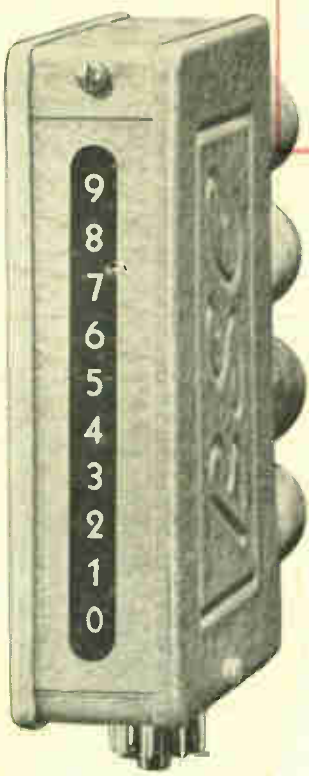
APRIL · 1953

Proceedings of the I·R·E

DIRECT DIGITAL DISPLAY



Berkeley Scientific Corp.

Development of high-speed (to 1,000,000 cps) electronic counting units capable of displaying results in digital form permits use of direct-reading digital instruments for precise frequency measurement, interval timing, tachometry, measurement of pressure, temperature, flow, viscosity.

Volume 41 Number 4

IN THIS ISSUE

Radio Progress During 1952
Admittance Diagrams in Oscillator Analysis
IRE Standards on Sound Recording
Reliability of Airborne Electronic Components
Noise in a Microwave Amplifier
Characteristics of Picture Tubes
Shaping and Filtering Networks
Characteristics of Single-Layer Coils
Abstracts and References

To order your 1953 Convention Record see page 554 for information.

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The IRE Standards on Sound Recording and Reproducing: Methods of Measurement of Noise, 1953, appear in this issue.

The Institute of Radio Engineers

for MINIATURIZED COMPONENTS

from STOCK

The constant miniaturization of military and portable civilian gear has required audio components of smaller and smaller dimension. This is particularly exaggerated in the case of transformers for use in transistor circuits. The "H" series of miniature and sub-miniature units described below are hermetic military types to cover virtually all audio applications. For even smaller structures our ultra-miniature types are available against quantity orders.

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

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.

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

SPECIAL

ULTRA-MINIATURE UNITS TO SPECIFICATIONS ONLY

UTC ultra-miniature units are uncased types of extremely small size. They are made to customers' specifications only, and represent the smallest production transformers in the world. The overall dimensions are ½ x ½ x 7/16" ...Weight approximately .2 ounces. Typical special units of this size are noted below:

Type K-16949 100,000 ohms to 100 ohms...6 MW...100 to 5,000 cycles.
Type M-14878 20,000 ohms (1 Ma. DC) to 35 ohms...6 MW...300 to 5,000 cycles.
Type M-14879 6 ohms to 10,000 ohms...6 MW...300 to 5,000 cycles.
Type M-14880 30,000 ohms (.1 Ma. DC) to 3,000 ohms...6 MW...300 to 5,000 cycles.
Type M-14881 25,000 ohms (.5 Ma. DC) to 1,000 ohms...6 MW...300 to 5,000 cycles.

TYPE UM

* 200 ohm termination can be used for 150 ohms or 250 ohms, 500 ohm termination can be used for 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 Co.

150 VARICK STREET • NEW YORK 13, N. Y.

EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y. CABLES: "ARLAB"

3 Important Engineering Meetings

NEREM

Saturday, April 11
Storrs, Conn.

The New England Radio Engineering Meeting is staged by, and is intended primarily to meet the needs of members of the North Atlantic Region, Institute of Radio Engineers. All engineers, scientists, educators, industrialists, students, and others interested in radio and allied fields, are cordially invited to take part in this one-day program of technical papers and exhibits of manufacturers' products, dealing with the broad field of electronics and radio engineering.

Registration should be made in advance, on or before April 4, 1953.

Technical Papers have been arranged to cover every field of radio, in two sessions, morning and afternoon, starting at 10 A.M. and ending at about 5 P.M. Briefly, the subjects are:

Extraneous Disturbances in Servomechanisms

Good Hearing in Auditoriums

Health Physics Survey at the Cosmotron

Propagation Discoveries, Their Lessons

Compatible Color Television

TD-2 Microwave Radio Relay Systems

North Atlantic Region Meeting.

The Luncheon talk is: "Electronics, A Challenger to Space and Time," by Daniel E. Noble.

49 Exhibitors will display a wide line of the latest electronic products. On a sense, no small part of the exhibit will be the campus of the University of Connecticut, to which this meeting and Show have been moved after six years in Boston.

A detailed program can be obtained by writing Mr. A. Millard, Southern New England Telephone Company, New Haven 6, Conn.

Television

Saturday, April 18
Cincinnati, Ohio

This meeting is jointly sponsored by the Cincinnati Section of the IRE, and the Professional Group on Broadcast and TV Receivers. Annually, a Saturday Meeting, held in the attractive Cincinnati Engineering Club Building, the morning session is comprised of five papers and the afternoon session four papers. All are on Television, and the afternoon papers feature color television exclusively.

Due to the facilities available, the exhibits are limited to television components and test equipment.

Mr. J. W. McRae, President of the IRE will be the principal Banquet Speaker.

Engineering Club Building, Cincinnati, Ohio

May 11, 12, 13
Wednesday, Thursday, Friday

Dayton, Ohio

Airborne Electronics

Now an annual event of national interest, this meeting is jointly sponsored by the Dayton Section of the IRE and the Professional Group on Airborne Electronics.

The exhibits are extensive and occupy several floors of the Hotel Biltmore. The meeting takes three days and includes two luncheons and a Banquet.

The technical sessions include as subjects: Components, Propagation, Human Engineering, Electronic Instrumentation, Antennas, Vacuum Tube, Microwave, Production Techniques, Servo Analysis, Dielectrics, Circuits, Communications, Analog Computers, Transistors, Network Analysis, Navigation, Measurements, Reliability; in fact every phase of radio-electronics as it applies in aviation.

A detailed program may be obtained from Mr. Peter R. Murphy, 121 Castle Drive, Dayton, Ohio.

IRE Meetings and Exhibits Speed Electronic Progress!

PROCEEDINGS OF THE I.R.E. April, 1953, Vol. 41, No. 4. 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.

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Meetings with Exhibits

As a service both to Members and the industry, we will endeavor to record in this column each month those meetings of IRE, its sections and professional groups *which include exhibits*.

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, 22, 23, 24 & 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

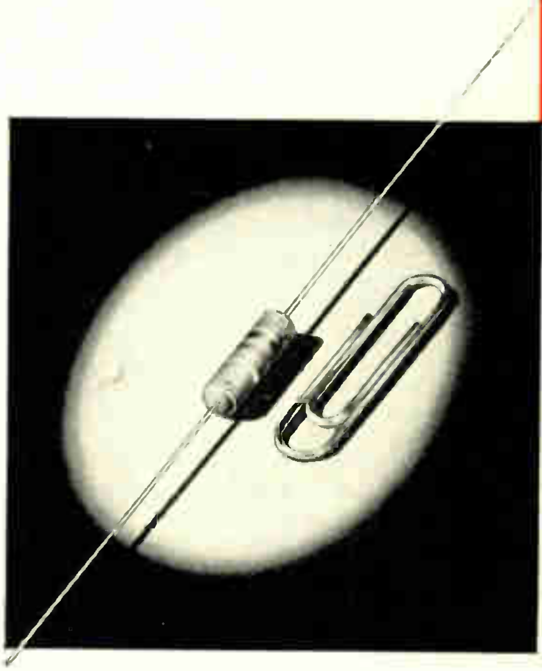
National Electronic Conference Hotel Sherman, Chicago.

Exhibits: Orville Thompson, c/o DeForrest's Training Inc., 2735 N. Ashland Ave., Chicago 14, Ill.

PROKAR® miniature molded **CAPACITORS**

. . . now all rated for operation at

125°C



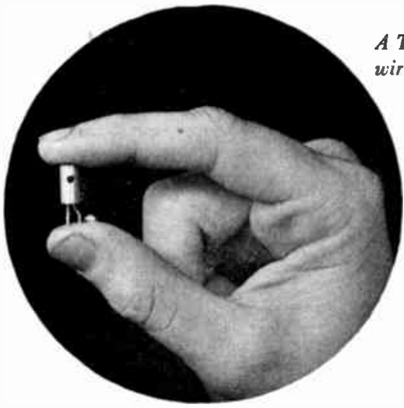
NEW processing developments now make it possible for every Prokar miniature molded capacitor to be used at temperatures up to 125°C without voltage derating!

An exclusive Sprague solid dielectric and a mineral-filled phenolic jacket assure stable performance from −55°C to +125°C.

Ten mold sizes—ranging upwards from the .175" dia. x 5/8" long unit pictured actual size at left—give you maximum space economy in miniaturized equipments. Originally developed for military uses, the moderate prices of these miniature capacitors make them well worth your investigation also for use in dependable commercial electronic equipment. Write today for Engineering Bulletin 205F to the Sprague Electric Company, 235 Marshall St., North Adams, Massachusetts.

SPRAGUE WORLD'S LARGEST CAPACITOR MANUFACTURER

EXPORT FOR THE AMERICAS: SPRAGUE ELECTRIC INTERNATIONAL LTD., NORTH ADAMS, MASS. CABLE: SPREXINT



*A **Transistor** of point-contact type. Two hair-thin wires control current flow in germanium metal.*

It's helping to win the Battle of the Watts

*Laboratories engineer examines **Transistor** oscillator. It is used in Englewood, New Jersey, where 10,000 subscribers can personally dial distant cities. **Transistors** generate the signals which carry the dialed numbers to other towns and cities. Other uses are in prospect.*

When you keep down the power needed to send voices by telephone you keep down the special equipment needed to supply that power. A great new power saver for telephony is the ***Transistor***, invented at Bell Telephone Laboratories, and now entering telephone service for the first time.

Tiny, simple and rugged, the ***Transistor*** can do many of the things the vacuum tube can do, but it is not a vacuum tube. It works on an entirely new principle and uses much less power than even the smallest tubes. This will mean smaller and cheaper power equipment, and the use of ***Transistors*** at many points in the telephone system where other equipment has not been able to do the job as economically.

It's another example of how Bell Telephone Laboratories makes basic discoveries, then applies them to improve telephone service while helping to keep its cost down.

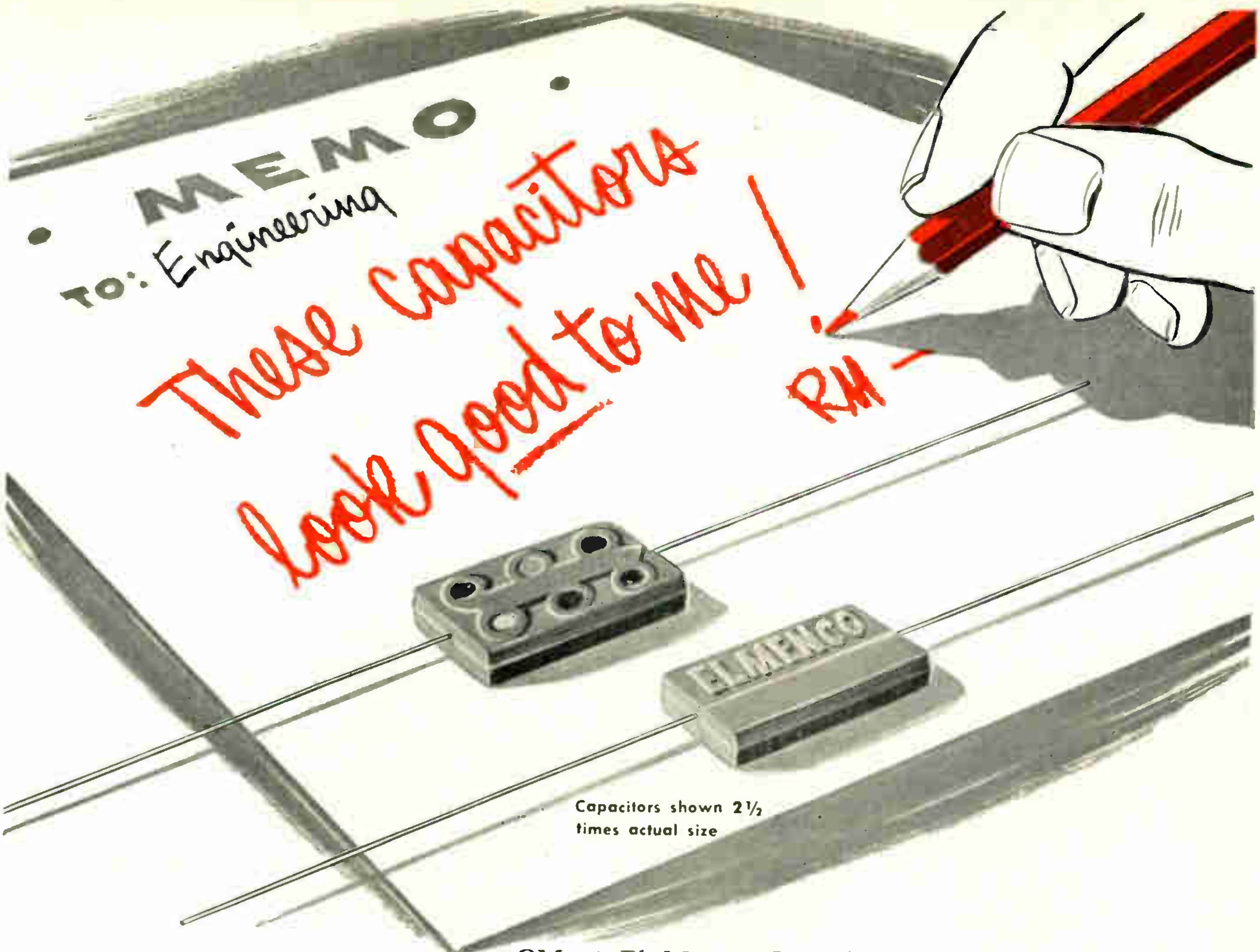
TRANSISTOR FACTS

Created by Bell scientists. First announced in 1948.

Has no glass bulb, requires no filament current or warm-up period. Operates instantly when called upon. Uses no energy when idle.

BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in scientific and technical fields.



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-5 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.

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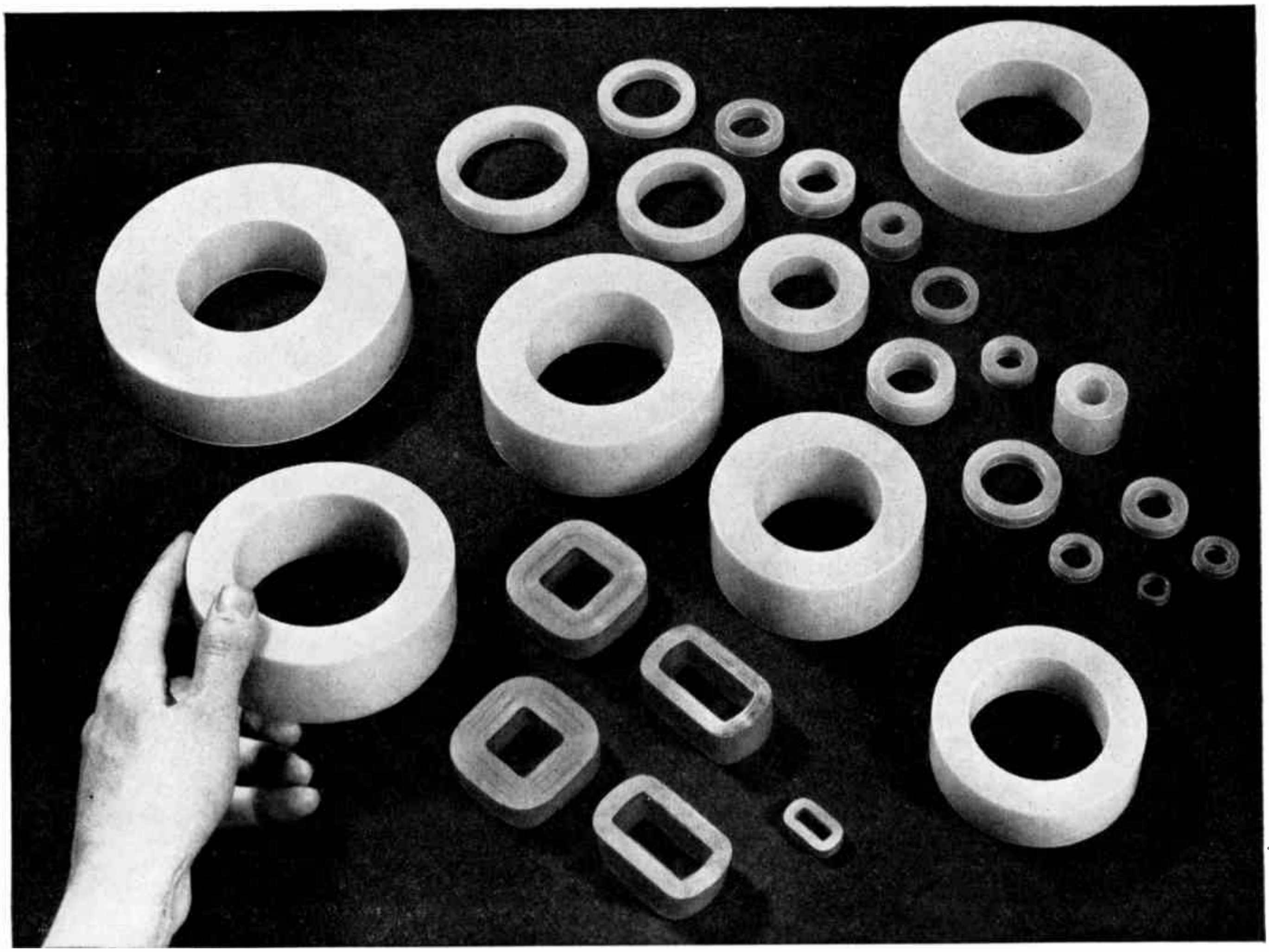
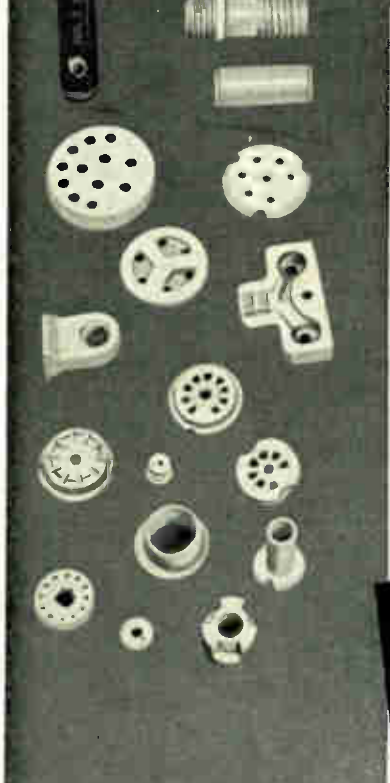
CAPACITORS

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

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





Pressed and Extruded Shapes to Close Tolerances

Engineered Steatite by General Ceramics offers the designer and engineer both excellent electrical and mechanical advantages and the economies of standard catalog body types. Offers low loss factor, zero moisture absorption, high surface and volume resistivity, high tensile and great compressive strength. Steatite insulators can be produced to countless sizes and shapes for practically all requirements.

Standard Shapes AVAILABLE:

- PILLAR INSULATORS
- LEAD-IN BUSHINGS
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- LEAD-IN INSULATORS
- SPREADER INSULATORS
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- COIL FORMS
- SUPPORT BARS
- COUPLING INSULATORS

"STEATITE-BONDED-TO-METAL" COMBINATIONS

Steatite bonded to metal by the Solder-Seal method produces a permanent hermetic seal. Also recommended for re-inforcing steatite where exceptional mechanical strength is required.

FOR UHF CIRCUITS, SPECIAL G-C STEATITE

General Ceramics Special Steatite developed for UHF service. An engineered insulation with extremely low loss factor. Recommendations made on specific applications without obligation.

CUSTOM DESIGNS TO SPECIFICATION—

Special steatite insulators can be produced in any size or shape by pressing, extruding, casting or machining. Experienced engineers are available for consultation.

*FULLY CONFORMS TO THE REQUIREMENTS OF GRADE L 6A IN ACCORDANCE WITH JAN-I-10.

IF YOU HAVE A PROBLEM—

For complete information on General Ceramics Steatite Insulators, request the new illustrated catalog; for engineering assistance on specific problems, contact a General Ceramics Sales Engineer.

GENERAL CERAMICS ... STEATITE CORPORATION STEATITE INSULATORS

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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

FOR DEPENDABLE ELECTRICAL CONTROL

Again and again, these rugged, vitreous-enameled wire-wound Ohmite resistors have demonstrated their ability to provide unfailing performance and long life under the most difficult service conditions.

Ohmite also offers the most complete line of wire-wound resistors on the market . . . fixed, tapped, adjustable, non-inductive, and precision units—in more than 60 wattage sizes ranging from 1″ to 20″ in length, in 18 types of terminals and in a wide range of resistance values. Investigate Ohmite resistors for your product.

Write on company letterhead for complete catalog.

Ohmite Manufacturing Co., 4860 Flournoy St., Chicago 44, Illinois

Ohmite vitreous-enameled resistors are available from stock or promptly made to order in a wide range of sizes and types.

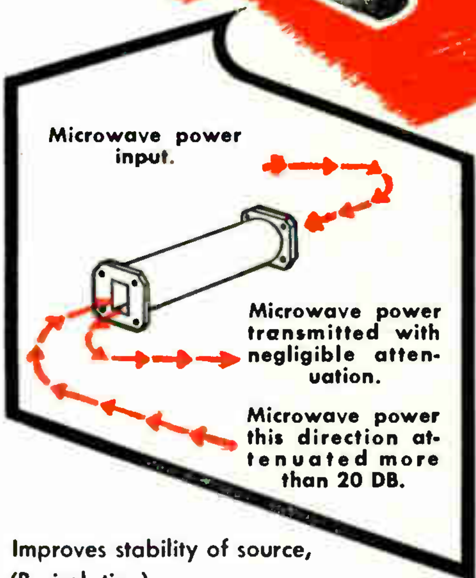
OHMITE®

first IN WIRE-WOUND RHEOSTATS AND RESISTORS

Uniline

THE UNIDIRECTIONAL TRANSMISSION LINE

Now available for higher frequencies



The Uniline section is a new development specifically designed for use in test measurements particularly where the impedance of the load is variable. For example, one of the several possible applications for the Uniline is as a replacement for the loss-type attenuator commonly used for isolation between source and load. In this instance, very substantial isolation is provided with negligible loss in transmitted power. Up to 100 times as much power is available for test purposes when the Uniline is used. The Uniline is a truly non-reciprocal transmission line element, not a directional coupler.

Improves stability of source, (By isolation).

Eliminates reflection from loads.

Eliminates reflection from detector with essentially no loss in sensitivity.

Eliminates pulling due to wavemeter.

Gives good broad-band match.

TYPICAL CHARACTERISTICS:

Frequency range: 8800-9600 megacycles.
9600-10,400 megacycles.

Wave guide size: ½"x1"x6½"

Attenuation in forward direction: Less than 1 DB.

Attenuation in reverse direction: 20 DB (approx.)

Voltage standing wave ratio: 1.3:1 (or less) either direction.

Finished with standard flat flange unless specified.

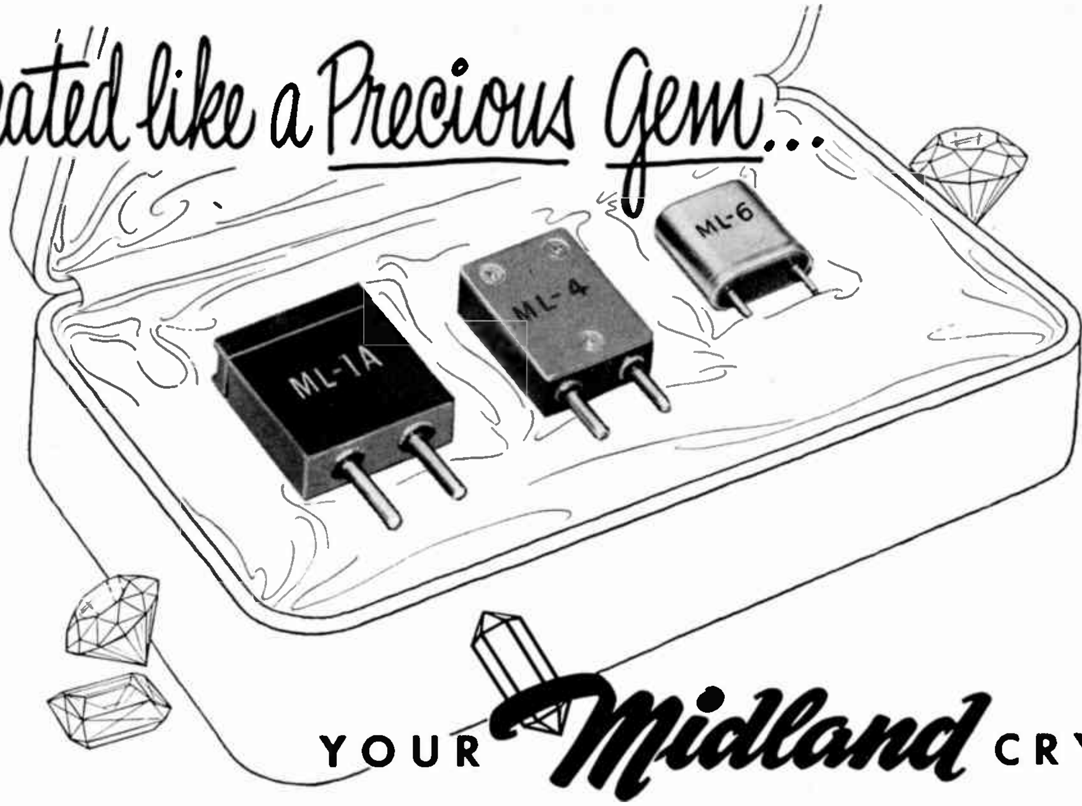
Available for immediate delivery

* Additional frequency ranges will soon be available.

Write for descriptive bulletin which gives theoretical and operational details.

CASCADE RESEARCH CORPORATION
53 Victory Lane Los Gatos, California

Treated like a Precious Gem...



YOUR *Midland* CRYSTAL

The art of cutting jewels is a thing of consummate skill and delicate touch. Gem cutting requires great accuracy.

But even gem cutting is not so precise or exacting as crystal processing by Midland's methods. As a result, you get the finest quality and highest accuracy scientific skill can produce in a frequency control crystal.

Midland Crystal Processing operations in many respects exceed the requirements of gem-cutting. Raw quartz is selected with regard to high electrical quality . . . proceeds through slicing, lapping, etching; and the final plating and sealing corresponds to setting a jewel. And at every step Midland's critical inspection and test procedures are applied, including precise angular control by X-ray.

Your Midland crystal is a gem of stability, accuracy, high output, long life. Whatever may be your requirements for better crystal performance, you'll get them in fullest measure from Midland.

Whatever your Crystal need, conventional or specialized
When it has to be exactly right, contact

Midland

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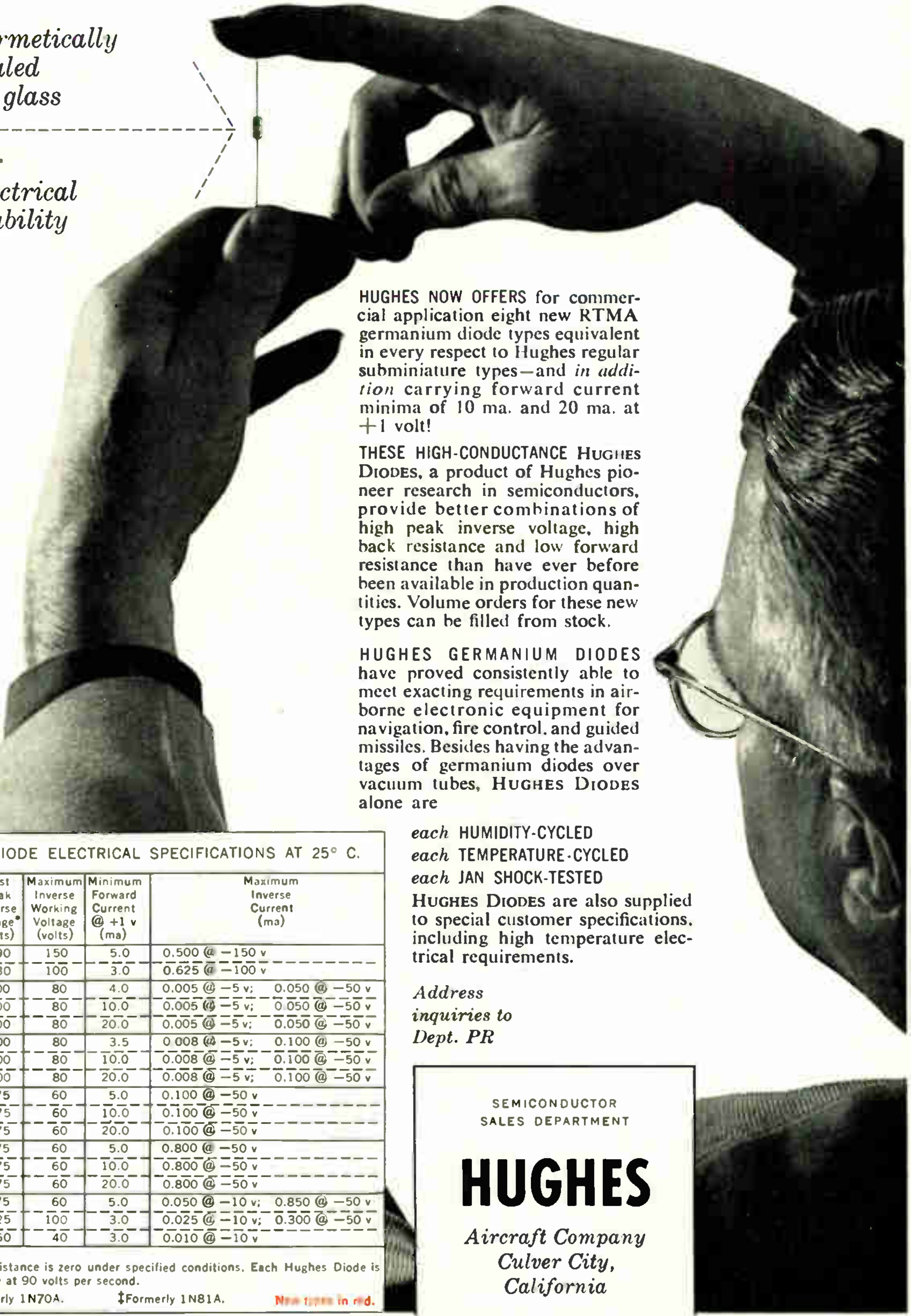
WORLD'S LARGEST PRODUCER OF QUARTZ CRYSTALS

HUGHES SETS NEW STANDARDS OF DIODE CONDUCTANCE



hermetically sealed in glass

for electrical stability

HUGHES NOW OFFERS for commercial application eight new RTMA germanium diode types equivalent in every respect to Hughes regular subminiature types—and *in addition* carrying forward current minima of 10 ma. and 20 ma. at +1 volt!

THESE HIGH-CONDUCTANCE HUGHES DIODES, a product of Hughes pioneer research in semiconductors, provide better combinations of high peak inverse voltage, high back resistance and low forward resistance than have ever before been available in production quantities. Volume orders for these new types can be filled from stock.

HUGHES GERMANIUM DIODES have proved consistently able to meet exacting requirements in airborne electronic equipment for navigation, fire control, and guided missiles. Besides having the advantages of germanium diodes over vacuum tubes, HUGHES DIODES alone are

each HUMIDITY-CYCLED
each TEMPERATURE-CYCLED
each JAN SHOCK-TESTED

HUGHES DIODES are also supplied to special customer specifications, including high temperature electrical requirements.

HUGHES GERMANIUM DIODE ELECTRICAL SPECIFICATIONS AT 25° C.

Description	RTMA Type	Test Peak Inverse Voltage* (volts)	Maximum Inverse Working Voltage (volts)	Minimum Forward Current @ +1 v (ma)	Maximum Inverse Current (ma)
High Peak	1N55B	190	150	5.0	0.500 @ −150 v
	1N68A	130	100	3.0	0.625 @ −100 v
High Back Resistance	1N67A	100	80	4.0	0.005 @ −5 v; 0.050 @ −50 v
	1N99	100	80	10.0	0.005 @ −5 v; 0.050 @ −50 v
	1N100	100	80	20.0	0.005 @ −5 v; 0.050 @ −50 v
High Back Resistance	1N89	100	80	3.5	0.008 @ −5 v; 0.100 @ −50 v
	[illegible]	100	80	10.0	0.008 @ −5 v; 0.100 @ −50 v
	[illegible]	100	80	20.0	0.008 @ −5 v; 0.100 @ −50 v
High Back Resistance	1N116	75	60	5.0	0.100 @ −50 v
	1N117	75	60	10.0	0.100 @ −50 v
	1N118	75	60	20.0	0.100 @ −50 v
General Purpose	1N90	75	60	5.0	0.800 @ −50 v
	[illegible]	75	60	10.0	0.800 @ −50 v
	[illegible]	75	60	20.0	0.800 @ −50 v
JAN Types	1N126**	75	60	5.0	0.050 @ −10 v; 0.850 @ −50 v
	1N127†	125	100	3.0	0.025 @ −10 v; 0.300 @ −50 v
	1N128‡	50	40	3.0	0.010 @ −10 v

*That voltage at which dynamic resistance is zero under specified conditions. Each Hughes Diode is subjected to a voltage rising linearly at 90 volts per second.

**Formerly 1N69A.. †Formerly 1N70A. ‡Formerly 1N81A. New types in red.

Address inquiries to Dept. PR

SEMICONDUCTOR SALES DEPARTMENT

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Aircraft Company
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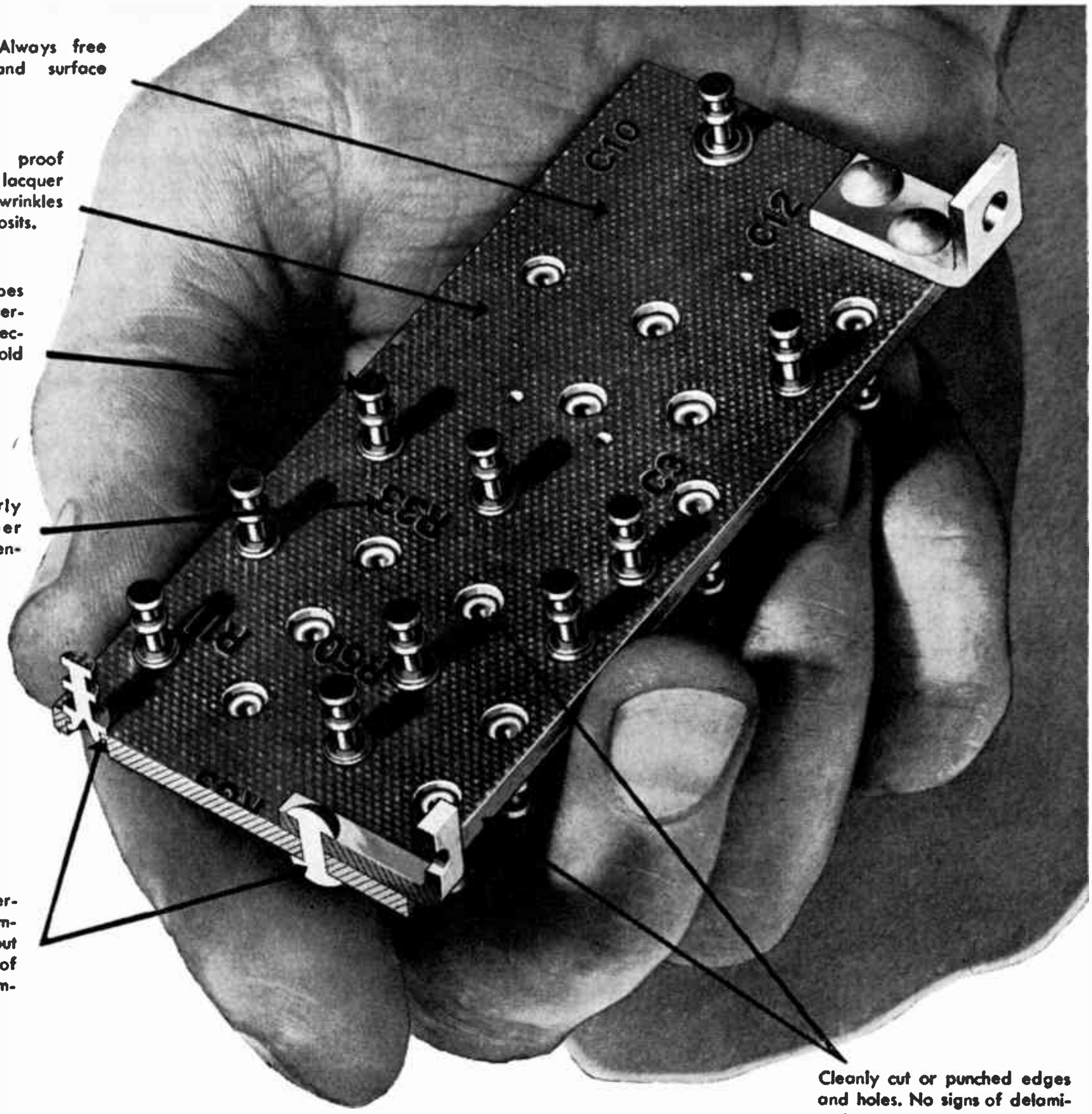
Selected stock. Always free from defects and surface blemishes.

Moisture and fungus proof coatings, varnish or lacquer smoothly applied. No wrinkles or unsightly heavy deposits.

C.T.C. standard terminals. Types for all applications. Silver-plated, cadmium plated, electro tinned, hot tinned or gold plated as required.

Precisely located, clearly defined imprinting: rubber stamped, silk-screened, engraved or hot stamped.

Riveting or staking of terminals, brackets and other components accomplished without radial cracks or splitting of rivet shanks, and without damaging the finish.



Cleanly cut or punched edges and holes. No signs of delamination.

Little details on terminal boards ...*make the big difference in quality*

C.T.C. is constantly supplying special terminal boards to the top names in electronics. These boards are built to strict government specifications, are fabricated of certified materials to fit the job. Among the specifications involved are: MIL-P-3115A, MIL-P-15037, MIL-P-15035, MIL-P-15047, MIL-P-997A.

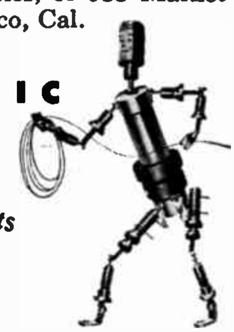
Our Custom Engineering Service is well-equipped to fill these specifications for you. We are thoroughly familiar with the JAN and MIL-approved materials and finishes in accepted usage by government agencies and the armed forces. This, combined with assembly know-how developed over many years of supplying electronic components and equipment to the government, enables us to meet your needs for quality above and beyond the basic government standards.

Boards can be made of cloth, paper, nylon or glass laminates (phenolic, melamine or silicone resin), and can be lacquered or varnished to specifications: JAN-C-173, MIL-V-173 and JAN-T-152. Lettering and numbering is done by rubber stamping, silk screening, hot stamping, engraving. Inks used in rubber stamping contain anti-fungus and fluorescent additives.

For complete information write: Cambridge Thermionic Corporation, 456 Concord Avenue, Cambridge 38, Mass. West Coast manufacturers, contact: E.V. Roberts, 5068 W. Wash. Blvd., Los Angeles, or 988 Market St., San Francisco, Cal.

CAMBRIDGE THERMIONIC CORPORATION

custom or standard ... the guaranteed components



FOUR TRANSMITTERS IN ONE

- Accommodates up to four individual R. F. channels available in the following frequency ranges: 125-525 k/c, 2-18 m/c, 118-132 m/c.
- Power output 400 watts LF and HF, 250 watts VHF.
- Accessibility of channels provides for easy inspection and maintenance.
- Single or simultaneous frequency transmission provides ultimate flexibility.
- Complete remote control operation.

Write today for complete specifications.

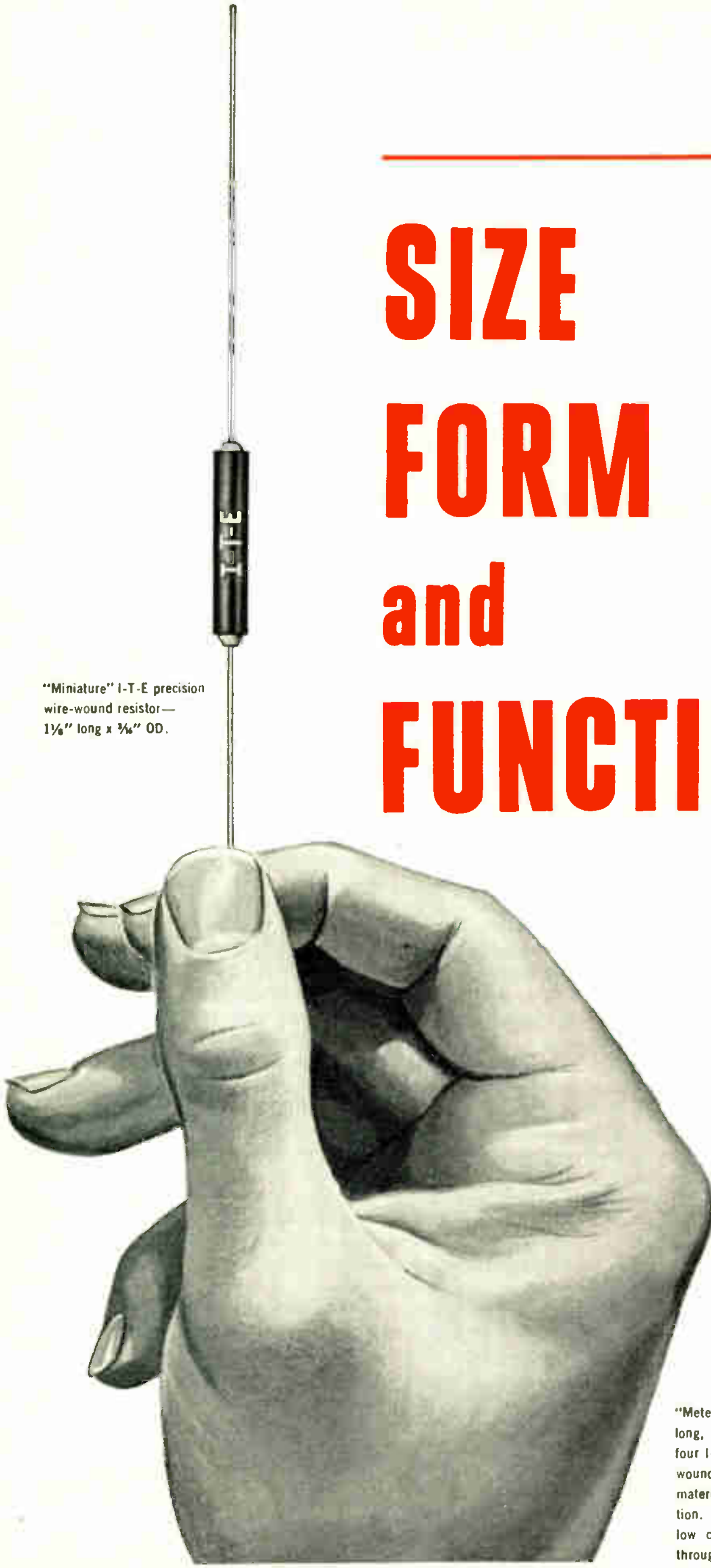
wilcox

ELECTRIC COMPANY, INC.

