low-pass filter could be designed to have its cutoff frequency (fc) at one-half of the commutation rate ($F/2$) it would be possible to realize information from amplitude-modulated pulses up to a frequency equal to ($F/2$), assuming that the filter had an infinite rate of attenuation. In practice, such a filter cannot be built, but these characteristics can be approached at the higher frequencies by using LC-types of networks. In the frequency spectrum employed in the RDB-FM-FM standard telemetering equipment, it becomes uneconomical and wasteful in terms of space to build such low-pass filters. It is possible, though, to duplicate the transfer function for a normal pi-section low-pass filter with 2 vacuum tube envelopes and a few resistor and condenser components. In this equipment two such filters are placed in a series and as an example, for a 30-cycle per-second commutator, the cutoff frequency is chosen at 10 cps, so that the maximum theoretical rate of attenuation of 36 db per octave produces an attenuation of approximately 60 db at the commutation rate of 30 cps. It can thus be seen that such a device when driven with amplitude-modulated pulses, essentially acts as not only a storage network but also as a very reliable integrator, producing at the output of the filters a voltage whose waveform is identical to that of the input-modulation voltage up to the limit of approximately 10 cps. The frequency response of this type of device is about twice that which can be expected with the generally used stair-step type of storage network, and the voltage between samples becomes usable since it contains a high order of intelligence approaching that of the input-modulation signal. The complexity of the equipment is quite a bit less than is normally accepted for a series-RC type of integrator and storage network, and as a consequence, the over-all reliability and operation efficiency is greatly increased. A much higher order of linearity and accuracy is also achieved with this type of device.

37.6. SOME INDUSTRIAL APPLICATIONS OF TELEMETRY

H. R. Hoyt
(Great Lakes Pipe Line Co., Kansas City, Mo.)
AND
J. H. Van Horn
(Midwest Research Institute, Kansas City, Mo.)

Some current techniques for telemetering process variables in those industries having widely distributed operations are presented, in particular, those associated with the petroleum industry. Telemetry systems employing carrier-telephone and microwave techniques in the transmission of such variables as pressure, flow rate, levels, positions, etc. and operating from a wide variety of transducer elements are described.

Session 38

Audio

(Organized by Professional Group on Audio)

Chairman, D. W. Martin
(Baldwin Co., Cincinnati, Ohio)

38.1. SOUND SYSTEM FOR PLENARY CHAMBER OF UN GENERAL ASSEMBLY BUILDING

C. W. Goyder
(Telecommunication Div., United Nations, N. Y.)
L. L. Beranek
(Massachusetts Institute of Technology, Cambridge, Mass.)

The sound system for the plenary chamber of the General Assembly Building of the United Nations in New York was especially designed to function properly in the unusual style of architecture of that room. The principal design requirements were intelligibility, naturalness, concealment, and freedom from danger of feedback even when operated with automatic-volume control. Satisfactory speech intelligibility is attained by faithful reproduction of the frequency range between 400 and 6,000 cps. Naturalness is assured by freedom from nonlinear distortion, uniform coverage of the hall at all frequencies, and by suitable employment of time-delay systems. Sound-level distribution and response tests have been performed and the data are presented in this paper.

38.2. DEVELOPMENT OF A VARIABLE TIME DELAY

Kenneth Goff
(Massachusetts Institute of Technology, Cambridge, Mass.)

This paper describes the design, construction, and performance of a magnetic-recording drum time-delay system. The device, which has been developed for use in such acoustic studies as noise localization, reverberation analysis, and others amenable to correlation techniques, utilizes conventional proportional recording. Two channels yield a relative time delay between their outputs which may be varied from minus 15 ms to plus 190 ms with an accuracy of ± 0.2 per cent using the instrument dial.

Principal attention in the paper will be paid to the following: 1. Obtaining a uniform layer of magnetic material by spraying with a dispersion of iron oxide. 2. Analyzing the effect of spacing between the magnetic material and the head upon the processes of recording the reproducing. 3. Developing a mechanical driving system as free from flutter as possible.

38.3. A FLUX-SENSITIVE HEAD FOR MAGNETIC RECORDING PLAYBACK

D. E. Wiegand
(Armour Research Foundation, Chicago, Ill.)

A playback head of special construction provides signals proportional to the flux from the recording medium, rather than its time derivative. Power from a high-frequency oscillator is applied to the head. The output signal appears across a separate winding and is in the form of a modulated carrier, the carrier frequency being twice that of the oscillator. Its inherently flat response extending to dc at the low-frequency end makes the head useful in many instrumentation applications, particularly in cases

where waveforms must be preserved, or when a recording is studied in detail by playing back the record at greatly reduced speed. Full signal levels are preserved when the speed of the recording medium is reduced. In fact, the recording can be examined point by point by taking readings with the medium stationary. Signal levels are unusually high. This fact, and the elimination of the usual low-frequency equalization make the new head appear attractive in sound recording. A simple adaptor for playback of magnetic recordings through a standard broadcast receiver requires, in addition to the drive mechanism, only a small oscillator feeding the head and a small transmitting-loop antenna fed by the signal winding of the head. The oscillator is tuned to one-half the frequency of a vacant spot on the radio dial.

38.4. UNIAXIAL MICROPHONE

H. F. OLSON, JOHN PRESTON, AND J. C. BLEAZEY
(RCA Laboratories, Princeton, N. J.)

A small unidirectional microphone has been developed with the following features: maximum sensitivity along the axis of the microphone, a high ratio of electrical output to size, a sharper directivity pattern than a cardioid, a directivity pattern that is independent of the frequency and a blast-proof vibrating system. The high discrimination which this microphone exhibits to sounds which originate from the sides and rear makes it particularly suitable for long-distance-sound pickup in radio, television, sound-motion pictures and sound-reinforcing systems.

38.5. SOUND PRESSURE MEASUREMENTS BETWEEN 50 AND 220 DB

J. K. HILLIARD
(Altec Lansing Corporation, Beverly Hills, Calif.)

The paper will describe applications of a miniature-condenser high-intensity microphone system in jet-rocket motor and industrial-plant measurement. Small probe tubes will be discussed which enable measurements to be made at ambient pressures of 300 p.s.i. and temperatures around 2000° F such as occur in combustion chambers. A system will be described to monitor continuously the noise interference of jet-engine testing cells over an area of several square miles.

SESSION 39
Engineering Management

(Organized by Professional Group on Engineering Management)

Chairman, C. F. HORNE
(Department of Commerce, Washington, D. C.)

39.1. GENERAL PROBLEMS OF ENGINEERING MANAGEMENT FACING THE ELECTRONICS INDUSTRY

HARADEN PRATT
(Telecommunications Advisor to the President, Washington, D. C.)

The rapidity of the evolutionary development which the electronics industry has experienced in a relatively few years, and the ramification in variety of uses and applications which has resulted, are dealt with from the point of view of the growing problems for engineering management consideration. It is emphasized that in addition to the many direct as well as allied fields there are also aspects such as education, training, social factors, research, invention, information dissemination, production, and marketing, all of which must be taken into account by management in order to plan and operate intelligently and efficiently.

39.2. RESEARCH AND DEVELOPMENT PROBLEMS OF ENGINEERING MANAGEMENT IN THE ELECTRONICS INDUSTRY

M. J. KELLY
(Bell Telephone Laboratories, Inc., New York, N. Y.)

The management of a research and development organization has in common with all industrial production organizations problems of human relations, fiscal control, and services auxiliary to the productive element of the organization. The extent to which these are different will be discussed. The programming of the research and development activities, the organization and control of the programs, and the long-range building of professional man power are areas of management in research and development that have unique characteristics. The paper will dwell principally on these areas of research and developing management.

39.3. PRODUCTION ASPECTS OF ENGINEERING MANAGEMENT IN THE ELECTRONICS INDUSTRY

W. A. MACDONALD
(Hazeltine Electronics Corporation, Little Neck, N. Y.)

There will be discussed the following: Three paramount factors in the problem of meeting a payroll; How it is possible to provide a uniform flow of products out of a plant, avoiding great peaks and valleys in productive output; Five necessary successive steps in a successful timing cycle; The electronics industry has entered the field of big business with related financial, personnel, and organizational problems, all the concern of management; Advantages of project responsibility for complex, custom-designed electronic equipment; Changes in the philosophy of business management; Importance of true leadership; What money cannot buy.

39.4. WHAT THE MILITARY SERVICES EXPECT FROM ENGINEERING MANAGEMENT IN THE ELECTRONICS INDUSTRY

D. L. PUTT
(Air Research and Development Command, Baltimore, Md.)

The military establishment makes use of electronics to augment and extend the physical and mental abilities of man. To maximize industry's contribution to defense there must be an understanding of the conditions in which military equipment must function. Environment problems may be grouped into logistic, personnel, and combat operations. Arising from the military environment, the following items need additional effort: *a.* increased reliability along with mission performance, *b.* increased ruggedness achieved simultaneously with weight and size reduction, *c.* "built in" ease of maintenance and adjustment, *d.* simplicity.

The military establishment desires the following contributions by engineering management: *a.* willing acceptance of military research, development, and production contracts, *b.* design for the environment of the anticipated use, *c.* realistic research and development schedules, *d.* realistic production schedules, *e.* plans for a switch to military production in the event of an emergency.

SESSION 40
Information Theory III—Coding

(Organized by Professional Group on Information Theory)

Chairman, W. R. BENNETT
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

40.1. A NECESSARY AND SUFFICIENT CONDITION FOR UNIQUE DECOMPOSITION OF CODED MESSAGES

A. A. SARDINAS AND G. W. PATTERSON
(Burroughs Adding Machine Co., Philadelphia, Pa.)

This report gives a rigorous formulation to the question: What is the underlying condition on a set of words or codes, so that all messages constructed with them may be decomposed uniquely? A complete answer is given to this problem in the form of a test which may be applied to any set of words or codes contemplated for a coding scheme.

40.2. A SYSTEMATIC SURVEY OF CODERS AND DECODERS

B. LIPPEL
(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

A number of coders and decoders will be described, and they will be organized in accordance with a classification system which recognizes three basic types of coders and three basic decoders. By means of feedback systems or other comparison schemes, all coders can be inverted to give decoders, and vice versa. Furthermore, basic converters can be combined with auxiliary converters, purely analog or purely digital, to change the analog mediums and the digital mediums between which the basic devices operate.

40.3. METHOD FOR TIME OR FREQUENCY COMPRESSION-EXPANSION OF SPEECH

GRANT FAIRBANKS, W. L. EVERITT, AND R. P. JAEGER
(University of Illinois, Urbana, Ill.)

A method has been developed which utilizes, by sampling techniques, the inherent redundancy in verbal speech to compress it into shorter time intervals without change in its frequency spectrum or to transmit speech information in the same time over a narrower frequency band.

The same device can be used to expand the time interval or frequency spectrum. A combination of two devices, one used to compress and the other to expand, permits transmission of speech signals over channels of limited bandwidth, and without delay.

The device can also be used to tailor broadcast programs, initially recorded with an undesired duration, into an assigned time interval without change in the frequency spectrum or observable distortion.

40.4. A NEW CODING SYSTEM FOR PULSE-CODE MODULATION

A. G. Fitzpatrick
(Burroughs Adding Machine Co., Philadelphia, Pa.)

This paper describes a new coding system for pulse-code modulation in which the operations of sampling, quantizing, and coding are accomplished by means of two simple special-purpose tubes and a minimum of circuitry. The first of these tubes is a beam-deflection type with ten individual outputs. The second is a quantizing-coding tube in which crossed electric and magnetic fields produce ten stable, controllable positions of an electron beam, each with parallel binary-coded outputs. Low cost and simplicity of this system will be compared with present systems. Adaptations of this same method to other analog-to-digital functions will be discussed.

40.5. COINCIDENCE DETECTORS FOR BINARY PULSES

Clarence Gates
(California Institute of Technology, Pasadena, Calif.)

The recovery of binary pulses when the signal-to-noise ratio is poor is investigated. The technique of using redundant channels for improving the effective signal-to-noise ratio is analyzed and optimum criteria developed for the two cases of interest; the first in which all channels are sampled for the precise value of signal in each before the decision as to whether a pulse is present is made, and the second in which the decision is made first in each channel. Methods of circuit synthesis for the second case are given, and a beginning towards the analysis of higher order pulses is made.

Session 41

Broadcast and Television Receivers—II

(Organized by Professional Group on Broadcast and Television Receivers)

Chairman, R. M. Bowie
(Sylvania Electric Products Inc., New York, N. Y.)

41.1 FACTORS AFFECTING THE DESIGN OF VHF-UHF TUNERS

E. H. Boden
(Sylvania Electric Products Inc., Emporium, Pa.)

This paper reviews some of the present arrangements for tuning the vhf and uhf television channels' performance and circuitry in the use of recently developed tubes which makes possible the design of a single unit that would tune both the vhf and uhf channels. Performance over the 82 television channels is reviewed.

41.2. THEORY OF AFC SYNCHRONIZATION

W. J. Gruen
(General Electric Co., Syracuse, N. Y.)

Automatic frequency control (afc) has been widely used for the horizontal sweep synchronization in television receivers, and more recently for the color synchronization in the proposed NTSC color system.

The paper deals with the theory of a generalized system in which the phase of local-oscillator signal is compared to the phase of the transmitted-reference signal in a phase discriminator. The resulting control voltage is then passed through a control network to control the frequency of the local oscillator. Systems having either a zero, single or double-time constant-control network are considered. The transient response, frequency response, and noise bandwidth. as well as the hold-in range and pull-in range of synchronization are presented.

41.3. STANDARDIZATION OF PRINTED CIRCUIT MATERIALS FOR MECHANIZED RADIO ASSEMBLY

W. Hannahs, J. Caffiaux, and N. Stein
(Sylvania Electric Products Inc., Bayside, N. Y.)

Conditions of use of "printed circuits" in radio and TV sets are critically examined with the purpose of developing standards of performance and comparison tests for wiring prefabricates and raw materials.

Tests for etched, stamped, and flexibly backed copper-foil circuits are described, and test results given for the various types and makes reveal characteristic differences affecting their selection for various applications. Some standards are proposed toward unification of the requirements which represent both suppliers' and users' viewpoints.

41.4. A COLOR TELEVISION RECEIVER FOR THE NTSC SYSTEM

K. E. Farr
(Westinghouse Electric Corporation, Metuchen, N. J.)

The basic elements of color television transmission will be outlined, and the salient features of the NTSC system in its present form will be discussed. A receiver designed for this system will be described. The receiver circuits are divided into four basic groups: 1. the monochrome or brightness signal channel, along with sound, deflection sync, and agc, 2. the color decoder and video circuits, 3. the color sync circuits, 4. the deflection, convergence, and power supply circuits.

The performance of this receiver will be discussed, and color photographs of color pictures taken from the picture-tube screen will be shown in the slides, as well as circuit details and photographs of the receiver.

41.5. A SIMPLIFIED VIDICON TELEVISION CAMERA

V. K. Zworykin, L. E. Flory, and W. S. Pike
(RCA Laboratories Division, Princeton, N. J.)

There are many everyday uses for a closed-circuit television system which have not previously been feasible even with available industrial equipment due to the cost of such units. The present paper describes a simplified camera using the vidicon pickup tube which, it is believed, will expand the usefulness in industry, commerce, and education. The camera contains the vidicon itself and a video amplifier which provides a signal in the form of a modulated carrier. Power for operating the amplifier and deflecting the vidicon beam are obtained from a television receiver on which the picture is viewed.

Session 42

Microwaves III—Ferrites and Detectors

(Organized by Professional Group on Microwave Theory and Techniques)

Chairman, W. W. Mumford
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

42.1. SPACE CHARGE DETECTOR FOR MICROWAVES

A. B. Bronwell, John May, Charles Nitz, T. C. Wang, and Hilliard Wachowski
(American Society for Engineering Education, Evanston, Ill.)

This paper presents results of theoretical and experimental studies of the vacuum-tube detector and converter for microwaves. Cylindrical diode tubes are used as detectors and converters at low-power levels and short wavelengths in the microwave spectrum. The theoretical studies treat the behavior of electrons in a space-charge cloud with superimposed dc and microwave fields.

Solutions are obtained for the cylindrical-diode space-charge equations in series form, based upon certain approximations. These solutions show the change in transit time and plate current resulting from superimposing the microwave field upon the dc field.

42.2. LOW LEVEL SYNCHRONOUS MIXING

M. E. Brodwin, and C. M. Johnson
(The Johns Hopkins University, Baltimore, Md.)
and
W. M. Waters
(Bendix Radio, Towson, Md.)

A synchronous detection system utilizing the same oscillator to furnish power for two signal channels has been used to obtain sensitivities of the order of 110 dbm at 100 kc, 9 kmc, and 33 kmc. The energy from an unmodulated RF source is divided into two channels. A portion of the energy is modulated in the signal channel where the desired measurements take place. The rest of the unmodulated carrier is directed through the reference channel where its phase and amplitude may be controlled. The signal and reference powers are mixed in the detecting element and the audio component is amplified and metered. The qualitative theory is arrived at by approximating the nonlinear element with a power-series and a Fourier-conductance representation.

42.3. GUIDED WAVE PROPAGATION THROUGH FERRITIES AND ELECTRON GASES IN MAGNETIC FIELDS

L. Goldstein, M. Gilden, and J. Etter
(University of Illinois, Urbana, Ill.)

Guided-microwave propagation through certain anisotropic dielectrics has been the object of recent investigations. In these experiments free electron gases and ferromagnetic dielectrics in magnetic fields constituted the anisotropic media. The results show that, in general, both polarization transformation and resonance phenomena are observed. This paper reports further results on the magnetic resonances and Faraday-rotation effects in ferromagnetic dielectrics and in free electron gases immersed in magnetic fields.

42.4. CAVITIES WITH COMPLEX MEDIA

A. D. Berk, and Benjamin Lax
(Massachusetts Institute of Technology, Cambridge, Mass.)

Expressions for the input and transfer impedances of cavities containing complex media, that is, media with tensor permeability, conductivity, or permittivity, are derived and discussed. It is shown that under certain conditions cavities of this sort possess the basic property of a gyrator. Special application of these results is made to the ferrites.

42.5. RESONANCE IN CAVITIES WITH COMPLEX MEDIA

Benjamin Lax, and A. D. Berk
(Massachusetts Institute of Technology, Cambridge, Mass.)

It is possible to study the tensor properties of such complex media as the ferrites and magneto-ionic gases by the use of resonant-microwave cavities. The impedance method of analyzing a cavity with degenerate or overlapping modes suggests the scheme for measuring the pertinent components of either the permeability or the conductivity matrix of these media. A specific illustrative example is treated in which rotating modes are considered.

Session 43

Remote Control Systems

(Organized by Professional Group on Radio Telemetry and Remote Control)

Chairman, C. H. Doersam, Jr.
(Office of Naval Research, Port Washington, N. Y.)

42.1. THE ORGANIZATION OF A DIGITAL REAL TIME SIMULATOR

H. J. Gray, Jr.
(Moore School of Electrical Engineering, Philadelphia, Pa.)

When a digital computer is used in a real time simulation problem, best results are not necessarily obtained with conventional machines. A typical set of thirteen first-order nonlinear differential equations was programmed for a machine similar to the Raytheon hurricane computer. Roughly 3,000 memory positions were required and the time required for computation in one integration interval was found to be greater than 0.22 second. Other studies indicated that the integration interval must be less than about one-tenth second. For various reasons, serial machines were considered over parallel machines. Several machine organizations were set up making use of one-address, three-address, and four-address codes, special partitioning of the memory, use of auxiliary storage registers, special codes, a high-speed multiplier, a high-speed divider, more than one arithmetic unit, use of digital-differential analyzer techniques, etc. Computation times for the above problem were obtained and compared for the different machine organizations and an "optimum" computer was evolved which, subject to the same assumptions as the hurricane with regard to programming, required about ten ms for one integration interval and after further manipulation of the original equations, this time was reduced to about 7 ms. Roughly 2,000 one-word memory positions were required.

43.2. CONTROL SYSTEM ENGINEERING APPLIED TO SUSPENSION SYSTEMS

G. J. Martin and R. Jeska
(University of Michigan, Ypsilanti, Mich.)

Automotive-suspension systems are studied by means of analogue-computing equipment, and the measured results compared with performance. The system is viewed as a closed-loop control system rather than a conventional open-ended passive system, which leads to new concepts of suspension synthesis, using the techniques of control-system engineering. The control system is then translated into practical hardware.

43.3. EXPERIMENTAL EVALUATION OF CONTROL SYSTEMS BY RANDOM-SIGNAL MEASUREMENTS

W. W. Seifert
(Massachusetts Institute of Technology, Cambridge, Mass.)

Theoretical advances in the past decade indicated the advantages of random-signal calculations over sinusoidal and step-response methods in control-system design, but practical application of random-signal measurements to experimental evaluation of control systems was relatively limited. At MIT the Dynamic Analysis and Control Laboratory has developed equipment and techniques for generating and monitoring random signals. One recent application of this technique, the experimental evaluation of a rate servomechanism, is presented and the experimental results are correlated with approximate theoretical results. The practical advantages of random-signal measurements are reemphasized and special attention given to the study of nonlinear systems under realistic operating conditions.

43.4. EXTENSION OF CONVENTIONAL TECHNIQUES TO THE DESIGN OF SAMPLED-DATA SYSTEMS

W. K. Linvill, and R. W. Sittler
(Massachusetts Institute of Technology, Cambridge, Mass.)

Techniques developed in feedback-amplifier design and servomechanisms can be extended for design of sampled-data systems. A sampled-data system is made from only three kinds of linear elements all of which can be described either in the time or the frequency domain. Flow graphs (or block diagrams) of sampled-data systems can be manipulated so as to reduce any complicated configuration to a simple equivalent configuration without feedback. A simple compensation procedure has been devised for sampled-error-data servosystems which uses error coefficients and correlates transient response with positions of system poles.

43.5. GENERALIZED SERVOMECHANISM EVALUATION

W. P. Caywood and William Kaufman
(Carnegie Institute of Technology, Pittsburgh, Pa.)

Servomechanism-performance evaluations for cases of statistically described signals have generally been made using the mean square of the error as a criterion of performance. There are many instances of applications of servos in which the mean square of the error holds little realism, such as in fire-control systems, and its use may result in a definitely inferior design or system adjustment.

Described in this paper is an analytic method of evaluating the operation of any linear system having unvarying parameters and an unvarying criterion of the importance of the instantaneous-error magnitude. The method comprises expanding in a power series the curve of relative importance of error versus error and, as is shown in the paper, using the coefficients of the power series to determine a new series, each term of which incorporates the first or a higher-moment correlation function taken of the statistically described signal. The highest-moment correlation needed is the same order as the degree of the power series needed to satisfactorily represent the criterion. An application of the calculus of variations completes the method and allows determining the best system adjustment. A magnetic-tape type of correlator to perform the higher-moment correlation is briefly described.

43.6. A METHOD FOR REDUCING THE FORCED DYNAMIC ERROR OF CLOSED-LOOP SYSTEMS

L. H. King
(Massachusetts Institute of Technology, Cambridge, Mass.)

This paper illustrates a method for reducing the forced-dynamic error in servomechanisms by design based on error coefficients. After a brief review of the dependence of the forced-dynamic error upon error coefficients, the relationship between error coefficients and the parameters of a servomechanism is derived. This relationship is then used to show how closed-loop systems can be modified to obtain favorable error coefficients, which reduce the forced-dynamic error. The method has been tested by simulation, and photographs of simulator response show how the effect of additional integrations can be achieved by error-coefficient adjustment.

Institute News and Radio Notes

Calendar of COMING EVENTS

IEE Symposium on Insulating Materials, London, Eng., March 16–18

Optical Society of America Meeting, Hotel Statler, New York, N. Y., March 19–21.

1953 IRE National Convention, Waldorf-Astoria Hotel and Grand Central Palace, New York, N. Y., March 23–26

IRE New England Radio Engineering Meeting, Storrs, Conn., April 11

9th Joint Conference of RTMA of United States and Canada, Ambassador Hotel, Los Angeles, Calif., April 16–17

IRE Seventh Annual Spring Technical Conference, Cincinnati, Ohio, April 18

Symposium on Nonlinear Circuit Analysis, Engineering Societies Building, New York, N. Y., April 24–25

SMPTE Convention, Statler Hotel, Los Angeles, Calif., April 26–30

URSI-IRE Meeting, National Bureau of Standards, Washington, D. C., April 27–30

NARTB Convention, Biltmore Hotel, Los Angeles, Calif., April 28–May 1

Electronic Components Symposium, Shakespeare Club, Pasadena, Calif., April 29–May 1

1953 National Conference on Airborne Electronics, Dayton, Ohio, May 11–14

1953 Electronics Parts Show, Conrad Hilton Hotel, Chicago, Ill., May 18–21

National Electronics Conference, Hotel Sherman, Chicago, Ill., September 28–30

1953 IRE-RTMA Radio Fall Meeting, Toronto, Ont., October 26–28

1954 Sixth Southwestern IRE Conference and Electronics Show, Tulsa, Okla., February 4–6

Technical Committee Notes

Under the Chairmanship of R. J. Wise, the **Facsimile** Committee met on December 5, 1952. There was a discussion regarding the definition for "facsimile"; however, agreement could not be reached and it was decided to carry the matter over to the next meeting. The Chairman suggested that each member prepare a solution and present it at that time. Pierre Mertz proposed that the term "effective band" be defined as a substitute for the term "nominal band" previously deleted. The proposal was accepted with the definition to read exactly as it is written in the IRE Standard, 42 IRE 9. S1. Kenneth McConnell (alternate for A. G. Cooley) proposed a new definition entitled "facsimile band width," which was approved by the Committee.

The **Electron Devices** Committee met on December 10, 1952, under the Chairmanship of G. D. O'Neill. Chairman O'Neill presented to the Committee the comments of R. S. Burnap and A. C. Rockwood concerning the proposed modification of the definition for "accelerating electrode" by adding the noun "(accelerator)" before the definition proper. The comments noted that the use of a single noun to describe a particular function violated IRE standardizing policy, which is to use the single noun for structural names, for example, "anode," and to progress logically from such a fundamental specification to particular usages with modifying adjectives or adverbs. It was further pointed out that the 1950 Electron Tubes Standard had not eliminated confusion over whether an electrode was an anode or a grid, depending on whether or not it drew current. Mr. Rockwood had referred to the minutes of a JETEC committee on cathode-ray tubes in which this difficulty was recognized, and had recommended some joint action be taken to improve the definitions, based upon a generally acceptable philosophy. This matter was referred to R. B. Janes for further action and Chairman O'Neill suggested that a member of the JETEC committee be recruited as a subcommittee member. It was decided that JETEC be notified of the change in attitude of Committee 7 toward the use of the shortened terms and that the definition in question is one of several which will be under review shortly for possible revision. Comments from the Standards Committee concerning the klystron definitions did not require action, with the exception of electronic efficiency. However, the discussion of electronic efficiency and circuit efficiency, revealed that these definitions were redundant, in the opinion of the Committee, and it was decided that they be deleted. Output-circuit electronic efficiency was added to the list of klystron definitions. R. M. Ryder presented the final draft of the proposed methods of test for noise. L. S. Nergaard and W. J. Dodds presented a complete roster of definitions recently or currently under consideration by this Committee.

On December 12, 1952, under the Chairmanship of P. C. Sandretto the **Navigation Aids** Committee convened. R. E. Gray who is compiling a list of all the terms defined this year reported discrepancies in the existing definitions of deviation sensitivity, low clearance field, and true axis of the nutation field. Corrections were made by the Committee. Action on the terms crystal holder, crystal-video figure of merit, output noise ratio, and crystal current sensitivity were deferred until the next meeting. The Committee took up the second half of Harry Davis' list of terms, which were under consideration for the remainder of the meeting.

The **Video Techniques** Committee, under the Chairmanship of W. J. Poch, met on December 9, 1952. A. J. Baracket reported on the Subcommittee on Video Systems and Components. Reports on geometric distortion and pickup-tube interlacing are ready for subcommittee action. A number of other reports are in preliminary stages of preparation. J. L. Jones summarized progress of the Subcommittee on Methods of Measurement of Video Transmission. Promising results have been obtained by the use of special signals for checking amplifier linearity and the preparation of a report has been initiated. Dr. Athey reported for the Subcommittee on Video Utilization. Several matters should come before the Subcommittee in the near future, such as a recommendation for a method of measurement on X-ray radiation, a re-evaluation of L. D. Grignon's tutorial paper on video recording, and a report on the reaction from network representatives to the questionnaire submitted some time ago. It was suggested that this Subcommittee review the proposed definitions in the field of video recording and make recommendations to the Video Techniques Committee for terms which should be standardized.

The **Radio Transmitters** Committee met on December 12, 1952, under the Chairmanship of M. R. Briggs. Chairman Briggs summarized the work done with the Annual Review and expressed his appreciation to members for their cooperation in voluntarily having accepted assignments and for their promptness in submitting summaries to P. J. Herbst. Chairman Briggs read a letter from J. B. Heffelfinger, Chairman of Subcommittee 15.3, Double Sideband AM Transmitters, who reported that his group is still working to produce a rough draft of the Standards on Double Sideband Transmitters: Methods of Testing. Harold Goldberg, Chairman of Subcommittee 15.4, Pulse-Modulated Transmitters, reported that his Subcommittee has completed the final draft of its proposed Standards on Methods of Measurement of Pulse Quantities. A. E. Kerwien, Chairman of Subcommittee 15.5, Single Sideband Radio Communication Transmitters, reported that during two recent meetings the group has attempted to define a number of terms of special significance to the single sideband transmitter field. Considerable progress has been made on a number of terms, which will enable the group to commence work on the methods of test soon. The remainder of the meeting was devoted to a review of the Proposed Standards on Methods of Measurement of Pulse Quantities, as resubmitted by Subcommittee 15.4. Dr. Goldberg outlined the work done and pointed out that the recommendations made last January for the most part had been incorporated in the present draft. The comments resulting from the discussion by the Radio Transmitters Committee will be passed along to Dr. Goldberg's subcommittee for review at their next meeting. It was the general opinion that every effort should be made to submit the standard to the measurements coordinator at an early date.

The **Standards** Committee did not hold a meeting during the month of December.

IRE Officers and Directors Appointed for 1953 Term

The IRE Board of Directors, at its annual meeting on January 7, 1953, New York, N. Y., appointed six officers and directors for the year 1953.

Haraden Pratt, telecommunications adviser to the President, was reappointed Secretary of the Institute, a post he has held since 1943. W. R. G. Baker, vice president of the General Electric Co., Syracuse, N. Y., was appointed Treasurer for the third successive year. A. N. Goldsmith, consulting engineer, was appointed Editor, an office he has held since the IRE was founded in 1912.

Appointed as directors for 1953 were R. D. Bennett, technical director, United States Naval Ordnance Laboratory, Silver Spring, Md.; W. R. Hewlett, vice president, Hewlett Packard Co., Palo Alto, Calif.; and A. V. Loughren, vice president in charge of research, Hazeltine Electronics Corp., Little Neck, L. I., N. Y.

MIT Offers Electronic Fellowships

A number of Graduate and Advanced Research Fellowships is offered by the Massachusetts Institute of Technology for study and research in the field of electronics. These "Industrial Fellowships in Electronics" are sponsored jointly by a group of industrial organizations concerned with the advancement of electronics and its applications.

Recipients of Student Fellowships will be awarded a stipend varying between $1,500 and $2,400, according to their experience and qualifications, and in addition will be granted a credit to meet the tuition fee. Advanced Research Fellowships will range from $3,000 upwards, according to the qualifications of the recipient.

Applicants should communicate with the Director, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass. Application should be made at least four months prior to the intended date of entrance.

URSI-IRE Meeting Scheduled for April

A meeting of the USA National Committee of the International Scientific Radio Union (URSI) and the IRE Professional Group on Antennas and Propagation is being held at the National Bureau of Standards, Washington, D. C., April 27–30, 1953.

Sessions of the meeting will be concerned with the topics of radio measurement methods and standards, tropospheric radio propagation, ionospheric radio propagation, terrestrial radio noise, radio astronomy, radio waves and circuits (including general theory), and electronics.

A preliminary program and advance registration forms will be available after March 16, 1953. These and further information about the meeting may be obtained from A. H. Waynick, Secretary, USA National Committee of URSI, The Pennsylvania State College, State College, Pa.

A certificate of recognition and pocket-size slide rule were presented to Vince Di Caudo (left), Akron, Ohio, by Irving Knapp on behalf of the Akron IRE Section, for Di Caudo's scholarship, interest, and achievement at the college of engineering, University of Akron.

Technical Conference Scheduled in Cincinnati

The Seventh Annual Spring Technical Conference, sponsored by the Cincinnati IRE Section, will be held April 18, 1953, Cincinnati, Ohio.

The Conference, which is the only IRE technical conference national in scope and entirely devoted to television, will be of interest to all executives, engineers, and technical personnel in television and allied fields. Papers to be presented will include the latest information in various phases of the art and will deal with material unpublished to date.

The list of speakers and papers to be delivered at the conference are as follows:

Morning Session, April 18

"Television and the Bell System," (speaker to be announced)

"A High Powered UHF-TV Broadcast System," F. J. Bias, General Electric Co., Syracuse, N. Y.

"The Design of TV Receivers Utilizing NON-Synchronous Power," G. D. Hulst, DuMont Laboratories, Inc., Clifton, N. J.

"Approach to Mechanized Assembly of Electronic Equipment Applicable to TV Receivers," L. K. Lee, Stanford Research Institute, Stanford, Calif.

Afternoon Session, April 18

"The Selection and Amplification of UHF Television Signals," Wilson Boothroyd and John Waring, Philco Corp., Philadelphia, Pa.

"Transient Considerations in the NTSC Color System," B. S. Parmet, Motorola, Inc., Chicago, Ill.

"A Four Gun Tube for Color Television Receivers," John Rennick and Charles Heuer, Zenith Radio Corp., Chicago, Ill.

"Latest NTSC Color System," (Orange Cyan Wide Band), R. D. Kell and A. C. Schoeder, RCA Laboratories, Princeton, N. J.

All information regarding advertising exhibits should be directed to R. H. Lehman, the Baldwin Company, 1801 Gilbert Avenue, Cincinnati, Ohio.

Matters of advance registration for the conference, including hotel, luncheon, and banquet reservations, should be directed to: A. C. Wahl, P.O., Box 8, Green Hills 18, Ohio. A late registration may be made at the conference.

Nonlinear Circuit Analysis Symposium Announced

An international symposium on Non-Linear Circuit Analysis will be held on April 23–24, 1953, at the Engineering Societies Building Auditorium, New York, N. Y.

The symposium, organized by the Polytechnic Institute of Brooklyn with the co-operation of the IRE Professional Group on Circuit Theory and with the co-sponsorship of the Office of Naval Research, Air Research and Development Command, and the Signal Corps, will be of particular interest to those working in the field of nonlinear systems. It is intended to cover the basic exposition of nonlinear phenomena and the fundamental mathematical methods of analysis, as well as illustrative applications to nonlinear electronic circuits, magnetic circuits, feedback systems, and feedback-control systems. American and European authorities, who have made original contributions to the art, will participate.

No registration fee will be charged for admission to the Symposium. However, all persons interested in attending are urged to register early. Copies of the detailed program, hotel accommodation information, and registration forms are available on request to: Polytechnic Institute of Brooklyn, Microwave Research Institute, 55 Johnson Street, Brooklyn 1, N. Y.

A "Proceedings of the Symposium on Nonlinear Circuit Analysis" will be published by October, 1953, at four dollars per copy. Members of the IRE Professional Group on Circuit Theory may obtain copies at three dollars per copy. Orders for the Proceedings, accompanied by check or money order made out to "Treasurer, Nonlinear Symposium," will be accepted in advance, at the above address.

1953 IAS Officers Announced

The Institute of the Aeronautical Sciences has announced the new officers for 1953. They are as follows.

President: C. J. McCarthy, United Aircraft Corporation.

Vice-Presidents: G. W. Brady, Curtiss-Wright Corporation; C. L. Johnson, Lockheed Aircraft Corporation; J. S. McDonnell, Jr., McDonnell Aircraft Corporation; E. G. Stout, Consolidated Vultee Aircraft Corporation.

Treasurer: P. R. Bassett, Sperry Gyroscope Company.

Director: S. P. Johnston.

Secretary: R. R. Dexter.

Controller: J. J. Maitan.

The men assumed the duties of their respective offices at the IAS Twenty-first Annual Meeting, January 26–29, 1953, Hotel Astor, New York, N. Y.

Professional Group News

Broadcast Transmissions Systems

The Boston Chapter of the Broadcast Systems Group held a meeting recently at Radio Station WCOP, Boston, Mass., P. K. Baldwin presiding. Twelve broadcast stations were represented. During the meeting a paper was presented on "The Future Prospects of UHF Television," by W. Y. Pan, RCA Victor Division, and an RCA film was shown entitled, "Success Hill."

Communications Systems

The Professional Group on Communications is planning a Symposium on Radio Communications, June 11–12, 1953, New York, N. Y.

The program will include technical sessions in the auditorium of the American Telephone and Telegraph Long Lines Building, New York City, and an inspection trip to the AT&T overseas radiotelephone transmitting and receiving stations at Lawrenceville and Netcong, N. J.

The Washington Chapter of the Communications Group has been officially approved by the IRE Executive Committee. At the inaugural meeting held in February the following officers were elected: Chairman, C. L. Engleman, United States Navy; Vice Chairman, W. C. Boese, Federal Communications Commission; Secretary, J. D. Wallace, Naval Research Laboratory. A documentary film, "Communications Systems of Operation Sandstone," was shown.

Electronic Computers

The Washington Chapter of the Electronic Computers Group has been officially approved by the IRE Executive Committee.

At the chapter's inaugural meeting held at the PEPCO Auditorium, Washington, D. C., the following officers were elected: Chairman: C. V. L. Smith, Office of Naval Research; Vice Chairman, D. H. Jacobs, Jacobs Instrument Company; Secretary, R. J. Slutz. National Bureau of Standards. The program included a paper on "How the Univac Predicted the Election," by H. F. Mitchell, Jr., Eckert, Mauchly Division, Remington Rand, Incorporated.

The San Francisco Chapter of the Electronic Computers Group also has been approved by the IRE Executive Committee. T. H. Meisling, University of California, is chairman protempore.

Engineering Management

An organizational meeting headed by F. W. Schor, Motorola, Inc., was held recently by the Chicago Chapter of the Engineering Management Group. The chapter has been officially approved by the IRE.

Notice!

Ultrasonics Professional Group

A petition to form an IRE Professional Group on Ultrasonics has been received. The proposed Group will hold an informal meeting at the 1953 IRE National Convention, Thursday from 1:30 to 2:30 p.m. in the Blue Room of the Grand Central Palace. All those interested in the activities of such a professional Group are urged to attend.

Transactions of IRE Professional Groups

The following issues of Transactions are available from the Institute of Radio Engineers, Inc., 1 East 79 Street, New York 21, N. Y., at the prices listed below.

Sponsoring Group	Publication	Group Members	IRE Members	Non-members*
Airborne Electronics	PGAE-4; "The Selectivity and Intermodulation Problem in UHF and Communication Equipment" (11 pages)	$0.45	$0.65	$1.35
	PGAE-5; "A Dynamic Aircraft Simulator for Study of Human Response Characteristics" (6 pages)	.30	.45	.90
	PGAE-6; "Ground-to-Air Co-Channel Interference at 2900 MC (10 pages)	.30	.45	.90
Antennas and Propagation	PGAP-4; IRE Western Convention, August, 1952 (136 pages)	2.20	3.30	6.60
Audio	PGA-5; "Design Interrelations of Records and Reproducers," by H. I. Reiskind (8 pages)	.30	.45	.90
	PGA-6; Editorials, Technical Papers, and News (42 pages)	.80	1.20	2.40
	PGA-7; Editorials, Technical Papers, and News (48 pages)	.90	1.35	2.70
	PGA-8; July 1952 Issue (40 pages)	.80	1.20	2.40
	PGA-9; September–October Issue (28 pages)	.60	.90	1.80
	PGA-10; November–December Issue (28 pages)	.70	1.05	2.10
	Vol. AU-1, No. 1; January–February Issue (24 pages)	.60	.90	1.80
Broadcast and Television Receivers	PGBTR-1; Round-Table Discussion on UHF-TV Receiver Consideration Presented at 1952 IRE National Convention, March 6, 1952, New York, N. Y. (12 pages)	.50	.75	1.50
Circuit Theory	PGCT-1; IRE Western Convention August, 1952 (100 pages)	1.60	2.40	4.80
Electron Devices	PGED-1; Papers from IRE Conference on Electron Tube Research and IRE-AIEE Conference on Semiconductor Research, June, 1952 (32 pages)	.80	1.20	2.40
Electron Devices	PGED-2; Papers on Electron Devices presented at the IRE Conference on Electron Tube Research, Ottawa, Ont., Canada, June 16–17, 1952 and the IRE Western Convention, Long Beach, Calif. (84 pages)	1.60	2.40	4.80
Electronic Computers	PGEC-1; Papers presented at Technical Sessions on Electronic Computers at Western Electronic Show and Convention, August 27–29, 1952, Long Beach, Calif. (75 pages)	1.50	2.25	4.50
Quality Control	PGQC-1; Papers presented at 1951 Radio Fall Meeting, and 1952 IRE National Convention, (60 pages)	1.20	1.80	3.60
Vehicular Communications	PGVC-2; Symposium on What's New in Mobile Radio (32 pages)	1.20	1.80	3.60

* Public libraries and colleges can purchase copies at IRE Member rates.

IRE People

Nathaniel K. Zelazo (M'47–SM'52) has been appointed vice president of the Ketay Manufacturing Corporation of New York City and Los Angeles, designers and manufacturers of electronic equipment. Mr. Zelazo's responsibilities include organizing industrial and government sales, and co-ordinating the corporation's research and development work. He was formerly with the Department of Defense as acting chief of the special projects division in the Electronics Production Resources Agency, Washington, D. C., and closely associated with the Munitions Board and its industry advisory committees.

N. K. Zelazo

Mr. Zelazo was born in Lomza, Poland, and received the B.S. degree from the College of the City of New York in 1940. He did graduate work at Columbia University and George Washington University. At the beginning of World War II, Mr. Zelazo was associated with the Army Air Force in their procurement of aircraft instruments and later transferred to the Army Signal Corps Radar Laboratory at Belmar, N. J. From 1942–1947, he was with the Bureau of Ships, Navy Department, as a project engineer on development of fire-control radar equipments. From 1947–1950, Mr. Zelazo was head of the bureau's miniaturization unit and as a result of his activity, the Research and Development Board established a subpanel on miniaturization for which he served as the first secretary. Prior to leaving the Navy Department, Mr. Zelazo was systems engineer and electronic consultant to the Armament Division, Bureau of Aeronautics.

❖

Arthur Albert Dyson (A'33) has been appointed an Officer of the Most Excellent Order of the British Empire, according to Her Majesty's New Year Honours List.

Mr. Dyson began his career as works manager for Pritchard and Simpson of Newcastle, England, in 1929. In 1932 he became works manager for Erie Resistor, Ltd., of London. He is now managing director and chief engineer of Eire Resistor.

❖

Gerard Lehmann (SM'44) has been elected president of the French National Committee of the International Scientific Radio Union (URSI) for the next three years.

Mr. Lehmann was born in Paris, France, on April 6, 1909. After receiving his degree in engineering from the École Centrale, in 1931, he became associated with the Sadir Company as a technical director, building vhf communications and radio navigation equipment.

After serving with the French Army until 1940, he joined the Lyon laboratory of Le Matériél Téléphonique. In 1943 he came to the United States and worked as a research engineer with Federal Telephone and Radio Laboratories. He later returned to Le Matériél Téléphonique in France.

In addition to research work, Mr. Lehmann has taught at the École Central and was appointed professor of direction finding and radio navigation at the École Supérieure d'Électricité. At present he is the scientific director of Laboratoire Central de Télécommunications, Paris, France.

❖

Bernard Hecht (M'45) has entered the field of quality control consulting, specializing in the problems of electronics industry.

Bernard Hecht

Mr. Hecht received the B.E.E. degree from the School of Technology City College of New York, and the M.S. degree from the University of Pennsylvania. At the beginning of World War II, he was a civilian officer in charge of radio inspection for the Signal Corps. In 1943 he was selected to represent the United Army-Navy Specification Program for electronic components, embracing the standardization of tubes, resistors, capacitors, and transformers. Later, he was assigned to aid in the reconversion to peacetime production the plant operation of the International Resistance Company. He has managed quality control for such firms as the Starrett Television Corporation and RCA Victor.

Mr. Hecht has lectured on quality control subjects at Temple, Princeton, and Rutgers Universities. He is a member of Tau Beta Pi, and a senior founding member of the American Society for Quality Control. He has served as Vice Chairman of the IRE Professional Group on Quality Control.

❖

H. B. Steinhauser (M'51) has been named manufacturing engineer of the Dumont Laboratories, Inc., instrument division.

Mr. Steinhauser was born in Norwich, N. Y., on July 25, 1914, and received the E.E. degree at Rensselaer Polytechnic Institute in 1934. In 1935 he became a junior radio engineer at the General Electric Company in Bridgeport, Conn., and then transferred to the Western Electric Company in Kearny, N. J., as test maintenance engineer. In 1938 he joined the Sperry Gyroscope Company as a production engineer, and in 1944, he became associated with the Boonton Radio Corporation as production manager. He later became administrative assistant to the general manager.

Mr. Steinhauser was a senior engineer with the Instrument Division of Dumont Laboratories, Inc., before his promotion.

Earl G. Ports (A'25–M'33–SM'43), assistant technical director of Federal Telecommunication Laboratories, Inc., Nutley, N. J., died recently at his home in Livingston, N. J.

E. G. Ports

Mr. Ports was born in Hanover, Pa., on August 14, 1901. He received the B.S. degree in electrical engineering in 1923, and the M.S. degree in physics in 1925, at Gettysburg College.

Serving on the engineering staff of the Bell Telephone Laboratories until 1929, he joined the International Telephone and Telegraph Corporation as an engineer with the International Communication Laboratories. In 1932, he became a transmitter engineer with the Federal Telegraph Company, Newark, N. J., and in 1934, he was appointed chief engineer. In 1942, Mr. Ports became manager of the communications product division of the Federal Telephone and Radio Corporation. He later held the positions of technical director, assistant vice president, and chief engineer and assistant manager of the radio division at FTR.

In 1947, Mr. Ports received the Navy Department's Certificate of Commendation for outstanding assistance in organizing and supervising the radio engineering staff at FTR, engaged in the development of radio transmitters, receivers, and direction finders for the United States Navy.

Mr. Ports served on the IRE Committees of Annual Review, Standards, and Transmitters and Antennas. He also served on committees of the Radio and Television Manufacturers Association, Radio Technical Commission for Aeronautics, National Electrical Manufacturers Association, and the American Standards Association. He was a fellow of the American Institute of Electrical Engineers.

Alex A. Javitz (A'48) has been named special features editor of *Electrical Manufacturing*. He was previously associate editor of the publication.

Mr. Javitz was born in New York, N. Y., and attended Columbia University. He received the B.S. degree in 1918 from the Cooper Union School of Engineering.

He is a member of the American Chemical Society, the Society of Plastics Engineers, the Inter-Society Color Council, and the Conference on Electrical Insulation.

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NOTE: The Institute of Radio Engineers does not have available copies of the publications mentioned in these pages, nor does it have reprints of the articles abstracted. Correspondence regarding these articles and requests for their procurement should be addressed to the individual publications, not to the IRE.

The Annual Index to these Abstracts and References, covering those published in the PROC. I.R.E. from February 1952, through January 1953, may be obtained for 3s. 9d. postage included from the *Wireless Engineer*, Dorset House, Stamford St., London, S.E., England. This Index includes a list of the journals abstracted together with the addresses of their publishers.

The number in heavy type at the upper left of each Abstract is its Universal Decimal Classification number and is not to be confused with the Decimal Classification used by the United States National Bureau of Standards. The number in heavy type at the top right is the serial number of the Abstract. DC numbers marked with a dagger (†) must be regarded as provisional.

ACOUSTICS AND AUDIO FREQUENCIES

534.21-14:534.321.9 302

† Critical [wave-] Length for the Propagation of Free Waves in a Viscous Fluid—C. Truesdell. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 702–704; October 6, 1952.) A re-examination of the theories of Stokes and others leads to the conclusion that ultrasonic vibrations of wavelength less than a critical value, dependent on the viscosity of the medium, will be overdamped and will not be propagated. Values of the critical wavelength are given for several fluids; the value for water at 15°C is 5×10^{-7} cm.

534.32:621.396.619.11/.13 303

The Limits of Perception of Amplitude- and Frequency-Modulation of a Pure Tone—E. Zwicker. (*Akus. Beihefte*, no. 3, pp. 125–133; 1952.) Measurements were made on tones of different pitch and loudness as a function of the modulation frequency (f). Below a certain value of f, about 30 cps for low tones, rising to 1 kc for tones around 10 kc, AM is perceived more readily than FM, but above this limiting frequency no difference between AM and FM is perceptible. The effect of the slope of the response curve of a transmission system on the perceptibility of FM was also investigated.

534.322.1:621.3.018.78 304

The Perception of Nonlinear Distortion in the Transmission of Musical Two-Tone Combinations—R. Feldtkeller. (*Akus. Beihefte*, no. 3, pp. 117–124; 1952.) In comparisons of the timbre of a sustained fifth before and after transmission through a nonlinear system, changes of a few parts per thousand are perceptible in the case of third-harmonic distortion, and of a few per cent with second-harmonic distortion. Loud high-pitch combinations are most susceptible to distortion. Harmonics due to the transmission system not only change the timbre but also render errors of intonation more evident.

534.615-14 305

Acoustic Particle-Velocity Measurements in Liquids with the Rayleigh Disk—A. Kösters. (*Akus. Beihefte*, no. 3, pp. 171–174; 1952.) Tests by two methods confirm Wood's corrections (3945 of 1935) of the König formula for Rayleigh-disk measurements. The results are not in agreement with King's theory (638 of 1936). Rigid disks are found necessary for reliable measurements. Disk rotation is independent of the viscosity of the surrounding liquid.

534.75 306

The Memory for Acoustic Effects—F. Enkel. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 4, pp. 142–143; July/August, 1952.) Subjective tests show that there are two different types of musical memory, termed respectively "linear" and "polar." The former discriminates on the basis of pitch differences and the latter on the basis of harmonic relations.

534.844.1 307

Composite Cathode Ray Oscillograph Displays of Acoustic Phenomena and their Interpretation—T. Somerville and C. L. S. Gilford. (*BBC. Quart.*, vol. 7, pp. 41–53; 1952.) A microphone receiving the test sound feeds a logarithmic amplifier; the dc output is applied through a directly coupled amplifier to the y-plates of a cro with a variable-speed timebase triggered at the end of a tone pulse. Reverberation time is read directly on a graticule scale aligned with the trace. Reverberation times <0.1 second have been measured. By photographing succeeding traces as the frequency is increased, "pulsed glide displays" are obtained. The interpretation of these is discussed and their use in studying structural vibrations is illustrated. See also *Radio Commun.* (formerly *FM-TV*), vol. 12, pp. 22–23, 43, 28, 30, and 22–23, 38; June–August, 1952.

534.845 308

Resonance-Type Absorbers for Water-Borne Sound—E. Meyer and H. Oberst. (*Akus. Beihefte*, no. 3, pp. 149–170; 1952.) The materials investigated were rubber sheets 4 mm thick backed by steel plates of various thicknesses. The rubber contained cylindrical air cavities acting as resonant absorbers, the number of cavities per unit area being adapted to the thickness of the steel backing plate to obtain maximum absorption. Amplitude reflection factors of under 10 per cent, corresponding to energy absorption of over 99 per cent, have been obtained in the frequency range 9–18 kc. Measurement technique is described. Results are shown in numerous curves.

534.845 309

Helmholtz Resonators as Acoustic Treatment at the New Swansea Studios—F. L. Ward. (*BBC. Quart.*, vol. 7, pp. 174–180; Autumn, 1952.) Description of the fitting of resonators for sound absorption in a large orchestral studio. The resonators consist of hollow plaster castings with flanged plaster backs, and project from the wall surface. Partitions divide each unit into eight equal cavities; cardboard tubes, of adjustable length and diameter, are inserted through holes in the front of the unit and serve to vary the cavity resonance frequency. Fabric is fitted across the mouths of the tubes to vary the neck resistance. Results of absorption measurements in the studio are to some extent inconsistent with theory. Performance tests indicate that there is little masking by the bass instruments; the adequate sound diffusion results in good tone quality and enables performers to hear each other easily.

534.845:534.414 310

Acoustic Resonators as Sound Absorbers—A. Lauber. (*Tech. Mitt. schweiz. Telegr. TelephVerw.*, vol. 30, pp. 209–213; July 1 1952. In German and French.) Two types of resonator have been tested in the laboratory and in practice: (*a*) tubes of four different lengths, with overlapping response curves, and with characteristic impedance matched at the open end by means of cotton-wool pads; (*b*) cavity bricks with holes, constituting Helmholtz resonators. In contrast to porous absorbers, the absorption of these resonant types depends on the room damping. They are particularly applicable for frequencies below 200 cps.

534.845.2 311

Building-Material Acoustics: Comparative Measurements—G. Becker, G. Bobbert and H. Brandt. (*Akus. Beihefte*, no. 3, pp. 176–180; 1952.) A report of measurements, carried out in eight different establishments, on typical building materials and floor structures, using both airborne and impact sound. The accuracy of the various measurements is discussed in relation to the methods adopted, methods using airborne sound resulting in lower mean errors of individual measurements than those for impact sound.

621.395.623.42:534.6 312

The Suitability of Dynamic Headphones for Measurements on Frequency-Modulated Tones—E. Zwicker and G. Gässler. (*Akus. Beihefte*, no. 3, pp. 134–139; 1952.) Resonances in the ear passage are found to be highly damped and of low intensity. By using a pair of equalizer networks with headphones, the frequency response curve of the combination can be made level to within ±3 db from 20 cps to

15 kc, so that the arrangement can be used for measurements of *FM* tones.

621.395.623.7 313
Metal-Cone Loudspeaker—F. H. Brittain. (*Wireless World*, vol. 58, pp. 490–492; December, 1952.) Continuation of description noted in 18 of February. The cone, of diameter 6 inches, is sufficiently rigid without being too heavy. The speech coil is of diameter 1 inch and is wound on a turned duralumin former welded to the cone. Methods of mounting in a closed box or vented cabinet or in conjunction with an acoustic labyrinth are discussed.

621.395.623.75 314
Horn-Loaded Loudspeakers—D. J. Plach and P. B. Williams. (*Proc. NEC* (Chicago), vol. 7, pp. 108–114; 1951.)

621.396.645:621.395.625.2 315
A Gramophone Pickup Pre-amplifier—E. J. Miller. (*Electronic Eng.*, vol. 24, pp. 498–499; November, 1952.) Description, with detailed circuit, of an amplifier whose frequency-response curve can be adjusted to suit records with the N.A.B. characteristic or with the characteristics favored by the E.M.I. and Decca groups of companies.

681.8 316
Wear of Phonograph Needles—B. B. Bauer. (*Proc. NEC* (Chicago), vol. 7, p. 120; 1951.) Summary only.

789.983 317
An Electronic Music Box—E. L. Kent and C. J. Tennes. (*Proc. NEC* (Chicago), vol. 7, pp. 115–119; 1951.) Description of an instrument using tube tone generators, with independent controls for timbre, loudness, vibrato, and slur from one note to another. Keying is effected by a perforated roll of paper.

789.983 318
The Clavioline—G. H. Hillier. (*Electronic Eng.*, vol. 24, pp. 454–455; October, 1952.) Description, with detailed circuit diagrams, of a small keyboard electronic instrument covering five octaves. Only individual notes can be played. Eighteen stops for adjustment of tone quality, vibrato, etc., enable various instruments to be simulated.

ANTENNAS AND TRANSMISSION LINES

621.392:621.396.67 319
Antiresonant H.F. Transmission Lines: Input Impedance Characteristics—H. M. Barlow. (*Wireless Eng.*, vol. 29, pp. 334–335; December, 1952.) Discussion on paper noted in 2430 of 1952.

621.392.21.09 320
The Launching of Electromagnetic Waves on a Cylindrical Conductor—R. B. Dyott. (*Proc. IEE*, part III, vol. 99, pp. 408–413; November, 1952.) The efficiency of the launching process is found to depend on the apex angle and the aperture of the horn used, and the power loss in the process is probably due to the generation of complementary waves which dissipate their energy as heat in the conductor. Details are given of experiments on a surface-wave transmission line, using a wavelength of 6.5 cm and suggestions are made for reducing the launching loss.

621.392.26 321
Electromagnetic Propagation in Two-Dielectric-Layered Parallel-Plane Waveguides—J. van Bladel and T. J. Higgins. (*Proc. NEC* (Chicago), vol. 7, pp. 601–607; 1951.) Formulas are derived for the modes and eigenvalues of infinitely wide parallel-plane waveguides partly filled with solid dielectric, and from these formulas graphs are plotted of cut-off frequency for a range of geometrical and dielectric parameters. The characteristics of such waveguides are discussed and applications of these and corresponding rectangular waveguides are suggested.

621.392.26:621.315.61 322
Radiation from a Dielectric Wave Guide—R. M. Whitmer. (*Jour. Appl. Phys.*, vol. 23, pp. 949–953; September, 1952.) Continuation of the analysis noted in 17 of 1949. The modal efficiency of a dielectric slab is defined as the ratio between the power propagated in a mode (only one mode being propagated) and the sum of the guided and radiated powers; values of this efficiency are plotted for a range of parameters. In practice cylindrical rather than slab guides are used; similar values of efficiency are to be expected, viz., up to 80–90 per cent.

621.392.26:621.396.677 323
Shunt Conductance of a Waveguide-Fed Slot—H. J. Venema. (*Proc. NEC* (Chicago), vol. 7, pp. 568–581; 1951.) A method is described for calculating the shunt conductance of a rectangular slot in a perfectly conducting infinite plane, the slot being excited by means of a rectangular waveguide normal to the plane The shunt conductance is given in terms of the aspect ratio of the slot and the excitation frequency. Experimental results confirm the theory.

621.396.67 324
A Dipole with a Tuned Parasitic Radiator—R. King. (*Proc. IEE*, part III, vol. 99, pp. 406–407; November, 1952.) Discussion on paper abstracted in 1202 of 1952.

621.396.677.2.029.64 325
Contribution to the Study of Dielectric Aerials—M. Bouix. (*Ann. Télécommun.*, vol. 7, pp. 217–238, 276–295, 336–348 and 350–363; May–September, 1952.) Practical arrangements of cylindrical and tapered dielectric-rod antennas are described and their radiation fields discussed. Coupling is effected by means of a circular aperture in a rectangular waveguide. Measurements of coupling impedance at wavelengths of 3 and 10 cm are reported; detailed descriptions are given of measurement apparatus and of a method for recording radiation diagrams. The theory of the dielectric radiator is then developed. A treatment of Schelkunoff's equations relative to an infinite cylinder is applied to derive a series of curves giving design parameters for EM_{11}-mode propagation. An infinite number of modes exist, for one of which there is no cut-off frequency. Numerical calculations are made for materials with a specific dielectric constant, including polythene, and design curves are given. Field equations are derived for transmission lines consisting of an outer dielectric coating on (*a*) a cylindrical conductor, (*b*) another dielectric, including the case of an air-filled tube. A theoretical treatment of the coupling and the gain of different arrays is given, with notes on practical designs.

621.396.677.3 326
Parabolic Aerials with Extremely Good Matching—O. Laaff. (*Fernmeldetech. Z.*, vol. 5, pp. 406–411; September, 1952.) The effect of the impedance of a radiating element located in front of a parabolic reflector is analyzed, and it is shown how this effect can be eliminated or, alternatively, used for matching the radiator to its feeder. The effect of axial defocusing of the radiator is discussed, and the reduction of parabola reaction on the radiator by means of a compensating disk a little distance in front of the vertex of the parabola is shown by a set of curves for a parabola 3 m in diameter and focal length 75 cm. The effect of a compensating disk on the radiation diagram is also considered.

621.396.677.5 327
The Radiation Resistance of a Small Horizontal Loop Antenna over a Conducting Plane—R. M. Powell. (*Proc. NEC* (Chicago), vol. 7, pp. 582–597; 1951.) The radiation component of the resistance of small loop antennas is measured at uhf by shielding the loop to prevent radiation, and substituting a known or calculable load resistance for the series radiation resistance of the loop. Measurements in the range 300–400 mc are checked by an indirect method. The accuracy of the measurements is to within about ±5 per cent.

CIRCUITS AND CIRCUIT ELEMENTS

519.242:621.3 328
Theory of the Prediction and Filtering of Stationary Time Series according to Norbert Wiener—H. Jacot. (*Ann. Télécommun.*, vol. 7, pp. 241–249, 297–303 and 325–335; May–August, 1952.) Digest of Wiener's book "The Extrapolation, Interpolation and Smoothing of Stationary Time Series, with Engineering Applications" (2465 of 1950).

621.314.13:535.215 329
Equipment for Amplification of Weak Photoelectric Currents—P. Dumontet. (*Jour. Phys. Radium*, vol. 13, Supplement, pp. 127A–128A; July/September, 1952.) Description, with detailed circuit diagram, of equipment using a double electrometer tube (Mazda Type E2) the currents in which are modulated by a square wave applied to the extraction grids, the photoelectric voltage being applied to the control grids.

621.314.25 330
Changing the Phase of a Low-Frequency Sinusoid—P. Huggins. (*Electronic Eng.*, vol. 24, pp. 462–464; October, 1952.) Description of various methods suitable for manual or automatic control, or combined automatic and manual control, of the phase of a sinusoidal low-frequency voltage.

621.314.25:621.392.26 331
Modified Magic-Tee Phase Shifter for Microwaves—R. H. Reed. (*Tele-Tech*, vol. 11, pp. 50–52; June, 1952.) The modified unit described has the symmetrical arms parallel to each other, thus allowing both short-circuiting plungers to be linked to a common drive. The E- and H- plane arms are replaced by "odd" and "even" coupling slots. Owing to the existence of several sources of impedance mismatch in the complete phase shifter, which uses a second magic-T junction, a special alignment procedure is necessary.

621.314.3† 332
Basic Operating Principles of Magnetic Amplifiers—E. V. Weir. (*Proc. NEC* (Chicago), vol. 7, pp. 235–240; 1951.)

621.314.3† 333
Low-Input-Power-Level Magnetic Amplifiers—L. W. Buechler. (*Proc. NEC* (Chicago), vol. 7, pp. 254–259; 1951.

621.314.3† 334
Rules of Similitude for Magnetic-Amplifier Systems—L. A. Finzi and H. L. Durand. (*Proc. NEC* (Chicago), vol. 7, pp. 498–514; 1951.) Rules are established which enable the properties of magnetic-amplifier systems to be deduced from the results of suitable tests on a "model" amplifier or analogue computer. The method covers cases in which model and prototype have different core materials and different circuits.

621.314.3†:621-526 335
The Application of a 60-Cycle Magnetic Amplifier to a Position-Indicating Servomechanism—A. E. Schmid. (*Proc. NEC* (Chicago), vol. 7, pp. 515–522; 1951.)

621.314.3† 336
A Magnetic Amplifier of High Input Impedance—G. M. Ettinger. (*Proc. NEC* (Chicago), vol. 7, pp. 523–528; 1951.)

621.314.3† 337

Use of the Flux-Charge Concept in Magnetic-Amplifier Analysis—P. M. Kintner. (*Proc. NEC* (Chicago), vol. 7, pp. 529–536; 1951.)

621.314.3† 338

A Series Magnetic Amplifier with Inductive Loading—T. G. Wilson. (*Elec. Eng.* (N. Y.), vol. 71, p. 729; August, 1952.) Analysis and discussion of the manner in which the current waveform is affected by varying the circuit resistances, inductances or control voltage. Digest only; full paper to be published in *Trans. Amer. IEE*, vol. 71; 1952.

621.396.729 339

A Synchronizing Circuit for Variable Input Voltages—P. A. V. Thomas. (*Electronic Eng.*, vol. 24, p. 509; November, 1952.) Description of a circuit suitable for use with a cro.

621.316.86 340

Boroncarbon Resistor Characteristics—G. Kende. (*Tele-Tech.*, vol. 11, pp. 48–49; 75; August, 1952.) Further developments are described leading to the mass production of ½-W resistors with extremely stable characteristics. See also 583 and 2365 of 1951 (Grisdale *et al.*).

621.316.86 341

Shaping of Nonlinear-Resistor Characteristics—J. J. Baruch. (*Proc. NEC* (Chicago), vol. 7, pp. 537–541; 1951; *Tele-Tech*, vol. 11, pp. 42–43, 88; June, 1952.) Feedback circuits are described which enable a wide variety of characteristics to be obtained with a single resistive element.

621.316.86:537.312.092 342

Effect of Pressure on the Resistance of a Thermistor—P. Tavernier and P. Prache. (*Jour. Phys. Radium*, vol. 13, pp. 423–426; July/September, 1952.) Measurements at canstant temperatures from 30° to 70°C and pressures up to 5,000 kg/cm² show that the relative diminution of the resistance of a thermistor for a given change of pressure is practically independent of temperature and is given by the formula $\Delta R/R_0 = -4.6 \times 10^6\ P$, P being expressed in kg/cm².

621.318.57 343

All-Triode Electronic Switch—C. W. Spindler, Jr. (*Electronics*, vol. 25, pp. 172, 174; November, 1952.) The basis of the arrangement described is a gate circuit using two high-μ triodes cathode-coupled respectively to two high-transconductance triodes, the grids of the latter being coupled to the anodes of a multivibrator.

621.319.4:621.315.614.6 344

Metallized-Paper Capacitors—H. Elsner. (*Bull. schweiz. elektrotech. Ver.*, vol. 43, pp. 721–727; September 6, 1952. In German.) Review of the development, construction and characteristics of this type of capacitor, particularly those using impregnated paper. Test methods are noted.