Fourteenth and Chestnut

Kansas City 27, Missouri, U.S.A.

SIZE FORM and FUNCTION



"Miniature" I-T-E precision wire-wound resistor—1⅛" long x 3/16" OD.

"Meter multiplier"—9 25/32" long, ferrule type—houses four I-T-E precision resistors wound on bobbins of the same material as the encapsulation. This assures uniform low coefficient of expansion throughout the resistor resulting in a true hermetic seal.

I-T-E precision wire-wound resistors can be specially engineered to your requirements

New electronic equipment designs often require special types of precision wire-wound resistors. A wide range of special types and ratings, built to exact customer specifications, is being produced by I-T-E in *quantity*.

Expanded I-T-E design and engineering facilities, and advanced production and testing techniques, are all combined to provide individually tested units guaranteed to perform within narrowly defined limits.

Here's what I-T-E offers you:

SIZE

Resistance values up to 500,000 ohms can be produced in a body as small as 1⅛″ long x 3/16″ OD—with emphasis on close accuracy, low temperature-coefficient, and high stability.

I-T-E also produces *multiple-tapped* units in cylindrical and card forms—or in any required special form. Number and spacing of taps are available to specification.

RESISTANCE

Special resistors are obtainable in tolerances down to ± 0.05%. I-T-E units surpass MIL-R-93A specifications.

Tiny plastic bobbins are used to obtain higher resistance values than ceramic-core resistors in the same size body.

Matched pairs can be supplied in any ratio—with ratio tolerance to within ± 0.05%. (Unity ratio to within ± 0.005%.)

FREQUENCY

Proper selection of wire and balanced winding techniques limit reactance within narrow ranges.

TEMPERATURE COEFFICIENT

I-T-E *selects* low temperature-coefficient resistance wire. Test procedures determine temperature coefficient of a precision wire-wound resistor to within ± 2 parts/million/degree C. In matched pairs, TC of one resistor can be matched to TC of the other within ± 5 parts/million/degree C.

Rigid testing of *each* resistor makes it possible to guarantee TC of an entire lot.

STABILITY

Accelerated aging of finished resistors obtains stability as low as 0.005%. Hermetic sealing protects against the destructive effects of salt water immersion and high humidity.

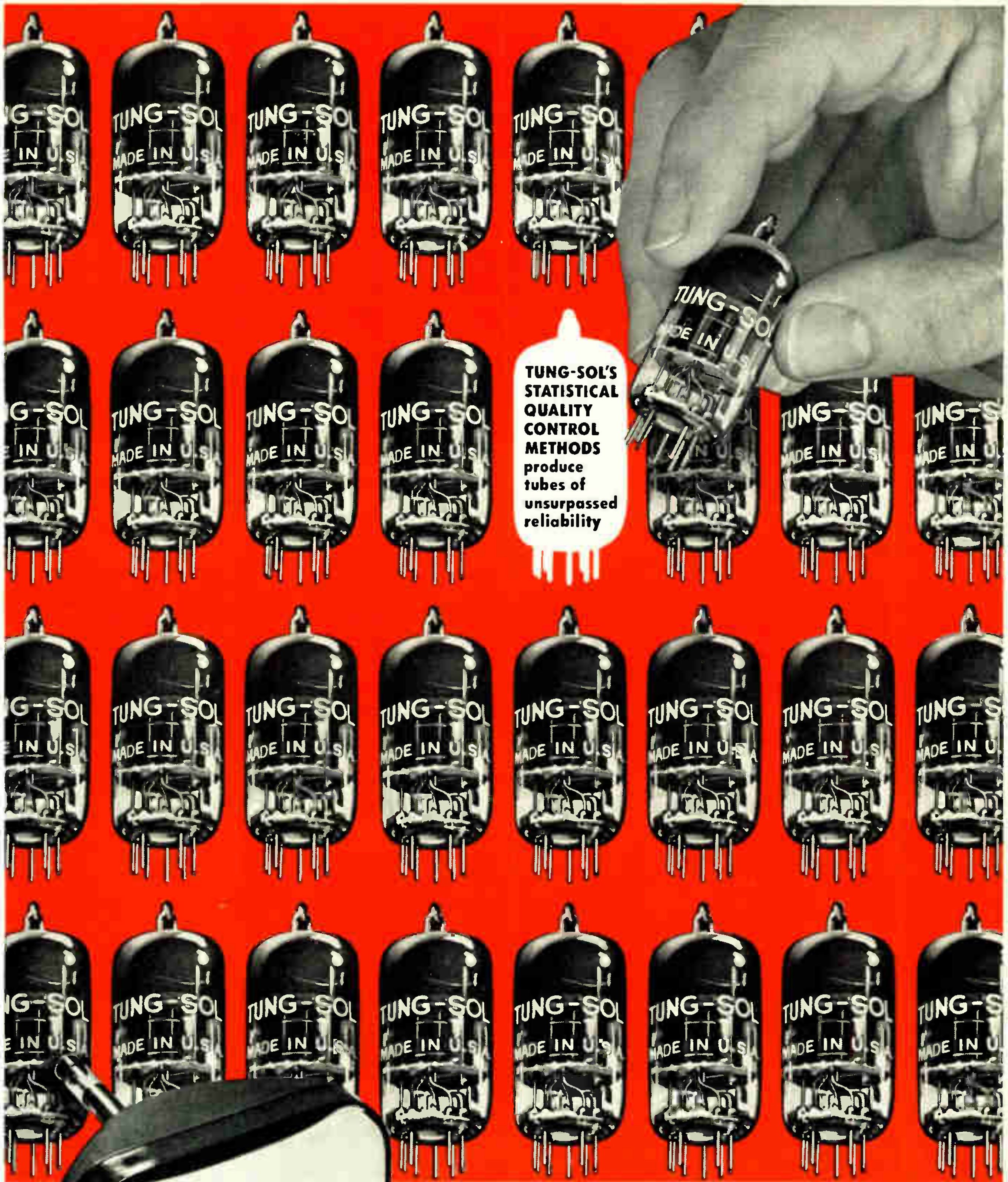
WHAT ARE YOUR REQUIREMENTS?

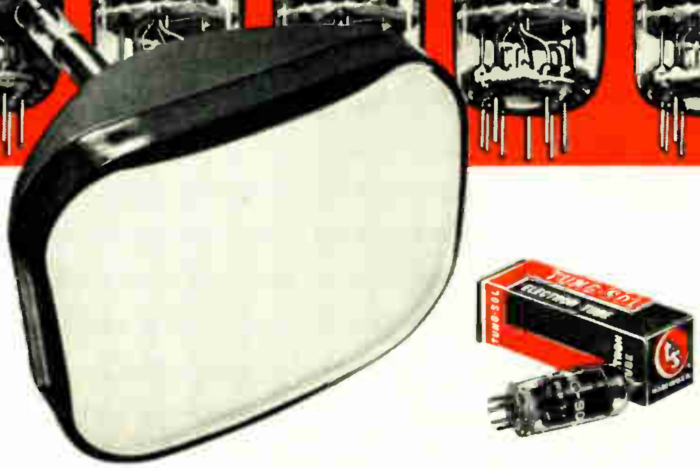
I-T-E engineering and production facilities offer you much more than a standard line of precision wire-wound resistors and other wire-wound components. If your problem is *special*, write us outlining your requirements. *Resistor Division, I-T-E Circuit Breaker Co., 1924 Hamilton St., Philadelphia 30, Pa.*

I-T-E

PRECISION WIRE-WOUND RESISTORS


PRODUCTS
keeping communications ON THE BEAM
JK STABILIZED
JKO-2 OVEN
CRYSTALS FOR THE CRITICAL
The JKO-2 oven provides the fast warm up needed for two way mobile communication — such as used in railroads, taxis, etc.
Unit holds two JK H-17 type crystals, is compact, light weight. Crystals sealed against dirt and moisture. A stabilized heat unit, one of many JK products made to serve every need.
Your "All Aboards" will be On Time!
It takes split second timing to maintain safe, "on the dot" railroad schedules, and the traffic control involved is highly complicated. Today, railroads rely on radio to help keep lines unsnarled and traffic moving. JK Crystals in railroad communication equipment helps keep your train on time, every time.
FREQUENCY & MODULATION MONITOR
Monitors any four frequencies anywhere between 25 mc and 175 mc, checking both frequency and amount of modulation. Keeps the "beam" on allocation; guarantees more solid coverage, too!
the JK FD-12
THE JAMES KNIGHTS COMPANY
SANDWICH ILLINOIS


TUNG-SOL
MADE IN U.S.A.
TUNG-SOL'S STATISTICAL QUALITY CONTROL METHODS produce tubes of unsurpassed reliability


TUNG-SOL
ELECTRON TUBE

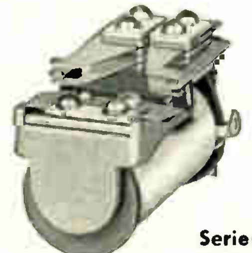
THESE NEW GUARDIAN RELAYS PROVIDE MORE POWER FOR ANY COMMUNICATIONS SYSTEM

Analyze the power increasing, space and weight saving features of Guardian's latest Series 595-P and 695-P Communications Relays . . . features that have created an increased demand for these already popular favorites: (1). New, improved *field piece* has enlarged end adjacent to the armature which reduces magnetic reluctance of the hinge gap. (2). *Armature* pivots on a stainless steel *pin bearing*, resulting in minimum friction and maximum utilization of available power. (3). *Magnetic circuit efficiency* is assured by use of the correct combination of winding to core size for sensitive or power types.

***The Series 595-P D.C.* will carry up to 4 pole, double throw contact combinations. Weight of unit (double pole, double throw)—2.5 ounces. *The Series 695-P D.C.* will carry up to 6 pole, double throw contact combinations. Weight of unit (double pole, double throw)—3.5 ounces. Both the 595-P and the 695-P are available *hermetically sealed* to meet Government specifications MIL-R-6106.**

Series
595 -P D. C.
RELAY

AN-3303-1



Series
695 -P D. C.
RELAY

WRITE—WIRE—TELETYPE—PHONE NOW!

GUARDIAN ELECTRIC

1628-D W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

For *Critical* Applications

Triplett 630-A Has No Counterpart

Accuracy
to 1½%

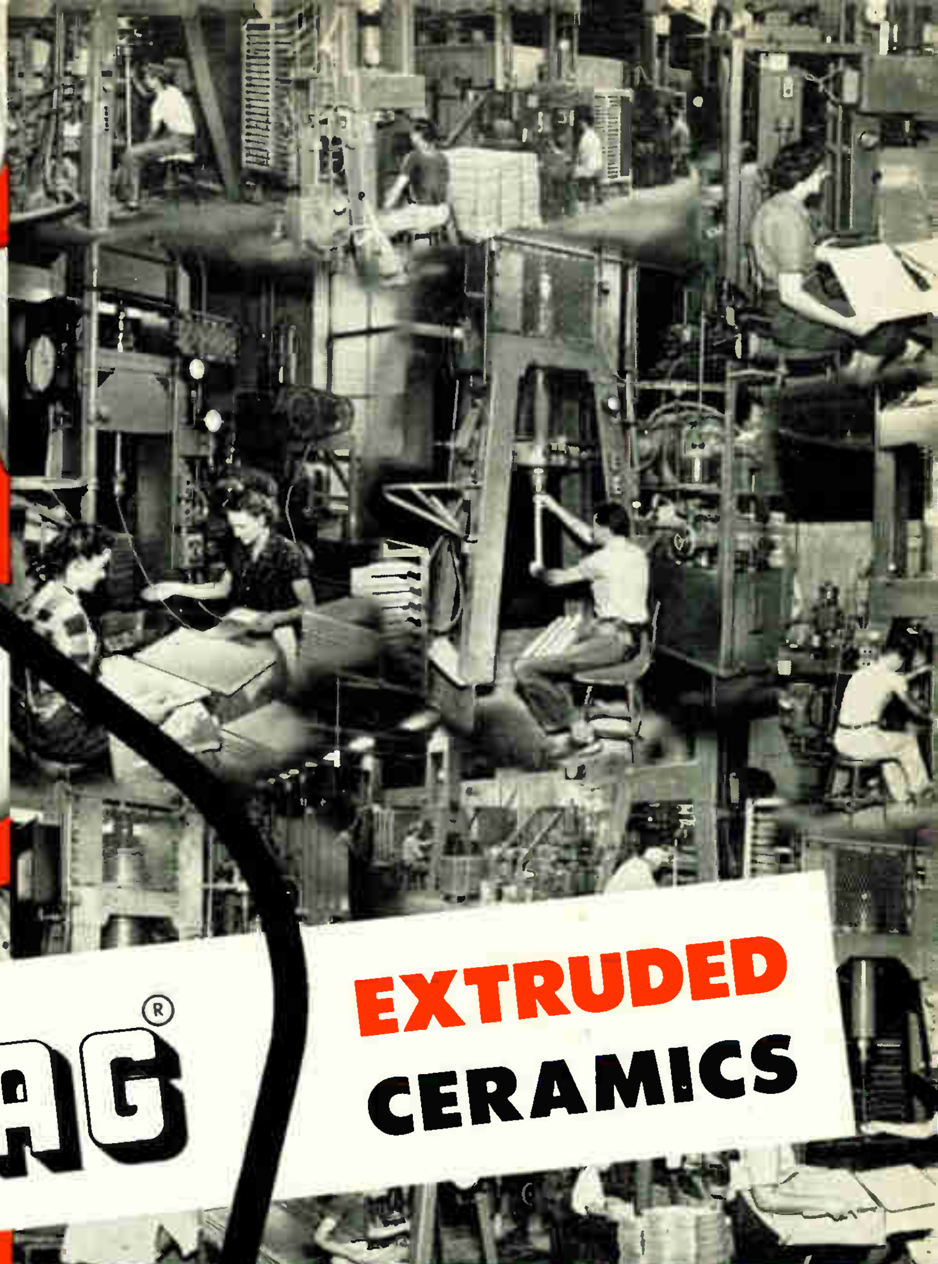
Readability
with a Mirror-Scale

Adaptability
with ½% resistors

Try This Volt-Ohm-Mil-Ammeter at your distributor's

Triplett

TRIPLETT ELECTRICAL INSTRUMENT CO., BLUFFTON— OHIO



ALSIMAG®

EXTRUDED CERAMICS

VOLUME PRODUCTION is available for your extruded ceramics at AMERICAN LAVA CORPORATION. Several batteries of presses from 10-ton to 100-ton capacity assure the right press for the job. Ceramics of uniform cross section up to 8½" diameter can be extruded, sawed and machined to intricate shapes. These pictures show part of our extrusion equipment and typical AlSiMag ceramics made from extruded material. Send us your blue prints or sample: let us show you what we can do for you.

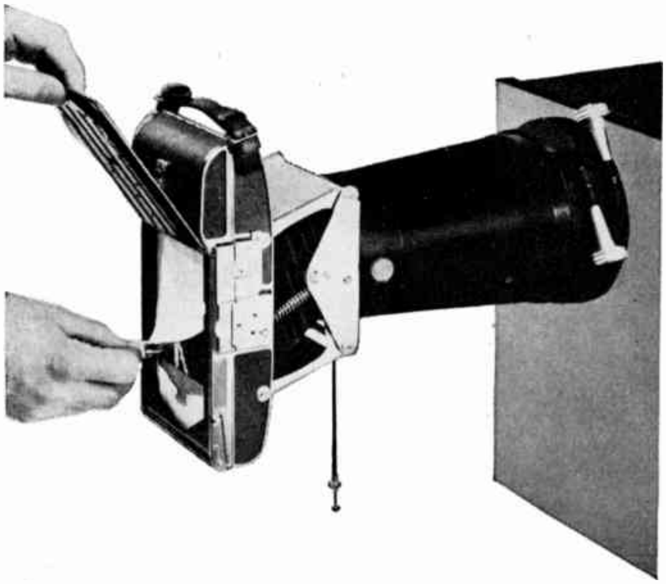
51ST YEAR OF CERAMIC LEADERSHIP

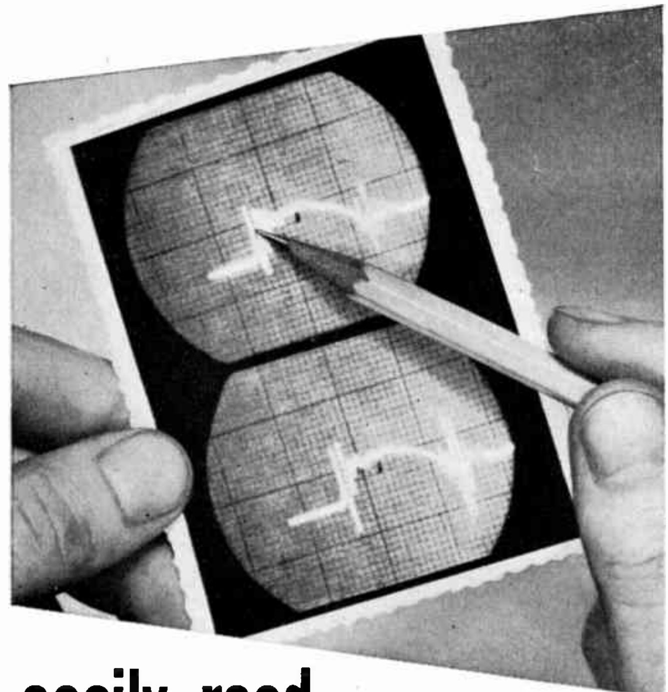
AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENNESSEE

NOTE: New offices at CLEVELAND, OHIO and SYRACUSE, N. Y.

OFFICES: METROPOLITAN AREA: 671 Broad St., Newark, N. J., Mitchell 2-8159 • SYRACUSE, N. Y. PHILADELPHIA, 1649 N. Broad St., Stevenson 4-2823 • CLEVELAND, 5012 Euclid Ave., Express 1-6685 CHICAGO, 228 N. LaSalle St., Central 6-1721 • ST LOUIS, 1123 Washington Ave., Garfield 4959 SOUTHWEST: John A. Green Co., 6815 Oriole Dr., Dallas 9, Dixon 9918 • NEW ENGLAND, 1374 Mass. Ave., Cambridge, Mass., Kirkland 7-4498 • LOS ANGELES, 5603 N. Huntington Dr., Capital 1-9114





Oscilloscope records are easily read

when prints are made with the Fairchild-Polaroid® Oscilloscope Camera

There are three good reasons why oscilloscope traces can be read quickly and easily when they are photographed by Fairchild's adaptation of the Polaroid camera:

1 The trace reads normally—left to right—instead of reverse.

2 Reduction is exactly half life-size for easy measurement of values, especially when a grid is used.

3 Each print records two images, especially handy for before-and-after work.

Operation is as easy as 1-2-3. In two minutes or less you can set up the camera, snap the shutter, and pull the tab. Then you wait one minute more and remove the finished print. No focusing and no special training are required.

Important note—Delivery of Fairchild-Polaroid Oscilloscope Cameras can be had in just a few weeks. Write today for prices and information.

For still or continuous-motion recording on 35-mm film or paper Use the FAIRCHILD OSCILLO-RECORD CAMERA

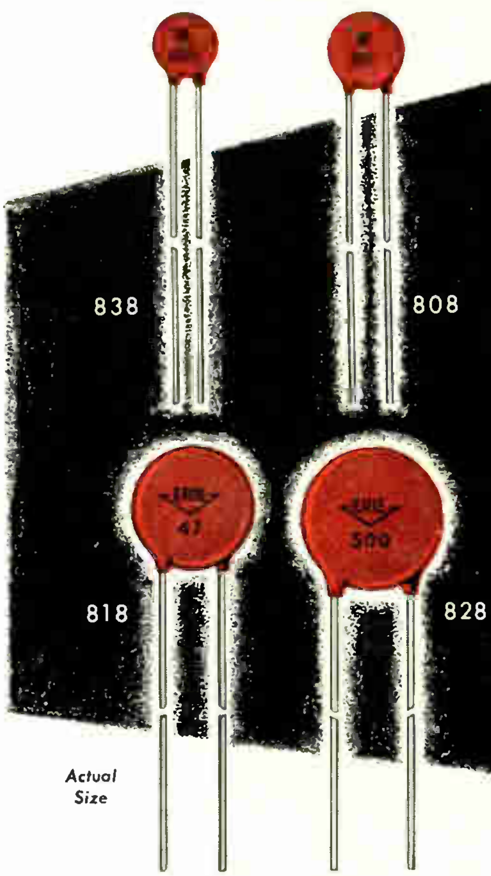
Speed is continuously variable through an exclusive electronic control. Film is sprocket-driven so there is no slippage. There are no belts or pulleys. Top-of-scope mounting eliminates need for tripod and keeps scope controls easily accessible. Provision for three film lengths—100, 400, or 1,000 feet. Delivery in about four months.

● Full information about the Fairchild-Polaroid and Oscillo-Record Cameras awaits your request. Write today to *Fairchild Camera and Instrument Corporation, Robbins Lane, Syosset, Long Island, New York, Department 120-19C.*

FAIRCHILD
OSCILLOSCOPE RECORDING CAMERAS

ERIE

HIGH VOLTAGE DISC CERAMICONS®



SPECIFICATIONS

Capacitance . . . Within stated tolerance at 1 KC, 1 to 5 volts RMS, and 25°C.

Standard Capacitance Tolerances . . . ±5%, ±10%, ±20%, guaranteed minimum value. (±5%, and in some cases ±10%, not available on Hi-K items.)

Standard Voltage Ratings, D. C. Working . . . 1000, 1500, 2000, 3000, 5000, 6000.

Dielectric Strength Test . . . Two times rated working voltage, with megohm series resistance.

Life Test . . . 1.5 times rated working voltage at 85°C. for 1000 hours.

Insulation Resistance . . . 10,000 megohms minimum.

Temperature Characteristic and Power Factor . . . One of four, depending on capacitance value and rating.

Characteristic	*Maximum Power Factor*	
P100 thru N1400	0.1%	Exact conformance per Erie GP1 Ceramicons, Bulletin 312.
Hi-K—12A	2%	Exact conformance per Erie Disc Ceramicons, Bulletin 438.
Hi-K—35	2%	
Hi-K—70	2%	

ERIE Disc Ceramicons have proven to be an ideal adaptation for high voltage application. Inherent construction simplicity means greatest economy yet for comparable voltage and capacitance values.

They are amazingly easy to install in small spaces . . . they simplify soldering and wiring operations, and speed up the assembly line. Erie Disc Ceramicons consist of round flat dielectrics with fired on silver plates and leads of No. 22 tinned copper wire firmly soldered to silver electrodes.

The Ceramicons are phenolic dipped and vacuum wax impregnated for moisture seal. They are identified by the Erie trademark and are marked with nominal capacitance and rated voltage.

Rated D.C. Voltage	Capacitance Range, MMF
1000	6 —10,000
1500	5 — 6,400
2000	3.5— 5,100
3000	6 — 3,250
5000	6 — 520
6000	5 — 340

Write for Bulletin 440. Erie Standard 500 volt By-pass and Coupling Disc Ceramicons are described in Bulletin 438. For Temperature Compensating Disc Ceramicons see Erie Bulletin 439.

ERIE components are stocked by leading electronic distributors everywhere.

ERIE TRADE MARK RESISTOR CORP.

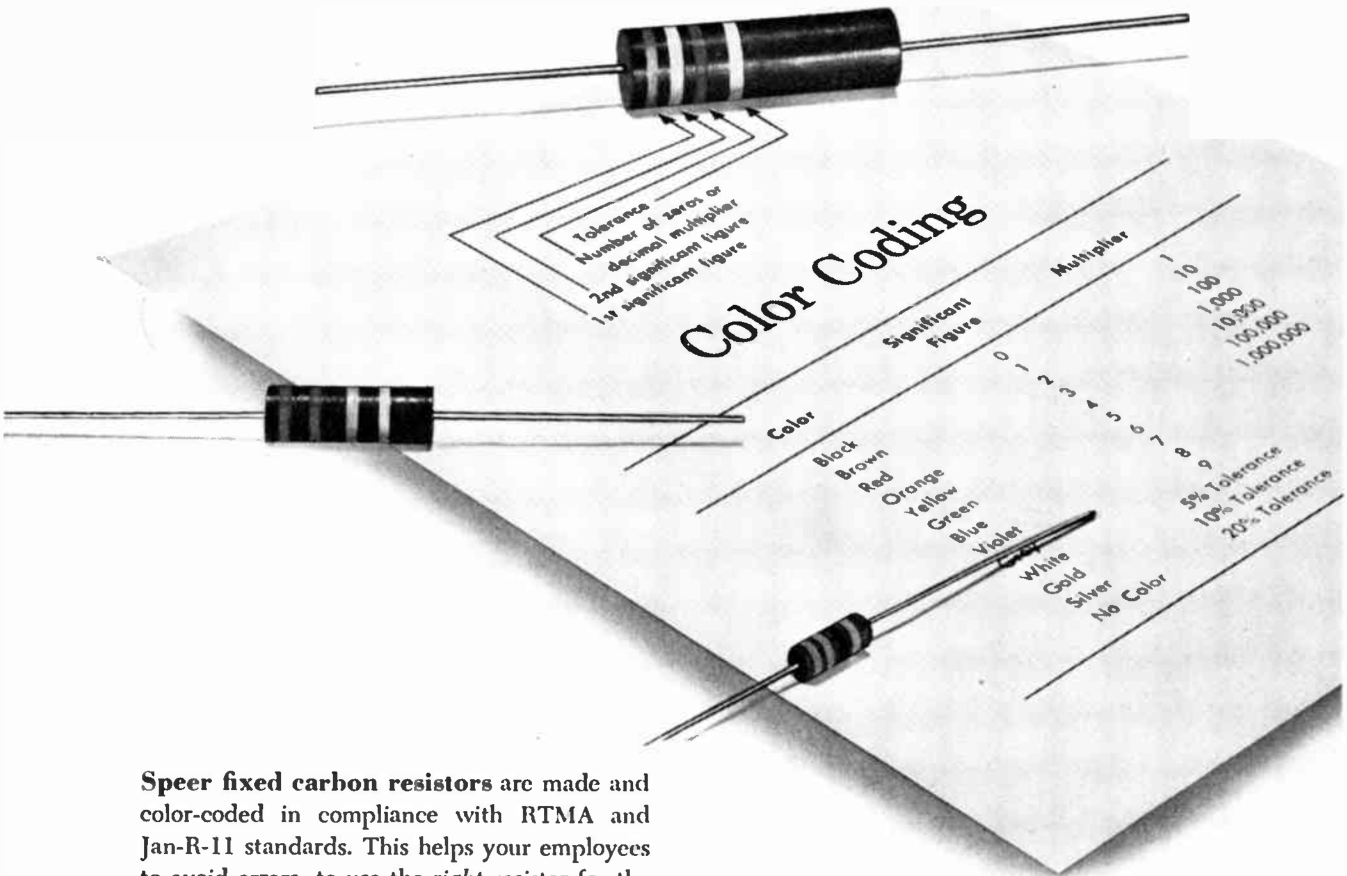
ERIE RESISTOR CORPORATION . . . ELECTRONICS DIVISION

Main Offices: **ERIE, PA.**

Sales Offices: Cliffside, N. J. • Philadelphia, Pa. • Buffalo, N. Y. • Chicago, Ill. Detroit, Mich. • Cincinnati, Ohio • Los Angeles, Calif.

Factories: **ERIE, PA. • LONDON, ENGLAND • TORONTO, CANADA**

Speer makes it easy for you to choose the right Carbon resistor!



Speer fixed carbon resistors are made and color-coded in compliance with RTMA and Jan-R-11 standards. This helps your employees to avoid errors—to use the *right* resistor for the circuit every time.

Speer resistors are made better – are the right resistors for *every* circuit. By using very high pressure to create an inseparable bond between the protective phenolic shell and the carbon core, Speer gives its resistors these important advantages:

1. More efficient heat transfer.
2. Greater ability to sustain overloads for long periods of time.
3. Uniform diameter resistive element for the entire length of the resistor, which eliminates weak points and potential burn-outs.
4. Uniformly thick protective covering over the entire length, which eliminates low-voltage breakdown between resistive element and adjacent conductor – makes for minimum change in resistance when subjected to adverse humidity conditions.

All shipments of Speer resistors are given numerous tests for resistance rating, and are backed by a minimum resistance change when exposed to an accelerated ten-day humidity test. Speer manufactures a complete line of ½, 1 and 2 watt resistors in all standard values from 10 ohms to 20 megohms. Nonstandard values are available for special applications.

Write today for your free copy of Speer Resistor's new complete catalog

SPEER RESISTOR

SPEER RESISTOR DIVISION

SPEER CARBON COMPANY

St. Marys, Pennsylvania

Other Divisions: Jeffers Electronics
International Graphite & Electrode

When it comes to making a *Real Saving* in space...

Stackpole cup cores with their self-shielding characteristic can be mounted close to the chassis or any other metal part for maximum results in extremely close quarters. In some instances, the high Q circuits made possible through their use permit reduction in the number of tubes needed.

Standard types include numerous shapes and sizes, each available in a wide range of permeability possibilities. Highly specialized types to meet the most critical specifications can be engineered and produced from a broad background of experience in this exacting field.

Electronic Components Division

STACKPOLE CARBON COMPANY

St. Marys, Pa.

STACKPOLE *Cup Cores*

Other Stackpole core types include:

ALL STANDARD MOLDED IRON CORE TYPES, SIDE-MOLDED, CHOKE COIL CORES, SLEEVE TYPES, THREADED TYPES and COIL FORMS . . . also Stackpole CERAMAG® CORES (FERRITES).

Write for Electronic Components Catalog RC-8

GERMANIUM DIODE INTERCHANGEABILITY CHART

TYPE & MFR.	G.E. REPLACEMENT	MINIMUM FORWARD CUR. @ +1V. (MA)	PEAK INVERSE VOLTAGE (VOLTS)	CONT. REVERSE VOLTAGE (VOLTS)	MAXIMUM REVERSE CUR. (μa) @ −50V.	MAXIMUM REVERSE CUR. (μa) OTHER	REMARKS
1N34 (S,K)		5.0	75	60	800	50 @ −10V.	
	1N48	4.0	85	70	833		
1N34A (S)		5.0	75	60	500	30 @ −10V	
	1N52	4.0	85	70	150		
1N35 (S,K)		7.5	75	50		10 @ −10V.	Matched pairs;
	G8A	4.0	85	70	150		See Note 1
1N38 (S,K)		3.0	120	100		6 @ −3V.	
						625 @ −100V.	
	1N70	3.0	125	100	300	25 @ −10V.	
1N38A (S)		4.0	120	100		5 @ −3V.	
						500 @ −100V.	
	1N63	4.0	125	100	50		
1N39 (S,K)		1.5	225	200		200 @ −100V.	
						800 @ −200V.	
	1N75	2.5	125	100	50		
1N40 (S)		12.75 @ +1.5V.	75	25		40 @ −10V.	Quad, See Note 2
	1N73	15.0 @ +1.7V.	75			50 @ −10V.	Quad; See Note 3
1N41 (S)	None						
1N42 (S)		12.75 @ +1.5V.	120	50		6 @ −3V.	Quad, See Note 2
						625 @ −100V.	
	1N73	15.0 @ +1.7V.	75			50 @ −10V.	Quad; See Note 3
1N43 (WE)		5.0	60		850	20 @ −5V.	
	1N69	5.0	75	60	850	50 @ −10V.	
1N44 (WE)		3.0	115		1000		
	1N70	3.0	125	100	300	25 @ −10V.	
1N45 (WE)		3.0	75		410		
	1N65	2.5	85	70	250		
1N46 (WE)		3.0	60		1500		
	1N48	4.0	85	70	833		
1N47 (WE)		3.0	115		410	4 @ −3V.	
	1N70	3.0	125	100	300	25 @ −10V.	
1N48 (GE)		4.0	85	70	833		
1N51 (GE)		2.5	50	40	1667		
1N52 (GE)		4.0	85	70	150		
1N54 (S,K)		5.0	75	35		10 @ −10V.	
	1N69	5.0	75	60	850	50 @ −10V.	
1N54A (S)		5.0	75	50	100	7 @ −10V.	
	1N52	4.0	85	70	150		
1N55 (S,K)		3.0	170	150		300 @ −100V.	
						800 @ −150V.	
	1N75	2.5	125	100	50		
1N55A (S)		4.0	170	150		500 @ −150V.	
	1N63	4.0	125	100	50		
1N56 (S,K)		15.0	50	40		300 @ −30V.	
	1N69	5.0	75	60	850	50 @ −10V.	
1N56A (S)		15.0	50	40		300 @ −30V.	
	1N69	5.0	75	60	850	50 @ −10V	
1N57 (S,K)		4.0	90	80		500 @ −75V.	
	1N52	4.0	85	70	150		
1N58 (S,K)		4.0	120	100		800 @ −100V.	
	1N63	4.0	125	100	50		
1N58A (S)		4.0	120	100		600 @ −100V.	
	1N63	4.0	125	100	50		
1N60 (S,K)			30	25			See Note 4
	1N64	.05 @ +0.25V.	20			25 @ −1.3V.	See Note 5
1N61 (K)		5.0	140	130		300 @ −100V.	
						700 @ −125V.	
	1N63	4.0	125	100	50		
1N63 (GE)		4.0	125	100	50		
1N64 (GE)		.05 @ +0.25V.	20			25 @ −1.3V.	See Note 5
1N65 (GE)		2.5	85	70	250		
1N66 (R)		5.0	70	60	800	50 @ −10V.	
	1N48	4.0	85	70	833		
1N67 (R)		4.0	100	80	50	5 @ −5V.	
	1N63	4.0	125	100	50		
1N68 (R)		3.0	120	100		625 @ −100V.	
	1N75	2.5	125	100	50		
1N69 (GE)		5.0	75	60	850	50 @ −10V.	
1N70 (GE)		3.0	125	100	300	25 @ −10V.	
1N71 (S)	None						Quad
1N72 (GE)		0.8 @ +.5V.	5			800 @ −.5V.	See Note 6
1N73 (GE)		15.0 @ +1.7V.	75			50 @ −10V.	Quad; See Note 3
1N74 (GE)		15.0 @ +1.8V.	75			50 @ −10V.	Quad, See Note 3
1N75 (GE)		2.5	125	100	50		
CK705 (R)							Same as 1N66
CK706 (R)			50	40		200 @ −10V.	See Note 7
	1N64	.05 @ +0.25V.	20			25 @ −1.3V.	See Note 5
CK707 (R)		3.5	100	80	100	8 @ −5V.	
	1N52	4.0	85	70	150		
CK708 (R)							Same as 1N68
CK709 (R)				60			Quad, See Note 8
	1N73	15.0 @ +1.7V.	75			50 @ −10V.	Quad; See Note 3
CK710 (R)		3 @ +0.5V.	10	5		200 @ −.6V.	See Note 9
	G7A						See Note 6
CK711 (R)				80	30		Quad; See Note 10
	1N73	15 @ +1.7V.	75			50 @ −10V.	Quad; See Note 3
CK712 (R)		2.0	225	200		800 @ −200V.	
	1N75	2.5	125	100	50		
CK713 (R)		21 @ +2.0V.	75	75		250 @ −40V.	
	1N52	4.0	85	70	150		
1N81 (GE)		3.0	50	40		10 @ −10V.	
1N82							UHF Mixer
	G7A	0.8 @ +.5V.				800 @ −.5	See Note 6
CK715 (R)							Frequency Mult.
	G7E	0.8 @ +.5V.	5			800 @ −.5	Frequency Mult.
1N91 (GE)		1000	100				Diffused Junction Rectifiers
1N92 (GE)		1000	200				
1N93 (GE)		1000	300				
1N94 (GE)		1000	400				
G11 (GE)							Transistor
G11A (GE)							Transistor

NOTE 1: Forward resistances matched within 10% at +1V.

NOTE 2: Four diodes in tube shell with forward resistances balanced within +2.5% at +1.5V. Forward resistances of each pair matched within 3 ohms.

NOTE 3: Four diodes in hermetically sealed tube shell. Forward resistances matched within 6.7 ohms for 1N73 and 13.4 ohms for 1N74 at 15 Ma. Forward resistances of each pair matched within 2 ohms for 1N73 and 6.7 ohms for 1N74 at 15 Ma.

NOTE 4: Tested with 1.8V. RMS input at 40 Mc. 70% modulated at 400 cycles. Minimum output is 1.8V. peak-to-peak across 4700 ohms shunted by 5 MMF.

NOTE 5: Tested with 0.1V. RMS, 44 Mc input to last I.F. grid. Minimum output is 100 μa through 3600 ohms shunted by 5 MMFD.

NOTE 6: Maximum conversion loss is 10db measured at 900 Mc with 0.7 Mw L.O. level and d-c forward bias from a 0.25V., 250 ohm source.

NOTE 7: Tested with 0.1V. RMS, 50 Mc input to last I.F. grid. Minimum output is 330 μa through 5100 ohms shunted by 5 MMFD.

NOTE 8: Four diodes in tube shell with forward resistances matched within 2.5%. At −10V. diodes are matched 2.5% or all have a resistance greater than 1.0 meg ohm.

NOTE 9: Typical noise temperature ratio of 2.

NOTE 10: Four diodes in tube shell. Each pair of diodes is shunted by 10,000 ohms center-tapped and the center tap of resistor and diodes connected by a microammeter. With 0 to +3V. dc applied unbalance current limit is 5 MA.

- *For a free file card copy of this data write: General Electric Co., Section 5243, Electronics Park, Syracuse, N.Y.*

GENERAL ELECTRIC

NEWS and NEW PRODUCTS

April 1953

Millimicrosecond Pulse Generator

Electrical and Physical Instrument Corp., 42-19 27th St., Long Island City, announces the Model 100 millimicrosecond pulse generator, which utilizes a new method of pulse shaping. Square pulses of rise time of 1 millimicrosecond, (0.001 μsec.) with a comparable decay time and of width which can be varied from 2 millimicroseconds to several microseconds are generated. The maximum pulse amplitude is 100 volts into low impedance cables (such as 50 ohms) for a pulsed power output of 200 watts; outputs up to 800 watts are also available. The output amplitude can be attenuated a total of 84 db in one db steps to cover the range of 100 volts to 0.006 volt. A polarity switch on the front panel allows the selection of either positive or negative pulses. Two or more pulse outputs, each of which can be individually attenuated and delayed are available in some models. The repetition rate is 60 pps with control for a single pulse operation available. Pulse widths are: 2.0 millimicroseconds 2.0×10^{-9}, 5.0 millimicroseconds 5.0×10^{-9}, 7.5 millimicroseconds 7.5×10^{-9}, 10 millimicroseconds 10^{-8}, 25 millimicroseconds 2.5×10^{-8}, 50 millimicroseconds 5×10^{-8}, $\frac{1}{10}$ microsecond 10^{-7}. Other values of pulse widths are available upon request, and instructions for obtaining any pulse width desired from 2 millimicroseconds to several microseconds are included with the unit.

Transformer Catalog

Peerless Electrical Product Div., Altec Lansing Corp., has just released its new 15-page transformer catalog and price list containing 92 items. This catalog lists many new items including the new line of 20-20 plus transformers, and also describes facilities for the design and manufacture of Class A, B, and H transformers, which are built to meet JAN-T27 and MIL-T 27 specifications. Catalogs and price lists may be obtained by writing to Peerless Electrical Products Div., Altec Lansing Corp., 9356 Santa Monica Blvd., Beverly Hills, Calif., or 161 6th Ave., New York 13, N.Y.

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

The **Panel on Electron Tubes of the Research and Development Board** is sponsoring a symposium on Ceramic-To-Metal Seals at the **Rutgers University** School of Ceramics on **April 21, 1953.**

For further information contact Harry J. Sullivan at 346 Broadway, New York, N.Y., REctor 2-8000.

Time Calibrator

The Type 190 Low-Frequency Time Calibrator, a synchronous-motor driven device furnishing pulses at intervals of 0.01, 0.1, or 1.0 second, is now available from Owen Laboratories, Pasadena, Calif.

It is intended for use with oscilloscopes and various types of recording equipment in electrical, mechanical, and biological investigations. Pulse amplitude is about 1.5 volts. Size is $5\frac{1}{4}\times3\frac{1}{4}\times3$ inches, and the price is $48 postpaid.

Sharp-Cutoff Pentode

Tube Dept., Radio Corp. of America, Harrison, N. J., has a new type 5654, a "premium" version of the miniature sharp-cutoff pentode 6AK5 for use as a broadband RF or IF amplifier in mobile and aircraft receivers. It is constructed and processed to meet military requirements.

Featured in the 5654 is a compact structure especially designed to provide increased mount strength against shock and vibration, and a pure-tungsten heater to give long life under conditions of on-off switching.

Elapsed Time Indicator

R. W. Cramer Co., Centerbrook 5, Conn., has a new type ET time totalizer, used to measure and indicate elapsed time intervals wherever very precise measurement of time is required.

Two models are available: One has scale divisions of 0.01 second and a total range of 50 seconds, and the other has divisions of 0.01 minute and a total range of 50 minutes. Accuracy for either is better than 0.02 of of 1 per cent.

Prime feature of the new time totalizer is a unique differential clutch mechanism that insures high accuracy and positive clutching throughout the life of the device. Instead of the conventional friction or face plate clutch, the motor is here permanently connected to the sun gear of a differential gear system. One of the differential members is connected to the pointer system, while the other goes to a free gear.

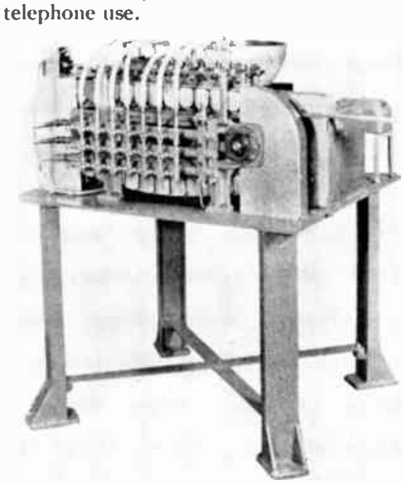
Forms of this time totalizer are available to meet the most exacting military specifications with regard to shock, vibration, temperature, etc.