621.319.4:621.315.614.64 345

High-Temperature Operation of Metallized-Paper Capacitors—L. Kahn. (*Proc. NEC* (Chicago), vol. 7, pp. 561–567; 1951.) Discussion of results obtained with capacitors impregnated with aerolene, a solid polyester, which permits operation at 100°C without derating, and up to 125°C with a derating of 25 per cent, the capacitance value at 125°C being 15 per cent higher than at room temperature.

621.392.087.6 346

An Electronic Square-Law Circuit for Use with a Graphic Recorder—M. J. Tucker. (*Electronic Eng.*, vol. 24, pp. 466–468; October, 1952.) The curvature of tube characteristics is used to produce an output voltage proportional to the square of the input voltage. Circuit details are given of a mean-square-value meter suitable for graphic recording of the output.

621.392.5:534.321.9:534.133 347

Performance of Ultrasonic Vitreous Silica Delay Lines—M. D. Fagen. (*Proc. NEC* (Chicago), vol. 7, pp. 380–389; 1951.) See 2462 of 1952.

621.392.5.018.75 348

The Synthesis of a Network to have a Sine-Squared Impulse Response—W. E. Thomson. (*Proc. IEE*, part III, vol. 99, pp. 373–376; November, 1952.) The method of moments, of the "mean moment" type used by Moss (619 of 1952), is applied to the problem of designing a network with an impulse response of prescribed form. The method is not applicable in all cases, but is particularly suitable for the design of a low-pass system with not too sharp a cut-off and not too oscillatory an impulse response. Calculation for the case of the sine-squared pulse results in design data for a ladder network of 3 inductors and 6 capacitors, with resistive terminations. The discrepancy between the impulse-response curve and the exact sine-square curve at no point exceeds 2 per cent of the peak amplitude of the pulse.

621.392.52:518.4 349

New Graphical Methods for Analysis and Design—W. Saraga. (*Wireless Eng.*, vol. 29, p. 334; December, 1952.) Reply to comment by Schneider (2751 of 1952) on paper noted in 1546 of 1952 (Saraga and Fosgate).

621.392.52:621.3.015.3 350

The Transient Response of R.F. and I.F. Filters to a Wave Packet—A. W. Gent. (*Proc. IEE*, part III, vol. 99, pp. 414–416; November, 1952.) Summary only. Analysis based on Fourier-integral transforms is applied to two particular circuits: (*a*) a single stage of tuned-anode coupling; (*b*) a single stage of tuned-transformer coupling. The analysis is valid for circuits of any bandwidth. Particular attention is paid to the build-up time of a transient, which for a band-pass network is usually assumed to be inversely proportional to the network bandwidth. The analysis shows that this assumption is correct for the tuned-anode coupling circuit if the ratio of the half-bandwidth to the resonance frequency is less than unity. For the tuned-transformer circuit, however, the rule does not hold good, since for a given bandwidth there are many possible transfer impedances, and hence transient responses. The rule should therefore only be applied to circuits to which its application is shown to be legitimate.

621.392.52.029.426 351

High-*Q* Low-Frequency Resonant Filters—J. S. Brown and W. Thayer, Jr. (*Proc. NEC* (Chicago), vol. 7, pp. 92–96; 1951.) Two 30-cps resonant filters are described in which a Q-factor >1,000 is obtained by application of positive feedback. Normal methods used for Q measurement are of little use on these circuits. A method based on the relation of Q to the transient response is described.

621.396.6 352

Printed Unit Assemblies for TV—W. H. Hannahs and N. Stein. (*Tele-Tech*, vol. 11, pp. 38–40, 120; June, 1952.) Etching and silk-screening techniques, and their suitability for the production of various circuit elements, are discussed. Experimental results are quoted which show that the performance of etched coils compares favorably with that of wire-wound coils.

621.396.6 353

Etched Circuits—(*Wireless World*, vol. 58, p. 488; December, 1952.) A brief note on the Technograph system for producing printed circuits and components, with special reference to the production of mains transformers.

621.396.61:621.357.7 354

Printed Circuits for Home Radio Receivers—E. Waverling. (*Electronics*, vol. 25, pp. 140–142; November, 1952.) Units for 5-tube superheterodyne sets are produced by plating conductors on to a plastic base in which holes have been punched previously. The walls of the holes are plated at the same time, thus providing connections and terminal points.

621.396.6.002.2 355

New Developments in the Auto-sembly Technique of Circuit Fabrication—S. F. Danko. (*Proc. NEC* (Chicago), vol. 7, pp. 542–550; 1951.) Various applications of the technique previously described [2949 of 1951 (Danko and Lanzalotti)] are reviewed. New copper-faced plastics are suitable for production of equipment for operating temperatures up to 200°C. Use of a solder-resistant paint or lacquer enables joints only to be soldered in the solder-dip process. Typical examples of circuits and assemblies produced by this method are illustrated.

621.396.611.1:518.4 356

Graphical Analysis for Circuits containing Overdriven Vacuum Tubes—R. J. Parent. (*Proc. NEC* (Chicago), vol. 7, pp. 263–274; 1951.) Methods of approach and graphical constructions for use in analysis of circuits such as those used for pulse forming and wave shaping are described, with applications to particular circuits.

621.396.611.21 357

Thickness Vibrations of Piezoelectric Crystal Plates—R. Bechmann. (*Arch. elekt. Übertragung*, vol. 6, pp. 361–368; September, 1952.) Continuation of investigation noted in 150 of 1941. The retroaction occurring in piezoelectric processes modifies not only the modulus of elasticity but also the direction of motion. The influence of this secondary effect is studied and a complete theory of the mechanical-electrical oscillating system is developed for plates of infinite area. For plates of finite area the amplitude distribution becomes nonuniform; the effect of this modification is studied in relation to the equivalent circuit.

621.396.611.21:621.3.018.3 358

A Method of Analysis of Fundamental and Overtone Crystal-Oscillator Circuits—F. G. R. Rockstuhl. (*Proc. IEE*, part III, vol. 99, pp. 377–388; November, 1952.) Use of the method of loci facilitates comparison between (*a*) the Pierce-Miller and (*b*) the Pierce-Colpitts type of crystal-oscillator circuit. Type (*a*) is much more suitable for harmonic oscillation and very high frequencies because it requires less mutual conductance. Type (*b*) is, under certain conditions, particularly suitable for frequency standards. Circuits with the crystal connected between anode and cathode have, under certain conditions, low power dissipation in the crystal. Conditions for frequency stability are analyzed and a simple and accurate method of determining crystal parameters is described.

621.396.611.3:621.394/.395.44 359

Broad-Band Coupling Unit for Power-Line Carrier with Associated Potential Device—J. A. Doremus, R. P. Crowand W. H. Freeman. (*Elec. Eng.* (N. Y.), vol. 71, pp. 707–713; August, 1952.)

621.396.611.4 360

Some Perturbation Effects in Microwave Cavities operating in Degenerate Modes—S. K. Chatterjee. (*Jour. Indian Inst. Sci.*, Section B, vol. 34, pp. 77–87; July, 1952.) Theoretical investigation of the perturbation caused by introducing a metal rod into a cylindrical cavity operating in the companion modes

TE_{01n} and TM_{11n}. The changes in Q-value and resonance frequency are different for the two modes. The magnitudes of these changes as dependent on the radius and depth of insertion of the rod are considered.

621.396.612.1 361
Precalculation of the Mains Loading in the Design of High-Frequency Generators using Quenched Sparks—W. Besthorn. (*Elektrotech. Z., Ed. A*, vol. 73, pp. 482–484; August 1, 1952.) The power required to drive a HF generator of the air-blast quenched-spark type is determined from consideration of the generator equivalent circuit. Such generators are frequently used for HF inductive heating.

621.396.615.016.35:621.396.822 362
The Effect of Noise on the Frequency Stability of a Linear Oscillator.—R. M. Lerner. (*Proc. NEC* (Chicago), vol. 7, pp. 275–286; 1951.) The standard conditions for a sinusoidal oscillation are that the attenuation and net phase shift around the closed loop be zero. Random fluctuations are relied upon to start the oscillation. If the level of oscillation is to remain finite in the continued presence of noise, the oscillating loop must have some attenuation, and functions like a highly regenerative amplifier with a loop gain very nearly unity. Accordingly, the oscillator produces not a single frequency, but rather a narrow band of noise that causes instability in the magnitude and in the apparent frequency of the output. These instabilities are discussed for oscillators in which all elements are linear except for some slow-acting amplitude control. The bandwidth of the noisy oscillation can be predicted from easily measured system characteristics. Several methods of defining the frequency of the output are considered with special reference to precision measurements. In general the measured frequency departs from the zero-phase-shift criterion and is dependent on the measuring equipment. Methods of minimizing instabilities due to noise are investigated.

621.396.615.142.2 363
The Effect of Long Transmission Lines on Klystron Oscillators—J. Cohn. (*Proc. NEC* (Chicago), vol. 7, pp. 46–58; 1951.) Discussion of effects occurring when the oscillator load is several wavelengths away from the tube. Equivalent circuits are applied to analysis of the FM distortion and of the discontinuities in the klystron characteristics. Experimental results are presented which corroborate the theory.

621.396.615.17.015.7 364
A Hard-Valve Pulse Generator—D. A. Levell. (*Electronic Eng.*, vol. 24, pp. 507–509; November, 1952.) Description, with circuit details, of a triggered generator producing pulses of width variable from 0.7 to 12.8 μs. Slight modifications result in (*a*) a free-running generator, (*b*) a triggered generator of 5-ms pulses which is easily converted to free running with a repetition period of 10 ms. Pulses of either polarity can be used for triggering.

621.396.645 365
A Design for a Constant-Volume Amplifier—G. J. Pope. (*Electronic Eng.*, vol. 24, pp. 464–465; October, 1952.) The so-called constant-volume amplifier is used extensively on overseas telephone circuits so that a reasonable modulation depth can be used without the risk of overmodulation. Circuit details are given of an amplifier which is simple to set up and reliable in operation and which uses a cathode-follower circuit as a variable impedance. The results obtained are comparable to those given by conventional networks using metal-rectifier bridge networks.

621.396.645 366
A Feedback-Pair Video Amplifier—V. H. Attree. (*Electronic Eng.*, vol. 24, pp. 504–506; November, 1952.) Details are given of a circuit with a gain of 100, frequency range 8 cps–8 mc, and midband output linear up to 50 v rms.

621.396.645 367
Cathode-Follower as High-Impedance Input Stage—D. A. Bell and H. O. Berktay. (*Wireless Eng.*, vol. 29, pp. 313–316; December, 1952.) If a cathode-follower is used as the first stage of an amplifier in order to raise the input impedance, the conductance of the grid-leak (between grid and cathode) may not be negligible compared with the conductance of the source (between grid and earth) from which the signal is derived. The noise performance under these conditions is examined, both in terms of the cathode-follower regarded as a 1:1 voltage device and in terms of the "noise figure," which takes account of the difference between input and output impedances.

621.396.645:621.396.822 368
Amplifier Noise, particularly in the Audio-Frequency Range—K. S. Nordby. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, vol. 30, pp. 185–197; June 1, 1952.) Noise in input stages is investigated; Nyquist's formula is taken as starting point, and only simple mathematics is used. Noise in resistors is dealt with by the usual device of substituting an equivalent noise voltage source in series with a noise-free resistor. The input circuit of a capacitor microphone is considered particularly; its noise voltage is determined largely by the slope and position of the low-frequency flank of the response curve. Noise in oscillating circuits is associated with the damping resistance. Formulas are given for calculating the equivalent noise resistance of tubes; for the same operating point, a tube produces much more noise in the AF range than at higher frequencies. The signal/noise ratio of a circuit with ideal input transformer is considered and the condition for obtaining maximum sensitivity is derived.

621.396.645.37.024 369
D.C. Amplifiers with Low-Pass Feedback—J. A. Colls. (*Wireless Eng.*, vol. 29, pp. 321–325; December, 1952.) Brockelsby (1910 of 1949) and Mayr (3110 of 1949) have shown how to design a voltage amplifier of high stability and with a response curve of maximum flatness, but their method has the disadvantage that the amplifier must have a particular value of loop gain. If the loop gain is varied, the over-all frequency response will be seriously affected and the amplifier may be unstable if used as an integrator or differentiator. The method is extended to cover the case of a dc amplifier with a low-pass feedback network. The gain of such an amplifier can be varied over a wide range without appreciable effect on the over-all frequency response, so that it can be used as a stable differentiator or integrator. The output noise level may limit the field of application.

GENERAL PHYSICS

53.08:001.61 370
Representation of Experimental Results by Equations. Linearized Empirical Laws—L. A. Sackmann. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 689–691; October 6, 1952.) An analytical method is discussed for determining the form of the equation representing the measurements of a dependent variable as a function of an independent variable; the accuracy with which values can hence be found for the numerical co-efficients is examined.

53.08:001.61 371
Representation of Experimental Results by Equations. New Useful Formulae—L. A. Sackman. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 783–784; October 13, 1952.) Methods are outlined for determining the co-efficients of equations fitting a series of observed values, weighted or not weighted.

535.37:539.2 372
Transfer and Transport of Energy by Resonance Processes in Luminescent Solids—T. P. J. Botden. (*Philips Res. Rep.*, vol. 7, pp. 197–235; June, 1952.) Experiment shows that the ratio between the efficiencies of activator and sensitizer fluorescence increases with increasing sensitizer concentration. This is at variance with theory. An explanation is given and a theory is developed that accounts for the temperature dependence of the energy transfer. Part 1: 1882 of 1952.

535.42 373
The Uniqueness of the Solutions in the Rigorous Theory of Diffraction—H. Hönl and A. W. Maue. (*Z. Phys.*, vol. 132, pp. 569–578; August 19, 1952.) The solutions previously given by Hönl (2182 of 1952) not only satisfy the usual conditions, but also meet the requirement that no subsidiary wave fields be radiated from the edges of the aperture, so that the uniqueness of the solutions is established.

535.42:538.566 374
A Simplifying Technique in the Solution of a Class of Diffraction Problems—D. S. Jones. (*Quart. Jour. Math.*, vol. 3, pp. 189–196; September, 1952.) Considerable simplification of the treatment of diffraction problems leading to Wiener-Hopf integral equations results from taking the transform before applying the boundary conditions. This is demonstrated by consideration of (*a*) the Sommerfeld problem for the semi-infinite plane, (*b*) the diffraction of small-amplitude sound waves by a semi-infinite rigid cylinder, (*c*) the diffraction of a plane em wave by a finite waveguide, (*d*) a vector field.

535.767:535.88 375
New Direct-Vision Stereo-projection Screen—W. W. Jennings and P. Vanet. (*Jour. Soc. Mot. Pic. Telev. Eng.*, vol. 59, pp. 22–27; July, 1952.) Russian work on stereo-projection screens is briefly described and a more detailed account is given of a system developed in France by F. Savoye (see *Rev. Photographie Optique*, p. 23; February, 1951). This uses a rotating cone-shaped grill moving round the screen, thus enabling collective direct vision of stereoscopic pairs in either monochrome or color.

537.291 376
Motion of Gaseous Ions in a Strong Electric Field: Part 2—G. H. Wannier. (*Phys. Rev.*, vol. 87, pp. 795–798; September 1, 1952.) The theory previously given for uniform ion densities (97 of 1952) is extended to deal with non-uniform densities. Errata in the earlier paper are indicated.

537.311.3:538.63 377
Mechanism of Resistance Variation in a Magnetic Field—A. Nedoluha and K. M. Koch. (*Z. Phys.*, vol. 132, pp. 608–620; August 19, 1952.) A model with two layers having different resistances and resistivities is proposed to explain the Hall effect and the variation of resistance of a material subjected to an electric field.

537.311.31:538.639 378
Theory of the Electrical Conductivity of Metals in a Magnetic Field—Yu. B. Rumer. (*Zh. Eksp. Teor. Fiz.*, vol. 22, pp. 214–222; February, 1952.) Formulas are derived for determining the resistance of metals in a transverse and in a longitudinal magnetic field, taking into account the quantization of the movement of electrons in a magnetic field.

537.311.4 379
Theory of the Contact between a Metal and a Semiconductor for a Large Contact Potential

Difference—A. I. Gubanov. (*Zh. Eksp. Teor. Fiz.*, vol. 22, pp. 204–213; February, 1952.) The I/V characteristics for the contact between a metal and a semiconductor is calculated for the case when the contact potential difference is so great that the type of conduction of the semiconductor near the contact is altered from the electron to the hole type. The calculations cover the cases of plane, knife-edge and needle types of contact.

537.525:537.533.79 380

Determination of Electron Density and Collision Frequency in a Gaseous Discharge by Microwave Propagation Measurements—L. Goldstein, M. A. Lampert and R. H. Geiger. (*Elec. Commun.*, vol. 29, pp. 243–245; September, 1952.) The gaseous discharge to be measured fills a section of waveguide several wavelengths long, and measurements are made of the absorption and phase shift of a low-power microwave signal passing through the discharge. Results are quoted for Ar at pressures respectively of 0.5 and 2.0 mm Hg.

537.525:621.385.2 381

Reliability of Probe Measurements in Hot Cathode Gas Diodes—G. Wehner and G. Medicus. (*Jour. Appl. Phys.*, vol. 23, pp. 1035–1046; September, 1952.) Erroneous results may be obtained due to the work function of the probe altering during the measurements. Particularly when investigating tubes with oxide cathodes, the measurement must be made immediately after cleaning the probe. In the experiments described, a cro plotter was used which took only some seconds to record the whole probe characteristic. In contrast to results obtained by other workers, no deviation from the Maxwellian velocity distribution of the plasma electrons was observed over a range of nearly four orders of magnitude of probe current.

537.533:538.566 382

Theory of the Propagation of Waves in an Electron Beam—L. N. Loshakov. (*Zh. Tekh. Fiz.*, vol. 22, pp. 193–202; February, 1952.) An approximate theory is developed for the propagation of em waves in a waveguide filled with a dielectric, when an electron beam passes through it. It is assumed that electrons can move freely along the waveguide in the dielectric and that they form a beam completely filling it. With certain assumptions, the types and characteristics of the waves which can travel in such a system are determined for various conditions. The results obtained can be generalized so as to cover the case of an arbitrary transmission line.

537.533.1:538.691 383

The Motion of Electrons in the Field of a Uniformly Wound Toroid—S. G. Nilsson. (*Ark. Fys.*, vol. 4, pp. 347–351; August 16, 1952.) The focusing properties of the toroid are investigated theoretically in relation to beta-particle or other spectroscopes.

537.533.8:621.385.833 384

Secondary Electron Emission from Certain Metals under the Impact of Positive Lithium Ions—G. Couchet. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 944–946; October 27, 1952.) An arrangement for measuring the emission is described and results are given for some metals used in electron microscopy.

537.562:533.15:551.510.535 385

The Relation between Electrical and Diffusion Currents—M. H. Johnson. (*Jour. Geophys. Res.*, vol. 57, pp. 405–412; September, 1952.) A linear relation is derived between (*a*) the electric current through a conducting gas in a magnetic field and (*b*) the currents due to diffusion of the charge carriers in the gas. From this relation the vertical displacements of the ionosphere E layer due to lunar effects are determined from the current system inferred from the lunar changes of the geomagnetic field. Both the amplitude and phase of the displacement are consistent with observations if it is assumed that the main lunar current flows in the lower part of the E layer, and that approximately equal numbers of ions and electrons are present at the point of observation.

537.562.001.11 386

Theory of the Plasma in a Rarefied Gas when the Current Strength varies—V. L. Granovski. (*Zh. Eksp. Teor. Fiz.*, vol. 22, pp. 3–10; January, 1952.) General equations for relatively slow processes in a plasma are applied to the calculation of the concentration of electrons and ions when the strength of the current through the gas varies. The partial de-ionization of the gas when the current decreases, and the residual concentration of electrons and ions after the current ceases to flow, are determined.

538.26 387

Calculation of the Leakage Flux of the Pendent-Armature Relay—J. W. Cohen and H. Grosser. (*Commun. News*, vol. 12, pp. 125–131; June, 1952.) The magnetic conductivity of the space between core and yoke is determined by application of Southwell's relaxation method.

538.311:621.318.42:513.647.1 388

Investigation of Electromagnetic Waves Guided by Helical Conductors—É. Roubine. (*Ann. Télécommun.*, vol. 7, pp. 206–216, 262–275 and 310–324; May–August, 1952.) Full theoretical analysis of the propagation of em waves along helical conductors. Shorter versions of parts of the paper have previously been abstracted. The continuous-cylinder approximation (1350 and 2691 of 1951) gives a solution in good agreement with experimental results at frequencies sufficiently low, and with the action of a narrow-beam traveling-wave tube. The second method of analysis (2978 of 1951), based on the infinitely-thin-wire concept, leads to difficulties in calculation but has more general application and is apparently correct to the second order of approximation. Its application to delay lines is illustrated. Results obtained by the two methods are compared (1580 of 1952) and discussed with reference to experimental measurements.

538.56:535.212:621.396.677 389

Reflection of Microwaves from Metal-Plate Media—J. J. Brady, M. D. Pearson and S. R. Peoples. (*Jour. Appl. Phys.*, vol. 23, pp. 964–975; September, 1952.) Experiments were made, using frequencies in the 3-cm band, to verify the theory worked out by Lengyel (1879 of 1951). Waveguide assemblies of various depths were used, with the reflecting surfaces normal to the plates. For single-surface measurements the absorbing wedges described by Ruze and Young (1880 of 1951) were used. Phase and amplitude of the reflection co-efficient were determined for angles of incidence 10°, 25° and 35° and for various ratios between plate separation and wavelength. Double-surface ("slab") measurements were also made, using assemblies of parallel plates instead of square waveguides.

538.566:517.942.82 390

The Propagation of the Wave Front in a Dispersive Medium—M. Marziani. (*R.C. Accad. naz. Lincei*, vol. 12, pp. 683–687; June, 1952.) The problem is investigated theoretically, by means of the Laplace transformation, for the general case of a plane em wave in a homogeneous medium.

539.153 391

A Soluble Problem in Energy Bands—J. C. Slater. (*Phys. Rev.*. vol. 87, pp. 807–835; September 1, 1952.) "The problem of an electron moving in a periodic simple cubic potential of the form cos x+cos y+cos z is investigated, with particular attention to the nature of the wave functions, Wannier functions, degeneracy of overlapping bands, etc."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

522.1(54)551.510.535 392

Kodaikanal Observatory (1901–1950)—(*Indian Jour. Met. Geophys.*, vol. 2, pp. 85–95; April, 1951.) An indication is given of the scope of the work carried on at this solar physics observatory, and of results so far achieved. Magnetic, meteorological and seismological observations are made, and the imminent commencement of ionosphere soundings is reported.

523.5:621.396.9 393

Double-Doppler Study of Meteoric Echoes—L. A. Manning, O. G. Villard, Jr. and A. M. Peterson. (*Jour. Geophys. Res.*, vol. 57, pp. 387–403; September, 1952.) Both the amplitude and phase of the signal returned from a meteor trail can be determined independently by use of a twin-channel Doppler system, details of which are presented. The technique has direct application to the determination of the drift of meteor trails, and to analysis of the spectra of echoes which exhibit amplitude fading.

523.746"1951" 394

Final Relative Sunspot-Numbers for 1951—M. Waldmeier. (*Jour. Geophys. Res.*, vol. 57, pp. 413–415; September, 1952.)

523.746"1952.04/.06" 395

Provisional Sunspot-Numbers for April to June, 1952—M. Waldmeier. (*Jour. Geophys. Res.*, vol. 57, p. 419; September, 1952.)

523.8:621.396.822:550.385 396

Scintillation of Radio Stars during Aurorae and Magnetic Storms—C. G. Little and A. Maxwell. (*Jour. Atmos. Terr. Phys.*, vol. 2, pp. 356–360; 1952.) During aurorae the rate of scintillation is four times that during normal conditions, probably as a consequence of a fourfold increase in the drift speed of the ionosphere irregularities causing the scintillations. More generally, the scintillation rate and the speed of the ionosphere irregularities are approximately proportional to the K index of geomagnetic activity.

550.38"1952.04/.06" 397

Cheltenham Three-Hour-Range Indexes *K* for April to June, 1952—R. R. Bodle. (*Jour. Geophys. Res.*, vol. 57, p. 419; September, 1952.)

550.38"1952.07/.08" 398

Indices of Geomagnetic Activity of the Observatories Abinger, Eskdalemuir and Lerwick, July and August 1952—(*Jour. Atmos. Terr. Phys.*, vol. 2, pp. 363–364; 1952.)

550.384.3 399

Secular Variation of the Magnetic Field at Colaba and Alibag—S. K. Pramanik. (*Jour. Geophys. Res.*, vol. 57, pp. 339–355; September, 1952.)

550.385"1952.01/.06" 400

Principal Magnetic Storms [Jan.–June 1952]—(*Jour. Geophys. Res.*, vol. 57, pp. 420–422; September, 1952.)

550.386 401

International Data on Magnetic Disturbances, First Quarter, 1952—J. Bartels and J. Veldkamp. (*Jour. Geophys. Res.*, vol. 57, pp. 416–418; September, 1952.)

551.510.5:546.17-1 402

Nitrogen in the Upper Atmosphere—S. Deb. (*Jour. Atmos. Terr. Phys.*, vol. 2, pp. 309–323;

1952.) The probable distribution of atomic N is investigated theoretically; the method of calculation adopted is a modification of that used by Penndorf in investigating the dissociation of oxygen (2224 of 1949). Within the height range 70–170 km the predissociation mechanism suggested by Herzberg and Herzberg (*Nature* (London), vol. 161, p. 283; 1948) operates, while in the range 200–400 km a dissociative recombination suggested by Mitra (*Nature* (London), vol. 167, p. 897; 1951) is effective. In the lower region there is a sharp maximum in the distribution curve at about 90 km; in the upper region the concentration increases monotonically with height. The total number of N atoms in a vertical column of cross section 1/cm² is calculated to be about 10^{16}.

551.510.53(54) 403

Physical Properties of the Upper Atmosphere over India—P. Koteswaram. (*Indian Jour. Met. Geophys.*, vol. 2, pp. 101–112; April, 1951.) The height/temperature curve for Central India from ground up to 100 km has been constructed using data obtained from balloon measurements and sound-propagation experiments. The isothermal region found in the lower stratosphere over middle latitudes does not exist over India, the temperature increasing steadily above the tropopause. A comparison of data for India and for Europe indicates that summer east winds over North India extend up to about 30 km, with strong westerly winds aloft.

551.510.535 404

Dynamic Phenomena in the Ionosphere—K. Bibl. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 734–736; October 6, 1952.) Records of F-layer height obtained with the rapid-sweep sounder at Freiburg show trace detail indicative of transient ionospheric variations. Various types of deformation of the trace are noted. These short-lived disturbances are nearly always propagated from a high level downwards.

551.510.535:523.32 405

An Effect of the Moon on the Median Height of the Ionosphere F_2 Layer—R. Eyfrig. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 736–737; October 6, 1952.) At Huancayo, on the magnetic equator, there is a lunar effect amounting to several per cent on the median height of the F_2 layer during local summer; the effect is very much smaller in winter. At Freiburg, in a moderate latitude, the effect is extremely small if it exists at all.

551.510.535:523.745 406

The Solar Control of the E and F_1 Layers at High Latitudes—J. C. W. Scott. (*Jour. Geophys. Res.*, vol. 57, pp. 369–386; September, 1952.) The monthly-mean critical frequencies of the E and F_1 layers at high latitudes vary diurnally with solar zenith angle according to a modified Chapman law. Measurements of the seasonal, latitude, and solar-cycle phase dependence of the E-layer sensitivity to solar zenith angle and subsolar frequency are shown graphically. In the auroral zone, E-layer sensitivity to solar zenith angle is very low, but to the north of the zone it has the Chapman theoretical value.

551.510.535:523.8:621.396.822 407

Ionospheric Refraction of 81.5-Mc/s Radio Waves from Radio Stars—F. G. Smith. (*Jour. Atmos. Terr. Phys.*, vol. 2, pp. 350–355; 1952.) An estimate of the total ionization of the F layer can be deduced from the refraction of radiation from radio stars caused by horizontal gradients of ionization occurring during normal diurnal variations in the layer. Interferometer measurements of the apparent positions of four radio stars are reported and the results are compared with calculated values based on ionospheric soundings; agreement is found if certain plausible assumptions are made regarding the vertical distribution of electrons about the maximum-concentration level of the F layer.

551.510.535:537.562:533.15 408

The Relation between Electrical and Diffusion Currents—Johnson. (See 385.)

551.510.535:551.594.12 409

A Procedure for the Determination of the Vertical Distribution of the Electron Density in the Ionosphere—J. M. Kelso. (*Jour. Geophys. Res.*, vol. 57, pp. 357–367; September, 1952.) Description of a method based on application of the Gauss-Christoffel quadrature formula to the numerical integration of the well-known integral for "true" reflection height as a function of group height. The earth's magnetic field and the effects of electron collisions are neglected, ray theory is assumed applicable and the electron-density/height curve is assumed to have no maxima or minima in the region considered.

551.510.535:621.396.11.029.51 410

A Method for Obtaining the Wave Solutions of Ionospherically Reflected Long Waves, including All Variables and Their Height Variation—J. J. Gibbons and R. J. Nertney. (*Jour. Geophys. Res.*, vol. 57, pp. 423–426; September, 1952.) Discussion on 137 of 1952.

LOCATION AND AIDS TO NAVIGATION

621.396.9:526.92]×534.88 411

Optimum Signal Characteristics for Distance Measurement by Echoes—L. Batchelder. (*Proc. NEC* (Chicago), vol. 7, pp. 29–38; 1951.) Carrier frequency, pulse duration and shape, properties of the medium, and target characteristics of radar and sonar systems are considered with particular reference to range and to measurement accuracy. Application is made to design of echo-sounding equipment.

621.396.932/.933].088 412

Dynamic Aspects of Errors in Radio Navigational Systems, particularly in Cases of Fast-Moving Receivers and Transmitters—H. Busignies. (*Elec. Commun.*, vol. 29, pp. 226–228; September, 1952.) A general discussion, including consideration of the effect of reflections from the surface of the earth. Accuracy can be effectively improved by sacrificing bandwidth for integration time. Errors due to reflections can be averaged out by radiating a frequency spectrum such that the various reflected components are received random phases. Integration can then be applied over the frequency spectrum.

621.396.933 413

Glide-Slope Receiver—R. C. Davis. (*Elec. Commun.*, vol. 29, pp. 219–225; September, 1952.) Description, with performance specification, block diagram, and some circuit details, of the new Type-154A receiver operating in the range 329.3–335.0 mc. Twenty frequency-determining crystals are provided and may be selected individually by means of a bank of 11 relays. With the exception of the voltage-regulator tube, the 12 tubes used are all of the "reliable" type developed for airline use.

621.396.933.2 414

The Origin of Errors in Airborne M.F. Direction Finding—J. H. Moon. (*Marconi Rev.*, vol. 15, pp. 97–113; 3rd Quarter, 1952.) The importance of accurate ground calibration is emphasized, and a description is given of a combined compass base and DF calibration site where no reinforcing steel is used. Bearings taken in the air wander more than those obtained in ground tests; the difference is attributed to the deviation of the aircraft from the even-keel attitude. Operational tests indicate that an accuracy within $\pm 2°$ can be achieved if proper attention is paid to details. Correct design and location of the sense antenna are important if the DF indicator is to reverse immediately above a radio beacon.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215×535.343.2]:546.22.19 415

Optical and Photoelectric Properties of Orpiment (As_2S_3)—G. I. Rekalova. (*Zh. Tekh. Fiz.*, vol. 22, pp. 143–147; January, 1952.) Experiments were conducted to investigate the spectral distribution of absorption and of photocurrent in monocrystals of orpiment at the temperature of liquid air. Contrary to the normally observed disappearance of photoconductivity when idiochromatic crystals are illuminated by wavelengths in the absorption band, an increase in the photoconductivity was observed over an interval of more than 120 mμ from the long-wave boundary of the absorption band in the direction of the shorter waves. In the region of weak absorption, from 437 mμ, the law of quantum equivalent does not hold good, and the photocurrent in this region is proportional to the absorbed energy.

535.215:546.3-1-86-36 416

Optical Factors and Effective Depth in the Photoeffect of Antimony-Caesium Cathodes—B. I. Dyatlovitskaya. (*Zh. Tekh. Fiz.*, vol. 22, pp. 84–100; January, 1952.) The correlation between the optical properties of an Sb-Cs cathode and the photoeffect is made more definite, and from comparison of experimental and calculated data on the dependence of the photoeffect on the thickness of the layer, the character of the movement of excited photoelectrons inside the layer is established and the corresponding depth of emission of photoelectrons is determined. Certain peculiarities of the photoeffect of an Sb-Cs cathode are discussed on the basis of calculations of the absorbed energy.

535.343:546.24-1:548.55 417

Optical Polarization in Single Crystals of Tellurium—J. J. Loferski. (*Phys. Rev.*, vol. 87, pp. 905–906; September 1, 1952.) Measurements of the infrared transmission of Te crystals show that the position of the absorption edge, as well as the amount of radiation transmitted at longer wavelengths, depends markedly on the polarization of the incident light. The value of about 5.3 for the refractive index at 6μ is somewhat higher than that found by Moss (2230 of 1952) for Te films.

535.37:546.472.84:537.29 418

Field-Dependent Fluorescence of Vitreous Zn_2SiO_4 Phosphor—A. Bramley and J. E. Rosenthal. (*Phys. Rev.*, vol. 87, p. 1125; September 15, 1952.) The lowest alternating voltage at which luminescence was observed varied from 100 v to 500 v, depending on the thickness and other parameters of the sample At a fixed voltage the light output varied by a factor <5 in the frequency range 120 cps–16 kc. See also 3439 of 1952 (Piper and Williams).

537.311.33:061.3 419

Seventh Conference on the Properties of Semiconductors (Kiev, 14th–21st October 1950)—(*Bull. Acad. Sci. U.R.S.S., sér. phys.*, vol. 16, pp. 5–138 and 139–232; January/February and March/April, 1952.) Full text of the papers given. See also 2728 of 1951.

537.311.33:537.568 420

Statistics of the Recombinations of Holes and Electrons—W. Shockley and W. T. Read, Jr. (*Phys. Rev.*, vol. 87, pp. 835–842; September 1, 1952.) The statistics of the recombination of holes and electrons in semiconductors are analyzed on the basis of a model in which the recombination occurs through the mechanism of trapping. A trap is assumed to have an energy level in the energy gap so that its charge may have either of two values differing by one electronic charge. The dependence of lifetime of injection carriers upon initial conductivity and upon injected carrier density is discussed.

537.311.33:546.28-1 421
An Application of the Cellular Method to Silicon—D. K. Holmes. (*Phys. Rev.*, vol. 87, pp. 782–784; September, 1952.) The method used by Mullaney (1576 of 1945) is applied to the determination of the lowest energy limit of the conduction band and also the highest limit of the filled band; the effective mass of the conduction electrons is then deduced.

537.311.33:546.28-1:548.55 422
Silicon Single-Crystal Rods—H. Kleinknecht. (*Naturwiss.*, vol. 39, pp. 400–401; September, 1952.) Single-crystal rods obtained from a melt in a quartz crucible by use of a seed crystal are described. The conductivity was *p*-type at the start of the crystal, then *n*-type nearly to the other end, finally reverting to *p*-type. The latter inversion is attributed to admixture of Al from the melt.

537.311.33:546.289-1 423
Temperature Dependence of the Backward Current of *p-n* Junctions in Germanium—D. Geist and K. Seiler. (*Naturwiss.*, vol. 39, p. 401; September, 1952.) Rectifiers of the *p-n* type with Sb as donor and Al as acceptor impurities were investigated. *I/V* characteristics for temperatures of −70°, 27° and 60°C show a saturation current varying exponentially with temperature for low voltages. At high voltage (∼100 v) the characteristics coalesce, the current increasing very rapidly.

537.311.33:546.289-1:535.343:535.61-15 424
New Infrared Absorption Bands in *p*-Type Germanium—H. B. Briggs and R. C. Fletcher. (*Phys. Rev.*, vol. 87, pp. 1130–1131; September 15, 1952.) Absorption bands at 3.4 μ and 4.7 μ are reported for Ge samples to which *p*-type impurities had been added.

537.311.33:546.289-1:537.565 425
Mobility of Electrons in Germanium—P. P. Debye and E. M. Conwell. (*Phys. Rev.*, vol. 87, pp. 1131–1132; September 15, 1952.) Measurements at room temperature on samples in various conductivity ranges have given higher mobilities than any previously found. In the range of resistivity for which drift mobility values are available, the results are in substantial agreement with those of Haynes and Shockley (1928 of 1951).

537.311.33:546.289-1:538.632 426
Interpretation of the Low-Temperature Hall Curve of a Degenerate Germanium Sample—D. M. Finlayson, V. A. Johnson and F. M. Shipley. (*Phys. Rev.*, vol. 87, pp. 1141–1142; September 15, 1952.) Measurements on *n*-type Sb-doped samples of Ge show a maximum of the Hall co-efficient near 120°K, with a 20 per cent drop from 116°K to 1.3°K. The results are discussed in relation to energy levels and carrier density.

537.311.33.001.8 427
Semiconductors and their Applications—J. M. Moulon. (*Ann. Télécommun.*, vol. 7, pp. 364–374; September, 1952.) A brief review of modern theories of the conductivity and rectifying properties of semiconductors, with discussion of their applications in thermistors, various devices for physical and electrical measurements, and in transistrons of the point-contact and *p-n*-junction types.

539.234:533.5 428
Uniform Metallization of Surfaces by Thermal Evaporation, using a Single Emissive Source or Several Sources—P. Prugne and P. Léger. (*Jour. Phys. Radium*, vol. 13, supplement, pp. 129A–130A; July/September, 1952.) Description of a method which effectively realizes a circular emissive source by rotation of the target at 50 rpm, the source remaining stationary.

539.234:537.311.31:546.77 429
Protection of Thin Layers of Molybdenum by a Coating of SiO obtained by Evaporation in Vacuum—C. Feldman. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 706–707; October 6, 1952.) The variation of resistivity with time is shown in graphs for Mo films with and without a SiO coating, in air at ordinary temperature, also for three similar coated Mo films kept respectively in vacuum, in dry air at ordinary temperature, and in dry air at the temperature of liquid N. The usefulness of the results for studying the oxidation of the Mo film is indicated.

539.234:546.59 430
Preparation and Properties of Thin Metal Films—G. Ranc. (*Le Vide*, vol. 7, pp. 1211–1219; July/September, 1952.) A more detailed account of the work on evaporated gold films noted in 2739 of 1951 and 172 of 1952 (Colombani and Ranc).

546.217:621.317.335.3.029.64 431
Some Preliminary Studies of the Rapid Variations in the Index of Refraction of Atmospheric Air at Microwave Frequencies—C. M. Crain and J. R. Gerhardt. (*Bull. Amer. Met. Soc.*, vol. 31, pp. 330–335; November, 1950.) Report of results obtained with the equipment previously described [2565 of 1950 (Crain)]. A marked correspondence is noted between air temperature and moisture content, which largely determines the microwave refractive index.

546.431-1:532.72 432
Diffusion of Barium in Barium Oxide—R. W. Redington. (*Phys. Rev.*, vol. 87, pp. 1066–1073; September 15, 1952.) Diffusion of Ba in single crystals of BaO was measured in the temperature range 550–1520°K. Two diffusion processes were found, defects being responsible for both.

546.814+546.824+546.834]-3:621.317.011.5 433
Polarization and Dielectric Losses of Zirconates, Stannates and Certain Titanates of Bivalent Metals—G. A. Smolenski. (*Zh. Tekh. Fiz.*, vol. 22, pp. 3–11; January, 1952.)

549.514.63:548.55:[535+537 434
Electrical and Optical Properties of Rutile Single Crystals—D. C. Cronemeyer. (*Phys. Rev.*, vol. 87, pp. 876–886; September, 1952.)

621.3.014.12:621.3.012.3 435
Universal Skin-Effect Chart for Conducting Materials—H. A. Wheeler. (*Electronics*, vol. 25, pp. 152–154; November, 1952.) Formulas and a chart are given for finding the depth of penetration of current in some metals and solutions (including sea water) and in ground, at frequencies from 1 cps to 1,000 kmc.

621.3.042.15 436
Magnetic-Powder Cores for Military Communication Equipment—E. Both. (*Tele-Tech.*, vol. 11, pp. 36–38, 105; August, 1952.) Discussion of core requirements, characteristics and shortcomings of present-day materials, and suitable tests of stability under severe conditions regarding temperature, humidity, etc.

621.314.632 437
Effect of Minority Carriers on the Breakdown of Point-Contact Rectifiers—E. Billig. (*Phys. Rev.*, vol. 87, pp. 1060–1061; September 15, 1952.) "On the application of short high-voltage pulses to point-contact rectifiers in the inverse direction, thermal instability is observed. Intrinsic conduction due to the thermal generation of electron-hole pairs and the subsequent passage of minority carriers (which are not affected by the potential barrier) is suggested as the cause of electrical breakdown."

621.315.612:621.315.62 438
The Properties of Semiconducting Ceramic Glaze—D. H. Lucas. (*Brit. Jour. Appl. Phys.*, vol. 3, pp. 293–296; September, 1952.) Further investigations were made of the glazes previously described by Forrest (1061 of 1948). Surface resistivity and contact resistance were measured over the temperature range −177° to +110°C. Rectification experiments and thermoelectric-power measurements indicate that the glazes are *n*-type semiconductors. Observed deterioration in service is attributed to electrolytic corrosion at the interface with surface films of water.

621.315.612.4:537.315.6 439
Potential Distribution in Barium Metatitanate and Other Ceramic Dielectrics—E. V. Singakov and B. K. Chernyi. (*Zh. Tekh. Fiz.*, vol. 22, pp. 265–267; February, 1952.) In investigations of the electrical conductivity of the titanates of metals of the second group, a fall of current with time is observed. In order to establish the cause of this phenomenon, the potential distribution in polycrystalline samples of TiO_2, (Ba-Sr)TiO_3 and $BaTiO_3$ was determined. The potential distribution in all the samples investigated remains linear for a wide range of temperatures and does not depend on the time during which the sample remains in an electric field. The fall of current is probably due to the presence of inhomogeneities uniformly distributed in the volume of the dielectric. In the case of barium metatitanate and (Ba-Sr)TiO_3, the formation of local volume charges may also be partly responsible for this phenomenon.

621.315.616:621.319.4 440
Polyethylene Terephthalate as a Capacitor Dielectric—M. C. Wooley, G. T. Kohman and W. McMahon. (*Elec. Eng.* (N. Y.), vol. 71, pp. 715–717; August, 1952.) An account of the properties which make this material, also known as "mylar," particularly suitable as a capacitor dielectric. See also 667 of 1951 (Reddish).

621.396.611.21 441
Some Notes on the Design and Application of Quart Crystals—R. A. Spears. (*Strowger Jour.*, vol. 8, pp. 99–105; July, 1952.) Temperature characteristics of plates of different cuts are discussed and flexure types of crystal for frequencies from 50 kc downwards are described. The relation between surface displacement and aging effects is considered briefly and typical crystal units, with dimensions and operating frequencies and temperatures, are illustrated.

621.396.611.21:549.514.51:532.111 442
Piezoelectric Resonance of Quartz up to 5000 atm—J. P. Pérez and P. Johannin. (*Jour. Phys. Radium*, vol. 13, pp. 428–429; July/September, 1952.) Experiments with a Y-cut crystal, immersed in petroleum ether and executing transverse oscillations parallel to the *x* direction (initial frequency 3.265 mc), show that the frequency decreases linearly with increasing hydrostatic pressure, the decrease being 3.1 parts in 10^6 per kg/cm². See also 1350 of 1952 (Michels and Pérez).

666.1:621.317.374 443
Some Experiments and Theories on the Power Factor of Glasses as a Function of their Composition: Part 3—J. M. Stevels. (*Philips Res. Rep.*, vol. 7, pp. 161–168; June, 1952.) An investigation of borosilicate glasses at frequencies of 1.5 mc and 24 kmc. Part 2: 3031 of 1951.

MATHEMATICS

517.65:621.396.11 444
A Table of $\sqrt{(\frac{1}{2}\pi)}\, e^{\frac{1}{2}i\pi\rho^2} \int_\rho^\infty e^{-\frac{1}{2}i\pi\lambda^2}\, d\lambda$ for Complex Values of ρ—P. C. Clemmow and C. M. Munford. (*Phil. Trans. A*, vol. 245, pp. 189–211; September 16, 1952.) "In the theory of wave propagation the above function has applications for which ρ may be complex within a certain range of argument. Tables of the real and imaginary parts of the function are given to four decimal places, for values of $|\rho|$ from 0 to 0.80 at intervals of 0.01, and for values of arg ρ from 0° to 45° at intervals of 1°."

519.24:621.396.822 445
On the Theory of Prediction of Nonstationary Stochastic Processes—R. C. Davis. (*Jour. Appl. Phys.*, vol. 23, pp. 1047–1053; September, 1952.) "We consider the following problem of prediction: During a finite time interval T the real valued function $S(t)+N(t)$ is observed, in which $S(t)$ is a signal and $N(t)$ is a linearly superimposed noise disturbance. The problem is to predict the value of a given linear functional of $S(t)$, the predictor formula having certain preassigned 'optimum properties' among a certain class of predictors."

681.142 446
The Whirlwind I Computer—R. R. Everett. (*Elec. Eng.* (N. Y.), vol. 71, pp. 681–686; August, 1952.) Description of a high-speed digital computer developed at the M.I.T., mainly for applications to control and simulation; an indication is given of some of the problems actually handled by the machine.

681.142 447
The Physical Realization of an Electronic Digital Computor—A. D. Booth. (*Electronic Eng.*, vol. 24, pp. 442–445; October, 1952.) Continuation of previous papers (3179 of 1949 and 1184 of 1951), giving descriptions of (*a*) the multiple-shift instruction methods, (*b*) the multiplier, (*c*) the function table, (*d*) the control system. Input-output devices for computers under development in the Birkbeck College research laboratory will be considered in the final article of this series.

681.142 448
Diode Limiters simulate Mechanical Phenomena—C. D. Morrill and R. V. Baum. (*Electronics*, vol. 25, pp. 122–126; November, 1952.) In analogue computers for simulating nonlinear systems characterized by discrete operating states, diodes are preferred to relays on account of their higher speed. Basic circuits are described and applications are shown to the study of cam-operated engine tubes and the simulation of static and coulomb friction.

681.142 449
Multi-stable Magnetic Memory Systems—J. D. Goodell and T. Lode. (*Proc. NEC* (Chicago), vol. 7, pp. 378–379; 1951.) See 1949 of 1952.

681.142 450
A High-Precision Analog-to-Digital Converter—B. Lippel. (*Proc. NEC* (Chicago), vol. 7, pp. 206–215; 1951.)

681.142 451
A Precise Electronic Function Generator—C. N. Pederson, A. A. Gerlach and R. E. Zenner. (*Proc. NEC* (Chicago), vol. 7, pp. 216–227; 1951.)

681.142 452
Photoformer Design and Performance—E. J. Hancock. (*Proc. NEC* (Chicago), vol. 7, pp. 228–234; 1951.)

681.142:519.272.119 453
An Analogue Electronic Correlator—J. F. Reintjes. (*Proc. NEC* (Chicago), vol. 7, pp. 390–400; 1951.) Description of equipment providing up to 110 points on the correlation curve of signals with frequency components in the range 500 cps–100 kc. Operation is based on the principle of discrete sampling, in pairs, of the input signal at periodic intervals. The delay, multiplication, and integration processes involved are carried out, for each pair of samples, by use of pulse techniques.

681.142:621.385.5 454
Germanium Photodiodes read Computer Tapes—L. Packer and W. J. Wray, Jr. (*Electronics*, vol. 25, pp. 150–151; November, 1952) A digital-computer input arrangement using Ge photodiodes of diameter 0.080 inch mounted six abreast above 6-channel tape enables up to 1,000 characters/seconds to be read. A representative value of peak signal voltage from a 1N77 photodiode is 1.75 v. Plug-in amplifier units associated with the photocells are described.

MEASUREMENTS AND TEST GEAR

531.761:537.525.4 455
Electronic Spark Timing Device—Á. Bardócz and Á. Kemény. (*Acta Tech. Acad. Sci. hungaricae*, vol. 3, pp. 389–392; 1952. In English.) A variable-frequency multivibrator controls the rate of the periodic discharge of a capacitor through a thyratron. The discharge current passes through the primary of a Tesla transformer which gives sparks that are used to produce time marks on oscillograms. The spark recurrence frequency can be varied from the mains frequency to that of any subharmonic.

621.3.018.4(083.74) 456
Industrial Frequency Standard—H. W. Kline. (*Electronics*, vol. 25, pp. 130–131; November, 1952.) A 1-mc frequency standard is obtained by means of an oscillator-divider locked to the 5-mc carrier from WWV, using a tuned-RF receiver with input filter and clipper to eliminate the effect of noise. Lower or higher frequencies for laboratory use are obtained by means of multivibrators.

621.317 457
Techniques in the Measurement of Several Components—I. Bady. (*Proc. NEC* (Chicago), vol. 7, pp. 551–560; 1951.) Methods are described for measuring (*a*) temperature co-efficients of a large number of capacitors, (*b*) resistance and capacitance of resistors from 300 Ω to 1 M Ω over the range 100–400 mc, (c) transmission unbalance of RF cable over the range 1–160 mc.

621.317.323.012.3:621.392.26 458
Charts for Coaxial-Line Probe Measurements—P. H. Smith. (*Proc. NEC* (Chicago), vol. 7, pp. 191–203; 1951.) Charts are provided for evaluating the impedance, voltage swr, etc., along a RF transmission line from probe measurements of relative current or voltage at three points along the line with spacings known in terms of wavelength.

621.317.33.028.3 459
Measurement of Resistances above $10^{12}\Omega$—K. H. Winterling. (*Arch. tech. Messen*, pp. 171–174 and 221–224; August and October, 1952.) Review of galvanometer and electrometer methods, including bridge methods and capacitor charge or discharge methods.

621.317.334:621.317.733 460
The Advantages of the Mutual-Inductance Bridge for Measurements of Ferromagnetic Cores—H. Wilde. (*Arch. elekt. Übertragung*, vol. 6, pp. 354–360; September, 1952.) Analysis is given for the mutual-inductance bridge circuit (see also 196 of 1952). To avoid magnetic leakage the core is wound with coaxial cable of over-all diameter 0.6 mm, the outer conductor forming the primary winding and the inner conductor the secondary. The influence of cable capacitance and of the error angle of the bridge is calculated and discussed. The frequency range is 1 cps–10 mc for the particular cable used.

621.317.335.029.63/.64 461
The Determination of Complex Dielectric Constants of Absorptive Liquids by Microwave Interferometry—F. H. Branin, Jr. (*Jour. Appl. Phys.*, vol. 23, pp. 990–997; September, 1952.) Measurements are made by means of a probe traveling along a slotted coaxial line filled with the dielectric liquid. Using a traveling-wave method, absolute measurements of wavelength and absorption index are made simultaneously and from them the dielectric constant is computed. Alternatively a standing-wave method can be used, in which case the absorption index is found graphically from the power swr. For low-loss media a simplified standing-wave method can be used, in which the absorption index is found from the widths of successive minima of the standing wave.

621.317.336:621.392.26 462
Three-Probe Method of Impedance Measurement—W. J. Duffin. (*Wireless Eng.*, vol. 29, pp. 317–320; December, 1952.) Measurements of the swr in a waveguide are usually effected by means of a slotted section with a traveling probe. The use of three fixed probes, inserted through very small apertures in the waveguide walls, minimizes some sources of error, and considerably reduces the time required for a set of readings. The probe separations are $\lambda_g/8$, where λ_g is the wavelength in the waveguide, this separation giving a simple expression for the load impedance. Suitable apparatus is described and the method of calibration outlined.

621.317.336.029.64:537.52 463
Methods of Measuring the Properties of Ionized Gases at High Frequencies: Part 3—Measurement of Discharge Admittance and Electron Density—D. J. Rose and S. C. Brown. (*Jour. Appl. Phys.*, vol. 23, pp. 1028–1032; September, 1952.) Methods applicable to discharges in both high-Q and low-Q resonant cavities are described. An equivalent-circuit representation of the system is used which is valid as long as the presence of the discharge only slightly modifies the resonance frequency of the cavity. Part 2; 3489 of 1952.

621.317.337:621.396.611.2 464
High-Q Measurement—W. J. Spaven. (*Electronics*, vol. 25, p. 166; November, 1952.) For values of $Q>1{,}000$ the value is determined by pulse excitation of the resonant circuit. A chart is provided for use in solving the equation giving Q in terms of the observed decrement of the oscillation.

621.317.337:621.396.611.4 465
A Sweep-Frequency Method of Q Measurement for Single-Ended Resonators—E. D. Reed. (*Proc. NEC* (Chicago), vol. 7, pp. 162–172; 1951.) A method is described in which an oscillographic display of reflected power and incident power as functions of frequency is used to determine the internal and external Q of a cavity resonator. The Q of the cavity when loaded only by its own losses is termed the internal Q, the external Q applying to the cavity (considered lossless) loaded only by a matched transmission line. The method avoids the point-by-point determination of voltage swr necessary in methods hitherto used and can give rapid and accurate results.

621.317.34 466
Ratio Meter measures Reflection Coefficient—L. A. Rosenthal, J. L. Potter and G. M. Badoyannis. (*Electronics*, vol. 25, pp. 136–139; November, 1952.) An arrangement is described in which two circuits, each comprising an amplifier and rectifier, are connected respectively to the two coils of a ratio meter, details of which are given. When measuring the reflection coefficient of HF transmission systems, signals

proportional respectively to the incident and reflected waves are fed to the two circuits, and their modulation components are compared by the ratio meter, which can be calibrated in terms of reflection co-efficient or voltage swr. The arrangement is suitable for permanent installation in a HF transmission line.

621.317.341:621.392.21 467
A Simplified Method for Measuring the Attenuation of Balanced Transmission Lines—R. C. Powell. (*Proc. NEC* (Chicago), vol. 7, pp. 287–290; 1951.) Limitations of methods normally used for measuring the attenuation of coaxial and shielded lines, when used for measurements on unshielded balanced lines, are reviewed. A method suitable for measuring the attenuation of unshielded lines to within 1 per cent is described.

621.317.343.3:621.392.26 468
A Recording Broad-Band Waveguide Reflectometer—A. L. Witten and R. E. Henning. (*Proc. NEC* (Chicago), vol. 7, pp. 173–180; 1951.) Description of equipment which records on a chart the reflection co-efficient of a circuit component under test over the frequency band 4.25–6.0 kmc. The energy reflected by the test item is isolated by means of a specially designed high-directivity coupler. Barretter detection, followed by narrow-band AF amplification, is used to ensure square-law detection and constant detection sensitivity. A circuit deriving the square-root of the amplifier output voltage furnishes direct-reading chart indications of reflection co-efficient.

621.317.35:621.396.619.11:373.62 469
Mechanical Synthesis of the Amplitude-Modulated Wave—A. M. Hardie. (*Wireless Eng.*, vol. 29, no. 351, pp. 326–333; December, 1952.) Description of demonstration apparatus, constructed almost entirely from standard Meccano parts, for synthesis of an AM wave from three components with any relative amplitudes and phases.

621.317.35:621.396.619.16 470
Narrow-Band Spectrum Analysis of a Pulse-Position-Modulated Signal—L. H. Lloyd. (*Proc. NEC* (Chicago), vol. 7, pp. 291–298; 1951.) Investigation of the capabilities and limitations of the sound spectrograph for obtaining relative frequency and position data from signals consisting of pairs of short pulses.

621.317.4:621.3.042.143 471
Magnetic-Amplifier Gapless-Core Tests—J. R. Conrath. (*Electronics*, vol. 25, pp. 119–121; November, 1952.) A production test method is described in which the core is subjected to conditions similar to those encountered in operation. Windings for test purposes are obtained by passing a multipin plug through the core window and into a socket.

621.317.41 472
Method for Determining Magnetic Moments and for Measuring Susceptibilities and Permeabilities—S. J. Barnett. (*Jour. Appl. Phys.*, vol. 23, pp. 975–976; September, 1952.) Two similar solenoids A and B, connected in series-opposition through a measuring circuit, are arranged within a third solenoid producing a uniform field. The specimen is first placed within A and then moved quickly to B; from the resulting galvanometer throw the susceptibility is found directly. As compared with the permeameter method this method has the advantage, when testing materials of low permeability, of giving the difference between the permeability of the specimen and that of air, rather than the ratio between the two.

621.317.7.087.6 473
Continuous Recorder Keep-Alive Circuit—R. L. Ives. (*Electronics*, vol. 25, pp. 161–163; November, 1952.) The performance of a pen recorder is improved by injecting an auxiliary 10-cps signal into the system to keep the pens in constant motion. A circuit comprising multivibrator with four independent cathode-follower outputs for producing this signal is described.

621.317.72:621.316.722.4 474
Precision Megohm Ratio Unit for High Voltage Measurements—J. N. Harris. (*Rev. Sci. Instr.*, vol. 23, pp. 409–413; August, 1952.) Description of the construction of a ratio box consisting of 100 10-kΩ manganin units in an oil bath maintained at 33°C, and capable of continuous operation at voltages up to 5 kv.

621.317.723:621.314.58 475
Theory of the Vibrating Condenser Converter and Application to Contact Potential Measurement—J. R. Anderson and A. E. Alexander. (*Aust. Jour. Appl. Sci.*, vol. 3, pp. 201–209; September, 1952.) Analysis indicates that provided the load impedance is large compared with that of the capacitor, the harmonic content of the ac signal generated is small even for large changes of capacitance. The magnitude of the generated signal decreases as the load impedance decreases.

621.317.729:537.291 476
Automatic Tracer for Electron Trajectories—F. Cassanas and P. Barchewitz. (*Jour. Phys. Radium*, vol. 13, supplement, pp. 73A-83A; July/September, 1952.) Theory and description of electrolyte-tank equipment producing plane trajectories, with typical examples of its application.

621.317.73.029.55/.62 477
The Reflectometer for Measurements in the Short-Wave Range—J. Grosskopf. (*Fernmeldetech. Z.*, vol. 5, pp. 307–313; July, 1952.) Theory is given for a new type of directional coupler consisting of a stretched wire antenna arranged parallel to and between the conductors of a coaxial line, and terminated at both ends by its characteristic impedance. The useful frequency range is from 10 to 300 mc. Details are given of construction and performance.

621.317.73.029.62/.63 478
Impedance-Measuring Equipment for the 50-500-Mc/s Range—J. E. Houldin. (*Proc. IEE* (London), part III, vol. 99, pp. 389–399; November, 1952.) Description of equipment for comparison of the modulus of an unknown impedance with that of a standard impedance consisting of a 100-Ω 0.1-w resistor with constant and minimum length of lead. From measurements of (*a*) the resonance impedance of an oscillatory circuit without and with the unknown impedance in parallel, (*b*) the impedance of a capacitor without and with the unknown in parallel, both the resistive and reactive components of the unknown impedance can be determined. Simplification of the general method is possible for several important cases. Typical results for high-value admittances, low-, medium-, and high-value conductances, and reactances of short-circuited transmission lines, are given.

621.317.733 479
The Wien Bridge and Some Applications—C. F. Brockelsby. (*Electronic Eng.*, vol. 24, pp. 450–453; October, 1952.) Analysis of the characteristics of the Wien bridge and discussion of its application to distortion measurement, wave analysis, and stabilization of the frequency of an oscillator.

621.317.735 480
An Electronic High-Voltage Insulation Tester—L. R. Hulls and K. A. Mackenzie. (*Electronic Eng.*, vol. 24, pp. 500–503; November, 1952.) Description, with detailed circuit diagram, of equipment providing a voltage continuously variable from 500 v to 10 kv dc, together with means for measuring resistance values up to $2.5\times10^{11}\Omega$, and an aural indication of the ac component of leakage or ionization current through the test specimen.

621.317.738.029.62 481
An Instrument for Dielectric Measurements in the Frequency Range 100–300 Mc/s—D. L. Hollway and G. J. A. Cassidy. (*Proc. IEE* (London), part III, vol. 99, pp. 364–372; November, 1952.) Description of a short-circuited coaxial line of adjustable length, permitting measurements at different frequencies. The line is terminated by a parallel-plate capacitor with a disk sample of the material under test as dielectric. All measurements are based on AF calibrations of the measurement capacitors. Frequency corrections are analyzed and possible errors discussed.

621.317.75 482
The Monitoring of High-Speed Waveforms—J. G. McQueen. (*Electronic Eng.*, vol. 24, pp. 436–441; October, 1952.) Description of Metropolitan-Vickers Type-500 equipment designed for observation of recurrent waveforms having frequency components up to 300 mc. The recurrence rate should preferably be >100/second. Waveforms with amplitudes as low as 0.1 v are displayed without distortion and two concurrent waveforms can be viewed simultaneously. Loading of the circuit producing the waveform is negligible. The waveform voltage is not used to deflect the beam in a cr tube, but is applied to a circuit capable of measuring its instantaneous amplitude at a selected point of the waveform. Each measurement is used to derive one *y* co-ordinate of a graph of the waveform and each co-ordinate persists for a considerable fraction of the recurrence period. The graph is traced relatively slowly by slightly changing the position of the selected point along the waveform at each recurrence. The *x* co-ordinates of the graph are produced by a deflection synchronized with the position of each selected point. The equipment can be used either with or without its additional anti-jitter unit. Applications to investigation of the build-up of oscillations in a magnetron, break-through in a tr switch to which a magnetron output is applied, build-up of a pulsed 150-mc oscillator, and waveforms associated with a blocking oscillator, are illustrated.

621.317.772 483
A Precision Phase Comparator for Use at Low Radio Frequencies—B. G. Pressey, C. S. Fowler and R. W. Mason. (*Proc. IEE* (London), part III, vol. 99, pp. 413–414; November, 1952.) Summary only. A calibrated phase shifter, such as an inductive goniometer, is connected in turn to the two cw sources whose phase difference is required, and adjusted with reference to an auxiliary source of the same frequency so as to obtain a convenient pattern, such as a straight line, on the screen of a cro. The difference between the successive goniometer settings then gives the required phase difference. Refinements of the method, resulting in increased accuracy of measurement, are described in detail. Modifications enabling the equipment to be used at any one frequency in the range 30 kc–3 mc, or over a range of frequencies, are suggested.

621.317.794.029.5 484
A Simple Bolometer for Dissipation Measurements—V. J. Tyler. (*Marconi Rev.*, vol. 15, pp. 114–117; 3rd Quarter, 1952.) Description of an instrument constructed from small squares of Cu foil, each tinned on one side and painted matt black on the other, arranged in a frame with adjacent squares facing in opposite directions, and with alternate Cu and eureka connections. Direct measurements can be made of the power dissipated by the anode of a small tube.

621.396.615 485
Two-Range Test Oscillator—H. B. Dent.

(*Wireless World*, vol. 58, pp. 508–511; December, 1952.) A compact unit is obtained by using a double-triode tube with the two sections functioning as separate oscillators, e.g. in the 100-mc and 10-mc bands respectively. The desired range is selected by switching the hv supply to the appropriate anode. Modulation voltage is applied across a common resistor to which the two grid leaks are connected. Design details and component values are given.

621.396.615.029.62/.63 486
Wide-Band Sweep Generator for V.H.F. and U.H.F. TV—H. A. Finke and F. Blecher. (*Tele-Tech.*, vol. 11, pp. 52–54, 75; August, 1952.) Description of a generator covering the range 35–900 mc. Tuning is effected by means of a variable shorted transmission line from 900 to 150 mc and by a variable inductor down to 35 mc. Capacitor plates mounted at the end of a vibrating reed provide a frequency sweep of over 30 mc in the uhf range.

621.396.615.14:621.317.75 487
A Sweep-Frequency Oscillator for the U.H.F. Television Band—J. A. Cornell and J. F. Sterner. (*Proc. NEC* (Chicago), vol. 7, pp. 433–439; 1951.) See 2285 of 1952.

621.396.615.17.015.7 488
Simple Pulse Generator for the Study and Testing of Amplifier, Selector and Counter Circuits, as well as Delay Lines—A. Fréon and A. Martin. (*Jour. Phys. Radium*, vol. 13, p. 427; July/September, 1952.) Outline description of equipment using a mains-fed rectifier with a polarized relay for periodic charging and discharging of a capacitor. The discharge takes place through a resistor, the pulse voltage across which is adjustable by means of a potentiometer across the output terminals of the rectifier. Pulse duration is variable from 1 ms to about 0.5 μs; recurrence frequency is that of the mains.

621.396.615.17.015.7:681.142 489
Test Pulse Generator for Digital Computers—A. A. Gerlach. (*Electronics*, vol. 25, pp. 158–160; November, 1952.) Description of a generator which can be arranged to give a wide variety of random pulse outputs. Pulse duration is variable from about 2 to 40 μs, and amplitude up to about 60 v. Gate circuits and multivibrators are constructed as plug-in units. Pulses as short as 0.1 μs are obtained by using blocking-oscillator output circuits in place of cathode followers.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.784:538.31 490
Electric Micro-dynamometer—T. Heim. (*Microtecnic*, vol. 6, pp. 197–208; 1952.) Description of an instrument with nine ranges, for torque measurements from about 10^{-4} to 3 g.cm. The torque to be measured is balanced by varying the current through a coil which can rotate in a radial magnetic field, as in a moving-coil galvanometer.

534.15+539.431]:629.135 491
Aircraft-Vibration Research—D. M. Corke. (*Electronic Eng.*, vol. 24, pp. 518–522; November, 1952.) An outline of various test methods involving electronic applications.

534.321.9.001.8 492
Method of Eliminating Parasitic Waves in Ultrasonic Flaw Testing of Metal Articles—L. Beaujard. (*Compt. Rend. Acad. Sci.* (Paris), vol. 235, pp. 804–806; October 13, 1952.) The parasitic echoes are found to be due to surface waves passing directly from transmitter to receiver. They can be practically eliminated by using a cro with a long-persistence screen.

534.321.9.001.8:678.1 493
Ultrasonic Techniques in the Rubber Industry—R. G. Patton and P. Hatfield. (*Electronic Eng.*, vol. 24, pp. 522–525; November, 1952.) An account of methods of detection of internal air films in rubber products, and measurement of rubber thickness when only one surface is accessible, using ultrasonic waves of frequencies in the range 50–250 kc.

538.24.001.8:659.24/.25 494
The Notched-Disk Memory—J. Rabinow. (*Elec. Eng.*, (N. Y.), vol. 71, pp. 745–749; August, 1952.) Devices developed at the N.B.S. are described in which information is stored magnetically. Pulses are recorded on both sides of coated Al disks threaded on a horizontal ring surrounding a vertical shaft carrying magnetic heads which can be rotated into association with any desired ring. Data can be recovered in a time of the order of 0.5 second.

539.16.001.8 495
Nucleonics and Industrial Applications—D. Taylor. (*Electronic Eng.*, vol. 24, pp. 533–535; November, 1952.)

539.165/.166].001.8:531.717.1 496
Beta-Particle and Gamma-Ray Thickness Gauges—M. G. Hammett and H. W. Finch. (*Electronic Eng.*, vol. 24, pp. 536–539; November, 1952.)

551.508.11:621.396.9 497
An Improved Fully Electric Radiosonde—K. Sittel and E. Menzer. (*Bull. Amer. Met. Soc.*, vol. 31, pp. 341–346; November, 1950.) Details are given of the equipment used for pressure, humidity and temperature measurements, and of the motor-driven switching system used for feeding data to the transmitter.

621.317.083.7 498
A Ten-Channel Pulse-Code Telemetering System—A. J. Bayliss. (*Electronic Eng.*, vol. 24, pp. 485–489; November, 1952.)

621.318.57 499
Speed-Sensing Relay—J. H. Porter. (*Electronics*, vol. 25, pp. 174, 176; November, 1952.) In an arrangement for triggering a circuit at predetermined speeds of a motor, the speed is sampled photoelectrically and the resulting alternating voltage is fed to a thyratron through an adjustable frequency-sensitive network.

621.365.55† 500
Correlation of Temperature and Electric Fields in a Material undergoing Dielectric Heating—J. A. M. Lyon and T. F. Dunsheath. (*Proc. NEC* (Chicago), vol. 7, pp. 475–488; 1951.) Assuming that the loss factor can be expressed as a second-degree function of temperature and that the thermal conductivity of the material is very small, an expression relating temperature, electric-field strength, and time is derived. The expression was checked by measurements made during the heating of a wedge-shaped plastic sample.

621.38:621.791.052 501
A Simple Electronic Weld Timer for Spot Welding Machines—F. Gerspacher. (*Brown Boveri Rev.*, vol. 39, pp. 140–142; April, 1952.) Description, with schematic circuit diagram, of equipment using two ignitrons for accurate control of weld-current times for powers up to about 100 kva and spot welds up to 180/minute.

621.38:621.791.7 502
Electronics in Resistance Welding—P. Huggins. (*Electronic Eng.*, vol. 24, pp. 526–529; November, 1952.) Discussion of various types of welding machine and of electronic systems for weld timing control and automatic compensation of mains-voltage fluctuations.

621.38.001.8:669-427.4 503
Electronic Inspection of Wire Ropes—(*Electronic Eng.*, vol. 24, p. 529; November, 1952.) Short note on equipment for inspection of every inch of a wire rope such as those used in mines, without interruption of service. Faults not detectable by routine visual inspection are easily detected.

621.38.001.8:677 504
The Applications of Electronics in the Textile Industry—A. A. Atkins. (*Electronic Eng.*, vol. 24, pp. 530–532; November, 1952.) Applications in the manufacture and processing of yarn are particularly noted.

621.384.6:614.48:[641+615.7 505
Electron Beams sterilize Food and Drugs—E. A. Burrill and A. J. Gale. (*Electronics*, vol. 25, pp. 98–101; November, 1952.) Packaged or bulk material is irradiated by a hv electron beam which is swept through an 8° arc 200 times/second. The electrons are accelerated by the voltage of 2 mv produced by a Van de Graaff generator, and emerge from the accelerator tube through a thin Al window.

621.384.611 506
Notes on the 225-cm Cyclotron at the Nobel Institute for Physics, Stockholm—H. Atterling and G. Lindström. (*Ark. Fys.*, vol. 4, pp. 559–563; August 19, 1952.) Report of the initial performance of the cyclotron previously described by Atterling (2254 of 1951).

621.384.62 507
The Linear Electron Accelerator—D. W. Fry. (*Philips Tech. Rev.*, vol. 14, pp. 1–12; July, 1952.) A general account, illustrated by reference to the 2-m corrugated-waveguide accelerator at Harwell. By feeding back RF power, high electron energies can be obtained with shorter structures.

621.384.62 508
A 1.5 MV Accelerator for Heavy Particles with Analyzing Magnet for Use in Nuclear Research—C. Mileikowsky and R. T. Pauli. (*Ark. Fys.*, vol. 4, pp. 287–298; August 16, 1952.) Detailed description of equipment installed at Stockholm, comprising accelerator tube fed by a cascade generator working under ordinary pressure.

621.384.62 509
Multiple-Cavity Linear Electron Accelerator—B. L. Miller. (*Rev. Sci. Instr.*, vol. 23, pp. 401–408; August, 1952.) Description of an accelerator comprising five cylindrical resonators operating in the TM_{010} mode, and producing beams with energies up to 1.4 mev.

621.385.833:537.291 510
Paraxial Electron Trajectories in Electrostatic Lenses—C. Fert. (*Jour. Phys. Radium*, vol. 13, supplement, pp. 83A–90A; July/September, 1952.) Description, with examples, of a simplified method of tracing paraxial trajectories by use of transformation matrices or tables characteristic of intervals or surfaces, following a classical optical method.

621.385.833:537.291 511
A Method of Calculating Trajectories in Electron Optics. Generalization to Homogeneous Linear Differential Equations—F. Bertein. (*Jour. Phys. Radium*, vol. 13, supplement, pp. 91A–98A; July/September, 1952.)

621.387.4:621.385.83 512
The 6BN6 Gated-Beam Tube as a Fast Coincidence Circuit—J. Fischer and J. Marshall. (*Rev. Sci. Instr.*, vol. 23, pp. 417–420; August, 1952.)

PROPAGATION OF WAVES

621.396.11 513
Deformation of Electromagnetic Pulses Propagated in the Ionosphere—B. N. Gershman. (*Zh. Tekh. Fis.*, vol. 22, pp. 101–104; January, 1952.) A formula (2) is quoted determining the waveform of a pulse which has passed through the ionosphere. The deforma-

tion experienced by such a pulse has previously been calculated to a first approximation. Corresponding second-approximation formulas are now derived. For the main part of the pulse, the difference between the amplitudes calculated in accordance with the two approximations is not greater than 2 per cent. The more exact formulas give a clearer picture of the phenomena and, in particular, indicate that the pulse becomes asymmetrical.

621.396.11:551.510.535 514
The Quasi-Transverse (Q.T.) Approximation to Appleton's Magneto-Ionic Equation—J. D. Whitehead. (*Jour. Atmos. Terr. Phys.*, vol. 2, pp. 361–362; 1952.) It is shown that the usually accepted form of Booker's quasi-transverse approximation (3306 of 1935) to Appleton's equation (1933 Abstracts) is incorrect; the correct form is given.

621.396.11:551.510.535 515
A Physical Interpretation of the Corrected Quasi-Transverse Approximation for the Ordinary Wave—F. Lied. (*Jour. Atmos. Terr. Phys.*, vol. 2, p. 362; 1952.) An interpretation of the approximation given in 514 above.

621.396.11.029.51:551.510.535 516
Theoretical Group Heights of Reflection of 150-kc/s Radio Waves Vertically Incident on the Ionosphere—N. Davids. (*Jour. Atmos. Terr. Phys.*, vol. 2, pp. 324–336; 1952.) The group heights of reflection for 250-μs Gaussian pulses of 150-kc radiation are calculated using a wave-theory treatment including coupling, and an ionosphere model of Chapman type. The results obtained by Gibbons and Nertney (137 of 1952) on cw are extended by taking account of dispersion, the characteristics of the received pulse being determined by means of a response function developed from a suitable Fourier-Hermite series. The rapid changes of polarization near the lower edge of the E layer (the "coupling region") give rise to reflection under suitable conditions, i.e. late night hours associated with low f_cE; but since dispersion is slight, group retardation should be almost negligible. At a higher level in the *E* layer the refractive index for one of the wave components varies rapidly, and time delays are large for models with low f_cE. Results obtained from the theory are in good agreement with observations.

621.396.11.029.51:551.510.535 517
Wave Solutions, including Coupling, of Ionospherically Reflected Long Radio Waves for a Particular E-Region Model—J. J. Gibbons and R. J. Nertney. (*Jour. Geophys. Res.*, vol. 57, pp. 323–338; September, 1952.) An extension of previous work (137 of 1952), the same ionosphere model being assumed. The method of variation of parameters is used to obtain approximate solutions of the wave equation for the case of coupling of the ordinary and extraordinary waves. The effect of coupling is to cause a wave traversing a coupling region to excite a new wave in the same direction as that of the incident wave, and also a back-scattered wave in the reverse direction. In the case of 150-kc waves, the coupling effects occur for electron densities around 300/cm^3, corresponding to the classical reflection level for the ordinary wave. The solutions obtained indicate that the assumed model may be satisfactory as regards group heights and the return of at least two echoes of a single incident pulse, but that for satisfactory explanation of absorption and polarization effects an electronic D region must be assumed below the E region.

621.396.11.029.51:551.510.535 518
A Method for Obtaining the Wave Solutions of Ionospherically Reflected Long Waves, including All Variables and Their Height Variation—J. J. Gibbons and R. J. Nertney. (*Jour. Geophys. Res.*, vol. 57, pp. 423–426; September, 1952.) Discussion on 137 of 1952.

621.396.11.029.53/.55:551.510.535 519
The Causes of Excessive Absorption in the Ionosphere on Winter Days—W. Dieminger. (*Jour. Atmos. Terr. Phys.*, vol. 2, pp. 340–349; 1952. In German.) In a previous paper by Dieminger and Hoffmann-Heyden (2317 of 1952) it was suggested that echoes observed on frequencies in the range 1.6-4 mc, due to reflections at heights of 75–100 km, were related to the abnormally high absorption experienced by waves traversing the ionosphere on some days in winter. Further investigations, now reported, confirm this view. The echoes are produced by a partial reflection at a sharp boundary of an ionized region extending down from the E layer to heights of 75–90 km. Solar control is indicated, but no conclusive explanation is yet available. Echoes produced by reflection at 95 km at night-time are attributed to meteoric-dust ionization.

621.396.11.029.58:551.510.535 520
Radio Links covering Very Great Distances—E. Harnischmacher and K. Rawer. (*Compt. Rend. Acad. Sci.* (Paris) vol. 235, pp. 709–711; October, 1952.) Observations obtained on links with the antipodes using decametre waves indicate lateral deflections due to ionospheric reflections. It seems possible that reflection occurs in a nearly horizontal plane at regions of horizontal ionization gradient at certain times of the day, e.g., around sunrise. An estimate is made of the decrease of received field strength caused by the deflection thus produced. This type of propagation may explain certain observations of reception at frequencies above the muf.

621.396.11.029.62 521
Optical Refraction and U.S.W. Propagation in the Baltic Area in the Spring of 1952—E. A. Lauter and G. Bartels. (*Z. Met.*, vol. 6, pp. 215–220; July, 1952.) An unusual case of anomalous optical refraction observed April 17, 1952 discussed in relation to the prevailing weather conditions and radio propagation at a frequency of 90.7 mc over the 180-km path from Copenhagen to Kühlungsborn. Both vertical and horizontal inhomogeneities of the lower atmosphere have an important influence on propagation. High values of received field strength do not always accompany abnormal optical refraction, but were observed throughout the season whenever there was a marked inversion over the Baltic.

621.396.8:621.3.018.41(083.74) 522
World-Wide Standard-Frequency Broadcast Reception—E. L. Hall. (*Tele-Tech.*, vol. 11, pp. 46–48, 99 and 64–65, 126; June and July, 1952.) A report of some thousands of observations during 1950 of the reception of WWV and WWVH signals at places distributed over a large part of the surface of the earth, and of a few observations made in U.S.A. and in Hawaii of the reception of 5-mc and 10-mc signals from station MSF (Rugby, England). Analysis of the available data indicates that (*a*) the 5-mc transmissions are generally useful for shorter distances during daylight and for a few thousand miles at night, (*b*) the 10-mc transmissions are useful for longer distances and do not show the pronounced day-time attenuation noted with 5-mc signals, (*c*) the 15-mc signals are useful for distances from a few hundred to 10,000 miles, day or night. Reception range is affected by changes in sunspot numbers, by season of year, ionosphere disturbances, and local conditions of atmospheric or man-made electrical noise.

621.397.26.029.63:621.396.81 523
Broadcasting TV in the U.H.F. Band—J. Epstein and D. W. Peterson. (*Electronics*, vol. 25, pp. 102–109; November, 1952.) An investigation was made of the coverage obtainable using frequencies of 530.25 and 850 mc; the difference between propagation conditions at these frequencies and at 85 mc is emphasized. Values of received field strength calculated from theory are presented for comparison with the observed values, which are lower. Two distance ranges are considered, viz. 1–5 and 5–21 miles respectively. Transmitting antennas with strong vertical directivity were used, the 850-mc antenna being also horizontally directive. Tilting the beam slightly downward was found to increase received field strength, so that the required coverage could be achieved with narrower vertical beam-width. Difficulties involved in making measurements in built-up areas are discussed; in the experiments a $\lambda/2$ dipole antenna with plane reflector was used. Small-aperture receiving antennas should be used to avoid field-distortion effects.

621.397.81:621.317.328:629.135.4 524
Measuring TV Field Intensities by Helicopter—Preston. (See 576.)

RECEPTION

621.396.621 525
La Météo assigns First Place to a French Communications Receiver—(*Électronique* (Paris), nos. 68/69, pp. 43–45; July/August, 1952.) Description of a W/T R/T receiver covering the range 1.94–30.8 mc in seven wavebands, and selected by the French Meteorological Office as the most robust and most easily demountable.

621.396.621.54 526
Design of Slug-Tuned Superheterodyne Receivers—P. S. Wessels. (*Electronics*, vol. 25, pp. 176–202; November, 1952.) Design procedures are given whereby the RF and oscillator coils can be made to tune with a sufficiently constant frequency difference by proper choice of the diameter of the tuning cores. Band coverage and oscillator circuits are discussed.

621.396.621.54:621.396.822 527
Second-Detector Signal-to-Noise Improvement—L. S. Schwartz. (*Proc. NEC* (Chicago), vol. 7, pp. 141–150; 1951; *Tele-Tech.*, vol. 11, pp. 56, 107; October, 1952.) Signal and noise levels in each functional division of a superheterodyne receiver are analyzed, the discussion being limited to radar types of pulse receiver and to signals not less than the noise, both signal and noise being large enough to cause linear operation of the second detector. Formulas are derived from which the noise figure of the receiver can be calculated, knowing only the signal/noise ratio at the output and the gain and loss parameters of the receiver. The theory is checked by measurements on a pulse receiver.

621.396.622:621.396.619.11 528
Synchronous Detection of Amplitude-Modulated Signals—J. P. Costas. (*Proc. NEC* (Chicago), vol. 7, pp. 121–129; 1951; *Tele-Tech*, vol. 11, pp. 55–57, 119; July, 1952.) The detection of periodic signals in noise by the method of correlation has been shown to give large improvements in signal/noise ratio. If an AM carrier wave is to be detected, correlation methods lead to synchronous AM detection. Demodulation is performed by generating in the receiver a sinusoidal oscillation with the same frequency and phase as the incoming carrier, and multiplying the incoming signals by the local-oscillator voltage. If in addition a second synchronous detection system is applied, with the oscillator in phase quadrature with the signal, considerable adjacent-channel interference suppression results from proper combination of the in-phase and quadrature detector outputs. Discussion shows that dsb signals, when properly received, are in general less susceptible to adjacent-channel interference or jamming than ssb signals.

621.396.622:621.396.822 529
Input versus Output Signal-to-Noise Characteristics of Linear, Parabolic, and Semi-cubical Detectors—A. H. Schooley and S. F. George. (*Proc. NEC* (Chicago), vol. 7, pp. 151–161; 1951; *Tele-Tech*, vol. 11, pp. 60–63, 75; July, 1952.)

621.396.622.71.029.64:537.562 530
An Ionized-Gas Energy Detector for Microwaves—H. Burroughs and A. B. Bronwell. (*Proc. NEC* (Chicago), vol. 7, pp. 598–600; 1951; *Tele-Tech*, vol. 11, pp. 62–63, 123; August, 1952.) An ionized-gas diode has been found to serve as an effective detector or heterodyne mixer of microwave signals. The gas is ionized by application of direct voltage to the diode terminals. When used in a waveguide, operation is independent of the waveguide mode.

621.396.82:621.396.619.11/.13 531
Interference caused by Interfering Transmitters—M. Kulp. (*Arch. elekt. Übertragung*, vol. 6, pp. 388–389; September, 1952.) Addendum to 2325 and 2886 of 1952. More accurate formulas can now be derived for certain of the cases considered, as a result of exact relations having been found between the Bessel functions involved.

621.396.822:519.241.1 532
Autocorrelation Function and Power-Density Spectrum of Clipped Thermal Noise. Filtering of Simple Periodic Signals in such Noise—L. Robin. (*Ann. Télécommun.*, vol. 7, pp. 375–387; September, 1952.) Analysis is presented relative to the noise resulting from passage of random noise, with a Gaussian distribution and uniform power-density spectrum in the frequency range considered, through a nonlinear clipping circuit. Two methods of determining the autocorrelation function of the clipped noise voltage have been used, an approximate statistical method due to Ville and a purely mathematical method based on the characteristic function [2168 and 2169 of 1945 (Rice)]. The latter method is preferred, as it gives the required function in the form of a convergent power series, the successive coefficients being respectively proportional to the square of the error function and of its successive derivatives of odd order. A formula, due to Mehler, on the series of products of Hermite polynomials, enables this series to be replaced by a fairly simple definite integral and finally by the sum of functions which are tabulated or easily calculated numerically. The power-density spectrum is given by the Fourier transform of the correlation function. The spectrum is shown to consist of the limited uniform spectrum existing before clipping, with reduced ordinates, with a superposed continuous spectrum extending to infinity and rapidly decreasing.

The filtering of a periodic rectangular signal plus noise by passage through a correlator is examined by the characteristic-function method. The autocorrelation function is obtained in the form of the sum of convergent power series. Hence in the steady state the autocorrelation function is found to be represented by a periodic succession of isosceles triangles whose height decreases as clipping is increased.

STATIONS AND COMMUNICATION SYSTEMS

061.3:621.39 533
The Work of the 16th Plenary Assembly of the Comité Consultatif International Téléphonique, Florence, 22nd to 27th October, 1951—A. Langenberger. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, vol. 30, pp. 214–225; July, 1952.)

[621.396.97.029.62+621.397.61.029.62:061.3 534
European Broadcasting Conference, Stockholm, 1952—H. Pressler. (*Fernmeldetech. Z.*, vol. 5, pp. 417–420; September, 1952.) Report of the proceedings. See also 3560 of 1952 (Stepp).

621.39.001.11:519.272 535
The Autocorrelation Function from the Ergodic Hypothesis—R. O'Neill, H. M. Thaxton and S. Cutler. (*Proc. NEC* (Chicago), vol. 7, pp. 74–77; 1951.)

621.39.001.11:536.758 536
Concept of Entropy in the Calculus of Probability—A. Fromageot. (*Ann. Télécommun.*, vol. 7, pp. 388–396; September, 1952.) In order to measure the quantity of information, Shannon has introduced a quantity whose mathematical expression is that of entropy in statistical mechanics. Different types of random phenomena for which an entropy can be defined are here distinguished and their principal properties are indicated. Application is made to the theory of communication in the presence of noise.

621.394.324.001.11:519.272 537
Application of the Ergodic Hypothesis in Calculating the Autocorrelation Function of Teletype Signals—S. Cutler, R. O'Neill and H. M. Thaxton. (*Proc. NEC* (Chicago), vol. 7, pp. 78–84; 1951.

621.395.659:621.387.032.212 538
Some Applications of Cold-Cathode Tubes to Switching Systems—S. Simon. (*Elec. Commun.*, vol. 29, pp. 207–218; September, 1952.) The structure and characteristics of Type-2313 cold-cathode relay tube, and some of its applications to telephone switching, particularly the rotary system, are described.

621.396(43) 539
Established Radio Services of the West German Post Office—(*Funk-Technik* (Berlin), vol. 7, p. 498; September, 1952.) A detailed list of the short-wave and long-wave transmitters and facilities for oversea telephony, telegraphy and teleprinting, and for radio services within Europe, including diplomatic news and press services.

621.396.323:621.396.82 540
Experimental Investigation of the Smallest Separation Permissible between the Frequencies of Two Radiotelegraph Transmissions—A. Niutta. (*Poste e Telecomunicazioni*, vol. 20, pp. 272–277; June, 1952.) The Italcable Co. in collaboration with the Dutch Post Office have made tests on teletype transmissions, using frequencies around 13 mc. Standard phrases and characters were transmitted by a frequency-shift transmitter; tables are presented of the number of errors recorded at the receiver for different values of the frequency separation and relative strength of a disturbing AM (on-off) transmitter. The results indicate that 1 kc is the smallest frequency separation permissible when the received field strengths from the two transmitters are about equal. For complete protection of one frequency-shift transmission against another, a separation of 2 kc is probably necessary.

621.396.5 541
Single-Sideband System for Overseas Telephony—N. F. Schlaak. (*Electronics*, vol. 25, pp. 146–149; November, 1952.) The system described operates in the frequency range 4–23 mc and provides 4 channels. Peak power output of the transmitter is 4 kw. Improvements with respect to earlier equipment include push-button selection of any of 10 preselected frequencies, use of varistors as modulators, a device to ensure full use of output whatever the number of channels in use, and reduction of out-of-band radiation and interchannel cross-talk. The companion receiver is described briefly.

621.396.5:621.396.931 542
The Suitability of the 1.6-3-Mc/s and U.S.W. Bands for the Development of the Rhine Radiotelephone Service—W. Kronjäger and H. Wallor. (*Fernmeldetech. Z.*, vol. 5, pp. 301–306; July, 1952.) Experimental work on the system for connecting ships on the Rhine with the public telephone service was begun in 1948, using the 1.6–3-mc band. Reception was good in the daytime, apart from atmospherics in summer, but was spoiled at night by interference from distant stations on this waveband. It was decided in 1950 to go over to the usw band, and experiments were started to decide the merits of the 2-m, 4-m and 7-m bands. Field-strength measurements in the hilly region between Rüdesheim and Coblentz and around Mannheim are reported. AM and FM systems were compared, FM showing several advantages. Use of the 2-m rather than the 4-m or 7-m bands would offer the advantage that equipment for the harbor radio service could be used.

621.396.619.16 543
Delta Modulation, a New Modulation System for Telecommunication—J. F. Schouten, F. de Jager and J. A. Greefkes. (*Commun. News*, vol. 12, pp. 115–124; June, 1952.) See 2603 of 1952.

621.396.621:621.316.726:621.396.931.029.62 544
A V.H.F. Multiband Panoramic Receiver—E. W. Crompton. (*Electronic Eng.*, vol. 24, pp. 478–484; November, 1952.) The AM system developed for county police and fire services [228 of 1949 (Brinkley)] involves the use of several (usually three) unattended vhf transmitters about 10–30 miles apart, operating on frequencies in the band 90–100 mc with spacings of 7–12 kc. A detailed description is given of equipment for monitoring the radiation, modulation and frequency spacing of four such county systems simultaneously. The signals from the different transmitters are displayed in the form of pulses on the screens of two double-beam cr tubes. Carrier power determines the pulse amplitude, and the degree of modulation is given approximately by the pulse width. A simple method for determining the frequency separation of any two transmitters is described.

621.396.65 545
Result of a Tour of Inspection of Radio Links in the U.S.A.—E. Dietrich. (*Fernmeldetech. Z.*, vol. 5, pp. 327–332; July, 1952.) Report of a survey made in October 1951. Station buildings are particularly discussed and illustrations are shown; some of the most modern antenna towers are of steel.

621.396.65:621.395.44 546
An Experimental Radio-Telephone Link between Eindhoven and Tilburg—J. M. van Hofweegen. (*Commun. News*, vol. 12, pp. 144–152; June, 1952.) Detailed description of the new FM transmitter and receiver designed for the 15-channel P/T link between two factories 30 km apart. Operating frequency is about 300 mc, channel bandwidth 4 kc, and power delivered to a Yagi antenna 20 w. Afc is applied magnetically to the oscillator coil, which is shunted by a NTC resistor (303 of 1950) ensuring correct operation when the transmitter is cold. Noise figure of the receiver referred to input and detector circuits is about 8.

621.396.65.029.62/.63 547
V.H.F. Radio—E. G. Hamer. (*Wireless World*, vol. 58, pp. 519–523; December, 1952.) A review of various systems in use, including mobile and fixed services, both broadcasting and multichannel. The relative merits of FM and AM in different cases are considered.

621.396.66:621.396.97 548
B.B.C. New Automatic Unattended-Transmitter Technique—F. A. Peachey, R. Toombs

and C. Gunn-Russell. (*Electronic Eng.*, vol. 24, pp. 446–449 and 490–492; October and November, 1952.) A description is given of the operating principles of (*a*) equipment providing automatic monitoring of an unattended transmitter over the line linking it to its parent station, (*b*) monitoring equipment for stations with several transmitters operating in parallel, each transmitter being checked by its own self-contained monitor, as in the case of the two-unit 150-kw transmitter at Daventry (2924 of 1952). Details have previously been given [1491 of 1951 (Rantzen et al.)] of the line type of monitor.

SUBSIDIARY APPARATUS

621–526 549
Design of Damper-Stabilized Instrument Servomechanisms—J. F. Koenig. (*Proc. NEC* (Chicago), vol. 7, pp. 24–28; 1951.)

621.526:621.3.012.8 550
A Transient Approach to the Solution of a Linear Servomechanism by an Equivalent Network—S. P. Tung. (*Proc. NEC* (Chicago), vol. 7, pp. 7–13; 1951.)

621–526:621.3.016.352 551
Stabilization of Variable-Carrier-Frequency Servomechanisms—K. Schurr. (*Proc. NEC* (Chicago), vol. 7, pp. 14–23; 1951.)

621.311.6:621.316.722.1 552
Highly Stable Power Supply—G. Cosci and K. Fränz. (*Rev. telegr. Electronica* (Buenos Aires), vol. 40, pp. 473–475; August, 1952.) Description of equipment giving voltages adjustable between 200 and 300 v with loads up to 100 ma; the variation of output voltage is of the order of 1 part in 10^{-4} for line fluctuations of 10 per cent. The dc output resistance is 0.14Ω and the residual hum voltage <0.2 mv. A VR75 tube is used as voltage comparison standard. The feedback circuit includes two pentode stages and a cathode-follower stage comprising two triodes in parallel.

621.311.6.027.7 553
High-Voltage Power Supplies—(*Electronics*, vol. 25, pp. 170, 172; November, 1952.) Two units are described: (*a*) an interrupted RF oscillator with rectifier-tripler, and (*b*) a continuous RF oscillator with rectifier doubler. Both give an output of about 200 μA at 25 kv and both include low-loss transformers with ferroxcube cores. (*a*) is housed in an oil-filled container; (*b*) is larger, and dispenses with oil.

621.316.722.1 554
A Variable-Voltage Stabilizer employing a Cold-Cathode Triode—F. S. Goulding. (*Electronic Eng.*, vol. 24, pp. 493–497; November, 1952.) A circuit is described in which a cold-cathode gas-filled triode acts as a dc amplifier. Such an arrangement has desirable characteristics as a voltage stabilizer in low-current circuits. A portion of the output voltage of a source is compared with a reference voltage, the difference being used to control the current through the parallel-connected stabilizer tube so that the output voltage is maintained at a constant value.

TELEVISION AND PHOTOTELEGRAPHY

621.397.26 555
Experimental U.H.F. Broadcast—R. P. Wakeman. (*Electronics*, vol. 25, pp. 168, 170; November, 1952.) Brief account of a school television broadcast made in April 1952. The video equipment was a standard DuMont dual orthicon camera chain. Signals were beamed on 7 kmc from the point of origin to the New York uhf broadcasting transmitter (558 of 1952) 12 miles away. The uhf antenna system comprised two slotted waveguides arranged back to back. Commercial vhf receivers were used with uhf converters; antennas were 12-element broadside arrays with reflectors.

621.397.26.029.63:621.396.81 556
Broadcasting TV in the U.H.F. Band—Epstein and Peterson. (See 523.)

621.397.3 557
Some Recent Developments in Photo-Telegraphy and Facsimile Transmission—J. Bell, J. A. B. Davidson and E. T. A. Phillips. (*Proc. IEE* (London), part III, vol. 99, pp. 344–359; November, 1952. Discussion, pp. 359–363.) An account of recently produced equipment, including machines for 500-lines/inch scanning and electrochemical receiving and monitoring equipment.

621.397.3 558
The Transmission of Pictures by Radio—A. W. Cole and J. A. Smale. (*Proc. IEE* (London), part III, vol. 99, pp. 325–334; November, 1952. Discussion, pp. 359–363.) A review of picture-telegraphy developments since 1842, and particularly of radio methods since the first transatlantic tests in 1924.

621.397.3:621.394.9 559
A Photo-Telegraph Transmitter-Receiver utilizing Subcarrier Frequency Modulation—R. O. Carter and L. K. Wheeler. (*Proc. IEE* (London), part III, vol. 99, pp. 335–343; November, 1952. Discussion, pp. 359–363.) Description of equipment using the same mechanical and optical system for transmission and reception. Drum speed is controlled by a crystal oscillator.

621.397.5 560
The Northern Television Outside Broadcasts—W. D. Richardson. (*BBC. Quart.*, vol. 7, pp. 55–61; Spring, 1952.) Description of technical arrangements in connection with the inauguration of the Holme Moss transmitter, October 1951.

621.397.5:535.623/.624 561
Definitions for Colour Television—(*Electronics*, vol. 25, pp. 208, 236; November, 1952.) Approved working definitions submitted to the U. S. N.T.S.C. in June 1952 are presented.

621.397.5:535.88 562
Instantaneous Theater Projection Television System—V. Trad and R. Muniz. (*Jour. Soc. Mot. Pic. Telev. Eng.*, vol. 59, pp. 125–139; August, 1952.) Description, with circuit details, of a dual projection system of the Schmidt type. A simple control box mounted in the cinema projection chamber provides almost instantaneous change-over in case of breakdown of either unit. An automatic brightness-control circuit is included in the equipment. The mechanical design facilitates operation and maintenance.

621.397.5:612.84 563
The Significance of Adaptation of the Eye for Television Transmission—P. R. Arendt. (*Fernmeldetech. Z.*, vol. 5, pp. 411–416; September, 1952.) Discussion of the characteristics of the human eye as regards its sensitivity to light stimulus, response to changes of intensity, perception of contrast, etc., in relation to the optical characteristics of television systems.

621.397.5:621.396.712.2/.3:061.4 564
Exhibition Broadcasting Studios—G. T. Myers and I. Newbiggin-Watts. (*BBC. Quart.*, vol. 7, pp. 181–192; Autumn, 1952.) Description of the arrangement and construction of the studio and control room for television broadcasts from the Radio Exhibition, London, 1951.

621.397.6:621.396.615.17 565
Grey-Scale Generator—G. E. Hamilton and R. Ilowite. (*Electronics*, vol. 25, pp. 143–145; November, 1952.) A thyratron circuit is described for generating a stepped signal, corresponding to a standard scale of graded greys, for investigating the transfer characteristics of television circuits. The signal includes blanking and synchronizing pulses. With this method of testing, operation conditions are the same as for picture signals, and there is no need to disable clamping circuits. The standard signal may be included on the film, when making photographic records of television, to provide a control.

621.397.61 566
Experimental 850-Mc/s TV Transmitter—G. A. Olive. (*Electronics*, vol. 25, pp. 110–115; November, 1952.) Description of the transmitter at station KC2XCY, near Bridgeport, Conn. A grounded-grid Type-6161 forced-air-cooled coaxial triode with single-tuned cavity is used for the final stage, with grid modulation. Neutralizing requirements are analyzed in detail. The peak power output of the modulated vision transmitter is 300 w, and the antenna gain is 19.2 db. When running unmodulated the output power is 200 w, the anode-circuit efficiency of the final stage being then about 58 per cent. Phase modulation on the Serrasoid principle is used in the sound transmitter, which operates on 854.5 mc and has a power output of 150 w to an antenna with a gain of 16.2 db. The circuit for preventing relative drift between sound and vision carrier frequencies is described particularly.

621.397.61:621.396.619.2 567
A Comparison of High-Level with Low-Level Modulation for Television Transmitters V. J. Cooper. (*Marconi Rev.*, vol. 15, pp. 118–137; 3rd Quarter, 1952.) A detailed study is made of various possible methods of achieving a 50-kw television transmitter, based on the performance to be expected from a representative selection of available tubes. It is assumed that the minimum possible bandwidth is provided conforming to the B.B.C. asymmetrical transmission characteristic; this assumption implies that there should be no external response-shaping filters. With low-level modulation the main problem is to achieve adequate coupling and bandwidth in the intervalve circuits; the possibilities of double-tuned and triple-tuned couplings are examined in relation to both 405-line and 625-line standards. While under laboratory conditions the low-level system can show a small saving of initial cost, the high-level system is preferable in general because it is simpler to maintain.

621.397.61:621.396.619.2 568
Low-Level Modulation—(*Wireless World*, vol. 58, pp. 512–514; December, 1952.) A comparison is made between low-level and high-level modulation systems, with particular reference to the B.B.C. television transmitters at Kirk O' Shotts and Wenvoe on the one hand and Sutton Coldfield and Holme Moss on the other. The low-level system costs less and is more adaptable.

621.397.62:621.311.69 569
High-Tension Generators for Large-Picture Projection Television—J. J. P. Valeton. (*Philips Tech. Rev.*, vol. 14, pp. 21–32; July, 1952.) Four methods are discussed for generating voltages of 5 kv and over. For producing a picture 3 m×4 m, a voltage of 50 kv is required; the method used in this case involves the rectification of a sinusoidal voltage of frequency 20–30 kc, generated by an oscillator incorporating a coil with ferroxcube core. With this arrangement the direct voltage is maintained steady from no-load to full-load conditions, and there is a rapid fall when full load is exceeded. The oscillator and rectifier are described; steps are taken to ensure a low internal resistance. Details, with illustrations, are given of two experimental 50-kv generators supplying 0.45 ma and 1.5 ma respectively.

621.397.62:621.316.726:621.317 570
Evaluating A.F.C. Systems for Television Receivers—G. Howitt. (*Electronics*, vol. 25, pp. 132–135; November, 1952.) Description of measurement techniques and circuits for assessing the performance of AFC systems used in conjunction with horizontal-deflection circuits.

621.397.62:621.396.662 571
Performance and Design of a Compact U.H.F. Tuner—H. F. Rieth. (*Tele-Tech*, vol. 11, pp. 42–43, 80; August, 1952.) Description of a frequency-converter attachment which uses a shorted transmission line for continuous tuning from 470 to 890 mc. Its associated IF amplifier, with 21-db gain, feeds directly into the vhf receiver.

621.397.621 572
Improved Blanking Circuit—S. Cuker. (*Electronics*, vol. 25, pp. 260, 264; November, 1952.) With the higher voltages used in large-screen picture tubes, an increase of retrace time is unavoidable, necessitating blanking of the horizontal retrace. To eliminate the so-called "curtain effect" thereby introduced, the retrace blanking is made proportional to the brightness level. A suitable circuit is shown.

621.397.621:621.318.23 573
Fundamentals of the Permanent-Magnet Focusing System for Cathode-Ray Tubes—K. Jekelius. (*Fernmeldetech. Z.*, vol. 5, pp. 320–326; July, 1952.) Formulas are derived from which, in conjunction with measured correction factors, the parameters of simple permanent- and energized-magnet electron lenses can be calculated with good accuracy. To avoid astigmatism in permanent-magnet lenses, attention must be paid to geometrical and magnetic symmetry and care must be taken that the external field is not made asymmetrical by the presence of iron parts.

621.397.621:621.318.4 574
Deflector-Coil Construction—W. T. Cocking. (*Wireless World*, vol. 58, pp. 480–486; December, 1952.) Detailed illustrated description of a method based on winding a flat slab coil and bending it to the required shape, using a special winding former and simple bending jig adapted for the production of both line-deflection and frame-deflection coils.

621.397.621.2:535.623 575
The 3-Gun Shadow-Mask Color Kinescope—H. B. Law. (*Elec. Eng.* (N. Y.), vol. 71, pp. 723–728; August, 1952.) See 844 of 1952.

621.397.81:621.317.328:629.135.4 576
Measuring TV Field Intensities by Helicopter—J. G. Preston. (*Tele-Tech*, vol. 11, pp. 64–65, 114; June, 1952.) Measurements carried out in a helicopter, using a retractable horizontal resonant loop as receiving antenna mounted well below the fuselage, were found very reliable. Reflection and terrain effects which interfered with measurements at ground level were avoided, so that the effect of antenna modifications on the radiation pattern could be quickly and accurately determined.

621.397.828 577
Bus-Bell Interference—(*Wireless World*, vol. 58, p. 511; December, 1952.) Simple methods are indicated for preventing interference with television reception due to operation of the stop-start bell on buses.

621.397.5 578
Television. [Book Review]—F. Kerkhof and W. Werner. Publishers: Cleaver-Hume Press, London. 475 pp., 50 s. (*Wireless Eng.*, vol. 29, p. 336; December, 1952.) A translation. See 2643 of 1952.

TRANSMISSION

621.396.619.27:621.3.011.21 579
The Performance of Rectifier Modulators: Part 1—The Input Impedance of Rectifier Modulators with Frequency-Selective Terminations—D. G. Tucker. (*Proc. IEE* (London), part III, vol. 99, pp. 400–402; November, 1952.) "The calculation of the input impedance appears to be impracticable in the general case; but in special cases where the terminating impedances can be restricted to zero or infinity or to a pure resistance at the various frequencies which can exist in the circuit, and where the resistance/time function of the rectifier can be expanded as a Fourier series independent of the signal frequencies, i.e., controlled solely by the carrier, calculation is possible, and a selection of results is tabulated."

621.396.619.27:621.3.011.21 580
The Performance of Rectifier Modulators: Part 2—Carrier-Leak Control in Rectifier Modulators by the use of a D.C. Meter—D. G. Tucker. (*Proc. IEE* (London), part III, vol. 99, pp. 402–404; November, 1952.) Monitoring of carrier leak in a modulator of the shunt type can be effected by means of a dc meter measuring the dc component of the leak. For very accurate results the back impedance of the rectifiers must be very high or else comparatively well balanced. This method should enable leak voltages of the fundamental carrier frequency to be maintained at a level 40 db below the carrier voltage. The method is not suitable for use with ring modulators.

621.397.61 581
Experimental 850-Mc/s TV Transmitter—Olive. (See 566.)

621.397.61:621.396.619.2 582
A Comparison of High-Level with Low-Level Modulation for Television Transmitters—Cooper. (See 567.)

621.397.61:621.396.619.2 583
Low-Level Modulation—(See 568.)

TUBES AND THERMIONICS

537.533.8 584
Angular Distribution of Secondary Electrons from Nickel—J. L. H. Jonker. (*Le Vide*, vol. 7, pp. 1230–1238; July/September, 1952.) See 1769 of 1952.

621.314.7 585
Transistors Operate at 300 Mc/s—G. M. Rose and B. N. Slade. (*Electronics*, vol. 25, pp. 116–118; November, 1952.) Point-contact transistors are considered. Operation at higher frequencies can be achieved by reducing the spacing between the emitter and collector electrodes, but limits are set by mechanical difficulties and stability considerations. Instability is due to a positive-feedback effect which can be controlled by suitable choice of Ge resistivity. Oscillations at frequencies up to 302 mc have been achieved with transistors having an electrode spacing of about 0.0005 inch.

621.314.7:621.396.822 586
Blocking-Layer Interaction and Statistical Fluctuations in Crystals with Three Electrodes [Transistrons]—H. F. Mataré. (*Jour. Phys. Radium*, vol. 13, supplement, pp. 112A–127A; July/September, 1952.) A brief review is given of the development in America of transistors and in France of transistrons, and measurable parameters are defined which determine the characteristics of transistrons under given operation conditions, such as the short-circuit stability, the power amplification, and the interaction factor. This factor is simply related to the fraction of the emitter current carried by the holes, which was introduced by Shockley for calculations on filament-type transistors. An equivalent circuit is developed which enables a calculation to be made of the output noise voltage. The physical mechanism which is the cause of the high noise level is discussed. Mathematical theory previously given (2928 of 1952), including derivation of the Einstein-Fokker-Planck equation for the density probability of scleronomic systems in the case of statistical fluctuations, is here repeated.

621.385:168.2 587
Electron Tubes for Industry and Research—C. C. Gee. (*Electronic Eng.*, vol. 24, pp. 540–544; November, 1952.) Electron tubes are classified into seven fairly distinct groups, with notes on the principal applications of each of the many sub-groups. The last main group, a miscellaneous one, includes ionization-type vacuum gauges, electron microscopes and particle accelerators.

621.385.029.6:621.396.9 588
U.H.F. Valves for 3-cm Radar Equipment—R. Musson-Genon. (*Le Vide*, vol. 7, pp. 1220–1229; July/September, 1952.) Descriptions are given of suitable magnetrons, reflex klystrons and T.R. and A.T.R. switches. See also 2044 (Musson-Genon *et al.*), 2066 (Lazzeri) and 2069 (Chantereau et al.), all of 1951.

621.385.032.21:061.3(47) 589
Conference on Cathode Electronics—I. Dykman. (*Zh. Tekh. Fiz.*, vol. 22, pp. 175–182; January, 1952.) Summaries are given of the papers read at a conference held in Kiev on 4th–9th June 1951. The papers are grouped under the following headings: (*a*) general questions on the operation and structure of cathodes, (*b*) photoelectric effect, (*c*) secondary electron emission, (*d*) thermoelectron emission, (*e*) cathodes under discharge conditions or ionic bombardment.

621.385.032.216:621.386 590
A Study of the Oxide-Coated Cathodes by X-Ray Diffraction Method: Part 1—E. Yamaka. (*Jour. Appl. Phys.*, vol. 23, pp. 937–940; September, 1952.) See 1158 of 1952.

621.385.032.216.2 591
Latest Disc-Cathode Developments—(*Electronics*, vol. 25, pp. 236, 252; November, 1952.) Cr-tube cathodes are described in which a ceramic disk is used as insulator between cathode and first grid. Improvements introduced include the use of more efficient alloys for cathode caps, techniques for maintaining critical spacings constant during long production runs, reduction of electron leakage across the ceramic disk and between heater and cathode, and elimination of heater shrinkage caused by damage during insertion.

621.385.032.24:537.533 592
Origin of Thermal Grid Emission and Investigations on its Elimination—H. Köppen. (*NachrTech.*, vol. 2, pp. 246–247; August, 1952.) The results of investigations of grid currents in tubes with grids and anodes of various materials and constructions show that such currents can be largely reduced by using grid materials with a high work function, by adopting a form of construction in which grid heating by radiation from the cathode is avoided as far as possible, and by choice of a suitable cathode-activation process.

621.385.1.032.212 593
Inertia Effects in Cold-Cathode Tubes—M. O. Williams. (*Strowger Jour.*, vol. 8, pp. 106–117; July, 1952.) The type of discharge in cold-cathode tubes is examined both for the current-growth and current-decay periods. Measurement methods are outlined and typical oscillograms of current rise and decay with recurrent pulses are shown. Investigations with small-amplitude ac superimposed on the dc glow discharge reveal inertia effects of considerable magnitude and also complex-impedance effects. Results obtained on several types of tube are given in graph form; they show sur-

prisingly high values of apparent inductance and appreciable values of effective resistance. The origin of the quadrature current in such tubes is discussed.

621.385.5 594
The Communications Valve C3m, a Commercial Amplifier Pentode with Universal Applications—F. Malsch. (*Fernmeldetech. Z.*, vol. 5, pp. 314–318; July, 1952.) This indirectly heated pentode was developed in connection with the German V60 carrier-frequency system, but has found many other telephony applications, being suitable both for AF and for RF up to 500 kc. Construction and characteristics are described; an average life time of 10,000 hours is guaranteed.

621.385.5 595
Proper Use of the Triode-Hexode Valve Type ECH42—R. de Saint-André. (*TSF et TV*, vol. 28, pp. 258–262, 266; September, 1952.) The uses of the tube as a frequency-changer and as a phase inverter are described, with full details of the operating characteristics.

621.387:621.316.722.1 596
A Study of the Characteristics of Glow-Discharge Voltage-Regulator Tubes—F. A. Benson. (*Electronic Eng.*, vol. 24, pp. 396–401 and 456–460; September and October, 1952.) Report and discussion of tests carried out on 14 types of voltage-regulator tube, using from 2 to 36 samples of any single type. Detailed studies were made of the variations of striking and running voltages for both short-period and long-period operation, hysteresis effects, voltage jumps, and the effects of temperature, overload currents, vibration, stray magnetic fields, and storage. It is concluded that though modern high-stability types show substantial improvement over earlier designs, glow-discharge tubes are not suitable for use in precision power-supply circuits unless they are specially selected and used under carefully controlled conditions.

621.396.615.141.2 597
A Statistical Approach to the Space-Charge Distribution in a Cut-Off Magnetron—G. Hok. (*Jour. Appl. Phys.*, vol. 23, pp. 983–989; September, 1952.) The state of a magnetron with anode voltage below nominal cut-off value is not initially strictly steady, and electron interactions in the interelectrode space produce a drift away from the initial condition. The steady state finally reached depends on the ratio of anode voltage to cut-off voltage. The electron distribution function is complicated, and only a qualitative picture of this distribution is presented.

621.396.615.141.2 598
Mode Interactions in Magnetrons—R. R. Moats. (*Tele-Tech*, vol. 11, pp. 39–41, 88; July, 1952.) A measure of the strength of any oscillation mode is its ability to persist against possible competition from other modes or against the destructive effect of excess anode voltage. The principal factor determining the strength of a mode is the effectiveness of feedback. Van der Pol's theory of nonlinear feedback oscillators is outlined and its bearing on magnetron oscillations is discussed. Experiments on mode interaction and mode transition are described. The results obtained indicate that the essential requirement for quick starting of oscillations under pulse conditions, and for stability with or without the presence of other modes, is the establishment and maintenance of effective electron bunching in the desired mode.

621.396.615.141.2 599
Study of the Magnetron in the Cut-Off Condition: Part 2—P. Fechner. (*Ann. Radioélect.*, vol. 7, pp. 199–220; July, 1952.) Taking account of the static space-charge distribution described in part 1 (3619 of 1952), the effects of a HF em wave on the electrons are analyzed. In a multicavity magnetron four resonance frequencies for the electrons in the electron cloud are found possible. One resonance frequency results from an effect of the radial component of the HF field, the other three from phenomena due to the tangential component of the field at the mouth of each cavity. Experiments are described which confirm the accuracy of the formulas obtained, and hence verify the theory of the distribution of space-charge density. The method used for observation of the electron distribution in the interelectrode space of the magnetron permits study of the space charge without distortion.

621.396.615.142.2 600
New Pulse Klystron Amplifier for the 960-1215-Mc/s Region—C. Veronda. (*Elec. Eng.* (N. Y.), vol. 71, pp. 686–689; August, 1952.) Description of the SAL-39, a three-resonator cascade-amplifier klystron developed for use in air-navigation aids. Beam focusing by space charge is basic to the design. See also 2393 of 1952 (Learned and Veronda).

621.396.615.142.2 601
Construction, Properties and Mode of Operation of Drift Valves (Klystrons), and Problems of their Application—R. Gebauer and H. Kosmahl. (*Z. angew. Phys.*, vol. 4, pp. 267–280; July, 1952.) A comprehensive review. 38 references.

MISCELLANEOUS

44-3:621.396 602
Detailed English-French Radio Lexicon—P. A. Boursault. (*TSF et TV*, vol. 28, pp. *Doc. tech.* 1–2; September, 1952.) A first selection of useful English terms (letters A–C) with French equivalent, taken from a radio glossary compiled by the author; to be continued in succeeding issues.

621.39:061.3 603
I.R.E. [Australia] Convention, 1952—(Proc. I.R.E. (Australia), vol. 13, pp. 319–329; August, 1952.) Summaries are given of the papers presented.

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Cross-sections: .005 to .060" or more

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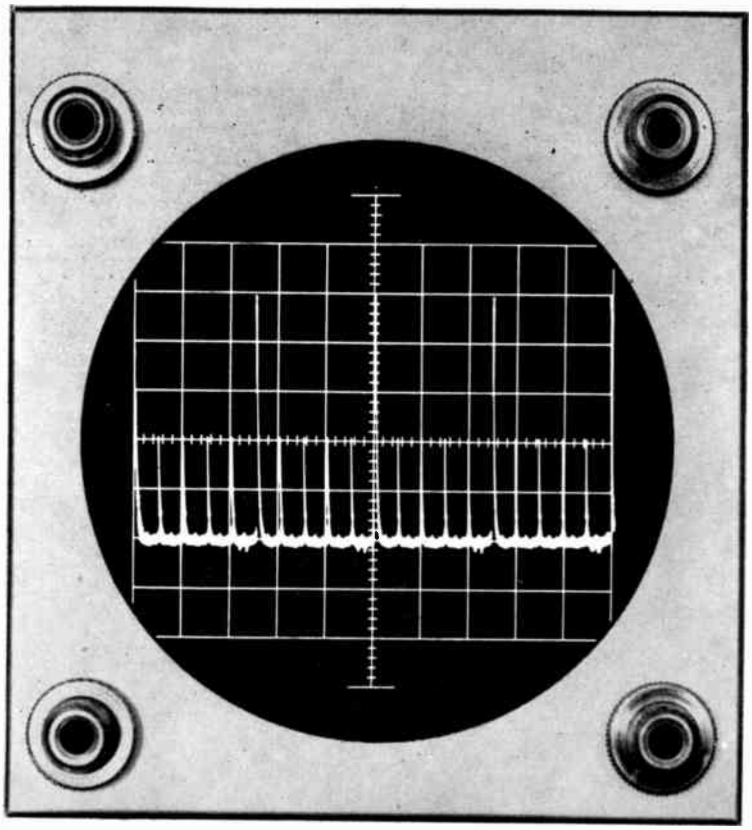


Industrial Engineering Notes

(Continued from page 87A)

mercial manufacturers. The survey shows an expanding market for radiation instruments outside of the AEC program as well as within AEC installations. According to the survey, military agencies of the government now provide about 50 per cent of the total market; the AEC and its principal contractors provide about 30 per cent of the total market; and the remainder is accounted for by private industry universities, hospitals and research institutes, civil defense, export, and uranium ore prospecting. The AEC survey is believed to cover more than 90 per cent of the radiation instrument industry in terms of business volume. Seven companies with probable business volume in excess of $1 million each in 1952 account for about 50 per cent of the industry's activity. More than 50 patents in the field of radiation instruments are owned by the government and held by the AEC. A total of 51 non-exclusive, royalty-free licenses have been granted on these patents. Application for such licenses may be made to the Chief, Patent Branch, Office of the General Counsel, U. S. Atomic Energy Commission, Washington, D. C.

New TV Grants by FCC

The Federal Communications Commission granted construction permits for 40 new television stations for the period December 31–January 23, including the first in Wyoming. To date, only Vermont and New Hampshire now remain without authorizations or stations. In all, 316 television stations have been authorized by the FCC, 208 since the freeze was lifted and 108 previously operating outlets.

The following new TV construction permits were authorized during the period December 31–January 23:

Altoona, Pa., The Gable Broadcasting Company, Channel 10, 316 kw visual, 160 kw aural

Bakersfield, Calif., Bakersfield Broadcasting Company, Channel 20, 20.5 kw visual, 11 kw aural

Bangor, Maine, Community Telecasting Service, Channel 5, 1.9 kw visual, 0.95 kw aural

Bellingham, Wash., KVOS Inc., Channel 12, 16 kw visual, 8 kw aural

Billings, Mont., Rudman-Hayutin Television Company, Channel 8, 12 kw visual, 6.2 kw aural

Boise, Idaho, Idaho Broadcasting & Television Company, Channel 9, 32 kw visual, 16 kw aural

Boise, Idaho, KIDO Inc., Channel 7, 51 kw visual, 26 kw aural

Buffalo, N. Y., Buffalo-Niagara Television Corporation, Channel 59, 91 kw visual, 51 kw aural

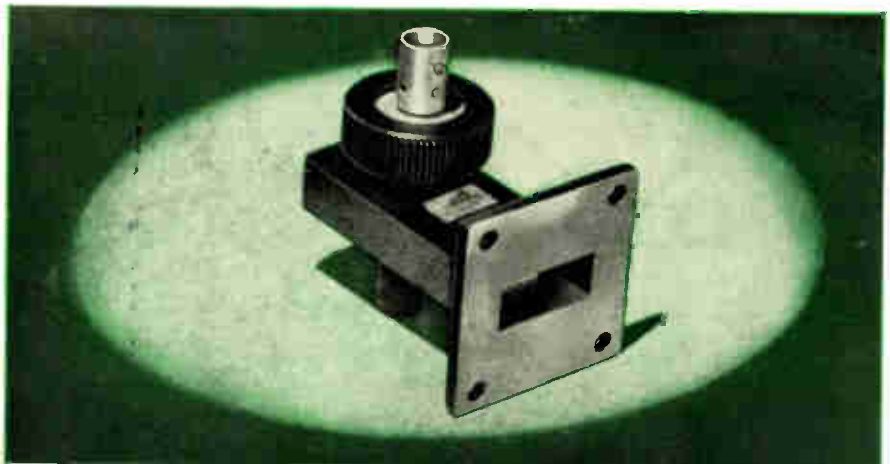
Butte, Mont., Copper Broadcasting Company, Channel 4, 14.5 kw visual, 7.3 kw aural

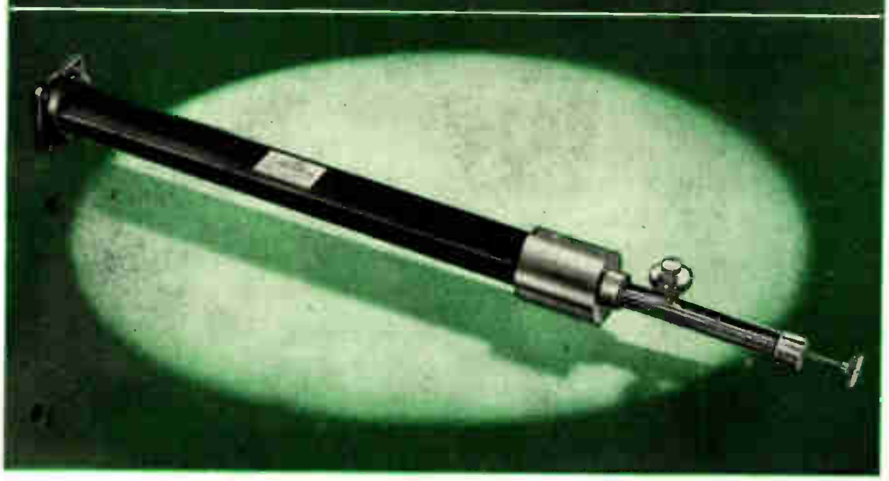
Cheyenne, Wyo., Frontier Broadcasting Company, Channel 5, 5.2 kw visual, 2.65 kw aural

(Continued on page 101A)

New X-Band Test Equipment

ADDITIONAL INSTRUMENTS ADDED TO MICROLINE*





Model 219C Waveguide Thermistor Mount

This instrument is used in conjunction with accessory equipment to measure and monitor microwave power at average power levels as low as 10 microwatts. It is particularly useful in the measurement of pulsed power. This thermistor mount is recommended for use with the Microline Model 123B Wattmeter Bridge.

Frequency Range	8.5 – 9.6 kmc.
Maximum VSWR	1.5
Operating Resistance	135 ohms
Maximum Power Rating	10 mw.
Waveguide Size	RG-52/U (1" x ½")

Model 495 Adjustable Termination

This instrument is specially adapted for use in precise microwave measurements where the quality of excellent impedance matching over a broad band is essential. The design of Model 495 provides for independent control of phase and amplitude of the reflection coefficient of the load. It is particularly useful in applications requiring a termination of minimum power reflection, a movable termination where the reflection from the termination can cause error in measurements, or as a means of matching low standing wave ratios to obtain the smallest possible reflections.

Frequency Range	8.1 – 12.4 kmc.
VSWR Range	1.005 – 1.15
Phase Variation	360°
Waveguide Size	RG-52/U (1" x ½")
Power Rating	5w.

Our nearest district office will be glad to supply complete information upon request.

*T.M. REG. U.S. PAT. OFF.

OTHER X-BAND MICROLINE INSTRUMENTS

MODEL	INSTRUMENT
167A, 486A	Adapter
377	Adjustable Short
173, 174, 183, 152A, 134A	Attenuator
184	Barretter Mount
170, 171	Waveguide Bends
360A	Detecting Section
234, 235, 236	Directional Coupler
126, 273	Frequency Meter
145	Impedance Meter
379	Mixer
165A, 166A	Waveguide Tee
406	Magic Tee
150, 246	Termination
146, 178	Transformer

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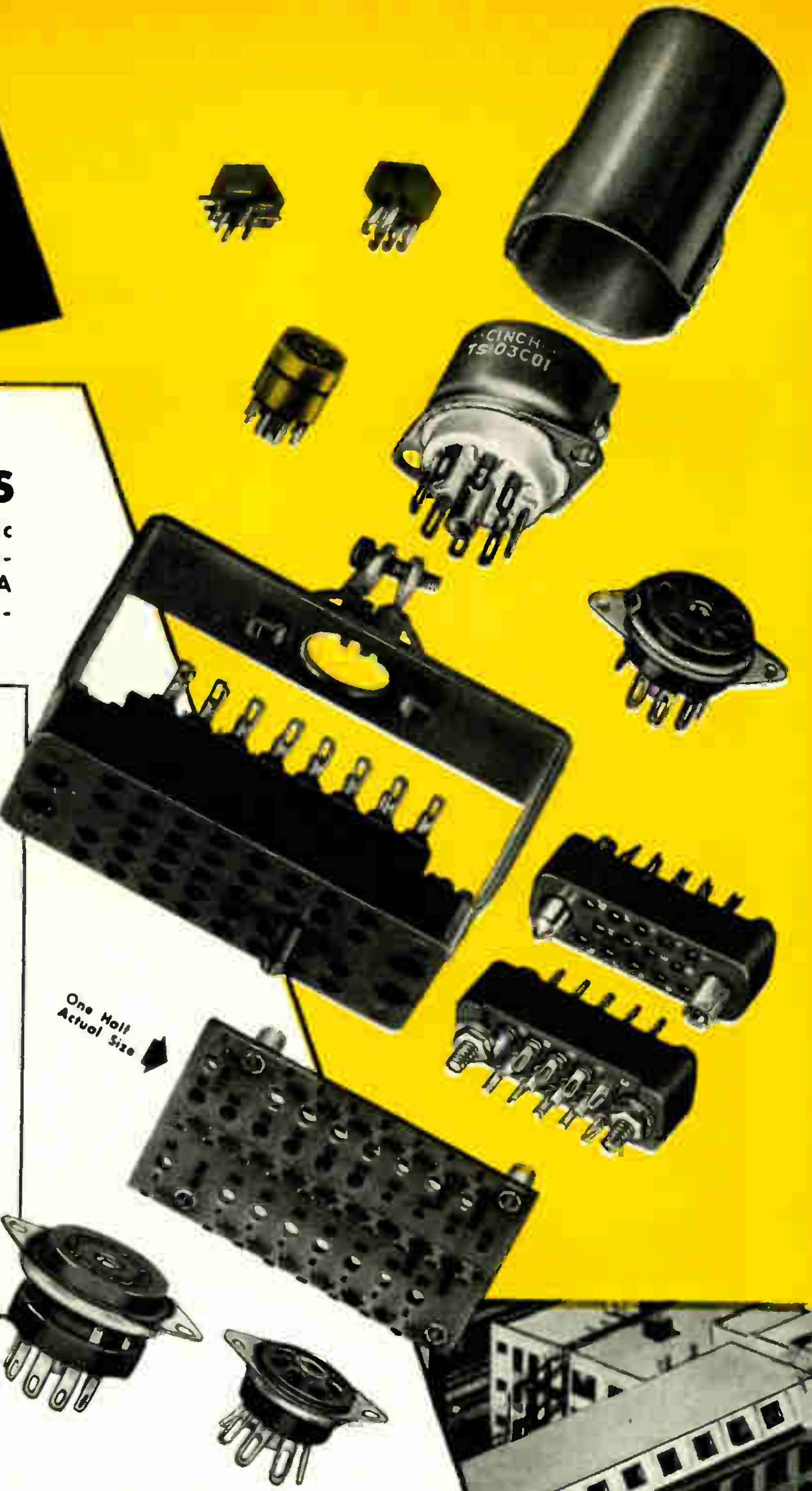

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SOCKETS: Tube (Receiver, Transmitter and Special); Battery, all types • C-R Tube • Crystal • Electrolytic • Glass Type; 4 to 7 prong laminated • Infra-red Ray Tube • High Altitude Airborne Types • Kinescope; Magnal, Duodecal, Diheptal • Loktal-Miniature-Multiplug-Noval-Octal (Molded bakelite, steatite, teflon, Kel-F and laminated) • Plexicon • Printed Circuit • Special Sockets to Specs • Sub-Miniature; Hearing Aid Types • TV; 110V Circuit Breakaway • Vibrator • Pencil Tube Transistor • Diode

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GRID CAPS
GRID CAP SHIELDS
HERMETICALLY SEALED TUBE SOCKETS
METAL STAMPINGS
MICRO-CONNECTORS
MOUNTING DEVICES
PHONO TIP JACKS
PRINTED CIRCUIT, CONNECTORS
SHIELDS, TUBE-MINIATURE & NOVAL & BASES SOLDERING LUGS—200 VARIATIONS
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TUBE HOLDERS—SPRING TYPE
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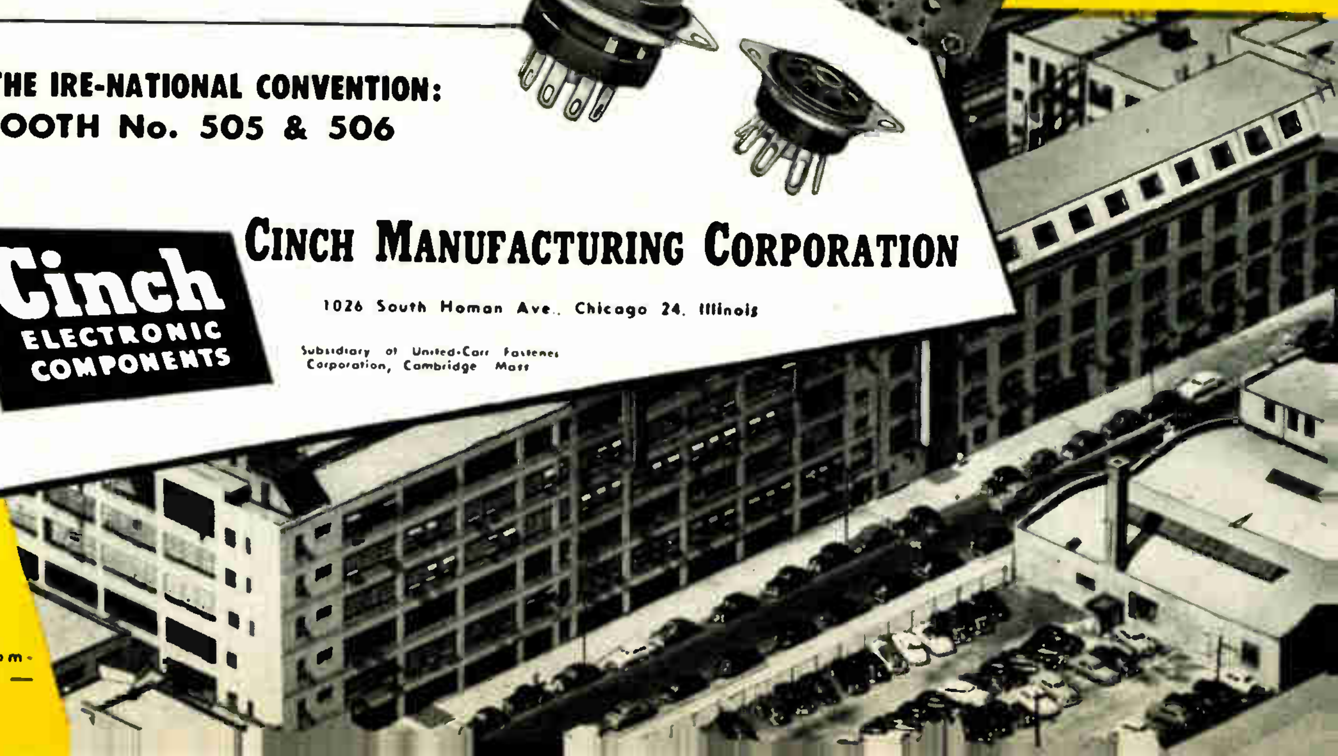

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Industrial Engineering Notes

(Continued from page 98A)

Columbia, Mo., The Curators of the U. of Missouri, Channel 8, 205 kw visual, 105 kw aural

Dallas, Tex., UHF Television Company, Channel 23, 220 kw visual, 115 kw aural

Fargo, N. D., WDAY Inc., Channel 6, 7 kw visual, 35 kw aural

Festus, Mo., Ozark Television Corporation, Channel 14, 170 kw visual, 89 kw aural

Great Falls, Mont., Buttrey Broadcast Incorporated, Channel 5, 8.9 kw visual, 4.5 kw aural

Greenville, S. C., Greenville Television Company, Channel 23, 22 kw visual, 11 kw aural

Harrisburg, Pa., Harrisburg Broadcasters Inc., Channel 71, 220 kw visual, 110 kw aural

Jamestown, N. Y., James Broadcasting Company, Incorporated, Channel 58, 100 kw visual, 56 kw aural

Kansas City, Mo., Empire Coil Company, Incorporated, Channel 25, 93 kw visual, 51 kw aural

Kingston, N. Y., Kingston Broadcasting Corporation, Channel 66, 25 kw visual, 13.5 kw aural

Lafayette, Ind., WFAM Incorporated, Channel 59, 20 kw visual, 105 kw aural

Lakeland, Fla., WONN-TV, Incorporated, Channel 16, 85 kw visual, 43 kw aural

Lawton, Okla., Oklahoma Quality Broadcasting Company, Channel 7, 10 kw visual, 5 kw aural

Louisville, Ky., Robert W. Rounsaville, Channel 41, 240 kw visual, 125 kw aural

Meridian, Miss., Mississippi Broadcasting Company, Channel 30, 210 kw visual, 110 kw aural

Muskegon, Mich., Versluis Radio & Television Incorporated, Channel 35, 270 kw visual, 140 kw aural

Neenah, Wis., Neenah-Menasha Broadcasting Company, Channel 42, 15.5 kw visual, 8.3 kw aural

New London, Conn., The Thames Broadcasting Company, Channel 26, 105 kw visual, 54 kw aural

Northampton, Mass., Regional Television Corporation, Channel 36, 21.5 kw visual, 11.5 kw aural

Pittsburgh, Pa., J. Frank Gallaher, Loren Berry, and Ronald B. Woodyard, a Partnership, Channel 47, 230 kw visual, 120 kw aural

Pittsburgh, Pa., Telecasting Company of Pittsburgh, Pa., Channel 16, 89 kw visual, 50 kw aural

Reno, Nev., Nevada Radio-Television Incorporated, Channel 8, 3 kw visual, 1.5 kw aural

Rochester, Minn., Southern Minnesota Broadcasting Company, Channel 10, 105 kw visual, 54 kw aural

Salinas, Calif., Salinas-Monterey Television Company, Channel 28, 105 kw visual, 60 kw aural

(Continued on page 102A)

Industrial Engineering Notes

(Continued from page 101A)

Sandusky, Ohio, Lake Erie Broadcasting Company, Channel 42, 18 kw visual. 9.1 kw aural

Santa Fe, N. M., Greer & Greer, Channel 2, 54 kw visual, 27 kw aural

St. Cloud, Minn., Granite City Broadcasting Company, Channel 7, 23.5 kw visual, 12 kw aural

St. Louis, Mo., Broadcast House Incorporated, Channel 36, 275 kw visual, 145 kw aural

Watertown, N. Y., The Brockway Company, Channel 48, 185 kw visual, 100 kw aural

Wichita Falls, Tex., Wichita Falls Television Incorporated, Channel 6, 22.5 kw visual, 11.5 kw aural

SECTION MEETINGS

Atlanta

"High Gain Antenna for Use in Television at WSB-TV," by R. A. Holbrook, WSB-TV; December 19, 1952.