For complete details write for Bulletin 690.

Tube Bottoming Machine

Kahle Engineering Co., 1307 Seventh St., North Bergen, N. J., has announced the production of a completely automatic tube bottoming machine.

This special-purpose machine, Model 2048, was designed and built to produce miniature lamp bulbs for switchboard and telephone use.



The machine, producing 4,000 units per hour, eliminates older methods of lifting the glass from one position to the next by using a continuous conveyor principle. Cut tubing of required length is dumped into a rubber-lined hopper; the glass is then indexed straight through the machine and is not "jumped" or "bumped" in the process. In machine breakage and rejects are consequently held to a minimum. In addition, Model 2048 can be used to produce round or flat bottomed test tubes, vials, and containers. *(Continued on page 44A)*

Shocking News About Super Davohm Resistors

Since Daven originated the first pie-type wire wound resistor more than a generation ago, it has pioneered many innovations in the production of resistors.

Today, *only Daven* uses a stranded lead wire to connect the resistance wire to the solder terminal of the Super Davohm Precision Wire Wound Resistor.

As a result, no matter how much strain, stress, heat or pressure is applied to the solder terminal, no accompanying shock is put upon the fine resistance wire itself, but is absorbed by the heavy lead wire without adversely affecting the resistor in any way.

Therefore, Super Davohm Resistors are substantially more rugged than conventional resistors and are able to withstand unusual vibration, rough treatment and abnormal shocks.

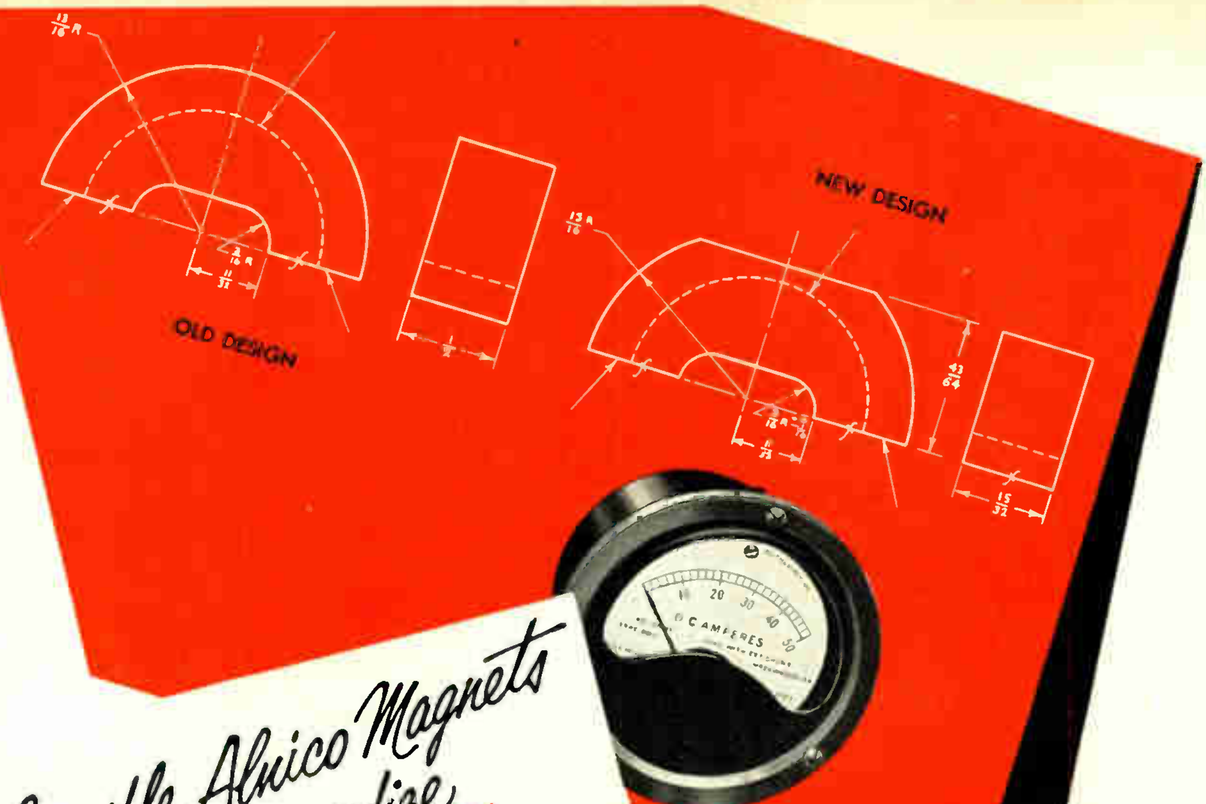
This exclusive Daven feature, plus the many other quality aspects of Super Davohm Precision Wire Wound Resistors, makes Daven the leader in the resistor field.

The Super Davohm line includes resistors made in accordance with MIL-R-93A specifications, as well as sub-miniature units to give you the most complete selection of resistors available anywhere. Deliveries can be made to meet your requirements.

Write for assistance with your problems, and ask for a copy of Daven's complete, new brochure on Super Davohm Precision Wire Wound Resistors.

THE DAVEN CO.

195 CENTRAL AVENUE, NEWARK 4, N. J.



Crucible Alnico Magnets help ruggedize Roller-Smith Instruments

13% smaller—same magnetic strength

When the Roller-Smith Corporation decided to ruggedize their electrical instruments to meet Military Specifications, they discovered that they needed a smaller permanent magnet — one that would do the same job as the old one they were using.

They called on Crucible's technical service for assistance. In short order, Roller-Smith's objective was attained. For through improved design, and better quality control in production, Crucible developed an alnico magnet that was 13.5% smaller and lighter than the previous one . . . but with the same magnetic strength.

The Roller-Smith story is typical of the many cases solved with Crucible Alnico Magnets, because Crucible magnets have the highest gap flux per unit of weight of any on the market. Crucible has been the leading producer of Alnico Permanent Magnets since the industry started. When you have a magnet problem, call on Crucible.

CRUCIBLE first name in special purpose steels

53 *years of Fine steelmaking*

PERMANENT ALNICO MAGNETS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

STAINLESS • REX HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS

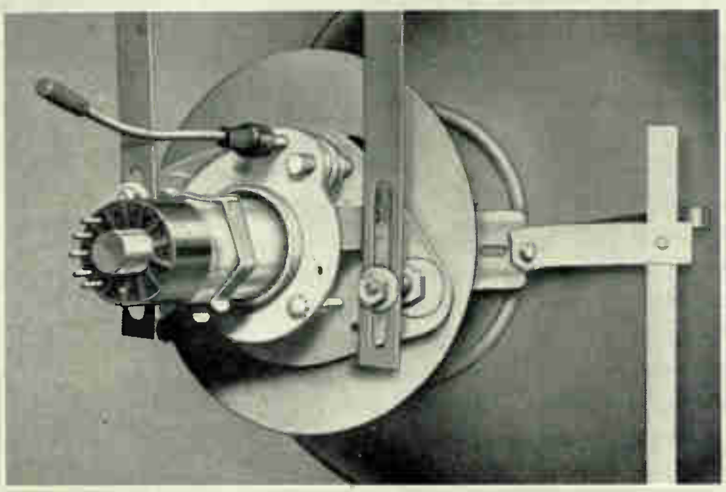
*i-m-f** Outmodes all others PICTURE TUBE

***with Internal Magnetic Focus**

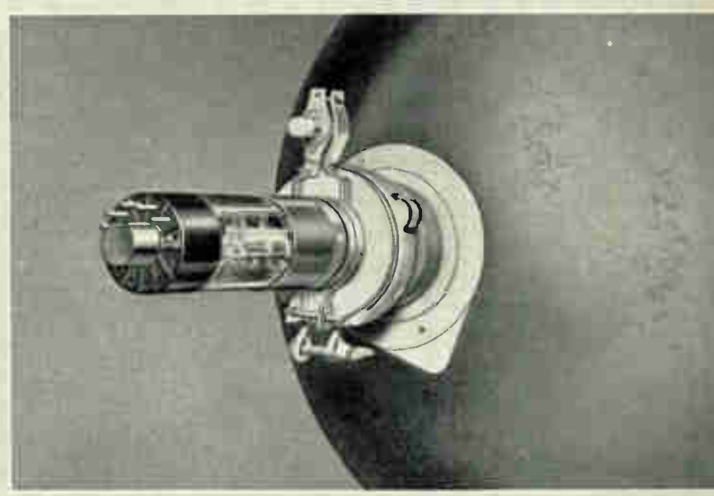
YEARS OF ELECTRICAL PROGRESS

- **Saves parts, circuitry, labor in set manufacture!**
- **Gives needle-sharp over-all image!**
- **Permanently pre-focussed for best viewing!**

COMPARE (left) the bulky parts needed for a standard tube with (right) the clean simplicity of an *i-m-f* tube ready to install!



The external ion-trap magnet on this standard tube, is an extra cost item for the TV manufacturer and requires special adjustment. The focus coil and complicated mounting also mean extra cost. They take up space, add weight, consume assembly and adjustment time. Get rid of all three parts with G. E.'s new *i-m-f* tube!



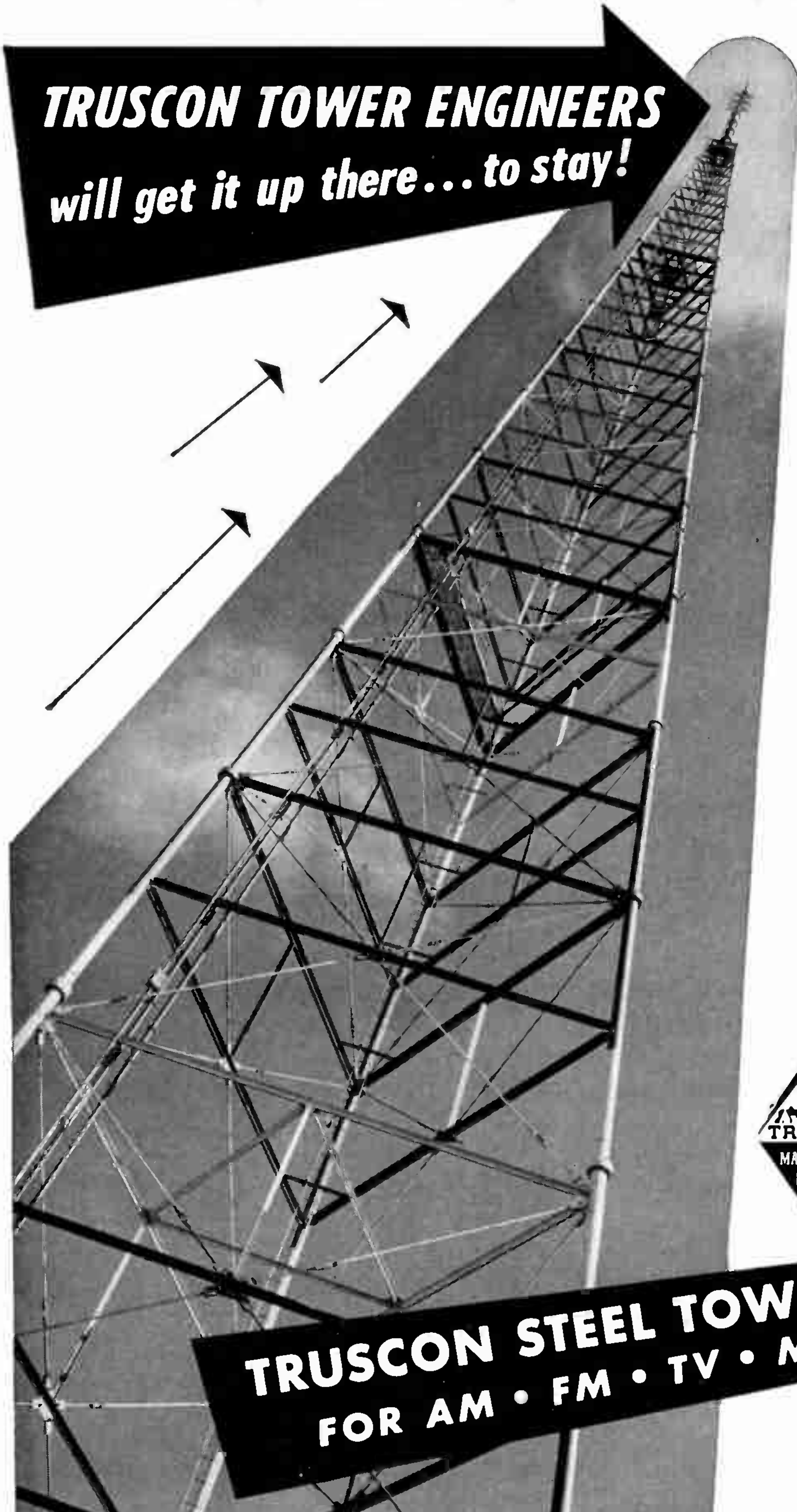
Now, no hard-to-adjust external ion-trap magnet! No focus coil, or external focus magnet, with cumbersome bracket! Instead, an *i-m-f* tube calls for just two parts when installed, both of them compact: (1) a close-fitting steel shunt band that is easily slipped on and (2) a small centering device to position the picture.

On this 75th anniversary year, General Electric takes pride in announcing its *i-m-f* picture tube as the latest in a long series of significant G-E "firsts". To the many advantages given by internal, factory-adjusted ion-trap and focus magnets, can be added radically improved design in important tube details. One example of this is the new, precision-made metal "lens" that greatly narrows the electron beam, assuring clean, sharp picture definition over the entire TV screen area. Now 90°-sweep tubes can have good detail across the whole face! You can expect production soon in 21" size. Other *i-m-f* types will be added rapidly. Television manufacturers and television designers will be sent full information on request. *Tube Department, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

162-1A2

You Name The Height Your Antenna Must Reach...



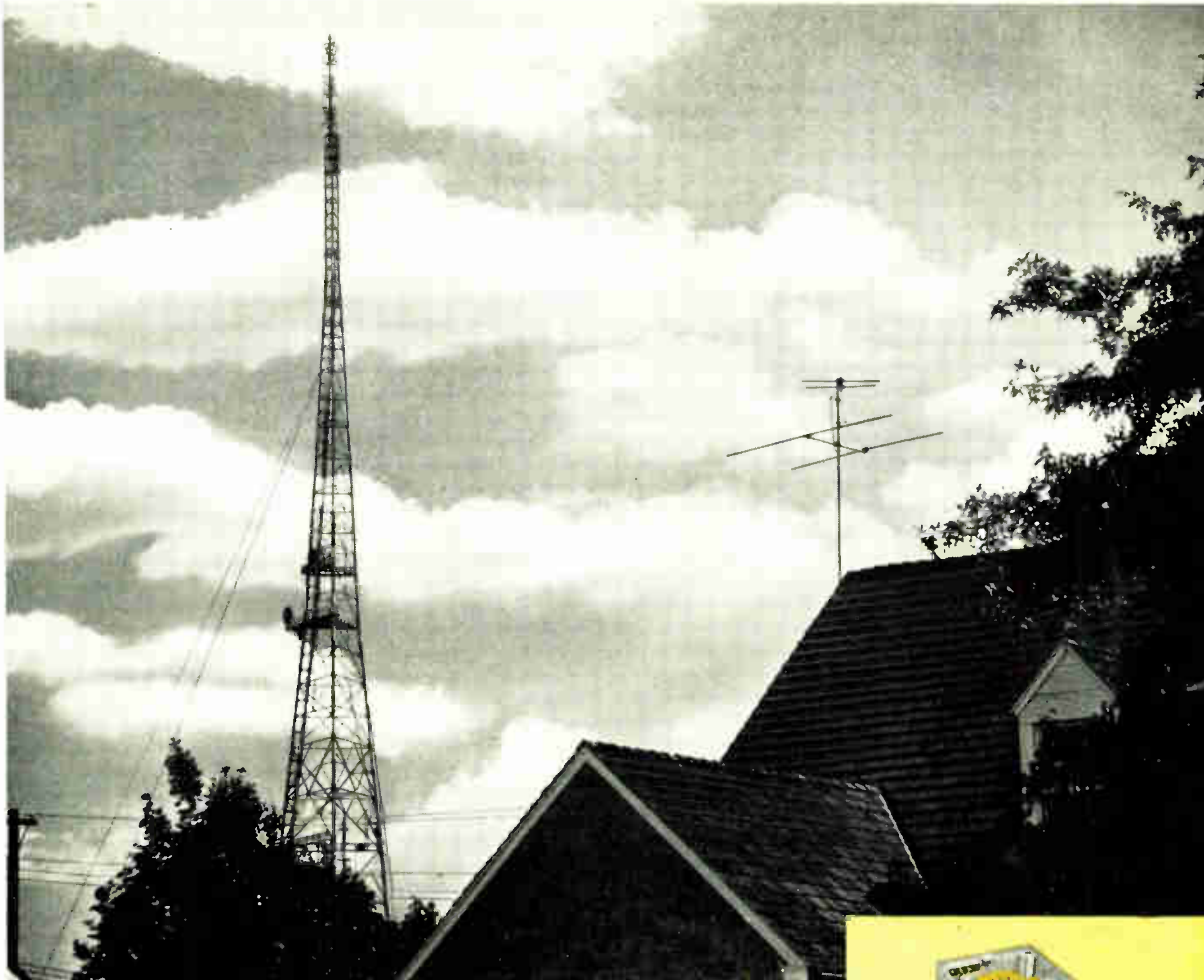
● Whether your needs call for a medium-sized 300 foot tower, a lofty 1200-plus foot giant, or any size in between, Truscon engineers have the answer . . . or can get it to you fast. Truscon has designed and built many hundreds of radio towers now serving in all kinds of climate and all types of topography. Truscon builds 'em for you tall or small . . . guyed or self-supporting . . . tapered or uniform in cross-section . . . for AM, FM, TV, and Microwave transmission. You just name the height your antenna must reach; then write, wire or 'phone your nearest Truscon district office or "tower headquarters" in Youngstown to get your tower program going as soon as defense requirements permit.

TRUSCON STEEL DIVISION

REPUBLIC STEEL CORPORATION
1072 ALBERT ST.
YOUNGSTOWN 1, OHIO

TRUSCON MARK OF MERIT PRODUCTS

TRUSCON®
— a name you can build on



SYNTHANE—out of sight, but in the picture

Whenever you turn on television you are using a little-seen, but essential, material called Synthane.

Synthane is a laminated plastic of multiple virtues, which recommend it for many jobs in television.

Synthane is an excellent insulator, laminable with metal, hence, a good base for space-reducing "printed" circuits. Synthane is notable for low power factor, low moisture absorption, and ease of fabrication, three properties desirable for radio and television insulation. Synthane plays a supporting part in many behind-the-screen and behind-the-camera applications.

Synthane is also light in weight, strong, vibration absorbing, chemically resistant, high in dielectric strength, dimensionally stable, heat resistant to about 300°F.

There may be a place for Synthane in your product. To find out more about the possibilities of Synthane for your purpose, write for the complete Synthane Catalog. Synthane Corporation, 12 River Road, Oaks, Pennsylvania.

Synthane in Television . . .

A—Television camera parts
B—Television receiver printed circuits—metal foil on Synthane sheets
C—Channel selector switch insulation

Synthane—one of industry's unseen essentials

SYNTHANE

LAMINATED PLASTICS

Searching

for more effective automatic control instruments?

Ketay's knowledge and experience will be helpful.

It was gained in developing and designing dozens of the precision control instruments that are today's military standards.

Take Ketay's Size 23 Synchro, for instance. This single development is an integral component in the controlling of the Skysweeper . . . the Army's latest automatic antiaircraft gun. Ketay's mass production techniques are making such controls economically practical.

Our instrument engineers, with more than 25 years of specialization in this field, could well put an end to your search for more effective automatic controls. There's no obligation, of course. Why not write for more information to Dept. A.

• NEWEST KETAY PRODUCT

ACTUAL SIZE

SUBMINIATURE TYPE 101A2D SYNCHRO CONTROL TRANSFORMER

Ketay Part No.	D—14450
Voltage rating	11.8v/0.4 v per deg.
Operating frequency	400 cps
Input power	0.4 w max.
Input current	140 ma max.
Input impedance	61 /77° ohms
Secondary voltage	23.2 ± 1 v
Total null voltage	40 mv max.
Fundamental Component of Null voltage	30 mv max.
Time Phase Shift	7°
Moment of Inertia	8.8 × 10^{-5} slug in^2
Frictional Torque	.05 oz. in.
Electrical Accuracy	—max. 10′

WHEN USED AS A CONTROL TRANSMITTER

Voltage rating	26/11.8 v.a.c.
Input power	0.4 w max.
Input current	65 ma max.
Input impedance	475 /77° ohms
Output voltage	11.8 v ± 0.3 v
Time phase shift	7.3°

Ketay MANUFACTURING CORP.

New York, N.Y. Hawthorne, Calif.

Executive Offices: 555 Broadway, New York 12, N. Y.

DESIGN
DEVELOPMENT
MANUFACTURE *of precision instruments*

- SYNCHROS • SERVOS • RESOLVERS
- MAGNETIC AMPLIFIERS • AUTOMATIC CONTROL SYSTEMS
- ELECTRONIC EQUIPMENT

The Standard of Quality

HICKOK

Model 292X

SIGNAL GENERATOR

Frequency Coverage:
125 KC to 220 MC

Calibrated Output:
Less than 1 microvolt,
up to 100,000
microvolts.

Professional engineers and technicians everywhere constantly rely on the accuracy of calibration and long dependability of HICKOK instruments.

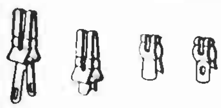
In electronic instruments, HICKOK pioneering leadership has been acknowledged for over 42 years.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
10514 Dupont Avenue • Cleveland 8, Ohio

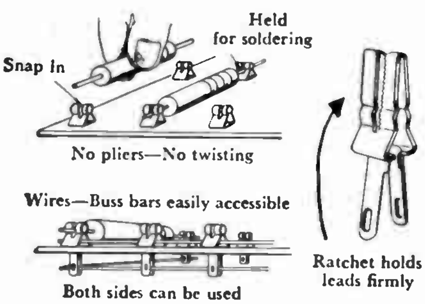
Here is Plug-in Unit Construction

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

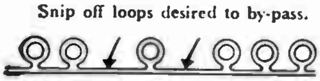
1st START WITH ALDEN MINIATURE TERMINALS



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.



Snip off loops desired to by-pass.



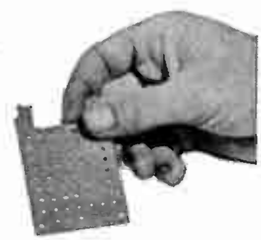
JUMPER STRIP

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

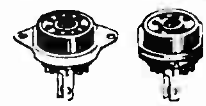
FOR YOUR SMALLER UNITS .

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

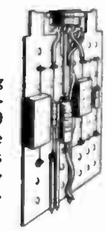
Prepunched Terminal Mounting Cards come in all sizes needed for Packages: miniature 7-pin and 9-pin units, or 11-pin and 20-pin plug-in units. Card is natural phenolic 1/16" thick prepunched on 1/4" centers with .101" holes for taking the Miniature Terminals.



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.

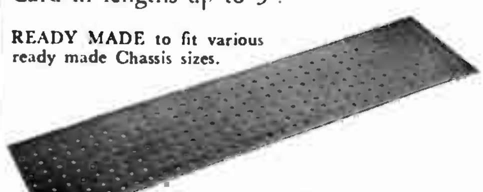


Mounting Brackets stake to the Prepunched Card, mount Card to Package Base and Lid.

FOR YOUR LARGER UNITS .

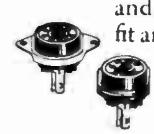
2nd Lay out circuitry with Prepunched Terminal Mounting Card in lengths up to 3′.

READY MADE to fit various ready made Chassis sizes.

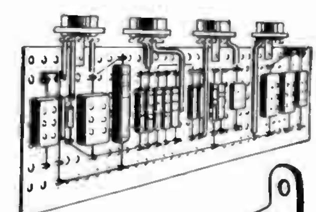


Organize circuitry in compact vertical planes. Use both sides of Prepunched Card to stake in Alden Miniature Terminals to your circuitry layout. Vertical position gives ready accessibility; there is no "underneath" in Alden design.

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.

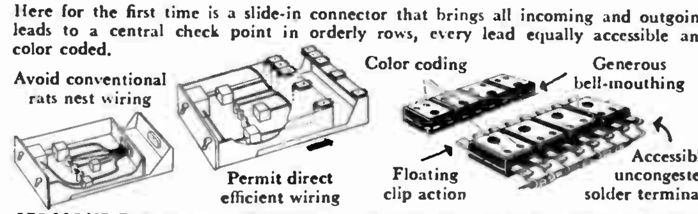
Signals immediately blown fuse. Lite visible from any angle. To replace fuse simply unscrew the 1-pc. Lite-lens unit. Mounts easily by standard production techniques, in absolute minimum of space. 110V Alden #440-4FH. 28V #440-6FH.

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.

NA-ALD

ALDEN PRODUCTS COMPANY

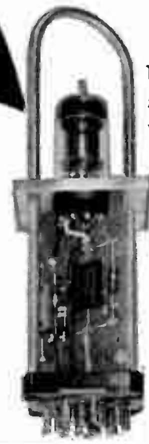
READY-MADE for your Electronic Equipment

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

ALDEN PLUG-IN PACKAGES

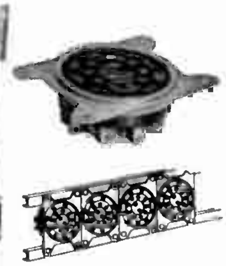
4th After mounting your circuits on Terminal Cards, use Alden Standard Plug-in Bases, Housings, Bails for packaging.

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



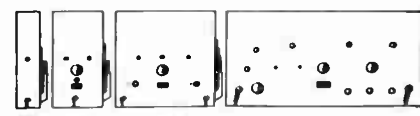
ALDEN PLUG-IN PACKAGES

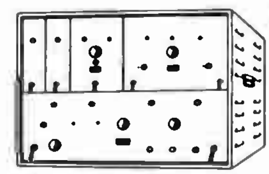
Using standard Alden Plug-in Packaging Components you can mount a tremendous variety of circuits on chassis or in racks.



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

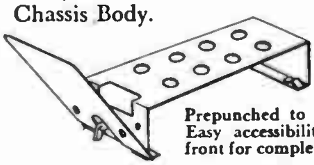




FOUR SIZES OF CHASSIS MOUNT IN ANY COMBINATION IN ALDEN UNI-RACKS

ALDEN BASIC CHASSIS

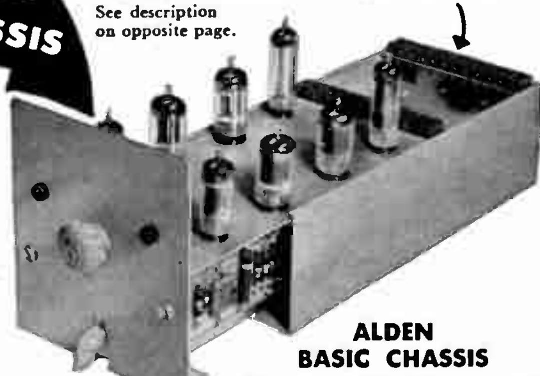
4th Fit Prepunched Cards carrying completed circuitry into Standard Alden Basic Chassis Body.



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

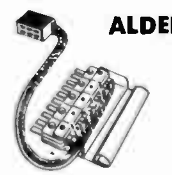
SERV-A-UNIT LOCK
pulls in or ejects chassis.

SLIDE-IN BACK CONNECTORS
See description on opposite page.



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

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 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 NA-ALD

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 30A)

Microwave Classes for Signal Corps by GE

A series of month long classes is being conducted by **General Electric Co.**, to instruct Signal Corps technicians on the installation, operation, and maintenance of microwave relay communications equipment. The company is producing the equipment for the Signal Corps at its Syracuse, N. Y. plant.

Assisting GE instructor (right rear) Gus Kandaris is J. N. Craver, chief radio engineer for the Signal Corps plant engineering agency, who attended the class to further familiarize himself with the GE equipment.

Junction Transistors

The **Receiving Tube Div., Raytheon Manufacturing Co.**, 55 Chapel St., Newton 58, Mass., announces the immediate availability of two P-N-P Germanium Junction Transistors types CK721 and CK722. Although CK722 may be had in production quantities, CK721 will be limited in quantity until April, 1953.

Types CK721 and CK722 are described in data sheets now available from Raytheon's Technical Information Service, or from sales offices in New York City, Chicago and Los Angeles. Both types have noise factors averaging 22 db at 1,000 cps. Type CK721 has an average power gain of 38 db while CK722 averages 30 db. The units require a volume of 0.03 cubic inches and leads may be soldered or welded into the circuit, or cut for insertion into standard subminiature sockets.

(Continued on page 45A)

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 44A)

IF Transformers

Radio Industries, Inc., 5225 N. Ravenswood Ave., Chicago 40, Ill., announces a new Series "A" design of the "RI-trans" intermediate frequency transformers, manufactured and in use since 1946.

It is available in two constructions. One with long, terminal lugs for conventional wiring and soldering, the other, for use with the new printed circuit chassis, employing short terminal lugs for pressure-fitting into the lug slot openings.

The transformers utilize silvered mica capacitors, with capacity accurately maintained, having zero temperature coefficient; perm tuned, top and bottom, and bandwidth maintained throughout the required core adjustment, reinforced one-piece terminal lugs; interchangeable, universal snap-clip mounting; uniform operation through wide variations of temperature and humidity, and availability with one or two internal diode capacitors. Size of the can encasing the new "RI-trans" is ¾ inch square; standard height is 2 inches, but shorter and longer heights are available as required.

Static Detector

Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio, has an improved Model 2005 Static Detector which clips onto a Keithley vacuum tube electrometer, providing a convenient and highly sensitive combination for detecting and locating static charges.

The new electrometer accessory consists primarily of two concentric, telescop-

(Continued on page 53A)

It's A Specialized Job...

designing vibrator power supply circuits

To avoid trouble with yours,

Call On MALLORY

If your mobile radio equipment is going to operate properly, under *all* sorts of conditions, the power circuit must be carefully designed. Experienced engineering must go into the design and selection of each element so the vibrator characteristics are in balance with the transformer and buffer capacitor.

These are some of the reasons vibrators can't be selected simply by size and rating alone if you are going to get long, trouble-free performance.

We have worked with leading manufacturers of electronic equipment on their vibrator power supply problems since we introduced the first commercial vibrator over 20 years ago. Our experience includes supplying more vibrators for original equipment than all other makes combined.

To avoid vibrator power supply troubles . . . call on Mallory in the design stage. Our engineers are thoroughly qualified by experience to study your specifications to be sure the power circuit will give maximum performance.

Our engineers will be glad to discuss your vibrator power supply problems. Write or call us today.

In addition to supplying vibrators, Mallory is equipped to design and manufacture complete power supply units . . . to your exact requirements . . . to meet your production schedules.

Expect more...Get more from **MALLORY**

Parts distributors in all major cities stock Mallory standard components for your convenience

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

P. R. MALLORY & CO., INC., INDIANAPOLIS 6, INDIANA

No ordinary relay...This! New CLARE Type T High Frequency Impulse Relay will follow 2500 cycles per second with life measured in billions of operations!

View of Clare Type T High Frequency Impulse Relay with dust cover removed

Exterior view of relay ready for mounting

specifications . . . .

MECHANICAL

SIZE:	1-15/16 in. diameter x 2-3/16 in. overall.
WEIGHT:	5 ounces.
MOUNTING:	Equipped with mica-filled bakelite plug, to fit a standard 8-pin octal socket.
COVER:	Removable dust-tight cover.
CONTACTS:	
Type:	Form A (s.p.s.t., normally open)
Material:	Platinum-iridium
Gap:	0.0005 inch
Pressure:	30 grams, min. (Coil energized with 50 ampere-turns)
COIL:	
Type:	Single winding, bobbin-wound
Wire:	Heavy formex

ELECTRICAL

COIL DISSIPATION:	0.5 watt (estimated max.)
CONTACT RATING:	0.05 amp., max. 50 volts ac, non-inductive. (estimated)
CONTACT BOUNCE:	None
OPERATION:	
Pull-in	15 ampere-turns
Drop-out	12 ampere-turns
Pull-in time	120 microseconds
Drop-out time	100 microseconds

RATE: Will follow 2500 cycles per second; aperiodic to 1000 cycles per second.

LIFE EXPECTANCY: 5 x 10^9 operations with zero contact current.

DIELECTRIC STRENGTH: 500 volts, rms.

TYPICAL APPLICATIONS

Coil inductance	0.3 hy (contacts open)
Coil inductance	0.35 hy (contacts closed)
Coil resistance	135 ohms
Pull-in current	10 to 12 ma.
Drop-out current	8 to 10 ma.
Normal coil current	40 ma.
Contact current	0.075 ma.

LIFE EXPECTANCY: Following a 1 x 10^6 operation run-in period, a life of 5 x 10^9 operations with a .075 ma. contact load over a 6-month period without readjustment.

Originally designed for use in an analog computer, the new CLARE Type T High Frequency Impulse Relay is now available for other applications which require a highly sensitive relay completely free from contact bounce and capable of a prodigious number of operations at extremely high speeds.

Its pull-in time of 120 microseconds and drop-out time of 100 microseconds enable this relay to follow up to 2500 cycles per second; aperiodic to 1000 cycles per second.

In a typical application, it has a life expectancy, following a run-in period of 1 x 10^6 operations, of 5 x 10^9 operations with a 0.75 ma contact load over a 6-month period without readjustment.

To achieve its high-speed, no-bounce, and other unusual characteristics, this relay is built to extremely close tolerances, with a high degree of precision, under conditions of utmost cleanliness. This necessitated the development of techniques never before employed in the manufacture of relays.

Even before this first public announcement of the availability of this truly remarkable relay, its fame has spread. Already dozens of inquiries and sample orders have been received from laboratories and development organizations which had learned of its existence through the manufacturer who first applied it in a well-known computer. It may provide the answer to one of your problems.

For full information on this new relay or for consultation on any relay problem, we invite you to contact your nearest CLARE sales engineer or write to C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13, Ontario. Cable address: CLARELAY.

WRITE FOR BULLETIN 117

CLARE RELAYS

FIRST IN THE INDUSTRIAL FIELD

"Radio" is a way of Thinking!

Just as "communication" needed to break its earthbound bonds of wire and take to the air, so industry is seeking and finding in radio controls new "tools" ranging from servo-mechanisms to electronic computors.

THIS IS NO DREAM

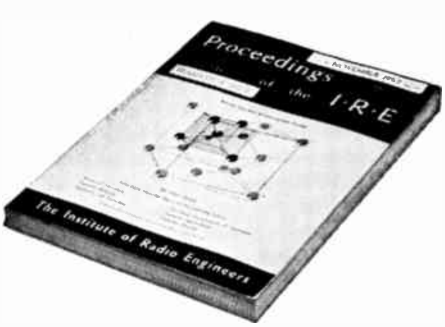
Radio engineers are making the "bright new world" which was the dream of men in World War II. Just as radio engineers bridged the lost silence of the sea by ship radio communications in the 1900s, so these same thinkers, as radio physicists unleashed the "radiation" power of the atom, and will harness it to industry. They have brought the picture of the world under your control by a knob in your home television — and have beaten the monotony of endless counting by the electronic computer.

TAKING THE GUESSWORK OUT

Such progress is no "happy accident." Men do not "discover" television — they "engineer" it. A good example is the inevitability of color television. From "fission" to "computation" the job is done by an enormous process of information exchange — the methodical and brilliant teaming together of engineering thinking to solve a problem. In radio this work has been done deliberately by a growing engineering society, through its meetings and published proceedings, which unleash the minds of men.

In 1952 "Proceedings of the I·R·E" published 1,792 text pages, exclusive of product news and departmental features. This is the word-count equivalent of seven 500 page textbooks on radio-electronics for engineers, and exceeds the contents of the next two contemporary publications put together. This "high" in genuine reader service was logically matched by advertising worth half a million dollars, by firms investing in the engineers' reading interest.

ABC AUDITED PAID CIRCULATION



"Proceedings of the I•R•E"

Published by the

INSTITUTE OF RADIO ENGINEERS

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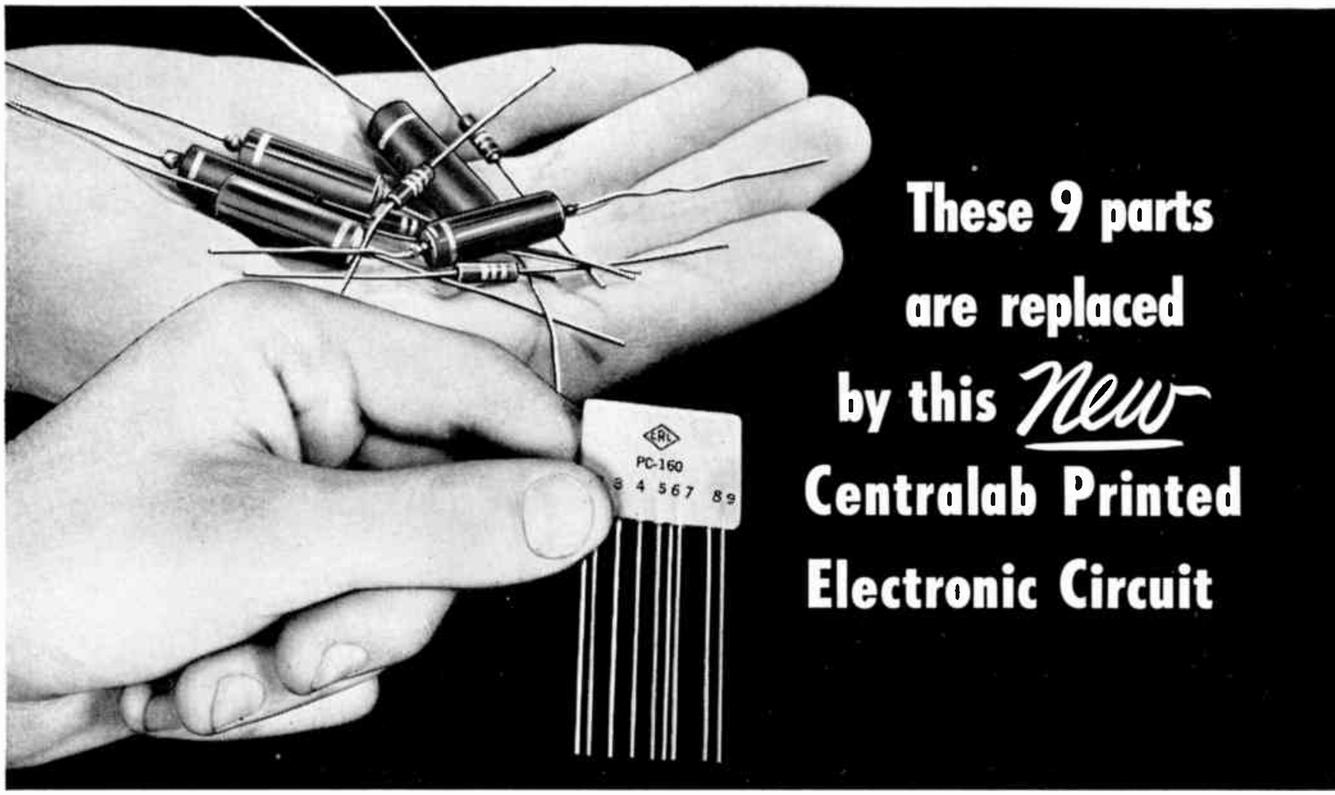
Radio • Communications • Television • Electronics



For scores of applications — Centralab Printed Electronic Circuits assure 6 tremendous SAVINGS in design, production and performance

1 25% to 80% fewer soldered connections | 2 Fewer pieces to buy or inventory | 3 Fewer connections minimize wiring errors | 4 Lower installation cost — with fewer parts | 5 Less weight, less space — "opens-up" chassis | 6 Improved circuit stability from uniform PEC's

ANY way you look at them, Centralab Printed Electronic Circuits mean more money in your pocket. No other modern electronic development offers you *six* such tremendous time and cost-saving advantages for low-power applications.

Pioneered and completely developed by Centralab, these resistor-capacitor combinations in complete or partial circuits are extremely economical to use. Many times, the *first cost of PEC's* is less than the components they replace.

As for versatility — there are more than 30 standard circuits already tooled for you. There is a tremendously wide range of sizes and capacities available to you.

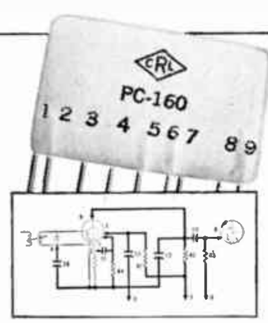
If you have a special circuit problem, we'll even design custom plates at nominal cost where volume warrants. *No wonder 25,000,000 PEC's are in use today!* No wonder scores of manufacturers say it's *good business* to specify and use Centralab Printed Electronic Circuits. Send coupon for full details.

Another Centralab first!
NEW PENDET

— a complete pentode detector and audio coupler circuit that replaces 9 parts . . . eliminates 9 soldered connections.

Talk about compactness—this new Pendet really has it! You get 4 resistors and 5 capacitors screened and fired to a *single* Ceramic-X plate. It replaces 9 conventional components. Only 9 connections are required instead of the usual 18.

"Think what this terrific PEC "package" can do in simplifying installation and cutting manufacturing costs of ac, dc and portable receivers. Get complete information on this new PC-160 Pendet NOW. Check No. 42-149 in coupon.



Pendet couples the combination detector and first audio pentode tube to the audio output tube. Plate is only 1-5/16" x 7/8" x 11/64" thick. Leads are 2-1/2" long. Capacitors are 450 vdcw, 800 vdc test. Resistors are 1/5 watt.

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Please send the following bulletins: ☐ 42-149, ☐ PEC guide No. 2. I'd also like a copy of Centralab's new Electronic Components Catalog No. 28.

Name.............................. Position..............................
Company..............................
Address..............................
City.............................. State..............................

RADIO FREQUENCY CONTROL UNITS

•

Partial List of Units Manufactured

Bulova Type	Frequency Range	Tol.	Temperature Range
70A	6000 KC to 15000 KC	.005%	−55°C to +90°C
70C	350 KC to 1100 KC	.03%	−40°C to +70°C
70D	200 KC to 500 KC	.01%	−40°C to +70°C
71E	90 KC to 110 KC	.02%	−40°C to +70°C

•

FOR THE FIRST TIME EVER... the high-precision production techniques of fine watchmaking is now being applied to the manufacture of radio frequency control units by Bulova.

•

Inquiries invited on crystals for your special application

•

Quartz Crystal Division

BULOVA WATCH COMPANY, INC.