Beaumont-Port Arthur

"The Research and Development Program of Military Establishment at Texas University," by Dr. C. P. Boner, Texas University; and Election of Officers; December 15, 1952.

Chicago

"Electronic Music—Past, Present and Future," by E. L. Kent, C. G. Conn, Ltd.; December 19, 1952.

Cincinnati

"Man-Made Heat Waves," by A. G. Billin, Liebel Flarsheim Company; December 16, 1952.

Cleveland

"Problems of Electronic Recording in the Medical Sciences," by R. S. Alexander, Western Reserve; November 20, 1952.

"Psychology of the Design of Electrical Instruments," by D. B. Sinclair, General Radio Company; December 18, 1952.

Columbus

"Space Travel," by F. McLean Mallett, Faculty, Ohio State University; December 2, 1952.

"Energy in Action," presented by the Westinghouse Company; December 16, 1952.

Connecticut Valley

"Engineering in Medicine," by J. H. Heller, Faculty, Yale University; November 11, 1952.

"Measurements of Piezoelectric Constants," by W. L. Skeel, Student, Wesleyan University, and "Use of Barium Titanate in Condensers, Transducers, Dielectric Amplifiers and Storage Devices," by W. P. Mason, Bell Telephone Laboratories; November 20, 1952.

"Radio Television Interference Control," by P. Rand and A. Riley, Remington Rand, Inc.; December 11, 1952.

Dayton

"Electronics in Music," by George Hadden, Minshall-Estey Company; January 8, 1953.

Denver

"Results of Cheyenne Mountain Measurements Transmitting and Receiving Facilities Used in Tropospheric Propagation Studies at Cheyenne Mountain Field Station," by A. P. Barsis and M. T. Decker, National Bureau of Standards; "1046 mc

(Continued on page 106A)

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Bendix Scinflex Electrical Connectors have been an immediate success wherever used. Completely pressurized electrical connectors are for all contact sizes and pin arrangements and have full A.N. approval.

Another recent development is the Bendix ignition analyzer that checks efficiency of both ignition units and spark plugs and actually predicts performance failures before they occur.

Eclipse-Pioneer

TETERBORO, N. J.

Eclipse-Pioneer Division is one of the world's most prolific and versatile suppliers to precision industries. Famous for over 30 years for the quality and design superiority, Eclipse-Pioneer is today a major supplier of Gyroscopes, Synchros, Low Inertia Motors, Rate Generators, special purpose Amplifiers, and other precision components for servomechanism and computing equipment to the electronic industry—*and manufacturing capacity is now available for these specialized products.*

Pacific Division

NORTH HOLLYWOOD, CALIF.

The Pacific Division provides a striking example of Bendix talent in combining advance engineering design with production facilities to provide tomorrow's products today. This is well illustrated by the Pacific Division's outstanding leadership in the fields of sonar, telemetering, air-borne radar, hydraulic servomechanisms and radio control. Be sure to get a copy of the booklet "Electronic Progress at Bendix Pacific" at the Bendix booth.

Millions Trust

Bendix AVIATION CORPORATION

SECTION MEETINGS

(Continued from page 102A)

4 kw Klystron Transmitter at Cheyenne Mountain Field Station," by C. F. Peterson, National Bureau of Standards; January 9, 1953.

Des Moines-Ames

"The Boolean Algebra Applied to Switching Circuits," by A. B. Kassander, Faculty, Iowa State College; December 11, 1952.

Detroit

"Upper Atmospheric Research (Signal Corps Rockets)," by Fred Bartman, Faculty, University of Michigan; election of officers; December 19, 1952

Emporium

"Eisenhower's Problems in Korea," by J. A Gathings, Faculty, Bucknell University; election of officers; December 16, 1952

Evansville-Owensboro

"Super Fringe Propagation of TV Signals," by L. E. Raburn, Electronic Research, Inc.; December 10, 1952.

"A Creative Approach to Design Problems," by L. W. Guth, General Electric Company; January 14, 1953.

Fort Wayne

"F.B.I. in Peace and War," by D. S. Horth, Federal Bureau of Investigation; January 6, 1953.

Hawaii

"Cosmic Disturbances," by Grote Reber, Research Corporation of New York; October 8, 1952.

"Super-Imposed Radio Communications on Power Transmission Systems," by Jack Barkel Westinghouse Electric and Manufacturing Company; November 20, 1952.

"Design and Operational Characteristics of Radar Systems," by L. M. Baxter, General Electric Company; December 10, 1952.

Little Rock

"UHF Tuners for TV Receivers," by W. J Stolze, P. R. Mallory and Company; "Report on Status of New Little Rock Television Station," by J. H. Tudor, Little Rock Telecasters, Inc.; and election of officers; October 9, 1952.

Los Angeles

"Nuclear Reactor Kinetics and Control," by W. E. Parkens, North American Aviation, Inc.; January 6, 1953.

Louisville

"NTSC System of Color with Accent on Color Receiver Design," by R. B. McGregor; January 9 1953.

New York

"Tropospheric Propagation Well Beyond the Horizon," by T J. Carroll, Massachusetts Institute of Technology; December 3, 1952.

Oklahoma City

"A Cage Type VHF Antenna for the Phase Comparison Omnidirectional Radio Range (VOR)," by F. J. Lundberg, Federal Telecommunication Laboratories; October 14, 1952.

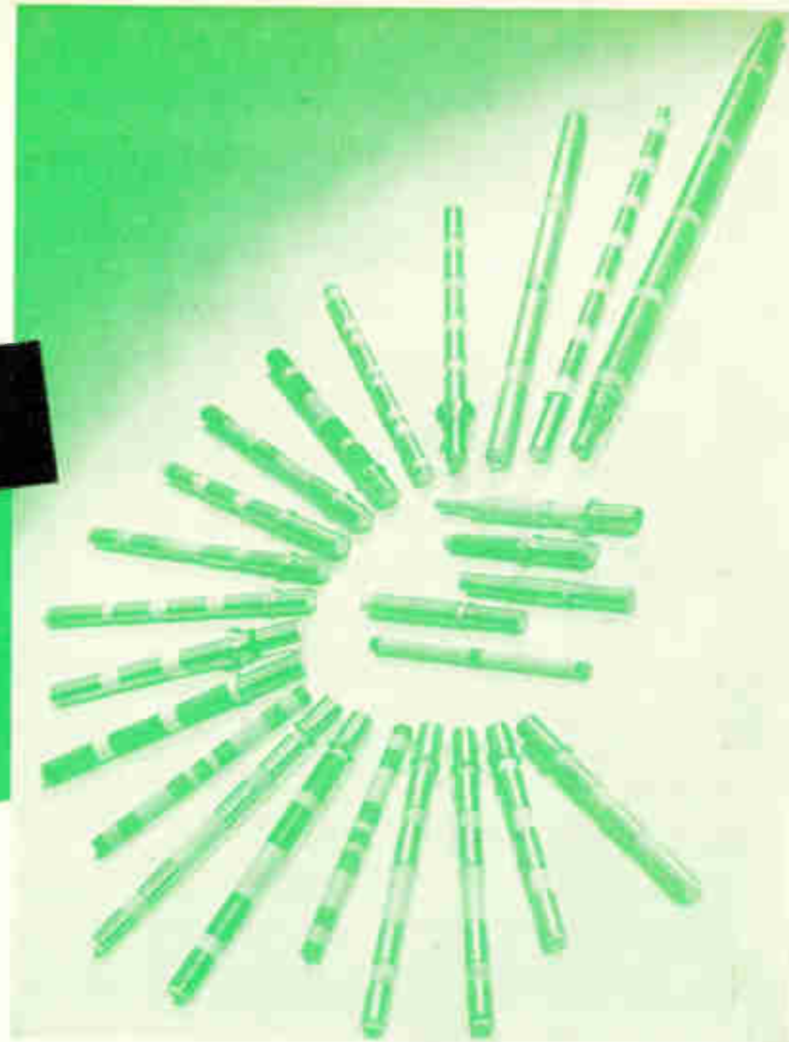
"Atomic Power Plants," by R. G. Lorraine, General Electric Company; November 18, 1952.

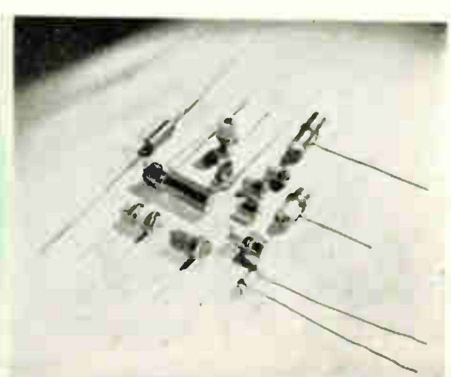
"Magnetic Resonance," by K. K. Darrow, Bell Telephone Laboratories; December 2, 1952

Ottawa

"Research Establishments," by Sir Robert Watson-Watt, Adalia Limited; January 12, 1953.

(Continued on page 108A)





SECTION MEETINGS

(Continued from page 106A)

PHILADELPHIA

"Switching Circuits for Automatic Control," by William Keister, Bell Telephone Laboratories; December 4, 1952.

PITTSBURGH

"Recent Developments in Broadband Microwave Amplifiers," by M. E. Hines, Bell Telephone Laboratories; December 15, 1952.

"Statistical Processes in Communications Engineering," by L. A. DeRosa, Federal Telecommunications Laboratories; January 12, 1953.

PORTLAND

"Pioneering in UHF Television," by Russel Olson, Station KPTV; "High Power Klystrons for UHF Television," by H. M. Stearns, Varian Associates; November 24, 1952.

"Germanium, The Magic Metal," by Fredrick Brown, Faculty, Reed College; "Model 2-C Idiosynchrovisor" by J. M. Henry and E. R. Moore (both talks tapescripts); December 11, 1952.

PRINCETON

"Nondestructive Testing," by R. C. McMaster, Battelle Memorial Institute; January 8, 1953

ROCHESTER

"Present and Future Fabrication Techniques of Printed Electronic Circuits," by William Tuscany, Globe Union, Inc.; November 20, 1952.

"Television and High Fidelity," by C. J Hunt and J. W. Farnell, Stromberg Carlson Company; December 9, 1952.

"Life Begins with Love," by Rev. J. F. Murphy, St. John Fisher College; December 16, 1952.

SACRAMENTO

"Some Interesting Aspects of Amplitude Modulation," by J. L. Reinartz, Eitel McCullough, Inc.; November 21, 1952.

"What is New in Science and Engineering," by E. S. Lee, Editor, General Electric Review; December 11, 1952.

SALT LAKE

"Research—Industry's Indispensable Ingredient," by F. R. Benedict, Westinghouse Electric Corporation; October 3, 1952.

"Mountain Top Television," by J. M. Baldwin, KDYL-TV, and V. E. Clayton, KSL-TV; December 15, 1952.

SAN ANTONIO

"Recent Developments in Radar Weather," by John Gerhardt, University of Texas; October 16, 1952.

SAN DIEGO

"Sea Surface Properties," by S. Q. Duntley, Scripps Institute of Oceanography; December 16, 1952.

SAN FRANCISCO

"Computer Engineering in Northern California," by P. Morton and Torben Meisling, University of California; J. L. Corl, Berkeley Scientific Company; G. B. Greene, Marchant Research; Jerre Noe, Stanford Research Institute; and L. D Stevens, IMB Corporation; November 12, 1952

"Radiation Theory in Retrospect," by S. A. Schelkunoff, Bell Telephone Laboratories; December 10, 1952.

SCHENECTADY

"Broadcast Station Monitoring Equipment," by H. R. Summerhayes, Jr., General Electric Company; October 20, 1952.

"Subminiaturization in Airborne Equipment," by D. W. Bulger and B. Pundick, General Electric Company; November 10, 1952.

(Continued on page 116A)

VARIAN X-BAND RADAR KLYSTRONS

Now in full production...

guaranteed specifications — quantity prices — assured delivery

V-260

Rugged local oscillator for mobile radar. Highly non-microphonic. Shaft tuner; no chatter or backlash; excellent for motor-tuned systems. Reflex, 8.5-10.0 kmc, replacing Varian V-50.

V-280

For radar, beacon or low-power transmitter operation under severe mechanical punishment. Lock-nut tuner holds the tube on frequency even under shocks of several hundred g. Reflex, 8.5-10.0 kmc, replacing Varian V-51.

V-270
V-290

For high altitude or high humidity applications. Silicone-rubber-potted base and reflector connections instead of conventional base and reflector cap. Electrically identical with V-260 and V-280.

X-13

Reflex tube for test and measurement work at x-band. Integral tuner covers the full frequency range, 8.2-12.4 kmc. Typical power output is 150 mw over the band, 500 mw at center frequency.

See them in Booth 1-617, New York IRE Show

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CHATHAM ELECTRONIC TUBES

Hydrogen Thyratrons

—for Pulse Voltage Generation

ELECTRICAL DATA*

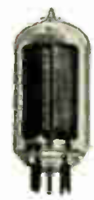
Type	VC-1258	5949/1907	5948/1754	VC-1257
Maximum Peak Forward Anode Potential	1000 volts	25000 volts	25000 volts	38000 volts
Maximum Peak Anode Current	20 amps	500 amps	1000 amps	2000 amps
Maximum Average Anode Current	0.05 amps	0.50 amps	1.0 amps	2.0 amps
Maximum Heating Factor (epy x prr x ib)	1.0×10^8	6.25×10^9	9.0×10^9	–
Nominal Filament Power	12.5 watts	95 watts	190 watts	230 watts
Hydrogen Reservoir	No	Yes	Yes	Yes

*More detailed information on electrical and mechanical data will be supplied on request.

TYPE VC-1257
Hydrogen filled, zero bias thyratron with hydrogen generator for generation of pulse power up to 40 megawatts.

TYPE 5948/1754
Hydrogen filled, zero bias thyratron with hydrogen reservoir for generation of peak pulse power up to 12.5 megawatts.

TYPE 5949/1907
Hydrogen filled, zero bias thyratron with hydrogen reservoir for generation of peak pulse power up to 6.25 megawatts.



TYPE VC-1258
Zero bias miniature hydrogen thyratron for the generation of peak pulse power up to 10 KW.

A NEW CONCEPT OF HYDROGEN THYRATRON DESIGN! The tubes illustrated represent a departure from conventional hydrogen thyratron designs and are a result of several years of concentrated development work. They are primarily employed in the generation of peak voltages with durations in the order of microseconds.

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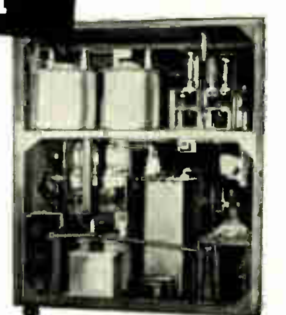
CHATHAM specializes in the development, design, and construction of custom-built electronic equipment to exactly meet customers' requirements. Our capable staff of engineers will furnish prompt estimates or, if desired, will call to discuss your problem personally. Call or write today.

20 Megawatt Hydrogen Thyratron Test Equipment built by CHATHAM to customers' specifications.

Pulse life test equipment built by CHATHAM checks receiver type tubes under pulse conditions.



5 Megawatt radar modulator built by CHATHAM to rigid government standards.

ELECTRONICS AND EQUIPMENT

Electronic Tubes

Ruggedized Type Tubes

The following tubes fully conform to JAN specifications and can be supplied promptly, usually direct from stock:

5R4WGY	2D21W
6AL5W	OC3W
6H6WGT	OD3W
25Z6WGT	2050W

TYPE 719-A HIGH VACUUM CLIPPER DIODE

This tube is used primarily for clipper diode service in hard tube modulator circuits. Filament 7 volts, 7 amps . . . Inverse peak anode voltage 25 kv, Max., peak anode current 10 amps, Max., anode dissipation 75 watts.

TYPE 1Z2 RECTIFIER

A small bulb high voltage vacuum rectifier. Low cathode heating power and low dielectric losses make tube suitable for radio frequency supply circuits. Filament 1.5 volts, .290 amps . . . Inverse peak anode voltage 20,000, average plate current 2 ma. . . . peak plate current 10 ma.

TYPE 1B46 REGULATOR

A cold cathode glow discharge tube designed for voltage stability. DC operating voltage 82 volts, operating current range 1 ma minimum, 2 ma maximum. Regulation 3 volts.

TYPE 395-A COLD CATHODE GAS TRIODE

Requires no filament supply and is used in many grid controlled rectifier and relay applications.
Maximum D.C. anode current— 10 ma.
Maximum D.C. anode voltage—150 volts

TYPE 4B32 RECTIFIER

A rugged half-wave Xenon filled rectifier. Operates in any position throughout an ambient temperature range of −75°C to +90°C. Filament 5 volts, 7.5 amp . . . Inverse peak anode voltage 10,000 average anode current 1.25 amps.

TYPE 394-A THYRATRON

A Mercury vapor and Argon filled thyratron for grid controlled rectifier service. Operates over wide ambient temperature range. Heater 2.5 volts, 3.2 amps . . . Inverse peak anode voltage 1250, average anode current 640 ma.

TYPE 3B28 RECTIFIER

This rugged half-wave Xenon filled rectifier will operate in any position and throughout an ambient temperature range of −75°C to +90°C. Filament 2.5 volts, 5.0 amps . . . Inverse peak plate voltage 10,000, average anode current .25 amp.

Chatham Vacuum Switches

TYPE 1S22 (illustrated) is a mechanically actuated, single-pole, double-throw, glass vacuum switch. This and other types can be supplied.

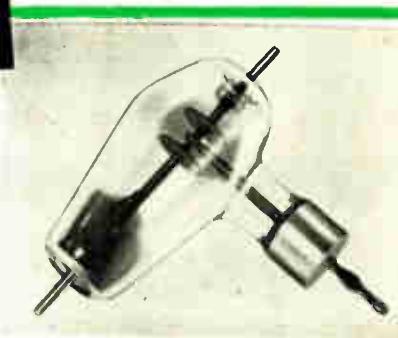
SPECIFICATIONS

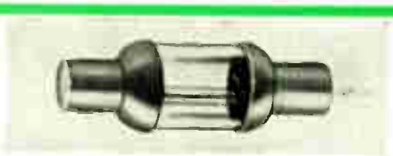
HOLD OFF VOLTAGE: Internal—10,000 volts rms; External* (at 27,000 feet altitude)—10,000 volts rms; External* (at 40,000 feet altitude)—7,500 volts rms.

INTERRUPTING RATING, RESISTIVE LOAD: 1,000 operations life at 10,000 v, ac, rms—10 amp, ac, rms; 1,000,000 operations life at 10,000 v, ac, rms — 2 amp, ac, rms; 500,000,000 operations life at 10,000 v, ac, rms—0.1 amp, ac, rms.

NET WEIGHT (approx.) .... 2 ozs.
MAXIMUM LENGTH (overall) .... 3 5/8 ins.
MAXIMUM WIDTH (overall) .... 4 1/16 ins.
MAXIMUM THICK. (overall) .... 1 1/16 ins.

*at 50% humidity





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TV DESIGNERS: see these—and other—G-E pace-setting u-h-f types at the March I.R.E. Show. Get all ratings and characteristics! TV MANUFACTURERS: learn how G-E tubes can help you successfully (1) meet stiff 1953 price competition, (2) establish new, higher standards of equipment performance, both transmission and reception!

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Trio of G-E tuner tubes for TV receivers, with a combined v-h-f, u-h-f frequency range that makes *single-dial 82-channel tuning* practical and economical.

GENERAL ELECTRIC

163-1A3

Section Meetings

(Continued from page 108A)

"Radio Communication in Industry," by J. A. McCormick. General Electric Company; December 10, 1952.

"Processing and Pressing of Transcriptions and Phonograph Records," by K. R. Smith. Allied Record Company; January 12, 1953.

Syracuse

"UHF Television," by C. G. Lloyd, General Electric Company; January 8, 1953.

Toledo

"Present Status of Transistor Development," by J. A Morton. Bell Telephone Laboratories January 14, 1953

Toronto

"Antennae for Circular Polarization," by George Sinclair, Sinclair Radio Laboratories; January 5, 1953

Tulsa

"Fundamental Theory of Transistors," by W. A Adcock, Stanolind Oil and Gas Company; December 17, 1952.

Vancouver

"Electronic Equipment on Jet Transports for Trans-Pacific Service," by Phil Kenney, Canadian Pacific Airlines; November 17, 1952.

"Germanium Devices," discussed by L R Kersey; December 15, 1952.

Washington, D. C.

"Recent Developments in Vibrators and Vibrator Power Supplies," by Joseph Mas, Vibration Research Laboratory; December 8, 1952

Williamsport

"The Application of Transistors to Home Receiver Design," by R. A. Jacobs, Westinghouse Electric Corporation; November 19, 1952.

SUBSECTIONS

Amarillo-Lubbock

Demonstration and Lecture on "Microwaves," by C. M. McKinney, Faculty, Texas Technological College; December 17, 1952.

Centre County

"Retrospect," by L. A Poggett, Faculty Pennsylvania State College; October 21, 1952.

"Discussion of Aims of Subsection," by Carl Volz, Chairman of Centre County Subsection; November 18, 1952.

"Ignitron Rectifier in Electric Locomotives," by W. M. Hutchison, Westinghouse Electric Corporation; "Comparison of Electric Locomotives," by S. V. Smith, Pennsylvania Railroad; December 16, 1952

Long Island

"Magnetic Amplifier Servo Applications," by S. B. Cohen, Sperry Gyroscope Company; December 9, 1952.

Mid-Hudson

"Guided Missiles," by J. Fletcher, Hughes Aircraft Company; December 16, 1952

Northern New Jersey

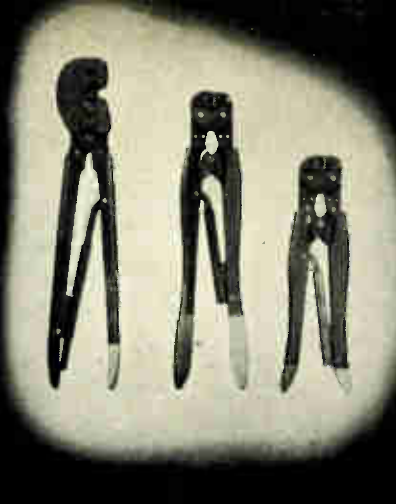
"A Survey of Magnetic Amplifiers," by George Wolf, General Electric Company; December 10, 1952.

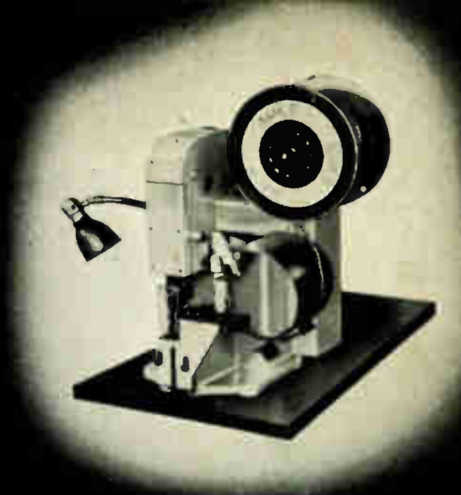
Palo Alto

Symposium on "Non-Vacuum Tube Amplifiers" Speakers: H. E. Hollman, Naval Air Missile Test Center; O. J. M. Smith, Faculty, University of California; H. M. Zeidler, Stanford Research Institute; December 3, 1952.

Wichita

"Induction Heating," by F. R. Hunter, Allis Chalmers Manufacturing Company; "Spot-Welding and Electronics," by H. R. Sartin, Boeing Airplane Company; December 6, 1952





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All the gadgets or combination tools in the world will not insure the correct installation of your wire terminations day in, day out, on the line. It's the extra factor of assurance that counts! AMP tools and terminals are made to use together. They're made so that you can be *sure* that you have a correctly installed termination. AMP application tools and dies and automatic machines are so designed that at the point of application you can control accuracy and uniformity within ±.003''. Remember: In wire termination there is no short cut to precision and foolproof production!

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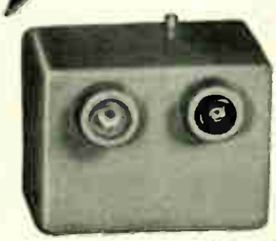

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- **High Input Resistance**
- **Polarity Sensing**

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MODEL 300

MODEL 700

The Ballantine Model 700 Sensitive Inverter adapts FOR THE ACCURATE MEASUREMENT OF SMALL DC POTENTIALS any AC voltage measuring device which is sensitive to 60 cycle voltages in the range 100 microvolts to 10 volts and which has an input impedance of 50,000 ohms or more. It may be used also as an ultra-sensitive transducer in servo-mechanisms and in telemetering systems.

The built-in calibrator eliminates the major errors of the AC voltmeter used with the inverter.

When used ahead of multimeters or diode voltmeters, levels as low as 1 millivolt DC can be measured with not less than 10 megohms loading.

For maximum DC sensitivity and stability the *BALLANTINE SENSITIVE ELECTRONIC VOLTMETERS, Models 300 (as illustrated), 302B, 310A, and 314,* are recommended for use with the inverter, in which case DC levels as low as 10 microvolts may be measured.

MODEL 700 INVERTER SPECIFICATIONS

INPUT VOLTAGE RANGE	10µv—100v (Sensitive to 1µv)
VOLTAGE RATIOS (DC INPUT TO AC RMS OUTPUT)	1:100 and 10:1
ACCURACY OF VOLTAGE RATIOS (> 100µV INPUT)	1%
ACCURACY OF CALIBRATOR	0.25%
INPUT RESISTANCE DC SOURCE	10 meg min for 1:100; 50 meg for 10:1
INPUT IMPEDANCE AC SOURCE	More than 200K all frequencies
INPUT NOISE LEVEL	Approx 3µv
MAX AC OUTPUT LEVEL	10 volt RMS
MAX DISTORTION IN OUTPUT	2%
RESPONSE TIME	0.25 second
POWER	105-125 volt; 50-70 cps; 15 watt

Write for complete information for this and other Ballantine Electronic Measuring Instruments.

ADDITIONAL FEATURES:

- Distortion-free output
- Low noise level
- Accurate for 50 to 70 cps line frequency range
- Insensitive to 60 cycle magnetic fields

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Tung-Sol's modern manufacturing techniques and advanced quality control methods assure you of a product that is second to none. Tung-Sol makes tubes—no sets—no equipment—just tubes. We do not compete with our customers. Tung-Sol design, development and application engineers work closely together for the sole purpose of producing a better tube so that you can make a better product. Engineering assistance is strictly confidential. Tung-Sol service by competent field sales representatives is nationwide. A Tung-Sol delivery promise is a promise. Closest cooperation is maintained to keep deliveries up to your production schedule requirements.

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TUNG-SOL MAKES: ALL-GLASS SEALED BEAM LAMPS • MINIATURE LAMPS • SIGNAL FLASHERS
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wire wound Potentiometers and Rheostats

Military and Commercial Types

To meet the exacting requirements of military specifications, Mallory potentiometers are especially designed to conform to specification JAN-R-19 for the following types:

RA20—2 watts—Insulated rotor
RA25-RA30—4 watts—Insulated rotor

In addition, Mallory C and QC controls of the 2-watt grounded rotor type—formerly covered by specification JAN-R-19, style RA15—are also available.

Into these military-type potentiometers go the same engineering know-how and production skill that has made Mallory potentiometers the standard of quality in industrial and electronic fields.

Precision built Mallory potentiometers and rheostats are used extensively in precision test equipment . . . special medical and laboratory electric and electronic devices . . . and in numerous applications for aircraft, marine and radio transmitting and receiving equipment.

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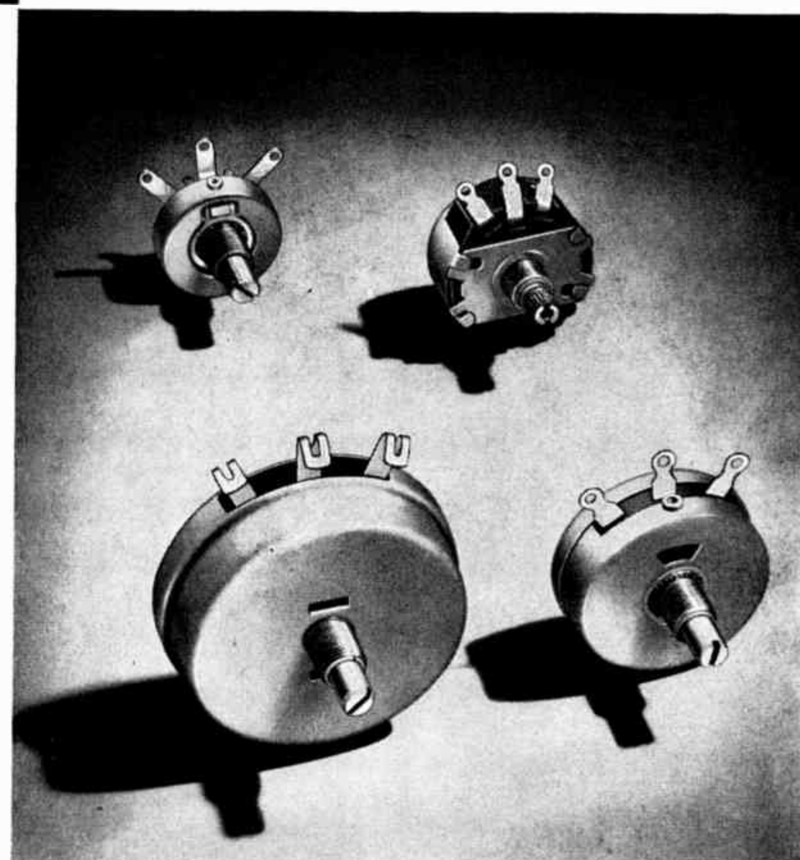
***Get more from* MALLORY**



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MODEL 85194

Self-locking screwdriver-actuated phasing adjustment. Each section easily adjusted to maximum resolution (one wire) in ±11° range. 2½" diameter; ¼" shaft; 2,000 to 300,000 ohms per section; 4 watts @ 25° C; 1 to 6 sections; body length 4.8" max.

SPECIFICATIONS

RESISTANCE: 2,000 to 300,000 ohms/section (±5%).
LINEARITY: ± 0.3% of total resistance.
POWER RATING: 4 watts per section at +25°C ambient.
ELECTRICAL CONTACT ANGLE: 356° standard. (Any winding angle up to 360° on order).
MECHANICAL SHAFT ROTATION: 360° continuous.
TORQUE: Starting torque for 6-section unit: 1.2 oz.-in.
TEMPERATURE RATING: Operating range from −55°C to +71°C ambient.
ACCELERATION: Will function during acceleration of 50G, applied along any axis.
WEIGHT: 4 oz./section.

MODEL 85193

Compact-rugged-accurate. A smaller version of the GANGPOT without the phasing feature. Diameter 1⅞"; ¼" shaft; aluminum housing; 500 to 70,000 ohms per section; 1 to 6 sections; body length 3.5" max.; dual mounting; linear or non-linear windings up to 360° available.

SPECIFICATIONS

RESISTANCE: 500 to 70,000 ohms/section (±5%).
LINEARITY: ±0.5% of total resistance.
POWER RATING: 2 watts per section at +25°C ambient.
ELECTRICAL CONTACT ANGLE: 354° standard (Any winding up to 360° on order), with the brush non-shorting.
MECHANICAL SHAFT ROTATION: 360° continuous.
TORQUE: Starting: less than 0.6 oz.-in. for a 6-section unit.
TEMPERATURE RATING: Operating range from −54°C to +71°C ambient.
ACCELERATION: Will function during acceleration of 50G, applied along any axis.
WEIGHT: 1 oz. per section.

For modifications of standard specifications, please forward requirements.

Specifically designed and built to performance standards far beyond present concepts of potentiometer design, GANGPOT Instrument-Quality potentiometers are ready to solve multiple potentiometer problems. Rugged, aluminum-housed units with low torque, high performance, and long-life accuracy, GANGPOTS are presented in two sizes to fill all requirements. GANGPOT EXTRAS include solid, stainless steel shafts, toroidally wound coils for up to 360° windings, shielded ball bearings, syncro or screw type mounting, and adaptability to non-linear functional windings. Built without any bulky external bolts, clamps or rings, the GANGPOTS lend themselves to an unsurpassed versatility of design applications.

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G. M. GIANNINI & CO. INC., PASADENA 1, CALIFORNIA—EAST ORANGE, NEW JERSEY

Performing in

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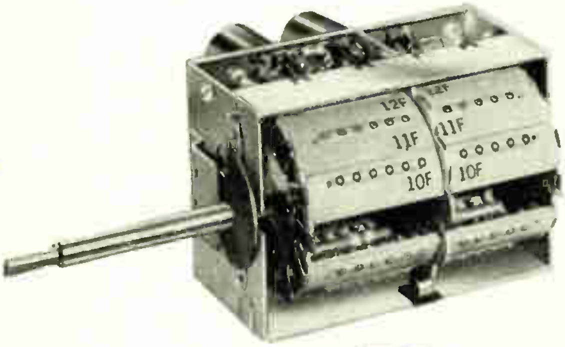
Television receivers!

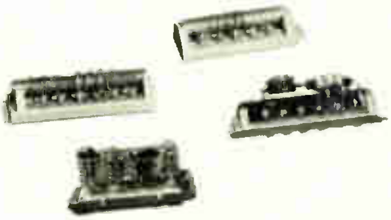
The STANDARD Tuner



. . . Specified as original equipment by approximately 40 per cent of the industry . . . confirming Standard Coil's position as the world's largest manufacturer of TV tuners.

All "Standard" tuners are easily and economically adaptable to any UHF station without any major adjustment.

Call on Standard Coil for diversified, prompt, economical production—*whatever* your requirements in the electronic field.



In TV it's Standard

Manufactured to Your Specifications

TV Components

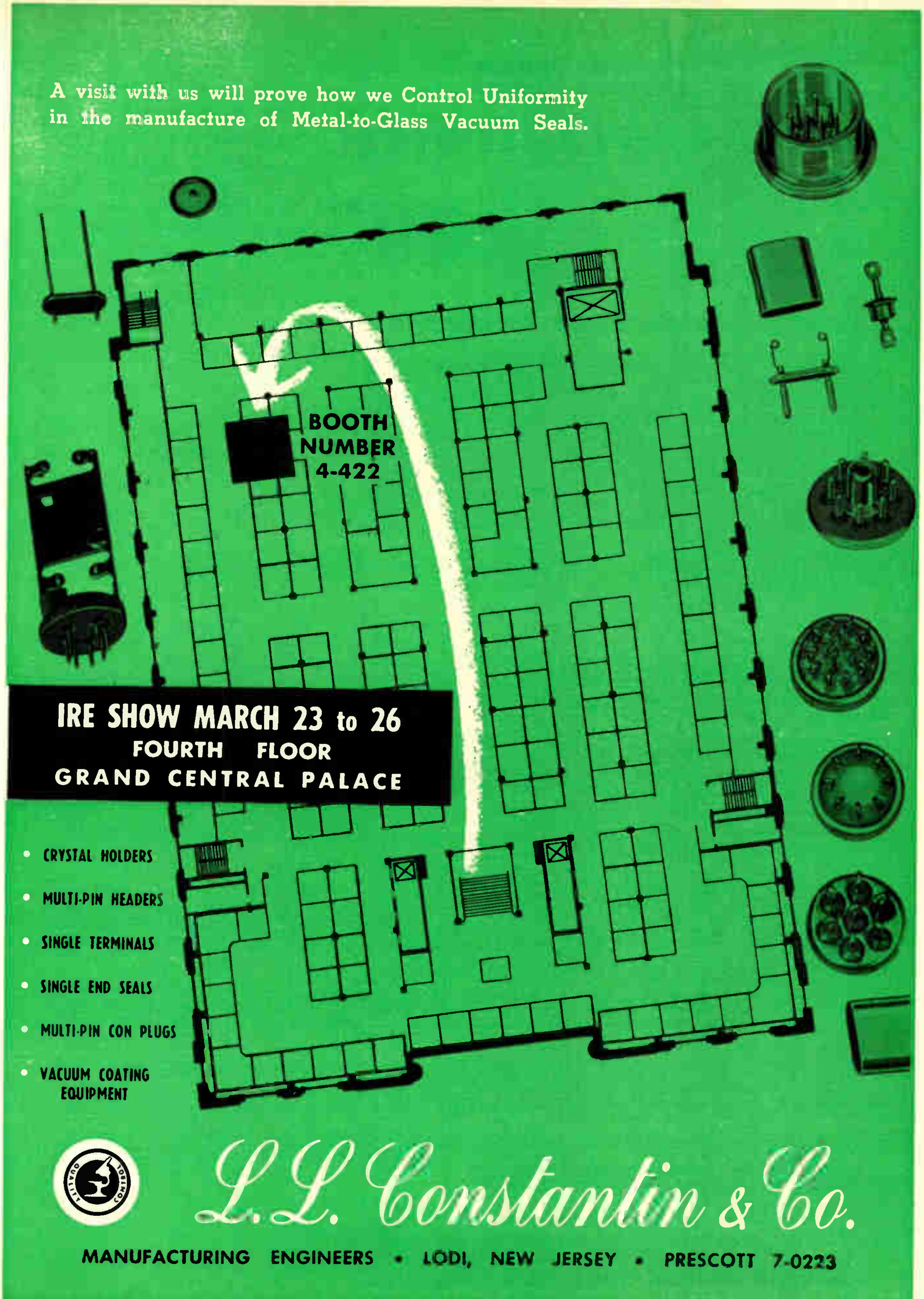
- Picture I. F. Transformers
- Cathode Trap Coils
- Video Peaking Coils
- Heater Choke Coils
- Sound I. F. Transformers
- Sound Discriminator Transformers
- Horizontal Oscillator Coils
- Horizontal Linearity Control Coils
- Width Control Coils
- I. F. Strips
- Flyback Transformers

Radio and Miscellaneous Components

- I. F. Transformers
- R. F., Oscillator & Solenoid Coils
- Antenna Loops
- Ferrite Core Antennas
- Permeability Tuning Pre-selector Assemblies
- Miscellaneous Electro-Mechanical Assemblies

Standard **COIL PRODUCTS CO. INC.**

CHICAGO • LOS ANGELES • BANGOR, MICHIGAN


A visit with us will prove how we Control Uniformity in the manufacture of Metal-to-Glass Vacuum Seals.
BOOTH NUMBER 4-422
IRE SHOW MARCH 23 to 26
FOURTH FLOOR
GRAND CENTRAL PALACE
• CRYSTAL HOLDERS
• MULTI-PIN HEADERS
• SINGLE TERMINALS
• SINGLE END SEALS
• MULTI-PIN CON PLUGS
• VACUUM COATING EQUIPMENT
L. L. Constantin & Co.
MANUFACTURING ENGINEERS • LODI, NEW JERSEY • PRESCOTT 7-0223

What to see at the Radio Engineering Show

(Continued from page 64A)

Firm — **Booth**

Bogue Electric Mfg. Co., Paterson 3, N.J. 4-205
Magnetic Amplifier systems for voltage regulation of generators and power supplies and speed and position control of D.C. motors, quality selenium rectifiers. 400 cps supplies and D.C. supplies.

Bomac Laboratories, Inc.
Beverly, Mass.
1-907
For Gas Switching Tubes—Bomac has available an extensive line of TR, ATR, Pre-TR and Attenuator tubes covering all the frequency bands and power levels in use. Many types are in high level production; specialized types can be supplied on short notice.

Bond Electronics Corp.
Springfield, N.J.
1-614
Wire-wound resistors—coils and associated assemblies.

Boonton Radio Corp.
Boonton, N.J.
2-251 & 522
Q-Meters—Low Frequency and VHF, FM-AM Signal Generators, Signal Generators for Telemetering, Aircraft Navigation Receiver Signal Generators, High Frequency Bridges, Aircraft Instrument Landing System Signal Generators, S-Band Radar Test Sets, Instruments for Measuring Low Loss Insulating Materials.

Borg Equipment Div.
George W. Borg Corp.
Janesville, Wis.
2-517
Borg Micropot Potentiometers, Borg Micropot Ten Turn Counting Dials, Precision Frequency Standards.

W. H. Brady Co., Chippewa Falls, Wis. 2-503
Brady self-sticking industrial products including wire markers, special markers, pipe markers, safety signs, masks and printed roll tape.

William Brand Co., Inc., Willimantic, Conn. 4-519
Turbo Electrical Insulating Materials—Varnished Tubing, Saturated Sleeving, Turbotuf Tubing and Sleeving, etc.; Turbotherm Insulated Plastic Wire, Extruded and Varnished Cambric Markers, etc.

H. Braun Tool & Instrument, Inc., 140 5th Ave., Hawthorne, N.J. 4-424
Beryllium copper and other metal stampings, electronic contacts—grounding strips flat-springs-diaphragms. Aircraft propeller precision parts and other metal fabrication.

Brentano's Technical Book Dept., New York 36, N.Y. 2-501 & 502
Technical books of all publishers in the fields of radio, television, electronics and nucleonics—including the related fields of mathematics and physics.

(Continued on page 128A)

CERAMAG
CERAMAG
CERAMAG
CERAMAG

Here's the full line of SORENSEN

STANDARD UNITS AND SPECIFICATIONS

AC REGULATORS Models available (numbers denote VA capacities) 150S 250S 500S (-2S) also 1000S (-2S) also 2000S 3000S (-2S) also 5000S (-2S) also 10000S (-2S) also 15000-2S	Input	95-130 VAC, 1Φ, 50-60∼, 190-260 VAC in "-2S" models
	Output	115 VAC ±5%; 230 VAC with "-2S" models
	Reg. accuracy	±0.1% against line or load
	Distortion	2% — 3% max.
	P. F. range	Down to 0.7
	Load range	0 to full load
	Miscellaneous	Fully protected against overload or over-voltage. Models 150S, 250S, 500S, 1000S, 5000S, 10000S, and 15000-2S are self-contained. Cabinets available for others.
NOBATRONS** (DC Supplys—low voltage) Models available (numbers indicate voltage & current) E-6-5A E-6-15A E-6-40A E-6-100A E-12-5 E-12-15 E-12-50 E-28-5 E-28-10 E-28-30 E-28-70 E-28-150 E-28-350 E-125-10 E-200-5 Also Model SWR-5 with output either 6VDC @ 10 amp or 12VDC @ 5 amp	Input	95 — 130 VAC, 1Φ, 50-60∼. In heavy current 28-volt series — 115/208, 3Φ, 4-wire, wye.
	Reg. accuracy	±0.2% against line or load changes
	Ripple	1% RMS max.
	Load range	1/10 to full load
	Output range	Adjustable ±10%; down to —25% at lesser accuracy
	Recovery time	0.2 seconds — this value includes charging time of filter circuit for most severe change in load or input conditions.
	Miscellaneous	Fully protected against overload and over-voltage. Normally for rack mounting — cabinets available. Normal finish — gray wrinkle. Meters standard in some models; available in all.
	Note	"A" models output either 6 or 7 volts.
400∼ EQUIPMENT: **LINE REGULATORS**	Similar to 60∼ regulators except: Accuracy ±0.5%; distortion 5% max.; VA capacities 250, 500, 1200, 2500.	
NOBATRONS**	Same general specifications as 60∼ Nobatrons. Models 6VDC @ 40 amp., 12VDC @ 10 amp., 28VDC @ 10 amp.	
B-NOBATRONS** (DC Supplys — high voltage)	Input	105-125 VAC, 1Φ, 50 — 60∼.
	Load range	0 — full load
	Ripple	10 mv (20 mv in 1000BB)

output					
Model	325BB*	500BB*	520BB**	560BB*	1000BB*
VDC	0-325	0-500	200-500	0-500	200-1000
Ma	0-125	0-300	0-200	0-200	0-500

* meters furnished as standard equipment.
regulation accuracy ±0.5%
bias supply 0-150 VDC @ 0-5Ma (except model 1000BB)

** no meters, no bias supply
regulation accuracy ±1.0%

All have 6.3 VAC, 6-10 amperes, unregulated, C.T. except Model 1000BB.

*"Isotronic" is a registered trademark denoting the electronic regulation and control of voltage, current, power, and frequency.

** Reg. U. S. Pat. Off. by Sorensen & Co., Inc.

SEE US AT BOOTH 2-318, 319, I.R.E. SHOW MARCH 23-26

Isotronic* PRODUCTS

STANDARD UNITS AND SPECIFICATIONS

RANGERS (Full-range-variable DC Supplys)	Input range	95 — 130 VAC, 1Φ, 50 — 60~.			
	Reg. accuracy	±0.25% at any voltage setting.			
	Ripple	1% RMS max.			
	Output	Model	SR-100	SR-30	SR-2
		VDC	3-135	3-30	100-300
		Amps	1-10	3-30	1-10

±0.01% ACCURACY MODELS

Super-accurate AC Line Regulator Model 1001	Load range	0 — 1000 VA
	Input volt. range	95 — 130 VAC, 1Φ, 55 — 65~.
	Load P. F. range	0.7 lagging to 0.95 leading
	Output voltage	115 VAC, 1Φ (adjustable from 110-120 volts)
	Distortion	3% max.
	Time constant	0.1 seconds
	Reg. accuracy	±0.01%
DC Power Source for Spectrophotometers Model E-6/2-5 Nobatron	Input volt. range	95-130 VAC, 1Φ, 50-60 cycles
	Output	
	#1 for lamp	6VDC adjustable ±10% at 5 amperes
	#2 for filament	6VDC at 100 Ma.
	#3 for bias	2VDC adjustable ±10% at 100 Ma.
	Filtering	
	#1	1% max.
	#2 & 3	0.05% max.
	Reg. accuracy	±0.01% against line changes
	Time constant	0.1 seconds under most severe line changes

FREQUENCY CHANGERS

MODELS FCD250 FCD500 FCD1000 (the above change 50-60 cycles to 400 cycles; capacities of 250, and 1000 VA. Input 230VAC ± 10%, 1Ø, or 208VAC ± 10%, 1Ø.)	Input voltage	105-125 VAC, 1Ø
	Input frequency	50-60 cycles
	Output voltage	115 VAC, 1Ø, adjustable between 110-120 VAC
	Output frequency	60 and 400 cycles ± 10%
	Output voltage regulation	± 1.0%
	Output frequency regulation	± 1% in standard model ± 0.01% with auxiliary frequency standard
FC1000 (the above changes 50-60 cycles to 60 cycles regulated; capacity 1000 VA. Input 105-125VAC, 10.)	Load range	0.1 to full load
	Distortion	5% maximum
	P. F. range	Down to 0.5 lagging
	Time constant	0.5 seconds
	Envelope modulation	2% maximum

NEW cheap DC POWER SUPPLIES

DUAL OUTPUT (Model 350B)

INPUT	105 - 125 VAC, 50 - 60 ~ , 1Ø.
OUTPUT	1. 175-350 VDC @ 0-60 Ma simultaneously from two independently adjustable outlets. 2. 175-350 VDC @ 0-120 Ma from one outlet. 3. 0-175 VDC @ 0-60 Ma from one outlet. 4. 6.3 VAC @ 5 amps., C.T., unregulated.
OUTPUT REG.	±1.0% max. or 1.5 volts (which-is greater).
RIPPLE	10 mv
SIZE	13" x 7½" x 8"

TUBELESS—GERMANIUM (Model 300G)

Input	0-125 VAC, 1Ø, 50-60~
Output	0-300 VDC
Load range	0 - 0.6 amps.
Ripple	2% at 300 v. to 5% at 100 v.
Regulation	No line regulation. ± 1.0% with output voltage setting between 100 and 300 VDC with a load change from .06 amperes to 0.6 amperes. Useful performance available at lower output voltages (typical data available upon request).
AC output	0-125 VAC @ 115 volts input. 5 ampere capacity. Not available simultaneously with DC output.

Mechanical—no meters. Size 12" x 8" x 8".

COAST TO COAST

Authorized Sorensen representatives and their field engineers are listed below. Find the one located nearest you — don't hesitate to call on him for consultation and advice.

CALIFORNIA — HOLLYWOOD
Neely Enterprises
7422 Melrose Ave.; Phone Whitney 1147

CALIFORNIA — SACRAMENTO
Neely Enterprises
1317-15th St.; Phone Gilbert 2-8901

CALIFORNIA — SAN FRANCISCO
Neely Enterprises
2830 Geary Blvd.; Phone Walnut 1-3960

COLORADO — DENVER
Ronald G. Bowen
852 Broadway

D.C. — WASHINGTON
Burlingame Associates — F. L. Horman
2017 S St., N.W.; Phone Decatur 8000

FLORIDA — FORT MEYERS
Arthur H. Lynch & Associates
P. O. Box 466; Phone 5-6762

GEORGIA — ATLANTA
Floyd Fausett & Son
777 Pinehurst Terr.; Phone Raymond 3104

ILLINOIS — CHICAGO
Loren F. Green & Associates
4949 W. Diversey Ave.; Ph. National 2-2370

KENTUCKY
H. A. Watson, Jr.
817 Citizens Bldg.; Cleveland, Ohio

MASSACHUSETTS — BOSTON
Burlingame Associates — P. G. Yewell
270 Commonwealth Ave.; Ph. Kenmore 6-8100

MICHIGAN — DETROIT
S. Sterling Company
15310 W. McNichols Rd.; Ph. Broadway 3-2900

MISSOURI — SAINT LOUIS
Harris Hanson Co.
5506 S. Kings Highway

NEW MEXICO — ALBUQUERQUE
Neely Enterprises
107 S. Washington St.; Phone 5-8731

NEW YORK — SYRACUSE
Burlingame Associates — J. D. Ryerson
712 State Tower Bldg.; Phone 2-0194

NEW YORK — NEW YORK
Burlingame Associates
103 Lafayette St.; Phone Digby 9-1240

NORTH CAROLINA — CHARLOTTE
James L. Highsmith
P. O. Box 1011; Phone 5-6436

OREGON — PORTLAND
The James L. Kearns Co.
P. O. Box 5108; Phone East 4331

PENNSYLVANIA — PHILADELPHIA
Burlingame Associates — Ivan Robinson
7060 Garret Rd. (Upper Darby);
Phone Flanders 2-1597

PENNSYLVANIA — PITTSBURGH
H. E. Ransford & Co.
Grant Bldg.; Phone Grant 1-1880

TENNESSEE — KNOXVILLE
A. R. Hough
P. O. Box 1452; Phone 8-4312

TEXAS — HOUSTON
Earl W. Lipscomb & Associates
2420-B Rice Blvd.; Phone Linden 9303

TEXAS — DALLAS
Earl W. Lipscomb & Associates
5103 W. Lovers Lane; Phone Elmhurst 5345

CANADA — TORONTO, ONT.
Charles W. Pointon
1926 Gerrard St., East; Phone Oxford 7435

Specify **SORENSEN**

See Us at Booth 2-318, 319
I.R.E. Show, March 23-26

SORENSEN AND COMPANY • 375 FAIRFIELD AVE., STAMFORD, CONN.

What to see at the Radio Engineering Show

(Continued from page 124A)

Firm — **Booth**

Ersin Multicore Solders
Div. of British Industries
New York 13, N.Y.
2-515
"AVO" Line of Douglas and Macadie Coil Winding Machines, Widney-Dorlec Cabinets, "Expamet" Expanded Aluminum Grill Material, Germanium Diodes, Selenium Rectifiers, KT 66 Tubes.

Brooks & Perkins, Inc., Detroit 16, Mich. **1-706**
Magnesium assemblies for electronic systems—radar reflectors, pillbox-type wave guide, electronic housings, military equipment, missile air-frame assembly, teletypewriter housings.

Brown Electro-Measurement Corp.
Portland 15, Oregon
4-917
PRODUCTS: Dekapots and Dekastats—Precision high resolution potentiometers and rheostats featuring the BECO DEKADIAL. Portable and laboratory Impedance Bridges. Battery and ac operation null amplifiers. Miniature precision decade boxes.

Browning Laboratories, Inc., Winchester, Mass. **2-106 & 107**
Introducing our new—Models OL-23 Oscillosynchroscope; OA-16 Oscillosynchroscope; TVN-11 Power Supply; TAA-16B SWR Amplifier; MD-33 Frequency Modulation Monitor; RJ-42 FM-AM Tuner.

Brush Electronics Co.
Cleveland 14, Ohio
1-809, 810, & 811
Synthetic Prezo-Electric Materials, Acoustic Products, Magnetic Recording Components, Industrial and Laboratory Instruments and Hypersonic Generator and Transducer.

H. H. Buggie and Co.
Toledo 1, Ohio
4-520
Many types of special and standard connectors (Receptacles and plugs) cable assemblies and component parts for the electronics industry.

BURLINGAME ASSOCIATES

LABSCOPE — precision equal-amplifier OSCILLOSCOPES

haledy — cold-cathode, industrial CONTROLS and COUNTERS—totalizing and preset

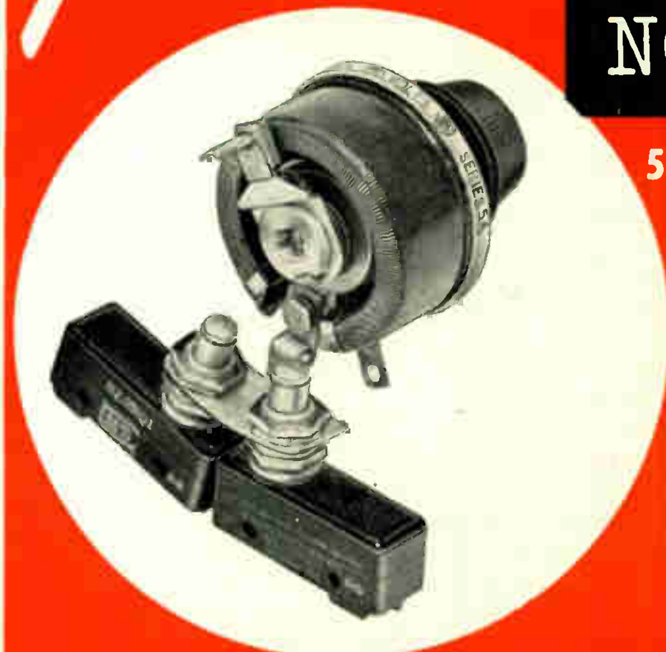
BOOTHS: 2-135-136

(Continued on page 130A)

TRU-OHM

Power Rheostats

NOW Available!



50 watt - 75 watt - 100 watt - 150 watt
(25 watt available shortly)

Special Features:

- ★ tapered windings
- ★ switch combinations
- ★ off positions
- ★ special shaft assemblies
- ★ tandem assemblies

May we have your prints for quotations and sampling? Prompt and courteous service is assured.

delivery we guarantee immediate delivery regardless of quantity, value and sizes.

price we guarantee that our prices will always save you money.

TRU-OHM VITREOUS ENAMELED RESISTORS — A complete line ready for shipment!

quality we guarantee our engineering techniques and selection of materials will provide the finest products available.

approval we guarantee to meet the requirements of the most rigid specifications.

TRU-OHM RHEOSTATS and RESISTORS are approved by the foremost manufacturers for civilian and government applications.

TRU-OHM **PRODUCTS** Division of Model Engineering & Mfg., Inc.

General Sales Office: 2800 N. Milwaukee Avenue, Chicago 18, Ill.
Factory: Huntington, Indiana

MANUFACTURERS: Power Rheostats, Fixed Resistors, Adjustable Resistors, "Econohm" Resistors, "Tru-rib" Resistors

What to see at the Radio Engineering Show

(Continued from page 128A)

Firm	Booth
Burroughs Adding Machine Co., Philadelphia 23, Pa. Computer components; Pulse control units; computation services.	4-921

Bussmann Mfg. Co., St. Louis 7, Mo. Buss Fuse Display will show small dimension fuses of various types. Fusetron dual-element (slow blowing) fuses, fast acting fuses for instrument protection—and fuses of all types for the protection of television, radio, controls, avionics, and automobiles. Plus many kinds of fuse blocks, fuse clips and fuse holders.	3-120
CGS Laboratories, Stamford, Conn. Increductor controllable inductors—no moving parts. Dynamic display showing wide range of response, operation at high and low frequencies, fast response, Q-meter demonstration. Microwave miniaturized S-Band cavity oscillator using pencil tube series, ruggedized to meet up to 1000 G acceleration. Stable to ± 2 mc under all operating conditions.	2-125 & 126
C & H Supply Co., Seattle, Wash. Metal-Cal. identification name plates and circuit diagrams.	3-526
The Calidyne Co., Winchester, Mass. VIBRATION TEST EQUIPMENT— Calidyne electro-dynamic Shakers—25 pound, 600 pound, 1250 pound, and 2500 pound force output. Accelerometer and Velocity Pickup Calibration Systems. Accelerometers and Accelerometer Couplers. Vibration Meter and Signal Monitor for velocity signal generators. Vibrascope, Calivolter.	2-518

Canadian Radium & Uranium Corp., 630 Fifth Avenue, New York 20, N.Y. Consult us on all luminous applications to instrument dials, panels and all other components. We manufacture complete dials, panels, etc., to your specification.	4-522

(Continued on page 132A)

What to see at the Radio Engineering Show

(Continued from page 130A)

Cannon Electric Co.
Los Angeles 31, Calif.
2-512

The widest selection of multi-contact electric connectors, including Mil Spec. types "AN," etc. Audio types P, O, X, XK, XL, U. Subminiatures will be featured, together with hermetic sealed also in sub-miniature. DC Solenoids are included in the exhibit.

Capitol Radio Engineering Institute, Washington 10, D.C. 3-106
CREI home study courses in Radio, Electronics and Television Engineering.

Carboloy Dept., General Electric Co., Detroit 32, Mich. 1-601
Carboloy Permanent Magnets. Carboloy Thermistors, and some suggested applications of these products. The display will also include one or two customer participation units.

Cargo Packers, Inc.
Brooklyn 11, N.Y.
4-802

Custom engineered packaging for the electronics industry featuring climate proof and shock proof designs for all applications—military and civilian. See fresh new approaches to transmitter tube and magnetron pack design. Specializes in packaging and packing of extremely delicate, sensitive electronic assemblies and components.

Centralab
A Div. of Globe-Union Inc.
900 East Keefe Ave.
Milwaukee 1, Wisconsin
SINCE 1922
"First in Components Research"

Centralab Div. of Globe-Union, Inc., Milwaukee 1, Wis. 2-403 & 404
The latest engineering developments and items produced by the pioneer and leader in electronic components. On display are new variable resistors, ceramic capacitors, rotary tone, lever, slide, and power switches, ceramic insulators and forms, and printed electronic circuits. Commercial and Military applications are covered.

Century Geophysical Corp., Dallas, Texas. 3-203
Recording Oscillographs, Recording Galvanometers, Linear-Integrating Amplifiers, Carrier Amplifiers.

Chase Resistor Co., Morristown, N.J. 4-712
Miniature hermetically sealed deposited carbon resistors for high temperature application. Rod and Disc. coated resistors for Microwave frequencies. Glass sealed helium filled resistors for precision networks.

Chatham Electronics Corp.
Livingston, N.J.
4-512

Electronic Tubes and Portable Equipment Units.

(Continued on page 134A)

Winchester Electronics Incorporated

ELECTRICAL CIRCUIT CONNECTORS

..can solve your toughest weight and space problems!

Our Engineering and Development Department can help you with your requirements for special connectors.

SERIES "B"

2/3 ACTUAL SIZE

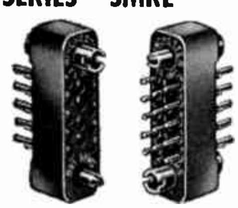
SERIES "A"

1/2 ACTUAL SIZE

SERIES "HMRE"

ACTUAL SIZE

SERIES "SMRE"



ACTUAL SIZE

SERIES "CR"

1/2 ACTUAL SIZE

SERIES "MRE"

2/3 ACTUAL SIZE

DESCRIPTION	Types Available	
LIGHTWEIGHT AIRCRAFT TYPE Polarized; Rack, Panel or Cable mounted—with Hood or Clamp and Cable strain relief.	*Receptacle* A7S A10S A15S A18S	*Plug* A7P A10P A15P A18P (Figures in above Code Nos. indicate number of contacts.)
HERMETIC PLUG Each special contact fused in glass into special base plate provided for soldering into a rectangular hole in an hermetically sealed housing or bulkhead. Used with Standard "MRE" Receptacle.		*Plug* HMRE7P-G HMRE9P-G HMRE14P-G HMRE18P-G HMRE20P-G HMRE21P-G HMRE26P-G HMRE34P-G HMRE41P-G HMRE50P-G (Used with Standard MRE Receptacles)
SUB-MINIATURE For Aircraft, Instruments and Portable Equipment Light weight, Polarized, Self-aligning with special guide pins. Rack, Panel or Cable mounted with Hood and Cable strain relief.	*Receptacle* SMRE7S-G SMRE14S-G SMRE20S-G SMRE26S-G SMRE29S-G SMRE34S-G	*Plug* SMRE7P-G SMRE14P-G SMRE20P-G SMRE26P-G SMRE29P-G SMRE34P-G (Other sizes to meet your requirements)
MINIATURE PRESSURE-TIGHT This connector is typical of several recent designs requiring a miniature connector (1" dia. x 1⅞" lgth.) in an aluminum die-cast shell. It is sealed with neoprene gaskets around the inserts and around each contact for pressure-tight construction.	*Receptacle* (Panel) CRS-2S (Standard type, pin contacts in plug) CRS-2P-R (Reversed type, pin contacts in receptacle) (5 contacts #20 AWG) (2 contacts #18 AWG)	*Plug* (Cable) CRS-2P CRS-2S-R
MINIATURE For Aircraft, Instruments and Portable Equipment Light weight, Polarized, Self-aligning with special guide pins. Rack, Panel or Cable mounted with Hood and Cable strain relief.	*Receptacle* MRE7S-G MRE8S-G MRE9S-G MRE12-2S-G MRE14S-G MRE18S-G MRE20S-G MRE21S-G MRE26S-G MRE34S-G MRE41S-G MRE50S-G MRE75S-G	*Plug* MRE7P-G MRE8P-G MRE9P-G MRE12-2P-G MRE14P-G MRE18P-G MRE20P-G MRE21P-G MRE26P-G MRE34P-G MRE41P-G MRE50P-G MRE75P-G

SERIES "SA"

2/3 ACTUAL SIZE

SERIES "HM"

ACTUAL SIZE

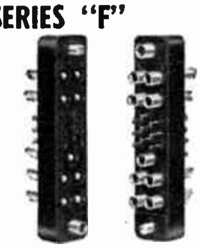
SERIES "QRE"

2/5 ACTUAL SIZE

SERIES "M"

4/5 ACTUAL SIZE

SERIES "F"



2/5 ACTUAL SIZE

DESCRIPTION	Types Available	
MINIATURE INSERT IN SPECIAL SHELL Aluminum die-cast shells available in ⅞" and 1-7/32" dia. with bayonet locking for quick engage and disengage. Shells have synthetic rubber gaskets. Flanges permit mounting of receptacle in panel or housing and special gland construction provides cable entry in plug.	*Receptacle* (Panel) B12S B14S B24S (Standard type, pin contacts in plug.) B12P-R B14P-R B24P-R (Reversed type, pin contacts in receptacle.) (Figures in above Code Nos. indicate number of contacts.)	*Plug* (Cable) B12P B14P B24P B12S-R B14S-R B24S-R
LIGHTWEIGHT AIRCRAFT SMALL Polarized: Rack, Panel or Cable mounted—with Hood or Clamp and Cable strain relief	*Receptacle* SA7S SA10S SA15S SA18S (Figures in above Code Nos. indicate number of contacts.)	*Plug* SA7P SA10P SA15P SA18P
HERMETIC PLUG (Round Hole) Special contacts fused in glass into special base plate provided for soldering into a round hole in an hermetically sealed housing or bulkhead. Used with Standard "M" Receptacle.		*Plug* HM4P HM5P HM7P (Used with Standard M4S, M5S or M7S Receptacles)
QUICK-DISCONNECTING SELF-ALIGNING Spring-loaded contacts for ease in separation. Self-aligning with special guide pins. Rack, Panel or Cable mounted with Hood and Cable strain relief.	*Receptacle* QRE6S QRE12S QRE18S QRE24S QRE34S QRE208S AQRE12S MAQRE18S	*Plug* QRE6P QRE12P QRE18P QRE24P QRE34P QRE208P AQRE12P MAQRE18P
MINIATURE For Aircraft, Instruments and Portable Equipment Light weight, Polarized, Locking Ring, Panel or Cable mounted with Hood and Cable strain relief.	*Receptacle* SM1S SM2S M4S M5S PM6S M7S M9S M12S M48S (Figures in above Code Nos. indicate number of contacts.)	*Plug* SM1P SM2P M4P M5P PM6P M7P M9P M12P M48P
SPECIAL CONNECTORS Unique design permits the use of two sizes of wire — #20 and #14 AWG—and assures uniform electrical and mating characteristics. Light-weight, polarized and panel mounted, these connectors are available with or without guides.	*Receptacle* F5S-G F2S-8P-G F9S-9P-G (Figures in above Code Nos. indicate number of contacts. First figure for #20 AWG, second figure for #14 AWG.)	*Plug* F5P-G F2P-8S-G F9P-9S-G

MANY FEATURES are covered by our Pat. No.'s 161900, 162795, 2411861, 2466370, 2513080, 2526325, 2532538. Other Pats. Pend.