630 FIFTH AVENUE, NEW YORK, N. Y. CIRCLE 5-7700

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 45A)

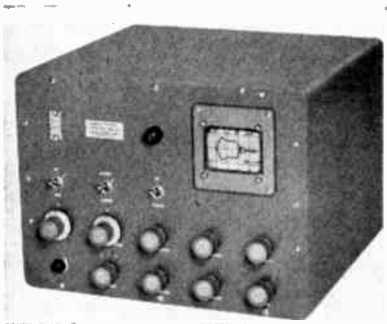
ing tubes and a center aluminum rod. When clipped over the HI terminal of the electrometer, the tubes act as a shield for the rod, limiting sensitivity to a narrow cone along their axis.

Qualitative results are obtained by noting the deflection of the meter pointer. Sensitivity can be varied by extending or lowering the inner tube. With the tube lowered to maximum sensitivity, a charged pocket comb throws the pointer off scale from a distance of ten feet.

Uses for the Electrometer and Static Detector include virtually every application where electrostatic charges are undesirable and an instrument of extreme sensitivity is needed.

Servo Tester

The 101-A Servo Tester designed for the rapid field maintenance and production testing of servo systems is available from **Industrial Control Co.,** Wyandanch, L. I., N. Y. The transient response of the loop under test is shown on a 3-inch cathode-ray screen, and viewed through a mask onto which has been previously drawn the response specified by the manufacturer. The operator adjusts the servo loop to match the two traces; if this is not possible, the loop is declared inoperative and returned to a laboratory area or maintenance depot for repairs.



A standard Servo Test receptacle is installed on the equipment to be checked, and wired into the data system in accordance with simple instructions. A single cable connects this plug to the 101-A. Thus the test can be performed in a very short time.

The 101-A complements the earlier 100-A, designed especially for laboratory servo evaluation. It can be rack mounted into complex servo equipments, where a stand-by checking means is necessary. It can be used with dc and carrier frequency servos, and operates from the 117 volt 60 or 400 cps line.

For further information, contact G. M. Attura, or phone Midland 3-7548.

(Continued on page 55A)

Designed for Application

The No. 90281

High Voltage Power Supply

The No. 90281 high voltage power supply has a d.c. output of 700 volts, with maximum current of 250 ma. In addition, AC filament power of 6.3 volts at 4 amperes is also available so that this power supply is an ideal unit for use with transmitters, such as the Millen No. 90800, as well as general laboratory purposes.

The power supply uses two No. 816 rectifiers and has a two section π filter with 10 henry General Electric chokes and a 2-2-10 mfd. bank of 1000 volt General Electric Pyranol capacitors. The panel is standard 8¾" x 19" rack mounting.

JAMES MILLEN MFG. CO., INC.

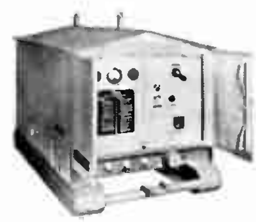
MAIN OFFICE AND FACTORY

MALDEN

MASSACHUSETTS

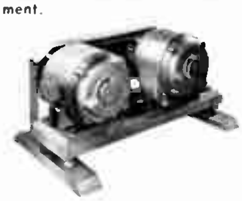
"packaged" *high frequency* power supplies *for ground installations*

American Electric supplies these complete, "*packaged unit*" power supplies for *all* high frequency requirements. Noted for their rugged, reliable performance, the amazingly low maintenance factor of American Electric alternators results from a unique and exclusive design principle: *a rotating inductor without coils; without springs, slip rings or brushes!* Nothing to wear out, nothing to service . . . *as maintenance-free as its two sealed ball bearings!*



Semi-portable, skid-mounted missile launching power supply completely weather protected.

Portable, caster-mounted 400 cycle installation for production test equipment.



Stationary installation, vee belt drive, resilient mounted for laboratory h.f. test equipment.

Variable frequency installation for research test work.

Manufacturers Also of Miniature A.C. (All Frequencies) Electric Drive Motors, Blowers and Fans

Correct Power Supply for Every Installation

Portable, semi-portable or stationary types, open models or completely enclosed for weather protection. Caster or pneumatic tire mounts, skid mounts and resilient rubber mounts on stationary types.

Wide Frequency Ranges

Fixed Frequencies from 250 cycles to 2400 cycles (up to 4000 cycles in the lower ratings).

Variable Frequencies from 380 cycles to 1200 cycles and 1200 cycles to 2400 cycles.

Excellent Voltage Regulation: Standard ± 1% to as low as ± .5% depending upon choice of drive. Electronic regulators or magnetic amplifier regulators supplied.

Motor Drives—Common shaft, direct connected, Vee belt or positive, no-slip timing belt types. Variable speed on variable frequency models.

Low Harmonic Content

Less than 2% on single phase.
Less than 1% on three phase.

Exceedingly low harmonic content results directly from alternator design without use of filters.

Output Ranges

single phase—500 watts to 15 KVA
three phase—500 watts to 30 KVA

(outputs up to 75 KVA available in other alternator designs.)

WHATEVER YOUR GROUND POWER SUPPLY REQUIREMENTS

Ask American Electric for quotation

NOW! Ask for Details!

American Electric Auxiliary Airborne MISSILE POWER SUPPLIES

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TRADE MARK

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California

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 53A)

Miniature Power Supply

The Airpax Products Company, Middle River, Baltimore 20, Md., has released the first of a series of miniaturized dc to dc power supplies using their high-frequency vibrator, 450 cps in illustration.

The total weight of the new item, Model A-1220, is 1 pound 14 ounces. Vibrator and power supply are hermetically sealed, vibrator attaches with snap fasteners. Output of 150 volts, 100 ma, is filtered to 1 per cent peak ripple. Three standard units of 6, 12, and 26.5 vdc input are offered. On special order output power up to 20 watts, output voltages up to 300 volts, and input between 4 and 100 vdc can be furnished.

Unit is designed to meet severe military standards of vibration, shock, temperature range, humidity, and altitude.

Hermetically-Sealed Accelerometer

The G. M. Giannini Co., Inc., 117 E. Colorado St., P.O. Box N, Pasadena 1, Calif., and East Orange, N. J., announces a new, long-life accelerometer, Model 24132. Smallness and compactness are noteworthy features of this instrument, which utilizes a potentiometer resistance and is hermetically sealed in an inert gas. It has low, natural frequency and in most cases a large output requiring no amplifying unit.

Model 24132 is obtainable in resistance ranges from 1,000 to 20,000 ohms and for any accelerometer measurement up to 300 with special adaptations possible. Potentiometer element safely carries current up to 10 ma. The 24132 has good resolution with 0.25 per cent minimum offered on the standard instrument, is a 1 per cent instrument in performance and has a good life expectancy under vibration. Optimum operation between −54°C and +71°C is obtained. Damping is 0.5±0.075 of critical for a 7.5G instrument as a typical case. A special shipping stop may be obtained for increasing instrument life, and the instrument is magnetically damped. Designed for applications in computing, telemetering and aircraft and missile control.

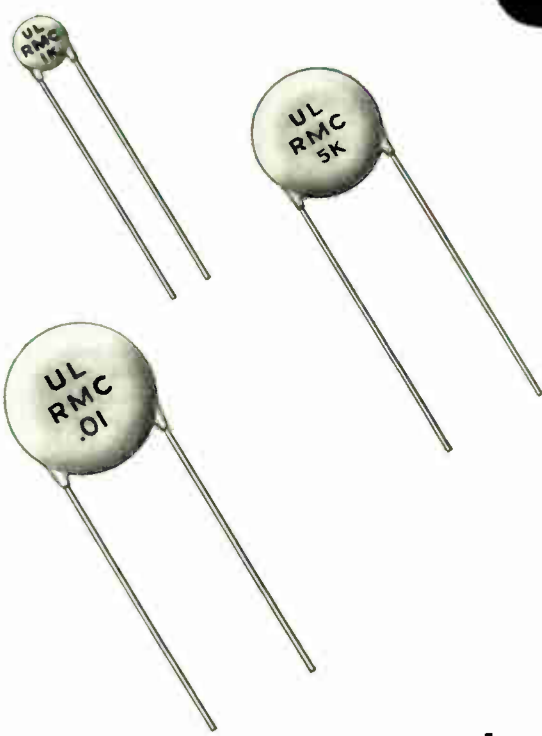
(Continued on page 114A)

ANOTHER

RMC FIRST!

New Ceramic DISCAPS®

Designed for AC Line By-Pass Applications



Underwriters' Laboratories specify that a ceramic capacitor used in AC line by-pass applications must withstand a 1500 volt AC 60 cycle one minute test.

RMC has developed Type UL DISCAPS for this or any application where a steady or intermittent higher voltage may occur. Capacities between .001 MFD and .02 MFD are now in production.

The use of Type UL Discaps will effect considerable cost savings over any other type of capacitor acceptable to the Underwriters' Laboratories.

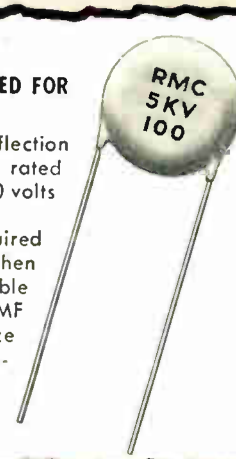
Two New Developments from the RMC Technical Ceramic Laboratories

NEW

HIGH VOLTAGE DISCAPS DESIGNED FOR 90° DEFLECTION YOKES

Designed especially for 90° deflection yokes, these RMC DISCAPS are rated at 2000, 3000, 4000, and 5000 volts DC.

The voltage safety factor required in this application is insured when DISCAPS are used. Now available in any capacity between 15 MMF and 240 MMF, their smaller size and lower initial cost offer definite production ease and overall savings.



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DISCAP CERAMIC CONDENSERS

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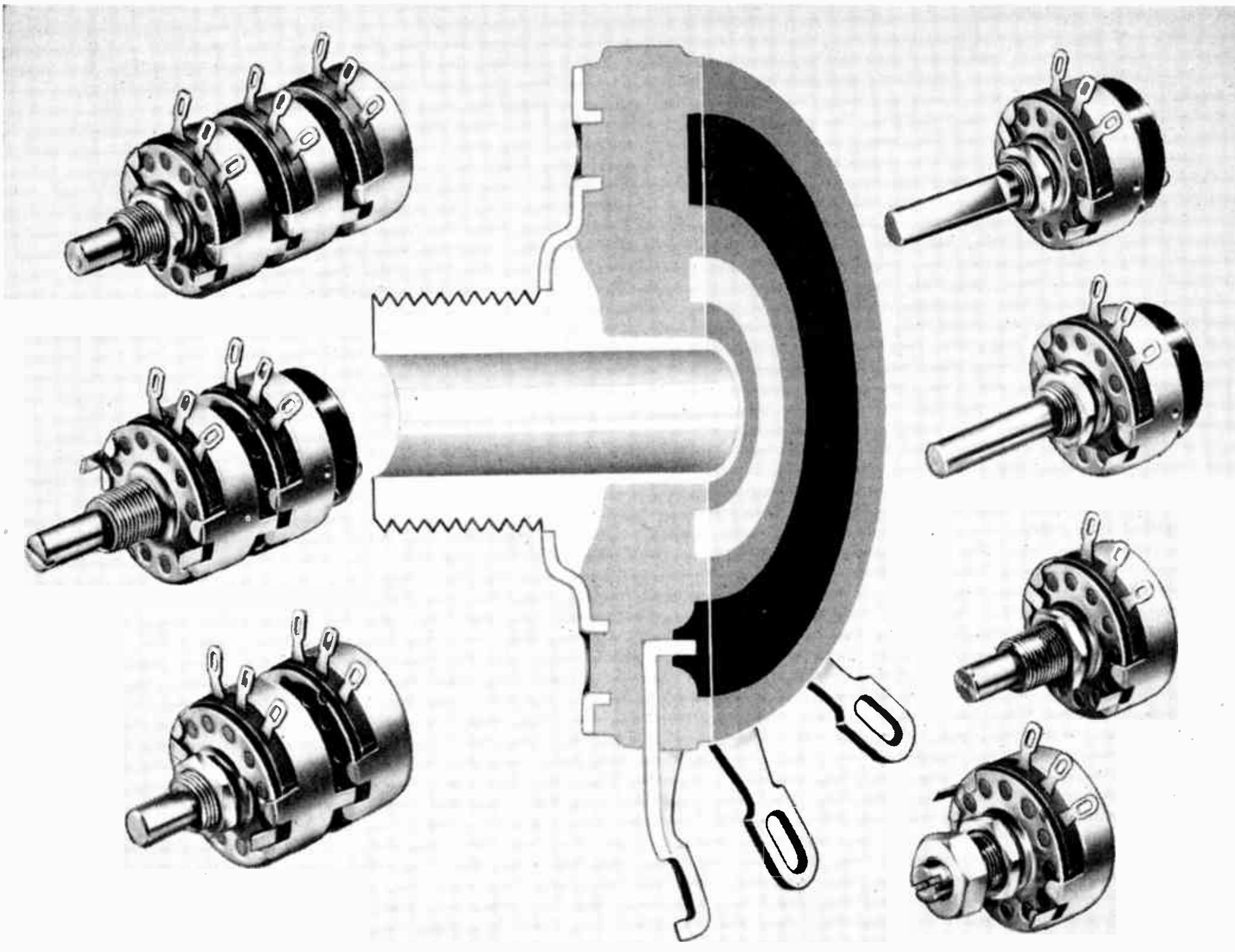

Have you heard *the latest*... IN BACKGROUND MUSIC?






An atmosphere to relax and enjoy—or the stimulation to work, to think, to play or buy—these are the benefits of background music. And background music is now practical *anywhere*, even beyond the reach of present wired services.

With the announcement of the new AMPEX 450, magnetic tape, musical wonder of a coming era, has become the ideal medium for background music. Hourly cost drops to a new low; quality rises to an all-time high. A wide variety of music for every purpose is now available on pre-recorded tape (see your Ampex distributor). Tape recordings eliminate needle scratch and their fidelity is permanent. They last for any conceivable number of plays.

On the AMPEX 450, up to eight hours of unrepeated music is available from one 14-inch reel of tape, and fully automatic repetition is available. The troubles and complexities of record changers are eliminated. And the AMPEX requires no standby attention from an operator.

AMPEX background music has a place in your business.

For further information, write to Dept. G1218A

THE NEW AMPEX 450

- 8 hours of uninterrupted music (rest periods as desired)
- Usable on land, sea or air
- No standby operator required
- Lowest cost per hour

AMPEX

MAGNETIC RECORDERS

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


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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.
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Actual Size

NEW

5 KW at 900 MC GL-6182

- "Custom-tailored" for military communications and medium-power TV transmitters!
- Compact. Only 8 5/16" high!
- One tube handles **all** military and TV frequencies, 200 to 900 mc.
- Tetrode design assures low drive requirement.
- Modern ceramic construction and ring-seal design.
- Quickly installed or removed. Spring-finger electrical contacts; convenient, firm-grip handle. Tube weighs only 2 pounds!

U-H-F DESIGNERS: this 5-kw tetrode is the power tube you've been waiting for! Provides ample r-f for your new medium-power transmitter, efficiently, with economy—takes up minimum space, is lightweight and easy to plug in. A tube that maintenance-conscious operators will welcome! . . . Military communications and radar—industrial dielectric heating—u-h-f TV—these are leading applications. Get ratings and the full tube story in special G-E Bulletin ETD-726. Write *Tube Department, General Electric Company, Schenectady 5, N. Y.*

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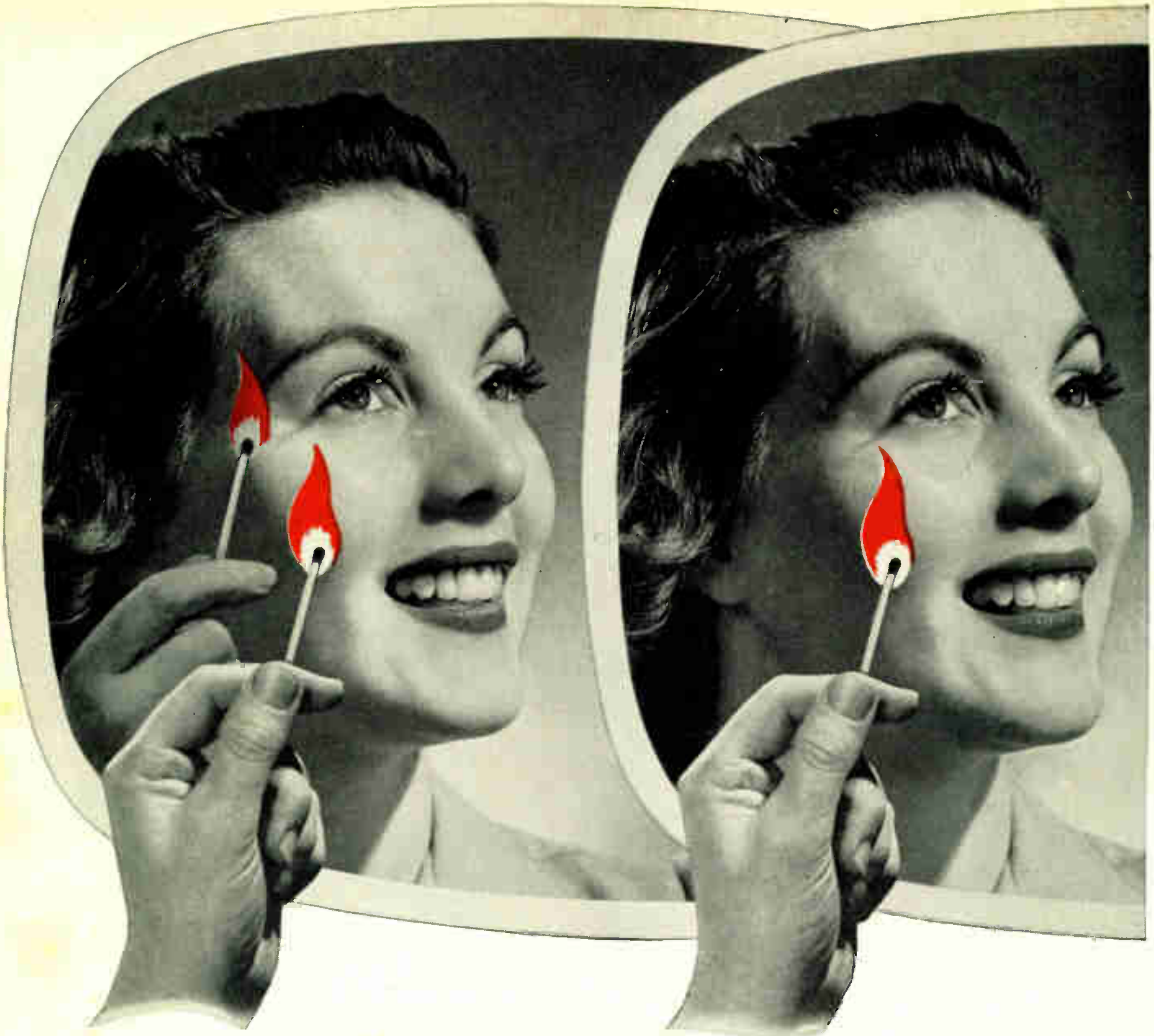
Diamond Anniversary

GENERAL ELECTRIC

163-1A4



Now you see it...now you don't!

THIS IS HOW IT'S DONE . . .

The etched surface on the faceplate of the metal-shell picture tube (right) diffuses the reflection from the lighted match—while the untreated faceplate of the other tube "mirrors" it.

Here is the answer to an awkward problem . . . and RCA metal-shell kinescopes solve it simply. They suppress bothersome reflections from room lights and other bright objects. And they reproduce clear, graphic pictures over the *entire faceplate area.*

Give your TV line a powerful new sales lift. Make your sets "reflection-free"—with RCA metal-shell kinescopes.

For technical data or design help, write RCA Commercial Engineering, Section 47DR. Or just call your nearest RCA Field Office:

(EAST) Humboldt 5-3900, 415 S. 5th St., Harrison, N. J.

(MIDWEST) Whitehall 4-2900, 589 E. Illinois St., Chicago, Ill.

(WEST) Madison 9-3671, 420 S. San Pedro St., Los Angeles, Cal.

RCA Metal-Shell Kinescopes

RCA-21AP4 (magnetic-focus type)	**RCA-21MP4** (electrostatic-focus type)

—the picture tubes with the faceplates that suppress annoying room reflections

RCA

RADIO CORPORATION of AMERICA

ELECTRON TUBES **HARRISON, N. J.**

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Published Monthly by

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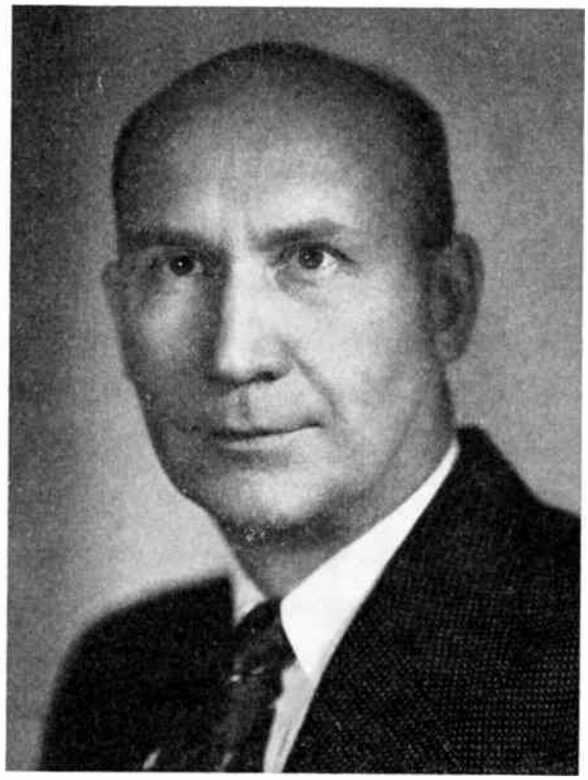

John Tasker Henderson

DIRECTOR, 1953–1954

J. T. Henderson was born on December 9, 1905, in Montreal, Canada. He received the B.S. and M.S. degrees in engineering physics at McGill University in 1927 and 1928, respectively, and the Ph.D. degree from the University of London in 1932. He carried out ionospheric experiments during the total solar eclipse in Canada in 1932, and studied further in Munich, Germany until 1933.

In 1933 Dr. Henderson joined the staff of the National Research Council of Canada in Ottawa. As head of the radio section he participated in direction-finding experiments on atmospherics in Ontario and Manitoba which gave rise to the development of a shortwave cathode-ray direction finder, widely used by the Royal Canadian Navy during World War II.

In 1939 Dr. Henderson represented Canada at the first official disclosure of British radar to the Commonwealth countries. He returned to Ottawa to start similar work at the Council, directed the development of radar equipment for the Armed Services, and contributed in organizing the radar division of Research Enterprises Limited, a Crown company for quantity manufacture of the Council's wartime developments. From 1942–1946 Dr. Henderson served as an officer in the Royal Canadian Air Force, where he was concerned with the installation and operation of the early warning radar chain in Nova Scotia, Newfoundland, and Labrador. He later served overseas.

Returning to the National Research Council, Dr. Henderson was the Canadian Delegation's scientific advisor to the United Nations Atomic Energy Commission. Back in Ottawa, he headed a group studying the application of radar to surveying, and succeeded in evolving methods now used extensively in northern Canada by the Dominion Geodetic Survey and Royal Canadian Air Force. In 1949 he took charge of the Council's electricity laboratory to expand its scope and set up new absolute electrical standards for Canada, in conformity with international agreements.

Dr. Henderson joined the Institute in 1928 as an Associate, became a Senior Member in 1947, and was elected Fellow in 1951. A member of the IRE Ottawa Section, he was Vice-Chairman in 1949–1950 and Chairman in 1950–1951. He is Director of IRE Region 8.

The Engineer: Expert or Citizen?

ARTHUR V. LOUGHREN

The activities and position of the engineer in a modern community have steadily become wider and more important. It has been found that the engineer is valuable in the civic sense both as an informed citizen and as one who is specially qualified to carry out an approved project. This dual function of the engineer is capably analyzed in the following guest editorial by a leading engineer who is a Fellow and Director of the Institute, and who is also Director of Research of the Hazeltine Corporation.—*The Editor.*

When the tool of specialization first became important in man's affairs it brought with it the concept of the specialist or expert, as distinct from the nonexpert, or perhaps we should say citizen. It became apparent that to make best use of experts they should be consulted in that capacity with respect only to questions which fell clearly within the field of their expertness. Their views on other questions were valuable, but no more so than the views of any other citizen.

The questions with respect to which the views of experts are particularly helpful are questions of such nature as, "how do we best accomplish this result?" It is implied here that the result to be achieved has been stated already and that the expert is consulted to find how best or most readily to achieve it. The result (the end desired) is a matter which in a democratic society should be selected by the majority vote of the citizens. There are no experts on such questions as, "are technicolor movies more pleasing than steak dinners?" Broadly, then, the collective voice of the citizens should choose the ends to be sought, and the advice of experts should be obtained in selecting the means by which to achieve those ends.

Many of our politically troublesome problems would be simple if we could get, case by case, a popular verdict on the end to be sought, and then separately get the advice of recognized experts on the means best calculated to achieve that end. Practically, however, the questions presented for solution often contain means and ends intermixed. In this kind of circumstance a public decision for a proposal may register correctly the public's preference for one end as opposed to another, but may accompany it with the prescription that an expensive and otherwise undesirable method be used. The special pleaders, those grinding their own personal axes or grinding for a fee the axes of others, do their best to obtain decisions favorable to them from the public by exploiting this kind of confusion.

In this own field the engineer is always in the position of the expert. In addition to having made him an expert in that field, his training also has impressed on him the importance of thinking clearly, of discarding the irrelevant, of deciding questions of means only with reference to their effect on the cost of reaching the intended end; it perhaps also has made him a better citizen, one better qualified to separate questions of means from question of ends in fields other than his own, even though in these other fields he cannot play properly the role of expert.

In the light of these considerations, one may ask, "should the engineer take active interest in the political life of his community, his state, his nation?" Of course he should, and on two separate planes. He should serve as expert with respect to the questions where his expert knowledge is appropriate, and, even more importantly, he should serve as a serious and intellectually able citizen joining with his fellow citizens in selecting the ends to be sought.

Radio Progress During 1952*

Introduction

THE SMALLER NUMBER of engineering graduates from our colleges, partly resulting from published fears of a predicted overabundance in the immediate post World War II period, combined with a greater-than-average increase in the need for engineers, produced a serious shortage. Whereas, it was anticipated that the termination of the war would release engineers to civilian pursuits, the needs of the military in Korea and the general rearmament program that is now in full operation, delayed a return to a normal peacetime economy.

Despite the reduced number of graduates, a larger proportion of engineers are required for production, maintenance, and operation, services that previously got along without them. In part, these assignments stem from the increased emphasis placed on guaranteed reliability of electronic equipment when operated in an unfavorable and hazardous environment.

Industrywide committees were set up to co-operate with the users of equipment, both military and civilian, to examine causes of failures and to recommend remedies to assure trustworthy operation. The basic design of tubes and their circuits, components, assemblies, installations, and maintenance are all significant elements in this search for predictable reliability.

The transistor is emerging from the laboratory with admirable promptness. Much has been done on methods of producing junction transistors in commercial quantities. Most of the output is going to the armed services, who are responsible for the contracts under which the production techniques are being developed.

The Federal Communication Commission in the United States resumed the licensing of television broadcasting stations, which was interrupted in 1948. Many licenses were issued for operation in the band from 470 to 890 mc and one of these uhf stations went on the air using an existing experimental transmitter. The problems of adapting standard vhf television receivers for operation in this higher frequency band received much attention in anticipation of the early installation of many such transmitters throughout the country in places already being served by vhf stations.

The reception of weak but steady uhf waves at distances greatly exceeding those predicted by accepted propagation theories presented another of the unexpected challenges that have characterized this field over the years.

* Decimal classification: R090.1. Original manuscript received by the Institute, January 26, 1953. This report was prepared by the 1952 Annual Review Committee of The Institute of Radio Engineers.

Electron Tubes and Semiconductors

Small High-Vacuum Tubes

Diodes: The transit-time spread due to difference in initial velocity in a planar diode was calculated for the normal diode and for the diode with reflected beam.

(1) J. T. Wallmark, "Influence of initial velocities on electron transit time in diodes," *Jour. Appl. Phys.*, vol. 23, pp. 1096–1099; October, 1952.

The anode current of a saturated diode is very sensitive to changes in filament current. The time response of the diode is important in incremental ammeters and servomechanisms where the diode is used as an element responsive to current changes of small amplitude. The factors determining the time response for small changes in filament voltage or current were investigated and procedures were described for calculating and for measuring its value.

(2) F. M. Hibberd, "The transient behaviour of thermionic filaments with temperature limited emission," *Jour. Sci. Instr.*, vol. 29, pp. 280–283; September, 1952.

Triodes and Tetrodes: With regard to triodes and tetrodes of the conventional negative-grid type, the development effort continued to be directed toward the attainment of higher power in the vhf and uhf regions with the requirements of television transmission the principal objectives.

Three papers on developmental tubes discussed specific features enabling improved performance at the desired frequencies. Power outputs ranged from a few watts to 50 kw.

(3) D. C. Roger, "Triode amplifiers for operation from 100 to 420 megacycles," *Elec. Commun.*, vol. 29, pp. 12–19; March, 1952. Also *Jour. Brit. I.R.E.*, vol. 11, p. 569; December, 1951.
(4) P. T. Smith, "Some new uhf power tubes," *RCA Rev.*, vol. 13, pp. 224–238; June, 1952.
(5) R. H. Rheaume, "A coaxial power triode for 50 kw output up to 110 mc," Proc. I.R.E., vol. 40, pp. 1033–1037; September, 1952.

Methods were derived for more accurate calculation of the characteristics of planar triodes under conditions of a nonuniform field along the cathode due to the finite pitch and diameter of the grid wires.

(6) W. Dahlke, "Grid effective-potential and cathode-current density of a plane triode under conditions of 'Inselbildung'," *Telefunken Zeitung*, vol. 24, pp. 213–223; December, 1951.
(7) W. Dahlke, "Calculations of characteristics families for the planar triode with a negative control grid of round parallel wires of finite thickness and pitch," *Telefunken-Zeitung*, vol. 25, pp. 83–92; June, 1952.

Three papers dealt with more general problems: one on the use of thoriated filaments, another on the magnetic effects of filament current, and the third on evaporation cooling.

(8) R. B. Ayer, "Use of thoriated tungsten filaments in high power transmitting tubes," PROC. I.R.E., vol. 40, pp. 591–594; May, 1952.
(9) A. M. Hardie, "Magnetron effect in high power valves," *Wireless Eng.*, vol. 29, pp. 232–245; September, 1952.
(10) C. Beurtheret, "Evaporation-cooled power tubes," *Electronics*, vol. 25, pp. 106–107; March, 1952.

A theory of microwave amplifier tube design was derived including parasitic capacitances and ohmic losses in the leads. The maximum-frequency limit for amplification was calculated to occur when the useful electrode areas are so chosen that the useful capacitance equals the parasitic capacitance.

(11) G. Diemer and K. Rodenhuis, "Optimum geometry of microwave amplifier valves," *Philips Res. Rep.*, vol. 7, pp. 36–44; February, 1952.

A high-g_m tube was developed based on the new principle of the space-charge deflection of a beam. The beam can fall either or both of two anodes, depending on the amount of beam deflection, which is in turn determined by the action of a conventional grid. The advantages found are high g_m without increase of noise level.

(12) J. T. Wallmark, "An experimental high-transconductance tube using space-charge deflection of the electron beam," PROC. I.R.E., vol. 40, pp. 41–48; January, 1952.

Tube Reliability: Tube failures in computing equipment represent a major problem in their field. The common causes of tube failures were discussed, with the conclusion that low plate current and defective cathodes accounted for about two-thirds of all tube failures in service.

(13) J. A. Goetz and A. W. Brooke, "Electron tube experience in computing equipment," *Elec. Eng.*, vol. 71, pp. 154–157; February, 1952.

A definition of tube reliability was proposed and the steps currently being taken to improve reliability were enumerated. Improvements in mechanical design and in manufacturing techniques were described. Methods of testing including vibration, resonance, shock, fatigue, and life were described.

(14) E. G. Rowe, "Technique of Trustworthy Valves," *Jour. Brit. I.R.E.*, vol. 11, pp. 525–540; November, 1951. See also: *Elec. Commun.*, vol. 28, pp. 257–275, December, 1951; PROC. I.R.E., vol. 40, pp. 1166–1177, October, 1952; and *Wireless World*, vol. 58, pp. 105–108, March, 1952.

It was urged that specifications for reliable tubes should define the tube so that tubes manufactured in accordance with such specifications will give the equipment designer and users of equipment the utmost in reliability.

(15) C. R. Knight and K. C. Harding, "General considerations in regard to specifications for reliable tubes," PROC. I.R.E., vol. 40, pp. 1207–1210; October, 1952.

Continued emphasis was placed on the problems involved in producing reliable tubes for military use.

(16) M. A. Acheson, "Tube reliability from the tube manufacturer's viewpoint," *Sylv. Tech.*, vol. 5, pp. 34–35; April, 1952.

Cathodes: Shifts in the characteristic parameters were observed in oxide-coated-cathode tubes. Studies showed that these shifts were due to cathode interface resistance and to changes in contact potential.

(17) W. B. Bartley and J. E. White, "Characteristic shifts in oxide cathode tubes," *Elec. Eng.*, vol. 71, p. 496; June, 1952.

A study was reported of decay and recovery of the pulsed emission of cathodes of BaO on nickel. Decay was found to be a function of aging, duty cycle, voltage, and cathode temperature.

(18) R. M. Matheson and L. S. Nergaard, "The decay and recovery of the pulsed emission of oxide-coated cathodes," *Jour. Appl. Phys.*, vol. 23, pp. 869–875; August, 1952.

A study of continuous and pulsed emission on oxide-coated cathodes with different base metals was made at low cathode temperatures and showed essentially the same results at cathode temperatures below 650°K. Base metals were a factor in life and initial performance.

(19) F. A. Horak, "Correlation of dc and microsecond pulsed emission from oxide coated cathodes," *Jour. Appl. Phys.*, vol. 23, pp. 346–349; March, 1952.

Measurements of the conductivity of a (BaSrCa)O emitter over a range from room temperature to 1,100°K indicated the existence of two conduction mechanisms at high and low temperatures. The results were in agreement with the Loosjes-Vink pore-conduction hypothesis.

(20) R. C. Hughes and P. P. Coppola, "Conductivity of oxide emitters," *Phys. Rev.*, vol. 88, pp. 364–368; October 15, 1952.

Calculations were made of the conditions under which pore conduction will modify the total conductivity of an oxide-coated cathode.

(21) E. B. Hensley, "On the electrical properties of porous semiconductors," *Jour. Appl. Phys.*, vol. 23, pp. 1122–1129; October, 1952.

A study made of thermoelectric power, electrical conductivity, and thermionic emission on BaO and (BaSr)O oxide-coated cathodes showed results not explainable by simple semiconductor theory, but in good agreement with the pore-conduction hypothesis.

(22) J. R. Young, "Electrical conductivity and thermoelectric power of (BaSr)O and BaO," *Jour. Appl. Phys.*, vol. 23, pp. 1129–1138; October, 1952.

A tube was constructed in which crystal size of the cathode coating could be measured by X-ray diffraction methods through thin mica windows. The relation of crystal size of barium-strontium oxide to the thermionic emission was studied over a range of temperatures.

(23) E. Yamaka, "A study of the oxide-coated cathode by X-ray diffraction method (I)," *Jour. Appl. Phys.*, vol. 23, pp. 937–940; September, 1952.

An extensive review of the practice and theory of oxide-coated cathodes was published in book form.

(24) G. Herrman and S. Wagener, "The Oxide-Coated Cathode," vol. 1, Manufacture, vol. 2, Physics, Chapman and Hall, London; 1951.

A study of the effects of impurities in the nickel base metal of an oxide-coated cathode showed both the dc and pulsed emission to be affected. The impurities studied were Mn, Al, Mg, and W. It was reported that all of the impurities caused interface layers that, with the exception of W, were detrimental to emission.

(25) H. A. Poehler, "The influence of the core material on the thermionic emission of oxide cathodes," Proc. I.R.E., vol. 40, pp. 190–196; February, 1952.

A new dispenser-type cathode known as the L cathode was compared with three common types of emitters. The efficiency of the L cathode was between that of the oxide cathode and thoriated tungsten. The principal advantages of this cathode were stated to be the accuracy of machined surfaces and spacings obtainable for microwave tubes.

(26) G. A. Espersen, "The L-cathode structure," Proc. I.R.E., vol. 40, pp. 284–289; March, 1952.

Changes in cathode emission were observed in oxide cathodes when tubes were subjected to impact shock. The effect was attributed to a gas evolution from various elements during impact.

(27) D. O. Holland, I. E. Levy, and H. J. Davis, "Loss of thermionic emission in oxide-coated cathode tubes due to mechanical shock," Proc. I.R.E., vol. 40, pp. 587–590; May, 1952.

Emission from cathodes continues indefinitely, but formation of a resistive barrier between the cathode and the coating causes a feedback and an apparent drop in the emissivity. Life studies showed that the resistance builds up to saturation value of about 40 ohm-square-centimeters. Detection of this resistance was achieved by measurement of the mutual conductance at two frequencies.

One author supported Eisenstein's chemical theory—resistive film formed at the interface by the formation of compounds of barium and core impurities deliberately introduced—which he felt explained the growth of cathode resistance. He favored this theory as being more probable and containing fewer inconsistencies than Raudorf's mechanical theory—shrinking of coating away from the core, leaving contact between the coating and the core only at minute discrete spots.

Methods were suggested of compensating for cathode resistance in design of circuits from audio to high radio frequencies.

(28) C. C. Eaglesfield, "Valve cathode life," *Wireless World*, vol. 57, pp. 505–506; December, 1951.

Other investigations by the British Post Office support Eisenstein's theory.

Another cause of oxide-cathode deterioration is poisoning attacks by residual gases. A method was developed of making a triode or pentode measure its own residual gas pressure.

(29) "Oxide cathode life," *Wireless World*, vol. 58, p. 76; Feb., 1952.

Noise measurements at high and low frequencies showed that the effect of space charge on flicker noise exceeds that for shot noise. Results reported were that the flicker-noise reduction factor had a value less than the shot-noise reduction factor at all current levels.

(30) T. B. Tomlinson, "Space charge reduction of low frequency fluctuations in thermionic emitters," *Jour. Appl. Phys.*, vol. 23, pp. 894–899; August, 1952.

Secondary Emission: Determinations were made of the the secondary-emission threshold energy for various composite surfaces. Results indicated that secondaries originate from the filled band of a compound rather than from electron traps.

(31) H. Jacobs, J. Martin and F. Brand, "Secondary emission from composite surfaces," *Phys. Rev.*, vol. 85, pp. 441–447; February, 1952.

Magnetrons

A number of papers, concerned with the theoretical aspects of magnetrons, considered such topics as space-charge distribution, RF phase control, amplifiers, potentials and instabilities.

(32) G. Hok, "A statistical approach to the space-charge distribution in a cut-off magnetron," *Jour. Appl. Phys.*, vol. 23, pp. 983–989; September, 1952.
(33) E. E. David, Jr., "RF phase control in pulsed magnetrons," Proc. I.R.E., vol. 40, pp. 669–685; June, 1952.
(34) F. Lüdi, "Theory of the magnetron amplifier," *Z. angew. Math. Phys.*, vol. 3, pp. 119–128; March 15, 1952. (German)
(35) K. Fritz, "Potentials and electron paths in multisegment magnetrons," *Arch. Elek. (Uebertragung)*, vol. 6, pp. 211–215; May, 1952.
(36) L. A. Harris, "Instabilities in the smooth-anode cylindrical magnetron," *Jour. Appl. Phys.*, vol. 23, pp. 562–567; May, 1952.

Theoretical and experimental studies were made of resonant-injection systems for the frequency control of magnetrons.

(37) L. L. Koros, "Frequency control of modulated magnetrons by resonant injection system," *RCA Rev.*, vol. 13, pp. 47–57; March, 1952.
(38) J. S. Donal, Jr. and K. K. N. Chang, "Analysis of the injection locking of magnetrons used in amplitude-modulated transmitters," *RCA Rev.*, vol. 13, pp. 239–257; June, 1952.

A number of papers described the design of magnetrons operating at frequencies of 7,000 and 9,310 mc.

(39) H. K. Jenny, "7000-megacycle developmental magnetron for frequency modulation," *RCA Rev.*, vol. 13, pp. 202–223; June, 1952.
(40) G. A. Espersen and B. Arfin, "A 3 cm beacon magnetron," *Philips Tech. Rev.*, vol. 14, pp. 250–258; August–September, 1952. (Dutch)

A unique magnetron of the interdigital type, intended for use with various external circuits as a local oscillator operating from 0 to 1,000 mc, delivered a maximum power output of 0.5 watt.

(41) D. A. Wilbur, P. H. Peters and H. W. A. Chalberg, "Tunable miniature magnetron," *Electronics*, vol. 25, pp. 104–109; January, 1952.

Various experimental studies were made on harmonics, secondary emission, mode interaction, inverted magnetrons, and conductance measurements.

(42) J. A. Klein, J. H. N. Loubser, A. H. Nethercot, Jr., and C. H. Townes, "Magnetron harmonics at millimeter wavelengths," *Rev. Sci. Instr.*, vol. 23, pp. 78–92; February, 1952.
(43) F. W. Gundlach and K. Schörken, "The influence of secondary emission on oscillation behaviour in cylindrical magnetrons," *Z. angew. Phys.*, vol. 3, pp. 416–424; November, 1951. (German)
(44) R. R. Moats, "Mode interactions in magnetrons," *Tele-Tech*, vol. 11, pp. 39–41; July, 1952.
(45) J. F. Hull, "Inverted magnetron," Proc. I.R.E., vol. 40, pp. 1038–1041; September, 1952.
(46) M. Nowogrodzki, "Conductance measurements on operating magnetron oscillators," Proc. I.R.E., vol. 40, pp. 1239–1243; October, 1952.

A review article appeared relative to the modulation of cw magnetrons.

(47) J. S. Donal, "Modulation of continuous-wave magnetrons," *Advances in Electronics*, vol. 4, Academic Press, New York, N. Y.; 1952.

Further experiments were reported on cw magnetrons having two and four segments.

(48) E. B. Callick, "Experimental study of low-power cw magnetrons having few segments," Proc. I.R.E., vol. 40, pp. 836–843; July, 1952.

A new textbook on magnetrons covered the properties, design, operation, constructional technique, and method of measurements.

(49) R. Latham, A. H. King, and L. Rushforth, "The Magnetron," Chapman and Hall, London; 1952.

Definitions of magnetron terms were completed by the IRE Magnetron Task Group.