MONOBLOC* CONSTRUCTION eliminates unnecessary creepage paths and reduces possibility of moisture and dust pockets and provides stronger molded parts.

MOLDED MELAMINE body parts insure greater mechanical strength and high dielectric and arc resistance.

PRECISION MACHINED CONTACTS are gold plated over silver for consistent electrical conductivity, prevention of corrosion and ease in soldering.

Connectors & components meet applicable government specifications.

Write or telephone our Engineering Department for information on the above or other connectors—or for consultation on difficult connector problems. Many other standard and special types available.

*Trade Mark

West Coast Branch:
1729 WILSHIRE BOULEVARD
SANTA MONICA, CALIFORNIA

WINCHESTER ELECTRONICS INCORPORATED

GLENBROOK, CONNECTICUT, U.S.A.

What to see at the Radio Engineering Show

(Continued from page 132A)

Chester Cable Corp.
Chester, N.Y.
4-704
Electrical wires and cables.

Chicago Telephone Supply Corp.
Elkhart, Ind. 4-608
For your military and commercial requirements a complete line of wire-wound and carbon composition variable resistors will be shown. JAN-R-19, JAN-R-94 and other military types of variable resistors available for immediate delivery from stock will also be displayed.

Ciba Company, Inc., New York 14, N.Y. 4-909
Resins and adhesives of interest to the electronics industry—Araldite, Redux, Cibanite.

Harold B. Jones Div.
Cinch Mfg. Corp.
Chicago 24, Ill.
2-505 & 506
Electrical Connecting Devices.

C. P. Clare & Co. New York 17, N.Y. 2-306
Relays for electric, electronic, and industrial uses. Hermatically sealed relays. Stepping switches. Lever keys and push keys.

Clarostat Mfg. Co., Inc., Dover, N.H. 2-507 & 508
Precision Potentiometers—Miniature Composition Potentiometers — Wire-Wound Miniature Potentiometers. Resistors and Resistance Devices for Communications—Radar—Aircraft—Television and Radio and Home Appliances.

Cleveland Container Co.
Cleveland 11, Ohio
Clevelite the paper base laminated phenolic tube—various grades and fabrications—also "Torkrite" the answer to stripping and torque problems encountered in coil forms requiring the use of iron cores or metal inserts. 2-309

Sigmund Cohn Corp.
Mount Vernon, N.Y.
2-214
Precious metal products, very small wires, gold plated wires, and enameled wires; gold and rhodium plating solutions.

(Continued on page 136A)

What to see at the Radio Engineering Show

(Continued from page 134A)

Coil Winding Equipment Co., Oyster Bay, L.I., N.Y. 3-521
Showing the latest developments in equipment for the winding of coils—Equipment for Laboratory, Schools, and Production. Engineering help on special problems. Special designs for winding stator coils, self-supporting layer wound coils, and coils with cotton inter-weaving. Unique cam design provides variable throw without back-lash at high speeds.

Condenser Products Co., Chicago 26, Ill. 2-112
Plasticon Capacitors.

Connecticut Telephone & Electric Corp., Meridien, Conn. 3-307A
Signal generator covering the complete rage of VHF to UHF frequencies. Hand microphone. Miscellaneous head set and hand sets. Miniature motors. Carrier equipment consisting of ringer filter units and voice frequencies line unit. Decibel meter.

Consolidated Engineering Corp., Pasadena 16, Calif. 4-413 & 415
"Sadic" data processing equipment, analog to digital converters, recording oscillographs, vibration meters, pickups and transducers, leak detector (mass spectrometer type), micromanometer, vacuum gauge, and other electronic analytical instruments.

Consolidated Vacuum Corp., Rochester 3, N.Y. 2-408 & 409
Featuring new 16 head high speed rotary exhaust machine for electron tubes; small compact, semi-automatic frequency crystal coater; 10-Port Vacuum Manifold System for leak testing and backfilling hermetics. Also expanded range Philips vacuum gauge, halogen sensitive leak detector, plus accessory high vacuum equipment items.

L. L. Constantin & Co., Lodi, N.J. 4-422
Manufacturing Engineers specializing in all varieties of metal-to-glass vacuum seals. Included in the complete line are crystal holders, multi-pin headers, single terminals, single and seals, multi-pin con plugs, vacuum coating equipment and precision parts.

(Continued on page 140A)

EXPANDING PRODUCTION

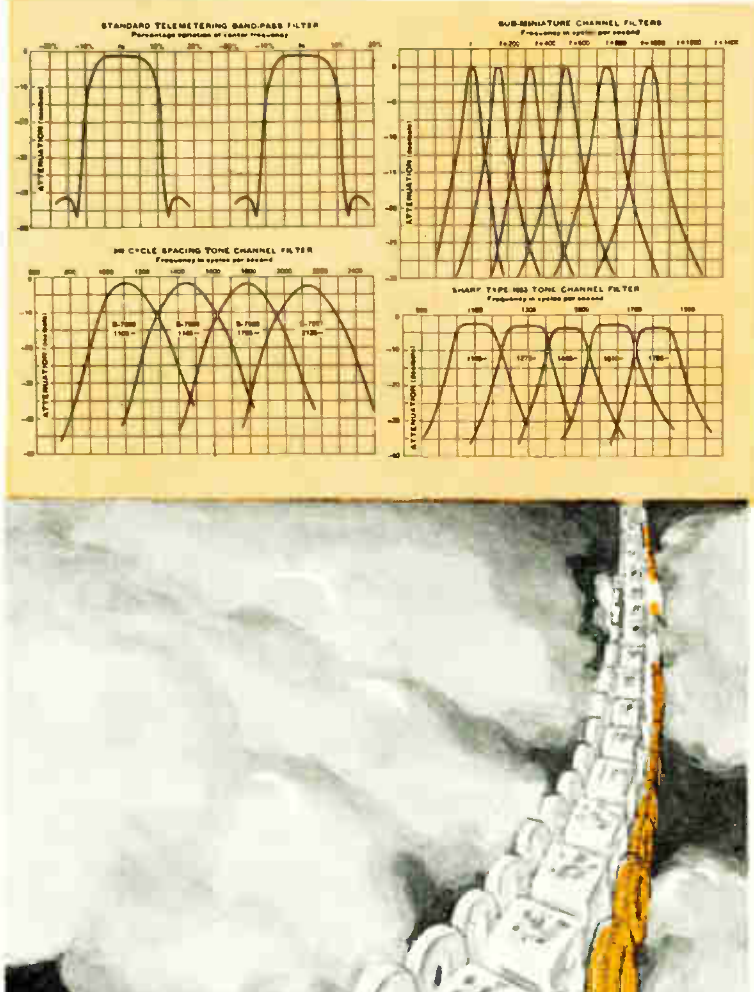
in Toroids & Filters

At every management meeting in Burnell & Company there is an unseen but highly respected visitor. He is the spectre of all our customers and his opinions carry weight. Recently he suggested that in addition to our other expansion measures that we must find a way to improve deliveries for emergency and special sample orders. Our solution is certainly not original but no less effective.

Burnell & Company's new sample department has been able to produce audio filters from proverbial 'scratch' to the customer's waiting hands in as little as ten days!

Frankly, this cannot always be accomplished but our average has been ranging between three to four weeks for emergency samples and four to six weeks for regular prototypes instead of the former twelve weeks of the pre-sample department days.

Adding this to our new winding department and our new testing and finishing departments the sum total has been a *still* better product at a better delivery than ever before.



EXCLUSIVE MANUFACTURERS OF COMMUNICATIONS NETWORK COMPONENTS

Burnell & Company
YONKERS 2, NEW YORK
CABLE ADDRESS "BURNELL"

What to see at the Radio Engineering Show

(Continued from page 136A)

Continental Carbon, Inc., Cleveland 11, Ohio 2-133
"Nobleloy" Precision Metal Film Resistors; Composition Resistors; Low Power Wire Wound Resistors; Auto Radio Capacitors and Suppressors; Oil Burner Suppressors.

Continental Connectors 4-125
Continental Connectors, by DeJur-Amsco Corporation, Long Island City, displays its complete line of precision multi-contact connectors, stand-off terminals, and terminal blocks. Engineers will be present at the booth to discuss specific problems relating to connector applications. Engineering bulletins will be available.

Continental Diamond Fibre Co., Newark 48, Del. 4-603
Manufacturing and fabricating of electrical insulation, molded and laminated plastics.

Copperweld Steel Co., Flexo Wire Division, Glassport, Pa. 4-911
Copperweld Steel Company's exhibit in booth No. 4-911 depicts the making of Copperweld Wire by the unique Molten-Welding process. Samples of Copperweld Fine Wires will be featured together with Copperweld Radio and Television Products such as ground rods and clamps, antenna wire, guy wire, and grounding wire.

Corning Glass Works, Corning, N.Y. 1-416-418 & 420
Glass bulbs for applications in all fields of electronics: metallized glassware for radio and television components.

The R. W. Cramer Co., Inc., Centerbrook, Conn. 3-504 & 505
Synchronous timing motors, Interval timers, time delay relays, cycle timers, percentage timers, Hermetically sealed aircraft type time delay relays, reclosing relays, running time meters, and miscellaneous electric timing devices.

Crest Labs., Inc., New York, N.Y. 4-128
See: Microtran Co.

(Continued on page 142A)

ELECTRONICALLY REGULATED

LABORATORY POWER SUPPLIES

BENCH MODEL 50

• STABLE • DEPENDABLE • MODERATELY PRICED •

ALSO AVAILABLE STANDARD RACK MOUNTING
MODEL 50-R
PANEL SIZE 10½" x 19"
DEPTH 14¼"

- **INPUT:** 105-125 VAC, 50-60c
- **OUTPUT #1:** 0-500 VDC at 500 ma regulated
- **OUTPUT #2:** 0-50 VDC, 0-200 VDC Bias Output.
- **OUTPUT #3:** 6.3 VAC at 5A unregulated
- **OUTPUT #4:** 6.3 VAC at 5A unregulated
- **RIPPLE OUTPUT:** Less than 8 millivolts rms

For complete information write for Bulletin 50S

LAMBDA ELECTRONICS CORPORATION
CORONA NEW YORK

ELECTRONICALLY REGULATED

LABORATORY POWER SUPPLIES

IRE SHOW
MARCH 23-26 1953
GRAND CENTRAL PALACE
NEW YORK CITY

BOOTH 3-501
VISIT OUR DISPLAY OF CURRENT AND NEW MODELS

LAMBDA ELECTRONICS CORPORATION
CORONA NEW YORK

ELECTRONICALLY REGULATED

LABORATORY POWER SUPPLIES

BENCH MODEL 25

• STABLE • DEPENDABLE • MODERATELY PRICED •

WIDTH 14"
DEPTH 6"
HEIGHT 8"
WT: 17 LBS.

- **INPUT:** 105 to 125 VAC, 50-60 cy
- **OUTPUT #1:** 200 to 325 Volts DC at 100 ma regulated
- **OUTPUT #2:** 6.3 Volts AC CT at 3A unregulated
- **RIPPLE OUTPUT:** Less than 10 millivolts rms

For complete information write for Bulletin N-5S

LAMBDA ELECTRONICS CORPORATION
CORONA NEW YORK

ELECTRONICALLY REGULATED

LABORATORY POWER SUPPLIES

RACK MODEL 32

• STABLE • DEPENDABLE • MODERATELY PRICED •

STANDARD RACK MOUNTING
PANEL SIZE 10½" x 19"
DEPTH 9"
WEIGHT 38 LBS

- **INPUT:** 105 to 125 VAC, 50-60 cy
- **OUTPUT #1:** 200 to 325 VDC at 300 ma regulated
- **OUTPUT #2:** 6.3 Volts AC CT at 5A unregulated
- **OUTPUT #3:** 6.3 Volts AC CT at 5A unregulated
- **RIPPLE OUTPUT:** Less than 10 millivolts rms

For complete information write for Bulletin N-2S

LAMBDA ELECTRONICS CORPORATION
CORONA NEW YORK

ELECTRONICALLY REGULATED

LABORATORY POWER SUPPLIES

RACK MODEL 28

• STABLE • DEPENDABLE • MODERATELY PRICED •

MODEL 28 STANDARD RACK MOUNTING
PANEL SIZE 5¼" x 19"
WEIGHT 16 LBS.

- **INPUT:** 105 to 125 VAC, 50-60 cy
- **OUTPUT #1:** 200 to 325 Volts DC at 100 ma regulated
- **OUTPUT #2:** 6.3 Volts AC CT at 3A unregulated
- **RIPPLE OUTPUT:** Less than 10 millivolts rms

For complete information write for Bulletin N-8S

LAMBDA ELECTRONICS CORPORATION
CORONA NEW YORK

ELECTRONICALLY REGULATED

LABORATORY POWER SUPPLIES

RACK MODEL 33

• STABLE • DEPENDABLE • MODERATELY PRICED •

STANDARD RACK MOUNTING
PANEL SIZE 10½" x 19"
DEPTH 9"
WEIGHT 38 LBS

- **INPUT:** 105 to 125 VAC, 50-60 cy
- **OUTPUT #1:** 100 to 200 VDC at 300 ma regulated
- **OUTPUT #2:** 6.3 Volts AC CT at 5A unregulated
- **OUTPUT #3:** 6.3 Volts AC CT at 5A unregulated
- **RIPPLE OUTPUT:** Less than 10 millivolts rms

For complete information write for Bulletin N-3

LAMBDA ELECTRONICS CORPORATION
CORONA NEW YORK

What to see at the Radio Engineering Show

(Continued from page 140A)

Crucible Steel Co. of America, New York 17, N.Y. 4-203 & 204
Permanent magnets, castings.

Curtis Development & Mfg. Co.
Milwaukee 16, Wis.
3-514
Curtis Terminal Blocks: For Every Purpose Factory Assembled or Kit Form.

DX Radio Products Co., Inc.
Chicago 47, Ill.
3-502
Toroid Coils, Speakers, TV Tuners Ion Traps, Crystals, RF & IF Transformers, Coil Assemblies, TV Deflection Yokes and TV Horizontal OutPut Transformers.

Dale Products, Inc.
Columbus, Nebr.
4-129
A Deposited Carbon Resistor Furnace in operation at our Booth. Also displaying Miniature Precision Power Resistors in wattage ranges from 2 watts to 250 watts with temperatures coefficient of less than 0.00002/°C and accuracy as close as .1%—Also a complete showing of precision deposited carbon resistors.

The Daven Co.
191 Central Ave.
Newark 4, N.J.
1-118, 119
Audio, Video, and R. F. Attenuators, Precision Wire Wound Resistors, Rotary Switches, Vacuum-Tube Voltmeters, Distortion Meters, Transmission Measuring Sets, Power Output Meters, Laboratory Test Equipment.

Bryan Davis Publishing Co., Inc., New York 17, New York 2-201
Magazine and books. "Service."

Decade Instrument Co.
Caldwell, N.J.
4-905
Frequency converters for use with frequency counters—"Decaviders," Decade - Switched Sweeping Oscillators—"Deca-Sweeps," and Decade-Switched Oscillators—"Decalators."

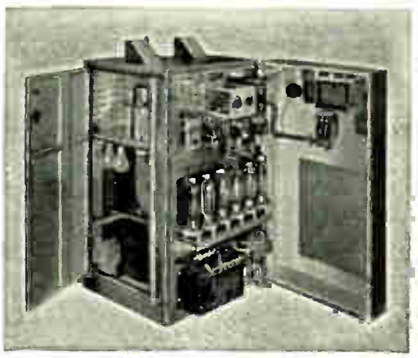
DeJur-Amsco Corporation, Long Island City, N.Y. 4-125
Precision potentiometers, meters, rheostats, and other electronic equipment designed to meet the exacting requirements of contemporary electronic needs. Engineers will be present at the booth to discuss specific application problems relative to all DeJur products. Complete technical literature available at booth.

(Continued on page 144A)

PANELS, LIDS, DOORS MADE RF-TIGHT BY LOW COST METHOD

Electronic Weatherstripping, made of knitted wire mesh compressed to required sizes and shapes, effectively "shields" these openings against RF leakage just as weatherstrips seal doors and windows.

Openings such as these are necessary for operating and servicing the electronic equipment housed in the metal cabinet. Yet these same openings destroy the full shielding efficiency which an "unbroken" metal container would otherwise provide. Careful machining of mating surfaces at



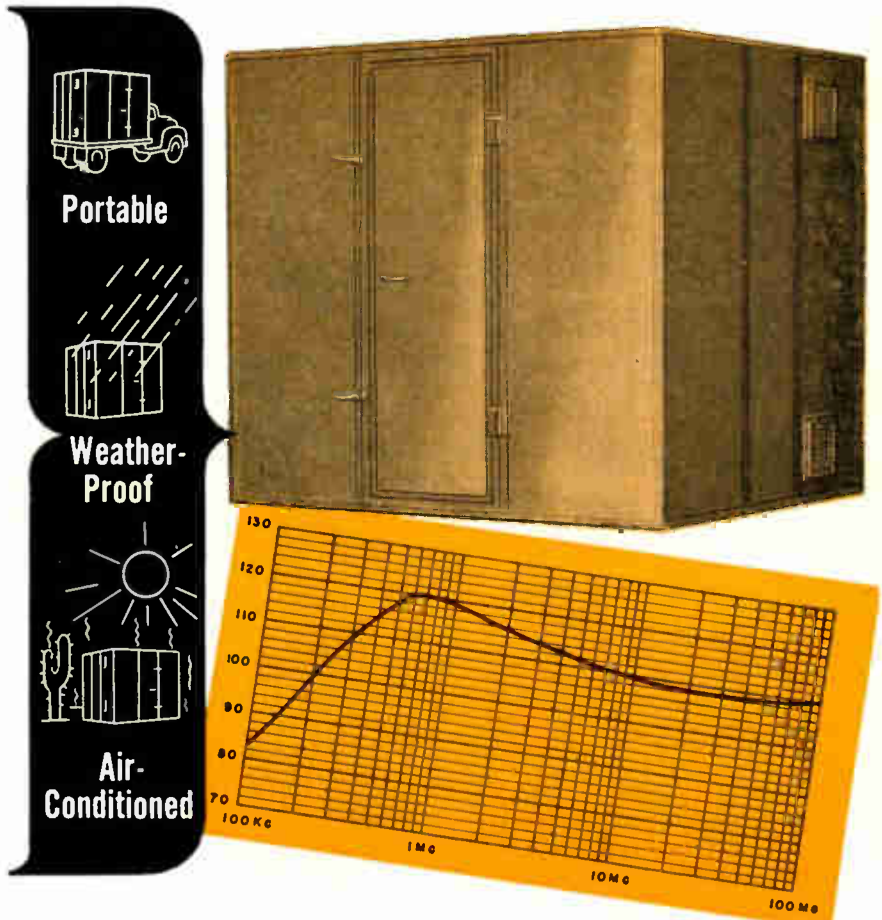
"Thermatron built by Radio Receptor Co., Inc."

these openings is an obvious answer. But such work is expensive, and the initial close fit is often destroyed by repeated openings and closings, by warping of the lid or door and by corrosion of the mating surfaces. Numerous latches, screws, bolts and other fasteners, closely spaced, will help keep these joints RF tight, but they are a time consuming nuisance whenever the cabinet must be opened and closed, and they are also expensive to purchase and install.

Metex Electronic strips and gaskets eliminate these objections. Being made of metal, they are conductive; and being knitted they are resilient and conform to normal surface irregularities. They actually "block" the otherwise leaky openings with a gasket of flexible metal, and make the cabinet as effective a conductive shield as if the openings had never been made.

Metex electronic strips and gaskets are easy to install. Not only are they inexpensive, but their use may well save more than their cost by eliminating many operations that would otherwise be necessary. They are available in different shapes, dimensions and resiliencies to meet the varied requirements of specific electronic applications and can be made of metals or alloys selected to meet actual or anticipated corrosive conditions.

A bulletin giving detailed information is available on request from the manufacturer, Metal Textile Corporation, East First Avenue, Roselle, N. J.



What to see at the Radio Engineering Show

(Continued from page 142A)

DeJur-Amsco Corp.
Long Island City 1, N.Y.
4-125

DeJur potentiometers, rheostats, panel instruments CONTINENTAL, connectors.

Tobe Deutschmann Corp., Norwood, Mass. 3-520
Capacitors, metallized paper, oil and wax impregnated paper, molded paper, high temperature. Filters: Radio TV-Noise suppression, low pass, high pass, band pass, audio. Special products, pulse forming networks, pulse capacitors, delay lines, toroidal coils.

Dialight Corp.,
Brooklyn 37, N.Y.
1-504

Sub-miniature indicator lights in non-dimmer, dimmer (complete or semi-blackout), polaroid and light shield types. Also featuring the New subminiature Press-to-test light. Plastic plate edge lighting assemblies with a choice of filter colors. Warning, signal, indicator, pilot light assemblies for neon and incandescent lamps.

Diamond Mfg. Corp., Wakefield, Mass. 4-309
RF coaxial cable connectors and associates components.

Digital Instrument Co., Inc., Coral Gables, Fla. 4-111
Digital decade counters, time base generators, preset counters, cycling counters, nuclear scalers, industrial counters.

Wilbur B. Driver Co.
Newark 4, N.J.
2-103, 104

Filament Grid Wire
Carbonized Nickel for Anodes
Wire & Ribbon Resistors
Glass to Metal Seals

Wilbur B. Driver Co., Newark 4, N.J. 2-103 & 104
Melters and Manufacturers of Alloys for the following electronic applications: 1-Filament 2-Grid Wire 3-Carbonized Nickel for Anodes, Wire and Ribbon 4-Resistors 5-Glass to Metal Seals, Alloy Names; Evanohm, Tophet, Cupron, Radiocard, Sylvaloy, Modified Hilo, Cobanic, Rodar, Nilstain, Balco, Manganin, #60, #90, #180 Alloy.

Allen B. Du Mont
Laboratories, Inc.
Instrument Division
760 Bloomfield Avenue
Clifton, N.J.
1-212, 213

General Purpose C-R Voltmeter; General Purpose Dualbeam Oscillograph; High-voltage, high frequency C-R Oscillograph; C-R oscillograph accessories and oscillograph-record cameras; tight-tolerance C-R tubes; special C-R tubes; new photomultiplier tubes.

(Continued on page 150A)

At the I.R.E. Show
BOOTH #4-215—4th Floor

Now available the revolutionary ELECTRO TEC process* for your LARGE SLIP RING ASSEMBLIES

featuring

- LOWER COST
- CLOSER TOLERANCES
- ONE-PIECE CONSTRUCTION
- JEWEL-LIKE FINISH
- UNIFORM RING HARDNESS
- REDUCED WEIGHT

An assembly with 14 concentric, hard silver rings electro deposited into machined plastic blank. Dovetail locks rings in place. Machined blank insures accuracy. Diameter approx. 11", thickness approx. 5/16".

Cylindrical assembly with 25 rings. Three wide rings accommodate large contact area brushes for high current capacity. Length 14", O.D. approx. 5 3/8".

An assembly with 30 rings of various widths to accommodate various current requirements. Unit is approx. 4-5/16" long, designed for flange mounting.

Cylinder type assembly approx. 3 3/4" long with 24 hard silver rings. 1 5/8" O.D. with wall thickness less than 1/4".

*PATENTS PENDING

Now a Complete Service in all sizes of Slip Ring Assemblies

ELECTRO TEC is now tooled up, with new expanded facilities for production of large Slip Ring Assemblies to exact customer specification. Sizes range up to 24" in diameter, either cylindrical or disc type.

The exclusive ELECTRO TEC PROCESS*—the electro-deposition of hard silver rings into an accurately machined plastic blank—consistently yields a high degree of dimensional accuracy, excellent concentricity, and a jewel-like ring finish. This process also eliminates expensive tooling and mold charges, frequently lowers costs to 30% of other methods of manufacture. The silver rings are uniformly hard for long life—75-90 Brinell.

ELECTRO TEC one-piece construction precludes dimensional variation due to accumulated errors. The plastic base is fully cured before rings are plated into it, thus preventing separation of base material from the rings.

ELECTRO TEC LARGE SLIP RING Assemblies are widely used in Radar Equipment, Fire Control Systems, Test Tables and many other critical applications. Light weight combined with rugged durability recommends their use in airborne applications.

Every user knows the ELECTRO TEC reputation for quality and superiority in miniature and sub-miniature slip ring assemblies.

Our Engineering Department is available for consultation on any of your slip ring problems without obligation.

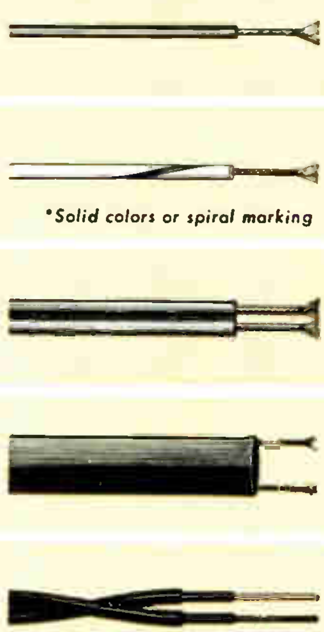
ELECTRO TEC CORPORATION
SOUTH HACKENSACK • NEW JERSEY

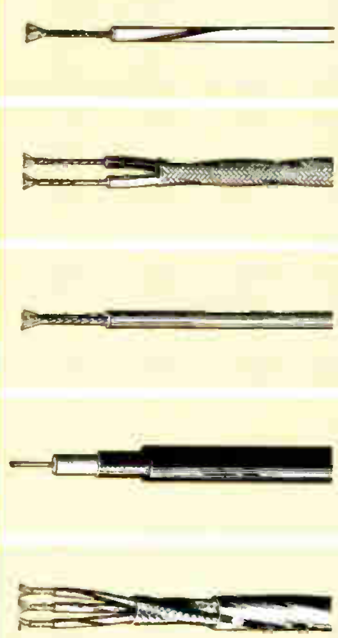
Keep TABS on WIRING PERFORMANCE with—

Tested and
Approved
Beyond
Specification

CHESTER *plasticord-plasticote* WIRES & CABLES

Chester ENGINEERED plastic insulation, laboratory and field tested to more than meet specifications provides both easier working qualities and longer service life. These rugged plastic coatings offer maximum immunity to abrasion, weather, oil and most chemicals. Smooth and pliable, they pull through channels and conduit easily and offer excellent appearance in open wiring. Chester single or multi-conductor wires and cables are available for electrical, electronic, TV, radio, telephone and many other industries. Call or write for illustrated bulletins, today!





JAN-C-76 WIRES* SRIR, SRHV, SRRF, WL	LACQUERED AND NYLON WIRES
105°C, 90°C, 80°C UL APPROVED; 120°C*	SHIELDED WIRES & CABLES
FLEXIBLE CORD	INSTRUMENT WIRES
TV LEAD-IN WIRES	COAXIAL CABLE
COMMUNICATION WIRES & CABLES TO SPECIFICATIONS	SPECIAL WIRES & CABLES TO SPECIFICATIONS

*Solid colors or spiral marking

VISIT US AT THE I.R.E. SHOW BOOTH 4-704 FOURTH FLOOR

"*Chesty*" HAS THE ANSWERS — Plasticord and Plasticote wires are available in standard constructions or custom built to specifications. For a practical solution to unusual insulated wiring problems, call or write.

CHESTER CABLE CORP.
CHESTER • NEW YORK

REGISTERED U.S. PAT. OFF.

COMPLETE CIVILIAN LINE

Exceptionally **good delivery cycle on civilian orders due to tremendous mass production facilities.**

TYPE C45-70

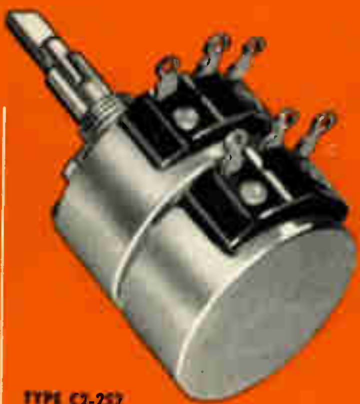
NEW HIGH QUALITY MINIATURIZED "DIME-SIZE" CIVILIAN CONTROL— ***Performance Fully Equals Larger Types.***

TYPE 70, 3/4" diameter variable composition resistor. Wattage rating: .3 watt for resistances through 10,000 ohms, .2 watt with 350 volts maximum across end terminals for resistances over 10,000 ohms. Also available in concentric shaft tandem construction C45-70 as shown above.

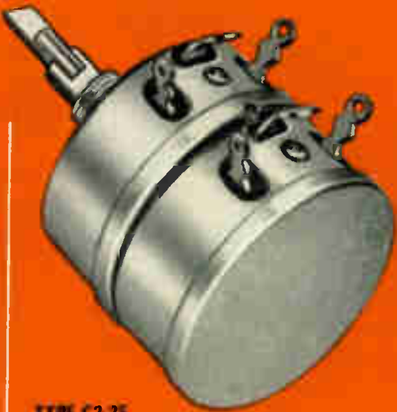
TYPE C2-45

TYPE C2-35

TYPE C2-252



TYPE C2-25



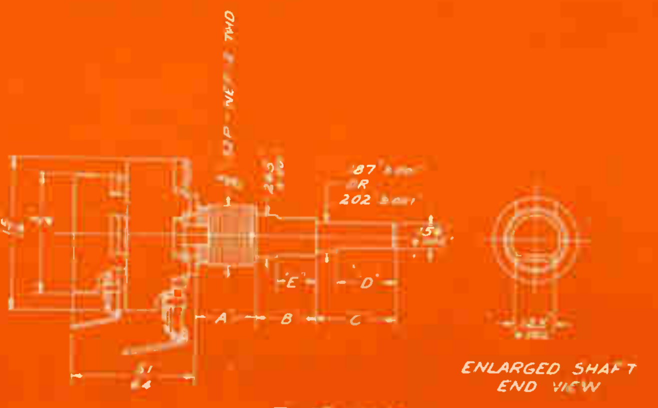
TYPE GC-45, 15/16" diameter variable composition resistor. Wattage rating: 1/2 watt for resistances through 10,000 ohms, 1/3 watt for resistances over 10,000 ohms through 100,000 ohms, 1/4 watt with 500 volts maximum across end terminals for resistances over 100,000 ohms. Available with or without illustrated attached switch and in concentric shaft tandem construction C2-45 as shown above.

TYPE GC-35, 1 1/8" diameter variable composition resistor. Wattage rating: 3/4 watt for resistances through 10,000 ohms, 2/3 watt for resistances over 10,000 ohms through 25,000 ohms, 1/2 watt with 500 volts maximum across end terminals for resistances over 25,000 ohms. Available with or without illustrated attached switch and in concentric shaft tandem construction C2-35 as shown above.

TYPE GC-252, 2 watt, 1 17/64" diameter variable wirewound resistor. Available with or without illustrated attached switch and in concentric shaft tandem construction C2-252 as shown above.

TYPE GC-25, 4 watt, 1 17/32" diameter variable wirewound resistor. Available with or without illustrated attached switch and in concentric shaft tandem construction C2-25 as shown above.

Typical concentric shaft tandem with panel and rear sections operating separately from concentric shafts **(TYPE C45-70 ILLUSTRATED).** Similar construction available for all military resistors.



TYPE C45-70

REPRESENTATIVES

Henry E. Sanders
McClatchy Bldg.
69th & Market St.
Upper Darby, Penna.
Phone: Flanders 2-4420

W. S. Harmon Company
1638 So. La Cienega Blvd.
Los Angeles 35, California
Phone: Bradshaw 2-3321

John A. Green Company
6815 Oriole Drive
Dallas 9, Texas

IN CANADA

C. C. Meredith & Co.
Streetsville, Ontario

SOUTH AMERICA

Jose Luis Pontet
Buenos Aires, Argentina
Montevideo, Uruguay
Rio de Janeiro, Brazil
Sao Paulo, Brazil

OTHER EXPORT

Sylvan Ginsbury
8 West 40th Street
New York 18, N. Y.

Specialists i

maintenance and replacement are simplified with Fairchild

plug-in potentiometers

These plug-in type ganged potentiometers are another excellent example of Fairchild's service in meeting the special requirements of customers. The problem was to provide ganged precision potentiometers that would simplify maintenance of airborne fire control equipment through quick and easy replacement. A series of packaged plug-in units like that shown was the answer.

An entire gang can be replaced in a few minutes because only the end mounting plates are fastened down. There are no wires to disconnect or solder. Test points are provided on the top of each potentiometer so it can be checked quickly.

Maximum rigidity of the gang is assured by mounting the individual units on a single shaft. These plug-in potentiometers have the same mechanical and electrical tolerances and performance characteristics that have made the Model 746 unit the first choice for many critical applications.

Use the coupon below to get full information.

FAIRCHILD
PRECISION POTENTIOMETERS

SEE THESE PLUG-IN UNITS AND OTHER INTERESTING DEVELOPMENTS IN PRECISION POTENTIOMETERS AT THE I. R. E. SHOW—BOOTH NOS. 2-405 AND 2-406

Potentiometer Division, Department 140-34H
Fairchild Camera and Instrument Corporation
Hicksville, Long Island, New York

Gentlemen:

Please send me complete information about Fairchild Precision Potentiometers and tell me how you might solve my potentiometer problems.

Name ____________________

Position ____________________

Company ____________________

Address ____________________

What to see at the Radio Engineering Show

(Continued from page 144A)

Allen B. Du Mont Laboratories, Inc.
C-R Tube Division
750 Bloomfield Avenue
Clifton, N.J.
1-214, 215, 216

Latest developments in television picture tubes.

Allen B. Du Mont Labs., Inc., Instrument Div., Clifton, N.J. 1-212 & 213
Type 304-A General Purpose Cathode-ray Voltmeter; Type 322 General Purpose Dual-beam Oscillograph; Type 303-AH High-voltage, high frequency cathode-ray oscillograph; complete line of cathode-ray oscillograph accessories and oscillograph-record cameras; complete line of tight-tolerance cathode-ray tubes; special cathode-ray tubes; new photo-multiplier tubes.

Allen B. Du Mont Labs., Inc., Television Transmitter Div., Clifton, N.J. 1-208 & 211
Image Orthicon Camera and Mobile Mount Dolly; Portable Sync Generator; Du Mitter—(miniature closed circuit TV transmitter); Video Recorder; New UHF Antenna; New General Purpose Studio 17" Picture Monitor; Special Program Console —(with audio and video switcher in a model studio control room with master control equipment); Two Monochrome Scanners.

Allen B. Du Mont Lab., Inc., CRT Division, Clifton, N.J. 1-214, 215 & 216
Latest development in television picture tubes, products of the Cathode-ray Tube Division of Allen B. Du Mont Laboratories, Inc.

Dumont Electric Corp., New York 34, N.Y. 4-504
Tubular paper, dry electrolytic, metal clad, bathtub and upright capacitors. "Zero-Loss durene capacitors." "Thermo-film" dielectric capacitors.

Dyna-Labs., Inc.
Garden City, L.I., N.Y.
4-402

D-79 Gaussmeter — Magnetic earphones in various applications.

Hugh H. Eby, Inc.
Philadelphia 44, Pa.
2-101

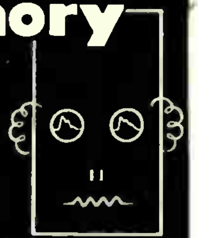
New Sockets:—Rack and panel connectors: Printed Circuits:—vibrator sockets: Tuner components: Enlarged catalog: Do you have a component problem? Arrange to visit our engineers on duty during entire show.

Edin Co., Inc., Worcester 8, Mass. 4-421
Extended frequency Galvanometers with range from DC to 300 cps, Oscillograph Recorders with chart speeds ranging from .1 to 625 mms. per second, and JAN rack and panel type AC, DC and Carrier Amplifiers. Complete recording systems will also be featured with a selection of these instruments into multi-channel Consolettes.

SEE all four floors!

(Continued on page 152A)

improve your memory



with

andersen SOLID ultra-sonic DELAY LINES

In electronic computers, Andersen <u>SOLID</u> ultra-sonic delay lines are:

PHYSICALLY STABLE ELECTRONICALLY DEPENDABLE

and <u>SOLID</u> delay lines mean minimum size and weight.

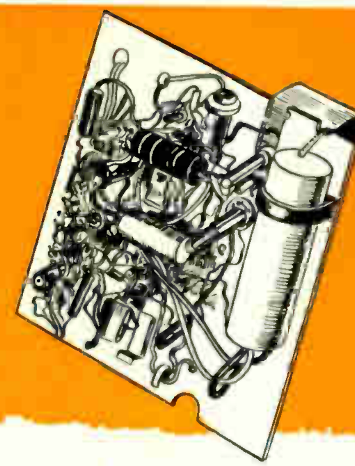
Spurious signals — 40db. or better.

Investigate Andersen **SOLID** ultra-sonic delay lines. Complete facilities for research and development.

andersen Laboratories INCORPORATED

37 Talcott Road
West Hartford 10, Conn.

Can You afford Spaghetti...

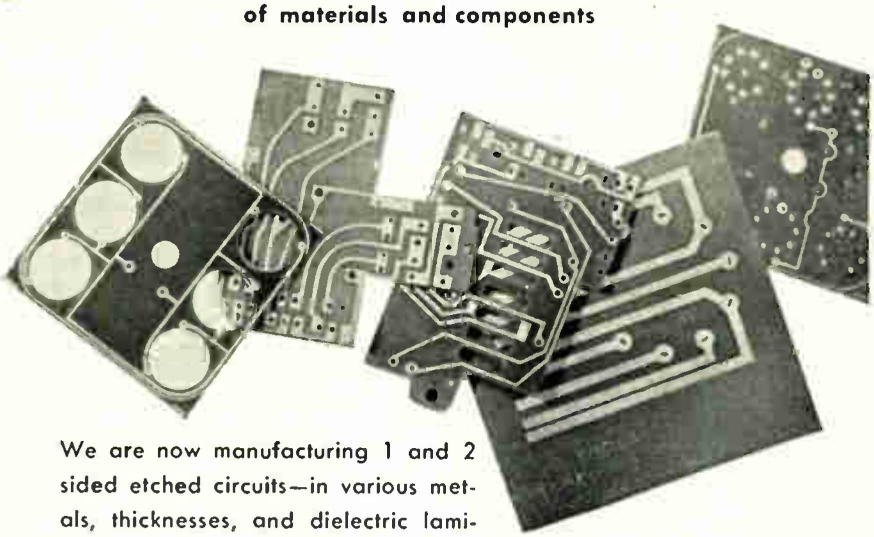


...WHEN ETCHED CIRCUITS NOW DO THE JOB

QUICKER Speed assembly, inspection, testing and servicing

BETTER Save space, solve miniaturization problems, eliminate wiring errors and breaks

AT LOWER COST Save labor costs, eliminate many tooling, fabrication, and assembly operations; reduce inventories of materials and components



We are now manufacturing 1 and 2 sided etched circuits—in various metals, thicknesses, and dielectric laminates—for many leading electronic manufacturers, large and small.

Tell us your current or future requirements and we will be glad to furnish samples and quotations on a strictly confidential basis. Our technical skill and modern production facilities are at your disposal.

Epco

Ask for Bulletin 26.

ETCHED PRODUCTS CORPORATION
3901 Queens Boulevard • Long Island City 1, N. Y.

ETCHED CIRCUITS • DIALS • NAME PLATES • PANELS • SCALES
ESCUTCHEONS • BEZELS AND OTHER DECORATIVE METAL TRIM

What to see at the Radio Engineering Show

(Continued from page 150A)

Thomas A. Edison, Inc.
Instrument Division
West Orange, New Jersey
4-714

Time Delay Relays, Sealed-in-Glass Thermostats, Sensitive Magnetic Relays, Electrical Resistance Bulbs.

Eitel-McCullough, Inc., San Bruno, Calif. 1-519
One of the world's largest manufacturers of transmitting tubes will have on display some of the more prominent tubes used in television transmitters: Tetrodes, triodes, klystrons for high power in VHF and UHF channels. Management and engineering representatives will be present and invite discussion of your tube applications.

Elastic Stop Nut Corp.
of America
Union, N.J.
4-209, 210

The ESNA booth will highlight the application potentialities of the Elastic Stop Nut and the Rollpin. Both fasteners are widely used throughout the electronic industry and sample sub-assemblies showing these applications will be displayed.
The Agastat, a compact, light-weight pneumatic time delay relay will also be displayed.

Electra Manufacturing Company, Kansas City 8, Mo. 4-217
Deposited Carbon Resistors.

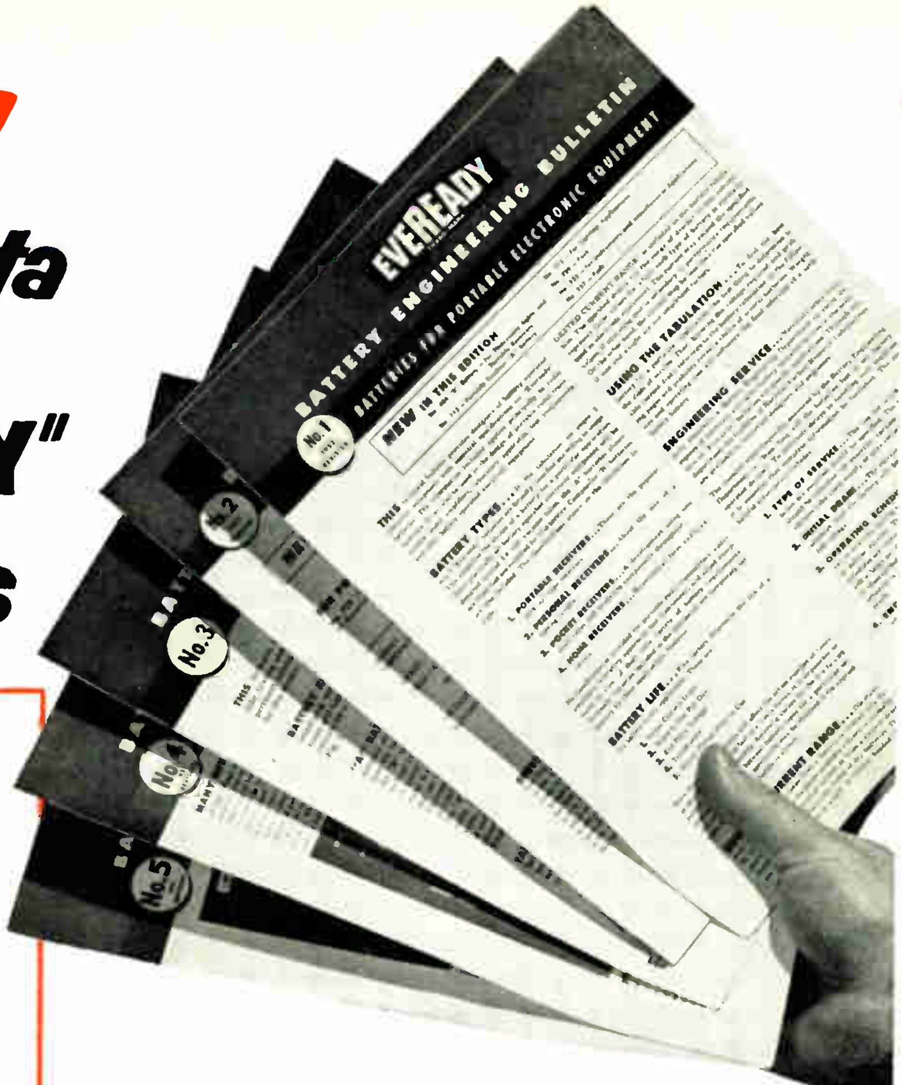
Electric Regulator Corp., Norwalk, Conn. 4-118
Regohm electric circuit controllers and exhibits showing the application of the device to various equipments.

Electrical Industries
Div. of Amperex
Electronic Corp.
Newark 4, N.J.
2-314

Hermetically-sealed Terminals & Headers.

(Continued on page 154A)

FREE! Latest Data on "EVEREADY" BRAND Batteries



- Batteries for Portable Electronic Equipment
- "Mini-Max" "A-B" Packs for Portable and Home Receivers
- Batteries for Hearing Aids
- High Voltage Batteries
- Photoflash Batteries

- NATIONAL CARBON COMPANY maintains a Battery Engineering Department to assist designers of electronic and other battery-operated devices in the selection of "Eveready" batteries for specific applications.

- Out of the Department's wide experience with all kinds of dry-battery applications comes this valuable set of Battery Engineering Bulletins — a total of 34 fact-filled pages . . . YOURS for the asking.

- The complete line of "Eveready" batteries includes types and sizes for every kind of dry-battery-operated device. Design *your* equipment around a *standard* "Eveready" battery and gain the advantages of lower-cost operation, ready availability to the user and superior performance with *exactly* the right battery for the job.

The terms "Eveready" and "Mini-Max" are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
IN CANADA: National Carbon Limited
Montreal, Toronto, Winnipeg

What to see at the Radio Engineering Show

(Continued from page 152A)

Electro Precision Products, Inc., College Point, L.I., N.Y. 3-410
RF Components: Connectors, Microwave Equipment and Waveguide Assemblies.

Electro Tec Corp.
South Hackensack, N.J.
4-215

Manufacturers of Precision Slip Ring Assemblies and Commutators. Electro Tec assemblies are specified by the nation's leading precision instrument and equipment manufacturers for proven greater dependability and longer life. Our process, employing one-piece construction, precludes dimensional variations due to accumulated errors. Our Engineering Department is available for consultation without obligation.

Electronic Associates, Inc.
Long Branch, N.J.
1-114-115

Analog Computers, Plotting Boards, and Data Reduction Equipment.

Electronic Computer Division of Underwood Corp., New York 13, N.Y. 4-425, 427
An electronic digital computer in operation may be seen at this exhibit. It is the Elecom 100, first moderately priced computer to be offered commercially. You can see this machine doing mathematical computations, and also performing payroll calculations. If you give it your earnings and deductions, it will even figure your income tax.

Electronic Devices, Inc., Brooklyn 15, N.Y. 4-219
Selenium Rectifiers for every purpose—manufactured by a unique process which produces Rectifier plates of extremely high reverse resistance and extremely low forward resistance. Minisel—High Voltage—Low Current Rectifiers. Plastisel—Enclosed subminiature Rectifiers. Rectisel—Conventional open type Rectifiers. Hermetically sealed Selenium Rectifiers. And a preview of a new type of Rectifier, the Ventisel.

Electronic Instrument Co., Inc., Broklyn 11, N.Y. 4-401
Electronic Test Instruments. Pre-wired or kits.

Electronic Mechanics, Inc.
Clifton, N.J.
4-610

Mykroy Teflon Kel-F

EPM TUBE PARTS

Electronic Parts Mfg. Co., Inc.
Union City, N.J.
Booth 3-508

Components for the ELECTRONIC FIELD
LEADS • SPRINGS • COILS
MACHINED TUBE PARTS • BEADING
CONTACTS • FORMED PARTS

(Continued on page 156A)

see these NEW COLLINS Advancements

at the IRE Show, March 23 to 26
Grand Central Palace, New York City

NC-101 Navigation System. Punch-card operated navigation equipment which automatically computes air miles to-from a selected destination.

618S Transceiver, 180L-2 Antenna Tuning Unit. A Transmitter-Receiver with 144 channels, automatically tuned — 2 to 25 megacycles — full 100 watt power.

51Z Marker Beacon Receiver. Fixed tuned to 75 megacycles — uses 8 ARINC tubes — Collins designed 3 light indicator. undesirable R-f signals rejected.

75A-3 Amateur Receiver. Incorporates 2 Mechanical I-F Filters with controls in addition to proven features of 75A-2 for instantaneous choice of desired selectivity.

17M VHF Transmitter. 360 channels — full 50 watt signal for executive and air-line use. Operates between 118.0 and 135.9 mc. with fingertip remote control.

Integrated Flight System. Provides the pilot with pictorial presentation of all necessary information for precise ILS approach flying and VOR navigation.

These and many other COLLINS developments will be on display.

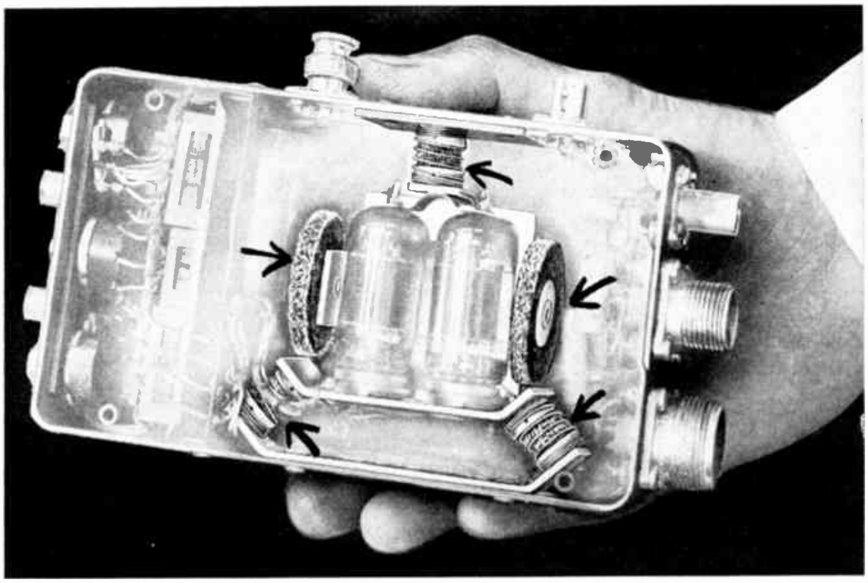
For advanced electronic communications and navigation equipment, it's . . . COLLINS

COLLINS RADIO COMPANY, Cedar Rapids, Iowa

11 W. 42nd St., NEW YORK 36 | 1930 Hi-Line Drive, DALLAS 2 | 2700 W. Olive Ave., BURBANK

...solved another
VIBRATION
problem

Sensational advances and increasing use of electronics and precision instruments have raised problems of vibration and shock unheard of a few years ago. How Robinson is meeting these problems is illustrated in this new Simmonds electronic aircraft fuel gage amplifier.



A Robinson internal mount, protecting only the critical component parts, fully isolates vibration and shock. Not only is service life greatly extended, but at the same time important savings in size and weight are achieved. The entire amplifier unit is so small it fits in the palm of your hand and weighs only 1 lb. 3 oz.

Wide range of applications

Robinson Met-L-Flex mounts are so versatile in application that they may be designed to protect light precision instruments, electronic equipment of any size or weight, or heavy equipment.

For more information about this new kind of engineered vibration control, drop us a line.

Visit Us at the I.R.E. Convention Booth Nos. 2-216 and 2-217

ROBINSON AVIATION INC.
TETERBORO, NEW JERSEY
Vibration Control Engineers

What to see at the Radio Engineering Show

(Continued from page 154A)

Electronic Tube Corp., Philadelphia 18. Pa. 2-519
Special purpose cathode-ray tubes and multi-channel oscilloscopes.

NOISE & FIELD INTENSITY METERS
DISTORTION ANALYZERS
IMPULSE GENERATORS
COAXIAL ATTENUATORS
CRYSTAL MIXERS
VISIT OUR BOOTH NO. 2-147
EMPIRE DEVICES, INC.
38-25 BELL BLVD.
BAYSIDE 61, N.Y.

Engineering Research Associates, Inc.
St. Paul 4, Minn.
4-913 & 915
Exhibits include an ERA 1103 General-Purpose Computer (model and Photos); ERA 1101 General-Purpose Computer (photos); ERA Magnetic Storage Drum, also slide sequence; ERA Shaft-Monitor Analog-to-Digital Converter; Automatic Conveyor Line Sorting System with ERA Industrial Memory and Dynamic Weigher; ERA Magnetic Recording Delay Line; Pulse Transformers; Plug-In High-Gain Amplifier.

Equipto Div. Aurora Equipment Co., Aurora, Ill. 4-805
Electronic Equipment designed for your needs. Storage for incoming and outgoing work—warm up or heat run racks—Electronic chassis and test equipment stand. Steel shelving and drawer units for the small fragile parts as well as the large bulky items.

Erie Resistor Corp.
Erie, Pa.
Booth 1-123
A Complete Line of
High Quality
Electronic Components

Erie Resistor Corp., Erie, Pa. 1-123
Fixed and variable ceramic capacitors, Button Silver Mica Capacitors, Deposited Carbon Resistors, Piezo Electric Active Barium Titanate Discs, Suppressors, Electronic Subassemblies, and Printed Circuits.

Etched Products Corp.
Long Island City 1, N.Y.
4-617
Etched Circuits. Modern practice in etched circuitry.

Fairchild Camera & Instrument Corp., Hicksville, L.I., N.Y. 2-405
Linear and nonlinear precision potentiometers, types 736, 746, 747 and 748, single, ganged and plug-in models.

(Continued on page 162A)

SHOWN 4½ TIMES ACTUAL SIZE

This assembly provides controlled heater-to-cathode positioning; eliminates heater shorts resulting from rupture of the heater coating, as shown below.

SHOWN 20 TIMES ACTUAL SIZE

Exclusive mounting makes the heater an integral part in the Teletron gun.

In the Du Mont Teletron, the heater "feet" are welded to stainless steel lugs which accurately position the heater on a ceramic disc. The result is a firmly welded, vertically aligned assembly which is inserted in the control grid cup and automatically positions the heater within the cathode. This eliminates critical, uncontrolled hand positioning of the heater. Positive centering prevents chafing of the delicate heater coating and avoids heater-to-cathode shorts.

Less open-heater failures

Stronger connections obtained by welding the tungsten heater "feet" to the stainless steel lugs rather than directly to the nickel stem leads, greatly reduce open heater failures.

Greater heater efficiency

When the control grid is assembled, the distance between the top of the heater helix and the outer ridge of the ceramic disc controls the depth to which the helix is seated inside the cathode. Optimum-depth seating is thus predetermined, insuring maximum heater efficiency.

Du Mont quality control of heater design and assembly builds longer, fuller, trouble-free life into every Teletron.

DU MONT *Teletrons**

*Trade Mark

in picture tubes... *fine details make Du Mont the finest*

Cathode-ray Tube Division, ALLEN B. DU MONT LABORATORIES, INC., CLIFTON, N. J.

Resistors STOP Humidity Failures

TYPE	NOMINAL WATTAGE RATING	RESISTANCE MIN.	RESISTANCE MAX.	NO. SECTIONS	SUPERSEDES JAN-R-93 TYPE
RB15 (M15)	.25 .50	0.1 ohm 0.1 ohm	.185 meg. .6 meg.	2	RB10
RB16 (M16)	.35 1.00	0.1 ohm 0.1 ohm	.3 meg. 1.5 meg.	2	RB11
RB17 (M17)	.50 1.00	0.1 ohm 0.1 ohm	.3 meg. 2.0 meg.	4	RB12
RB18 (M18)	.50 1.00	0.1 ohm 0.1 ohm	.75 meg. 4.0 meg.	4	RB13
RB19 (M19)	1.00 2.00	0.1 ohm 0.1 ohm	4.0 meg. 15.0 meg.	8	RB14
RB52 (M52)	.25 .50	0.1 ohm 0.1 ohm	.1 meg. .5 meg.	2	RB51

MIL - R - 93A
WATTAGE & RESISTANCE TOLERANCE

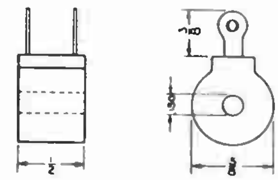
TOLERANCE SYMBOL	RESISTANCE TOLERANCE	PERCENT OF NOMINAL WATTAGE
B	0.10 %	50 %
C	0.25 %	50 %
D	0.50 %	75 %
F	1.00 %	100 %

MIL - R - 93A
TEMPERATURE COEFFICIENT
(REFERRED TO 25°C)

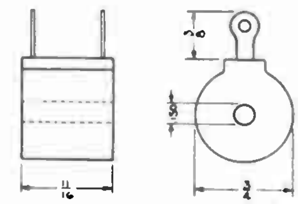
SYMBOL	EXPRESSED IN PERCENT PER DEGREE C. NEGATIVE, MAX.	POSITIVE, MAX.
E	0.0022	0.0022
J	0.0040	0.0155
K	0.0050	0.0255

SPECIAL REQUIREMENTS

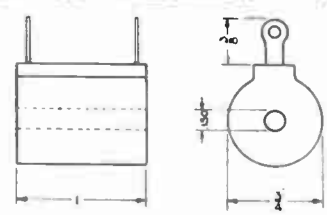
Variations of the above ratings, tolerances, temperature coefficient, etc., can be supplied to special order.



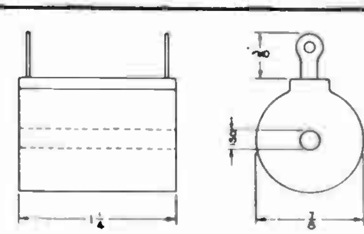
MIL RB15 MEPCO M15



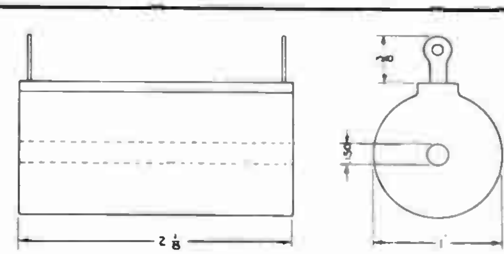
MIL RB16 MEPCO M16



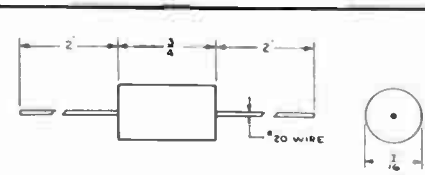
MIL RB17 MEPCO M17



MIL RB18 MEPCO M18



MIL RB19 MEPCO M19



MIL RB52 (PROPOSED) MEPCO M52

MORRISTOWN, NEW JERSEY

40 KV High Voltage Power Supply, 100 MA.

Model J Spot Welder.

5 & 7½ KW Induction Heating Unit.

Model JT2 Spot Welder, complete with power supply, foot pedal and electronic timer.

For DEPENDABLE Electronic Equipment

Pioneers and leading manufacturers of Induction Heaters, Vacuum Tube Bombarders, Test Units, Spot Welders, Industrial High Voltage Power Supplies, Dielectric Heaters, and custom built electronic equipment . . . Scientific Electric has the engineering experience which prevents costly errors in equipment selection and application . . . gives you the right machine for the specific job.

You will find our engineers make sound recommendations which result in better, faster, quality-controlled production at lower unit cost.

Your samples and requirements will be examined and our operations demonstrated in our factory showroom in Garfield, New Jersey. Visit us or write now for full information.

See us at the I.R.E. Show, Booth 605 on the first floor

2 KW Induction Heating Unit.

40 KW High Frequency Induction Heater — with worktable.

4½ KW Dielectric Pre-Heater.

20 KV High Voltage Power Supply 35 MA.

20 KW Dielectric Heating Unit.

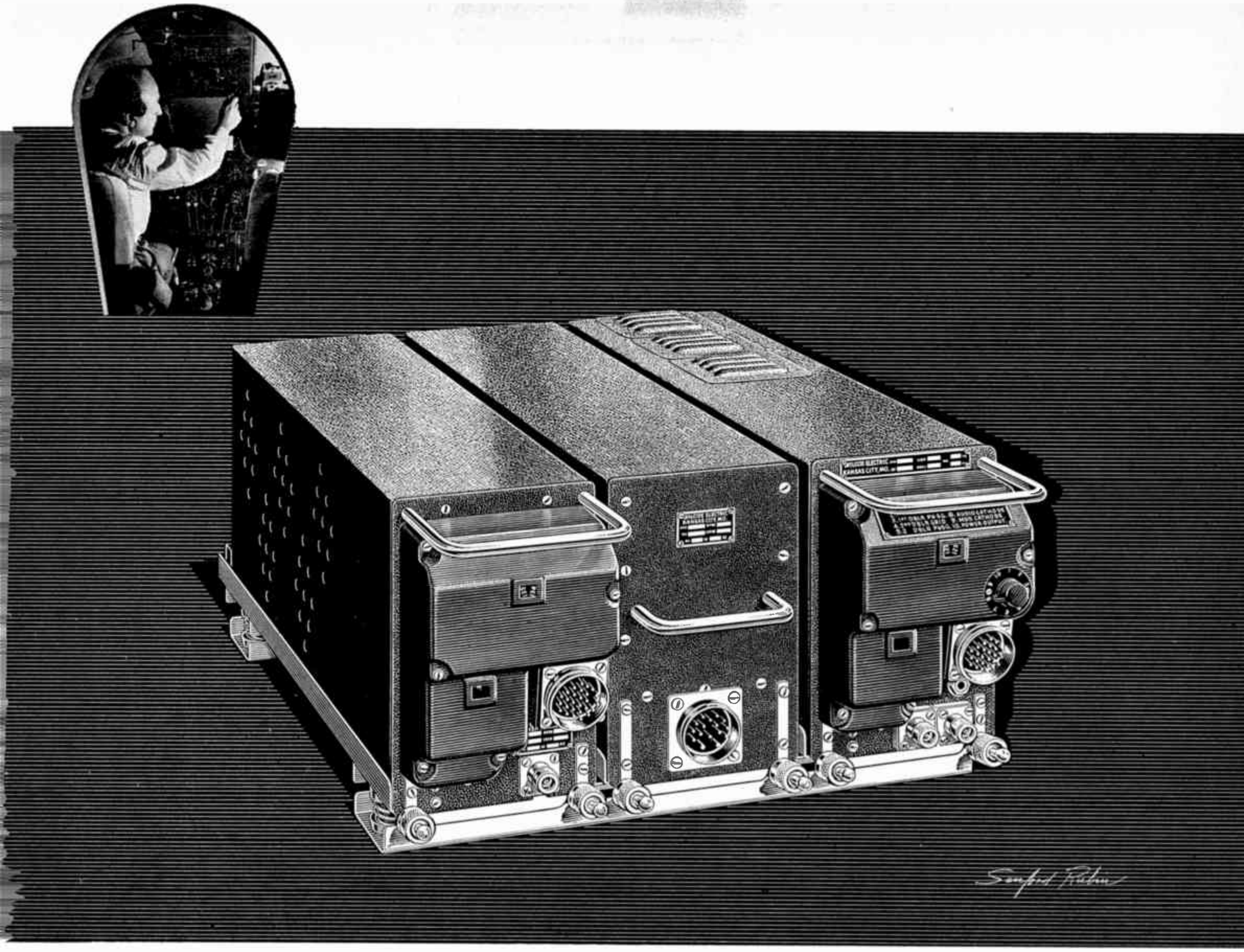
10 KW Dielectric Heating Unit.

SCIENTIFIC ELECTRIC

SCIENTIFIC ELECTRIC

105-119 MONROE STREET • GARFIELD, NEW JERSEY

DESIGNERS and MANUFACTURERS of HIGH FREQUENCY and HIGH VOLTAGE EQUIPMENT SINCE 1921



You didn't hesitate a minute!

Long ago you learned a concept of buying this world's goods that has stood you well. You learned how wise it is to examine the grain of fine leathers. You learned that more than dedicated craftsmanship is woven into the warp and woof of fine woolens. You learned that, year-in-year-out, quality *more* than pays its way.

Your concept of buying was confirmed by happy and painful experiences in purchasing materials and services in the business world. This concept became a part of you . . . part and parcel of your hard-won maturity of judgment.

You faced a communications equipment decision for your corporation's aircraft. You heard that the Wilcox 440A VHF Airborne System—used by airlines all over the world—had been designed and built to unparalled standards of quality. That not once —from dream to drawing board to loading dock—had the promise of *dependability* been compromised.

Each feature offered stronger evidence. Powerful plane-to-tower attention guaranteed by the 50 watt transmitter. Clear-as-a-bell signals *always* because of the extra sensitive receiver. You grew more excited as you learned that no matter where in the world you fly—now or in the future—*all 180 channels* would be yours to use.