(50) "Standards on magnetrons; definitions of terms, 1952," Proc. I.R.E., vol. 40, pp. 562–563; May, 1952.

A review article traced the historical development of magnetron theory and practice. Some of the constructional details of various magnetrons were included.

(51) J. Verweel, "Magnetrons," *Philips Tech. Rev.*, vol. 14, pp. 50–64; February, 1952. (Dutch)

Klystrons

With the dimensional limitations of negative-grid tubes operating to reduce the power obtainable in the uhf and higher regions, considerable work on klystron development was reported.

In the design of high-powered oscillators, it was found that an adverse effect, which was caused by the deflection of the electrons in the high-frequency field of the input gap, could be reduced by giving the output gap a suitable shape. An L cathode simplified the structure as well as supplying high current densities.

(52) B. B. van Iperen, "Velocity-modulation valves for 100 to 1,000 watts continuous output," *Philips Tech. Rev.*, vol. 13, pp. 209–222; February, 1952.

Three methods of electron-beam focusing of cascade-type klystron amplifier tubes were reported.

(53) V. Learned and C. Veronda, "Recent developments in high-power klystron amplifiers," Proc. I.R.E., vol. 40, pp. 465–469; April, 1952.

Design concepts, tube structure, and tube characteristics were presented for a pulsed klystron amplifier covering the range 960–1,215 mc.

(54) C. Veronda, "New pulse klystron amplifier for the 960–1,215 megacycle region," *Elec. Eng.*, vol. 71, pp. 686–689; August, 1952.

The application of klystrons in frequency-modulated radio links was described.

(55) J. Cohn, "Operating klystrons in f-m microwave links," *Electronics*, vol. 25, pp. 124–127; June, 1952.
(56) D. E. Lambert, "A coaxial-line velocity-modulated oscillator for use in frequency-modulated radio links," *Proc. IEE* (London), paper 1337, TV Convention, 1952.
(57) A. H. Beck and A. B. Cutting, "Reflex klystrons for centimetre links," *Proc. IEE* (London), paper 1343, TV Convention, 1952.
(58) A. F. Pearce and B. J. Mayo, "The design of a reflex-klystron oscillator for frequency modulation at centimetre wavelengths," *Proc. IEE* (London), paper 1301, TV Convention, 1952.

Theoretical work continued on the space-charge effects in reflex klystrons and included modification of electronic admittance by a bunching-effectiveness parameter.

(59) M. Chodorow and V. B. Westburg, "Space-charge effects in reflex klystrons," Proc. I.R.E., vol. 39, pp. 1548–1555; December, 1951.

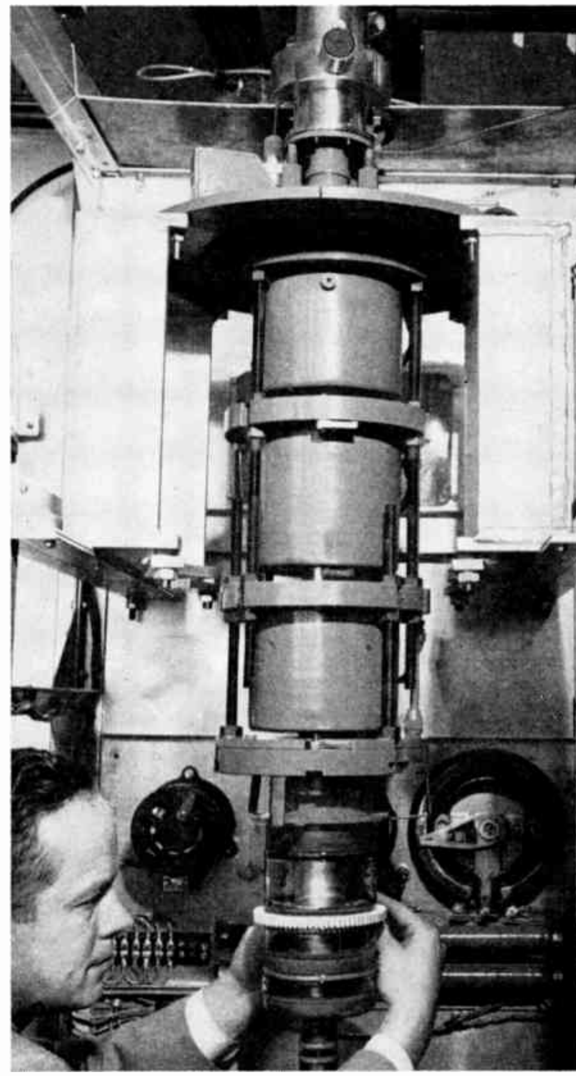

Fig. 1—This 200-pound electronic giant, the "klystron" tube developed by Varian Associates to G-E specifications, supplies power for the world's most powerful television station, WHUM-TV, Reading, Pa. The tube, which has a power rating of 15,000 watts, is here being adjusted in its carrying rack by G-E engineer.

A number of review articles of interest appeared tracing the historical development of the art of klystrons as well as the progress of the past year.

(60) J. Racker and L. Perenic, "Microwave klystron oscillators," *Radio and TV News*, vol. 47, pp. 54–56; April, 1952 and pp. 64–66; May, 1952.
(61) R. H. Varian, "Recent developments in klystrons," *Electronics*, vol. 25, pp. 112–115; April, 1952.

Pulsed klystrons found applications in the uhf region. Two papers describing tubes used for air navigation appeared.

(62) V. Learned, "Power amplifier klystron for air navigation," *Electronics*, vol. 25, pp. 156–166; May, 1952.
(63) V. Learned, "Ground transmitter klystron for air navigation," *Electronics*, vol. 25, p. 136; January, 1952.

Traveling-Wave Tubes

A number of papers considered the theoretical aspects of traveling-wave tubes. The effect of thermal-velocity spread on the gain and noise figure was computed and found to be in good agreement with the empirical data. A theory was developed for an internal-feedback oscillator that neglects space-charge effects.

(64) D. A. Watkins, "Traveling-wave-tube noise figure," PROC. I.R.E., vol. 40, pp. 65–70; January, 1952.
(65) P. Parzen, "Effect of thermal-velocity spread on the noise figure in traveling-wave tubes," *Jour. Appl. Phys.*, vol. 23, pp. 394–406; April, 1952.
(66) E. M. T. Jones, "Internal feedback traveling-wave-tube oscillator," PROC. I.R.E., vol. 40, pp. 478–482; April, 1952.
(67) J. Labus, "Optimum amplification in the helix traveling-wave tube," *Arch. Elek.* (*Uebertragung*), vol. 6, pp. 1–5; January, 1952. (German)

Theoretical and experimental studies of the traveling-wave tube included its applications as a phase modulator, frequency shifter, and phase shifter.

(68) W. J. Bray, "Traveling-wave valve as a microwave phase-modulator and frequency-shifter," *Proc. IEE* (London), Part III, vol. 99, pp. 15–20; January, 1952.
(69) I. D. Olin, "Traveling-wave tube as a phase-shifter," *Bib. of Tech. Reports*, vol. 18, p. 95; October 17, 1952. PB111036.

The application of traveling-wave tubes in radio beam links was reported in France.

(70) "Two traveling-wave valves for radio beam links," *Ann. Télécomm.*, vol. 7, pp. 150–204; April, 1952.
(71) G. Goudet, "Traveling-wave valves in radio beam links," *Ann. Télécomm.*, vol. 7, pp. 152–154; April, 1952.
(72) M. Kuhner and P. Lapostolla, "Two traveling-wave valves for radio beam links: general results and technology," *Ann. Télécomm.*, vol. 7, pp. 155–168; April, 1952.
(73) P. Clostre and R. Wallauschek, "Two traveling-wave valves for radio beam links: measurements and characteristics," *Ann. Télécomm.*, vol. 7, pp. 169–172; April, 1952.

A number of papers were published relative to traveling-wave-tube measurements and impedance matching to coaxial lines and waveguides.

(74) P. Clostre and R. Wallauschek, "A generator for measurements at U.H.F.," *Ann. Télécomm.*, vol. 7, pp. 196–204; April, 1952.
(75) P. Clostre and R. Wallauschek, "Impedance matching of traveling-wave valves (Types M8 and M11) to coaxial lines," *Ann. Télécomm.*, vol. 7, pp. 181–190; April, 1952.
(76) P. Chavance and L. Moutte, "Impedance matching of a traveling-wave valve (Type M8) to a waveguide," *Ann. Télécomm.*, vol. 7, pp. 191–195; April, 1952.

A unique traveling-wave tube without retarding line employed a density-modulated beam that traverses a path along which the direction of the electric field is alternately positive and negative by using a cylindrical waveguide divided into short cylinders, all the even-numbered cylinders being connected at one terminal and all the odd-numbered cylinders being connected at the other terminal.

(77) H. Kleinwächter, "Traveling-wave valve without retarding line," *Elektrotech Z.*, vol. 72, pp. 714–717; December 15, 1951.

A tube combining the properties of a klystron and distributed amplifier was described.

(78) T. G. Mihran, "The duplex traveling-wave klystron," PROC. I.R.E., vol. 40, pp. 308–315; March, 1952.

Some work on electron-gun structures indicated that magnetic screening was necessary to reduce the deleterious effect of the magnetic field. Electron guns producing convergent beams made possible the use of lower current densities and thus prolong life.

(79) J. E. Pidquendar, "Electron guns for traveling-wave valves (Types M8 and M11)," *Ann. Télécomm.*, vol. 7, pp. 172–180; April, 1952.

A developmental low-noise traveling-wave amplifier for small signals was built for the 3,000-megacycle band and gave 8.5 decibels noise factor and 15-decibels gain under wide-frequency-band operation. An essential factor in this tube was a special "three-region" low-noise gun controlling the electrical drift angle of the beam.

(80) R. W. Peter, "Low-noise traveling-wave amplifier," *RCA Rev.*, vol. 13, pp. 334–368; September, 1952.

A low-noise low-voltage traveling-wave tube of improved mechanical design was described. The theory of noise reduction was given, along with operating characteristics.

(81) J. H. Bryant, T. J. Marchese, and H. W. Cole, "Some recent developments in traveling-wave tubes for communication purposes," *Elec. Commun.*, vol. 29, pp. 229–233; September, 1952.
(82) A. G. Peifer, P. Parzan, and J. H. Bryant, "Low-noise traveling-wave tube," *Elec. Commun.*, vol. 29, pp. 234–237; September, 1952.

Space-charge-wave theory was applied to the study of space-charge-wave propagation in a cylindrical beam.

(83) P. Parzan, "Space-charge-wave propagation in a cylindrical electron beam of finite lateral extension," *Elec. Commun.*, vol. 29, pp. 238–242; September, 1952.

A method of solving electron-beam problems was described that took into account the thermal-velocity spread by a method based on Liouville's theorem.

(84) D. A. Watkins, "Effect of velocity distribution in a modulated electron stream," *Jour. Appl. Phys.*, vol. 23, pp. 568–573; May, 1952.

A comprehensive treatment of the theory of velocity-modulation tubes was published.

(85) R. Warnecke and P. Guenard, "Les tubes a commande par modulation de vitesse (Velocity-modulation tubes)," Gauthier-Villars, Paris; 1951.

The performance of space-charge-wave amplifier tubes was analyzed by considering them to be composed of basic "regions" or "spaces." A generalized electronic theory for all regions was developed and the circuit problem of individual regions discussed. A combination of the electronic and circuit relations for each region leads to equations describing the behavior of that region.

(86) R. G. E. Hutter, "Space-charge-wave amplifier tubes, basic principles of operation," *Sylv. Tech.*, vol. 5, pp. 94–99; October, 1952.

Resnatrons

A resnatron amplifier using the reflex principle in the output resonator was described as providing greater bandwidth than theretofore possible with this type of tube.

(87) G. I. Sheppard, M. Garbuny, and J. R. Hansen, "Reflex resnatrons show promise for VHF-TV," *Electronics*, vol. 25, pp. 116–119; September, 1952.

Video Camera Tubes

The most recently developed video camera tube, the vidicon, opened up new orbits of television in the industrial fields and allowed simplified camera equipment. In Europe, considerable interest was shown in the rather complex image iconoscope type of pickup tube, for which a number of refinements have been worked out. A new monoscope based on secondary emission as a function of the angle of incidence was developed.

(88) R. Barthélemy, "Television analyzer (camera)," *Onde Elect.*, vol. 31, pp. 415–419; November, 1951.
(89) R. Theile, "Image iconoscope for improved TV film scanning," *Tele-Tech*, vol. 10, pp. 44–46, 114–115; November, 1951.
(90) R. Theile and F. H. Townsend, "Improvement in image iconoscopes by pulsed biasing of the storage surface," Proc. I.R.E., vol. 40, pp. 146–154; February, 1952.
(91) J. E. Cope, L. W. Germany, and R. Theile, "Improvements in design of image iconoscope type camera tubes," *Jour. Brit. I.R.E.*, vol. 12, pp. 139–149; March, 1952.
(92) B. H. Vine, R. B. Janes, and F. S. Veith, "Performance of the vidicon, a small developmental television camera tube," *RCA Rev.*, vol. 13, pp. 3–10; March, 1952.
(93) J. E. I. Cairns, "A small high-velocity scanning television pick-up tube," *Proc. IEE* (London), part IIIA, vol. 99, pp. 89–94; April–May, 1952.
(94) R. D. Nixon, "The monoscope," *Proc. IEE* (London), part IIIA, vol. 99, pp. 132–135; April–May, 1952.
(95) R. Theile and H. McGhee, "An investigation into the use of secondary-electron multipliers in image iconoscopes," *Proc. IEE* (London), part IIIA, vol. 99, pp. 159–165; April–May, 1952.
(96) P. Schagen, H. Bruining, and J. C. Francken, "The image iconoscope, a camera tube for television," *Philips Tech. Rev.*, vol. 13, pp. 119–133; November, 1951 (also abstract in *Jour. SMPTE*, vol. 58, pp. 501–514; June, 1952).
(97) S. T. Smith, "A novel type of monoscope," Proc. I.R.E., vol. 40, pp. 666–668; June, 1952.

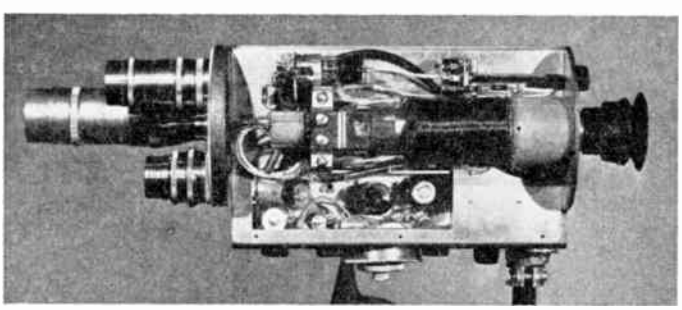

Fig. 2—Side view of portable television camera using Vidicon tube and a built-in microphone for the narrator's use. The camera performs in conjunction with a battery-operated back-pack TV transmitter having a range of one mile. This new equipment, designed by RCA, permits "on-the-spot" pick-ups of special events and remote viewing of industrial processes.

Cathode-Ray Tubes

The size of direct-view picture tubes was increased steadily up to a 27-inch rectangular tube. Both all-glass and metal-glass envelopes were used. Associated with this trend was the development of wide-angle deflection. Work was continued on tube envelopes, deflection and focusing systems with a view of reducing the amount of critical materials and production costs.

(98) C. S. Szegho and R. G. Pohl; "TV picture tubes with iron envelopes." *TV Eng.*, vol. 2, pp. 8–9, 26–27; November, 1951.
(99) R. B. Mackenzie, "The modulation characteristic of cathode-ray tubes in television," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 54–58; February, 1952.
(100) C. S. Szegho, "Large flat-face cathode-ray tubes for radar," *Tele-Tech*, vol. 10, pp. 52–53, 94; January, 1952.
(101) W. H. Buchsbaum, "Electrostatic focus for picture tubes," *Radio & TV News*, vol. 47, pp. 62–63, 130; March, 1952.
(102) S. T. Smith, R. V. Talbot, and C. H. Smith, Jr., "Cathode-ray tube for recording high speed transients," Proc. I.R.E., vol. 40, pp. 297–302; March, 1952
(103) L. S. Allard, "Design factors in television cathode-ray tubes," *Proc. IEE* (London), paper 1238, TV Convention, proof issue 1952.
(104) A. Y. Bentley, K. A. Hoagland, and H. W. Grossbohlin, "Self-focusing picture tube," *Electronics*, vol. 25, pp. 107–109; June, 1952.
(105) G. N. Patchett, "Line eliminator," *Wireless World*, vol. 58, pp. 219–221; June, 1952.
(106) K. Schlesinger, "Internal electrostatic deflection yokes," *Electronics*, vol. 25, pp. 105–109; July, 1952.
(107) C. S. Szegho, "Cathode-ray picture tube with low focusing voltage," Proc. I.R.E., vol. 40, pp. 937–939; August, 1952.
(108) C. V. Bocciarelli, "Low-power deflection for wide-angle C-R tubes," *Electronics*, vol. 25, pp. 109–111; September, 1952.
(109) C. V. Fogelberg, E. W. Morse, S. L. Reiches, and D. P. Ingle, "Using C-R tubes with internal pole pieces," *Electronics*, vol. 25, pp. 102–105; October, 1952.

Color Television Tubes

Development of tri-color kinescopes was being carried on along the various lines proposed in previous years.

(110) W. H. Buchsbaum, "The RCA tri-color tube," *Radio & TV News*, vol. 46, pp. 52–54, 120–125; November, 1951.
(111) J. H. Battison, "Analysis of latest Lawrence color-TV tube," *Tele-Tech*, vol. 10, pp. 38–39, 115; November, 1951.
(112) W. P. O'Brien, "New Lawrence tri-color tube shown," *Electronics*, vol. 24, pp. 146, 148; November, 1951.
(113) "Lawrence Color Tube," *Sci. Am.*, vol. 185, pp. 33–34; November, 1951.
(114) D. G. Fink, "Phosphor-strip tri-color tubes," *Electronics*, vol. 24, pp. 89–91; December, 1951.
(115) H. R. Lubcke, "Color television reproducers," *Jour. Soc. Mot. Pic. and Telev. Eng.*, pp. 22–27; January, 1952.
(116) E. G. Ramberg, "Elimination of moiré effects in tri-color kinescopes," Proc. I.R.E., vol. 40, pp. 916–923; August, 1952.
(117) "Eidophor projector for theatre TV," *Tele-Tech*, vol. 11, pp. 57, 112–113; August, 1952.
(118) "What is eidophor?," *Radio & TV News*, vol. 48, pp. 94, 96; August, 1952.
(119) Aaron Nadell, "The eidophor projector," *Radio-Electronics*, vol. 13, pp. 34–36; October, 1952.

Storage Tubes

Storage tubes found numerous applications for scan conversions and for computer memory systems. In addition to new developments, a comprehensive study of the basic principles was published.

(120) B. Kazan and M. Knoll, "Fundamental processes in charge controlled storage tubes," *RCA Rev.*, vol. 12, pp. 702–753; December, 1951.
(121) V. K. Zworykin and E. G. Ramberg, "Standards conversion of television signals," *Electronics*, vol. 25, pp. 86–91; January, 1952.
(122) W. E. Mutter, "Improved cathode-ray tube for application in Williams memory system," *Elec. Eng.*, vol. 71, pp. 352–356; April, 1952.
(123) F. C. Williams, T. Kilburn, C. N. W. Litting, D. B. G. Edwards, and G. R. Hoffman, "Recent advances in cathode-ray tube storage," *Proc. IEE* (London), paper 1359, TV Convention, proof issue, 1952.
(124) M. Knoll and B. Kazan, "Storage Tubes and Their Basic Principles," John Wiley and Sons, Inc., New York, N. Y., Chapman & Hall Ltd., London; 1952.

Electron Optics

The quest for simple electron-lens designs led to an attack from various directions: theoretical analyses, development of devices for study of electron trajectories, and new lens configurations.

(125) L. Marton, M. M. Morgan, D. C. Schubert, J. R. Shah, and J. A. Simpson, "Electron-optical bench," *Jour. Res. Nat. Bur. Stand.*, vol. 47, pp. 461–464; December, 1951.
(126) J. C. Burfoot, "Numerical ray-tracing in electron lenses," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 22–24; January, 1952.

(127) P. Grivet et M. Bernard, "Théörie de la lentille électrostatique constituée par deux cylindres coaxiaux," *Ann. Radioelec.*, vol. 7, pp. 3–9; January, 1952.
(128) M. G. Piétri, "Les tubes à faisceau électronique laminaire, leur principle et quelques-unes de leurs applications," *Vide*, vol. 7, pp. 1113–1122; January, 1952.
(129) G. H. Vineyard, "Simulation of trajectories of charged particles in magnetic fields," *Jour. Appl. Phys.*, vol. 23, pp. 35–39; January, 1952.
(130) P. Schagen, H. Bruining and J. C. Francken, "A simple electrostatic electron-optical system with only one voltage," *Philips Res. Rep.*, vol. 7, pp. 119–130; April, 1952.
(131) M. Schiekel, "Electron optical velocity filters," *Optik*, vol. 9, pp. 145–153; April, 1952.
(132) C. T. Allison and F. G. Blackler, "A univoltage electrostatic lens for television cathode-ray tubes," *Proc. IEE* (London), paper 1333, TV convention, 1952.
(133) J. A. Hutton, "The focusing of cathode-ray tubes for television receivers," *Jour. Brit. I.R.E.*, vol. 12, pp. 295–304; May, 1952.
(134) K. Jekelius, "Principles of permanent-magnet focusing systems for cathode-ray tubes," *Fernmeldetech. Z.*, vol. 5, pp. 320–326; July, 1952.
(135) K. F. Sander, C. W. Oatley, and J. G. Yates, "Factors affecting the design of an automatic electron-trajectory tracer," *Proc. IEE* (London), part III, vol. 99, pp. 169–179; July, 1952.
(136) H. Poritsky and R. P. Jerrard, "An integrable case of electron motion in electric and magnetic field," *Jour. Appl. Phys.*, vol. 23, pp. 928–930; August, 1952.
(137) D. W. Shipley, "Calculation of spherical aberration for the electrostatic electron lens," *Sylv. Tech.*, vol. 5, pp. 87–93; October, 1952.

Phototubes

Great interest developed in multiplier phototubes. Their use in scintillation counters became the predominant means for particle counting. Photoconductivity in various semiconductors was studied.

(138) L. Dunkelman and C. Lock, "Ultraviolet spectral sensitivity characteristics of photomultipliers having quartz and glass envelopes," *Jour. Opt. Soc. Amer.*, vol. 41, pp. 802–804; November, 1951.
(139) J. A. Jenkins and R. A. Chippendale, "The application of image converters to high speed photography," *Jour. Brit. I.R.E.*, vol. 11, pp. 505–517; November, 1951.
(140) B. T. Kolomiets, "Industrial types of photo-resistors," *Electrichestvo*, vol. 11, pp. 44–51; November, 1951.
(141) L. Reiffel, C. A. Stone and A. R. Brauner, "Fatigue effects in scintillation counters," *Nucleonics*, vol. 9, pp. 13–15; December, 1951.
(142) R. H. Warring, "Light sensitive cells; differentiation between photoelectric types," *Elec. Rev.* (London), vol. 149, pp. 1198–1200; December 14, 1951.
(143) T. N. K. Godfrey, "Satellite pulses from photomultipliers," *Phys. Rev.*, vol. 84, pp. 1248–1249; December 15, 1951.
(144) V. Schwetzoff, S. Robin, and B. Vodar, "Electron-multiplier photocell for the ultraviolet down to 1450 Å, *Compt. Rend. Acad. Sci.* (Paris) vol. 243, pp. 426–428; January 21, 1952.
(145) W. C. Dunlap, Jr., "Germanium photocells," *Gen. Elec. Rev.*, vol. 55, pp. 27–31; March, 1952.
(146) A. F. Gibson, "Single contact lead telluride photocells," *Proc. Phys. Soc.* (London), vol. 65B, pp. 196–214; March, 1952.
(147) A. F. Gibson, "Lead sulphide rectifier photocells," *Proc. Phys. Soc.* (London), vol. 65B, pp. 214–216; March, 1952.
(148) J. I. Pantchechnikoff, "Large area germanium photocell," *Rev. Sci. Instr.*, vol. 23, p. 135; March, 1952.
(149) R. W. Engstrom, R. G. Stoudenheimer, and A. M. Glover, "Production testing of multiplier phototubes," *Nucleonics*, vol. 10, pp. 58–62; April, 1952.
(150) P. H. Keck, "Photoconductivity in vacuum coated selenium films," *Jour. Opt. Soc. Amer.*, vol. 42, pp. 221–225; April, 1952.
(151) E. A. Taft and M. H. Hebb, "Note on quenching of photoconductivity in cadmium sulfide," *Jour. Opt. Soc. Amer.*, vol. 42, pp. 249–251; April, 1952.
(152) Edward P. Clancy, "Polarization effects in photomultiplier tubes," *Jour. Opt. Soc. Amer.*, vol. 42, p. 352; May, 1952.
(153) J. F. Raffle and E. J. Robbins, "Non-linear amplification in EMI photomultipliers," *Proc. Phys. Soc.* (London), B, vol. 65, pp. 320–324; May, 1952.
(154) R. K. Swank and W. L. Buck, "Observations on pulse-height resolution and photosensitivity," *Nucleonics*, vol. 10, pp. 51–53; May, 1952.
(155) R. F. Post, "Performance of pulsed photomultipliers," *Nucleonics*, vol. 10, pp. 46–50; May, 1952.
(156) R. Wilson, "The fundamental limit of sensitivity of photometers," *Rev. Sci. Instr.*, vol. 23, pp. 217–223; May, 1952.
(157) C. J. Milner and B. N. Watts, "Lead sulphide photo-cells," *Research* (London), vol. 5, pp. 267–273; June, 1952.
(158) D. W. Mueller, G. Best, J. Jackson, and J. Singletary, "Afterpulsing in photomultipliers," *Nucleonics*, vol. 10, pp. 53–55; June, 1952.
(159) E. S. Rittner and F. Grace, "Impedance measurements on PbS photoconductive cells," *Phys. Rev.*, vol. 86, pp. 955–958; June, 1952.
(160) E. H. Gilmore and R. H. Knipe, "A method for spectral calibration of photomultipliers at low intensity levels," *Jour. Opt. Soc. Amer.*, vol. 43, pp. 481–483; July, 1952.
(161) J. A. Jenkins and R. A. Chippendale, "Some new image converter tubes and their applications," *Electronic Eng.*, vol. 24, pp. 302–307; July, 1952.
(162) E. F. Kingsbury and R. S. Ohl, "Photoelectric properties of ionically bombarded silicon," *Bell Sys. Tech. Jour.*, vol. 31, pp. 802–815; July, 1952.
(163) J. I. Pantchechnikoff, S. Lasof, J. Kurshan, and A. R. Moore, "Use of flying spot scanner to study photosensitive surfaces," *Rev. Sci. Instr.*, vol. 23, pp. 465–467; September, 1952.
(164) G. A. Morton, "The scintillation counter," *Advances in Electronics*, vol. IV, Academic Press Inc., New York, N. Y., pp. 69–107; 1952.

Gas Tubes

The cathode spot of mercury-pool cathodes was studied. Previous work was reviewed and an analysis was made of pool-surface and spot temperatures and of the current density in the cathode spot. It is concluded that the highest temperature found for the cathode spot is much too low for thermionic emission and that no relation can exist between the spot temperature and the mechanism of electron emission. Current densities of the order of 10^4 to 10^7 a/cm^2, much higher than the generally accepted value of about 4,000 a/cm^2 for cathode spots, have recently been measured. The difference appears to be due only to the difference in time, after spot initiation, at which the current density was measured. There is a continuous decrease of current density and an increase in spot area with life of the spot.

(165) H. v. Bertele, "Pool surface and cathode spot temperature of mercury cathodes as a problem in heat conduction," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 127–132; April, 1952.
(166) H. v. Bertele, "Current densities of free-moving cathode spots on mercury," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 358–360; November, 1952.

Techniques of gaseous breakdown processes were explored and the results indicate their complexity. Three cathode and two anode mechanisms were analyzed and compared. Proper modern methods of discharge analysis were indicated.

(167) L. B. Loeb, "Secondary processes active in the electrical breakdown of gases," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 341–349; November, 1952.

New measurements of the drift velocity of electrons in argon as a function of electric field, gas pressure, and impurity content (principally nitrogen) of the gas were made.

(168) L. Colli and U. Facchini, "Drift velocity of electrons in argon," *Rev. Sci. Instr.*, vol. 23, p. 39; January, 1952.

A description of high-frequency gas-discharge breakdown is given describing the similarities and differences between these discharges and the more familiar dc type. High-frequency discharge breakdown is controlled by the process of electron diffusion and besides the theory of its behavior, the physical limitations of tube size, gas pressure, and frequency for this type of breakdown are given. The particular case of hydrogen is cited. The effects of superimposing a weak steady electric field and a magnetic field on the ac field are also described.

(169) S. C. Brown, "High-frequency gas-discharge breakdown," PROC. I.R.E., vol. 39, p. 1493; December, 1951.

A new cold-cathode high-voltage rectifier was described. Both theory and extensive experimental data were included. The operation of the tube is based on an improved type of electron trapping similar to that occurring in a cylindrical magnetron in a cutoff condition, but augmented due to the use of end plates on the cathode. Mercury vapor was used. This tube appears to offer for the first time a practical cold-cathode rectifier for voltages up to 14 kv and currents up to 1 ma.

(170) E. G. Linde, J. H. Coleman, and E. G. Apgar, "A high-voltage cold-cathode rectifier," PROC. I.R.E., vol. 40, pp. 818–827; July, 1952.

Factors involved in the use of thyratrons at increased values of peak current and for short-time pulse switching continued to receive attention. The initial conduction interval was shown to depend on tube construction and on circuit elements.

(171) J. B. Woodford, Jr. and E. M. Williams, "The initial conduction interval in high speed thyratrons," *Jour. Appl. Phys.*, vol. 23, pp. 722–724; July, 1952.

The "plasmatron," a new type of continuously controllable gas tube, was described and its operation analyzed. This tube utilizes an independently generated gas discharge plasma as a conductor between a hot cathode and an anode. Continuous modulation of the anode current can be effected by varying either the conductivity or effective cross section of the plasma.

Applications were reported to include motor drive, direct loudspeaker drive, high-efficiency rectification and inversion, and many others that require low-impedance operation.

(172) E. O. Johnson and W. M. Webster, "The plastmatron, a continuously controllable gas-discharge developmental tube," PROC. I.R.E., vol. 40, pp. 645–659; June, 1952.

The special characteristics of some of the new miniature high-stability glow-discharge voltage-regulator tubes were studied in detail.

(173) F. A. Benson, "The characteristics of some miniature high-stability glow-discharge voltage-regulator tubes," *Jour. Sci. Instr.*, vol. 28, pp. 239–341; November, 1951.

(174) H. Bache and F. A. Benson, "A note on the temperature coefficients of running voltage of glow discharge tubes," *Jour. Sci. Instr.*, vol. 29, pp. 25–26; January, 1952.

(175) H. Bache and F. A. Benson, "Peak-noise characteristics of glow-discharge voltage-regulator tubes," *Electronic Eng.*, vol. 24, pp. 278–279; June, 1952.

(176) H. Bache and F. A. Benson, "Mean-noise characteristics of glow-discharge voltage-regulator tubes," *Electronic Eng.*, vol. 24, pp. 328–329; July, 1952.

Major design features of new types of cold-cathode glow-discharge tubes were outlined and their useful applications in diverse kinds of circuits were indicated.

(177) G. H. Hough and D. S. Ridler, "Some recently developed cold cathode glow discharge tubes and associated circuits," *Electronic Eng.*, vol. 24; Part 1, pp. 152–157; April, 1952; Part 2, pp. 230–235; May, 1952; Part 3, pp. 272–276; June, 1952.

New types of gas-filled cold-cathode counting tubes were described. The first one differs from early dekatrons in requiring only a single input pulse to move the cathode glow a complete step. Tentative specifications were given for a developmental tube to operate at pulse rates up to 20,000 per second.

(178) J. R. Acton, "The single-pulse dekatron," *Electronic Eng.*, vol. 24, pp. 48–51; February, 1952.

Another type of multicathode decade counter was described.

(179) G. H. Hough, "The development of a multi-cathode decade gas tube counter," *Proc. IEE* (London), Part III, vol. 99, pp. 166–167; May, 1952.

The design of a ten-stage counting tube designated 6167 was described. This tube operates up to about two thousand pulses per second and has the features which permit performing this pulse counting function with a minimum of circuit components and with a high degree of reliability. Such a tube can be used for pulse counting, frequency divisions, time measurements, and similar functions. The mechanism of discharge transfer used in this design is reviewed and the details of construction and operating characteristics, and factors affecting life are described.

(180) D. S. Peck, "Ten stage cold cathode stepping tube," *Elec. Eng.*, vol. 71, pp. 1136–1139; December, 1952.

Advances in the analysis of rectifier operation were reported.

(181) R. E. Turkington, "Analysis of the 3-phase inverter with resistive load," *Elec. Eng.*, vol. 70, p. 1076; December, 1951.

(182) L. D. Harris, "Servo characteristics of a rectifier driven motor," *Elec. Eng.*, vol. 71, p. 76; January, 1952.

(183) C. R. Reiter and C. R. Ammerman, "Dc motor losses with rectifier operation," *Elec. Eng.*, vol. 71, p. 1025; November, 1952.

The two new ignitron-rectifier electric freight locomotives of 6,000 hp recently placed in service were described. The ability of a rectifier locomotive to operate at commercial frequencies higher than 25 cycles, necessitated by the limitations of ac motor design, offers the possibility of reducing electrification costs and widening the field of application.

(184) C. C. Whitaker and W. M. Hutchinson, "Pennsylvania Railroad ignitron rectifier locomotive," *Elec. Eng.*, vol. 71, pp. 432–437; May, 1952.

A simplified analysis of loss mechanisms in gas discharges was presented.

(185) S. C. Brown, "Physics of some loss mechanisms in gas discharges," *Elec. Eng.*, vol. 71, pp. 501–503; June, 1952.

A novel portable radiation detector of phosphor-phototube type was described. It was reported as being stable, having a very fast time constant, can be zeroed and calibrated in a radiation field, operates from common flashlight cells, and covers the range from approximately 0.05 to 500 roentgens per hour in four linear decades.

(186) Cole, Duffy, Hayes, Lusby, and Webb, "The phosphor-phototube radiation detector," *Elec. Eng.*, vol. 71, pp. 935–939; October, 1952.

The anode-glow mode in which all ionization and excitation occur in a sheath close to the anode has been found to occur at low current values and at pressures in excess of 300 microns. The plasma potential approximates cathode potential and the tube drop occurs primarily in the anode sheath. Analysis shows that in this mode the anode current varies as the fourth power of the voltage excess above ionization potential. Axial and radial plasma density distributions have been determined.

(187) W. M. Webster, E. O. Johnson, and L. Malter, "Studies of externally heated hot cathode arcs part II—the anode-glow mode," *RCA Rev.*, vol. 13, p. 163; June, 1952.

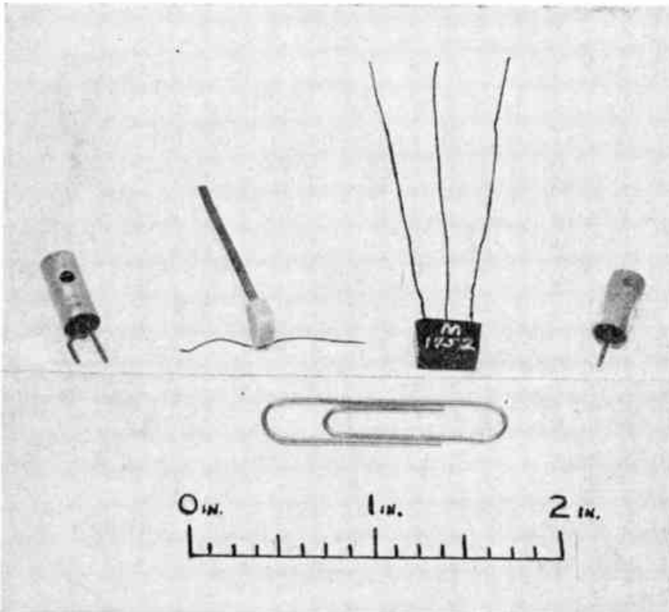

Fig. 3—(L to R)—Two-point contact transistors, junction transistor, and photo transistor. Paper clip and rule show comparative sizes. (*Bell Telephone Laboratories*).

Semiconductor Devices

The fourth year since the announcement of the transistor saw development progress greatly intensified in all areas of semiconductor technology. Perhaps in no other field in recent years has effort been so accelerated, with the result that so much has been learned about the physics of semiconductor material and devices with consequent improvement, modification, and development that now the manufacture and application of transistors has assumed a prominent position in any discussion of semiconductor work.

General: Some of the broader aspects of the application of transistors, as well as simplified discussion of the mechanism of conduction in germanium, were published.

(188) J. W. McRae, "Transistors in our civilian economy," Proc. I.R.E., vol. 40, pp. 1285–1286; November, 1952.
(189) I. R. Obenchain, Jr. and W. J. Galloway, "Transistors and the Military," Proc. I.R.E., vol. 40, pp. 1287–1288; November, 1952.
(190) J. P. Jordan, "The ABC's of germanium," *Elec. Eng.*, vol. 71, pp. 619–625; July, 1952.

Semiconductor Material: The properties of single-crystal germanium allowed the prediction of characteristics of junctions. The evaluation of fundamental properties of silicon was continued; measurements on single-crystal *p*-type silicon gave an electron mobility to 1,200 cm²/volt-sec, and a value of 250 for holes in *n*-type silicon. *P-n* junctions were made by varying the rate of growth of a crystal from a melt containing two opposite-type impurities whose segregation constants vary at different rates with growth velocity. Vacuum preparation of single-crystal germanium was performed. A new method of alloying and diffusing indium into germanium to form *p-n* junctions was developed. Lifetime studies of injected carriers in germanium continued. The photoelectric and rectification properties of silicon bombarded by various ions were studied.

(191) G. K. Teal, M. Sparks, and E. Beuhler, "Single crystal germanium," Proc. I.R.E., vol. 40, pp. 906–908; August, 1952.
(192) J. R. Haynes and W. C. Westphal, "The drift mobilities of electrons in silicon," *Phys. Rev.*, vol. 85, p. 680; February 15, 1952.
(193) R. N. Hall, "*P-n* junctions produced by growth rate variation," *Phys. Rev.*, vol. 88, p. 139; October 1, 1952.
(194) E. M. Conwell, "Properties of silicon and germanium," Proc. I.R.E., vol. 40, pp. 1327–1337; November, 1952.
(195) L. Roth and W. E. Taylor, "Preparation of germanium single crystals," Proc. I.R.E., vol. 40, pp. 1338–1341; November, 1952.
(196) L. D. Armstrong, "*P-n* junctions by impurity introduction through an intermediate metal layer," Proc. I.R.E., vol. 40, pp. 1431–1342; November, 1952.
(197) D. Navon, R. Bray, and H. Y. Fan, "Lifetime of injected carriers in germanium," Proc. I.R.E., vol. 40, pp. 1342–1347; November, 1952.
(198) L. B. Valdes, "Measurement of minority carrier lifetime in germanium," Proc. I.R.E., vol. 40, pp. 1420–1423; November, 1952.
(199) R. S. Ohl, "Properties of ionic bombarded silicon," *Bell Sys. Tech. Jour.*, vol. 31, pp. 104–122; January, 1952.

Semiconductor Device Theory: Theory of alpha, the current-multiplication factor, and of noise in junction transistors and of current multiplication in point-contact transistors was studied. A nonmathematical discussion including the energy-band structure in semiconductors was used to explain rectification and transistor phenomena. A colloidal suspension of semiconductor materials in an electric field has a nonlinear resistance characteristic which is claimed to have surprisingly good frequency characteristics up into the microwave region. The formation of transistor collector was explained in terms of the more rapid diffusion of lattice vacancies than donor impurities, which should cause a *p-n* hook in *n*-type transistors but not in *p*-type. The location of a *p-n* junction with a probe was used as the basis for determining the diffusion constants in germanium for arsenic, antimony, indium, and zinc. The diffusion constants obtained for arsenic into germanium using a capacitance method were found to be several orders of magnitude smaller than those obtained by probing for the location of a *p-n* junction. A theory of contact noise was proposed based on temperature fluctuations in the neighborhood of the contact. It was found that noise in single crystals of germanium resides in the behavior of minority carriers and is quantitatively related to lifetime and transit time of these carriers.

(200) W. R. Sittner, "Current multiplication in the type-A transistor," Proc. I.R.E., vol. 40, pp. 448–453; April, 1952.
(201) E. Billig, "The physics of transistors," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 241–248; August, 1952.
(202) H. E. Hollman, "Dielectric and semiconductive suspensions," *Tele-Tech*, vol. 11, pp. 56–59; September, 1952.
(203) R. L. Longini, "Electric forming of *n*-germanium transistor using donor-alloy contacts," *Phys. Rev.*, vol. 84, p. 1254; December 15, 1951.
(204) C. S. Fuller, "Diffusion of donor and acceptor elements into germanium," *Phys. Rev.*, vol. 86, pp. 136–137; April 1, 1952.
(205) K. B. McAfee, W. Shockley, and M. Sparks, "Measurements of diffusion in semiconductors by a capacitance method," *Phys. Rev.*, vol. 86, pp. 137–138; April 1, 1952.
(206) R. L. Petritz, "A theory of contact noise," *Phys. Rev.*, vol. 87, pp. 535–536; August 1, 1952.
(207) H. C. Montgomery, "Electrical noise in semiconductors," *Bell Sys. Tech. Jour.*, vol. 31, pp. 950–976; September, 1952.

Further theoretical work included treating as imperfections in a nearly perfect crystal the concepts of holes, electrons, etc. A new class of *unipolar* transistors was discussed, including the *analog* transistor. Two new elements in the theoretical small-signal equivalent circuit resulted from a study of how junction-transistor base thickness decreased as collector voltage increases. A comprehensive treatment of the Hall effect and the elimination of the effect of associated phenomena was presented. A theoretical analysis of the variation of base resistance with electrode spacing in point-contact transistors was checked fairly well by experiment. Postulation of traps in the germanium *p* layer near the point electrode was used to explain several recovery-time effects in germanium point-contact diodes. Matrix methods for transistor circuit analysis were used for theoretical work.

(208) W. Shockley, "Transistor electronics: imperfections, unipolar and analog transistors," PROC. I.R.E., vol. 40, pp. 1289–1313; November, 1952.
(209) J. M. Early, "Effects of space-charge layer widening in junction transistors," PROC. I.R.E., vol. 40, pp. 1401–1406; November, 1952.
(210) O. Lindberg, "Hall effect," PROC. I.R.E., vol. 40, pp. 1414–1419; November, 1952.
(211) E. L. Steele, "Theory of alpha for *p-n-p* diffused junction transistors," PROC. I.R.E., vol. 40, pp. 1424–1428; November, 1952.
(212) L. B. Valdes, "Effect of electrode spacing on the equivalent base resistance of point-contact transistors," PROC. I.R.E., vol. 40, pp. 1429–1434; November, 1952.
(213) R. L. Petritz, "On the theory of noise in *p-n* junctions and related devices," PROC. I.R.E., vol. 40, pp. 1440–1456; November, 1952.
(214) M. C. Waltz, "On some transients in the pulse response of point-contact germanium diodes," PROC. I.R.E., vol. 40, pp. 1483–1487; November, 1952.
(215) J. Shekel, "Matrix representation of transistor circuits," PROC. I.R.E., vol. 40, pp. 1493–1497; November, 1952.

Semiconductor Devices: Construction and characteristics of junction diodes, transistors, and photocells were reviewed. A simplified equivalent circuit of the grounded-emitter-transistor amplifier was presented. Experimental evidence was reported that supports the *p-n* hook mechanism in point-contact transistors. The use of thermosetting resins for embedding point-contact transistors resulted in a marked improvement in transistor mechanical and electrical stability.

Analysis of impedance versus frequency on lead-sulfide photoconductive cells offered an explanation in terms of distributed capacitance, which was not by itself evidence for or against a barrier picture. The cause of electric breakdown in point-contact diodes was suggested to be intrinsic conduction due to thermal generation and subsequent passage of minority carriers. Characteristics and operation of point-contact and junction transistors were compared with respect to linear and large-signal characteristics, reliability, life, temperature effects, and electrical performance. Measurements on developmental germanium photovoltaic cells were carried out. Photocells were made from ionically bombarded silicon with properties dependent on the energy of bombarding particles and silicon temperature.

(216) J. S. Saby, "Germanium transistors," *Gen. Elec. Rev.*, vol. 55, pp. 21–24; September, 1952.
(217) T. J. Ferguson, "The G-10 germanium rectifier," *Gen. Elec. Rev.*, vol. 55, pp. 29–31; July, 1952.
(218) J. A. Morton, "Present status of transistor development," PROC. I.R.E., vol. 40, pp. 1314–1326; November, 1952. Also *Bell Sys. Tech. Jour.*, vol. 31, pp. 411–443; May, 1952.
(219) W. C. Dunlap, Jr., "Germanium photocells," *Gen. Elec. Rev.*, vol. 55, pp. 26–31; March, 1952.
(220) "The junction transistor," *Electronics*, vol. 24, pp. 82–85; November, 1951.
(221) F. J. Lingel, "Germanium power rectifier construction," *Electronics*, vol. 25, p. 210; June, 1952.
(222) M. J. E. Golay, "The equivalent circuit of the transistor," PROC. I.R.E., vol. 40, p. 360; March, 1952.
(223) L. B. Valdes, "Transistor forming effects in *n*-type germanium," PROC. I.R.E., vol. 40, pp. 445–447; April, 1952.
(224) B. N. Slade, "A method of improving the electrical and mechanical stability of point-contact transistors," *RCA Rev.*, vol. 12, pp. 651–659; December, 1951.
(225) E. S. Rittner and F. Grace, "Impedance measurements on PbS photoconductive cells," *Phys. Rev.*, vol. 86, pp. 955–958; June 15, 1952.
(226) E. Billig, "Effect of minority carriers on the breakdown of point-contact rectifiers," *Phys. Rev.*, vol. 87, pp. 1060–1061; September 15, 1952.
(227) J. A. Morton, "New transistors give improved performance," *Electronics*, vol. 25, pp. 100–103; August, 1952.
(228) B. J. Rothlein, "A photovoltaic germanium cell," *Sylv. Tech.*, pp. 86–88; October, 1951.
(229) E. F. Kingsbury and R. S. Ohl, "Photoelectric properties of ionically bombarded silicon," *Bell Sys. Tech. Jour.*, vol. 31, pp. 802–816; July 1952.

Silicon *p-n* junction diodes have been constructed with rectification ratios as high as 10^8 at 1 volt, ability to operate at ambient temperatures up to 300°C, and other improved characteristics. Further work was done on fused-contact *p-n-p* germanium transistors. The equivalent circuit of the four-terminal *p-n-p-n* transistor was derived, and the current gain analyzed when the transistor is connected as a hook-collector transistor. This work included a method of adjusting gain by external means. The theory was developed for a new form of transistor of the field-effect type in which the conductivity of a layer of semiconductor is modulated by a transverse electric field. A device, the fieldistor, with input impedance of about 10 megohms, low output impedance, and a g_m of 1,000 micromhos was developed whose control electrode was separated by a few microns from the *p-n* junction. Operating frequency of conventional junction transistors was increased by 10 times or more on experimental models by adding a fourth electrode to the base and biasing it so that the base resistance is decreased by a substantial factor. A new photoelectric device was proposed that would permit modulation of a light beam by the change in absorption due to injected carriers. A *p-n* junction photocell was developed with a sensitivity of 30 ma per lumen corresponding to a quantum yield of approximately unity, and with a frequency response flat into the 100-kc region.

(230) G. L. Pearson and B. Sawyer, "Silicon *p-n* junction diodes," PROC. I.R.E., vol. 40, pp. 1348–1951; November, 1952.
(231) R. R. Law, C. W. Mueller, J. I. Pankove (Pantchechnikoff), and L. D. Armstrong, "A developmental germanium *p-n-p* junction transistor," PROC. I.R.E., vol. 40, pp. 1352–1357; November, 1952.
(232) J. S. Saby, "Fused impurity *p-n-p* junction transistor," PROC. I.R.E., vol. 40, pp. 1358–1360; November, 1952.
(233) J. J. Ebers, "Four terminal *p-n-p-n* transistors," PROC. I.R.E., vol. 40, pp. 1361–1364; November, 1952.
(234) W. Shockley, "A unipolar 'field effect' transistor," PROC. I.R.E., vol. 40, pp. 1365–1376; November, 1952.
(235) O. M. Stuetzer, "Junction fieldistors," PROC. I.R.E., vol. 40, pp. 1377–1381; November, 1952.
(236) R. L. Wallace, Jr., L. G. Schimpf, and E. Dickten, "A junction transistor tetrode for high-frequency use," PROC. I.R.E., vol. 40, pp. 1395–1400; November, 1952.

(237) K. Lehovec, "New photoelectric devices utilize carrier injection," Proc. I.R.E., vol. 40, pp. 1407–1409; November, 1952.
(238) J. N. Shive, "Properties of m-1740 *p-n* junction photocell," Proc. I.R.E., vol. 40, pp. 1410–1413; November, 1952.

Transistor Circuits: Application and circuit development progressed rapidly with work on transistor amplifiers, oscillators, modulators, and multivibrators. Substitution of transistors for vacuum tubes in a frequency-shift converter for radio-teletype equipment was reported. Maximizing power gain and efficiency of junction transistors in class-A and -B audio amplifiers was analyzed.

A transistor audio oscillator with varistor stabilization was developed for operation over a range of temperatures and supply voltages. Transistor amplifier instability due to variation in emitter and collector bias currents was analyzed. Transistor noise was investigated theoretically and experimentally for both junction and point-contact types; noise was found to vary with collector voltage and emitter current with the former and to be relatively independent of those factors with the latter type. Several theorems on noise spectra and noise correlation were derived; the noise figure of transistors can then be calculated for any desired external circuit from equivalent noise generators of simple but arbitrary configuration that have their noise spectra given. Studies of temperature variation of transistor parameters on two point-contact types showed that gain is reduced by only 2 db up to approximately 60°C and units at this temperature are satisfactory for many small-signal applications. The control possibilities of transistors were discussed with reference to fairly large units performing functions now handled by magnetic amplifiers, amplidynes, and thyratrons. Numerous other circuit applications were developed including transistor binary counters, high-voltage low-current power supplies, printed circuits applied to transistors, transistors in airborne equipment, transistor trigger and switching circuits and theory, and various phases of digital-computer circuits.

(239) G. Raisbeck, "Transistor circuit design," *Electronics*, vol. 24, pp. 128–134; December, 1951.
(240) G. S. Epstein, J. A. Bush, and B. Shellhorn, "Transistorizing communication equipment," *Electronics*, vol. 25, pp. 98–102; May, 1952.
(241) R. F. Shea, "Transistor power amplifiers," *Electronics*, vol. 25, pp. 106–108; September, 1952.
(242) D. E. Thomas, "Low-drain transistor audio oscillator," Proc. I.R.E., vol. 40, pp. 1385–1395; November, 1952.
(243) R. F. Shea, "Transistor operation: stabilization of operating points," Proc. I.R.E., vol. 40, pp. 1435–1437; November, 1952.
(244) E. Keonjian and J. S. Schaffner, "An experimental investigation of transistor noise," Proc. I.R.E., vol. 40, pp. 1456–1460; November, 1952.
(245) H. C. Montgomery, "Transistor noise in circuit application," Proc. I.R.E., vol. 40, pp. 1461–1471; November, 1952.
(246) A. Coblenz and H. L. Owens, "Variation of transistor parameters with temperature," Proc. I.R.E., vol. 40, pp. 1472–1476; November, 1952.
(247) E. F. W. Alexanderson, "Control applications of the transistor," Proc. I.R.E., vol. 40, pp. 1508–1511; November, 1952.
(248) G. W. Bryan, "Application of transistors to high-voltage low-current supplies," Proc. I.R.E., vol. 40, pp. 1521–1523; November, 1952.
(249) S. F. Danko and R. A. Gerhold, "Printed circuitry for transistors," Proc. I.R.E., vol. 40, pp. 1524–1528; November, 1952.
(250) O. M. Stuetzer, "Transistors in airborne equipment," Proc. I.R.E., vol. 40, pp. 1529–1530; November, 1952.

Test Methods: Transistor and semiconductor test methods also received considerable attention. Oscilloscopic displays of families of transistor characteristics were developed, some of which permitted easy evaluation of alpha and other parameters. Dynamic test methods were developed to facilitate extensive germanium-diode-testing programs; these included visual *I–E* characteristics, recovery tests, and temperature and humidity characteristic tests. Test procedures were described which check selenium cells for forward and reverse characteristics over a range of temperatures.

(251) M. L. Wood, "Transistor characteristic curve plotter," *IBM Corp. Report*, No. 06,071.402; August 19, 1952.
(252) N. Golden and R. Nielson, "Oscilloscopic display of transistor static electrical characteristics," Proc. I.R.E., vol. 40, pp. 1437–1439; November, 1952.
(253) D. J. Crawford and H. F. Heath, Jr., "Germanium diode testing program," *IBM Corp. Report;* March 6, 1952.
(254) C. A. Kotterman, "Production testing of selenium cells," *Electronics*, vol. 25, pp. 272–284; March, 1952.

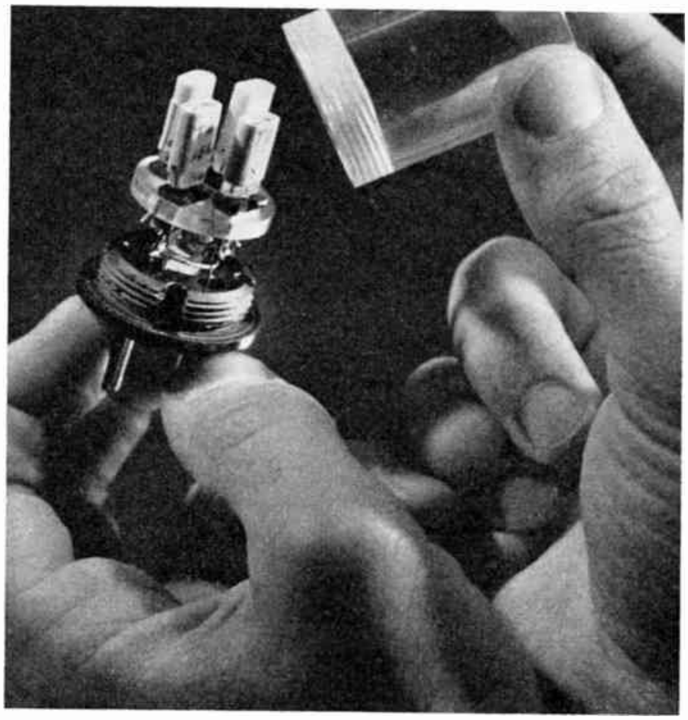

Fig. 4—Audio amplifier stage with four-junction transistors, developed at the David Sarnoff Research Center of RCA at Princeton, New Jersey, provides sufficient amplification to operate a loudspeaker.

Audio Techniques

Several historical summaries were presented and are of particular interest because they include the background of the early telephone applications of audio techniques.

(255) M. J. Kelly, "Communication and electronics," *Elec. Eng.*, vol. 71, pp. 965–969; November, 1952.
(256) A. B. Clark, "The development of telephony in the United States," *Commun. and Electronics, AIEE*, no. 3, pp. 348–364; November, 1952.

Mutual understanding between audio art and science was furthered by a book. Several reviews and summaries of principles appeared.

(257) H. F. Olson, "Musical Engineering," McGraw-Hill Book Co., New York, N. Y.; 1952.
(258) N. H. Crowhurst, "The prediction of audio frequency response," *Electronic Eng.* (London), vol. 23, pp. 440–443, November, 1951; pp. 483–489, December, 1951; vol. 24, pp. 33–38, January, 1952; pp. 72–86, February, 1952.
(259) J. G. Miles, "Types of magnetic amplifiers—Survey," *Commun. and Electronics, AIEE*, no. 1, pp. 229–238; July, 1952.
(260) E. M. Villchur, "Handbook of sound reproduction," *Audio Eng.*, vol. 36, pp. 18–20; June 1952; pp. 15–18, 40, July, 1952; pp. 20–21, 54–55, August, 1952; pp. 38–40, 51–54, September, 1952; pp. 36–37, 88–91, October, 1952; pp. 40–44, 74–75 November, 1952; pp. 20–22, 39–45, December, 1952.

Reports of specific audio-system applications and equipment refinements included the industrial application of loudspeakers and the avoidance of "splatter."

(261) S. C. Bartlett, "Loudspeaker systems in power plants," *Elec. Eng.*, vol. 70, pp. 1057–1062; December, 1951.
(262) J. L. Reinartz, "Increased audio without splatter," TRANS. I.R.E., PGA-9, pp. 22–28, September–October, 1952.
(263) A. Peterson and D. B. Sinclair, "A single-ended push-pull audio amplifier," PROC. I.R.E., vol. 40, pp. 7–11; January, 1952.
(264) A. L. Hammond, "Neutralizing hum and regeneration," *Audio Eng.*, vol. 36, pp. 22, 53–56; May, 1952.
(265) V. Brociner and G. Shirley, "The OTL (output-transformer-less) amplifier," *Audio Eng.*, vol. 36, pp. 21–23, 45–46; June, 1952.

There were two reports on the perennial intermodulation distortion measurement.

(266) P. J. Aubry, "Intermodulation testing," *Audio Eng.*, vol. 35, pp. 22–23, 41–42; December, 1951.
(267) R. C. Hitchcock, "Intermodulation distortion," *Audio Eng.*, vol. 36, pp. 21–22, 56; October, 1952.

Sound Recording and Reproduction

Progress in disk recording was confined principally to refinements of existing techniques and devices. Increased playing time without reduction of maximum peak amplitude of the modulated groove was achieved by extensive use of variable groove spacing, controlled either manually or automatically. Automatic adjustment of groove spacing to accommodate peak-to-peak program amplitude was accomplished by means of a control signal taken from a special level-monitoring magnetic pickup head over which the master program tape passes before reaching the pickup feeding the recording cutter amplifier. The control signal was used to regulate the speed of the motor driving the cutter feed screw in such a way as to increase the groove spacing above a set minimum at any given time proportional to the peak-to-peak amplitude of the program signal at that time. Playing time up to 65 minutes on a single 12-inch disk at 33.3 rpm became possible by use of this technique. Improved quality of cut was accomplished by extensive use of heated stylus cutters, and reduction of cutter head bounce. A trend among record producers to standardize on a 500-cycle turnover frequency became noticeable, but no general agreement on the shape of the response curve below turnover appeared.

Processes for duplicating disk recordings were improved by adoption of electrolytic cleaning and polishing for masters and stampers, and a wider use of all-nickel stampers. Some 45-rpm disks were duplicated by injection molding in polystyrene.

Much greater use of multiple recording at differing speeds was made, producing novel effects such as artificial extension of instrumental range beyond the actual acoustic range.

In reproduction from disks, substantial general improvement in compliance and tracking of pickups was accomplished, together with better damping and transient response. Use of diamond styli in reproduction was substantially increased, in both professional and nonprofessional applications. Considerable improvement in signal-to-noise ratio in commercially available preamplifiers for disk reproduction in custom installations was noted, together with increased range and flexibility of frequency response control, and reduction of transient and other distortions was apparent.

Further investigation of applications of mechanical principles to sound recording problems was made.

(268) J. F. Doust, "The application of elementary mechanics to sound recording," *Sound Recording and Reproduction*, vol. 3, pp. 198–201; December 1951.

In the field of magnetic recording on tape, further investigation of the mechanism of the magnetic recording process was conducted, and considerable information on the inherent characteristics of tape was developed. Improved dynamic range and average signal-to-noise ratio was achieved in tapes providing a greater maximum signal amplitude capability for a given percentage distortion. Tape with 1.5 and 2.0 mil Milar bases became available, giving greater freedom from humidity and varying tension effects. Timing difficulties due to large ratios of maximum-to-minimum tape tension in machines with constant torque take-up were reduced through adoption of tape reels with larger hub diameter than older types.

(269) P. E. Axon, "Mechanism of magnetic recording," *Wireless World*, pp. 47–50; February, 1952.

A new method of recording on magnetic tape analogous to variable-area optical sound-on-film recording was reported. A new type of three-pole magnetic recording head was described in which the normal gap field was nonsymmetrically distorted, resulting in increased resolution and an improved optimum bias adjustment. Further studies of wear of magnetic recording and playback heads were made in an effort to establish the general characteristics of normal wear in use. Further work was done in development of mixed ferrites for use in magnetic recording heads and in grinding and polishing tape-bearing faces of ferrite heads.

Certain standards for disk and magnetic tape recording were recommended for adoption internationally. There was apparent agreement among various recommendations on disk speeds and response curves. Considerable agreement on tape speeds was also evident, but lack of agreement on response curves for tape media still existed. The problem of print-through in magnetic tape was also given further study. There was some indication that the print-through effect was increased by oxide carried over the tape edge in the slitting operation.

(270) H. L. Daniels, "Boundary-displacement magnetic recording," *Electronics*, vol. 25, pp. 116–120; April, 1952.
(271) M. Camras, "New magnetic recording head," *Jour. Soc. Mot. Pic. and Telev. Eng.*, vol. 58, pp. 61–66.
(272) British Standards Institution, CO (ACM) 4731-2-3.

Binaural recording and reproduction on both disk and tape media was introduced, and binaural broadcasting over paralleled AM and FM transmitters was presented experimentally.

(273) B. Cook, "Recording binaural sound on disk," *Tele-Tech*, vol. 11, pp. 48–50, 136–140; November, 1952.
(274) O. Bixler, "A commercial binaural recorder," *Jour. Soc. Mot. Pic. and Telev. Eng.*, vol. 59, pp. 109, 117; August, 1952.

In usage of magnetic recording, there was widespread adoption of the medium for all steps in the production of sound motion-picture film. Such usage provides immediate playback and lowered costs in most intermediate editing operations. Two systems of magnetic recording for this purpose are in use. One system employs a magnetic coating on sprocketed film, the second uses standard ¼-inch magnetic tape with a synchronizing signal recorded with the program material taking the place of the sprocket holes to provide synchronization with the picture film.

For editing and processing operations up to the final release negative, use of a magnetic strip on sprocketed film became almost universal practice. Such usage was in three forms: as a full-width track on sprocketed 35-mm stock; as a strip of lesser width (magnestrip) on clear stock, or stock for positive optical printing of a parallel duplicate track for editing convenience; and on clear stock with a visible editing track put on mechanically with a ball-point pen head for similar reasons.

In the use of ¼-inch tape for recording sound track, there was general informal agreement on the use of 14 kc as a carrier frequency in synchronizing control tracks with 60-cycle modulation and an average carrier level 20 to 30 db below the average program level in the medium. Exception to the trend toward use of 60-cycle modulated 14-kc carrier remained in the continued use of a 60-cycle control signal recorded in the tape medium at an angle of 90 degrees to the program recording.

Devices to start and stop magnetic tape in synchronism with motion picture film in projectors (automatic framing devices) began to find acceptance in major networks and film companies. Devices were also developed for applying visible numbers and frame lines to ¼-inch magnetic recording tape to correspond with footage and frame indications on standard 35-mm motion-picture film. This permitted direct editing of such tape without need for a parallel optical track for footage and frame referencing.

A demonstration of recording and reproduction of sight and sound on magnetic tape was made using a speed of 100 inches per second with results improved over those of last year but still marred by ghosts and snow. The tape used was 1 inch wide and bore 12 parallel magnetic tracks, ten carrying picture information, the remaining two carrying sync signals and sound.

Electroacoustics

Loudspeakers

An interesting development was the ionic loudspeaker. Klein utilized an alternating ionic discharge in a horn formed of quartz to obtain a faithful reproduction of sound without a moving membrane. Meager data were given on efficiency; apparently the output was found to be adequate for practical purposes. The chief drawback seems to be the use of expensive quartz, which is necessary because of the high temperatures and voltages involved.

For the first time, a simple method was developed for measuring the amplitude and phase at various points on a vibrating loudspeaker cone. The cone is covered with a light coat of conducting paint, and a capacitive probe is brought near the point to be measured. The varying capacitance is measured during movement to give the amplitude and phase.

An outstanding paper on the use of loudspeakers in speech reinforcment was that of Beranek and his coworkers. It outlined methods for using speech-reinforcement systems in large auditoriums. The principal suggestion was that there be less use of reinforcement at low frequencies, in order to prevent masking of the higher frequencies by low-frequency reverberation.

(275) S. Klein, "The ionic loudspeaker," *TSF pour Tous*, vol. 27, pp. 278–281; September, 1951; "The physical principles of the ionic loudspeaker and microphone," *TSF pour Tous*, vol. 27, pp. 340–342; October, 1951.
(276) M. S. Corrington and M. C. Kidel, "Amplitude and phase measurements on loudspeaker cones," Proc. I.R.E., vol. 39, pp. 1021–1034; September, 1951.
(277) L. L. Beranek, W. H. Radford, J. A. Kessley, and J. B. Wiesner, "Speech-reinforcement system evaluation," Proc. I.R.E., vol. 39, pp. 1401–1408; November, 1951.

Sound Absorption and Room Acoustics

Progress was made in understanding the fundamental properties of acoustic materials and in relating these properties to the random sound fields that occur in enclosed spaces. Ingård and Bolt reported on a method of measuring the acoustic impedance of an absorbing surface to waves of oblique incidence. The impedance was found for materials for which it is incorrect to assume a constant normal impedance. The method consists of measuring, with a probe microphone, the change in amplitude and phase of the pressure on a flat area when it is changed from a hard surface to one covered with the acoustic material under test.

Lawhead and Rudnick applied the Sommerfeld theory of propagation of radio waves over an absorbing surface to the case of acoustic propagation. They were able to measure the complex propagation constants of acoustic materials.

The modern acoustic design of the legislative chambers of the National Capitol was described by P. E. Sabine.

(278) U. Ingård and R. H. Bolt, "Free field method of measuring the absorption coefficient of acoustic materials," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 509–517; September, 1951.

(279) R. B. Lawhead and I. Rudnick, "Measurements on an acoustic wave propagated along a boundary," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 541–546; "Acoustic wave propagation along a constant normal impedance boundary," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 546–550; September, 1951.
(280) P. E. Sabine, "Acoustics of the remodeled House and Senate Chambers of the National Capitol," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 121–125; January, 1952.

Noise and Hearing

Noise reduction and prevention of hearing loss due to excessive noise levels received much attention. A considerably better understanding of the hearing mechanism has evolved in the past five years. Fletcher developed a mathematical theory for the mechanics of the inner ear based on Békésy's experimental data, and this now explains most of the dynamics of the hearing mechanism.

Much data on the hearing mechanism are now being obtained in terms of bands of noise instead of pure-tone data. Pollack published equal-loudness contours for broad-band noise and otuer data on the aural response to broad-band excitation. Mintz and Tyzzer published a loudness chart by which the loudness of broad-band noise measured in octave bands can be quickly converted into a single loudness figure.

(281) H. Fletcher, "On the dynamics of the cochlea," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 637–646; November, 1951.
(282) H. Fletcher, "Dynamics of the middle ear and its relation to the acuity of hearing," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 129–131; March, 1952.
(283) I. Pollack, "On the threshold and loudness of repeated bursts of noise," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 646–650; November, 1951.
(284) I. Pollack, "Sensitivity to differences in intensity between repeated bursts of noise," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 650–654; November, 1951.
(285) I. Pollack, "On the measurement of the loudness of white noise," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 654–658; November, 1951.
(286) I. Pollack, "Comfortable listening levels for pure tones in quiet and noise," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 158–163; March, 1952.
(287) I. Pollack, *Jour. Acous. Soc. Amer.*, vol. 24, pp. 533–538; September, 1952.
(288) F. Mintz and F. G. Tyzzer, "Loudness chart for octave-band data on complex sounds," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 80–82; January, 1952.

Sound Instrumentation and Measurement

In Europe, there was considerable activity in the development of sound spectrographs or "visible-speech" apparatus. Edgarth developed a spectrograph using sound film. Tamm and Putsching developed a precise narrow-band filter using mechanical elements. This filter uses coupled steel resonators, giving a 15-cycle bandwidth. It is capable of resolving two components 25 cycles apart that differ in level by 40 db. The dynamic range is 65 db.

In the United States, LeBel and Dunbar announced a high-speed level recorder operating electronically, which uses improvements on Hunt's early methods to obtain writing speeds up to 10,000 db per second.

Several laboratories applied to accelerometers and vibration pickups the reciprocity techniques of calibration formerly used for microphones (underwater and in air). Harrison, Sykes, and Marcotte extended this technique to 10,000 cps.

(289) W. Kallenbach, "Further investigation of pitch recorders for application to phonetic research," *Akus. Beihefte*, vol. 1, pp. 37–42; 1951.
(290) B. H. Edgarth, "The sound film spectrograph," *IVA* (Stockholm), vol. 22, no. 5, pp. 134–153; 1951.
(291) K. Tamm and I. Putsching, "A frequency analyzer with a mechanical high frequency filter," *Akus. Beihefte*, vol. 1, pp. 43–48; 1951.
(292) C. J. LeBel and James Y. Dunbar, "Ultra speed recording for acoustical measurements," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 559–563; September, 1951.
(293) M. Harrison, A. O. Sykes, and P. G. Marcotte, "Reciprocity calibration of piezoelectric accelerometers," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 384–390; July, 1952.

Theory of Transducers

Hunt pointed out that correlation methods, which are making important contributions to such diverse fields as communication, information theory, and aerodynamic turbulence, can be used to enhance the space resolution of directional receivers. Since noise can be expected to come from all directions and the signal from only one, a space correlation of the direction of arrival of energy can give much information.

Bauer gave a valuable analysis of acoustic diaphragms by considering them in analog form as a series of ideal transformers, each of which corresponds to a particular area of the diaphragm.

Stevenson published a number of equations for wave propagation in horns.

(294) F. V. Hunt, "Perturbation and correlation methods for enhancing the space resolution of directional receivers," PROC. I.R.E., vol. 39, p. 840; July, 1951.
(295) B. B. Bauer, "Transformer analogs of diaphragms," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 680–683; November, 1951.
(296) A. F. Stevenson, "Exact and approximate equation for wave propagation in acoustic horns," *Jour. Appl. Phys.*, vol. 22, pp. 1461–1463; December, 1951.

Ultrasonics

The field of ultrasonics has continued to be very active, especially in Europe. A book on this subject has been written by Vigoureux. Several scientists discovered new methods of detecting an ultrasonic field, such as the use of a starch plate in a dilute solution of iodine, temperature-sensitive chromatic components, leucobases of dyes, thermostimulable phosphors, temperature-sensitive phosphors, and various types of Schlieren equipment.

The use of ultrasonic equipment in pathological treatments has developed to a greater extent in Europe than in the United States. However, the mechanism that causes acoustic energy to be absorbed in tissue appears to have been solved by an American scientist, W. J. Fry.

Another application of ultrasonics has been the study of details in aerodynamic fields. By this method much more information can be obtained without disturbing the field than by hot-wire techniques.

Also of interest to the electronic industry was the announcement of a nondestructive method for testing ceramic insulators by the use of ultrasonics.

(297) P. Vigoureux, "Ultrasonics," John Wiley and Sons, Inc., New York, N. Y.; 1951.

(298) P. J. Ernst and C. W. Hoffman, "New methods of ultrasonoscopy and ultrasonography," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 207–211; March, 1952.
(299) G. S. Bennett, "New method for the visualization and measurement of ultrasonic fields," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 470–474; July, 1952.
(300) R. Hanel, "Making ultrasonic waves visible," *Radio Tech.* (Vienna), vol. 27, pp. 325–329; August, 1951.
(301) W. J. Fry, "Mechanism of acoustic absorption in tissue," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 412–415; July, 1952.
(302) M. Merle, "Use of ultrasonic waves for the study of an aerodynamic field," *Acustica*, vol. 1, 263, pp. 104–108; 1951.
(303) H. Barthelt and A. Lutsch, "Nondestructive testing of ceramic insulators by ultrasound," *Siemens Zeit.*, vol. 26, pp. 114–121; April, 1952.

Video Techniques

A tutorial paper described the basic method of specifying the performance of photographic materials and discussed some of the variables which affect film performance and the relations of these variables to video recording. Video recording on film has been the subject of considerable theoretical and experimental attack. Work on video recording has not been restricted to film. Advances were made in the experimental recording of video information on tape.

(304) G. H. Gordon, "Video recording, film considerations," Proc. I.R.E., vol. 40, pp. 779–782; July, 1952.
(305) P. J. Herbst, R. O. Drew, and J. M. Brumbaugh, "Factors affecting the quality of kinerecording," *SMPTE Jour.*, vol. 58, pp. 85–104; February, 1952.
(306) R. I. Kuehin, "Improved photo-recording from cathode-ray TV tubes," *Tele-Tech*, vol. 11, pp. 48–49; February, 1952.
(307) P. Mandel, "An experimental system for slightly delayed projection of television pictures," Proc. I.R.E., vol. 40, pp. 1177–1184; October, 1952.

Fundamental investigations of gradation and resolution were reported.

(308) O. H. Schade, "Image gradation, graininess and sharpness in television and motion picture systems," *SMPTE Jour.*, vol. 58, pt. II, pp. 181–222; March, 1952.
(309) L. C. Jesty and N. R. Phelp, "The evaluation of picture quality with special reference to television systems," *Marconi Rev.*, pt. I, vol. 15, pp. 113–116; 3rd quarter, 1951; pt. II, vol. 15, pp. 156–186; 4th quarter, 1951.

Picture quality and ways and means of improving it have been the subject of concerted attacks by workers in the field. One report described a relatively rapid method of measuring resolution and localizing the sections of a television system that degrade it. This measurement utilized a special signal generator giving a picture containing a white rectangle on a black background.

(310) R. K. Seigle, "Television streaking test set," *Electronics*, vol. 24, pp. 96–99; November, 1951.
(311) G. G. Gouriet, "A method of measuring TV picture detail," *Elec. Eng.*, vol. 24, No. 293, pp. 308–311; July, 1952.

Some of the factors affecting interlacing were discussed in another paper.

(312) G. N. Patchett, "Faulty interlacing," *Wireless World*, vol. 58, pp. 250–254, 315–319; July and August, 1952.

The effective cross talk in the video channel introduced from a second circuit was examined under conditions where the effective intercoupling network had four different loss-frequency characteristics.

(313) A. D. Fowler, "Observer reaction to video crosstalk," *SMPTE Jour.*, vol. 57, pp. 416–424; November, 1951.

One of the elements in a picture monitor, the characteristics of which contribute to resolution, is the picture tube. The accurate measurement of spot dimensions under operating conditions is described in a report on this subject. By means of a multiplier phototube and a line-selector type of blanking circuit, oscillograms are obtained showing the vertical distribution of light intensity for single lines and for adjacent lines.

(314) J. Green, "Evaluating performance of TV picture tubes," *Electronics*, vol. 25, pp. 124–129; February, 1952.

Theoretical and experimental evaluation of the signal-to-noise ratio in flying-spot scanners and a discussion of the influencing factors were given in another report.

(315) A. J. Baracket, "Signal-to-noise ratio in television flying spot scanner," *Tele-Tech*, vol. 10, pp. 42–44; December, 1951.

The measurement of amplitude linearity in a television system often requires the disabling of line to line-clamping circuits. A description was given of a method of measurement using familiar laboratory equipment, such as a square-wave generator and oscilloscope together with a gray-scale generator, for making the test with the clamping operative.

(316) G. E. Hamilton and R. Ilowite, "Gray scale generator," *Electronics*, vol. 25, pp. 143–145; November, 1952.

An examination of the possibilities of using information theory in an attempt to reduce bandwidth requirements was made.

(317) C. W. Harrison, "Experiments with linear prediction in television," *Bell Sys. Tech. Jour.*, vol. 31, no. 4, pp. 764-783; July, 1952.
(318) E. R. Kretzmer, "Statistics of television signals," *Bell Sys. Tech. Jour.*, vol. 31, no. 4, pp. 751–763; July, 1952.

The interconnection of stations transmitting under different standards is possible, using either the intermediate-film method or storage-type tubes. The problems that remain in the latter method have been considerably reduced by recent work.

(319) V. K. Zworykin and E. G. Ramberg, "Standards conversion of TV signals," *Electronics*, vol. 25, pp. 86–91; January, 1952.

A more complete description was given of a continuous motion-picture projector utilizing a system of mirrors rotating in synchronism with the film to produce an effective optical lap dissolve from one frame to another. A servomechanism is used to minimize intensity flicker.

(320) A. G. Jensen, R. E. Graham, and C. F. Mattke, "Continuous motion picture projector for use in television film scanning," *SMPTE Jour.*, vol. 58, pp. 1–21; January, 1952.

Improvements in techniques and equipment were described for both the image orthicon and the image iconoscope type pickup tubes.

(321) A. Reisz, "A new all-purpose television camera," *Tele-Tech*, vol. 11, pp. 38–40; April, 1952.
(322) R. Theile and F. H. Townsend, "Improvements in image iconoscopes by pulsed biasing the storage surface," Proc. I.R.E., vol. 40, pp. 146–154; February, 1952.

Radio Transmitters

Television Broadcasting

Television broadcasting was initiated in Canada during 1952, a station being placed in operation in Toronto and one in Montreal.

(323) J. E. Hayes, "Television Facilities of the Canadian Broadcasting Corp," Presented at Soc. Mot. Pic. and Telev. Eng. Convention; October 6, 1952.

New and improved facilities were also made available in the United States.

(324) J. R. Poppele, "The new WOR Studio and Transmitter Building, 60th Street and Columbus Avenue, N.Y.C.," Presented at I.R.E. National Convention, New York, N. Y.; March, 1952.
(325) J. G. Leitch, "New Building and Technical Facilities at WCAU, Philadelphia, Pa." Presented at I.R.E. National Convention, New York, N. Y.; March, 1952.
(326) C. L. Dodd, "The WFAA-TV plant, Dallas, Texas," Presented at I.R.E. National Convention, New York, N. Y.; March, 1952.
(327) R. D. Chipp, "Television control room layout," *Tele-Tech*, pp. 48–50; October, 1952.

Due mostly to the unfavorable economic situation, there was little activity abroad, except in France and England.

In the United States, television played an important part in providing coverage of the Democratic and Republican national presidential conventions.

(328) R. D. Chipp, "Pool Master Control," Presented at I.R.E. Professional Group on Broadcast Transmission Systems Conference, Philadelphia, Pa.; October 27, 1952.

The production of programs was enhanced due to the steady evolution of production techniques, and the improvement of equipment generally.

(329) C. R. Paulson, "TV Production Techniques," Presented at I.R.E. Professional Group on Broadcast Transmissilns Systems Conference, given at Second Annual Prof. Group Broadcast Symposium, Philadelphia, Pa.; October 27, 1952.
(330) L. L. Pourciau, "Television Camera Equipment of Advanced Design" Presented at Soc. Mot. Pic. and Telev. Eng. Convention; October, 1952.
(331) "Tele prompter," *Jour. Soc. Mot. Pic. and Telev. Eng.;* June, 1952.
(332) F. Fodor, "Filmcraft's Camera Control System," Presented at Soc. Mot. Pic. and Telev. Eng. Convention; October, 1952.

The development of flying spot scanners occupied the attention of many engineers and equipment manufacturers during 1952.

(333) G. R. Tingley, R. D. Thompson, and J. H. Haines, "A Universal Scanner for Color Television." Presented at I.R.E. National Convention, New York, N. Y.; March, 1952.
(334) J. W. Wentworth, "Flying-Spot-Scanner Gamma-Correction Circuits," Presented at I.R.E. Professional Group on Broadcast Transmission Systems Conference, Philadelphia, Pa.; October 27, 1952.
(335) R. H. Hammans, "Flying Spot Telecine Equipment and Its Use at BBC," Presented at Second Annual I.R.E. Prof. Group Broadcast Symposium; October 27, 1952.
(336) J. H. Haines, "Flying Spot Scanner Optics," Presented at I.R.E. Professional Group on Broadcast Transmission Systems Conference, Philadelphia, Pa.; October 27, 1952.
(337) R. E. Graham, "Flying Spot Scanner Design," Presented at I.R.E. Professional Group on Broadcast Transmission Systems Conference, Philadelphia, Pa.; October 27, 1952.

There was a considerable improvement in rear-of-screen projection techniques for studio use, in the development of new projection equipment, as well as in the use of teletranscriptions or kinescope recordings.

(338) A. Jenkins, "Rear Screen Projection," Presented at IRE Professional Group on Broadcast Transmission Systems Conference, Philadelphia, Pa.: October 27, 1952.
(339) W. E. Stewart, "New Professional Television Projector," Presented at, Soc. Mot. Pic. and Telev. Eng. Convention; October, 1952.
(340) R. E. Lovell, "Time-zone Delay of Television Programs by Means of Kinescope Recording," Presented at Soc. Mot. Pic., and Telev. Eng. Convention; October, 1952.

The use of image orthicon cameras for the televising of motion picture film also came into use.

(341) R. D. Chipp, "Film Projection Using Image Orthicon Cameras," Presented at Soc. Mot. Pic. and Telev. Eng. Convention; October, 1952.

Considerable advances were made in tue "shooting" of live television shows on film.

(342) K. Freund, "Shooting Live Television Shows on Film," Presented at Soc. Mot. Pic. and Telev. Eng. Convention; October, 1952.

Broadcasters were occupied with station planning throughout the United States because of the lifting of the "freeze" on construction permits by the Federal Communication Commission, and many new stations were planned throughout the country for 1953.

UHF Television

The Federal Communications Commission on April 14, 1952 issued its "Sixth Report and Order Concerning the Television Broadcast Service," suspending the "freeze order" on construction of new stations in effect since September 30, 1948. The Commission's "Rules, Regulations, and Engineering Standards" were amended and an additional 70 channels, each 6 mc wide, in the 470–890 mc band were allocated for television stations.

(343) Federal Communications Commission, "Sixth Report and Order" F.C.C. 52–294; adopted April 11, 1952, and released April 14, 1952.

Of the more than 100 new station authorizations issued by the FCC since the lifting of the freeze, the majority were for stations in the uhf band but only a very few were in operation at the end of the year. With the demand for early completion of new uhf broadcasting stations and for home receivers the television industry activity in engineering development, product design, and manufacture of uhf equipment received great impetus.

The first commercial uhf station, KPTV, in Portland, Oregon was put in operation on Channel 27 with approximately 16-kw effective radiated power produced by a 1-kw development model transmitter and high-gain slot antenna. Beam tilting of the main lobe of approximately 2° down from the horizontal was employed in the antenna system. Field testing of propagation and coverage as well as the performance of receivers in this new area has provided much valuable information.

(344) J. P. Taylor "UHF in Portland—how is it doing?," *Broadcast News*, special ed., pp. 2–23; October, 1952.

Progress in uhf transmitter development and design covered a broad front, with particular design effort being directed toward final product and manufacture in the shortest possible time. Initial designs were limited in power output to approximately 1, 5, and 10–12 kw, being based on the use of tetrodes or klystron tubes for the power output stage.

(345) V. Zeluff "Transmitters for uhf television," *Electronics*, vol. 25, pp. 102–104; July, 1952.

The types of tetrode tubes for approximately 1-kw output were of low-loss ceramic-to-metal seal construction and with anode fin radiators for air cooling. These types permitted the transmitter cavities to be designed for full coverage of the 470-890-mc frequency band with external tuning controls.

(346) *Electronics*, vol. 25, p. 244; June, 1952.

Klystrons were of the three-cavity type and stagger tuned to obtain the required bandwidth for each 6-mc channel. The 5-kw klystron was designed for use with external cavities and the 12–15-kw klystron with cavities integral with the tube.

(347) R. H. Varian "Recent developments in klystrons," *Electronics*, vol. 25, pp. 112–115; April, 1952.
(348) "High power uhf klystron," *Tele-Tech*, vol. 11, pp. 60–61; October, 1952.

Development work on both tubes and circuits, looking toward improved methods for obtaining the desired uhf power most efficiently, continued and included systems based on triode, tetrode, klystron, resnatron, magnetron, and traveling-wave types of tubes. Development was started on a klystron tube capable of producing 75 kw over the 470–890 mc band.

(349) V. Learned and C. Varonda, "Recent developments in high-power klystron amplifiers," Proc. I.R.E. ,vol. 40, pp. 465–469; April, 1952.
(350) D. B. Harris, "New uhf resnatron designs and applications," *Electronics*, vol. 24, pp. 86–89; October, 1951.
(351) D. B. Priest, "Coaxial tetrode as a TV amplifier at vhf and uhr," *Tele-Tech*, vol. 11, pp. 52–53 and 80–88; January, 1952.
(352) P. T. Smith, "Some new ultra-high frequency power tubes," *RCA Rev.*, vol. XIII, pp. 224–238; June 1952.
(353) G. E. Sheppard, M. Garbuny, and J. R. Hansen, "Reflex resnatron shows promise for uhf TV," *Electronics*, vol. 25, pp. 116–119; September, 1952.
(354) D. H. Priest, "Tetrodes improve harmonic generation at vhf and uhf," *Tele-Tech*, vol. 11, pp. 60–61, 118–120 and 123; April, 1952.
(355) "A 75 kw klystron tube for uhf TV," *TV Digest*, vol. 8, p. 5; November 1, 1952.