Then it came—the icy realization that you couldn't take a chance, that far more than an equipment purchase was at stake.

And you didn't hesitate a minute!

Your inquiry on the Wilcox 440A System or its companion, the Wilcox 429A Glideslope Receiver, is invited. Please address your inquiry to the personal attention of Mr. Donald E. Busse.

wilcox
ELECTRIC COMPANY, INC.
1406 Chestnut
Kansas City 27, Missouri, U.S.A.

What to see at the Radio Engineering Show

(Continued from page 156A)

Fairchild Camera & Instrument Co.
Jamaica 1, L.I., N.Y.
2-405 & 406

Precision linear & non-linear potentiometers.

Fairchild Recording Equipment Corp., Whitestone, L.I., N.Y. 3-400
Professional synchronous tape recorders, disk recorders and transcription tables, multi purpose pickups, equalizers, pre-amplifiers, cuing amplifiers, thermostylus kits, control track generators, automatic framing devices, etc.

Falstrom Co.
Passaic, N.J.
4-507

Instrument Panels; Aluminum and Steel Fabrication; Consoles and Cabinets; Enclosures and Housings; Television and Radio Control Cabinets; Transmitter Cabinets; Transmitter Cabinets; Long and Short production runs; Custom metal assemblies.

Federal Telecommunication Labs., Inc., Nutley 10, N.J. Federal Hall 1-707
Typical UHF Television Station, Exhibit of Microstrip-Microwave Printed Circuitry, Exhibition of High Quality Materials and Components.

Federal Telephone & Radio Corp., Clifton, N.J. Federal Hall 1-107
Communication equipment.

Federal Tool Engineering Co.
Cedar Grove, N.J.
4-505

Small parts welding demonstration, automatic tab welding. Machines, examples of Microscopic welding. Technical and practical answers to your welding problems.

Federated Metals Div., American Smelting & Refining Co., New York 5, N.Y. 4-511 & 513
Federated exhibit booth will include periodic demonstrations of their new "RTS-200" Rosin Core Solder. Proven by actual tests to be (5) five ways better than ordinary rosin solders, the properties and working characteristics of "RTS 200" will be demonstrated for all to see.

Federated Semi-Conductor Co.
New York, N.Y.
4-605

Exclusive Sales Agents for Germanium Products Corp., Jersey City, N.J. Manufacturers of N-P-N Junction Transistors and Semi-Conductor Devices, Booth 4-605, on Components Ave., near elevators.

Federated Semi-Conductor Co., New York 7, N.Y. 4-605
N-P-N Junction Transistors and Semi-Conductor devices. Sole agents for Germanium Products Corp.

(Continued on page 164A)

ARCO TRANSFORMER

ATLAS Engineering Co., Inc.

BALTIMORE TRANSFORMER

Ballantran

Burnell & Company

THE BERKSHIRE TRANSFORMER CORPORATION

Gramer Transformer Corp.

Kenyon Transformer Co., Inc.

BEST BEST MFG CO

K-V TRANSFORMER

FTR I.T.T.

ONTARIO INDUSTRIES

Industrial TRANSFORMER CORPORATION

Magnavox

utah

Transformers INC

LEONARD ELECTRIC PRODUCTS

SYLVANIA

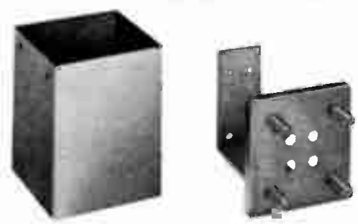
Sarkes Tarzian

LEADING MANUFACTURERS find it GOOD BUSINESS to specify *Heldor*

how about YOU?

— *Heldor* —

COMPLETE ASSEMBLY SERVICE



CANS

HERMETIC SEAL BUSHINGS

- SAVE TIME
- SAVE MONEY
- SAVE INVENTORY LOSSES
- SAVE PRODUCTION HEADACHES
- INCREASE PRODUCTION CAPACITY

Take advantage of Heldor's complete assembly service — its compression-type hermetic seal bushings ASSEMBLED in can covers to meet MIL-T-27 or commercial specifications — ready for your final assembly. Send specifications or prints on your can, bushing or assembly requirements. *You'll save plenty!*

Just off the Press! Write today for your copy of the new Heldor "Cans and Covers" catalog.

Heldor **HELDOR MANUFACTURING CORPORATION**

HELDOR BUSHING & TERMINAL CO., INC.

225 Belleville Ave., Bloomfield, N. J.

SEE HELDOR AT BOOTH 2-111, 1953 IRE SHOW, GRAND CENTRAL PALACE

What to see at the Radio Engineering Show

(*Continued from page 162A*)

Ferris Instrument Co., Boonton, N.J. 1-301, 302 & 303

Radio Receiver Testing Equipment—Signal Generators, Radio Noise and Field Strength Meters, Calibrators, Slotted Measuring Lines.

Fisher Radio Corp., New York 17, N.Y. Theatre 3-304A

Model 50A Laboratory Standard Amplifier, Model 50C Master Audio Control, Model 50R Tuner, Model PR-4 Pre-Amplifier and other audio accessories. This display will be in conjunction with the new 1501 Concertone and Network Recorders.

Ford Instrument Co., Div., The Sperry Corp. Long Island City 1, N.Y. 2-315

Precision built components and sub-assemblies developed for armament controls and computers. Made to highest government specifications for use in aircrafts, warships and other military equipment. Including servo control motors, synchros, linear potentiometers, differentials, integrators, resolver systems, three dimensional cams, magnetic amplifiers and similar items.

(*Continued on page 166A*)

AIDS FOR THE ELECTRONIC ENGINEER-DESIGNER

Visit our exhibit at
BOOTHS 2-103, 104
Second Floor
I.R.E. SHOW

CAN YOU USE THESE UNUSUAL QUALITIES IN YOUR PRECISION EQUIPMENT?

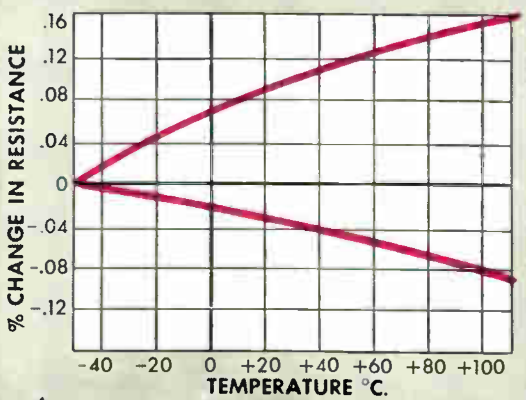
Specify EVANOHM*

RESISTANCE WIRE

for high specific resistance...low temperature coefficient and low thermal EMF to copper... great stability over wide temperature ranges

EVANOHM is recommended for all precision applications where complete dependability for a wide temperature range is essential. It is especially well suited for guided missiles, rockets and other airborne equipment.

EVANOHM* RESISTANCE CURVE, CHARACTERISTICS AND PROPERTIES



1. Analysis — Ni 74.75%, Cr 20.00%, Al 2.75%, Cu 2.50% **2.** Excellent corrosion resistance. **3.** Resistivity — 800 ohms per circular mil foot (134 microhm cm.) **4.** Temperature coefficient of electrical resistance — Plus or minus .00002 ohms per ohm per degree centigrade between minus 50°C. and plus 105°C. **5.** Thermal E.M.F. vs. Copper — .0025 mv. per degree between —50 and 105°C. (max.) **6.** Non-magnetic. **7.** High tensile strength in fine sizes — 150,000 to 200,000 p.s.i. **8.** It may be readily welded or brazed and soft soldered with special care. **9.** Available in: (a) Bare wire sizes .0009 and larger. (b) Enameled, Formex, Cotton, Silk, Nylon and glass insulated wire in sizes .0015 to .0113.

*EVANOHM — a patented, exclusive alloy produced by

* REGISTERED TRADE NAME

WILBUR B. DRIVER CO.

RIVERSIDE AVENUE, NEWARK 4, NEW JERSEY

What to see at the Radio Engineering Show

(Continued from page 164A)

Furst Electronics, Chicago 25, Ill. 3-104
Klystron Power supplies, wideband D.C. amplifiers, wow meter, & laboratory power supplies.

The Fusite Corp., Cincinnati 13, Ohio. 3-109
A complete line of Fusite glass-to-metal terminals for hermetic sealing of all types of electrical components. Exhibit will include Fusite terminals applied to actual products of our customers in the field of electronics, instruments, switches, transformers, and refrigerator compressors.

Gates Radio Co., Quincy, Ill. 2-324, 325 & 326
New Equipment for TV: Broadcast and Communications Including the new Gates VHF 500 watt Television Transmitter. New Audio Control Apparatus, featuring a new Speech Input Control Console. A low Frequency Communication Transmitter, of recent design. Several assemblies and group displays for TV, Broadcast and Communications.

General Electric Co., Chemical Dept., Pittsfield, Mass. 1-201 & 207
G-E Textolite* Industrial Laminates—New Punching grades, fire resistant laminates, punched parts and assemblies for the radio and electronics industry. New G-E Mico Mat insulation for electronic applications.

General Electric Co. Apparatus Sales Div., Schenectady 5, N.Y. 4-120
In the Radiation Annex see: High Temperature Type and Air Equivalent Type Ionization Chambers and Radiation Monitors; Neutron Counter Tube Proportional Counter; Pocket Chamber Electro-meter Readers; Alpha, Beta, Gamma, and Thermal Neutron type Scintillation Counters, and Portable Radiation Probe.

General Instrument Corp., Elizabeth 3, N.J. 4-518
TV V.H.F. Tuners, TV U.H.F. Tuners, Variable Air Capacitors, Complete R.F. Tuning Units, Complete Electronics Assemblies, UHF Converters. F. W. Sickles Division: 90° Deflection System, 70° Uniform Deflection Systems, I.F. Coil Assemblies, Miscellaneous Small Coils, S-Trans.

(Continued on page 168A)


Bring your
tough problems to us at
ELECTRONIC TRANSFORMER CO.
If standard, mass-produced transformers won't do for your product or application, consider this . . .
Since 1938 we've concentrated exclusively in the specialized field of CUSTOM-DESIGNED and CUSTOM-BUILT Transformers for government and industry.
Our engineering staff can solve your transformer problems by assimilating your circuitry in Electronic Transformer Co.'s fully equipped laboratory.
Why not write or phone us regarding your special requirements . . . today!
TRANSFORMERS • REACTORS • RESONANT FILTERS
ELECTRONIC TRANSFORMER COMPANY
209 WEST 25th STREET • NEW YORK 1, N. Y.
Telephone: WAtkins 4-0880

What to see at the Radio Engineering Show

(Continued from page 166A)

General Precision Laboratory, Inc.
Pleasantville, N.Y.
1-407, 409 & 411
Studio Television Cameras and associated equipment; professional 16mm projectors.

General Radio Co.
Cambridge 39, Mass.
1-121 & 122
Limit Bridge for Production Testing. Unit Instruments. UHF Impedance Measuring Equipment. Coaxial Elements and Adaptors. Standard-Signal Generators. Electronic Test Equipment.

General Transformer Co., Homewood, Ill. 4-310
Electrical transformers—Military and commercial, and military battery charger.

Germanium Products Corp., Jersey City 4, N.J. 4-605
N-P-N Junction Transistors, semi conductor devices. See: Federated semi-conductor.

Gertsch Products, Inc., Los Angeles 25, Calif. 4-113
Precision Instruments. Frequency Meters. Sonic and Ultrasonic Filters, Precision AC Potentiometers. Generation and measurement of frequencies, 20-1000 MC., ± 0.001%. Passive Filters from 37.5 cps to 160 KC, attenuation rate of 80 db per 1/2 octave. Measurement of AC voltages from 50 cps to 3000 cps, accuracy ±0.005%. 3000 cps to 50 KC, accuracy ± 0.05%.

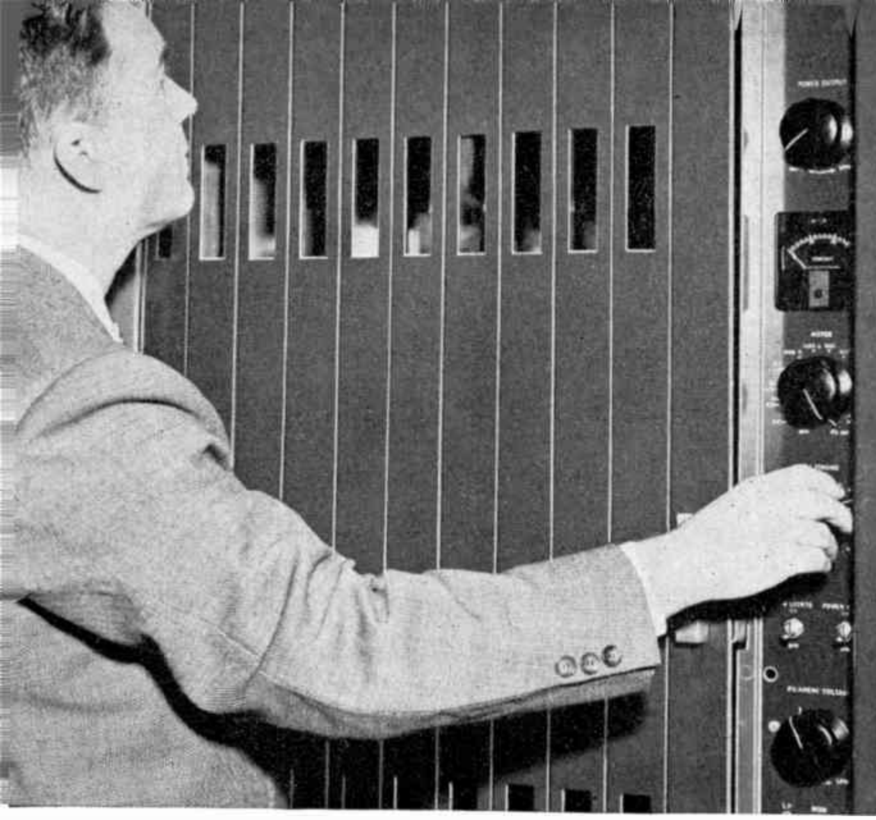
G. M. Giannini & Co., Inc., Pasadena 2, Calif. 4-706
Precision potentiometers, commutators, pressure, gyro, accelerometer instruments, and digital recording computer.

John Gombos Co., Inc.
Irvington 11, N.J.
2-516
Precision Electronic Assemblies; Cross Bar Contact Switches; Buttontype Capacity Filters; Dial Light Sockets; Connectors; High Frequency and Ultra-High Frequency Connectors; Jack Assemblies and Crystal Converters.

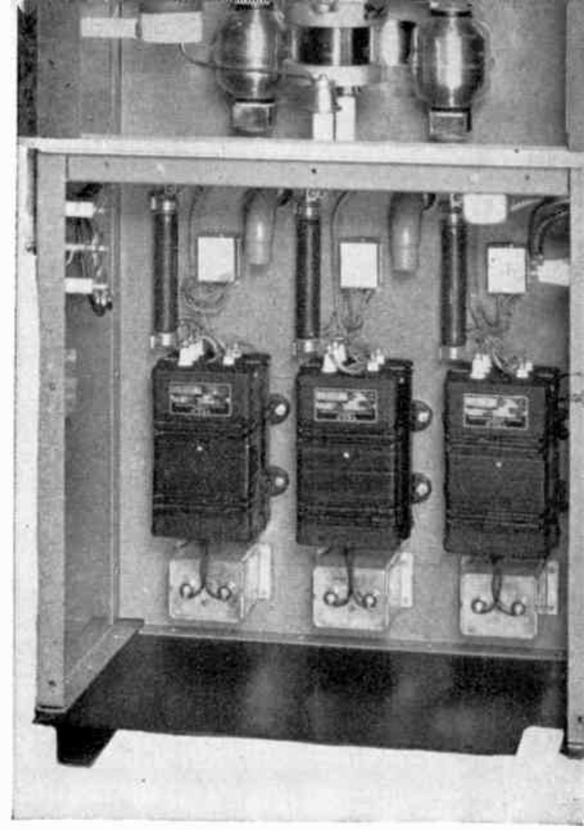
Grant Pulley & Hdwe. Co.
Flushing, L.I., N.Y.
4-306
Electronic Equipment Slides, Radio and TV Chassis Slides, Special sliding devices.

Gray Research & Development Co., Manchester, Conn. 1-402 & 404
New TeloJector, Dual 2" x 2" slide projector for TV stations. Gray telops and associated studio equipment viscous damped transcription arms. Sound effect consoles. Special effects equipment for video. Gray audograph electronic soundwriters.

(Continued on page 172A)



TUNING AN RCA TRANSMITTER. This AM broadcast transmitter is the ultimate in engineering. It's easy and simple to operate . . . compact . . . high in fidelity . . . easy to install and maintain . . . economical to operate. All tube filament voltages of RCA BTA-5G and 10G transmitters are regulated by Sola Constant Voltage Transformers for longer tube life.



REAR-VIEW OF POWER AMPLIFIER. This is the lower section showing three Sola Constant Voltage Transformers installed in a BTA-10G unit. Sola regulators are relatively compact compared to other equipment for comparable ac voltage regulation.

RCA INCREASES TUBE LIFE BY REGULATING FILAMENT VOLTAGE

RCA transmitters are built for 1) *operating ease*, 2) economy and 3) *reliability*. Sola Constant Voltage Transformers are used by RCA in their AM Broadcast Transmitters Types BTA-5G and 10G to help provide these three important advantages.

Sola Constant Voltage Transformers are static-magnetic regulators. In this particular application, they were used as the source of regulated voltage for all tube filaments. They provide secondary voltages regulated within ±3% regardless of primary voltage (transient or continuous) variations as great as 30%.

1. ***They provide operating ease because:*** **regulation is completely automatic, continuous . . . no manual adjustments required . . . no moving or renewable parts.**
2. ***They provide economy because:*** **conventional unregulated power transformer and voltage regulating circuit are eliminated . . . tubes last longer with regulated filament voltage.**
3. ***They provide reliability because:*** **regulating response time is 1.5 cycles or less . . . self protecting against short circuits on output and load circuits . . . current-limiting characteristic protects load equipment against faulty currents.**

That's how Sola Constant Voltage Transformers helped maintain RCA's high performance standards. They can solve your voltage regulation problems too. When your equipment is protected by a Sola built-in stabilizer you know that you automatically have provided the proper operating voltage level regardless of line voltage conditions.

STATIC-MAGNETIC REGULATION. **Standard Sola stabilizers are available in capacities from 15va to 10kva, and with a variety of common power line and filament voltages. Special designs can be produced for quantity orders.**

Send for the twenty-four page catalog which gives electrical and mechanical specifications for Sola Constant Voltage Transformers. Write on your letterhead for Bulletin KCV-142.

Applications unlimited for

SOLA *Constant Voltage* **TRANSFORMERS**

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Mercury Vapor Lighting • Luminous Tube Signs
Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • **SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 50, Illinois**
New York: 103 E. 125th St., New York 35, N.Y., TRafalgar 6-6464 • Cleveland: 1010 Euclid Ave., Cleveland 15, O.

What to see at the Radio Engineering Show

(Continued from page 168A)

Grayhill, Ill. 4-612
See: Wally B. Swank.

Green Instrument Co., Inc., Cambridge, Mass. (39) 3-118
Pantograph engraver for name plates, dials and scales. Instrument panels up to 19" in height by any length. New GreenArc electric etching attachment. Rotary tables, drum dial fixtures, self-centering vises, clamping fixtures, and cutter grinder. Special machinery for production engraving.

Halldorson Transformer Co., Chicago 40, Ill. 4-615
Showing a complete stock-type transformer line or new construction and replacement in television, radio, amplifier, and other electronic applications. Line includes power, filament, audio, reactor, H.B. flyback and deflection yoke types. See also lines of isolation and autoformer types of Varivolt line-adjusting units.

Hammarlund Mfg. Co., Inc., New York 1, New York 4-214
New "HQ-140-X" Communications Receiver. Model of the "Super-Pro 600" Professional Communications Receiver. Data Transmission equipment for remote supervisory control and signaling applications. This will include the new "DSU-2" duplex signaling unit and the "RCR-RCT" remote equipment. Included among the line of variable capacitators on display will be the miniature units, the "MAPC" and the "MAC."

Hastings Instrument Co., Inc., Hampton, Virginia 4-420
Air-Meter, Vacuum Gauge, Electronic Standard Cell, Electronic Manometer and Flowmeter.

The A. W. Haydon Co., Waterbury (20), Conn. 1-619
Featured at the 1953 exhibit will be newly developed miniaturized Repeat Cycle Timers, Time Delay Relays and Elapsed Time Indicators designed expressly for military applications, primarly in the aircraft and missile field. These units are powered by the revolutionary A. W. Haydon standard or governed DC Motors or 400 Cycle AC Motor.

(Continued on page 178A)

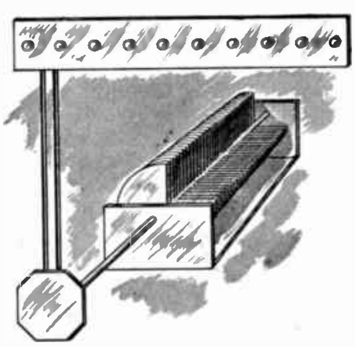
NEW PRODUCT DEVELOPMENT SHOWS LAVOIE HAS EYES ON FUTURE

NEW AUTOMATIC HYDRO-TUNER NEEDS NO PRE-SETTING

Here, at last, is an electronically controlled hydraulic power transmission system for tuning stages of electronic equipment that needs no mechanical pre-setting.

This system has many advantages:

It tunes on the signal rather than on a pre-set mechanical point. This eliminates the possibility of errors due to wear, chassis distortion, shock and temperature changes . . . Means less maintenance problems, longer life for equipment.



Dependable tuning of high Q circuits is made possible because of the extreme accuracy of the tuner.

Rigid locking of moving parts after tuning eliminates the chance of detuning due to shock, vibration, etc.

Greater flexibility—The basic system may be applied to many types of tuning or positioning problems, because of the simplicity of the operating principles.

We invite you to write for more information on the Hydro-Tuner and how it can be applied to your particular problems. Write Lavoie Laboratories, Morganville, N. J.

VHF OMNIRANGE NOW PACKAGED IN SINGLE UNIT

Now . . . A VHF Omnirange which is packaged in a single unit, eliminating the purchase of components section by section from different manufacturers.

VHF Omnirange has been accepted by international agreement as the most desirable, dependable, and economical system for short range navigation.

Instead of permitting only four courses as is the case with the conventional Aural "A-N" system, VHF Omnirange will:

Make possible a theoretically infinite number of courses;

Allow for tangential approaches in addition to conventional head-on approaches;

Enable the pilot to determine his position quickly by "fixes" on two Omni stations;

Allow the pilot to maintain any angle of approach, either in azimuth or elevation, by pre-setting the aircraft receiver.

The transmitter has a nominal range of 100 miles at normal flying altitudes, and the system operates in the VHF range, on an assigned band of 112 to 118 Megacycles. For further information, contact Lavoie Laboratories, Morganville, N. J.

239-B OSCILLOSOPE SHOWS ADVANCED DESIGN

For those who require a rugged, precision instrument for the study of pulse phenomena, here is a new, revised oscilloscope. Its new features make it one of the most outstanding instruments in its field. Look at these features:

1. New scale design allows insertion of special scales as aid in interpretation of curved patterns.
2. Frequency range from 5 to 15 Megacycles.
3. Improved rise time of .035 microseconds.

4. New Input impedance without probe —1 Megohm. With Probe—10 Megohms.
5. Continuous trigger rate permits selection of any rate from 10 cycles to 10 Kilocycles. For further information, write Lavoie Laboratories, Morganville, New Jersey.

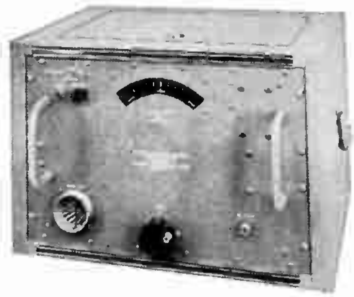
Lavoie Laboratories Inc.

MORGANVILLE, NEW JERSEY

"Be sure to visit us at our booth number 1-126—1-127, at the IRE Show"

PRECISION LABORATORY INSTRUMENTS

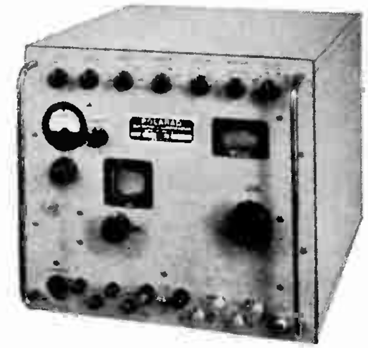
NEW



MICROWAVE SIGNAL SOURCES

Models SSR, SSL, SSS, SSM SSX, 634 MC to 10,750 MC

A reliable source of microwave energy in transmission loss meaurements, standing wave determination, etc. Unidial Control for accuracy and ease of operation. Direct reading (no mode charts to consult).



MICROWAVE SIGNAL GENERATOR

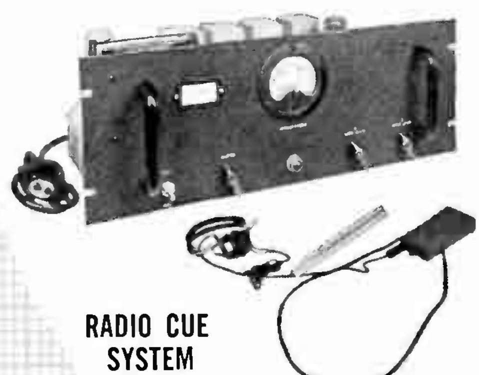
Model MSG-4
7,000 mc—10,750 mc

An ideal source of an accurately known signal voltage, precisely modulated. Sensitivity, frequency and performance of radio and radar equipments in the frequency range from 7 to 10.75 kmc can be readily measured on this continuously variable, direct reading signal generator.

Polarad *Electronics Corporation*

POLARAD ELECTRONICS

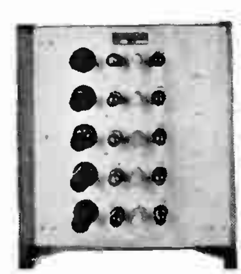
TELEVISION EQUIPMENT



RADIO CUE SYSTEM

Model AB

Used to direct the activities of persons within a limited area from a central control point. Widely used in broadcast and motion picture studios (sound and television). Ideal for factories, yards, hangars, airports, auditoriums, and places where the noise level is high. The Radio Cue System permits efficient operation under difficult conditions.



TELEVISION DISTRIBUTION AMPLIFIER

Model TDA-1

Isolates and distributes television signals over transmission lines for station and production use. TV Synchronizing and picture signals, both monochrome and color can be distributed to as many as five separate points.

See us at Booth 2-511, Radio Engineering Show

REGULATED POWER UNITS

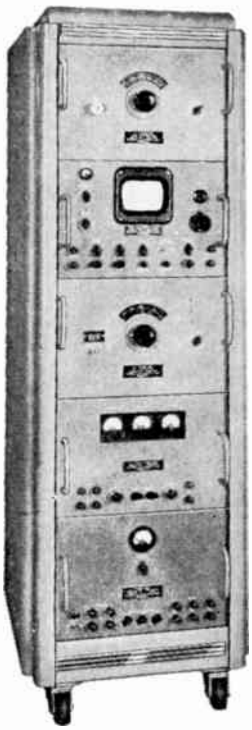
All Band, Direct Reading

IMPROVED

SPECTRUM ANALYZER

Model LSA

10 MC to 21,000 MC



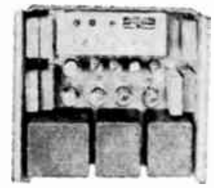
The Model LSA is the result of years of research and development. It provides a simple and direct means of rapid and accurate measurement and spectral display of an rf signal.

- Frequency accuracy 1 percent.
- No Klystron modes to set.
- Broadband attenuators supplied from 1 to 12 KMC.
- Frequency marker for measuring differences 0-25 MC.
- Only four tuning units required to cover entire range.

MODEL PT111D

(Dual Regulated)

Consists of two independently regulated D.C. power sources (isolated from ground), mounted on one chassis. Each power source has its own power switch, fuse, pilot light and voltage control.



MODEL PT111

Consists of a positive and a negative voltage supply independently regulated.

MODEL PT112

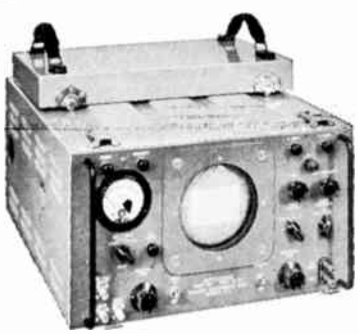
Heavy duty electronically regulated D.C. power source.

WIDE BAND VIDEO AMPLIFIER

Model VT 10 CPS to 20 MC

Designed for use as an oscilloscope deflection amplifier for the measurement and viewing of pulses of short duration and rise time.

CORP. 100 METROPOLITAN AVENUE, BROOKLYN 11, N. Y.



PORTABLE TELEVISION WAVE FORM MONITOR

Model TO-1

Designed for precise wave form analysis and amplitude measurement of video signal in television circuits. Also ideal as a general purpose instrument in many applications, because of its wide frequency response, high sensitivity, excellent synchronizing capability, precision calibrating circuits and unusually large symmetrical horizontal expansion.

STUDIO PICTURE MONITOR

Model M-105

A high fidelity picture monitor of large size, sufficient for ease of observation under studio conditions. It is a high impedance device and may be connected across a video transmission line without affecting the terminal impedance of the line. Monochrome and/or color signals in black and white reception is provided.

See us at Booth 2-511, Radio Engineering Show

What to see at the Radio Engineering Show

(Continued from page 172A)

Heinemann Electric Co.
Trenton, N.J.
4-620

Exhibit and demonstration of hydraulic-magnetic circuit breakers, time delay relays and overload relays for electronic circuits. A giant operating model will demonstrate circuit breaker response to various overload and short circuit conditions, and applicational data will be available showing the wide range of functions performed by circuit breakers in many practical new circuits.

Heldor Manufacturing Corp., Heldor Bushing & Terminal Co., Corp., Bloomfield, N.J. 2-111
Heldor compression-type Hermetic Seal Bushings, Transformer Cans and Covers to MIL-T-27 (plain, electro-tinned, electro-plated or painted) that can be supplied, punched, formed (with numerals) with weld studs; and the assemblies with terminals for hermetic seal transformers and other special applications. Also, Heldor drawn cans and covers; brackets; channels and end-bell.

The Helipot Corp.
S. Pasadena, Calif.
1-120

Precision linear wire-wound potentiometer-rheostats, helical (multi-turn) and single turn; turns counting indicating dials.

Heminway & Bartlett Mfg. Co., New York 36, N.Y. 3-513
NEW! Fungus-proof Nylon Lacing Cords and Flat Braided Tape. Their special synthetic resin coating resists growth of mold and micro-organisms—factors most often responsible for deterioration of linen and cotton lacing cords and tapes. High abrasion resistance—low moisture absorption—non-toxic to humans.

Heppner Mfg. Co.
Box 1207, Round Lake, Ill.
3-312

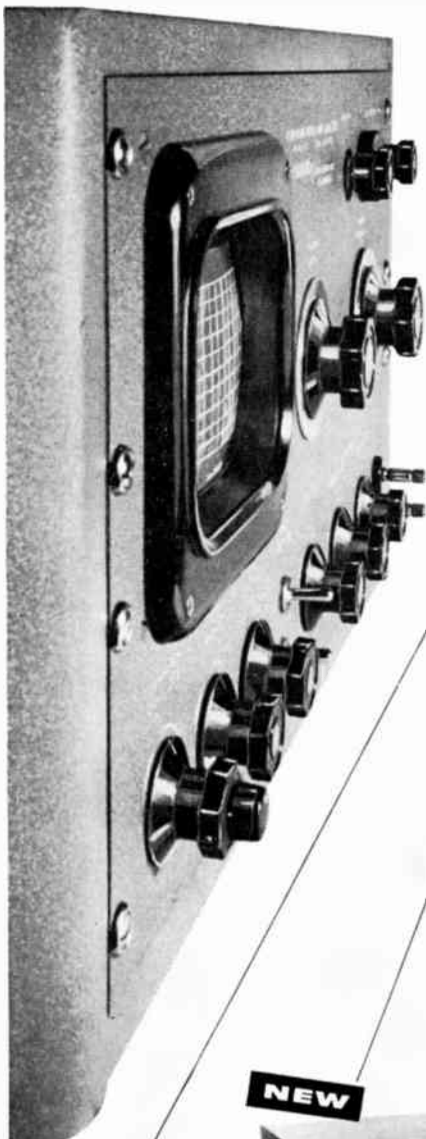
Loud speakers, horizontal transformers, ion traps, beam centering controls, focus devices, ferrite antenna coil correcting magnet, magnetic door catch.

Hermetic Seal Products Co., Newark, N.J. 1-701
Hermetic Seals: Glass-Metal, single or multiple headers for Relays, Condensers, Crystals, Transformers, etc., for all branches of the field of Electronics. The Only Seals you can hot tin dip at 525° F. for Easy Assembly Soldering, for a Strain and Fissure-Free Sealed Part with Resistance of over 10,000 Megohms!

(Continued on page 180A)

the pioneer is the leader

PANORAMIC



As pioneers and developers of the panoramic technique, the measure of our success is reflected in the fact that the electronic field refers to the transformation of spectrum content into visual spectographic displays as the "Panoramic Method."

Panoramic leads the industry in producing instruments unexcelled for laboratory, research and production applications requiring high speed spectrum or waveform analysis. Whatever your problem, a Panoramic Analyzer solves it quickly, accurately. Specialized models covering audio to microwave frequencies simplify analysis of waveform distortions, sounds, vibrations, spurious oscillations or modulation, response characteristics of filters or transmission lines, characteristics of AM, FM or pulsed signals, or monitoring many frequency channels simultaneously.

ULTRASONIC RESPONSE INDICATOR—MODEL G-3

Used as an adjunct to the Model SB-7 Panoramic Ultrasonic Analyzer, the G-3 permits visual inspection of amplitude versus frequency characteristics of networks and devices between 2KC and 300KC. Direct readings of frequency and amplitude. Indicates fundamental response only.

SIGNAL SWITCHER—SW-1

Designed to apply alternately test and standard signals to Panoramic Sonic Analyzers. Enables frequency comparisons to within a fraction of a cycle. Used with the G-2 Sonic Response Indicator, it facilitates rapid comparisons of the frequency responses of amplifiers, filters, transmission lines, etc.

PANALYZOR—MODEL SB-12

Designed specifically for applications requiring extreme resolution or demanding measurement of levels of signals spaced very closely in frequency or widely divergent in amplitude.

- Maximum Sweepwidth—100KC
- Maximum Resolution—10 CPS
- Sweep Rates—30 cps, 5 cps, 1 cps and 1 scan in 10 seconds.

The new products described here, together with the complete line-up of standard Panoramic equipment will be demonstrated at the I.R.E. Show,

BOOTH #2-123

Models AP-1 & LP-1—Panoramic Sonic Analyzers, Model SB-7 Panoramic Ultrasonic Analyzer, Panalyzors—Models SB-3 & SB-8a, Panadaptors—Models SA-3 & SA-8a, Model G-2—Sonic Response Indicator.

PANORAMIC
RADIO PRODUCTS, INC.

Inquiries invited on special Panoramic Spectrum Analyzers

12 South Second Avenue, Mount Vernon, N.Y.
Mount Vernon 4-3970

WRITE TODAY FOR COMPLETE SPECIFICATIONS AND PRICES

What to see at the Radio Engineering Show

(Continued from page 178A)

Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif. 1-509, 511
Audio oscillators, the 200AB and the 200CD, covering a combined frequency range from 5 cps to 600 kc. Television frequency monitor, Model 335E. The new 612A UHF Signal Generator for the design and testing of color television receivers and equipment. The Model 512A Frequency Converter (designed to operate with the 524A Counter for direct measurements of frequencies from 0 cps to 100 mc.) Model 382 Calibrated Waveguide Attenuator. The 618B and 622A Signal Generators extend the frequency range of the H-P line up to 11 kmc. The 522B Electronic Frequency Counter for a variety of measurements for industrial and electronic measurements involving frequency, time, speed, rate, etc.

Hickok Elec. Instrument Co., Cleveland 8, Ohio 2-118
Laboratory and commercial type tube testers; cathode-ray oscilloscopes with DC vertical amplifiers, plus wide and medium band AC amplifiers; portable 3-inch and laboratory type 5-inch instruments; television alignment generators; crystal-controlled marker oscillator generators; complete line of vacuum tube voltmeters; noise generators; television video generators; microvolt generators.

Hi-Q, Div. Aerovex 1-602

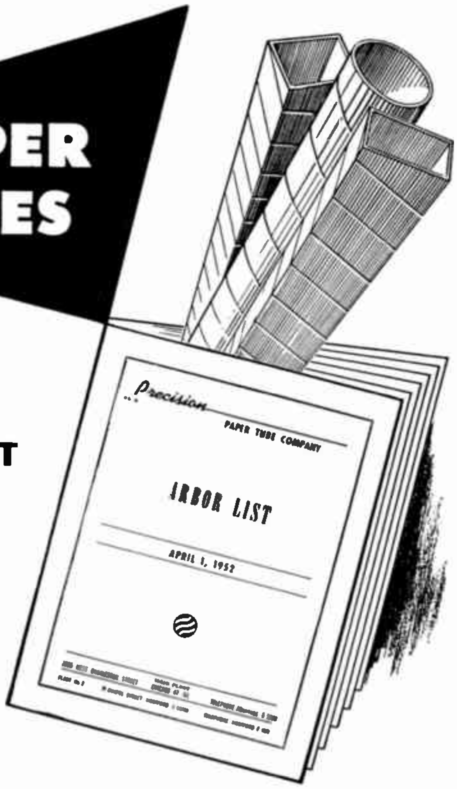
Harvey Hubbell, Inc., Bridgeport, Conn. 4-515
Interlock connectors and wiring devices.

Kenneth E. Hughes Co., New York 23, N.Y. 4-617
Kenneth E. Hughes Company manufacturers representatives. Division Lead Co., Chicago, Ill., manufacturers of all types of solder, soldering fluxes & soldering chemicals. Other companies whose products we will exhibit are: Advance Electronics, Rochester Electronics, Oryx, J. W. Hobbs Corp., Chemical Electronic Eng., Inc., Highland Engineering Co. & El Mec Labs.

(Continued on page 182A)

PRECISION PAPER TUBES

any shape . . . length . . .
ID or OD . . . to meet
your specific requirements



SEND FOR ARBOR LIST

Free to you upon request . . . lists over 1500 sizes . . . all promptly available. A free sample is also yours for the asking . . . just send your specifications.

Precision Paper Tubes are spiral-wound of finest dielectric kraft, fish paper, cellulose acetate, or combinations.

Write us today!

PRECISION

PRECISION PAPER TUBE CO.

2051 W. Charleston St. Chicago 47, Ill.
Plant No. 2: 79 Chapel St., Hartford, Conn.
Also Mfrs. of Precision Bobbins

New UHF SWEEP GENERATOR for UHF TV Production Testing

TYPE 1211

The Type 1211 UHF Sweep Generator has been specifically designed to rapidly and accurately align UHF Television heads, converters and complete receivers,

SPECIFICATIONS

FREQUENCY COVERAGE: 450 to 900 MC. Dial calibrated in 36 MC steps. **BANDWIDTH:** Constant bandwidth of 50 MC over entire spectrum. Can be adjusted to narrower bandwiths, with internal controls. **MARKERS:** Pulse type crystal controlled accurate to 0.02% spaced 36 MC throughout the 450 to 900 MC spectrum. **OUTPUT:** At least 1 volt across a 75 ohm load. **ATTENUATOR:** Electrostatically coupled piston type, range approximately 80 db. **AUXILIARY OUTPUT SIGNALS:** 1. Automatically phased sine sweep for X axis of scope. 2. Marker pulses either plus or minus polarity, continuously variable in amplitude.

PRICE $950.00 F.O.B. PLANT

Manufacturers of a Complete Line of TV Test Equipment

TIC Tel-Instrument Co. Inc.

50 PATERSON AVENUE • EAST RUTHERFORD, N. J.

What to see at the Radio Engineering Show

(Continued from page 180A)

A HUGHES DIODE actual size

SEE THE HUGHES EXHIBIT

Hughes Aircraft Co., Culver City, Calif. 4-814
Semiconductor products—germanium diodes—Eight new RTMA types of high conductance diodes; higher forward currents combined with higher back resistance than ever before available in commercial quantity. UHF diodes. Nine RTMA types of general purpose diodes with high back resistance. Diodes classified to customer specifications.

HYCOR *Company Inc*

North Hollywood, Calif.

3-309

New plastic encapsulated toroid coils and series "H" plastic encapsulated precision wire wound resistors, in addition Hycor will display the latest in wave filters designed for precision applications. Technical inquiries will be answered at the booth.

Hytron Radio & Electronics Co. Division of CBS, Inc.

Danvers, Mass.

2-316 & 317

Radio receiving tubes, television receiving tubes, C-R tubes, transmitting tubes, special purpose tubes.

Illinois Condenser Co., Chicago 22, Ill. 4-222
Fixed Capacitors.

Indiana Steel Products Co., Valparaiso, Ind. 2-208
A new ceramic permanent magnet material with unusually high coercive force and very high specific resistivity, permitting its use in high-frequency fields, will be introduced. Also on display: Alnico permanent magnets, Cunife permanent magnets, steel permanent magnets, ion traps and radar magnets.

Visit "INDUSTRIAL" at BOOTH #2-101 for

- Laminated Tube Sockets
- Terminal Strips
- Wired Assemblies
- Metal or Bakelite Stampings
- Terminal Board
- Assemblies
- Screw Machine Parts

NEW ITEMS
Tuner Strips, Sockets, and Brackets for UHF

INDUSTRIAL HARDWARE MFG. CO., INC.
109 Prince Street, New York 12, N.Y.
Phone: DRegon 7-1881

Industrial Products Co., Danbury, Conn. 2-320 & 321
Connectors and RF Components.

Industrial Tape Corp., New Brunswick, N.J. 4-607
Pressure Sensitive Electrical Tapes vinyl, cellulose acetate, paper and cloth tapes.

Industrial Television, Inc., Clifton, N.J. 3-509
Oscilloscopes, Field Strength Meters.

(Continued on page 184A)

What to see at the Radio Engineering Show

(Continued from page 182A)

Inet Inc., Los Angeles, Calif. 4-423
Power Supplies: High, Medium and Low Voltage, Voltage Regulated Rectified power sources—Magnivolt.

Instruments Publishing Co., Inc., Pittsburgh 12, Pa. 2-108
Instruments—The Magazine of Measurement and Control; The Instruments Index; Instrument Manufacturing; The Instrument Manufacturing Guide; Handbook of Measurement and Control; Books Published and Sold by Instruments Publishing Company.

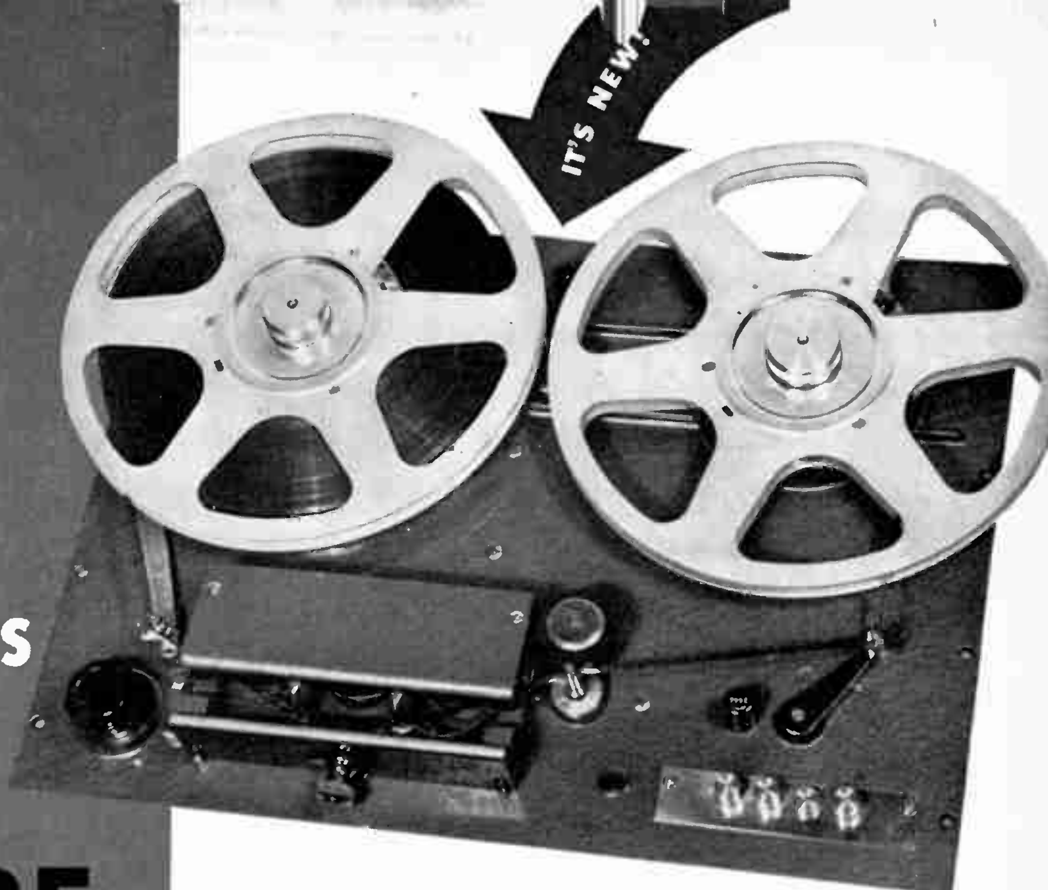
Insuline Corp. of America, Long Island City 1, N.Y. 2-202
Electronic assemblies, Electronic Components, Metal Housings, Test Equipment, UHF-VHF Antennas, Special Facilities for Government Contract Needs, JAN type plugs, jacks, terminal strips, special metal fabrications.

International Nickel Co., Inc., New York 5, N.Y. 1-521
Nickel and Nickel Alloys as used by the Industry.

J-B-T Instruments, Inc., New Haven 8, Conn. 2-130
Vibrating Reed Frequency Meters, Panel or portable, including 1½" and 3½" sealed types, 60 and 400 cycles combination for audio-oscillators, and new 2-cycle increment models for 400 cycle bands; Elapsed Time Meters, including 400 cycle sealed model, others in combination with frequency meters; Lever Action Switches, 3 or 4 position, 1 or 2 deck; Rotary Selector Switches, 14 and 20 position types, instrument quality, laminated or fully-enclosed molded models; Switch Kits for special models; Pyrometers and other temperature measuring instruments and accessories. Also 2" electrical Instruments: Shurite panel and pocket A.C. and D.C. voltmeters, milliammeters, etc. made by subsidiary.

JFD Manufacturing Co., Inc., Brooklyn 4, N.Y. 2-134
TV antennas and accessories. Variable piston type capacitors.

(Continued on page 186A)



puts other tape recorders in the SHADE...the PRESTO RC-11

PRESTO introduces a precision-engineered tape recorder with a radical new type of construction!

Featuring a self-contained capstan drive unit, the PRESTO RC-11 provides durability, flexibility and rapid maintenance heretofore unheard of in tape equipment. Motor, fly wheel, capstan shaft, pressure pulley and solenoid are all pre-mounted on a cast aluminum sub-assembly . . . a complete working unit quickly removable for service or replacement.

A heavy, ribbed, cast aluminum panel designed for rack or case mounting supports all other components. Overall durable construction gives additional reinforcement and protection during shipping and adds years to the life of the machine.

In terms of performance and operational case, the RC-11 also steps out front. This new recorder, with complete push button operation, automatic microswitch in case of tape breakage and a reel capacity of 10½ inches, is an engineer's delight.

The combination of advanced design and engineering in the RC-11 puts ordinary tape recorders in the shade . . . makes this instrument an *investment*, not an expenditure. Ask your PRESTO distributor for full information on this important development in tape recorder design . . . the *all new* RC-11.

The "unitized" construction of the Presto RC-11

. . . allows a complete flexibility in the manufacture of various types of instruments. By the simple rearrangement of components the RC-11 becomes a high fidelity recorder, a dual track, bi-directional recorder or reproducer or a long-playing reproducer with automatic tape reversal.

PRESTO RECORDING CORPORATION
PARAMUS, NEW JERSEY

Export Division: 25 Warren Street, New York 7, N. Y.
Canadian Division: Walter P. Downs, Ltd., Dominion Square Bldg., Montreal

WORLD'S LARGEST MANUFACTURER OF PREC[illegible]N RECORDING EQUIPMENT AND DISCS

What to see at the Radio Engineering Show

(Continued from page 184A)

Jeffers Electronics, Pa. 4-127
See: Speer Resistor

Jennings Radio Mfg. Co.
San Jose, Calif.
4-211
Our development laboratory is available to design and produce units for specialized applications.

Jennings Radio Mfg. Co., San Jose (8), Calif. 4-211
Fixed and variable types of vacuum capacitors; vacuum switches and relays, vacuum capacitance voltage dividers; vacuum feed-thru capacitors; other vacuum units for specialized applications.

Jensen Mfg. Co., Chicago 38, Ill. 3-506 & 507
Loudspeakers, TV and Radio Components. parts include: coils, resistors, condensers. deflection yokes, fly-back transformers.

Jerrold Electronics Corp., Philadelphia, Pa. 4-618
Multiple Television Distribution outlet systems and complete associated equipment.

Jerrold Electronics Corp.
Philadelphia 46, Pa.
4-618
- Community television antenna systems
- Television field strength meter
- Variable and fixed rf antenuators
- Master television antenna systems for hotels, apartments, motels
- rf preamplifiers and fixed frequency UHF converters.

Howard B. Jones Div., Cinch Mfg. Corp., Chicago 24, Ill. 2-505 & 506
Electrical Connecting Devices.

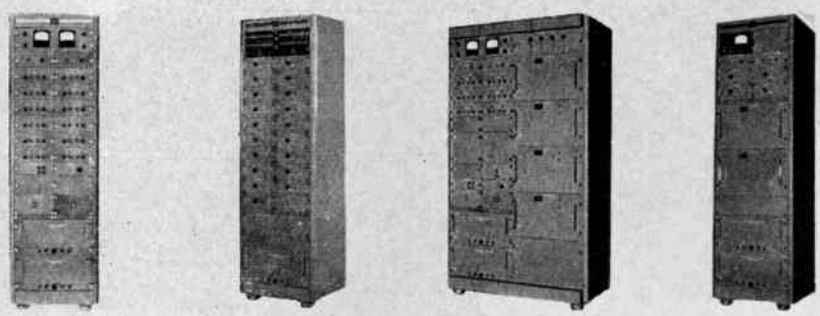
Kalbfell Labs., Inc.
San Diego 10, Calif.
2-206 & 207
Displaying a revolutionary new line of chopper stabilized power supplies—high powered standard cells, with extremely low output impedance and excellent long-time stability. Also standard line of Logatene—non-linear attenuators; Twin-T Filters; Peaked Amplifiers; Servo-Stabilizers; Electronic Thermostats; Logarithmic Time Bases; Plug-In Amplifiers; Micro-Mikers; Decade Amplifiers; Automatic Potentiometer Positioners.

Karp Metal Products Company, Inc.
Brooklyn 20, N.Y.
1-510 & 512
On display are cabinets, housings and enclosures especially fabricated for the electronics industry. See how Karp's use of the latest sheet metal fabrication and welding techniques renders sturdy, attractive and functional housings to protect your most sensitive instruments.

Be sure to visit all four floors!

(Continued on page 188A)

Preview of a New Precision Analog Computer for Solving Problems in Dynamics . . .



Amplifier Group Type 16-31B 24 contact - stabilized d-c amplifiers.

MultiplierGroup Type 16 - 31A 20 multiplying channels.

Resolver Group Type 16 - 31D 4 resolving channels. 6 amplifier channels.

Servo Group Type 16 - 31G 2 resolving channels. 4 multiplying channels.

True, you'll find many analog computer systems on the market. However, we have spent a great deal of time developing a system which we feel does a more effective, more efficient job with the highest degree of accuracy. Here are the reasons:

New 20-channel servo-mechanical multiplier in which several channels may be used as incremental function generators.

New centralized control from operating console for greater flexibility.

New automatic select and set keyboard-operated attenuator system for ease of operation.

New controlled environment to insure maximum accuracy at all times.

New grounded metal problem board eliminates errors due to leakages between terminals.

For more information on this system, write for our Components Book. Address inquiries to:

ELECTRONIC ASSOCIATES, INCORPORATED
COMMERCIAL SALES DEPARTMENT
200 LONG BRANCH AVENUE
LONG BRANCH, NEW JERSEY

ELECTRONIC ASSOCIATES *Incorporated*

See this new system at Booths 1-114, 1-115—I.R.E. Show, Grand Central Palace

What to see at the Radio Engineering Show

(Continued from page 186A)

Kay Electric Co.
Pine Brook, N.J.
1-401

Electronic Test and Measuring Instruments.

Kenyon Transformer Company, Inc.
New York 59, N.Y.
1-615

Displaying up to date models of specially engineered transformers. This year the emphasis will be on small oil-filled units, and the new "Ken-seal" molded units. Various other types of Kenyon components will be displayed also.

Voltage Regulated Power Supplies
4-406 & 408

For Industrial & Research, Excellent Regulation & Stabilization, Low Output Impedance. Low Ripple Content.

KEPCO LABORATORIES
131-38 Sanford Ave., Flushing 55, N.Y.

Kepco Laboratories, Flushing 55, N.Y. 4-406 & 408
Super Voltage Regulated Power Supply DC Voltage Regulated to 0.01%). Will show 16 of 30 Standard DC Voltage Regulated Power Supplies. Low Voltage High and Low Current—Medium Voltage—High & Low Current. High Voltage—High & Low Current.

Kester Solder Co.
Chicago 39, Ill.
2-411

Featuring Kester " 'Solderforms' in Action," this firm's booth shows how pre-formed solder pieces are used by various industries to cut down on production labor and speed up assembly. All the special "Solderform" shapes are presented, including rings, discs, pellets, washers, and springs. Various Flux-Core Solders will also be displayed.

Ketay Manufacturing Corp., N.Y. 4-711
The revolutionary Ketay designed miniature synchro has set new standards for the industry. Other mass-produced Ketay miniatures include servo motors, high precision resolvers, and high-performance resolver amplifiers.

Ketay Manufacturing Corp.
555 Broadway, New York 12, N.Y.
4-711

Ketay
Synchros
Servos
Resolvers
Magnetic Amplifiers
Electronic Equipment

(Continued on page 190A)

What to see at the Radio Engineering Show

(Continued from page 188A)

Keystone Products Co., Union City, N.J. 4-609
Custom built aircraft and special purpose transformers. A complete servo set-up illustrating the MOTOMAG, a new packaged magnetic amplifier.

Kimble Glass Co., Toledo 1, Ohio. 1-124 & 125
Makers of all-glass rectangular cathode-ray tube bulbs. Exhibit will show how the glass industry has progressively reduced weight and increased sizes of bulbs. Exhibit will also show the basis of how all-glass bulbs are manufactured.

James Knights Co., Sandwich, Ill. 2-109
Quartz crystals and holders: quartz oscillator plate, filter and ultrasonic crystals; phenolic, hermetic-sealed holders; ovens of all sizes and capacities; tourmaline and quartz crystals; custom cut and ground; frequency standard; and frequency and modulation monitors.

Kupfrian Mfg. Co., Binghamton, N.Y. 3-101
Flexible Shaft Couplings, and Flexible Shaft Assemblies for remote control of potentiometers, tuners, switches, repeaters, revolution counters and other instruments and components. Also electrostatic wire shielding, push-pull controls and Universal Joints.

(Continued on page 206A)

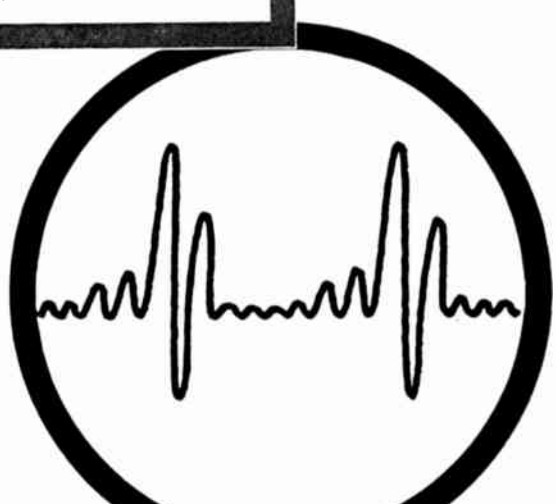
Instruments

that complement the high quality of fine electronic equipment

Available in all the types, sizes, and ranges for all electronic and electrical built-in requirements . . . including *approved* ruggedized panel instruments. Complete literature on request . . . WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston PANEL INSTRUMENTS

"See Us at Booths 4-409, 4-411"



POSITIONS OPEN

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. ....

The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

PROCEEDINGS of the I.R.E.
1 East 79th St., New York 21, N.Y.

PRINTED CIRCUITRY

Engineer with design and development experience in printed resistors desired by small, fast growing company in southern California. Position offers permanency and advancement. Write stating age, experience and education. Box 715.

ELECTRONIC ENGINEER

Wanted electronic engineer for sales work, high technical content, nice manner, adaptable, good traveller. Salary $5000. Write details fully. Box 716.

ENGINEERS

A department in Sylvania located in Salem, Mass. is rapidly expanding in the microwave tube business. There is always a need in this field to coordinate customer circuits and tube performance. There are many problems involving frequency drift, tube life, frequency modulation characteristics, pulse response, etc. which may be solved either by changes in the tube or in the circuitry of the equipment. It is our policy to work very closely with the customer on an en-

(Continued on page 193A)

gineering basis to arrive at the most economical and best solution from an over-all systems point of view. There is a good opportunity for a personable engineer to get broad experience, both technically and from a business point of view. Apply Sylvania Electronic Products Inc. Microwave Dept., 60 Boston St., Salem, Mass.

TECHNICAL EDITOR

Technical editor wanted for research organization at the Pennsylvania State College. Background in engineering and journalism required. Opportunities for graduate work. Write Personnel Director, Box 30, State College, Pennsylvania.

ENGINEERS, MATHEMATICIANS AND PHYSICISTS

The Moore School, University of Pennsylvania, has openings for electrical engineers, mathematicians and physicists. Work is available in the fields of digital and analogue computers, mathematatical analysis, circuit design, and solid state physics. Applicants should be citizens and have at least a B.A. degree. Salary commensurate with experience. For information write: Professional Personnel Officer, Moore School, University of Pennsylvania, Phila. 4, Pa.

ELECTRICAL ENGINEERS

Electrical engineers with experience in communications and television system engineering required by a large organization in Montreal. Salary commensurate with ability and experience. Apply P.O. Box 6000, Montreal, Canada.

ASSOCIATE PROFESSOR

Engineering school in the southeast has an opening for an Associate Professor in communications and electronics for teaching and research. Salary $9,000. Write Box 717.

(Continued on page 199A)

ELECTRONIC ENGINEERS

FOR DESIGN AND DEVELOPMENT WORK IN

RADAR

COMPUTERS

TELEMETERING

DATA REDUCTION

SERVO MECHANISMS

DIGITAL TECHNIQUES

A CHANCE TO GROW WITH A YOUNG PROGRESSIVE COMPANY, SALARIES AND ADVANCEMENT COMMENSURATE WITH ABILITY, LIBERAL VACATIONS, SICK LEAVE, EIGHT PAID HOLIDAYS, GROUP INSURANCE, EDUCATIONAL ASSISTANCE PROGRAM, EXCELLENT WORKING CONDITIONS. SEND RESUME OF EXPERIENCE AND EDUCATION WITH SALARY REQUIREMENTS AND AVAILABILITY DATE TO:

Electronic Engineering Company
of California
180 SOUTH ALVARADO STREET
LOS ANGELES • 4 • CALIFORNIA

TO:

THE PROJECT ENGINEER

Does your project require, or will future projects require?

PLASTIC LIGHTING PLATES
MIL-P-7788 (AN-P-89)

Have you ever designed one?

Are you familiar with the technical problems involved?

Do you realize that your complete equipment is judged by the operating layout and lighting of the control box?

Do you know that our approved laboratory and facilities can help you?

IRE BOOTH 708 FOURTH FLOOR

BODNAR INDUSTRIES, INC.
New Rochelle, N.Y.

ASSISTANT CHIEF ENGINEER
Electronic

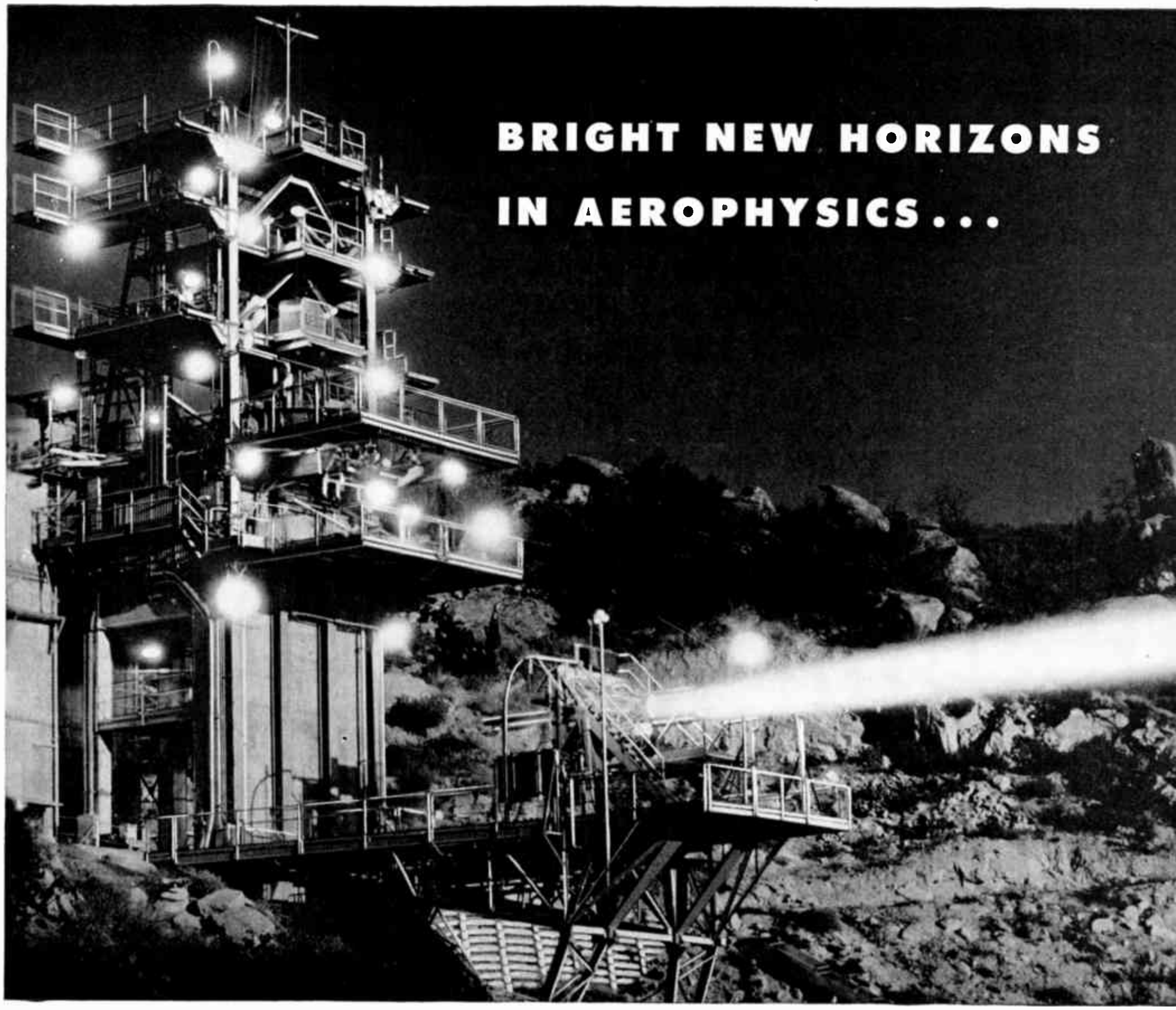
Established company located in the metropolitan New York area is expanding its electronic-nucleonic departments and requires the services of a mature engineer with dominant experience in administration, design and development of radio and radar transmitters, receivers and test equipment; servos, telemetering, scalers and associated equipment. Must be a meticulous analyst, familiar with military specifications; able to examine and negotiate terms and conditions of military contracts and must be capable of estimating and preparing bids and proposals. Our staff knows of this ad. Submit resume to

"President"
Box 723
INSTITUTE OF RADIO ENGINEERS
1 E. 79 St. New York 21, N.Y.

DEPARTMENT HEAD MISSILE ELECTRONICS

Prominent well-established aircraft and missile manufacturer offers an outstanding opportunity to a person qualified to head an expanding electronics organization. Salary commensurate with responsibility. Must have at least ten years experience in airborne electronics, five of which should be in missile or radar design and development. Advanced degree preferred. Position reports to chief engineer. Send detailed resume of background and recent photograph to

BOX 722
Institute of Radio Engineers
1 East 79 St., New York 21, N.Y.


BRIGHT NEW HORIZONS
IN AEROPHYSICS...

Positions Wanted By Armed Forces Veterans

In order to give a reasonably equal opportunity to all applicants and to avoid overcrowding of the corresponding column, the following rules have been adopted:

The Institute publishes free of charge notices of positions wanted by I.R.E. members who are now in the Service or have received an honorable discharge. Such notices should not have more than five lines. They may be inserted only after a lapse of one month or more following a previous insertion and the maximum number of insertions is three per year. The Institute necessarily reserves the right to decline any announcement without assignment of reason.