Much progress was made in high-gain antennas, transmission lines, sideband filters, and notch diplexers. One slot-type antenna has a power gain varying from 24 to 27 depending on the frequency. Methods of pattern testing and adjustment before erection were developed. New coaxial transmission lines were developed and made available. A 50-ohm $3\frac{1}{8}$-inch diameter line with teflon insulators, permits a power rating of 24 kw and a loss of 0.220-db feet at channel 14 and a 14-kw power rating and loss of 0.406 db feet at channel 83. For high towers where long lengths of line are required and for higher powers, a 75-ohm $6\frac{1}{8}$-inch diameter line with teflon insulators was developed having a power rating of 100 kw and loss of 0.102 db feet at channel 14 and 50-kw power rating and loss of 0.210 db feet at channel 83. For still higher power ratings and still lower losses, copper-clad steel waveguides were developed. Further field measurements were made and work continues on the effects of expected in coverage by antenna-beam tilting and to verify the results obtained by increasing antenna heights under different terrain conditions. An important development for uhf antenna systems was an improved combination of vestigial sideband filter and constant-impedance notch diplexer, called a "filterplexer," having the necessary filter characteristics and feeding both sound and picture transmitters into a single transmission line.

(356) M. W. Scheldorf, "Broad band antenna element," *Tele-Tech*, vol. 11, pp. 50–51; January, 1952.
(357) O. O. Feit, "A new uhf television antenna TFU24B," *Broadcasting News*, pp. 8–23; March–April, 1952.
(358) E. H. Shively, "Pattern testing the TFU24B UHF antenna," *Broadcasting News*, pp. 42–51; May–June, 1952.
(359) O. O. Feit, "New $3\frac{1}{8}$" uhf ultra low loss coaxial line," *Broadcasting News*, pp. 30–35; September–October, 1951.
(360) J. Epstein, D. W. Peterson, and O. M. Woodward, Jr., "Some types of omnidirectional high gain antennas for use at ultra-high frequencies," *RCA Rev.*, vol. XIII, pp. 137–162; June, 1952.
(361) J. Epstein and D. W. Peterson, "Broadcasting TV in the uhf Band," *Electronics*, vol. 25, pp. 102–109; November, 1952.
(362) Federal Communication Commission, "Public Notice No. 74835"; April, 1952.
(363) R. I. Brown, "WABD's new television transmitter," *Tele-Tech*, vol. 11, pp. 53–55, 96; May, 1952.
(364) J. S. Donal, Jr. and K. K. N. Chang, "An analysis of the injection locking of magnetrons used in amplitude modulated transmitters," *RCA Rev.*, vol. XIII, no. 2, pp. 239–257; June, 1952.
(365) R. G. Peters, "Ultra-high transmitter and antenna design and applications," *TV Eng.*, vol. 2, pp. 14–17, 29; October, 1951.
(366) P. Guenard, B. Epsztein, and P. Cahoun, "Klystron amplificateurs de 5 kilowatts a large bande passante," *Ann. Radioelec.*, vol. 6, no. 24, pp. 109–113; April, 1951.
(367) W. H. Sayer, Jr., "UHF transmitter uses beer-barrel cavity," *Electronics*, vol. 24, pp. 125–127; December, 1951.
(368) Staff Written, "The Holme-Moss television transmitter," *Elec. Eng.* (London), vol. 23, pp. 434–435; November, 1951.
(369) D. B. Weigall, "Holme-Moss television transmitting station," *BBC Quart.*, vol. 6, pp. 183–192; Autumn, 1951.
(370) Staff Written, "Kirk o'Shotts transmitting station," *Jour. Telev. Soc.*, vol. 6, no. 9, p. 357; January–March, 1952.
(371) Staff Written, "Kirk o'Shotts television transmitting station," *Engineer* (London), vol. 193, pp. 371–373; March 14, 1952.
(372) W. Burkhardtmaier, "Development problems of the television transmitter," *Telefunken Z.* ,vol. 24, pp. 193–203; December, 1951.
(373) H. de Waard, "Television broadcasting in Holland," *Jour. Telev. Soc.*, vol. 6, no. 8, p. 299; October-December, 1951.
(374) E. Demus, "Experimental television transmitter of the German Postal Administration on the Gr. Feldberg (Tannus)," *Funk Technik* (Berlin), vol. 7, no. 9, pp. 232–233; 1952.
(375) P. A. T. Bevan and others, "Symposium of papers on the Sutton Coldfield television station," *Proc. IEE* (London), vol. 98, pt. 3, pp. 416–470; November, 1951.

Microwave Communication

The demand for new microwave installations for approved services and for extension of facilities to other services was of sufficient magnitude to require a review of the entire allocation plan under the sponsorship of the FCC. Considerable activity in this field was reported from abroad.

(376) JTAC Report, "Radio Spectrum Conservation," McGraw-Hill Book Co., Inc., New York, N. Y.; 1952.
(377) D. N. Lapp and A. B. Hopple, "VHF-UHF turnpike radio systems," *FN-TV*, vol. 12, pp. 29–31, 34; June, 1952.
(378) Staff Written, "Microwave links Freeport mines," *Chem. Eng.*, vol. 48, p. 41; June, 1952.
(379) C. M. Backer, "Microwave system design for utilities," *Tele-Tech*, vol. 10, pp. 48–50, 84; December, 1951.
(380) L. Christensen, "Twenty-four channel microwave telephone equipment of Danish manufacture," *Teleteknik*, vol. 2, pp. 161–167; July, 1951.
(381) J. B. L. Foot, "1400-MC/s radiophone," *Wireless World*, vol. 58, pp. 132–135; April, 1952.
(382) H. Keeling, "Gas pipeline radio system," *FM-TV*, vol. 12, pp. 17–21, 40; January, 1952.
(383) J. A. Craig, "Automatic radio repeater system," Proc. I.R.E., vol. 39, pp. 1524–1529; December, 1951.
(384) C. F. Hobbs, "Close channel spacing at vhf and higher frequencies," Proc. I.R.E., vol. 40, pp. 329–334; March, 1952.
(385) J. Peters, "Carrier-frequency systems free from linear distortion," *Arch. elekt.* (Uebertragung, vol. 5, pp. 509–515; November, 1951.
(386) P. Marzin, "Radio links, general technical consideration," *Ann. Telecommun.*, vol. 6, pp. 363–380; December, 1951.
(387) L. Persson, "Radio links for power stations," *Ericsson Rev.*, no. 2, pp. 42–47; 1951.
(388) R. Siegert, "Transportable USW directional link equipment," *Telefunken Z.*, vol. 24, pp. 204–212; December, 1951.
(389) K. O. Schmidt, "Planning radio links," *Fernmeldteck. Z.*, vol. 43, pp. 531–536; December, 1951.
(390) M. J. Dockes, "Frequency generation for radio relay systems," *Echo de Recherches*, no. 7, pp. 20–25; April, 1952.

Common Carrier Radio Relay

The facilities for wide-band communication service were expanded rapidly. Many new cities received service for both television programs and multi-channel telephone traffic. In Europe, multiplexed communications for toll service received considerable attention with major emphasis on equipment of somewhat less traffic-handling capacity than the newer United States installations.

(391) J. G. Chaffee and J. B. Maggio, "Frequency-modulation terminal equipment for transcontinental relay system," *Elec. Eng.*, vol. 70, pp. 880–883; October, 1951.
(392) B. R. Tupper and P. B. Patton, "Multiple-channel telephony on VHF radio links," Proc. I.R.E., vol. 40, pp. 913–916; August, 1952.
(393) R. W. Friis and K. D. Smith, "An unattended broad-band microwave repeater for the TD-2 radio relay system," *Elec. Eng.*, vol. 70, pp. 976–981; November, 1951.
(394) P. Barkow, "Linearity limits of discriminators, particularly for wide-band FM radio beam links," *Fernmeldteck. Z.*, vol. 5, pp. 179–186; March–April, 1952.
(395) F. Ring, "Transmission characteristics of the V 60 carrier-frequency equipment," *Fernmeldteck. Z.*, vol. 5, pp. 101–108 and 179–186; February, 1952.
(396) K. O. Schmidt, "Some data on two former multichannel beam links from Athens to Rome and Crete," *Telefunken Z.*, vol. 25, pp. 64–68; March, 1952.
(397) H. J. Fründt, "A 50 MC/S beam link with ±500 KC/S frequency swing," *Telefunken Z.*, vol. 25, pp. 510–519; March, 1952.
(398) E. Kniel and K. H. Baer, "The radio common-wave system of the Südwestfunk," *Tech. Hausmitt. Nordw. Dtsch. Rdfunks.*, vol. 4, pp. 47–51; March–April, 1952.
(399) L. C. Simpson, H. J. B. Nevitt, and E. J. Eriksen, "VHF radio multi-channel carrier telephone circuits in Colombia," *Ericsson Rev.*, vol. 28, pp. 62–72; 1951.
(400) K. O. Schmidt, "The planning of beam links in the decimeter and centimeter wave bands," *Telefunken Z.*, vol. 24, pp. 129–139; October, 1951.
(401) G. Ulbricht, "The IDA-2 beam-link equipment," *Telefunken Z.*, vol. 24, pp. 143–162; October, 1951.
(402) Staff Written, "Radio telephone communication in the Chamonix Valley," *Rev. des Postes*, vol. 7, no. 9, pp. 18–23; March–April, 1952.
(403) R. Rivere and M. Schwindenammer, "The equipments of the Dijon-Strasbourg multi-channel radio link," *Onde Elec.*, pp. 163–173; April–May, 1952.
(404) H. Gutton, J. Fagot, and J. Hugon, "The equipment of the Paris-Lille multi-channel radio link," *Onde Elec.*, pp. 174–180; April–May, 1952.

Television Relaying

In addition to the relay facilities made available by the common carriers, considerable progress was reported on mobile equipment for use in remote programming. This field received considerable attention in foreign countries.

(405) A. H. Mumford, "Television radio relay links," *Jour. Telev. Soc.*, vol. 6, pp. 290–299; October–December, 1951.
(406) J. H. Battison, "Microwaves: backbone of network television," *Tele-Tech*, vol. 11, pp. 62–63, 113; January, 1952.
(407) T. H. Bridgewater, "Paris-London television," *Elec. Eng.* (London), vol. XXIV, no. 295, pp. 410–412; September, 1952.
(408) Y. Angel and P. Riche, "The Paris-Lille television radio link," *Onde Elec.*, pp. 152–157; April–May, 1952.
(409) J. Laplume, S. Schirman, R. Fraticelli, and R. Jeannin, "The Paris-Lille television radio link equipment," *Onde Elec.*, pp. 158–162; April–May, 1952.

International Broadcasting and Communication

Further progress in the utilization of single-sideband transmission and multichannel operation was reported. Efforts were mainly directed toward better utilization of the spectrum.

(410) L. M. Klenk, A. J. Munn, and J. Nedelka, "A multi-channel single side-band radio transmitter," Proc. I.R.E., vol. 40, pp. 783–796; May, 1952.
(411) A. E. Kerwien, "Modulation equipment for modern single-sideband transmitters," Proc. I.R.E., vol. 40, pp. 797–803; July, 1952.
(412) L. R. Kahn, "Single-sideband transmission by envelope elimination and restoration," Proc. I.R.E., vol. 40 pp. 803–806; July, 1952.
(413) N. Lund, C. F. Rose, and L. G. Young, "Amplifiers for multi-channel single-sideband radio transmitters," Proc. I.R.E., vol. 40, pp. 790–796; July, 1952.
(414) D. J. Ambercrombie, "Parasitic oscillation in radio transmitters," *Proc. I.R.E.* (Australia), vol. 12, pp. 206–209; July, 1951.
(415) M. Suppan, "The new Italcable radio transmitting station of Torrenova," *Poste e Telecommun.*, vol. 19, pp. 473–481; October, 1951.
(416) A. Gaillard, "Le Groupe H. F. D'Allouis—Issondun de la Radio-Diffusion Francoise," *Onde Elec.*, 31st year, no. 296; November, 1951.
(417) Veaux, "Progress and Development of Long Distance Radio Links by the Administration of P.T.T.," *Rev. des P.T.T.*, vol. 7, pp. 34–42; January–February, 1952.
(418) J. R. Heck, "4.5 KW in 2 sq. ft.," *FM-TV*, vol. 12, pp. 30–31, 34; August, 1952.
(419) W. A. Krause, "Portable radio telephone equipment for communication between ship and shore," *Frequenz*, vol. 6, pp. 146–149; May–June, 1952.

AM Broadcasting

Several new transmitters were described. The major activity was reported by workers outside of the United States with emphasis on remote control, automatic control, and unattended operation. Parallel operation of transmitters is being extended for the purpose of transmission continuity.

(420) M. H. Hutt, "AM transmitter design," *Radio and Telev.*, vol. 47, pp. 3–5, 29; January, 1952.
(421) M. H. Hutt, "New 5 KW AM transmitter," *Broadcast News*, no. 66, pp. 48–55; September–October, 1951.
(422) M. H. Hutt, "Mechanical design of a 10 KW radio transmitter," *Elec. Mfg.*, vol. 48, pp. 92–95, 266, 268; November, 1951.
(423) A. G. Robeer and B. Swets, "Description of a 40 KW broadcast transmitter," *Commun. News*, vol. 12, pp. 16–32; October, 1951.
(424) A. Schweisthal, "Twin drive as active research for broadcast transmitters," *Tech, Hausmitt. NordwDtsch. Rdfunks.*, vol. 4, pp. 42–45; March–April, 1952.
(425) A. Schweisthal and K. H. Baer, "The Ravensburg 2×20 KW broadcast transmitter," *Tech. Hausmitt. NordwDtsch. Rdfunks.*, vol. 4; March–April, 1952.
(426) A. Kolarz and E. Kniel, "Problems of automatic operation of transmitting groups," *Tech. Hausmitt. NordwDtsch. Rdfunks.*, vol. 4, pp. 59–62; March–April, 1952.
(427) Staff Written, "Broadcasting installations for the two programmes in Denmark," *Teletenik*, (Copenhagen) vol. 2, pp. 207–249; October, 1951.
(428) Staff Written, "Unattended high power radio transmitter," *Engineer*, vol. 193, p. 146; March 21, 1952.
(429) Staff Written, "Remote control of BBC high power transmitter," *Elec. Eng.* (London), vol. 24, p. 229; May, 1952.
(430) F. A. Peachy, R. Toombs, and C. Gunn-Russell, "BBC new automatic unattended technique," *Elec. Eng.* (London), vol. 24, pp. 446–449; October, 1952.

FM Broadcasting

Circuit developments in FM transmitters were reported. Very few new stations were erected in the United States. The greatest interest in this field has been in other countries.

(431) H. G. Stratman, "FM transmitter for 42 MCS," *Radio and Telev.*, vol. 47, pp. 10–13, 31; June, 1952.
(432) J. Hacks, "Investigations of FM systems with negative feedback," *Arch. elekt. Ubertragung*, vol. 5, pp. 441–446; October, 1951.
(433) W. Mansfeld, "Realizability of the point of inflection of a modulation characteristic for FM by means of reactance valves," *Frequenz*, vol. 5, pp. 317–333; November–December, 1951.

(434) R. Otto, "Frequency modulation by means of a capacitor with controlled charging cycle," *Frequenz*, vol. 5, pp. 323–327; November–December, 1951.
(435) E. Kettle, "New master oscillator of high frequency stability for FM USW broadcast transmitters," *Telefunken Z.*, vol. 25, pp. 60–64; March, 1952.
(436) E. Kettle, "New control transmitter of high frequency stability for ultra-short wave, FM broadcast transmitters," *Telefunken Z.*, vol. 25, pp. 60–64; March, 1952.
(437) E. Roessler, "Effect of the pilot transmitter," *Fernmeldtech. Z.*, vol. 5, pp. 97–100; March, 1952.

Television

The various panels of the National Television System Committee (NTSC) in the United States made continued progress towards the eventual development of a compatible color-television system. A number of manufacturers and networks began experimentally to transmit NTSC color signals for limited field testing.

The research laboratories throughout the television industry in the United States were busily engaged in the development of experimental color equipment. The recently developed color flying-spot scanners were already in limited use in research and development programs in the industry.

Of academic interest, was the release by NTSC of a glossary of color-television terms, these working definitions being widely circulated for the benefit of those currently engaged in color work.

(438) B. D. Loughlin, "Recent improvements in band-shared simultaneous color television," PROC. I.R.E., vol. 39, pts. I and II, pp. 1264–1279; October, 1951.
(439) N. Marchand, H. R. Holloway, and M. Leifer, "Analysis of dot-sequential color television," PROC. I.R.E., vol. 39, pp. 1280–1287; October, 1951.
(440) P. C. Goldmark, J. W. Christensen, and J. J. Revees, "Color-television—U. S. A. standard," PROC. I.R.E., vol. 39, pp. 1288–1313; October, 1951.
(441) R. B. Dome, "Spectrum utilization in color television," PROC. I.R.E., vol. 39, pp. 1323–1331; October, 1951.
(442) K. McIlwain, "Requisite color bandwidth for simultaneous color-television systems," PROC. I.R.E., vol. 40, pp. 909–912; August, 1952.
(443) E. G. Ramberg, "Elimination of moiré effects in tri-color kinescopes," PROC. I.R.E., vol. 40, pp. 916–922; August, 1952.
(444) K. Schlesinger and L. W. Nero, "A phase indicator for color television," *Electronics*, vol. 25, p. 112; October, 1952.
(445) S. Applebaum, "Gamma Correction in Constant-Luminance Color-Television Systems," presented at IRE National Convention, New York, N. Y.; March 4, 1952.
(446) D. C. Livingston, "Theory of symchronous demodulator as used in NTSC color television receiver," *Sylv. Tech.*, vol. 5, pp. 60–63; July, 1952.
(447) S. W. Moulton, "Colorimetric Measurements in Color Television," presented at the IRE National Convention, New York, N. Y.; March 4, 1952.
(448) D. Richman, "Frame Synchronization for Color Television," presented at the IRE National Convention, New York, N. Y.; March 4, 1952.
(449) F. J. Bingley, "Colorimetric Electronics," presented at the IRE National Convention, New York, N. Y.; March 4, 1952.
(450) J. Fisher, "The Generation of Compatbile Color Signals for Research and Testing," presented at the IRE National Convention, New York, N. Y.; March 4, 1952.
(451) G. R. Tingley, R. D. Thompson, and J. H. Haines, "A Universal Scanner for Color Television," presented at the IRE National Convention, New York, N. Y.; March 4, 1952.
(452) W. F. Bailey, "Vestigial-Sideband Transmission of the Color Subcarrier in NTSC Color Television," presented at the IRE National Convention, New York, N. Y.; March 4, 1952.
(453) "Definitions for color TV," *Electronics*, vol. 25, p. 208; Nov., 1952.
(454) C. J. Hirsch, W. F. Bailey, and B. D. Loughlin, "Principles of NTSC compatible color television," *Electronics*, vol. 25, pp. 88–95; February, 1952.
(455) R. B. Dome, "NTSC color-TV synchronizing signal," *Electronics*, vol. 25, pp. 96–97; February, 1952.

An important device, the Eidophor, was demonstrated for large-screen theatre television. Further interest in larger home television pictures led to active development of the 27-inch wide-angle picture tube.

(456) E. Baumann, "The Fischer large-screen projection system," *Jour. Brit. I.R.E.*, vol. 12, pp. 69–78; February, 1952.
(457) C. E. Torsch, "Ninety Degree Cathode-Ray Sweep System Consuming Less Than 'Fifty Degree' Power," IRE Fall Meeting, Syracuse, N. Y.; October, 1952.

Improved methods of rapidly measuring phase and frequency response of television systems were discussed. Better methods of reproducing moving-picture film for television were demonstrated using flying-spot scanners with steady motion of the film.

(458) E. D. Goodale, "Phase, Amplitude and Aperture Correction in Television Systems," IRE Convention, Cincinnati, Ohio; April, 1952.
(459) T. C. Nuttal, "The development of a high-quality 35 mm film scanner," *Proc. IEE* (London), pt. IIIA, pp. 136–144, 174–178; 1952.

A proposal for a "light" amplifier for television pictures was discussed. Demonstrations were given of experimental television receivers using transistors.

(460) "Electronic light amplifiers for TV," *Tele-Tech*, vol. 11, pp. 41, 110, 112; July, 1952.
(461) "Portable television receiver," *Sci. Newsletter*, p. 392; November 29, 1952.

Methods of obtaining stereoscopic television were developed. Further work was done in improving synchronization and interlace of television receivers.

(462) V. K. Zorykin and L. E. Flory, "Television in medicine and biology," *Elec. Eng.*, vol. 47, pp. 40–45; January, 1952.
(463) G. B. Townsend, "On overcoming the non-interlacing of television receivers which are accurately synchronized," *Proc. IEE* (London), pt. 3A, IIIA, vol. 99, pp. 645–650; 1952.
(464) A. W. Keen, "A Precision Synchronizing System for Large-Screen Television Equipment," Institution of Electrical Engineers, Paper 1344, 12 pp.; 1952.
(465) M. Marks, "Noise-immune sync. separator," *Electronics*, vol. 25, pp. 124–127; April, 1952.
(466) G. N. Patchett, "Faulty interlacing," *Wireless World*, vol. LVIII, pp. 250–254; July, 1952.

A new sweep generator tunable over the whole uhf and vhf band at fundamental frequency and with relatively large output became commercially available. Further studies of IF and video-amplifier characteristics leading toward linear phase response were made.

(467) H. A. Finke and F. Blecher, "Wideband sweep generator for VHF and UHF TV," *Tele-Tech*, vol. 11, pp. 52–54; August, 1952.
(468) H. Kiehne and S. Mazur, "Phase-linear television receivers," *Electronics*, vol. 25, pp. 103–105; May, 1952.

To reduce the visibility of line structure on large picture tubes, there was described a method of vertical "spot stretching." Improvements in gamma-control amplifier circuits were described while a useful multiple-channel-output laboratory television source became commercially available.

(469) G. N. Patchett, "Line eliminator," *Wireless World*, vol. LVIII, pp. 219–221; June, 1952.
(470) L. Lax and D. Weighton, "A Gamma-Control Circuit Using Crystal Diodes," Institution of Electrical Engineers, Paper 1308, 7 pp.; 1952.
(471) S. R. Patremio, "The Du-Mitter," *Radio Electronic Engineering*, vol. 31, pp. 3–5; February, 1952.

Receivers

The quantity of new material covering home-entertainment receivers has been greatly reduced as a result of conversion to defense orders.

The use of printed circuits has been extended to small radio receivers and to sections of television receivers. A major advance in assembly-line technique has been the introduction of a dip-soldering process whereby several hundred connections are soldered simultaneously.

(472) W. A. Tervell, "Printed circuit design methods and assembly techniques," *Telev. Eng.*, vol. 3, pt. I, pp. 10–12; February, 1952; pt. II, pp. 19, 29; March, 1952.
(473) W. H. Hannahs and N. Stein, "Printed unit assemblies for TV," *Tele-Tech*, vol. 11, pp. 38–40; June, 1952.
(474) E. Wavering, "Printed circuits for radio receivers," *Electronics*, vol. 25, pp. 140–142; November, 1952.
(475) "Plated circuit process for radio production," *Tele-Tech*, vol. 11, pp. 56–57; November, 1952.

Transistors are being used in the laboratory to replace conventional tubes in television, in AM radio, in FM radio, in personal and auto radios, and in phonograph oscillators. The November, 1952 issue of the PROCEEDINGS OF THE I.R.E. is devoted to 48 articles on transistors.

Some of these are continuously variable for complete coverage of the uhf band and others are turret designs with strips for both vhf and uhf channels. Many circuit variations have been employed, some using harmonics of the oscillator for frequency conversion and some having double and others with single conversion with a wide range of intermediate frequencies. Recent designs trend toward the use of somewhat simpler and more conventional circuitry with fundamental oscillator operation and single conversion to the standard 41.25-mc and 45.75-mc sound and picture intermediate frequencies. With progress in receiving tube development for uhf amplifier and oscillator application, circuit development has been directed toward the addition of an amplifier stage preceding the mixer.

(476) H. Hesse, "A new uhf television converter," *Tele-Tech*, vol. 11, pp. 36–39 and 114, 116, 118; March, 1952.
(477) T. Murakami, "A study of grounded-grid uhf amplifiers," *RCA Rev.*, vol. 12, pp. 682–701; December, 1951.
(478) Wen Yuan Pan, "Relative magnitudes of undesired responses in uhf receivers," *RCA Rev.*, vol. 12, pp. 660–681; December, 1951.
(479) E. G. Hamer and L. J. Herbst, "Receivers for use at 460 mc/s," *Wireless Eng.*, vol. 28, pp. 323–329; November, 1951.
(480) E. E. Harris and M. Cawein, "Concentric lines tune uhf channels," *Electronics*, vol. 25, pp. 108–112; February, 1952.
(481) S. R. Scheiner and G. W. Carter, "Measuring uhf receiver noise figures," *Electronics*, vol. 25, pp. 128–129; March, 1952.
(482) H. F. Reith, "Performance and design of a compact uhf tuner," *Tele-Tech*, vol. 11, pp. 42–43, 76, 78, 80; August, 1952.
(483) H. A. Finke and S. Deutsch, "Combination uhf-vhf television tuner," *Tele-Tech*, vol. 11, pp. 58–59 and 176–180; September, 1952.
(484) W. B. Whalley, "Design considerations for uhf and vhf receivers," *Tele-Tech*, vol. 11, pp. 36–38 and 104, 106, 108, 110; November, 1952.
(485) "Tele-Tech's guide to latest uhf receiving tubes," *Tele-Tech*, vol. 11, p. 92; November, 1952.

New items of measuring and test equipment for use in the 470–890-mc television band were developed. Two types of sweep frequency generators necessary for laboratory development and production testing of uhf television receivers appeared.

(486) J. A. Cornell, and J. F. Sterner, "Sweep frequency generator for uhf television band," *Tele-Tech*. vol. 11, pp. 38–40, 86, and 88; February, 1952.
(487) H. A. Finke and F. Blecher, "Wideband sweep generator for vhf and uhf television," *Tele-Tech*, vol. 11, pp. 52–54 and 75; August, 1952.

Work on uhf receiving antennas for home installation continued with emphasis on design simplification and field measurements of directivity, bandwidth, and gain over the uhf frequency band. Various types include single and stacked fan dipoles; single and stacked rhombics; stacked V; sheet, paraboloidal, and corner reflectors; and Yagi arrays. For home antenna installations a 300-ohm transmission line with low losses (particularly when wet), has two parallel Copperweld 22-gauge wires each centered by spiral polyethylene threads in a polyethylene tube, the whole covered by a polyethylene sheath.

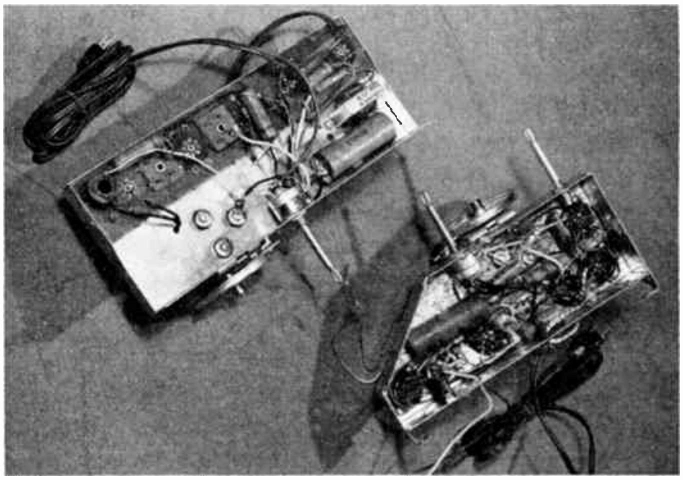

Fig. 5—Dip-soldered radio chassis (L), compared with hand-soldered counterpart. (*General Electric Co.*)

(488) E. O. Johnson and J. D. Callaghan, "Receiving antennas for uhf television," *Tele-Tech*, vol. 10, pp. 38–41 and 82; December, 1951.
(489) E. O. Johnson and J. D. Callaghan, "UHF receiving antennas," *Electronics*, vol. 25, pp. 132 and 134; January, 1952.
(490) "New uhf television transmission line," *Tele-Tech*, vol. 11, pp. 150 and 153; December, 1952.

The appearance of larger picture tubes with wide-angle deflection has stimulated progress in the design of sweep circuits.

(491) B. M. Cole, "Improved horizontal TV sweep circuits," *Tele-Tech*, vol. 11, pp. 92–93; September, 1952.
(492) C. E. Torsch, "Ninety-Degree Cathode Ray Sweep System Consuming Less than 'Fifty-Degree' Power," presented at IRE/RTMA Fall Meeting; October, 1952.

Activity has continued in the development of methods for improving picture sharpness that is directly related to the receiver transient response. It has been suggested that the receiver phase response be made linear. The quadrature component affects the transient response adversely and a method for reducing it by use of a receiver with a step type of amplitude response has been described.

(493) H. Kiehne and S. Mazur, "Phase-linear television receivers," *Electronics*, vol. 25, pp. 103–105; May, 1952.
(494) J. Ruston, "Improved TV system transient response," *Electronics*, vol. 25, pp. 110–113; August, 1952.

There is an increasing trend toward incorporating circuits for cancellation of large noise peaks in the synchronizing circuit. With ordinary limiting, large noise peaks tend to make the sync separator inoperative for a short time after their occurrence.

(495) M. Marks, "Noise-immune sync separator," *Electronics*, vol. 25, pp. 124–127; April, 1952.

The problems of television interference continue to receive attention. In Canada, where interference regulations are more strict, the design of receivers is especially difficult.

(496) W. B. Smith, Canadian Dept. of Transport, "Problems of television interference," presented at IRE/RTMA Fall Meeting; October, 1952.

Progress was made in the reduction of oscillator radiation, and most receivers now being sold are within the limits of RTMA standard REC-129C. The selection of sites for radiation measurements are discussed in an IRE report.

(497) "Practical considerations in measuring vhf receiver oscillator radiation," supplement to 51 IRE 17S1.
(498) E. W. Chapin and W. K. Roberts, "Reducing TV receiver oscillator radiation," *Electronics*, vol. 25; pp. 116–120; July, 1952.

The IRE Subcommittee on Spurious Radiation is working on a preliminary standard for sweep radiation measurements.

Although the industry has been preparing for uhf for some time the feverish activity started when station KPTV in Portland, Oregon began commercial uhf broadcasting in September, 1952. Improving the noise performance and noise-measurement technique of uhf amplifiers continued to be a major objective. Noise figures for uhf tuners are 10–15 db higher than for vhf tuners.

(499) S. R. Scheiner, and G. W. Carter, "Measuring UHF-TV rereceiver noise figures," *Electronics*, vol. 25, pp. 128–129; March, 1952.
(500) A. B. Glenn, "Study of noise reduction by feedback in ultrahigh frequency amplifiers," presented at IRE/RTMA Fall Meeting; October, 1952.

A multitude of new types of tuners and converters were reported. These vary in complexity from a one-channel converter to an 82-channel turret tuner, using distributed or lumped elements, single or double conversion, and a variety of mechanical designs.

(501) R. G. Peters, "Ultra-high tuner, converter and receiver research and design," *TV Eng.*, vol. 3, pp. 6–9; April, 1952.
(502) W. B. Whalley, "Design considerations for combination UHF and VHF receivers," *Tele-Tech*, vol. 11, pp. 36–38; November, 1952.
(503) N. Edwards, "UHF Conversion methods," *Radio and Telev. News*, vol. 47, pp. 56–58; June, 1952; vol. 48, pp. 47–49; July, 1952.
(504) E. E. Harries and M. Cawein, "Concentric lines tune UHF channels," *Electronics*, vol. 24, pp. 108–112; 1952.

Facsimile

A facsimile system to handle interoffice correspondence in connection with television broadcasting systems operations was placed in service. This system provides a reproduction rate of 28 square inches per minute at 105-line definition over an 8-kc channel by vestigial-sideband operation employing linear phase filters.

The use of facsimile for terminal handling of regular traffic in commercial telegraph systems continued to increase with some 6,900 "Desk-Fax" units in operation in United States cities, connecting patrons directly with the nearest central office. In addition, this facility was provided nearly 100 subscribers in London, England to expedite the handling of cablegrams.

To speed communications within large commercial organizations a similar system, "Intrafax," has been developed. This system employs the basic transmitter and recorder units in a flexible arrangement adaptable to the needs of each individual organization. Several such private systems were placed in operation during the year.

Further information has been made available on Western Union's new high-speed facsimile system.

(505) "London inaugurates facsimile service," *Tele. and Tele. Age*, vol. 4, p. 21; April, 1952.
(506) H. H. Haglund, "Thirty-line concentrator for private facsimile systems," *Western Union Tech. Rev.*, vol. 6, pp. 143–144; October, 1952.
(507) C. R. Deibert, F. T. Turner, and R. H. Snider, "A high-speed direct-scanning facsimile system," *Western Union Tech. Rev.*, vol. 6, pp. 37–46; April, 1952.
(508) D. M. Zabriskie, "A high-speed telefax recorder," *Western Union Tech. Rev.*, vol. 6, pp. 48–55; April, 1952.
(509) L. G. Pollard, "A high-speed facsimile transmitter," *Western Union Tech. Rev.*, vol. 6, pp. 56–60; April, 1952.

Recent developments in the graphic arts which may have a significant effect upon progress in the field of facsimile and which have already stimulated considerable research activity include zerography, and more recently, ferrography and ferromagnetography. These latter two involve the use of the familiar magnetic-coated tape or sheet and means for rendering the magnetic image visible. All would seem to present bases for the development of new facsimile recording and storage techniques.

(510) R. B. Atkinson and S. G. Ellis, "Ferrography," *Jour. Frank. Inst.*, vol. 252, pp. 373–381; November, 1951.
(511) T. M. Berry and J. P. Hanna, "Ferromagnetrography, high speed printing with shaped magnetic fields," *Gen. Elec. Rev.*, vol. 55, no. 4, pp. 20–22, 61; July, 1952.

Industrial Electronics

Magnetic Amplifiers

In the last two years, a rapid growth of interest in magnetic amplifiers has materialized among practicing engineers.

(512) W. J. Dornhoefer and V. H. Krumnenacher, "Applying magnetic amplifiers," *Elec. Mfg.*, March, April, August, September, 1951. Reprints available.
(513) L. A. Finzi and G. F. Pitman, Jr., "A Critical Comparison of Methods of Analysis of Magnetic Amplifiers," presented at National Electronics Conference; September 29, 1952.

A practical understanding of circuit operation and design procedure based on the relations between performance and circuit parameters, while known to those developing magnetic-amplifier techniques, had appeared in the technical literature only by implication prior to the publishing of the reference listed below.

(514) J. T. Carleton and W. F. Horton, "The Figure of Merit of Magnetic Amplifiers," AIEE Communication and Electronics; September, 1952.

Many groups are interested in the application of magnetic amplifiers to servomechanisms, and valuable experience was gained in circuit techniques.

(515) W. A. Geyger, "A New Type of Magnetic Servo Amplifier," AIEE Communications and Electronics; September, 1952.
(516) C. W. Lufey, A. E. Schmid, and P. W. Barnhart, "An improved magnetic servo amplifier," AIEE Communications and Electronics; September, 1952.

Others recognized the applicability of magnetic amplifiers to the solution of difficult measurement problems.

(517) W. A. Geyger, "Magnetic Amplifiers of the Self-Balancing Potentiometer Type," AIEE Technical paper 52–271, presented, AIEE Fall General Meeting, New Orleans, La.; October 15, 1952.
(518) G. M. E. Hinger, "A magnetic amplifier of high input impedance," *Proc. NEC*, (Chicago), vol. 7, p. 523; 1951.

The problem of stability, or drift, of amplifiers is recognized as one of the most formidable. It is essentially this problem that is dealt within measurements and in detection of small signals. It seems to be widely agreed that the limitations are imposed by the characteristics of the receivers and that the stability of the magnetic amplifier in practical circuitry is not appreciably better than that of the vacuum tube.

Nonlinear Dielectrics

Notable progress has been made in the application of nonlinear dielectrics to storage and low-frequency amplifiers.

Single barium titanate crystals of useful size are now being grown in several university, industrial, and military laboratories. Thin slabs of such single crystals have been used for ferroelectric storage in digital computers. It is estimated that for storage rates of 10^6 binary digits per second using 20.5 mw read-in power, 2.8 mw read-out power can be obtained. Simplicity of construction and concentration of information are outstanding features. Work is continuing using polycrystalline titanates, with, however, less spectacular results.

(519) J. R. Anderson "Ferroelectric storage elements for digital computers and switching systems," *Elec. Eng.*, vol. 71, pp. 916–922; October, 1952.
(520) W. N. Papian, "Ferromagnetic and Ferroelectric Memory Devices," Engineering Note E-470, Digital Computer Laboratory, M.I.T. Cambridge, Mass.; August, 1952.
(521) A. von Hippel, "Piezoelectricity, Ferroelectricity and Crystal Structure," Report dated Mar. 1952, on O.N.R. contracts, N5-ori-07801, N5 ori-07858. Laboratory for Insulation Research, M.I.T., Cambridge, Mass.

The analysis of low-frequency dielectric amplifiers circuits has been attacked by several approximate methods. In one, the curve of electric displacement versus applied electric intensity is approximated by a hyperbolic sine function; in another method, a power series is used. With suitable simplifying assumptions, solutions to the nonlinear differential equations have been obtained, yielding useful relations for design purposes.

Audio-frequency amplifiers have been built at the Philco Corporation and at Carnegie Institute of Technology, the latter having achieved outputs of approximately 1 watt with efficiencies exceeding 25 per cent.

(522) L. A. Pipes, "A mathematical analysis of a dielectric amplifier," *Jour. Appl. Phys.* vol. 23, pp. 818–824; August, 1952.
(523) H. Urkovitz, "A ferroelectric amplifier," Report No. 199M, Philco Research Division; March, 1952.
(524) A. M. Vincent, "Dielectric amplifier fundamentals," *Electronics*, vol. 24, pp. 84–88; December, 1951.

In general, slow progress is being made in the search for new nonlinear dielectric materials, such as the niobates and zurconates, and in improving the titanates in an effort to obtain more thermally stable dielectrics. A possible new class of such dielectrics consisting of colloidal mixtures of dielectrics suspended in insulating oils, or in gels, has been reported, with emphasis, however, on the sensitive rather than dielectric properties.

(525) H. E. Hollman, "Polaresistivity and polaristors," Proc. I.R.E., vol. 40, pp. 538–545; May, 1952.

Electronic Computers

Large-Scale Machines

An increasing number of large-scale computers was put into operation in the United States to speed up the nation's defense effort.

(526) C. R. Strang, "Computing machines in aircraft engineering," *Rev. Electronic Digital Computers*, pp. 94–101; February, 1952.

Large electronic digital computers received most attention. The characteristics of completed machines and their operating experience were the subjects of a Joint AIEE-IRE Electronic Computer Conference held in Philadelphia in December, 1951. This conference included papers by the users of the machines as well as by

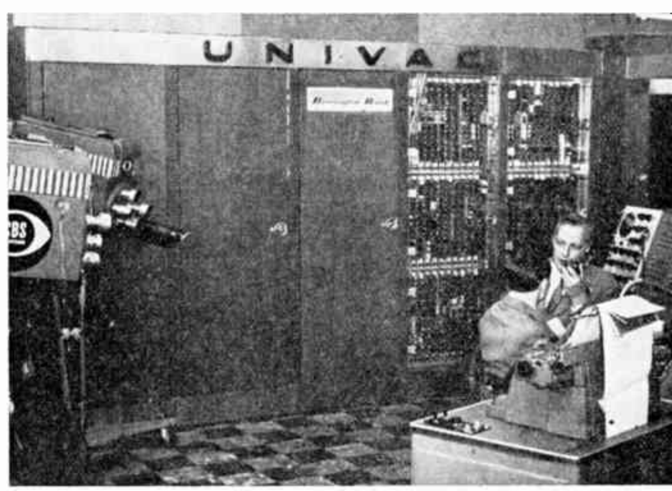

Fig. 6—Mr. Arthur F. Draper, who is in charge of new products research for Remington Rand, shown at the microphone of the UNIVAC on election night.

the designers. An example of the advanced state of development, as compared with the period only several years ago when most large-scale machines were in the hands of their designers, is the Univac, a high-speed serial machine employing elaborate checking devices and designed for both scientific and business applications. In addition, it is the first digital-computer system with extensive input-output equipment, utilizing from one to ten magnetic-tape units for high-speed input and output transfers. There is an array of auxiliary equipment including keyboard-to-tape and punched-card-to-tape converters and printing devices, all of which function independently of the central computer. The Univac is the first computer to be manufactured on a production basis and several have already passed acceptance tests.

(527) J. P. Eckert, Jr., J. R. Weiner, H. F. Welsh, and H. F. Mitchell, "The UNIVAC system," *Rev. Electronic Digital Computers*, pp. 6–15; February, 1952.
(528) J. L. McPherson and S. N. Alexander, "Performance of the census UNIVAC," *Rev. Electronic Digital Computers*, pp. 16–20; February, 1952.

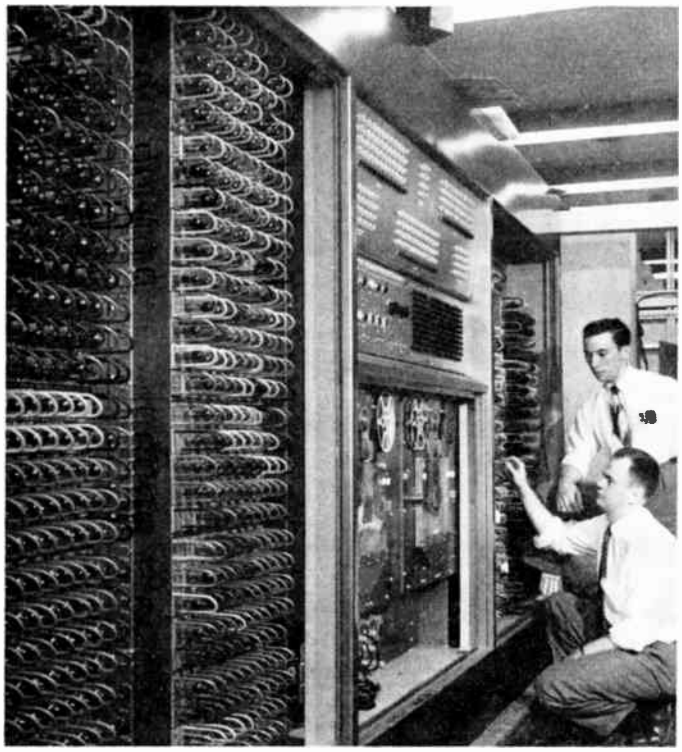

Fig. 7—General Electric engineers Earl Theall, (kneeling) and Bernard Geyer inspect parts of General Electric's new digital computer, "OARAC," developed by G.E. for the Air Force's Research and Development Command. The central panel of the OARAC, used primarily for testing purposes, is flanked on either side by rows of plug-in turrets containing most of the 1,400 tubes and many of the 7,000 diodes used in this giant computer.