ELECTRONICS ENGINEER—PHYSICIST

B.A. in chemistry, M.A. and Ph.D. in physics. 8 years experience in electronics development. Desires responsible position in electronics design and development in west or southwest. Age 34, married. Box 606 W.

ENGINEER

B.E.E. Graduate studies toward M.S. 2½ years varied electronic engineering experience including pulse circuitry, microwave circuitry, and radar modulators. 1 year technical writing. Age 27. Desires position in electronic development and research in New York city area. Box 608 W.

(Continued on page 202A)

POSITIONS OPEN

(Continued from page 193A)

SALES & ELECTRICAL ENGINEERS, PHYSICIST, PRODUCTION MANAGER

(1) Sales engineers with E.E. degree and 5 years capital goods selling experience. Knowledge of paper, plastics or rubber industry helpful. (2) Senior Project Engineer with E.E. degree and 5 years experience in direction of design projects for industrial electronic, servomechanism, or radar equipment. (3) Senior research engineer with Ph.D. or equivalent in physics or engineering, and 5 years experience in direction of radiochemistry, physics and electronic systems analysis. (4) Production Manager with E.E. degree and 5 years experience in supervision of electronic and mechanical production including production and materials planning. Salaries open. Send complete résumé. Box 718.

ELECTRONIC ENGINEER—PHYSICIST

Electronic engineer or physicist to contribute to instrument development program of major petroleum refiner in Chicago area. Prefer M.S. with servo training. Age 25-35. Reply with details of education, experience and salary requirements. Replies will be held confidential. Box 721.

PROFESSORS—ENGINEERS

The U.S.A.F. Institute of Technology has several vacancies for qualified professors or engineers to teach on a graduate and undergraduate level in electrical engineering. Employment will be effected in accordance with Civil Service regulations. Grade levels range from GS-9, $5,060. per annum to GS-13, $8,360. per annum. Applications should be made on Standard Form 57 available at any Post Office or by letter to the Dean, Resident College, U.S.A.F. Institute of Technology, Wright-Patterson Air Force Base, Ohio.

ENGINEERS OR PHYSICISTS

A midwestern manufacturer of electrical resistors, rheostats and allied components, is looking for experienced engineers or physicists interested in research and development or production engineering work in this field. Replies from men with experience in specialized types of these components will be welcome. Excellent opportunity, attractive conditions. Give full details as to training and experience, and salary desired. Box 719.

RESEARCH AND DEVELOPMENT

The M.I.T. Instrumentation Laboratory is developing equipment for fire control, navigation and air control. Several openings exist for engineers and scientists, recent graduates with outstanding academic and performance records, to do electronic and electromechanical component development and system design work followed by testing in the laboratory, in flight, and in field. Opportunity for academic study. Send résumé to Instrumentation Laboratory. 68 Albany St., Cambridge 39, Mass., Att: M. Phillips.

ELECTRONICS ENGINEERS OR PHYSICISTS

Electronics engineers or physicists are needed by the Weapon Systems Laboratory, a division of the Ballistic Research Laboratories. Interesting projects include design of electronic circuitry in connection with image converter and other high-speed cameras, oscillographic recording systems, high-speed radiographic equipment, pressure and strain gages, etc. Positions are permanent. Starting salary $4,205 to $7,040 depending on qualifications. Opportunity for graduate study. Also summer vacancies. Address: Weapon Systems Laboratory, Room 221, Bldg. 328, Aberdeen Proving Ground, Maryland.

Engineers... Scientists...

Mechanical Engineers—Electrical Engineers
Servo Engineers—Aerodynamicists—Physicists

Do You Know the MELPAR Story?

For complete information about the opportunities available for qualified engineers and scientists write to

PERSONNEL DIRECTOR

melpar, inc.

The Research Laboratory of Westinghouse Air Brake Co. and its subsidiaries

452 Swann Avenue, Alexandria, Virginia

or 10 Potter St., Cambridge, Mass.

CHIEF CHEMIST

for

NEW RAYTHEON CATHODE TUBE PLANT

We are expanding our commercial picture tube manufacturing facilities. A new 100,000 square foot plant now being built at Quincy, Massachusetts, incorporating the most advanced engineering features in the industry, will be in production by mid-summer. We are announcing an unusual opportunity for an alert engineer with experience in Cathode Ray screening and aluminizing, to earn industry-wide recognition as a key man in an outstanding company.

Send complete resume of experience and qualifications, including salary expected, to

RAYTHEON MANUFACTURING COMPANY

Donald Blanchard, *Personnel Manager*

465 Center Street

Quincy 69, Mass.

ENGINEERS PHYSICISTS

TAKE INVENTORY OF YOUR FUTURE

WHAT MAKES A GOOD JOB?

Check off the items in the following list that you look for in a good job.

1—Professional Recognition
2—Interesting work
3—Equitable salary
4—Recognition of Ability
5—Security
6—Good future prospects
7—Reward for ideas
8—Good working conditions
9—Liberal benefit program
10—Family protection
11—Paid vacations and holidays

If you look for all of the above items and more, in a good job, it will be to your advantage to investigate the opportunities in Electronic Circuit Design and Specialized vacuum tube research and development at . . .

NATIONAL UNION RADIO CORP.
ELECTRONIC RESEARCH DIVISION
P. O. Box 352 Orange, New Jersey

PHYSICISTS AND ENGINEERS

ATTENDING THE

I.R.E.

CONVENTION
NEW YORK CITY
MARCH 23-26...

Inquiries are invited regarding openings on our Staff

- RADAR LABORATORIES
- GUIDED MISSILE LABORATORIES
- ADVANCED ELECTRONIC LABORATORIES
- ELECTRON TUBE LABORATORIES
- FIELD ENGINEERING DEPARTMENT

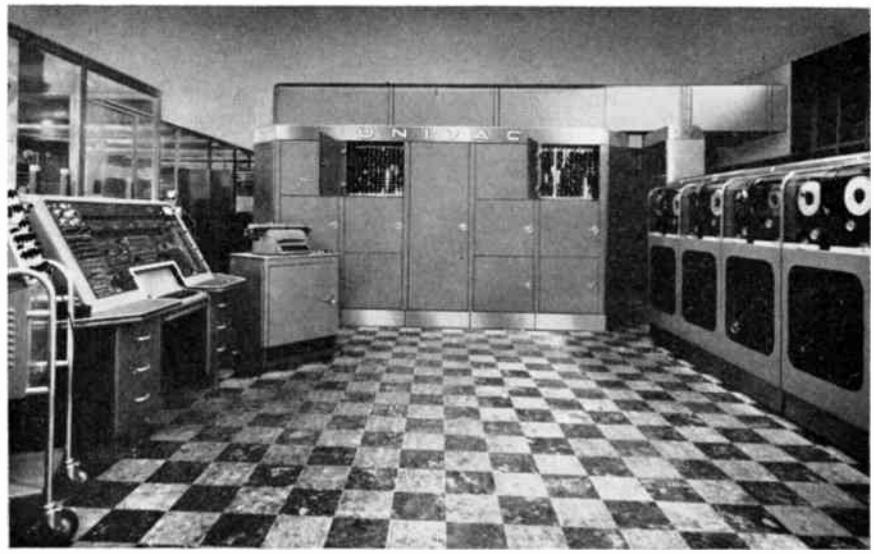
For the convenience of those attending the I.R.E. meetings and Radio Engineering Show, members of the Laboratory Staff will be available for interviews at the Convention hotel. For appointment telephone Hughes New York office, LAckawanna 4-9350.

HUGHES

RESEARCH AND
DEVELOPMENT LABORATORIES
Scientific and
Engineering Staff
CULVER CITY, LOS ANGELES
COUNTY, CALIFORNIA

Assurance is required that relocation of the applicant will not cause disruption of an urgent military project.

Remington Rand INC



UNIVAC

ENGINEERS

Electronic • Electro-Mechanical • Mechanical

The manufacturers of the UNIVAC—the first electronic, general-purpose, digital computer system to be sold commercially—have interesting and important positions with challenging futures. Engineers and physicists are needed for work at all levels in any of the following fields:

System Studies	Storage Techniques
Logical Design	Circuit Design
New Components	Pulse Techniques
Solid State Physics	Input-Output Devices
Semi-conductors	Product Design
Magnetic Materials	Test Equipment Design

Computer Development and Design
High Speed Electro-Mechanical Devices
System Test and Maintenance

Design — Research — Development — Test

Our rapidly expanding engineering and production programs have created many permanent positions paying excellent salaries. These positions offer outstanding opportunities for professional development. The possibilities for graduate study in this locale are excellent and the Company's plan for reimbursement of tuition expenses is extremely liberal. Other Company benefits include retirement and group insurance plans and the payment of moving expenses.

Replies kept strictly confidential. Interviews arranged at our expense.

REMINGTON RAND INC.
Eckert-Mauchly Division
2300 West Allegheny Avenue, Philadelphia 29, Pennsylvania
Telephone: BAldwin 3-7300.

Positions Wanted

(Continued from page 198A)

ENGINEER

Naval Reserve officer, now on active duty with the Office of Naval Research, expects release end of 1952. 11 years electronic experience including development, administration and instruction. B.E.E. and M.E.E. degrees; continuing graduate studies. Married, age 34. Desires executive or administrative position in New York or New England area. Box 609 W.

ENGINEER

B.S.E.E. Purdue, 1948. Age 35, married. 6 years operation-maintenance military electronic equipment. Several years experience design and development of communications and navigational equipment, technical writing, teaching, broadcast station operation. Available part-time New York City vicinity. Box 610 W.

ENGINEER

Position in Toledo, Ohio, area. B.S.E.E. University of Toledo June 1950. Age 23. 21 months experience PPI deflection and multiplexing; data transmission and handling; available January 1953. Box 611 W.

ELECTRONIC ENGINEER

3 years experience as research engineer, department head in charge of instrumentation and electro-mechanical development. B.S.E.E., communications, 1949. Married, age 27. Desires responsible, challenging work in electronics development. Will locate in New Jersey, Pennsylvania or Ohio. Box 612 W.

(Continued on page 203A)

Positions Wanted

(Continued from page 202A)

ELECTRONIC ENGINEER

B. E. E. Manhattan College 1950. 18 months experience Army Signal Corps. Operation test and maintenance carrier telegraph equipment. Desires position with future in electronic field. New York metropolitan area. Box 613 W.

ELECTRONIC ENGINEER

Electronic engineer, specializing in pulse techniques, radar, digital computers; B.S. and M.S. from M.I.T.; 10 years experience, seeks permanent position. Prefer west coast location. Box 614 W.

TELEVISION ENGINEER

B.S.E.E. 1949. (communication option) graduate work, Polytechnic Institute of Brooklyn. 5 years experience in radio and television broadcasting fields. Interested in position in television design, development, or in television broadcasting. Box 615 W.

DEVELOPMENT ENGINEER

M.S. in E.E. 2½ years college teaching. 4 years industrial experience research, development, test, design, and supervision. Current work servos. Desires development servos, circuits, analogs, etc. Pacific coast area. $650. min. Box 624 W.

ENGINEER

B.E.E. January 1950, M.E.E. June 1953; 2½ years design and development experience on automatic control systems; Electronic Technician, U. S. Navy. Desires position in the field of automatic control or medical engineering in New York area. Box 625 W.

ELECTRONIC ENGINEER

Electronic engineer, executive, age 44 with 25 years experience research, development, design, installation, maintenance radio communications equipment; 5½ years Naval electronics officer, over 5 years Navy Dept. Civilian Electronics Engineer. Salary $10,000; desires change. Established Washington, D.C., but will move. Prefer Philadelphia, Penna. Box 626 W.

ENGINEER

B.S.E.E. Northwestern University; Eta Kappa Nu. Married, age 30. Private pilot, H.A.M. 14 years 1st class radiotelephone. 3 years USN Airborne Technician Radar officer. 1 year cyclotron const. 4 years electro-mech. timers. Box 627 W.

PHYSICIST

B.S. in physics with minor in E.E. 3 years experience in application of electromagnetic waves. Desires location permitting further academic study either days or nights. Box 628 W.

ELECTRONIC ENGINEER

Servo. specialty. 1½ years experience in electro-mechanical servos, radar and analog computers, production and redesign. B.E.E., electronics option Rensselaer Polytechnic Institute 1951. Married, age 27. Assistant project engineer on computer project. Desires challenging and responsible position in electronic-mechanical design and development in northern New York or New England. Box 637 W.

(Continued on page 204A)

Positions Wanted

(Continued from page 203A)

ELECTRONIC ENGINEER

B.E.E. highest honor, communications option 1950. Eta Kappa Nu, Tau Beta Pi, Phi Kappa Phi. Age 26, single. 2½ years with large electronics company as design and development engineer. 2 years navy electronics experience, AETM 2nd Class; radio telephone 1st class license. Desires position in design and development of electronic equipment. Box 638 W.

PRODUCTION MANAGEMENT

B.E.E., M.E.E., Polytechnic Institute of Brooklyn. Studying for masters in management at N.Y.U. 3 years electronic production supervisory experience. Desires position in production management. Tau Beta Pi, Eta Kappa Nu, Sigma Xi. Box 639 W.

ENGINEER

B.S.E.E., M.S. communications. 3 years research and development. 3 years navy radio. 7 years amateur radio. Age 28, married. Desires work with a future, preferably located in central or mid-west U.S. Will consider other locations for premium salary. Box 640 W.

ELECTRONIC ENGINEER

10 years experience as Project Engineer and group leader designing EMC, radio control, radar, computer, military TV, missile guidance equipment. 2 years heading an electronic research and consultation group. B.S.E.E. 1942, M.S.E.E. 1948, E.E. 1949. Age 32, married, one child. $700 minimum. Box 641 W.

ELECTRONIC ENGINEER

Age 25. B.E.E. highest honor, 1951. Eta Kappa Nu, Tau Beta Pi, W4MIA. Ex-Navy ETM 1st Class. Presently Navy electronics officer (LTjg), to be released September 1953. Interested in development, production, administration. If possible, additional study. Primarily desires challenging, interesting work. Partial to southeast location, but others considered. Box 642 W.

ELECTRONIC ENGINEER

E.E. 1951. Desires work as Project Engineer on government contracts. Intimate knowledge of JAN and MIL specifications, also government contractual procedure. Age 27, married, one child. Signal Corps Officer. Available June 1953. Box 643 W.

ENGINEER

M.S.E.E. 2 years university instructor; 2 years R & D, prominent laboratory; analog computer, gyros, servos, some supervisory experience. World War II technician, administration, and staff experience in communication and radar. Congenial, creative. Age 33, married, children. Desires R & D work in instrumentation with supervisory future. Box 644 W.

ELECTRONIC ENGINEER

B.E.E. 1950. Tau Beta Pi, Eta Kappa Nu. Age 28. 3 years design and development in pulse circuitry, radar, and receivers. Desires position in design and development of electronic equipment. New York metropolitan area preferred. Box 645 W.

Openings

Offered by Exhibitors will be listed on the Job Bulletin Board—IRE Desk, 4th Floor of the Radio Engineering Show, March 23-26.

What to see at the Radio Engineering Show

(Continued from page 190A)

Laboratory for Electronics, Inc.
Boston 14, Mass.
4-105 & 106

- LFE oscilloscopes
- Nuclear Resonance magnetometers
- Stable microwave oscillators
- Packaged circuits.

Lambda Electronics Corp.
Corona 63, L.I., N.Y.
3-501

Laboratory Power Supplies.

The La Pointe-Plascomold Corp., Rockville, Conn. **4-503**
VEE-D-X UHF Antennas—UHF-VHF Antenna divider networks for incorporation in your TV receiver designs. UHF-VHF divider networks for TV antenna installations. Press-Wireless—radar voltage dividers, slotted line, electrical design.

Lavoie Laboratories, Inc.
Morganville, N.J.
1-126 & 127

Exhibit will feature a new design in radar scanners hydraulically actuated and light in weight; a fast acting hydraulic system for transmitters and communication systems etc.; frequency measuring and calibrating equipment and other new developments.

G. H. Leland, Inc.
Dayton, Ohio
4-820

Ledex Rotary Solenoids, six basic models with various degrees of rotation and torque values up to 50 pound-inches. Ledex Circuit Selectors, 8, 10, 12, 18, and 24 positions. Ledex Relays, stopping and homing. Bridge Type Rectifiers for use with Ledex products.

Linde Air Products Co., Div. Union Carbide & Carbon Co., New York 17, N.Y. **1-514-516 & 518**
Xenon, Krypton, Argon, Helium, Neon, and Rare Gas Mixtures as well as Synthetic Sapphire Boules, Rods, and Balls.

Littelfuse, Inc.
Des Plaines, Ill.
1-702

Circuit protection devices including glass enclosed cartridge fuses and related accessories, such as fuse holders for both civilian and government use, circuit breakers, mercury switches and blown fuse indicators.

(Continued on page 208A)

What to see at the Radio Engineering Show

(Continued from page 206A)

Lord Manufacturing Co., Erie, Pa. 2-124

Shock Mountings for mobile electronic equipment; Temproof Mountings and equipment bases for equipment protection at high and low temperatures; precision type Friction Drive Wheels; Flexible Couplings from 1/50 to 100 H.P.; specialized Flexible Mountings for protection of sensitive equipment; component parts, meters, instruments, etc. New J-5572 Mountings for base-mounted electronic equipment throughout the temperature range from —80 to + 250 F.

M B Manufacturing Co., Inc., New Haven 11, Conn. 2-110

Headquarters for Vibration Equipment (Reproduction-Measurement-Control) exhibits: New Cycling Control Systems, automatic or manual, with vibration exciters to conform to Military Specifications—Vibration Meters and Pickups, including new high temperature model Isomode Isolator Mounts and Isomode Pad.

(Continued on page 209A)

What to see at the Radio Engineering Show

(Continued from page 208A)

Maclen Corp., Washington 17, D.C. **4-810 & 812**
Radio communications and navigational equipment. Regulated Power Supplies—aircraft type—direct current 400 cycle Motor Generator sets.

MacLeod & Hanopol, Inc., Charlestown 29, Mass. **4-919**
Vacuum tube capacitance meters, megohmmeters, capacitance standards, megohm-standards, High Impact Testing accessories, and samples of contract work.

Magnetics, Inc., Butler, Pa. **4-616**
Will exhibit tape wound cores of all high permeability magnetic materials. Tape thickness ranges from .014" to .000125", including ultra-thin cores for computer and high frequency applications. Also reactors and specialized magnetic amplifier components and assemblies.

Be sure to visit all four floors!

(Continued on page 210A)

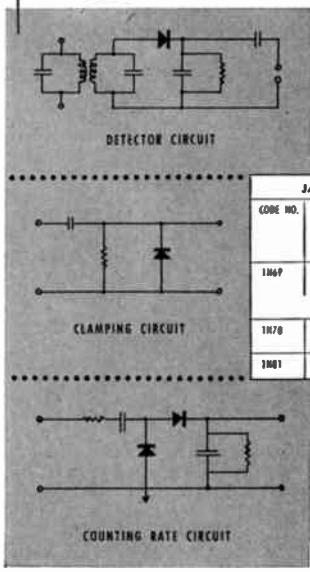
See Us At Radio Engineering Show Booth 2-113 Grand Central Palace March 23-26

To meet the strictest requirements of both Government and Industry, specify **JAN TYPE**

RR Germanium Diodes

Precision made, easy to handle, easy to assemble—the tapered shape shows polarity at a glance! Make Radio Receptor Germanium Diodes your first choice in the large variety of electronic circuits where JAN types are a must.

1N69
1N70
1N81



TYPICAL USES

- COMPUTOR CIRCUITS
- CLAMPING CIRCUITS
- RF DETECTORS
- CONTROL CIRCUITS
- DISCRIMINATORS
- MODULATORS
- NOISE ELIMINATORS
- CLIPPERS
- LEVEL SETTERS
- RESTORER CIRCUITS

JAN TYPES • ALL VALUES MEASURED AT 25°C.

CODE NO.	Min. Forward Current at 1 Volt (MA)	Max. Reverse Current (Micro-Amperes)	*Average Rectified Current (MA Max.)	†Minimum Reverse Volts	Max. Cont. Reverse Operating Volts
1N69	5.0	50 @ –10V 850 @ –50V	40	75	60
Rectification efficiency: 35% minimum in 100 MC test circuit					
1N70	3.0	25 @ –10V 300 @ –50V	30	125	100
1N81	3.0	10 @ –10V	30	50	40

*Average half wave rectified current at 60 CPS and 25°C. Consult us for ratings at other conditions.
†For zero dynamic resistance.

Radio Receptor Germanium Diodes may hold the answer to many of your problems. Our engineers will be glad to study your requirements and submit their recommendations. Many other types, both standard and special, are available . . . Write us!

Seletron and Germanium Division

RADIO RECEPTOR COMPANY, INC.

Since 1922 in Radio and Electronics

SALES DEPT. 251 West 19th Street, New York 11, N. Y. • FACTORY, 84 North 9th Street, Brooklyn 11, N. Y.

IT'S ALLIED FOR RCA

AUTHORIZED RCA DISTRIBUTOR

ELECTRON TUBES FOR INDUSTRY

Quick, Expert Service on RCA Tubes

ALLIED maintains in stock for *quick shipment*, the world's largest distributor inventory of RCA special-purpose tubes. We specialize in supplying the needs of industrial, broadcast, governmental and other users. To save time, effort and money—phone, wire or write to ALLIED. Fill *all* your electronic needs from one complete reliable supply source.

ALL TYPES IN STOCK

- Vacuum Power
- Thyratrons
- Vacuum & Gas Rect.
- Ignitrons
- Cold-Cathode
- Phototubes
- Oscillograph Tubes
- Camera Tubes
- Monoscopes
- Special Types

FREE Interchangeability Directory

Valuable guide to selection of proper RCA tube type replacements. Lists 1600 tube types. Write today for this FREE RCA Guide No. 37-046.

1953 ALLIED CATALOG

Refer to your ALLIED Catalog for *all* electronic supplies—parts, tubes, test instruments, audio amplifiers, accessories—available from the world's largest stocks. Write today for FREE 1953 ALLIED Catalog.

Everything in Electronics
FROM ONE RELIABLE SOURCE

ALLIED RADIO

833 W. Jackson Blvd., Dept. 35-C-3
Chicago 7, Ill.

FREE CATALOG!—Send for it now!

What to see at the Radio Engineering Show

(*Continued from page 209A*)

Marconi Instruments Ltd.
New York 4, N.Y.
1-520

FM and AM Signal generators, Q Meters, Admittance bridges, X Band Test Sets, Direct-Reading High Frequency Wavemeters, Vacuum tube voltmeters, and FM Deviation Meters.

Marion Electrical Inst. Co.
Manchester, N.H.
2-303

Marion Multi-Dialer in several ranges; Marion Ruggedized, Hermetically sealed Instruments in accordance with all Government Specifications; Marion regular line of plastic cased, dust sealed instruments; Marion low powered Induction Heating Unit; Marion Model M2 New Improved Multi-Ranger Metertester and related products.

McGraw-Hill Publishing Co., Inc.
New York 36, N.Y.
2-301 & 302

Magazines and Books, Electronics and Nucleonics.

LABORATORY STANDARDS

2-327 & 328

MEASUREMENTS CORPORATION
Boonton New Jersey

Measurements Corp., Boonton, N.J. 2-327 & 328
New Standard Signal Generator, Model 84-TV, with frequency range of 300 to 1000 Mc. The instrument has been designed for work in the UHF TV band, and has many other applications in that frequency range. Various other instruments in the company's group of Laboratory Standards.

Melpar, Inc.
Alexandria, Va.
4-816

Miniature and Subminiature S-Band Radar Beacons of both crystal video and superheterodyne types which are suitable for a wide variety of missile and aircraft applications. An electronic correlator capable of plotting auto-correlation or cross-correlation curves on complex functions.

Be sure to visit all four floors!

(*Continued on page 211A*)

Metalcraft, Inc., Richmond Hill 18, L.I., N.Y. 4-312
Sheet metal products

Metal Powder Association, New York 17, N.Y. 4-719
New Standards and Specifications for the Iron Powder Electronic Core Producing and Consuming Industries.

Metal Textile Corp., Roselle, N.J. 4-223
Metex electronic weather stripping. Resilient metallic shielding gaskets and strips for controlling Radio-Noise and TVI. Special electronic application of knitted wire shapes, including radar reflectors, tube grids, washers, etc.

Mica Fabricators Association, New York N.Y. 3-517
Mica parts and components using mica.

Microtran Company, Far Rockaway 91, N.Y. 4-128
SALES AFFILIATE OF CREST LABORATORIES, INC. Transformers; Reactors; Coils; Hermetically sealed and open frame Miniature, Sub-Miniature, and sub-sub Miniature Transformers; specialized transistor transformers; Hi-Q Audio Components; Line Voltage adjusters; Cathode Ray Tube Rejuvenator Transformers.

Micro Div. of Minneapolis-Honeywell Reg. Co., 101 Park Ave., New York 17, N.Y. 2-122
Makers of precision switches. Manual control switches: AN & JAN toggles, subminiature toggles, multipole toggles, hermetically sealed toggles. Sealed pushbuttons, multipole subminiature pushbuttons. Interlocks: Small multipole cheatable many variations. Precision snap-acting switches: cam operated, enclosed, hermetically sealed, subminiature, double pole, magnetic blowout, and special assemblies.

Microwave Associates, Inc., Boston 15, Mass. 4-218
New improved Silicon diodes for radar and Microwave relay mixer use featuring low noise and constant RF and IF characteristics. Radar magnetrons, TR and ATR tubes for S, X, and millimeter bands. Waveguide components and test equipment for millimeter and centimeter wave lengths.

Microwave Development Labs., Inc., Waltham 54, Mass. 4-601
Waveguide Components including Side and Top-wall hybrids, balanced mixers, balanced duplexers, temperature compensated tunable cavities, E and H bends, high power rotary joint and custom built directional couplers.

(Continued on page 212A)

What to see at the Radio Engineering Show

(Continued from page 211A)

Midland Manufacturing Co., Inc., Kansas City, Kan. 4-613
Exhibiting some of the standard Quartz Crystal Types available in production quantities and a new type unit in the audio frequency range. There will also be demonstrations of the basic phenomena of Piezoelectricity. Midland's representatives will be present to discuss crystal problems and applications.

Midwestern Geophysical Laboratory, Tulsa, Okla. 4-403
Hydraulic Servo Components, Recording Oscillographs, Galvanometers

Milwaukee Transformer Co., Milwaukee 9, Wis. 4-807
Transformers and allied products

Minneapolis-Honeywell Reg. Co., Aeronautical Div., Freeport, Ill. 2-122
The display will feature a complete line of automatic controls for aircraft including operating demonstrations of rate gyros, vertical and cageable vertical gyros, and Hermetic Integrating gyros. Also demonstration of altitude control and display of various actuators and amplifiers.

Muirhead & Co., Ltd., Beckenham, Kent, Eng. 4-804
D-489 Muirhead-Pametrada Wave Analyser. This analyser breaks away completely from the conventional heterodyne principle and employs two R.C. tuned selective amplifiers in cascade. Though intended primarily for vibration measurements the instrument can also be used for general waveform analysis. Features: Range 19 cps-21 Kc; frequency accuracy ±0.5% over most of range. Selectivity and band-width variable; maximum 2nd harmonic suppression 70 db over whole range. Power supply: 91-120 V; 60 cps; 130 W.

Multi-Metal Wire Cloth Co., Inc., New York 59, N.Y. 4-314-316
Cathode-Ray Tube Shields, Cabinets, Chassis, Dust Covers, Panels, Racks, Shields.

Muter Co., Chicago 5, Ill. 3-506 & 507
Ceramic capacitors, wire wound resistors, rf and IF coils, precision potentiometers, switches.

(Continued on page 214A)

What to see at the Radio Engineering Show

(Continued from page 212A)

Mycalex Corp. of America, Clifton, N.J. **1-130 & 131**
Mycalex glass-bonded mica Ceramoplastic: insulation takes 2000° F for very brief periods; telemetering commutator; coil form for coded radio; air circuit break arc chute; molded-with-fragile-inserts switch for correcting gyro compensation; radio frequency switch; minimum differential expansion spur gear, functional part with solderable molded-in inserts and printed circuit.

National Carbon Co., Div. of Union Carbide & Carbon Corp., New York 17, N.Y. **1-514-516 & 518**
Outstanding examples of famous "Eveready" battery line, grouped in six separate categories: Personal Radio, Portable Radio, Home Radio, Radiation Detectors, Hearing Aid, and Photoflash. New Batteries on display will be the compact No. 964-477 "Personal" Radio Battery Complement, round-cell photoflash types and the tiny No. 1002E Hearing Aid "A" Battery.

National Co., Inc., Malden 48, Mass. **2-105**
The latest in Government, Commercial, Amateur Communication Equipment, and Components. A new communication receiver in the low price field will be shown for the first time and several new electronic components.

National Research Corp., Vacuum Engineering Div., Cambridge 42, Mass. **1-705**
Pumping dolly for in-line exhaust system; new, improved, and more compact diffusion pumps; new Model 511 "Alphatron" vacuum gauge.

New Hermes Engraving Machine Corp., New York 3, N.Y. **2-131 & 132**
New Hermes pantograph engraving machines in action, for engraving name plates, panels, dials, profiling, milling on all metals and plastics.

Be sure to visit all four floors!

(Continued on page 216A)

These 3 insulating materials now available in the

BIGGEST SINGLE SHEETS *ever made*

King-sized TEFLON sheets, *60" x 72"*, prevent leakage and blow-through on large gaskets. Ideal for many uses.

•

5 foot KEL-F discs open vast new potentialities for this versatile thermoplastic. New size increases economy, eliminates waste.

•

It's no secret that the A. E. C. chose *4 foot* MYKROY rings to insulate its generator. There's a growing demand for this perfected glass bonded mica.

•

Sheets, rods — machined or molded to specification. Write today for our new TEFLON, KEL-F and MYKROY brochures.

ELECTRONIC MECHANICS INC.

101 CLIFTON BOULEVARD, CLIFTON, NEW JERSEY

MYKROY, INC., WHEELING, ILL.

See us at Booth #4-610, Radio Engineering Show

Sensitive DC-VTVM Furthers Electronic Research and Production

Progress in electronic engineering, as in other fields of engineering, is closely linked with the development of more sensitive measuring instruments. During the past 4 years our MV-17B DC Vacuum Tube Millivoltmeter has helped substantially to advance both research and production throughout the entire electronic field. Crystal diodes and transistors for instance have benefited from it due to its ability to measure small DC voltages with minimum circuit loading (1 mV full scale, 6 megohms input impedance). As a null detector, in bridges, the MV-17B can be overloaded up to 100,000 times, thereby eliminating suspension-galvanometer trouble and increasing measuring ranges and sensitivity. Grid current measurements, small voltage drops in regulated power supplies, delicate temperature measurements, insulation material research are but a few other applications which have made this instrument a reliable stand-by in nearly all leading laboratories in America and abroad.

MV-17B DC-Millivoltmeter

•

"It Measures Where Others Fail"

Other Millivac Meters, Similar to MV-17B.

- MV-17BX DC Millivolt meter, identical with MV-17B but equipped with external output terminals. Used as high-gain DC amplifier or to operate external indicating and recording instruments.
- MR-67B DC Millivolt Recorder, sensitivity 200 microvolts per centimeter. Uses Sanborn heat-writing unit.
- MV-18B High Frequency Voltmeter. Has MV-17B DC measuring circuit and external crystal probes. Covers 1 MC to 2,500 MC, lowest reading 1 mV. Measures also 100 microvolts to 10 mV DC.

MILLIVAC INSTRUMENT CORPORATION
P.O. BOX 997, Schenectady, N.Y.

What to see at the Radio Engineering Show

(Continued from page 214A)

The J. M. Ney Co.
Hartford 1, Conn.
4-101

Precious metal alloys and their uses in precision electronic instruments. Contacts, slip rings and assemblies to customer specifications. Fine size resistance wire in precious metal alloys.

North Electric Mfg. Co., Galion, Ohio 4-517
The North Electric Manufacturing Co. has had 50 years' experience in the manufacture of relays. We manufacture relays designed for military aircraft, for computers, remote and studio, and calculating machines, also relays for general communication equipment.

Northern Radio Co., Inc., New York 11, N.Y. Theater 3-210
Communications Equipment

Nuclear Instrument & Chemical Corp., Chicago 10, Ill. 4-123
Complete line of electronic instrumentation for detecting and measuring nuclear energies. Several new sealing instruments will be shown, as well as portable survey meters and accessories. Nuclear's new revolutionary automatic sample changer will also be on exhibit.

Oak Mfg. Co., Chicago 10, Ill. 4-606
Rotary, pushbutton and slide switches; television converters and tuners; choppers, vibrators and power supplies; Ledex rotary solenoids and other special electromechanical assemblies. Development and production for manufacturers only.

Optical Film Engineering Co.
Philadelphia 33, Pa.
4-216

A complete line from 1" to 10" of our superior Multijet Oil Diffusion Pumps. The "Vapor Frac" fractionating pump group using the new vapor separation principle. The SC-3 high vacuum evaporator designed for research on evaporated coating. Evaporated films of metals and dielectrics for electrical and optical purposes.

John Oster Mfg. Co., Racine, Wisconsin 4-815
Fractional horsepower motors synchros, servo motors, and actuators.

PSC Applied Research Limited
Toronto 13, Canada
4-122

Airborne Magnetometer, Airborne Profile Recorder, Photogrammetric Instruments, Intervalemeters, Cameras, Recording Time Interval Measuring Sets, Navigational Computers, Airborne Radiation Detector.

(Continued on page 218A)

OIL IMPREGNATED

CHICAGO

APPROVED

VACUUM FILLED

CAPACITORS

Approved SILICONE BUSHING *capacitor, oil impregnated, hermetically sealed.*

Featuring SILICONE BUSHINGS *for peak performance at high temperature operation.*

SILICONE BUSHING BATHTUB TYPE *capacitor, oil impregnated, hermetically sealed, and tested at twice rated voltage to meet all specifications.*

GLASS SEALED TUBULAR TYPE *capacitor, oil impregnated, hermetically sealed to meet all specifications.*

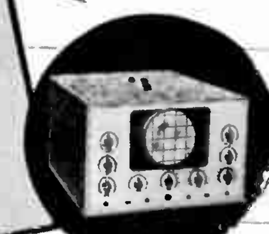
WRITE US FOR FURTHER INFORMATION.

CHICAGO CONDENSER CORPORATION

3255 WEST ARMITAGE AVE.
CHICAGO 47, ILLINOIS

how Can it be made

If your problem requires 1 Close tolerance 2 High interior surface finish 3 Intricate design



It can be LECTROFORMED!*

If the radio frequency component you need cannot be made by conventional methods or is difficult and costly to manufacture, the possibilities are it can be *LECTROFORMED.*

Write Dept. IRE-53 for "Lectroforming Applications and Procedure"

* Trademark

LECTROFORMING can produce parts of intricate design, accurate interior dimensions and with high interior surface finish up to 5 micro-inch. Various metals may be used (such as silver, gold, copper, nickel and/or iron) to meet specific requirements for conductivity, strength and corrosion resistance.

LECTROFORMING achieves dimensional stability impossible by any other method.

LECTROFORMING is the manufacturing of an article by the electrode position of metal on a form of predetermined size, shape and finish. We welcome the opportunity to discuss your problem, no matter how difficult it may seem.

Visit our Booth 3-525 at IRE Show

BART

BART LABORATORIES CO., INC.
227 Main Street, Belleville 9, New Jersey

DX *Announces*

a NEW 90° YOKE for 27" TUBES

It's Engineered for TOP PERFORMANCE ... in Production NOW!

This new DX 90° Deflection Yoke has everything a television receiver manufacturer wants . . . a sharp full-screen focus, a minimum of pincushioning, the ultimate in compactness and a price that's downright attractive. Because this yoke has been brilliantly designed for mass production on DX's specialized equipment, it warrants immediate consideration in your 27" receiver plans. Write us today.

DEFLECTION YOKES . . . TOROID COILS . . . CRYSTALS
I. F. TRANSFORMERS . . . R. F. COILS . . . DISCRIMINATORS
SPEAKERS . . . TV TUNERS . . . ION TRAPS . . . TRANSFORMERS

DX COMPONENTS "the heart of a good television receiver" TRADE MARK

DX RADIO PRODUCTS CO.

GENERAL OFFICES: 2300 W. ARMITAGE AVE., CHICAGO 47, ILL.

Model 109

"Complete Radar Test Facility"

Multi-Purpose X Band Test Equipment

Spectrum Analyzer	Displays supplied spectra from 8.5 to 10. KMC on a 3" CRT
Signal Generator	Delivers CW, square wave, FM, or pulse (1, 5 or 10 μs) modulated RF, 8.5 to 10 KMC up to 25 MW
Power Monitor	Measures average power of CW or pulsed RF, external or internal, from 8.5 – 10.5 KMC
Frequency Meter	Measures applied RF from 8.5 – 10.5 KMC to .1% accuracy.

All major units plug in, 17" x 10½" x 13". 45 lbs.

ELECTRONIC DIVISION

Century Metalcraft Corporation
BOX 2098—14806 OXNARD STREET
VAN NUYS, CALIFORNIA

What to see at the Radio Engineering Show

(Continued from page 216A)

Panelyte Division, St. Regis Paper Co., New York 17, N.Y. 4-619 & 621
Laminated resinous plastics—sheets, rods, tubes, fabricated parts, molded specialties in paper, fabric, glass, nylon base; with phenolic, melamine and silicone resins. Injection molded parts. Decorative Panelyte. Featured parts for the television, radio and electronics industries. High strength, high heat resisting laminates. Metal clad laminates for printed circuits.

Panoramic Radio Products, Inc.
Mount Vernon, N.Y.
2-123

Spectrum analyzers covering the audio to Microwaves, and Response Curve Indicators dynamically demonstrated. New instruments include Panalyzor, Model SB-12, a slow sweep, high resolution, RF Spectrum Analyzer; Model G-3; Ultrasonic Response Indicator covering range between 2 KC and 300 KC and a Signal Switcher for Panoramic Sonic Analyzers, Models AP-1 and LP-1.

Paramount Paper Tube Corp.
Fort Wayne 2, Ind.
4-705

If you wind coils or transformers of any size, get a free sample of the "Paraformed" square and rectangular paper tubes made by Paramount Paper Tube Corp.—Mfgrs. of coil cores exclusively for more than 20 years.

Par-Metal Products Corp.
Long Island City 3, N.Y.
2-119

Metal Products for Electronic Industry.

Penta Laboratories, Inc.
Santa Barbara, Calif.
4-710

Displaying their new line of medium and high-power Power Tetrodes incorporating a high efficiency anode of unique design. Also on display will be other power tubes, Hydrogen Thyratron, Vacuum Switch and special purpose tubes of their manufacture.

Phalo Plastics Corp., Worcester 8, Mass. 4-508
Thermoplastic insulated wire and cable, cord sets, and harness assemblies.

Philco Corp., Government and Industrial Div., Philadelphia 44, Pa. 1-501, 505
Microwave communications and television relay equipment, including associated time and frequency division multiplexing equipment, antennas and towers. Also tube exhibits displaying research, development and production of receiving, cathode-ray and special-type tubes for government & industry.

Be sure to visit all four floors!

(Continued on page 220A)

(Continued from page 218A)

Phillips Control Corp., Joliet, Ill. 4-702
A complete line of relays, hermetically sealed relays, and actuators. We will feature our new Type 6 relay, first introduced in the publications this month. We will also show our new Electronic Timer, which will time our relays and operate lights in our display.

Photo Chemical Products, Ind., New York 51, N.Y. 3-308
Screen printing. Metal furnishing and spraying of industrial panels, instrument dials and schematics. Radium luminescent applications.

The Pioneer Elec. & Research Corp., Forest Park, Ill. 3-519
SRX-Electro-Mechanical Remote Switching systems; ERX—Electronic Remote Switching systems; Electrowriter—Permanent Magnet Motors and Generators; Electronic Keyer.

(Continued on page 222A)

What to see at the Radio Engineering Show

(Continued from page 220A)

Popper & Sons, Inc.
New York 10, N.Y.
4-818

Marking equipment to print on electronic Components.

Potter & Brumfield, Princeton, Ind. 2-407
Relays and Electro Mechanical Assemblies

Potter Instrument Co.
Great Neck, N.Y.
1-113

New High Speed Digital Magnetic Tape Handler. High Speed Digital "Teldeltos" Recorder, Universal Frequency-Time Counters, Multiple Sequence pre-determined counters. High Resolution 8-mc Chronograph. Data Handling Equipment. Plug-in Decades, Shift Registers, Frequency Dividers.

Precise Development Corp., Oceanside, L.I., N.Y. 4-426 & 428
Voltmeters (Indicating Instruments) Low Voltage Power Supplies, Pulse Generators, Microwave & Radar Test Equipment. Oscilloscopes, Cathode-Ray. General Purpose General Test Equipment, Bridges, capacitance. Bridges, resistance.

Precision Apparatus Company, Inc.
Elmhurst, L.I., N.Y.
2-307

High quality electrical indicating instruments (meters electronic test and measuring instruments and accessories. Cathode-ray Oscillographs, Vacuum tube voltmeters, Cathode-ray tube testers, Vacuum tube testers, AM signal Generators, Sweep signal generators, Volt-ohm milliammeters etc.

Premier Metal Etching Co.
Rockville Centre, L.I., N.Y.
4-710

Etched & Lithographed metal, name plates, scales, Dials for Instruments, Radio-Electronic panels. Plate facilities to etch, under cut, recess, and pierce to close tolerances on all dielectrics clad with copper, brass, aluminum, silver, nickel or steel.

Premier Metal Products Co.
Bronx 67, N.Y.
4-509

Premier Metal Products Company will exhibit a complete line of precision built metal housings including desk panel, relay, enclosed relay and transmitter racks. Various types of cabinet—rack, grille, meter and door panels will be shown. Also a line of utility cases, blank chassis and other items for the electronic industry.

What to see at the Radio Engineering Show

Presto-Recording Corp.
Paramus, N.J.
Theater 3-306

See the new PRESTO RC-11 Tape Transport Mechanism in sound theater No. 3-306.

Presto Recording Corp., Paramus, N.J. Theater 3-306
Presto is showing for the first time a completely new line of tape recorders and tape reproducers. The mechanical innovations have resulted in a number of exceptionally fine professional units. Disc recorders and transcription turntables for professional use will also be displayed.

Price Electric Corp., Frederick 1, Md. 4-501
Husky Relays and controls for military and commercial uses. Specializing in hermetically sealed telephone type relays. Manufacturers of the RO-T-RY, the relay that resists vibration.

Product Development Co., Inc., Kearny, N.J. 3-115
UHF-TV and microwave antenna systems. Waveguide, coaxial transmission lines and related system components; parabolic reflectors, cavity fed corners and horn antennas for use to 2700 mc. Prodelin "Job Packaged" installations for antenna systems with complete site facilities including appropriate towers, shelters, etc. Provided planning and single source responsibility.

Production Tool & Fixture Co.
Oyster Bay, L.I., N.Y.
3-522

Introduction of "Tiny-Fix," a new miniature assembly fixture designed especially to eliminate problems in small wiring and assembly. "Tiny-Fix" the outcome of suggestions received at last year's IRE Show for a problem-eliminator, will be on display at Booth No. 3-522, along with PTF's new, revolutionary universal TV fixture adapter.

Pyramid Electric Co.
North Bergen, N.J.
2-310

Capacitors; Electrolytics, Dry Electrolytics, papers, oil papers, metallized papers.

REF Manufacturing Corp., Mineola, L.I., N.Y. 3-202
Presents a complete display of electronic units showing REF's functional type of Construction. The units shown have all bee expertly designed, engineered, fabricated and assembled by REF, in accordance with customer's specific requirements combining lightness, strength, appearance and low cost of manufacture.

Racon Electric Co., Inc., New York 3, N.Y. 3-315
Driver units, straight and re-entrant horns, Marine speakers, Tweeters, cone speaker enclosures, explosion-Proof driver units, Microphone stands. Also speakers for all Industrial and Military requirements.

Be sure to visit all four floors!

(Continued on page 224A)

What to see at the Radio Engineering Show

(Continued from page 223A)

Radell Corp., Indianapolis, Ind. 4-121
Deposited Carbon Resistors

Radio City Products, Inc., New York 1, N.Y. 3-307B
Television and Radio Signal Generators, Multimeters, tube and set testers, Vacuum tube voltmeters, oscilloscopes and accessories.

Radio Corp. of America
Camden, N.J.
1-304-1-309
Electronic components, dry batteries, test and measuring equipment, Projectors, and UHF equipment.

Radio Corp. of America
Harrison, N.J.
1-304-1-309
Will exhibit a representative line of tubes used in INDUSTRIAL, ENTERTAINMENT, and MILITARY equipment. RCA Premium types, storage types, UHF-VHF Receiving and Transmitting types, Multiplier Phototubes, Industrial tubes and printed circuits will be featured.
The reflection-free characteristic of frosted filterglass face plates will also be demonstrated.

The RCA Laboratories Division, Princeton, N.J. 1-304-1-309
The RCA Laboratories exhibit will present various phases of electron solid state research with emphasis on transistors. Steps in germanium purification will be illustrated and a variety of devices using transistors will be displayed—some in operation.

Radio Materials Corp.
Chicago 18, Ill.
2-509
RMC "DISCAP" ceramic capacitors, By pass and temperature compensating disc, types, special purpose and special voltage types.

Radio Receptor Co., Inc.
New York 11, N.Y.
2-113
Manufactures of seletron selenium rectifiers, germanium and silicon (polarity at a glance) diodes, transistors, germanium power rectifiers, UHF converters and tuners, communications equipment, thermatron high-frequency dielectric heat sealing and wood glueing equipment.

Radio-Electronics, New York 7, N.Y. 2-141
Radio-Electronics is a highly technical magazine covering radio, television, high-fidelity, audio and the practical application of electronics with special emphasis on servicing, construction and new developments. Gernsback Publications, Inc., also publishes the Gernsback Library of low-cost technical books with titles on the theory, practice and application of radio, television and electronics at the service technician's level.

What to see at the Radio Engineering Show

Radio Magazines, Inc., Mineola, N.Y. 3-316
Audio Anthology—Reprints from Audio Engineering; 2nd Audio Anthology—Reprints from Audio Engineering; Audio Engineering—The magazine devoted solely to the science of reproduced sound.

Radio & Television News, New York 17, N.Y. 3-402
Magazines.

Radioactive Products, Inc., Detroit 26, Mich. 4-115
Instruments for detection and measurement of radioactivity.

Rawson Electrical Instr. Co., Inc., Cambridge 42, Mass. 2-412
Laboratory meters for AC or DC measurements, extremely high sensitivity. New improved Fluxmeter for testing magnets, may be used with any search coil from zero to 100 ohms! Rotating Coil Gaussmeters for magnetic field measurements, several new models. Electrostatic Voltmeters for voltage measurements with zero current drain. Sine-Cosine Potentiometers.

Raymond Engineering Lab., Inc., Middletown, Conn. 4-903
Magnetic fluid clutches for industrial control and servo-mechanism application.

Raytheon Manufacturing Co.
Waltham 54, Mass.
1-422, 424

Electronic equipment. Receiving tubes, plastics.

Reeves Instrument Corp., New York 28, N.Y. 1-423
The new C202 REAC, new miniature bread board parts, new miniature resolver and gyro, and the new six channel recorder.

Reiner Electronics Co., Inc., New York 1, N.Y. 3-307B
Limit Bridges, Square Wave Generators, Vacuum Tube Voltmeters.

The Rex Corp., West Acton, Mass. 3-119
Rex Kel-f Insulated hook-up wire. Rex Microwall hook-up wire. Rexolite #1422 UHF Insulating Material, rods and sheets. Rextrude electrical tubing, Underwriters' approved 105° C and service approval Per MIL-I-631A. Rex extruded Teflon rod. Rex custom extrusions to your specifications.

Rhode Island Insulated Wire Co., Inc.
Cranston, R.I.
4-703

A complete line of Insulated Wire including goverment specification wire.

(Continued on page 226A)

Radio Telemetering
Data Handling
Vehicle Instrumentation
High Speed Sampling

Research, Development, Design, and Production Services
Involving Specialized Application of the
Principles of Electronics, Mechanics, and Optics

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WE PROVIDE THE LEVER • YOU MOVE THE WORLD

Your Inquiries Are Invited — Wire, Write or Phone

APPLIED SCIENCE CORPORATION OF PRINCETON
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See Us at the Radio Engineering Show—Booth No. 4-806

SQUARE PULSE GENERATORS for the MILLIMICROSECOND to MICROSECOND RANGE

Model 100
Square Pulse Generator

PRICE: $395.00 F.O.B. New York
Standard Rack Mounting

For Nuclear Pulse Work, Radar, TV, Wide Band Amplifiers, and in the design, calibration and servicing of fast electronic systems:

FOR THE FIRST TIME—A Square Pulse Generator with a rise time of one millimicrosecond (10^{-9} seconds) and a pulse width which can be varied from 2 millimicroseconds to several microseconds is commercially available. Both positive and negative pulses of a 100 volts maximum amplitude, into low impedance (such as 50 OHM cable) are generated; the pulse amplitude can be varied from 100 volts to .006 volts in 1 decibel steps by means of selector switches on the front panel. One, two, or more pulse outputs, each of which can be individually attenuated and delayed are available in various models.

For further details, write for bulletin P-1 or contact our Engineering Division.

ELECTRICAL AND PHYSICAL INSTRUMENT CORPORATION

Sales and Business Office
25 West 43 Street
New York 36, N.Y.
Telephone: LOngacre 4-8510

Engineering Division
42-19 27th Street
Long Island City, N.Y.
Telephone: STillwell 4-6389

What to see at the Radio Engineering Show

(Continued from page 225A)

John F. Rider Publisher, Inc., New York 13, N.Y. 3-523
Rider AM-FM Radio, Television and public address equipment service manuals; rider TEK-FILE (a monthly technical data service for TV Equipment); Textbooks on electronics, with emphasis on television, radio and allied subjects. A special service of the organization is the preparation of technical manuals for government, industry and civilian uses.

SHEET METAL FABRICATIONS
Custom Built Cases and Covers for Electrical Equipment
4-130
THE RIESTER & THESMACHER COMPANY
1526 W. 25th St. Cleveland, O.

The Riester & Thesmacher Co., Cleveland 13, Ohio. 4-130
Manufacturers of sheet metal enclosures displaying several items of custom built metal cabinets and housings for electrical and electronic devices in steel, aluminum and stainless steel.

Robinson Aviation, Inc.
Teterboro, N.J.
2-216 & 217
All-Metal Vibration Isolators and Shock Control Systems, Units and Devices. Engineered Mountings to customers exact requirements, and exceeding applicable performance specifications. MET-L-FLEX is the copyrighted designation for the ALL-METAL resilient cushions developed and pioneered by Robinson Aviation, Inc.

Rocket Distributors, Inc., Bayside, L.I., N.Y. 3-526
See: C & H Supply Co.

Rola Co., Inc., Cleveland 14, Ohio. 3-506 & 507
Loudspeakers, deflection yokes and flybacks, headphones, transformers: Audio types, hermetically sealed types, TV types.

Roller-Smith Corp.
Bethlehem, Pennsylvania
4-521
Ruggedized and Hermetically Sealed Instruments, JAN type Instruments, Switchboard and Portable Instruments, Indicating Relays, Rotary Switches, Precision Balances.

Rotron Mfg. Co., Inc., Woodstock, N.Y. 3-201
Latest new devices for cooling electronic equipment including: silicone fluid pumps, heat exchangers, mechanical refrigeration units, wide frequency range motors, multi-stage turbines, blowers, fans, transmitting tube supports and air interlocks.

Rutherford Electronics Co.
Culver City, Calif.
3-111
Manufacturers of Precision Lab. test instruments displaying: A-2 Time Delay Generator, provides accurate and variable time delays from .8 to 100,000 micro-seconds. A-4 Time delay generator from 10 microseconds to 10 seconds. B-2 Pulse Generator is a source of pulses of variable width, repetition rate, delay, and amplitude. D-2 Pulse Train Calibrator.

(Continued on page 228A)

Burlington

HERMETICALLY AC-SEALED-DC INSTRUMENT

- Copper — cadmium — dichromate finished case.
- Black satin onodized aluminum bezel.
- Excellent shielding due to case material and construction.
- Double strength clear glass.
- Glass to metal seal under controlled humidity and temperature conditions.
- D'Arsonval permanent magnet type movement for DC applications.
- Magnetically damped, moving iron vane type movement for AC applications.

RUGGED CONSTRUCTION FOR SUPERIOR PERFORMANCE

- Available in 1½" square, 2½" and 3½" round case types.
- Guaranteed for one year against defective workmanship and materials.

Burlington "Hermetically Sealed" Instruments are designed to conform to JAN and MIL specifications.

BURLINGTON INSTRUMENT COMPANY
DEPT. I-33, BURLINGTON, IOWA

See us at Booth 2-323, I.R.E. Show, March 23-26

HYCOR

TYPE 4200

Sound Effects Filter

This unit has been developed to meet present day requirements for compactness. The filter requires only 3½ inches of rack space.

Features . . .

- **LOW HUM PICKUP** through the use of toroid coils. The unit may be used in circuits having signal levels as low as —40 dbm without the necessity for taking special precautions against hum pickup.
- **LOW DISTORTION:** The filter may be used at levels up to plus 20 dbm with negligible intermodulation distortion.
- **RELIABILITY:** All capacitors and inductors are hermetically sealed for lifetime service. Aging effects are negligible.

General Specifications . . .

DIMENSIONS: Standard rack panel, slotted, 3½" high. Maximum depth 7½".
CONTROLS: Low frequency cutoff selector knob, high frequency cutoff selector knob, on-off key.
RANGES: Both low and high frequency cutoff controls cover 100, 250, 500, 1000, 2000, 3000, 4000 and 5000 cycles.
ATTENUATION: Approximately 16 db, per octave on both high and low frequency cutoff points.
IMPEDANCE: 500/600 ohms, in-out.
FINISH: Engraved panel finished in medium gray baked enamel. (Special colors available upon request.)
The filter has standard input and output jacks located on the front panel in addition to the terminal block at the rear.

11423 VANOWEN ST., NORTH HOLLYWOOD, CALIFORNIA **HYCOR** *Company, Inc.* **SUnset 3-3860**

Manufacturers of Precision Resistors, Toroid Inductors and Electric Wave Filters

REPRESENTATIVES:
Jack Beebe, 5707 W. Lake Street, Chicago, Illinois
George E. Harris & Co., Box 3005, Municipal Airport, Wichita, Kansas
Marvin E. Nulsen, 5376 E. Washington St., Indianapolis 19, Indiana
Burlingame Associates, 103 Lafayette Street, New York City

For further information contact your nearest Hycor representative or write for Bulletin S

What to see at the Radio Engineering Show

(Continued from page 226A)

St. Regis Paper Co., New York 17, N.Y. See Panelyte Div. 4-619 & 621

Sanborn Company
Cambridge 39, Mass.
2-116

New Series of direct-writing recording systems. Features of the new systems (Model 150 Series) to be shown and demonstrated will include: standard relay reack design; improved paper drive with selection of 9 speeds; individual stylus temperature control; and a basic amplifier and power supply assembly providing for plug-in installation of individual amplifiers and preamplifiers, including: AC-DC, Carrier (strain gage), Coupling, Log-Audio, Servo Monitor, DC Converters (Chopper).

Those who know ...choose Sangamo

SANGAMO

3-510

Sangamo Electric Co., Capacitor Div., Marion, Ill. 3-510
A complete line of radio and electronic capacitors, featuring such Sangamo developments as: HUMIDITE . . . the new plastic molding compound that offers previously unheard-of moisture resistance. E-THERM . . . an impregnant for oil paper capacitors that permits 125° operation. TELECHIEF . . . new premium molded tubular capacitor that's resin-impregnated and molded in Humiditite.

Scheidl Manufacturing Co.
Copaigue, L.I., N.Y.
4-416

Panel and Control Box Assemblies. Machine Details. Edglight Panels made to MIL-P-7788 specifications. Reinforced Plastic Housings for Electrical Units. Low Pressure Laminating. Precision and Vacuum Forming.

Carl W. Schutter Mfg. Co., Lindenhurst, L.I., N.Y. 2-205
RADAR AND ELECTRONIC COMPONENTS.

Scientific Electric
Garfield, N.J.
1-605

Scientific Electric, Designers and Manufacturers of High Frequency and High Voltage equipment since 1921 invite you to visit their exhibit to see the latest: High Frequency Vacuum Tube Bombarders, Induction and Dielectric Heaters, High Voltage Power Supplies, Precision Spot Welders.

Scientific Specialties Corp., Boston 35, Mass. 4-822
Specialized laboratory instruments for workers in Nuclear Physics Histology, Pathology, and Ophthalmology, as well as the new products of associate Transistor Products, Inc. including Transistors, Gold Bonded Germanium diodes & a Transistor Test Set.

What to see at the Radio Engineering Show

Secon Metals Corporation
New York 17, New York
4-506

Special Metallurgical Items Including Fine Wire and Ribbon and Components in Electronic Vacuum Tubes.

Servo Corp. of America
New Hyde Park, L.I., N.Y.
3-524

Servomechanisms, analyzers, Servotherm Thermistor Bolometers & accessory equipment, sub-audio generators and direction finding equipment.

Servomechanisms, Inc.
East Coast Division & Home Office
Post and Stewart Avenues
Westbury, Long Island, N.Y.
Westbury 7-2700
4-207 & 208

West Coast Div.
316 Washington St.
El Segundo, Calif.
El Segundo 1517

Servomechanisms, Inc., Westbury, L.I., N.Y. 4-207 & 208
"Designers and manufacturers of electronic and electromechanical components and systems. Featuring functionally packaged plug-in components, instrument motors, mechanical development apparatus, recorders, transducers, and automatic control systems for both 60 cycle and 400 cycle applications.

The Sessions Clock Co., Forestville, Conn. 3-107 & 108
Switch Timers for clock radios. Miniature Snap-Action Switches. Timing motors, movements, and switches for industrial applications.

Shallcross Mfg. Co.
Collingdale, Pa.
2-210 & 211

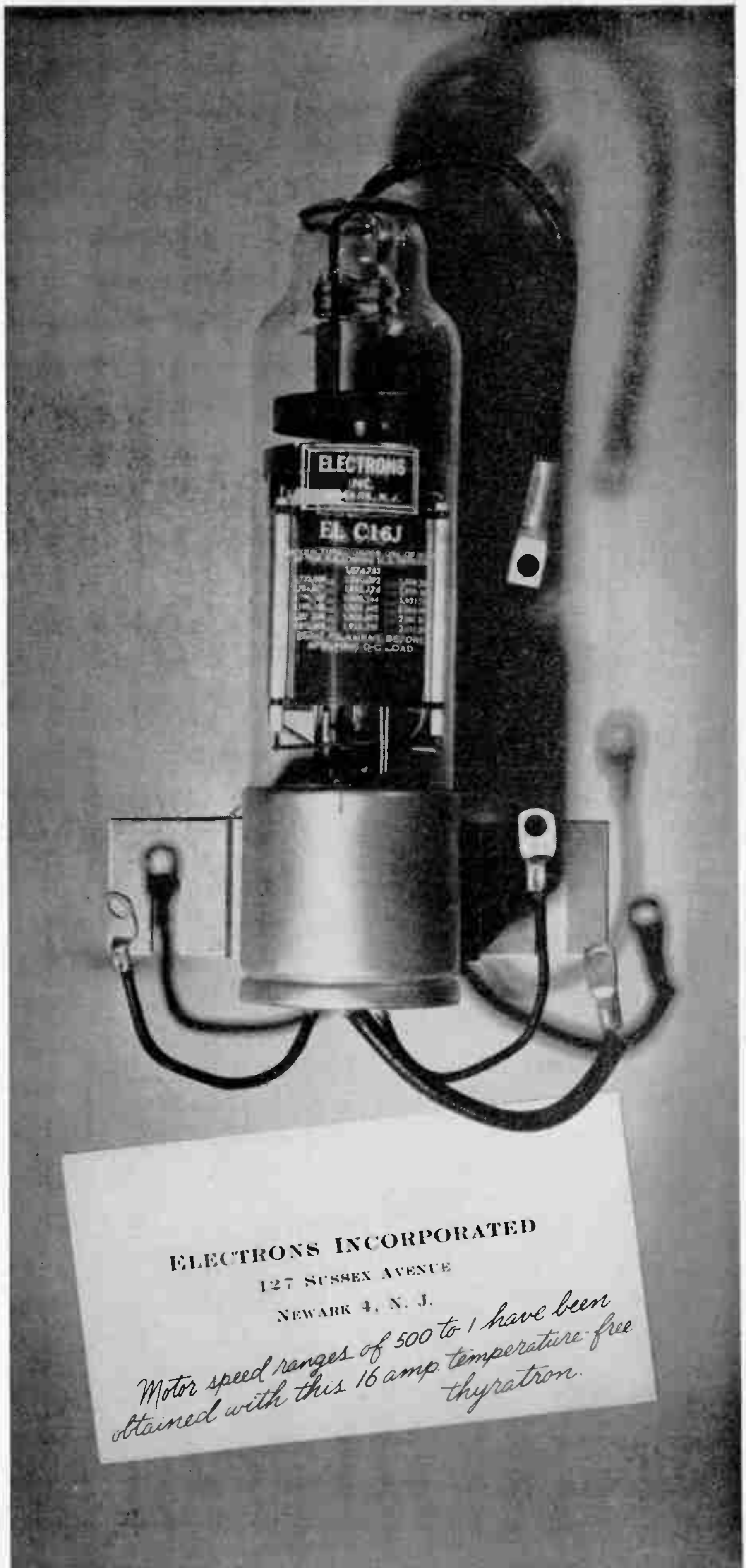
Precision wire-wound resistors; Rotary Selector Switches; Audio Attenuators; Decade Resistance; Voltage Dividers; Resistance Standards; Low Resistance Test Sets; Wheatstone Kelvin-Wheatstone Bridges; Wheatstone-Megohm, Percent Limit and Fault Location Bridges; High Voltage Measuring Apparatus; Telephone Transmission Test Set Equipment; Galvanometers.

Sheldon Electric Co., Div. of Allied Electric Prods. Inc., Irvington 11, N.J. 3-206 & 207
Cathode-Ray Tubes, Receiving Tubes, Tiago Tube & Adapter, Spring-Action Plugs, Fluorescent Starters, Time Delay Relays.

Shielding Inc., Riverside Park, N.J. 4-114
Screen rooms and filters.

F. W. Sickles Division. SEE General Instrument Corp. 4-518

(Continued on page 230A)



What to see at the Radio Engineering Show

(Continued from page 229A)

Sigma Instruments, Inc., Boston 85, Mass 2-311
Sensitive AC, DC, Polar, and Telegraphic Keying relays, Available as standard relays with general purpose adjustments or as specified relays adjusted and adapted for particular requirements involving unusual or exacting circuit behavior. Application engineering service available. Fourteen page catalog on request.

Simpson Electric Company
Chicago 44, Ill.
1-128

See an amazing engineering advance in panel meters! For the first time, the Simpson core movement is on display. And, for a complete line of panel meters of all types together with a diversified selection of easy to use radio, television and industrial test equipment.

Herman H. Smith, Inc., Brooklyn 15, N.Y. 3-511
Electronic Components and Radio Hardware.

Sola Electric Co.
Chicago 50, Ill.
1-405

Sola Constant Voltage Transformers, Sensivolt AC Control Units, and related products.

Sorensen & Co., Inc.
Stamford, Conn.
2-318 & 319

AC Line Regulators, electronic, 60 & 400 cps; Regulated DC supplies, both high and low voltage, high and low current; Electronic Frequency changers, 0.01% accuracy; AC regulator and Spectrophotometer Power Supply.

Southwestern Industrial Electronic Co.
Houston 19, Texas
4-116 & 117

Electronic Test Instruments—Oscillators; Resistance Meters; DC Amplifiers: Vacuum Tube Voltmeters & Potentiometers; Impedance Bridges; Special Amplifiers & Power Supplies.

Speer Resistor Div. of Speer Carbon Co., St. Marys, Pa. 4-127
Fixed Carbon Composition Resistors, Condensers, Capacitors and other electronics parts.

Spencer-Kennedy Laboratories, Inc.
Cambridge 39, Mass.
2-142

Be sure to see our new extended range Chain Amplifiers at Booth 2-142.

(Continued on page 232A)

What to see at the Radio Engineering Show

(Continued from page 230A)

Spencer-Kennedy Labs., Inc., Cambridge 39, Mass. **2-142**
Be sure to see the new extended bandwidth Model 214B Chain Pulse Amplifier and 202C Wide-Band Chain Amplifier; the new 212A-TV Television Amplifier with again control and connection for automatic level control. See SKL's Variable Electronic Filters. Wide-Band Distribution System, new pulse and square wave generators, and high speed oscilloscope.

Sperry Gyroscope Co. Div., The Sperry Corp., Great Neck, L.I., N.Y. **1-607, 609, 611**
Celebrating its fifteenth anniversary in the klystron and microwave test equipment business, Sperry will exhibit latest designs of klystrons for local oscillator, medium power transmitter, high power transmitter, bench oscillator and multiplier service. Latest designs of field test equipment and automatic production testing equipment at microwave frequencies will be featured.

Visit all four floors

What to see at the Radio Engineering Show

Sprague Electric Co.
North Adams, Mass.
1-410, 412

Capacitors, resistors, Ferroxcube Cores, pulse networks, radio interference locators.

Square Root Mfg. Corp., Yonkers 5, N.Y. 2-520
Television Components, Toroidal Coils, Transformers, Filter Networks.

Standard Electric Time Co., Springfield 2, Mass. 4-417
New line of ELECTRONIC COUNTER TIMERS and TACHOMETERS featuring: (a) Compact Units (b) New Readout Indicator (c) plug-in Component Parts Construction. 400 Cycle Timer. d-c Motored Timer. Lab. Power Distribution Panels.

Standard Piezo Co., Carlisle, Pa. 2-305
Crystals (Oscillating), and Accessories. Crystal holders. Crystal ovens.

Standard Transformer Corp.
Chicago 18, Illinois
BOOTH 4-801

DON'T MISS STANCOR'S ULTRA-MINIATURE TRANSISTOR TRANSFORMERS

STANCOR

The smallest iron core audio transformer ever built.

(Continued on page 234A)

FINE INSTRUMENTS *deserve* FINE PANELS

QUALITY METAL FABRICATING for AVIATION INSTRUMENTS, AUDIO COMPUTORS, TELEVISION, RADIO, RADAR, FACSIMILE

DESIGN AND ENGINEERING SERVICE. Falstrom engineers will work with your staff from the planning stage to fill your needs efficiently and economically. For complete data write for illustrated bulletins; for consultation on a specific problem contact a Falstrom engineer. Visit us at the I.R.E. ELECTRONICS SHOW, Grand Central Palace, March 23 to 26. Booth 4-507.

FALSTROM COMPANY

56 Falstrom Court, Passaic, New Jersey

ENGINEERS • DESIGNERS • FABRICATORS SINCE 1870

MEASURE AIR VELOCITY DIRECTLY AND ACCURATELY

WITH A

HASTINGS AIR-METER

The most sensitive of all air meters for research, industrial and agricultural applications. Reads directly in feet-per-minute on a logarithmic-type scale expanded at lower velocities. Highly sensitive — will indicate the velocity of smoke rising from a cigarette. Response time less than one second. Accurate to within ± 2% regardless of ambient temperature or static pressure.

Uses the exclusive Hastings noble metal thermopile in an extremely stable circuit. Instantaneous range switching without recalibration. Probes available for directional or non-directional reading. Easily adapted for remote recording since the calibration is independent of lead length. Available in several models to meet your specific requirements.

Hastings Model H Air Meter. Compact unit for field and laboratory use. Velocity Ranges: 10-750 fpm; 750-5500 fpm.

Hastings Model G Air-Meter. Small hand type instrument. Velocity range: 0-6000 fpm; Weight: 26 ounces.

Hastings Model B Air Meter for measurements of greatest precision. Velocity ranges: 0-400 fpm; 400 to 6,000 fpm. Meter type continuous calibration check. Knife edge, parallax free indicator.

Write for descriptive literature and prices on Hastings Air Meter, Manometer and Flowmeters, and Vacuum Gauges.

HASTINGS INSTRUMENT COMPANY, INC.

HAMPTON, 33 VIRGINIA

DESIGNERS AND BUILDERS OF RAYDIST AND SPECIAL ELECTRONIC, ELECTRICAL, AND MECHANICAL INSTRUMENTS

What to see at the Radio Engineering Show

(Continued from page 233A)

Standard Transformer Corp., Chicago 18, Ill. 4-801
The world's smallest transformers—Stancor Uutra-Miniature Transistor Transformers, will be displayed. In addition, there will be a complete exhibit of all types of hermetically sealed transformers that meet MIL-T-27 specifications, as well as all types of units for TV, radio, audio and other electronic applications.

Stelma, Inc., Stamford 1, Conn. 2-125 & 126
SEE C. G. S. Laboratories, Inc.

George Stevens Mfg. Co., Chicago 30, Ill. 4-516
We are exhibiting and demonstrating machines for winding almost any type of coil, including armature, bobbin lattice wound, variable pitch, random wound, resistor coils, solenoid, space wound, repeater, choke and toroidal coils. Models exhibited will include the new TW-A Tronidal Coil Winder and the new High speed bobbin Winder.

Stevens Mfg. Co., Inc., Mansfield, Ohio 2-140
"Display of bimetal thermostats, adjustable, non-adjustable, open, closed, hermetically sealed, such as are so widely used by the electronic and aviation industry. The display will include both snap-acting, that is, quick make and quick break, as well as, positive-acting. Also manual resets will be available."

Stupakoff Ceramic & Mfg. Co., Latrobe, Pa. 3-105
Multi-Metal specializes in MuMetal shields, aluminum cabinets and chassis. Racks, panels, watertight units, and dial plates are precision engineered to customer's specs.

Superior Electric Co., Bristol, Conn. 1-103 & 104
On display in booths 1-103 and 1-104 will be the complete line of products manufactured by The Superior Electric Co. These include Powerstat variable transformers; Stabiline Automatic Voltage Regulators; Varicell DC Power Supplies; Voltbox AC Power Supplies and Superior 5-Way Binding Posts. This new, colorful display will be of interest to those in the Electrical, Electronic and Engineering fields.

Wally B. Swank, Syracuse 4, N.Y. 4-612
Switches, Special molded parts.

(Continued on page 237A)

What to see at the Radio Engineering Show

(Continued from page 234A)

Switchcraft, Inc., Chicago 22, Ill. 3-114
Recent additions to the line, such as, the #480 Littel Plug (JAN type PJ-068), the Jack and Boot Assemblies, JACK COVERS, TELEVER SWITCH, ADAPTERS, in addition to the standard JACKS; Telephone and Microphone Plugs; Push Button, Rotary and Lever-Action Switches.

Sylvania Electric Products, Inc.
New York 19, N.Y.
2-102

Sylvania will exhibit new tubes for use in UHF, Subminiatures, Klystrons, Magnetrons, a story on tests conducted by an independent laboratory which depicts the quality of Sylvania Television Picture Tubes plus a complete line of parts for use in radio and TV manufacture.

Sylvania Electric Products, Inc., Tungsten & Chemical Div., New York 19, N.Y. 1-106, 107 & 108
Sylvania will exhibit tungsten and chemical products for the electronic industry that meet the highest standards of purity, precision, and uniformity. Tungsten wire and rod, gold-plated tungsten wire, hand wound coils, cathode ray tube phosphors, potassium silicate, carbonate emission coatings, silicon powder are among the noteworthy products to be displayed.

Synthane Corporation
Oaks, Pa.
2-129

Laminated plastic products sheets, rods, tubes, molded macerated, molded laminated, also fabricated plastic parts.

Tech Laboratories, Inc.
Palisades Park, N.J.
2-146

New solenoid switches for remote control, motor driven switches, hermetically sealed switches, manually operated rotary switches, many sizes including miniature, push button switches, attenuators, potentiometers, gain sets, decade boxes, Artificial Reverberation Generator.

Tech-Master Products Co.
New York 13, N.Y.
3-112

Presenting TV designed by engineers for engineers. In wired chassis or in deluxe kits, Tech-Master produces finest custom quality receivers incorporating the very latest in design for true fidelity video with clean FM audio. Now available to the discriminating Hi-Fi enthusiast with an eye for economy. The Williamson type amplifier kits and versatile wide-range preamplifier kits, both adhering to the same standards made famous by Tech-Master in TV; only finest components used.

The Technical Materiel Corp., Mamaroneck, N.Y. 1-703 & 704
Remote Control Receiver Systems, Communications Receivers, Frequency Shift Exciters, High Stability Oscillators, Diversity Receivers, Frequency Shift Converters, Tone Keyers, & Demodulators, Rhombic & Beverage Antennae Couplers, Multiplex, Teletypewriter Regenerative Repeaters, Aircraft Crash Locator Beacons, High Speed Morse Keying & Receiving Equipment, Peak Clipping Amplifiers.

(Continued on page 238A)

What to see at the Radio Engineering Show

(Continued from page 237A)

Technitrol Engineering Co.
Philadelphia 33, Pa.
4-107

Miniature Pulse Transformers
Electric Delay Lines
Varipulser-Laboratory pulse generator
Electronic Digital Computers and Memories.

Technology Instrument Corp.
Acton, Mass., 1-111

Phase Measuring Devices, Impedance Measuring Devices, Signal Generators, Wide - Band Amplifiers, Complex Plane Analyzers, Precision Linear and Non-Linear Potentiometers, and Potentiometer Noise Analyzers will be displayed.

Tektronix, Inc.
Portland 7, Ore.
2-401, 402
The Symbol of Excellence
In Electronic Instrumentation

Tektronix, Inc., P.O. Box 831, Portland 7, Ore. **2-401 & 402**
Laboratory type Oscilloscopes, Precision type High Speed Oscilloscopes, Square and Special Wave Form Generators, Direct Coupled and Wide Band Amplifiers.

Telechrome, Inc.
Amityville, L.I., N.Y.
3-407

Color TV Generating and Monitoring equipment for all systems; also equivalent monochrome instrumentation; flying spot picture generators; fluorescent noise generators and wave guides; telecast studio electronic prompter.

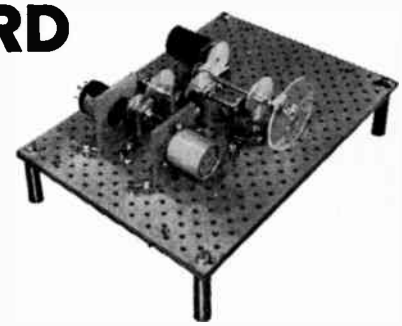
Telechrome, Inc., Amityville, L.I., N.Y. **3-407**
Five-rack battery of color-generating and monitoring equipment will be demonstrated in actual operation. Full color transparency slides will be employed as transmission material. Will also show two types of monochrome picture generators—one composite, one economy version.

Telechron Dept. of General Electric Co., Ashland, Mass. **1-129**
Presents at the Radio Engineering Show its line of timers and synchronous timing motors. Included are timers for radios, television sets, ranges, refrigerators, washers, and many other products—also Telechron timing motors for many applications. The company offers complete application Eng. and appearance design services.

Teletronics Lab., Inc., Westbury, L.I., N.Y. **4-901**
Pulse Generators, Calibrators, Diode, Test Sets, Audio Oscillators, Telemetering Test Sets, Crystal Test Sets.

(Continued on page 240A)


manufactured
to your design



What to see at the Radio Engineering Show

(Continued from page 238A)

Television Equipment Corp., New York 4, N.Y. 3-406
Wide band-high gain general purpose oscilloscope, multi-wave form generator SYNCROPLEX, Model T-602 Projection Oscilloscope.

Tele-Tech & Electronic Industries, New York 17, N.Y. 2-215
This TV-electronic engineering magazine, published by Caldwell-Clements, Inc., is exhibited in blown-up form in a totally new display which also includes Tele-Tech supplements, maps, charts, directories, etc., on subjects such as existing microwave systems, Armed Forces procurement structure, TV special effects, etc.

Tel-Instrument Co., Inc.
East Rutherford, N.J.
2-114 & 115

A complete line of T-V Production Test Equipment. Of particular interest is the new Type 1211 UHF Sweep Generator covering the range from 430 MC to 910 MC. This instrument will be set up in a working demonstration for interested visitors. Other instruments will include a new type 2113 12 channel transmitter and a Type 1212 Sweep Generator having 13 channels.

Tensolite Insulated Wire Co., Inc.
Tarrytown, N.Y.
4-124

Miniature plastic insulated wire & cable; teflon insulated hook-up wire; flexible tone-arm lead wire; hearing aid cordage.

Thomas Electronics, Inc., Passaic, N.J. 4-220 & 221
Cathode-Ray Tubes.

Thompson Products, Inc., Cleveland 3, Ohio Theatre 3-209
Microwave component and accessory equipment, specialized test equipment which include RG-9/U, RG-17/U size Coaxial Switches; with various types of actuators; Lobing Switches; Wavemeters; antennas; and Pattern measuring range systems which are comprised of polar recorders, model support towers, bolometer-crystal amplifiers, monitor amplifiers, and high voltage power supplies.

Thor

STEATITE COMPONENTS
for
ELECTRONIC and ELECTRICAL APPLICATIONS
3-409
THOR CERAMICS, INC.
BLOOMFIELD, N.J.

Thor Ceramics, Inc., Bloomfield, N.J. 3-409
A complete display of STEATITE INSULATORS including bushings, bobbins, stand-offs, machined and metallized components for electronic and electrical applications.

Tinnerman Products, Inc., Cleveland 1, Ohio 3-404 & 405
Speed nuts, speed clips, speed clamps, speed grips and engineered fasteners.

Titeflex, Inc., Newark 5, N.J. 2-308
Microwave components and the Titeflex Connector.

What to see at the Radio Engineering Show

Trad Television Corp.
Asbury Park, New Jersey
Booth 4-419

UHF and VHF step attenuators. Variable frequency power supply. UHF test equipment.

Triad Transformer Corp.
Venice, Calif.
4-602

Input, interstage, output, line matching, plate, power, auto, isolation, pulse, and 400 cycle transformers, hermetically sealed power and audio components, toroids, filters, television components, flyback transformers, yokes, vertical oscillator transformers, vertical output transformers, hermetically sealed terminals and transformer cases.

Transformer & Electronic Specialties Co., Philadelphia, Pa. 4-622
Display of Transformers and Electronic Assemblies manufactured by TRESCO. Canned Transformers Per MIL-T-27. Magnetic Amplifiers. Specialized Electronic Assemblies Canned and Potted Standard Commercial Types Transformers.

The Triplett Electrical Instrument Co., Bluffton, Ohio 2-504
Electrical Measuring Instruments and Radio-TV Test Equipment.

Truscon Steel Co.
Youngstown 1, Ohio
2-322

Radio Towers

Tung-Sol Electric, Inc.
Newark 4, New Jersey
4-715

Electron Tubes, Flashers, Miniature Lamps

George Ulanet Co.
Newark 5, N.J.
4-131

Complete line of Miniature Thermostats and Thermal Timers as well as standard line of Thermal Control Units, Immersion and Air sensitive units. Special Thermostats for all industrial requirements.

Ungar Electric Tools, Inc., Los Angeles 54, Calif. 4-303
Soldering Irons & Soldering Pencils.

(Continued on page 242A)

What to see at the Radio Engineering Show

(Continued from page 241A)

Union Carbide and Carbon Corp. 1-514, 1-516, 518
SEE: Linde air & national carbon.

United Catalog Publishers, Inc., New York 13, N.Y. 3-518
Radio's Master—1220 pages—17th edition, catalogs over 80,000 electronic products with thousands of illustrations, descriptions, and specifications. Eighteen product sections and complete detailed index makes it easy to locate and compare. Radio's Master is the Industry's Official Buying Guide and Reference Book.

University Loudspeakers, Inc., White Plains, N.Y. 3-311
Commercial, Industrial, High Fidelity, and Military loudspeakers. The new Cobreflex-2 wide angle horn, ideal for commercial and high fidelity applications will be introduced.

Vacuum Electronic Eng. Co., New Hyde Park, L.I., N.Y. Booth 4-404
Manufacture Veeco Mass Spectrometer Leak Detector: unexcelled for testing electronic tubes and hermetically sealed equipment. Test tables and manifold for use with leak detectors. High vacuum valves and valve manifolds. Special vacuum equipment such as evaporators, desiccators, impregnators, etc. Couplings, leaks and other vacuum accessories.

Vacuum Metals Corp., Cambridge, Mass. 1-705
Vacuum-cast, high purity, gas-free metals for magnetrons, klystrons, and hydrogen thyratrons.

What to see at the Radio Engineering Show

(Continued from page 242A)

Varian Associates, San Carlos, Calif. 1-617
New production-series klystrons for x-band radar. Advanced nuclear induction instrumetation. 15 kw UHF TV amplifier klystron. Relay, beacon and missile klystrons. The new x-band radar tubes feature extreme ruggedness and frequency stability unaffected by ambient pressure. Leads are molded in silicone rubber for high-altitude and high-humidity protection.

Vector Electronic Co., Los Angeles 65, Calif. 3-515
Tube Sockets, Plugs, Adapters.

(Continued on page 244A)

The following 1952 Exhibitors gave up their space in the interests of MANUFACTURERS who otherwise could not exhibit

• • •

Arrow Electronics

H. L. Dalis

Harrison Radio Co.

Sun Radio and Electronics Co.

Terminal Radio Co.

What to see at the Radio Engineering Show

(Continued from page 243A)

Victoreen Instrument Co., Cleveland 3, Ohio 4-103 & 104
An expanding group of miniaturized components will be displayed to include: Voltage regulators 50 to 15,000 V, new current regulators, new glass sealed resistors 800 Ohms to 10 Megs., vibrators and vibrator power supplies, subminiature electrometer and special purpose tubes, counter tubes, radiation measuring instruments, accelerometers.

Victory Engineering Corporation
Springfield Road • Union, New Jersey
Telephone UNionville 2-7150
3-403
See Thermistors in action! Amplitude control. Time delay. Voltage regulation. Oscillator Stabilization. Surge protection. Air flow measurement. Combustion analyzer. Gas analysis cells. See the actual production of Veco Thermistor Beads, the smallest mass-produced electronic item! Ask for the Veco Data Book.

Vitramon, Inc., Bridgeport 1, Conn. 3-516
Vitramon Capacitors, low-loss, high stability, and wide temperature range.

Waldes Kohinoor, Inc., Long Island City 1, N.Y. 2-127
Truarc Retaining Rings.

Wang Laboratories, Boston 16, Mass. 4-803
Static Magnetic Memory Units and Systems; Shift Register Systems; Digital Signal Generator—A Versatile Instrument for Testing Computers and Data Processing Equipments; Character Display Signal Generator—The Fastest Available Output Device; Pulse Count Converter; Magnetic Constant Charge Device; Frequency Meter; Perma-Memory Multiple Scalers.

Ward Leonard Electric Co., Mt. Vernon, N.Y. 3-113
Vitrohm Resistors in 7 stock types and 11 Made-to Order styles, High current resistors, Load banks, Vitrohm Ring and Plate type Rheostats, A.C. and D.C. Relays, Magnetic Contractors, Motor starters, Controllers, Theatre Dimmers, Chromaster industrial chrome plater.

Waterman Products Co., Inc.
Philadelphia 25, Pa.
1-414
In the field of electronic research and development, Waterman Products is leading the way. The HIGH, WIDE and TWIN Pocketscopes have become the "triple threat" of the oscilloscope industry. Waterman pioneering has brought forth revolutionary rayonic cathode-ray tubes for miniaturized oscilloscopes and continues to lead the way in electronic development.

Waveforms, Inc., New York 14, N.Y. 3-313
Miniature Precision Instruments: Extended-Range Audio Oscillator (18 cycles to 1.2 megacycles; less than 0.2% distortion); Sensitive Voltmeter (1 millivolt full scale; 10 cps to 2 mc); Precision Crystal Calibrator with heterodyne mixer; Audio Curve Tracer (visual display). High Quality Audio Amplifiers and Preamplifier-control Units: Laboratory Instruments: AM-FM Signal Generator (100 kc.-170 mc).

W. M. Welch Scientific Co., Chicago 10, Ill. 2-137
Duo-seal vacuum pumps, capable of .05 micron and better. New totally enclosed belt guards. Dubrovin vacuum gauges and other vacuum accessories.

Western Lithograph Co., Los Angeles, Calif. 1-105
E-Z Code wire identification markers. N.E.M.A. color code markers. TEL-A-PIPE cable, conduit, and pipe markers, Westline contact labels, Breakaway labels hundreds of stock items to solve your coding problems and identification easily and inexpensively.

Visit all four floors!

(Continued on page 246A)

What to see at the Radio Engineering Show

(Continued from page 244A)

Westinghouse Electric Corp., Pittsburgh 30, Pa. 1-610, 612, 614, 616 & 618
Westinghouse will feature Electrical tubes; speciality transformers; hipersil cores; magamps; electrical instruments; circuit breakers; motor starters; thermostats; and fire control demonstration.

Westinghouse Electric Corp., Bloomfield, N.J. 1-610, 612, 614, 616 & 618
Electronic Equipment Components.

Weston Electrical Instrument Corp.
Newark 5, N.J.
4-409 & 411
Service Instruments for Television and Radio—Panel Instruments for electronic equipment—Approved Ruggedized Instruments—Sensitive Relays—New Sealed Relay with core magnet mechanism and built-in solenoid device—D-C Amplifier—Contact Making Instrument—Portable A-C and D-C Instruments.

White Industries, Inc.
New York 19, N.Y.
3-304B
Noise Amplifiers, Pre-Amplifiers, Phase Adapters, Wire Recording Amplifiers and Drive Mechanism, Control Boxes, Noise Measuring Probes, Noise Measuring Antennas, High Fidelity Amplifiers and Preamplifier, Radio Receivers and Transmitters, Transformers, Variable Capacitors, Special Electronic Assemblies, Telemetering Equipment, Tools and Dies, Precision Machine Parts, Electro-Mechanical Development & Engineering, Drafting, Schematics.

Whitso, Inc., 9328 Byron St., Schiller Park, Ill. 4-721
Plastic standoff terminals. New metal hex sub-miniature in addition to large selection of conventional fork and turret types with stud, female, rivet mountings inquiries are invited as to special problems and materials.

Wilkor Div., Cleveland 13, Ohio 1-602
SEE Aerovox Corp.

Wind Turbine Co., West Chester, Pa. 1-508
TRYLON Ladder Towers.

The Workshop Associates, Div. Gabriel Co., Needham Heights 94, Mass. 1-513
UHF-TV Transmitting antennas plus a complete line of Microwave Relay Antennas.

(Continued on page 267A)

The following 1952 Exhibitors gave up their space in the interest of MANUFACTURERS who otherwise could not exhibit

• • •

Arrow Electronics

H. L. Dalis

Harrison Radio Co.

Sun Radio and Electronics Co.

Terminal Radio Co.

STUDENT BRANCH MEETINGS

Bucknell University, IRE-AIEE Branch

"Instrumentation" by Mr. Daniels of Minneapolis Honeywell and "Professional Engineering" by Mr. John West. Sec. Professional Engineering Society Pa.; January 14, 1953.

University of California, IRE-AIEE Branch

"Electromedical Applications" by R. S. Mackay, Faculty, University of California; December 2, 1952.

Nominations Meeting; December 15, 1952.

California State Polytechnic College, IRE Branch

"Engineering and Research Management" by Myrl Stearns, Executive Vice Pres. and General Manager of Varian Associates; December 4, 1952.

University of Colorado, IRE-AIEE Branch

"Recent Developments in Public Utilities" by Mr. W. Pullen, Engineer for General Electric Co.; November 19, 1952.

"What is Ahead for the Engineer" by Mr. E. S. Lee, Engr. for General Electric; December 3, 1952.

Short talks were given by several senior students; December 17, 1952.

The Cooper Union School of Engineering, IRE-AIEE Branch

"Theory of Magnetic Amplifiers" by Mr. I. Kaelish, Student, Cooper Union; December 22, 1952.

University of Dayton, IRE Branch

"Radar Traffic Speed Controller & Municipal Communications Systems" by Mr. Martin Schultz & Mr. Robert Baker, Municipal Signal Division, Dayton, Ohio; November 4, 1952.

"An Executive's Views on Important Points of an Education" by Dr. J. W. Ballard, Head of E.E. Dept., Commonwealth Engineering Co., Dayton, Ohio; November 18, 1952.

"The Electronic Switch" by J. L. Nelson, Student, Dayton Univ.; January 6, 1953.

University of Detroit, IRE-AIEE Branch

"Electrical Controls in the Production of Automobiles" by Bernie Meldrum & J. Strakey, Electrical Engineering Dept., Desoto; December 17, 1952.

Fenn College, IRE Branch

"Saturable Iron Core Reactors and Magnetic Amplifiers" by Mr. H. M. Huge, V.P. and Chief Engineer of Lorain Products Corp., Lorain, Ohio; December 17, 1952.

Illinois Institute of Technology, IRE Branch

Nomination of Officers; January 20, 1953.

Lehigh University, IRE Branch

"The IBM Card-Programmed Electronic Calculator," by Donald J. Glick, Former Mathematician at IBM Vestal Laboratory and General Meeting; December 11, 1952.

University of Maine, IRE Branch

"Opportunities with the National Bureau of Standards" by Mr. Frederick Mitchell, Representative of the National Bureau of Standards; January 14, 1953.

(Continued on page 250A)

STUDENT BRANCH MEETINGS

(Continued from page 248A)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, IRE-AIEE BRANCH

"Latest Developments in the Audio Field" by H. H. Scott, Scott Audio Amp. Co.; December 18, 1952.

"Latest Developments in F.M." by Professor L. B. Argiumbau, Faculty, M.I.T.

MICHIGAN COLLEGE OF MINING AND TECHNOLOGY, IRE-AIEE BRANCH

"Walls Without Welds" Film, U. S. Steel and General Meeting; December 16, 1952.

MISSISSIPPI STATE COLLEGE, IRE BRANCH

"Interoffice Communication" by N. J. Lemberius, Kellog Switchboard Supply Co.; January 8, 1953.

UNIVERSITY OF MISSOURI, IRE-AIEE BRANCH

"Career Seminar Panel Discussion" by H. E. Gove, Union Electric; R. H. Baxter, Bell Telephone Labs; H. D. Sanborn, General Electric; January 13, 1953.

NEW YORK UNIVERSITY (DAY DIVISION) IRE BRANCH

Business Meeting; October 2, 1952.

Film, "Energy in our Business" by Westinghouse; October 9, 1952.

Business Meeting; October 16, 1952.

"Feedback Control Systems" by Prof. C. F. Rehberg, Faculty N.Y.U.; October 23, 1952.

"Lightning Phenomena & Protection Methods" by Mr. D. W. Bodle, Bell Telephone Labs; October 30, 1952.

Business Meeting; November 6, 1952.

Films, "Rocket Instrumentation" and "R. F. Induction Heating"; November 13, 1952.

Film, "Proving Grounds" by Westinghouse; November 20, 1952.

"Transistors & Semiconductors" by Messrs. Kirtcher & Grossman, Bell Telephone Labs; November 21, 1952.

Film, "Electronics"; December 4, 1952.

"Microwave Techniques" by Mr. Dominco, Griffis Air Base; December 8, 1952.

Films, "Submarine Cable" and "Distribution System"; December 11, 1952.

Film, "Paper-impregnated Cable"; December 18, 1952.

Film, "Circuit Breakers" and "Commutation in d-c machines" by Westinghouse; January 8, 1953.

NORTHEASTERN UNIVERSITY, IRE-AIEE BRANCH (DIV. B)

"Transistors" by Mr. George Harford, New England Telephone & Telegraph Co.; December 11, 1952.

"Servo Mechanisms" by C. D. Burdick, Sperry Gyroscope Company; December 18, 1952.

"The Electron" (motion picture); December 23, 1952.

"Films," "Radar Equipment," "Synchro Systems," "The Jet Story," General Electric and U. S. Navy Public Information Office, Boston, Mass.; December 30, 1952.

"Electric Power Engineering" by Professor Chester Dawes, Prof. Electrical Engineering, Harvard University" January 8, 1953.

OHIO STATE UNIVERSITY, IRE-AIEE BRANCH

"Installation of an Underground Transmission Line" by Mr. Campbell, Columbus & Southern Ohio Electric Co.; December 4, 1952.

"Advantages & Disadvantages of Big and Small Business" by 4 representatives of Columbus Industries; January 13, 1953.

STUDENT BRANCH MEETINGS

Oregon State College, IRE Branch

"Some American Rivers and Their Utilization" by Dr. C. A. Mockmore, Faculty, Oregon State College; November 13, 1952.

"Germanium The Magic Metal" (A tape recorded program with 75 slides); January 8, 1953.

University of Pittsburgh, IRE Branch

"Uses of Electronics in Research" by Mr. A. Peterson, Mellon Institute; December 18, 1952.

Rutgers University, IRE-AIEE Branch

"Generation, Transmission and Distribution of Power" by H. W. Phillips '24, Philadelphia Electric Co., John Betz '37, Public Service Gas & Electric Co. and Rodney P. Gibson '28, Public Service Generation Co.; December 18, 1952.

San Diego State College, IRE Branch

Film, "Air Navigation" by Collins Radio Company; January 13, 1953.

"Aspects of Printed Circuits, their Design, Production and Uses" by Mr. McDonald, Digital Controls Systems, Inc. of La Jolla; January 15, 1953.

South Dakota School of Mines and Technology, IRE Branch

General Business Meeting and Films, "Radio Waves" and "Radio Antennas"; December 18, 1952.

Film, "Walls without Welds" by U. S. Steel; January 8, 1953.

University OF Texas, IRE-AIEE Branch

"Realism in Reproduced Sound" Discussion of student paper contest; December 15, 1952.

Election of Officers; January 12, 1953.

Tufts College, IRE-AIEE Branch

"Applications of Engineering in Industry" by Mr. Fred Snider, Westinghouse Electric Corp.; January 13, 1953.

University of Utah, IRE-AIEE Branch

Films on Electric Measuring Instruments by Philip Weinberg and Charles Alley, Advisers; January 8, 1953.

University of Washington, IRE-AIEE Branch

Film, "Construction of McNary Dam" by the Corps of Engineers; November 6, 1952.

General Meeting; November 13, 1952.

Field Trip to the Pacific Telephone & Telegraph Co., Seattle; November 15, 1952.

"Germanium the Magic Metal" (a transcribed lecture with slides) by the General Electric Co., November 28, 1952.

Wayne University, IRE-AIEE Branch

"A Panel Discussion of Curriculum" by Mr. C. S. Lawrence, Pres. Electronic Control Co., Melvin Cole, Pres. EE Wayne Alumni Assoc., Howard Hess, Head of EE Dept. at Wayne and Dr. Schoonover, Ass't Dean and Election of Officers; December 11, 1952.

Yale University, IRE-AIEE Branch

"Digital Computers" by J. Presper Eckert, Director of Engineering, Remington-Rand Corp.; January 8, 1953.

MEMBERSHIP

The following transfers and admissions were approved to be effective as of March 1, 1953:

Transfer to Senior Member

Allerton, G. L., R.F.D. 4, Allentown, Pa.
Ayres, W. R., 311 W. Oakland Ave., Oaklyn 6, N. J.
Benham, T. A., Haverford College, Haverford, Pa.
Biggs, J. A., 725-19 St., S.E., Cedar Rapids, Iowa
Chenery, P. J., 339 Highbrook Ave., Pelham 65, N. Y.
Crispell, H. L., 720 Cornish Dr., San Diego 7, Calif.
DeMinco, A. P., c/o W. Leyden Stage, Lee Center, N. Y.
dePasquale, R. H., Windy Hill, 700 West St., Harrison, N. Y.
Fischer, L. G., 200 Gold St., Apt. 11-N, North Arlington, N. J.
Elbinger, L. P., Illinois Institute of Technology, Electrical Engineering Department, 3300 S. Federal, Chicago 16, Ill.
Gissing, H. R., c/o Northern Electric Co., Ltd., 65 Rorie St., Winnipeg, Man., Canada
Haefner, S. J., 109 Ridgewood Ave., New London, Conn.
Harvey, G. L., 196 Horton Hwy., Mineola, L. I., N. Y.
Horne, C. F., 222 Virginia Ave., Alexandria, Va.
Howell, F. S., 313-B Tyler St., China Lake, Calif.
James, R. L., 1830 Shaftesbury, Dayton, Ohio
Leger, R. M., MTD. R.F.D. 2, Palatine, Ill.
McGaughan, H. S., 502 Coddington Rd., Ithaca, N. Y.
Mizell, M. H., 501 Avondale Ave., West Los Angeles 49, Calif.
Nelson, N. A., 310 Lewiston Rd., Dayton 9, Ohio
Pleasure, M., 3713-74 St., Jackson Heights 72, L. I., N. Y.
Porter, N. E., 1585 Edgewood Dr., Palo Alto, Calif.
Ratts, B. H., 2506 Terrace Rd., Fort Wayne 3, Ind.
Rowe, D. E., 3617 School St., Riverside, Calif.
Rosenberg, P., 100 Stevens Ave., Mount Vernon, N. Y.
Ryan, C. M., USN, U. S. Naval Postgraduate School, Monterey, Calif.
Scheiner, S. R., 3917 Wabash Ave., Baltimore 15, Md.
Seeberger, L. M., 541 Park Dr., Woodbury, N. J.
Shepard, B. R., 201 Alexander Ave., Scotia 2, N. Y.
Skipper, L. C., 5 Warner Ave., Roslyn Heights, L. I., N. Y.
Trittenbach, J. M. P., 2106 Berwyn Ave., Chicago 25, Ill.
Webb, H. D., 812 W. Delaware Ave., Urbana, Ill.
White, E. S., 194-01 B 64 Cir., Fresh Meadows 65, L. I., N. Y.

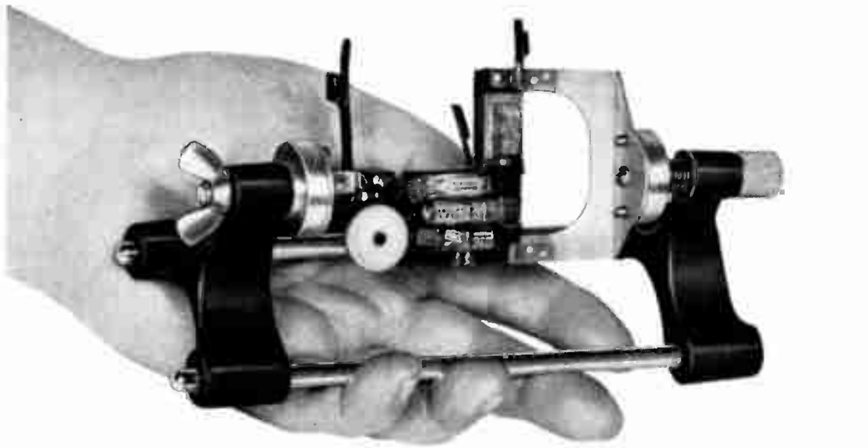
Admission to Senior Member

Gallo, P., 66 W. Chestnut Ave., Merchantville, N. J.
Head, H. T., 342 Munsay Bldg., Washington 4, D. C.
Kent, G. J., 145 West 86 St., New York 24, N. Y.
Pfleger, K. W., c/o Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.
Pinciroli, A., Istituto Ellettrotecnico Nazionale, "Galileo Ferraris," Corso Massimo d'Azeglie, 42, Torino, Italy
Shoaf, J. R., 11, 22 E. Browning Rd., Collingwood 7, N. J.
Sonnenfeldt, R. W., Apt. 266B, Haddon Hills, Haddonfield, N. J.
Sterner, J. F., 206 E. Buttonwood St., Wenonah, N. J.
Yarbrough, J. E., Orlando Broadcasting Co., Inc., Box 3707, Orlando, Fla.
Zenor, H. M., Box 7415, Houston 8, Tex.

Transfer to Member

Bassler, S. G., 43 Sixth Ave., Long Branch, N. J.
Bartholomew, R. G., 526 W. Broad, Quakertown, Pa.
Bellor, W. F., 186 Dorsey Rd., Rochester 16, N. Y.
Boyle, H., 89C Nithdale Rd., Plumstead, London S.E. 18, England
Bright, R., Jr., 44 Beaver St., New York 4, N. Y.
Eckert, J. A., Jr., 5514 Ruthelen St., Los Angeles 62, Calif.
Evans, R. J., 4133 Lake Lansing Rd., East Lansing, Mich.
Kreis, R. J., 508 Chatham, Columbus 14, Ohio
Kuehn, R. L., 437 Broad Ave., Palisades Park, N. J.
Ladof, L. G., 2023 Cecilia Pl., Seaford, N. Y.
Langevin, R. Z., 703 S. View Way, Redwood City, Calif.
Lee, R. E., 205A Entwistle St., China Lake, Calif.
Linhardt, R. J., 57 Van Breeman Dr., Clifton, N. J.
Lowe, M. H., 1941-82 St., Brooklyn 14, N. Y.
Mahurin, C. R., 2131 Byron St., Palo Alto, Calif.
Nissen, J. H., 1057 Stratford Ave., New York 72, N. Y.
Pattenson, C. F., 3 Braemer St., Ottawa 2, Ont., Canada
Pollack, P., 5668 Montezuma Rd., San Diego 15, Calif.
Rogers, C. E., Jr., 717 Santander Ave., Coral Gables 34, Fla.
Ropa, R. L., 115-19 St., Hermosa Beach, Calif.
Schwartz, L. J., 823 Doughty Ave., Franklin Square, L. I., N. Y.
Sheffield, A. G., Box 22 Woodroffe, Ottawa, Ont., Canada
Skillman, B. D., 4957 University Ave., San Diego 5, Calif.
Spooner, A. J., 1415 Westwood Blvd., Oklahoma City 8, Okla.
Trock, R., 251-37-71 Ave., Bellerose, L. I., N. Y.

(Continued on page 254A)



MEMBERSHIP

(Continued from page 253A)

Trueblood, D. B., 911 N. Rudolph St., Goldsboro, N. C.
Viener, A. H., 3817 Stokes Dr., Baltimore 29, Md.
Votava, V., Box 277, Griffiss AFB, Rome, N. Y.
Wilkinson, J. E., 410 W. First St., Dayton 2, Ohio

Admission to Member

Ahlgren, W. E., 192 Elm St., San Carlos, Calif.
Alter, A. C., Via Tor Fiorenza 28, Rome, Italy
Andersen, E. A., 2256 San Francisco Ave., Long Beach 6, Calif.
Ashley, A. B., 4913 N. Miller, Oklahoma City 12, Okla.
Black, E., 1701 N.W. 35, Oklahoma City 6, Okla.
Bradley, W. H., 1226 Beechview Dr., S.E., Atlanta, Ga.
Brown, A. C. L., 1641 Ridge Ave., Evanston, Ill.
Burdick, G. E., c/o New England Conservatory of Music, 290 Huntington Ave., Boston, Mass.
Carter, G. E., Jr., Bomac Laboratories, Inc., Salem Rd., Beverly, Mass.
Delk, E. T., 1627 N. Belmont, Wichita 14, Kans.
Ebert, H. K., Jr., Blacksburg, Va.
Fonseca, N. J., A/C Apartado 3276, Caracas, Venezuela, S. A.
Garon, R. J., c/o Wyle Laboratories, 340 E. Franklin, El Segundo, Calif.
Gladding, E. B., USN, 6000 Benalder Dr., Fairway Hills, Washington, D. C.
Griffin, P. W., Third and Elm St., Dunn Loring, Va.
Hadady, R. E., Audio & Video Products Corp., 261 Constitution Ave., N.W., Washington 1, D. C.
Hardesty, G. A., 820 Robinson St., West Lafayette, Ind.
Heuer, C. H., 1095 Merrill St., Winnetka, Ill.
Hoag, D. S., R.F.D. 1, Schuylerville, N. Y.
Horowitz, L. A., 27-B Parkway Apts., Haddonfield, N. J.
Howe, J. K., 7344 N. Odell Ave., Chicago 3, Ill.
Howell, E. K., 209 Marilyn Ave., North Syracuse, N. Y.
Jahren, A. S., Jr., 282 Linden Ave., Dayton 3, Ohio
Jones, R. M., 821 N.W. Seventh St. Rd., Miami 36, Fla.
Keller, J. W., Jr., 126 Forrester St.. S.W., Washington 20, D. C.
Kidwell, N. E., 6 Middle Dr., Windsor Locks, Conn.
Kilham, L. F., 140 Main St., Concord, Mass.
King, R. C., 176 Hedge Rd., Menlo Park, Calif.
Kinney, E. S., 2500 Maywood Ave., San Jose, Calif.
Lamont, K., 116 Crystal Palace Park Rd., Sydenham, London S.E. 26, England
Lanning, W. C., 30 Relda St., Plainview, L. I., N. Y.
Latham, C., Air Service Training, Ltd., Technical Training College, Jalahalli, Bangalore, Mysore State, India
Lazecki, S., 937 Hare Ave., Box 3, Westboro, Ottawa, Ont., Canada
LeGendre, V., 432 W. Colfax Ave., Roselle Park, N. J.
Levy, G. I., Caixa Postal 8026, Sao Paulo, Brazil
Long, R. G., 21 Clive Rd., Scarborough Bluffs, Ont., Canada
Lubbert, G. L., 5609 Merville Ave., Baltimore 15, Md.
MacAdam, J. F., Box 132-W, Oklahoma City, Okla.
Mass, J., Box 1, Kiryat Motzkin, Haifa, Israel
Miller, M. D., 3618 Mossman, Wichita 6, Kans.
Nord, G. L., 4500 Alpine Ave., Cincinnati 36, Ohio
O'Kelley, H. E., 22-A Graves Apts., Auburn, Ala.
O'Meara, J. P., Southwest Research Institute, 8500 Culebra Rd., San Antonio 6, Tex.
Olson, H. M., 26 Hillside Ave., Cedar Grove, N. J
Perrier, J. F., Bldg. 3, Apt. 2B, Jacob Ford Village, Morristown, N. J.

(Continued on page 256A)

MEMBERSHIP

(Continued from page 254A)

Pollack, M., 3096 Brighton Sixth St., Brooklyn 35, N. Y.
Powell, N. E., 106-A South Cornell, Albuquerque, N. Mex.
Roberts, J. G., "Little Meadow," 40 Barrow Bridge Rd., Bolton, Lancs., England
Roggenstein, E. O., 140 Main St., Box 683, Norwalk, Conn.
Sakamoto, T., Electrical Engineering Department, University of Tokyo, Bunkyo-ku, Tokyo, Japan
Samsky, B. S., 588 North Broadway, Saratoga Springs, N. Y.
Schreiber, E. J., 2339 Elsmere Ave., Dayton 6, Ohio
Scull, J. R., 1325 N. Wilson Ave., Pasadena 6, Calif.
Shoaf, J. H., 2923 Weisman Rd., Silver Spring, Md.
Smith, H. C., McKinley High School, King St., Honolulu, Hawaii
Spanier, B., 5201 D Blanco St., El Paso, Tex.
Taylor, W. G., 2117 S. Curtis Alhambra, Calif.
Tyron, J. G., 191 Hillside Ave., Chatham, N. J.
Vangunten, L. F., 2323 Eden La., Dayton 3, Ohio
Watstein, J. I., 7937 Essex Ave., Chicago 17, Ill.
Wertman, R. C., 442 Hamilton Pl., Hackensack, N. J.
Wood, R. M., 4458 Tiedeman Rd., Brooklyn, Cleveland 9, Ohio

The following elections to the Associate grade were approved to be effective as of February 1, 1953:

Alcott, E. H., 179-06 Anderson Rd., Springfield Gardens, L. I., N. Y.
Allen, C. F., Box 3054 USAFIT, Wright-Patterson AFB, Ohio
Alman, J., 401 Helen St., Vestal, N. Y.
Alsabrook, C. M., 113 James St., Burlington, N. C.
Amedeo, P., 42-22-161 St., Flushing, L. I., N. Y.
Appelbaum, G., 367 E. 48 St., Brooklyn, N. Y.
Axford, W. R., 215 Weldy Ave., Oreland, Pa.
Ayer, W. T., Radio WBEC, 30 Eagle St., Pittsfield, Mass.
Baker, A., Raytheon Manufacturing Co., 148 California St., Newton 58, Mass.
Baker, M. L., 403 Landfair Ave., Los Angeles, Calif.
Balugo, J. J., 707 E. 89 St., Los Angeles 2, Calif.
Barres-Barreto, L. A. G. C., Inst. Tecno. De Aero., S. Jose Des Campos, Est. S. Paulo, Brasil
Barrowcliff, T. A., 406 Grover Cleveland Hgwy., Buffalo, N. Y.
Bastian, A. L., 7 Burbank St., Yonkers, N. Y.
Belcher, R. D., 82 Railroad Ave., Valhalla, N. Y.
Bell, R. W., 576 Center Dyre Ave., West Islip, L. I., N. Y.
Bentivegna, M. J., 65 Coit St., Irvington 11, N. J.
Bergeron, W. F., 4 County St., Ipswich, Mass.
Berlin, J., 1832-64 St., Brooklyn, N. Y.
Bickel, S. O., 2201 Riedmiller Ave., Fort Wayne, Ind.
Blair, D. R., 180 S. Alvardo St., Los Angeles, Calif.
Blumenberg, A., 66 Pinehurst Ave., New York, N.Y.
Bode, G. F., 1302—18 St., N.W., Washington, D. C.
Bondarenko, A. J., 333 Jackson Ave., New York, N.'Y.
Boyd, C. H., Box 512, Grand Rapids, Mich.
Brett, C. F., 5622 E. Sewells Point Rd., Norfolk 13, Va.
Brinker, H., 60—48 Woodbine St., Ridgewood, L. I., N. Y.
Bryson, V. E., 7315 Fairchild Ave., S.E., Albuquerque, N. Mex.
Buehler, 10150 Dallas Ave., Silver Spring, Md.
Burdick, D. D., 484 Richmond Ave., Buffalo 22, N. Y.
Caldwell, Burn Brae, Clifton Heights, Pa.
Candiotti, J., 201 S. Fourth St., Brooklyn, N. Y.
Castown, R. W., 142 Manhattan Ave., New York, N. Y.

(Continued on page 258A)

MEMBERSHIP

(Continued from page 256A)

Cesario, D. J., 2739 Sheffield Ave., Chicago, Ill.
Cheeseman, P. R., Palmer Physical Laboratory, Princeton University, Princeton, N. J.
Chowdary, T. H., Control Room, Broadcasting House, New Delhi, India
Churchon, S. P., 2104 Lyon Ave., Belmont, Calif.
Clee, L. W., 2110 W. Olmos Dr., San Antonio 1, Tex.
Coachman, J. E., 8 Roosevelt Rd., Maplewood, N. J.
Cohen, L. A., 357 E. 95 St., Brooklyn, N. Y.
Conrad, R. W., Box 212, Weston 93, Mass.
Cool, P. E., R.F.D. 1, Medway, Ohio
Cooper, J. I., 135 Winding Way, San Carlos, Calif.
Cora, A. M., Jr., 1220 N. Broad St., Philadelphia, Pa.
Cordray, R. E., 20 Oak Ter., Neptune City, Avon, N. J.
Crane, P. H., 421 W. 21 St., New York 11, N. Y.
Creacy, J. N., 2308 Roberts St., Wichita Falls, Tex.
Cullom, J. H., 4708-B Gateway Ter., Baltimore, Md.
Davis, J. L., Box 907, Pasadena, Tex.
Delp, R. H., Redstone Arsenal, Huntsville, Ala.
Dite, W., 18 Manhattan Ct., Nutley 10, N. J.
Dodgson, J. G., 5406 Hamilton St., Apt. 3, Rogers Heights, Md.
Donat, O. E., Keystone Products Co., 904—23 St., Union City, N. J.
Doty, W. E. N., Development and Research Department, Continental Oil Co., Ponca City, Okla.
Dunn, C. J., 6 Greenmeadow Rd., Tuckahoe 7, N. Y.
Eames, F. M., Jr., 4920 Dinsmore Rd., Dayton, Ohio
Eckess, W. S., Jr., 1300 Oakland Rd., N.E., Apt. 1408, Cedar Rapids, Iowa
Edwards, D. F., Box 3133, USAFIT, Wright-Patterson AFB, Ohio
Edwards, J. M., Southwestern Bell Telephone Co., 900 W. Fifth St., Little Rock, Ark.
Elders, D. S., 14 James St., Englewood, N. J.
Elkins, R., 88-28—188 St., Hollis, L. I., N. Y.
Elliott, W. S., R.F.D. 2, Cedar Rapids, Iowa
Fierstein, J. H., 329 Wister St., Philadelphia, Pa.
Frank, J., 105 Winthrop St., Brooklyn 25, N. Y.
Fritsche, A. J., 424 E. 52 St., New York, N. Y.
Gardner, R. A., 733 W. Vineyard, Anderson, Ind.
Gensel, W. L., 1309 Northup Rd., Drexel Hill, Pa.
Gessner, R. J., 4619 Ninth St., N.W., Washington, D. C.
Gignoux, F. E., 2515 Massachusetts Ave., N.W., Washington, D. C.
Gillis, J. F., Box 296, Hartsdale, N. Y.
Goff, W. S., Jr., Box 3151, USAFIT, Wright-Patterson AFB, Ohio
Goldberg, O. D., 20 Springate St., Utica 4, N. Y.
Goldberg, S. R., 306 Terrace Ave., Hasbrouck Heights, N. J.
Goodwin, J. W., 2123 Guilford Rd., Hyattsville, Md.
Guyton, R. D., 5109 Flagstone Dr., Fort Worth, Tex.
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Hartzell, R. A., Box 3166, USAFIT, Wright-Patterson AFB, Ohio
Hayden, H. P., Box 2902, Baltimore, Md.
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Hibbard, H. C., 1347 S. Florence, Tulsa 3, Okla.
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(Continued on page 260A)

MEMBERSHIP

(Continued from page 258A)

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Hollepeter, W. C., 6620 Elmer Ave., North Hollywood, Calif.
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Hurley, L., 2736 Rosemont, Shreveport, La.
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Kiciak, C. J., 8316 Manistee Ave., Chicago 17, Ill.
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Long, J. A., Squawbuck Rd., Columbia City, Ind.
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(Continued on page 262A)

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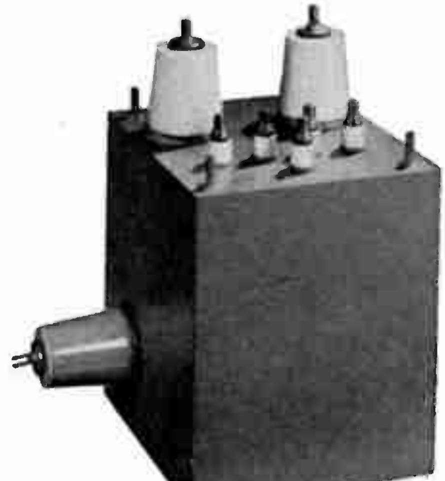

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(Continued on page 264A)

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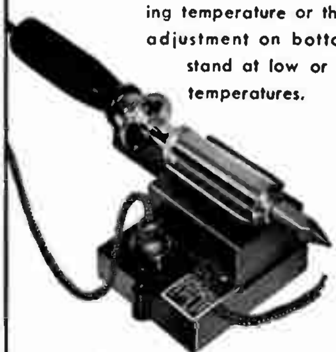

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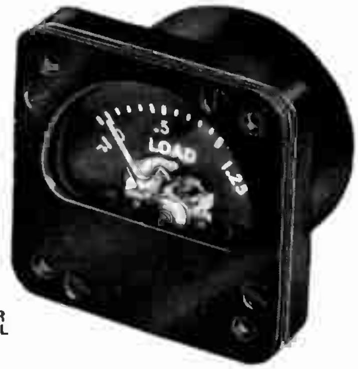

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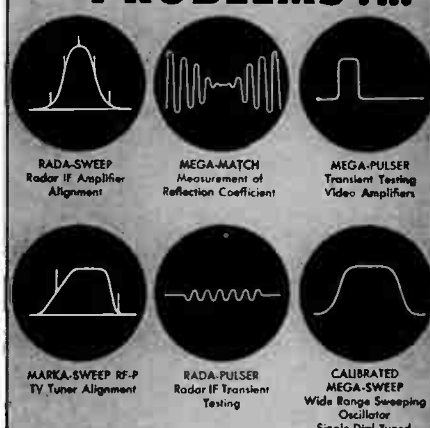

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Thompson, R. E., 424 Stambaugh St., Redwood City, Calif.
Thormahlen, W. H., 1044 Berkeley Ave., Menlo Park, Calif.
Thorp, H. R., Box 3285, USAFIT, Wright-Patterson AFB, Ohio
Trigg, R. J., 47 Elthorne Park Rd., London W. 7, England
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Whipple, M. M., 700 Delay Dr., Eugene, Ore.
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Williams, L. D., 1800 AACS Wing, Tinker AFB, Okla.
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Witkowski, A. J., Jr., 6 Norfolk St., Hartford, Conn.
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Woolley, P. V., 2406 Lake Ave., Cheverly, Md.
Wurthmann, G. E., 169 Main St., Matawan, N. J.
Young, J. K., Box 3402, USAFIT, Wright-Patterson AFB, Ohio
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Zieger, J. A., Box 864, Denville, N. J.

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

Power Supply

The Type 200 Low-Voltage Power Supply, a highly regulated unit for use with resistance strain-gage elements, and for similar exacting applications has been developed by **Owen Labs.,** 9130 Orion Ave., San Fernando, Calif.

Output is 1 ampere maximum, at from zero to 15 volts dc. Where absolute freedom from drift is required, a small chopper-amplifier provides precise stabilization against an external reference. The supply may be rack mounted.

(Continued on page 265A)

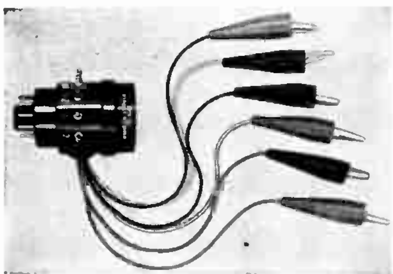
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 264A)

CRT Dynamic Analyzer

Electronic Beam Corp., 923 Old Nepperhan Ave., Yonkers 3, N. Y., announces the production of their new CRT Dynamic Analyzer which attaches to any VTVM and converts it into a CRT tester. According to the manufacturer, it is the only instrument that checks both set and tubes under actual operation.

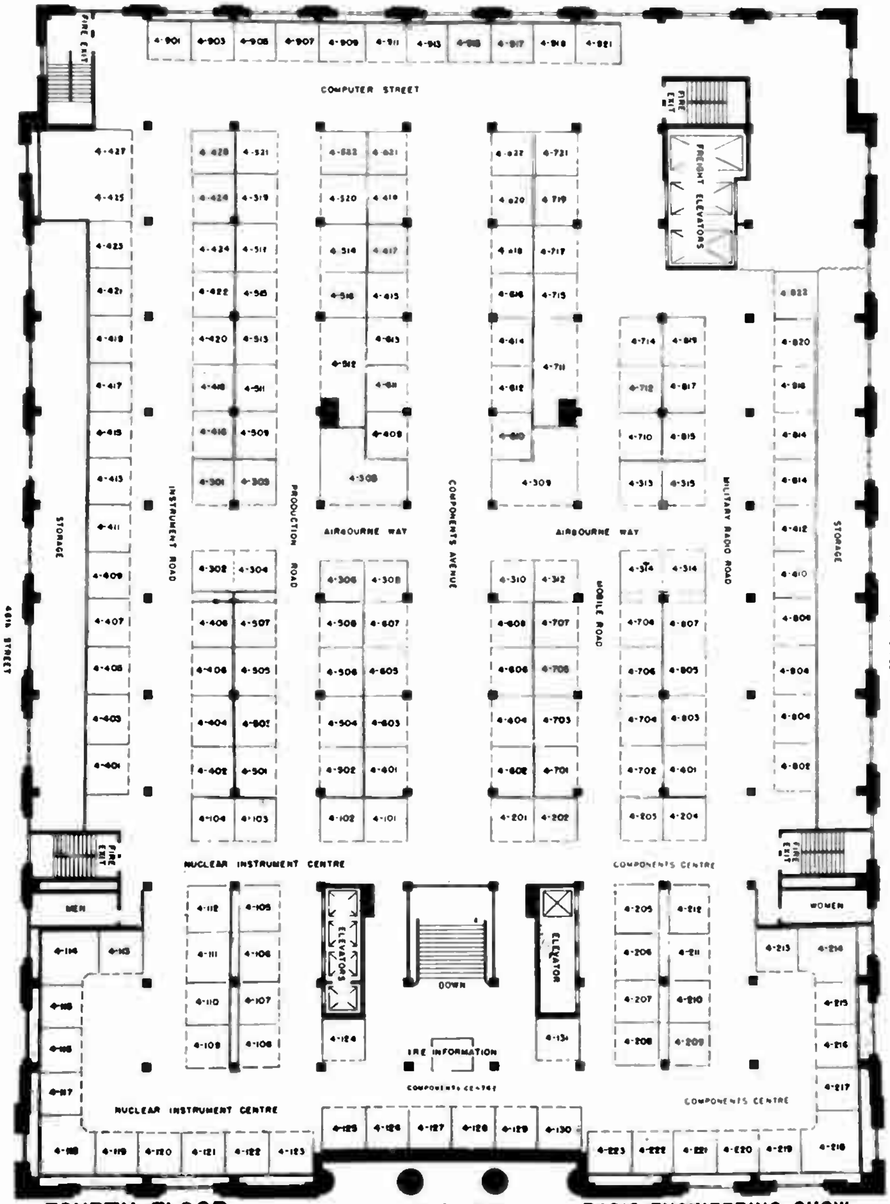


The instrument checks all socket voltages of a TV set while in operation, and checks emission of the CR Tube and gives the related emission reading. (The related emission reading is the only reliable one that eliminates the errors encounted with readings on other type testers.) It also checks CR Tubes for open and shorted elements, and leakage.

(Continued on page 268A)

What to see at the Radio Engineering Show

(Continued from page 246A)



FOURTH FLOOR **RADIO ENGINEERING SHOW**

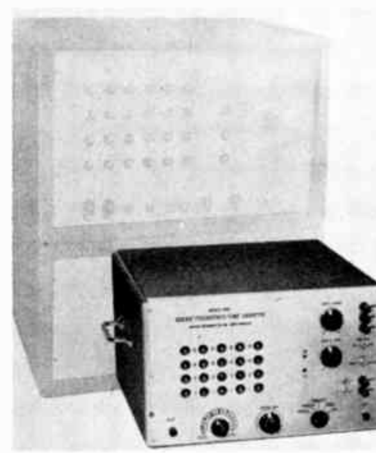
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 265A)

Frequency-Timing-Counting Equipment

With the introduction of four new models, a very complete line of frequency-counting equipment is announced by the **Potter Instrument Company, Inc.,** 115 Cutter Mill Road, Great Neck, L. I., N. Y.



The Model 820 and 830 Frequency Counters suit the production line and are useful for calibrating oscillators, for measurement of flow and pressure with appropriate pickup device, and for obtaining rpm data on engine test stands, among other applications.

Much greater versatility is featured in the Model 840 and 850 Frequency-Time-Counters, which contain all the timing, gating and switching facility necessary for the widest possible range of measurement functions. These include direct counting of frequencies up to 1 mc or timing the period of a cycle with 10 μsec. Elapsed time is measurable in increments variable from 10 μsec up to one second. Two unknown frequencies can be compared to obtain a ratio or an external standard introduced for a higher accuracy time base. For use as a secondary frequency standard outputs are provided from a divider at 100 kc, 10 kc, 1 kc, 100 cps, 10 cps and 1 cps.

Plant Expansion

Dorne and Margolin, 30 Sylvester St., Westbury, L. I., N. Y., an electronics firm specializing in high-frequency antenna development, have moved to a new and larger plant in Westbury, New York. The new plant was designed to provide expanded research and production facilities Versatile pattern and impedance-measurement facilities are currently available with particular emphasis on applications for airborne electronics.

(Continued on page 271A)

News—New Products

(Continued from page 268A)

Audio Amplifier

A new precision audio amplifier combining unusually low signal-to-noise and distortion factors with high power output has been announced for laboratory measurement application by **Summit Electronics, Inc.,** 7 Industrial Pl., Summit, N. J. The equipment is available in several models for varying input impedance requirements, while output impedance is switch controlled from 4 to 600 ohms in all models.

Employing negative feedback on all stages, the new amplifier offers extremely stable characteristics. Distortion is less than 1 per cent at the full rated output of 30 watts, while frequency response is exceptionally flat over a 30 cps to 15 kc range; with a high impedance input the response is flat ±0.2 db over the entire range and similarly low variances are encountered when bridging or terminating low impedances are used.

The amplifier is sold only by the manufacturer at a price of $150 f.o.b. with no input transformer. For balanced operation with an input transformer there is an additional charge of $15.00.

Medium-Mu Twin Triode

Tube Dept., Radio Corp. of America, Harrison, N. J., has developed the 6211, a new medium-mu twin triode of the 9-pin miniature type designed especially for frequency-divider circuits in electronic computers and other "on-off" control applications involving long periods of operation under cutoff conditions.

For such control service, the 6211 maintains its emission capabilities even after long periods of operation under cut-off conditions and, therefore, provides good consistency of plate current during its "on" cycles.

The 6211 has separate terminals for each cathode to facilitate flexibility of circuit arrangement, and a mid-tapped heater to permit operation from either a 6.3-volt or 12.6-volt supply. The heater is made of pure tungsten.

(Continued on page 272A)

News—New Products

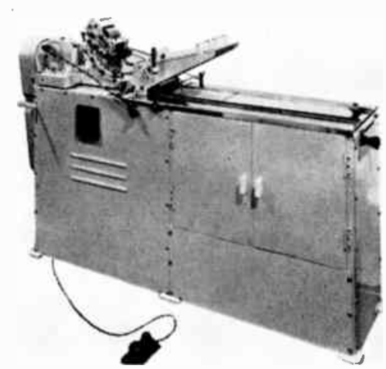
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 271A)

Marking Machine

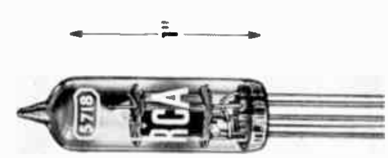
Popper & Sons, Inc., 300 Fourth Ave., New York 10, N. Y., distributors for Rejafix, Ltd., are bringing out the latest model of a fully automatic marking machine.

This machine will print on cylindrical objects such as capacitors, relays, condensers, controls, electronic valves, etc., at a speed of up to 6,000 pieces per hour. Whether the components are made from glass, plastics, metal, or cardboard, etc., the prints will come out with greatest accuracy down to the minutest letterings.



Other Rejafix models will handle objects regardless of shape, whether they are round, tapered, rectangular, or flat. One of the outstanding features of Rejafix machines is the very fast exchange of printing type or plates, which permits the use of frequent changes in code numbers and specifications.

Medium-Mu Triode



Tube Dept., Radio Corp., of America, Harrison, N. J., has a new type 5718, a medium-mu subminiature triode designed for use as an RF power amplifier and oscillator in uhf applications where dependable performance under shock and vibration is a prime consideration. It is capable of giving a useful power output of nearly 1 watt at 500 mc. Operation with full input is permissible up to 1,000 mc.

Because of its high transconductance, the 5718 is suitable for use in cathode-follower, multivibrator, and blocking-oscillator circuits. It is also useful as a resistance-coupled amplifier.

(Continued on page 274A)

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 272A)

Tester-Reactivator-Sparker

Transvision, Inc., Dept. DG-3, New Rochelle, N. Y., has released to the television industry its new 6-pound CR Tube Tester-Reactivator-Sparker. This portable instrument is a complete testing and repair unit, self-powered, and completely self-contained. A three-fold function of the instrument is as follows: as a tester, it measures cathode emission, locates shorts between elements, and locates high resistance shorts or leakage as high as 3 megohms; it indicates whether the tube has lost or is losing its vacuum; as a reactivator, the unit can save many dim, worn-out tubes. (The reactivation can be done without removing the picture tube from the TV set.)

In most cases the reactivation is complete and permanent, amounting to a virtual rejuvenation, light emission increases, brightness goes up, and detail is enlivened, which is ideal for new tubes which have lost brightness from prolonged shelf life. This instrument is very effective for aging-in such new tubes.

This unit sparks out electrical leakage which very often develops in picture tubes and makes them inoperative.

Unlike devices used for "flashing" the filament, or permanently raising the filament temperature for temporary relief, this instrument gives a full complex reactivation complete with short aging cycle.

The tester is priced at $34.95 net.

Carbon Film Resistors

The Chase Resistor Co., 9 River St., Morristown, N. J., announces the beginning of production of two high-stability carbon film resistors. For maximum stability these are sealed in glass envelopes, evacuated, baked at high temperature under vacuum, and finally sealed in helium of spectroscopic purity. These units are stable to 0.01 per cent under all environmental conditions, and have long time drift of 0.01 per cent per year or less. They can be supplied in networks with ratios and temperature coefficients held to very close tolerances.

(Continued on page 275A)

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 274A)

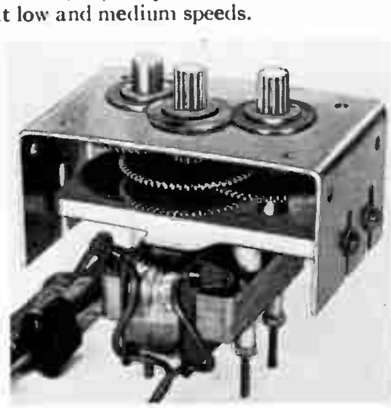
Less expensive units are made by solder-sealing resistors in ceramic tubes with metallized ends. The stability of these is less than that of the glass-helium sealed

resistors, but much better than that of varnished resistors, particularly under conditions of high humidity and temperature. Delivery of these in large quantities has begun, with delivery schedules at present of 3 to 4 weeks.

Inquiries for prices on special orders to your specification will be answered promptly. Free literature and sample card for physical dimensions are available upon request on your company stationery.

Geared Motors

General Die & Stamping Company, 262 Mott St., New York 12, N. Y., has developed geared motors that can be supplied with single or multiple shafts, permitting the use of any one, or combination, of a number of speeds from 1 rpm to 1,150 rpm. The shaft diameter is 7/16 inch, while the dimensions are $3\frac{1}{4} \times 4\frac{5}{8}$ inches $\times 3\frac{1}{4}$ inches. The motors operate on 110/120 volts ac, 50/60 cps, and have great torque at low and medium speeds.



Standard attachments, such as pistons, bushings, belt pulleys, adaptor plates, and extension shafts are available for the motors, and special attachments and gearing can be supplied if quantity warrants.

The uses of the geared motors include valve controls, electric control drives, sign flashers, remote control devices, current interrupter, industrial mixers, water circulators, etc.

The basic motor also is available, stripped, without gears or bracket, with a shaft speed of 3,000 rpm. Dimensions are $2\frac{1}{8}$ inches $\times 3\frac{1}{8} \times 2$. The shaft length is $\frac{5}{8}$ inch, and the diameter is 3/16 inch.

A catalog page illustrating and describing the entire series of Kasson motors is available upon request to the company.

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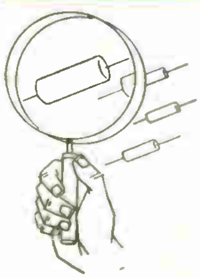

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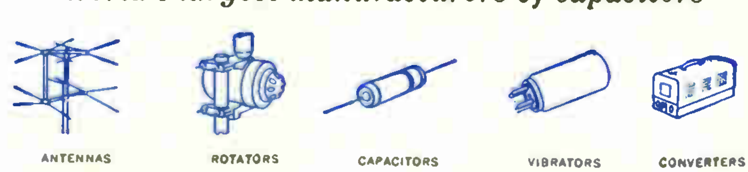

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