Several machines of the Institute for Advanced Study type were put in operation. These are high-speed parallel binary machines using Williams' electrostatic-tube memories. The Ordvac, the first of these machines to be put in operation, was delivered by the University of Illinois to the Ballistic Research Laboratories of Aberdeen Proving Grounds. A similar computer with a photoelectric-tape reader and a high-speed punch was completed at the University of Illinois.

(529) R. E. Meagher and J. P. Nash, "The Ordvac," *Rev. Electronic Digital Computers*, pp. 37–42; February, 1952.
(530) G. Estrin, "A description of the Electronic Computer at the Institute for Advanced Studies," presented Association for Computing Machinery, Toronto; September 8, 1952.
(531) N. Metropolis, E. F. Klein, W. Orvedahl, J. R. Richardson, H. H. Demuth, and J. B. Jackson, "Maniac," presented Association for Computing Machinery, Toronto; September 8, 1952.

The Raydac, designed and constructed by the Raytheon Manufacturing Company, passed its acceptance tests. It employs a serial acoustic memory, parallel arithmetic unit, and magnetic-tape input-output equipment.

The Harvard University Mark IV, a serial decimal machine employing magnetic-drum memory and magnetic-core shifting registers, was put in operation.

Another machine of considerable importance was finished, an engineering prototype of the IBM type 701 calculator. This computer contains a large electrostatic memory of the Williams type and is notable for its extensive input-output facilities.

(532) M. M. Astrahan and N. Rochester, "The logical organization of the new IBM scientific calculator," *Proc. Assoc. Computing Machinery*, pp. 79–83; 1952.

The M.I.T. Whirlwind I computer, a very high-speed calculator using an electrostatic storage tube of special design, was used for scientific, engineering, and military computation.

(533) R. R. Everett, "The Whirlwind I Computer," *Elec. Eng.*, vol. 71, pp. 681–686; August, 1952.
(534) N. H. Taylor, "Evaluation of the engineering aspects of Whirlwind I," *Rev. Electronic Digital Computers*, pp. 75–83; February, 1952.

The National Bureau of Standards Eastern Automatic Computer now has over two years of scheduled operating experience on an extremely wide variety of problems from all parts of government.

(535) S. N. Alexander, "The National Bureau of Standards Eastern Automatic Computer," *Rev. Electronic Digital Computers*, pp. 84–89; February, 1952.
(536) R. J. Slutz, "Engineering experience with the SEAC," *Rev. Electronic Digital Computers*, pp. 90–93; February, 1952.

Three variations of this type of machine, extensively repackaged, are being constructed at the National Bureau of Standards and elsewhere.

The National Bureau of Standards Western Automatic Computer located at UCLA, a parallel machine using Williams memory, was able to perform considerable useful computation while undergoing engineering improvements.

The Edvac, a serial-binary machine using mercury-acoustic delay-line memory and designed and constructed at the Moore School of Electrical Engineering at the University of Pennsylvania, was put into regular production service at the Aberdeen Proving Grounds.

A high degree of reliability was obtained with the ERA 1101 computer, a large-scale machine employing a magnetic-drum memory.

(537) F. C. Mullaney, "Design features of the ERA 1101 Computer," *Rev. Electronic Digital Computers*, pp. 43–48; February, 1952.

A background of operating experience with many other large-scale digital computers became available.

(538) E. G. Andrews, "A review of the Bell Laboratories' digital computer development," *Rev. Electronic Digital Computers*, pp. 101–105; February, 1952.
(539) G. E. Poorte, "The operation and logic of the MARK III electronic calculator in view of operating experience," *Rev. Electronic Digital Computers*, pp. 50–55; February, 1952.
(540) G. G. Hoberg, "The Burroughs Laboratory computer," *Rev. Electronic Digital Computers*, pp. 22–29; February, 1952.
(541) A. A. Auerbach, J. P. Eckert, Jr., F. R. Shaw, J. R. Weiner, and L. D. Wilson, "The Binac," Proc. I.R.E., vol. 40, pp. 12–29; January, 1952.
(542) J. W. Sheldon and L. Tatum, "The IBM card-programmed

electronic calculator," *Rev. Electronic Digital Computers*, pp. 30–36; February, 1952.

(543) F. C. Williams and T. Kilburn, "The University of Manchester computing machine," *Rev. Electronic Digital Computers*, pp. 57–61; February, 1952.

(544) B. W. Pollard, "The design, construction, and performance of a large-scale general-purpose digital computer," *Rev. Electronic Digital Computers*, pp. 62–69; February, 1952.

(545) A. D. Booth, "The physical realization of an electronic digital computer," *Elec. Eng.* (London), vol. 24, pp. 442–445; October, 1952.

(546) T. Pearcey, "An automatic computer in Australia," *Mathematical Tables and other Aid to Computation*, vol. 6, pp. 167–172; July, 1952.

Two excellent review articles appeared, one emphasizing applications, the other engineering developments.

(547) M. Rees, "Digital Computers—their nature and use," *Amer. Sci.*, vol. 40, pp. 328–335; April, 1952.

(548) J. W. Forrester, "Digital computers: present and future trends," *Rev. Electronic Digital Computers*, pp. 109–113; February, 1952.

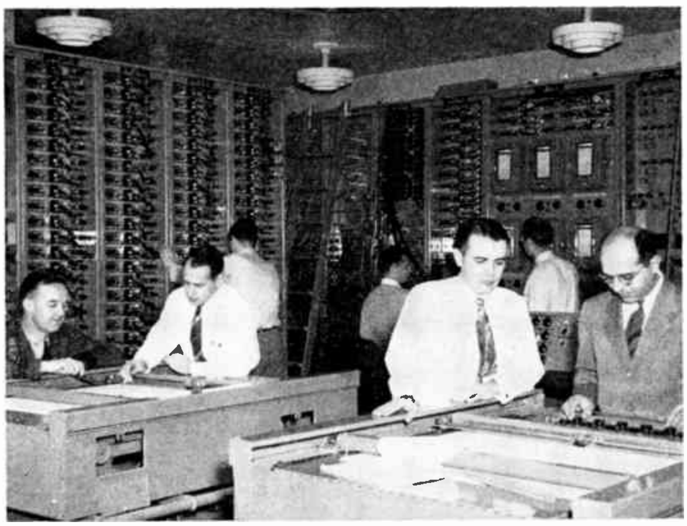

Fig. 8—The Typhoon Computer, developed and built by the RCA Laboratories Division of the Radio Corporation of America, in operation at the Naval Air Development Center at Johnsville, Pennsylvania. The Typhoon has extreme flexibility of design, and has been adapted to unusual uses.

The Typhoon computer, developed and built by RCA Laboratories, was moved to the Naval Air Development Center at Johnsville, Pennsylvania. It is believed to be the largest and most accurate analog computing system in use at the present time. It features new electronic computing devices, such as the stabilized dc amplifier, the step multiplier, and the time-division multiplier.

(549) E. A. Goldberg, "A high-accuracy time-division multiplier," *Electronics*, vol. 13, pp. 265–274; September, 1952.

Although originally designed as a missile simulator, Typhoon is currently employed for studying in three-dimensional form the performance of a piloted aircraft with associated maneuver autopilot. The fact that Typhoon was readily adapted for this problem verifies the flexibility of the design.

Commercial Digital Computers of Moderate Price

Commercially available general-purpose electronic digital computers of moderate price were the subjects of a symposium held at the Pentagon in Washington, D. C., on May 14, 1952. These are small serial machines having magnetic-drum memories, requiring less than 10-kw total power, and costing from $50,000 to $100,000.

(550) D. H. Jacobs, "The JAINCOMP-BI Computer," presented Symposium on Commercially Available General-Purpose Electronic Digital Computers of Moderate Price, Pentagon, Washington, D. C.; May 14, 1952.

(551) E. J. Quinby, "The MONROBOT Electronic Calculators," presented Symposium on Commercially Available Digital Computers of Moderate Price, Pentagon, Washington, D. C.; May 14, 1952.

(552) R. E. Sprague, "The CADAC," presented Symposium on Commercially Available Digital Computers of Moderate Price, Pentagon, Washington, D. C.; May 14, 1952.

(553) J. Greig, "The Circle Computer," presented Symposium on Commercially Available Digital Computers of Moderate Price, Pentagon, Washington, D. C.; May 14, 1952.

(554) A. Auerbach, "The Elecom 100," presented Symposium on Commercially Available Digital Computers of Moderate Price, Pentagon, Washington, D. C.; May 14, 1952.

(555) L. P. Robinson, "Model 30-201 Electronic Digital Computer," presented Symposium on Commercially Available Digital Computers of Moderate Price, Pentagon, Washington, D. C.; May 14, 1952.

(556) G. B. Greene, "The Miniac," presented Symposium on Commercially Available Digital Computers of Moderate Price, Pentagon, Washington, D. C.; May 14, 1952.

Special Computers

The Maddida and other digital differential analyzers appeared and came into wide use. A magnetic-drum memory and electronic digital techniques were used in this small machine, providing greater flexibility and precision than conventional differential analyzers.

(557) J. F. Donan, "The serial-memory digital differential analyzer," *Mathematical Tables and other Aids to Computation*, vol. 6, pp. 102–112; April, 1952.

(558) R. E. Sprague, "Fundamental concepts of the digital differential analyzer method of computation," *Mathematical Tables and other Aids to Computation*, vol. 6, pp. 41–49; January, 1952.

The use of both digital and analog computers for simulation and control is a subject of vital interest. A mixture of analog and digital techniques is frequently useful.

(559) H. H. Goode, "Simulation—its place in system design," Proc. I.R.E. vol. 39, pp. 1501–1506; December, 1951.

(560) B. M. Gordon and R. N. Nicola, "Special-purpose digital data-processing computers," *Proc. Assoc. Computing Machinery*, pp. 33–45; 1952.

(561) M. J. Mendelson, "The quadratic arc computer," *Proc. Assoc. Computing Machinery*, pp. 53–59; 1952.

Many analog computers, varying widely in complexity and application, were developed.

(562) E. A. Baldini and A. P. Fugill, "Power system analogue and network computer," *Elec. Eng.*, vol. 71, p. 439; May, 1952.

(563) F. W. Bubb, Jr., "Circuit for generating polynomials and finding their zeroes," Proc. I.R.E., vol. 39, pp. 1556–1561; December, 1951.

(564) G. A. Korn, "The difference analyzer: a simple differential equation solver," *Mathematical Tables and other Aids to Computation*, vol. 6, pp. 1–8; January, 1952.

(565) B. B. Young, "Advanced time scale analog computer," *Jour. Frank. Inst.*, vol. 253, pp. 169–271; Fall, 1952.

Components and Techniques

The reliability of vaccum tubes for use in large-scale computers is a subject of primary concern that has received little attention in the literature. One important study, based on 2,500,000 electron-tube sockets in the field and a two-year program of defective-tube analysis, was published.

(566) J. A. Goetz and A. W. Brook, "Electron tube experience in computing equipment," *Elec. Eng.*, vol. 71, pp. 154–157; February, 1952.

The most important engineering problem continues to be that of how to make the memory. The most widely used high-speed memory at the present time is the electrostatic storage tube. A number of important papers reflecting a better understanding of the processes involved appeared. Several of these described important improvements in the Williams type of memory including a cathode-ray tube specifically designed for the purpose.

(567) A. Robinson, "The testing of cathode ray tubes for use in the Williams type storage system," presented Association for Computing Machinery, Toronto; September 9, 1952.
(568) A. J. Lephakis, "Electrostatic-tube storage system," PROC. I.R.E., vol. 39, pp. 1413–1415; November, 1951.
(569) W. E. Mutter, "Improved cathode-ray tube for application in Williams memory system," *Elec. Eng.*, vol. 71, pp. 352–356; April, 1952.
(570) R. Schumann, "Improvement of Williams memory reliability," presented Association for Computing Machinery, Toronto; September 9, 1952.
(571) B. Kazan and M. Knoll, "Fundamental processes in charge-controlled storage tubes," *RCA Rev.*, vol. 12, pp. 702–753; December, 1951.

Perhaps the most important technical development for the digital computer field was the use of ferromagnetic or ferroelectric materials with rectangular hysteresis loops for high-speed random-access memory. These techniques offer the possibility of extremely reliable large-capacity memories with access times of the order of microseconds.

(572) J. A. Rajchmann, "Static magnetic matrix memory and switching circuits," *RCA Rev.*, vol. 13, pp. 183–201; June, 1952.
(573) W. N. Papian, "A coincident-current magnetic memory cell for the storage of digital information," PROC. I.R.E., vol. 40, pp. 475–478; April, 1952.
(574) J. R. Anderson, "Ferroelectric storage for digital computers and switching systems," *Elec. Eng.*, vol. 71, pp. 916–922; October, 1952.
(575) I. L. Auerbach, "A static magnetic memory system for the ENIAC," *Proc. Assoc. Computing Machinery*, 1952, pp. 213–222.

Other memory techniques have been stimulated by the development of new materials.

(576) A. E. DeBarr, R. Millership, P. F. Dorey, R. C. Robbins, and P. D. Atkinson, "Digital storage using ferromagnetic materials," *Proc. Assoc. Computing Machinery*, pp. 197–202; 1952.
(577) A. Wang, "Static magnetic memory—its applications to computers and controlling systems," *Proc. Assoc. Computing Machinery*, pp. 207–212; 1952.
(578) N. B. Saunders, "Magnetic binaries in the logical design of information handling machines," *Proc. Assoc. Computing Machinery*, pp. 223–229; 1952.
(579) T. F. Rogers and W. A. Anderson, "Some recent research on ultrasonic propagation in solid media," *Proc. Assoc. Computing Machinery*, pp. 203–205; 1952.
(580) A. W. Holt, "A very rapid access memory using diodes and capacitors," presented, IRE National Convention, New York, N. Y.; March 6, 1952.
(581) A. W. Holt, "Progress report on a very rapid access memory using diodes and capacitors," presented Association for Computing Machinery, Toronto; September 9, 1952.
(582) J. Rabinow, "The notched disk memory," *Elec. Eng.*, vol. 71, pp. 745–749; August, 1952.
(583) H. L. Daniels, "Boundary displacement recording," *Electronics*, vol. 25, pp. 116–120; April, 1952.

The point-contact transistor was reported as being admirably suited for application in high-speed pulse circuits.

(584) J. H. Felker, "The transistor as a digital computer component," *Rev. Electronic Digital Computers*, pp. 105–108; February, 1952.
(585) R. L. Trent, "Binary counter uses two transistors," *Electronics*, vol. 25, pp. 100–101; July, 1952.

Besides the transistor, many other new components for arithmetic and control circuits were reported.

(586) F. A. Schwertz and B. Moffat, "Nonlinear switching elements," *Proc. Assoc. Computing Machinery*, pp. 143–157; 1952.
(587) C. Isborn, "Ferroresonant flip-flops," *Electronics*, vol. 25, pp. 121–123; April, 1952.
(588) R. A. Ramey, "The single core magnetic amplifier as a computer element," AIEE Technical Paper 52-293.
(589) B. O. Marshall, Jr., F. A. Schwertz, and B. Moffatt, "Optical elements for computers," *Proc. Assoc. Computing Machinery*, pp. 159–163; 1952.
(590) N. Hardy, "The selenium rectifier—a non-linear and asymmetric resistance element," *Proc. Assoc. Computing Machinery*, pp. 165–172; 1952.

Other selected references to new techniques are listed.

(591) M. Rubinoff, "Further data on the design of Eccles-Jordan flip-flops," *Elec. Eng.*, vol. 71, pp. 905–910; October, 1952.
(592) D. L. Johnston, "Standardized printed circuit units for digital computers," *Proc. Assoc. Computing Machinery*, pp. 135–141; 1952.
(593) H. J. Gray, Jr., "Logical description of some digital-computer adders and counters," PROC. I.R.E., vol. 40, pp. 29–33; January, 1952.
(594) R. Weissman, "High-speed counter uses ternary notation," *Electronics*, vol. 25, pp. 118–121; October, 1952.
(595) J. Broomall and L. Reibman, "Sampling analog computer," PROC. I.R.E., vol. 40, pp. 568–572; May, 1952.
(596) H. J. Geisler, "R-f bursts actuate gas tube switch," *Electronics*, vol. 25, pp. 104–105; February, 1952.

Input-Output Equipment

Input-output equipment is a subject of increasing importance and many commercial units became available. This equipment was the subject of the Joint AIEE-IRE Computer Conference held in New York in December, too late in the year to be included in this report.

(597) J. J. Wild, "High-speed printer for computers and communications," *Electronics*, vol. 25, pp. 116–120; May, 1952.
(598) J. Lindsmith, "A system for counting and recording electrical impulses in printed decimal form," *Proc. Assoc. Computing Machinery*, pp. 61–78; 1952.
(599) M. Miller, B. L. Waddell, and J. Patmore, "Digital to analog converter," *Electronics*, vol. 25, pp. 127–129; October, 1952.

Professional Activities

The IRE Professional Group on Electronic Computers now includes over 1,000 members and has commenced publication of quarterly TRANSACTIONS.

A number of colleges and universities now offer one or more graduate courses in the design and application of electronic digital computers. These include Harvard University, Massachusetts Institute of Technology, University of Pennsylvania, Columbia University, University of Illinois, University of California, Wayne University, and University of Toronto.

Navigation Aids

Historical

The study of patent literature, generously supplemented by the reading of contemporary scientific articles, provides a systematic procedure for tracing the distant roots of modern technical devices. An interesting example is a report that traces the origins of displays such as the plan position indicator (PPI).

(600) C. D. Tuska, "Pictorial radio," *Jour. Frank. Inst.*, vol. 253, pp. 1–20 and 95–124; January and February, 1952. IRE Abstract 2219.

Present Trends

In some recent aircraft, electronic equipment represents 60 per cent of the cost. In guided missiles, the figure may reach 75 per cent. Electronic equipment on a modern fighter represents a larger investment than the entire cost of a comparable World War II fighter. General Ira Eaker therefore emphasizes the great importance of designing a single well-planned electronic system, instead of a jumbled assortment of individual devices. In some cases it may be desirable to design the airplane around the electronic equipment.

Recent descriptions of a fighter interceptor illustrate current progress toward automatic operation. The pilot gets the plane into the air and is vectored by ground radar to the general vicinity of the target. Automatic controls then lock on the target, track it, aim the plane, and fire the rockets. The pilot is an interested observer, who is aware of his plane's success when the target's echo vanishes from the cathode-ray-tube screen. The landing is assisted by radio.

Projects designed to decrease the weight of navigational apparatus while preserving reliability have received high priority. Despite current progress, accessory apparatus designed to safeguard a fighting pilot may have the contrary effect in battle. The Russian MiG15 and the American F86 have similar engines and airframe dimensions. Yet the loaded Russian plane weighs 12,500 pounds in comparison with the 16,500-pound U.S. plane, permitting better performance.

Trends in long-distance guided-missile navigation envisage, in advance, the complete computation of a normal flight path. Deviations from normal would be measured by a series of tracking stations along the path and the first-order quantities in these deviations supplied to a high-speed digital computer to determine the proper instant for power cut-off and correction of the advance programming of the elevator controls.

Basic Problems

Practically all studies of radio wave propagation are of basic interest in electronic navigation. In cases of fast-moving receivers and transmitters, the dynamic aspects of errors require attention. These include the various effects of Doppler shifts, with attention given to waves reflected from the ground that produce a considerable spectrum at the receiver. Errors can be reduced by various forms of integration. The theory of random processes was applied to the study of fluctuations of "ground clutter" in airborne radar. Different kinds of clutter were investigated, and the survey extended to include all kinds of physical phenomena that can result in a radio reflection. Using the principle of inverse probability, information theory was applied to the design of radar receivers.

In view of the world-wide installation of short-distance navigational aids, their maintenance and calibration has assumed great importance. Larger countries maintain special planes with elaborate instrumentation. Light-weight test gear, quickly installable in a rented plane was designed for intermittent service elsewhere.

(601) H. Busignies, "Dynamic aspects of errors in radio navigational systems," *Elec. Commun.* (London), vol. 29, pp. 226–228; September, 1952.
(602) "Radio aid accuracy," *Flight*, vol. LXII, pp. 447–448; October 3, 1952.

Simplified Design

Representative of a trend in simplification of design and construction is a paper on the construction of waveguides by milling slots in block castings, two such castings being fastened face-to-face in order to close the guide. When this construction is applicable, it is said to be lighter, smaller, cheaper, and better than conventional plumbing.

For small planes, a simplified version of the earth-inductor compass has been designed, using an inexpensive stroboscopic device as the remote indicator. British designers offer a low-cost approach radar giving range and azimuth information only, height being determined by an altimeter. They also propose a simplified 33-track ground facility, providing guidance for 100 miles and serving as a localizer for final approach. A relatively inexpensive airborne unit was described making extensive use of delay lines for time discrimination to select the correct ground stations and track. Departures from track are indicated by a left-right meter.

Specific Applications of Conventional Devices

Several unusual photographs were published, indicating the fine detail obtainable under favorable conditions by the use of K-band radar. This airport-surface-detection-equipment (ASDE) is used solely for directing the "taxi" movement of planes and other vehicles on the runways. Designed primarily for use during low visibility, its remarkably clear presentation assists the controller even in broad daylight, since relative distance can be seen on the radar screen more accurately than it can be estimated by perspective vision. Planes may actually appear in miniature, with wing and fuselage structure, in place of conventional radar's shapeless "blob" of light. Such fine detail stems, of course, from the use of a 1.25-cm wavelength, with an azimuthal beam width of ½ degree.

For commercial flights with jet aircraft, an "anticollision" radar has been designed. This is a 10-kw, 3-cm radar weighing 180 pounds and having a 6-degree beam width. It uses an 18-inch paraboloid, mounted on a horizontal platform that is servostabilized with respect to a vertical gyro. It scans ±75 degrees horizontally while set at angles between ±10 degrees vertically, and has a range of 40 miles on dangerous cumulo-nimbus clouds. It may provide guidance through gaps in such clouds and through mountain passes, and is useful as a terrain-clearance indicator. Clouds are considered harmless if they give no response at distances greater than 10 miles. The distance-range on other aircraft is 5 to 15 miles.

For use on Aerobee rockets, a miniature transponder beacon was produced. It occupies a cylindrical space

$2\frac{1}{2}$ inches in diameter, 6 inches long and weighing less than 2 pounds. The power supply is of similar size and weight.

In direction finding, the rotatable H-type Adcock retains its popularity. The National Physical Laboratory issued a comprehensive report on the optimum design of the instrument and an analysis of its residual errors. Such errors have been grouped into unbalance, screen-image, and coupling errors. Other papers describe specific designs appropriate to the 26–60-mc, the 300–600-mc, and the 30,000-mc frequency ranges.

(603) F. Horner, "An investigation of polarization errors in an H-Adcock direction-finder," *Proc. IEE* (London), pp. 229–240; July, 1952.

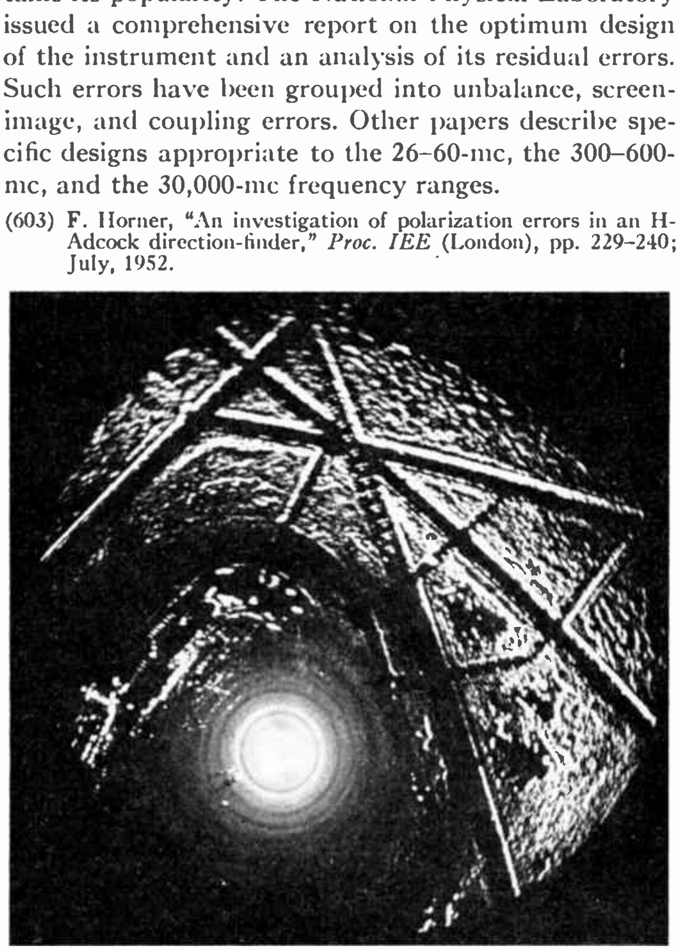

Fig. 9—Airport surface-detection equipment radar picture of Idlewild Airfield with aircraft-type DC 6 taxiing on the runway. (*Rome Air Development Center*).

New Devices

While the radar mechanism that procures the data for a plan-position indicator (PPI) necessarily uses a very short pulse and therefore a very wide radio-frequency spectrum, no such width of spectrum should be necessary to relay the resulting maplike picture to a remote supervisory location. In fact, even a 100-to-1 reduction in bandwidth would be permissible without loss of essential information. In other words, the points of interest on the electronic map change their positions slowly. Hence, any reasonable equivalent of a very slow television scan should suffice. A variety of electronic mechanisms could be devised for such use. During the past year, the Wright-Field group has described a device employing a traveling gate that slides slowly outward along a radial line, the recurrence period of the slow radial sweep being not less than the time required for the radar beam to sweep through a beam width. As it travels, the gate selects informatiom from as many as 100 adjacent and partially overlapping radar sweeps, thus preserving the essential data while discarding much of the redundancy. At the receiving point, the data are reassembled in the obvious way by intensity modulation of a slow radial sweep, synchronized with the selecting gate.

A different relay system employs an equivalent, though less obvious, device. Information, displayed on successive high-speed radial sweeps over the original PPI, is also displayed (and integrated) as intensity modulation on a single trace that appears on an auxiliary cathode-ray tube. Since this trace may be swept 1,000 times per second (for example), the multitude of coincident lines convey no visible information. However, if the trace be swept optically at slow speed (say 30 scans per second), the derived photocell voltage pattern will alter slightly on successive scans. This change in pattern results from the slow change of the radar-beam azimuth (at, for example, 10 rpm). Optimum persistence of cathode-ray-tube phosphor depends, of course, on the PPI rotation rate. For convenience of mechanical scanning, the single trace is displayed by a rotating-lens method as a circle on the auxiliary tube. At the receiving point, the deflection yoke of a cathode-ray tube rotates at 10 rpm, while radial deflection occurs at 30 rps. Modulation derived from the phototube at the radar site controls the intensity of the radially deflected beam at the distant monitor site, thus reconstructing a reasonable facsimile of the original PPI picture. The original video bandwidth was at least 250 kc. The modified video bandwidth is about 2.3 kc wide, corresponding to 27,000 space elements for each rotation of the radar antenna and the consequent transmission of 4,500 bits per second.

The United States Naval Research Laboratory described a device called an organ-pipe radar scanner. For rapid scanning purposes, it is frequently desirable that a radar beam shall sweep or oscillate at frequencies far beyond the convenient range of vibration of a relatively massive object, such as a radar reflector. Hence, it is customary to sweep the radiation source across a focal surface of the paraboloidal reflector, the reflector remaining motionless (or moving slowly for other purposes). Using waveguide techniques, the physical motion of the radiation source may in turn be replaced by an effective motion, as the energy emerges successively from 36 different apertures linearly arrayed across the focal surface. These output apertures are fed by 36 waveguides, all of equal length. The input apertures are arranged radially in a complete circle, facing inward so that they receive energy successively from a steadily rotating electromagnetic horn. To minimize amplitude fluctuations, the output aperture of the horn spans three adjacent distribution waveguides. To accomplish all of this mechanically with 36 very short (and equal) lengths of waveguide necessarily implies a very neat physical arrangement of the plumbing.

Artificial-horizon devices on the pilot's instrument panel have normally featured a small self-contained gyro. The trend is toward a remote gyro of larger size and greater accuracy integrated with basic navigational aids. The instrument board retains its customary external appearance, but the horizon-bar is positioned by servomotors. In order that fighters shall be operable within two minutes after an alert, the initial erection of the gyro is assisted and speeded by a special motor operated by a gravity-controlled switch that senses gross departures from the desired vertical axis.

(604) W. Otto, "Radar signal sampler compresses bandwidth," *Electronics*, vol. 25, pp. 132–135; April, 1952. IRE Abstract 1921.
(605) J. L. McLucas, "Narrow-band link relays radar data," *Electronics*, vol. 25, pp. 142–146; September, 1952.
(606) K. S. Kelleher and H. H. Hibbs, "Organ-pipe radar scanner," *Electronics*, vol. 25, pp. 126–127; May, 1952. IRE Abstract 1920.
(607) P. Klass, "New AF gyro gets avionics assist," *Aviation Wk.*, vol. 57, pp. 52–57; July 14, 1952.

Omnibearing-Distance Program (OBD)

By international agreement several years ago, standards were established covering the design of ground facilities that are to provide azimuth and distance information suitable for guiding aircraft on overland flights.

With ground stations standardized and in an advanced stage of installation, attention has shifted largely toward progressive refinement of the airborne instrumentation. It should be noted that the pilot is by no means limited to courses defined by straight lines between ground stations. Having continuous distance and bearing information referred to one or more known points on the ground, he may plot, with ruler and pencil, any suitable course on a map and may correct his heading and air speed at suitable intervals. From the start of the program, however, various automatic devices were designed and tested, all of them intended to minimize human participation in this routine navigational procedure, and thus to minimize errors and misinterpretations of data. Early versions were called offset-course computers and were later referred to as course-line computers. The pilot could be given a left-right indication with respect to an arbitrary course set up on the electronic computing machine, with progress indicated by conventional map-plotting techniques or by an ink line drawn automatically on co-ordinate paper.

Attention was directed toward the pictorial computer, which includes a 35-mm film-strip projector, essentially similar to a slide projector installed behind a 10-inch translucent screen. One hundred feet of film accommodates as many as 700 navigation charts, each centered at an OBD ground-station. Important areas may be represented by several different charts drawn to different map-scales. After the pilot selects an appropriate chart and adjusts the illumination level, the electronic apparatus takes over. Coded holes punched in the film tune the receiving set to the correct OBD station and match the scale of the computing mechanism to the scale of the chart. Two servomechanisms position a miniature airplane correctly on the projected image of the map. A third servo orients the miniature plane and an attached arrow in accordance with the magnetic heading of the actual plane. Position should be indicated correctly to 0.4 mile in distance and approximately ½ degree in azimuth. The maximum range is 115 miles, and the pilot changes charts at 20- to 30-minute intervals on the average. With a compact, simple, and up-to-date presentation of his situation constantly in view, the pilot may choose to follow the course by manual control, or may apply appropriate instructions and corrections to an automatic pilot.

(608) H. C. Hurley, S. R. Anderson, and H. F. Keary, "The Civil Aeronautics Administration VHF omnirange," Proc. I.R.E., vol. 39, pp. 1506–1520; December, 1951. IRE Abstract 1000.
(609) S. J. Davey, "The pictorial computer for air navigation," *Military Engineer*, vol. XLIV, pp. 274–276; July–August, 1952.

Decca Program

Decca is a well-known, intermediate-distance, hyperbolic navigation system, based on continuous recording of phase changes derivable from the programmed transmissions of four related ground stations. Such an array of stations, comprising a master and three slaves, is called a "chain." A third Decca chain was recently activated in England, thus completing effective coverage of the British Isles and adjacent waters. In addition, the network now includes one Danish and one German chain. One French chain is under construction, while an Italian chain and one additional French chain reached the planning stage. About 1,100 British ships and 400 other ships have been equipped with Decca navigation instruments. Airborne Decca instrumentation now includes a pen that draws a line on moving co-ordinate paper to record the movements of the vehicle.

Overseas Navigation Program

The Loran system (hyperbolic co-ordinates, defined by differences in arrival-time of pulses from related pairs of stations) continues to be the chief source of overseas guidance for ships and planes. Here also there is a trend toward further mechanization of routine navigational procedures. The Sperry adapter, when connected to standard Loran receivers, provides a servomechanism for aligning the leading edges of received pulses. In comparison with manual alignment, accuracy and speed are improved.

Interest in the very-low-frequency range continues. Reference is made to a comprehensive report on long-range navigation instrumentation and to reports on radio-propagation studies intended to provide a factual basis for the design of any long-range navigation system.

Medium-distance navigation might some day exploit the new brute-force method of sending vhf signals reliably far beyond the optical horizon. This is wasteful of power, but perhaps not necessarily more so than vhf transmitters and antennas. Usable range, however, appears to be limited to the "single-hop" zone.

(610) B. Alexander, "Long-range-navigation instrumentation," *Elec. Commun.*, vol. 29, pp. 9–11; March, 1952. IRE Abstract 1925.

(611) A. T. Waterman, Jr., "Ray Theory Applied to a Spherical Ionosphere," and "Ionospheric Absorption of Obliquely Incident Radio Waves," Technical Reports No. 152 and 153, ONR Contract N5ori-07628 (to be published).
(612) J. A. Pierce, "Sky-Wave Field Intensity (I.) Low and Very Low Radio Frequencies," Technical Report No. 158, ONR Contract N5ori-07628 (to be published).
(613) "New Kind of VHF Propagation," *Wireless World*, vol. LVIII, pp. 273–274; July, 1952.

Countermeasures

Public attention was recently drawn to the Federal Communications Commission's control of electromagnetic radiation (CONELRAD) plan for stopping all normal broadcast transmission in the event of an air-raid alert. Defense broadcasts will continue after all participating stations have switched to 640 or 1,240 kc, thereafter juggling all schedules and power outputs every few seconds, to confuse (by planned disorder) all enemy planes attempting to home on broadcast transmissions.

Vehicular Communications

There was an increase of about 15 per cent in the number of mobile units used in the land transportation, public safety, industrial, and common-carrier fields. Common-carrier mobile telephone service was extended to 160 cities serving over 12,000 mobile stations on 252 channels in the 30–50-mc and 152–162-mc bands. By the end of the year, a total of 19 "crack" passenger trains, mainly in the eastern part of the United States, were equipped for mobile telephone service.

Field tests and measurements were initiated to compare 450, 900, and 3,700 mc with 150 mc for vehicular communications. These tests indicated a broad optimum of performance around 500 mc and that 450- and 900-mc transmission is more favorable than 150 mc if full use can be made of antenna gain. Vehicular communications above 1,000 mc were not very satisfactory.

(614) W. R. Young, Jr., "Comparison of Mobile Radio Transmission at 150, 450, 900, and 3700 mc," presented I.R.E. Conference on Vehicular Communications, Washington, D. C.; December 3–5, 1952.

Equipments providing 20-kc channel spacing in the 152–162-mc band were made available by several manufacturers and provided satisfactory service.

(615) H. E. Strauss, "Channel-Space Consideration in 152–174 mc band," presented I.R.E. Conference on Vehicular Communications, Washington, D. C., December 3–5, 1952.
(616) N. H. Sheperd, "Report on Channel-Splitting Demonstration Conducted in Syracuse," presented I.R.E. Conference on Vehicular Communications, Washington, D. C.; December 3–5, 1952.
(617) D. E. Noble, "Commercial Experience with 160-mc, 20-kc equipment," presented I.R.E. Conference on Vehicular Communications, Washington, D. C.; December 3–5, 1952.
(618) C. F. Hobbs, "Techniques for close channel spacing at vhf and higher frequencies," Proc. I.R.E., vol. 40, pp. 329–333; March, 1952.

Increasing demand for additional channels resulted in several existing services moving into the 460–470-mc band. Some receiving equipment for this band employed automatic frequency control of the receiver oscillator. Operations indicated less noise than at 150 mc and that the line-of-sight range was about the same in urban areas.

Feedback-Control Systems

Professional Growth

Each year of the past decade has seen increased professional interest in the field of feedback-control systems and an acceleration in the rate of appearance of significant technical contributions.

A new I.R.E. technical committee in this field was established in 1951 and is now preparing working standards.

Conferences

A number of important technical conferences of nation-wide scope were held. On December 6–7, 1951 a conference sponsored by the A.I.E.E. Committee on Feedback Control Systems was held at Atlantic City, N. J. The opening address discussed systems engineering as a new field that utilizes knowledge from many branches of engineering and science. The importance of training engineers to develop this systems approach was stressed.

(619) G. S. Brown, and D. P. Campbell, "Control systems," *Sci. Amer.* vol. 187, no. 3, pp. 51–64; September, 1952.

This conference featured papers on the application of statistical concepts, the use of digital and analog data (to control machine processes), and the use of frequency-response techniques in the design of nonlinear and sampled-data control systems. Practical component problems were discussed, and one session was devoted to control systems utilizing human operators. None of the papers was published.

Another conference was held in Dallas, Texas, on March 10–11, 1952, sponsored by the A.I.E.E. In addition, technical sessions on feedback-control systems were included in the general meetings of the I.R.E., A.I.E.E., and A.S.M.E.

Books

In addition to revised editions of various well-known books, the following new books appeared:

(620) G. H. Farrington, "Fundamentals of Automatic Control," John Wiley and Sons, Inc., New York, N. Y.; 1951.
(621) A. Tustin (editor), "Automatic and Manual Control," Academic Press, Inc., New York, N. Y.; 1952.
(622) Selected Government Research Reports, "Servomechanisms," H. M. Stationery Office, London, England, vol. 5.
(623) A. E. Fitzgerald and C. Kingsley, Jr., "Electrical machinery," McGraw-Hill Book Co., Inc., New York, N. Y.; 1952.

Farrington's book is primarily of interest to process-control engineers. The next two books are actually collections of technical papers. Fitzgerald and Kingsley's book is not specifically directed toward the field of feedback control systems, but contains valuable introductory material in two chapters and detailed treatments and analyses of machinery used in feedback-control systems.

Contribution to General Theory and Design Methods

New contributions to the design and analysis of linear feedback-control systems are represented by the following papers.

(624) J. R. Moore, "Combination open-cycle closed-cycle control systems," Proc. I.R.E., vol. 39, pp. 1421–1432; November, 1951.
(625) A. S. Baskenbom and R. Hood "Automatic Control Systems Satisfying Certain Criterions on Transient Behavior," NACA TN 2378, 45 pp.; June, 1951.
(626) D. W. St. Clair, W. F. Coombs, Jr., and W. D. Owens, "Frequency response analysis for industrial automatic control systems," *Trans. Amer. Soc. Mech. Engr.*, vol. 74, no. 7, pp. 1133–1155; October, 1952.
(627) A. A. Hauser, Jr., "A generalized method for analyzing servomechanisms," Proc. I.RE., vol. 40, pp. 197–202; February, 1952.
(628) O. J. M. Smith, "Stabilization Templates for Servomechanisms," A.I.E.E. Tech. Paper 52-239; September, 1952.
(629) D. W. Russell, C. H. Weaver, "Synthesis of Closed Loop Systems Using Curvilinear Squares to Predict Root Location," A.I.E.E. Tech. Paper 52-82; December, 1951.
(630) Yuohan Chu, "Synthesis of Feedback Control Systems Using Phase-Angle Loci," A.I.E.E. Tech. Paper 52-297; September, 1952.

Nonlinear Systems

Emphasis was placed on nonlinear feedback control systems and particularly on the frequency-response techniques for analyzing and synthesizing such systems.

(631) J. Loeb, "Hereditary phenomena in servomechanisms; A general criterion of stability," *Ann. Télécomm.*, vol. 6, pp. 346–352; December, 1951.
(632) National Bureau of Standards, "Translation of Papers on Stability of Non-Linear Feedback Control Systems," Nat. Bur. Stand. Report, No. 1691; 1952.
(633) E. C. Johnson, "Sinusoidal Analysis of Feedback Control Systems Containing Non-Linear Elements," A.I.E.E. Tech. Paper 52-154; April, 1952.
(634) C. Leondes, "A Study of Amplifier Saturation and Magnetic Saturation in a Servomechanism," A.I.E.E. Misc. Paper 52-198; May, 1952.

Loeb's paper is a mathematical treatment and generalization of stability criteria applicable to both linear and nonlinear systems. The National Bureau of Standards report contains translations of earlier contributions by Goldfarb and Lichtman of the U.S.S.R. and by Oppelt of Germany. This recent translation makes previous contributions readily available in English. Johnson's paper extends the earlier work of others where the frequency-response approach is applied to nonlinear control systems. Leonde's paper cites a specific example of this approach and includes numerical data.

Sampling Feedback-Control Systems

Another general problem in feedback-control system theory concerns the design and analysis of systems employing intermittent or sampled data. Significant advances are described in the following papers.

(635) W. K. Linvill, "Sampled Data Control Systems Studied through Comparison of Sampling with Amplitude Modulation," A.I.E.E. Tech. Paper 51-324.
(636) J. R. Ragazzini and L. A. Zadeh, "The Analysis of Sampled Data Systems," A.I.E.E. Tech. Paper 52-161; April, 1952.
(637) R. G. Brown and G. J. Murphy, "An Approximate Transfer Function for the Analysis and Design of Pulsed Servos," A.I.E.E. Tech. Paper 52-134; September, 1952.
(638) D. F. Lowden, "A general theory of sampling servo systems," *Proc. I.E.E.*, pt. IV, vol. 98, pp. 31–36; October, 1951.

Human Operator and Human Problems

A notable recent advance was the use of feedback-control system techniques of analysis in the study of human beings and human problems. In some of these studies, the subject of interest has been the action of a human being when he becomes part of a feedback-control system, as in aircraft tracking.

(639) L. S. Beals, Jr., "The human operator as a link in closed-loop control systems," *Elec. Eng.*, vol. 71, pp. 319–324; April, 1952.
(640) C. E. Warren, P. M. Fitts, and J. R. Clark, "An Electronic Apparatus for the Study of the Human Operator in a One-Dimensional Closed-Loop Continuous Pursuit Task," A.I.E.E. Tech. Paper 52-8; November, 1951.

Although these studies concern specific applications of human beings as servo elements, these and related investigations are expanding the knowledge of human physiology and the human nervous system. Feedback-control theory is being applied to studies of human beings as individuals and as groups (mass dynamics). One very significant application to an important medical problem is described in the following paper.

(641) R. G. Bickford, "The use of feedback systems in the control of anesthesia," *Elec. Eng.*, vol. 70, October, 1951.

Components

Among the papers describing new components and presenting advanced analyses of existing components are

(642) R. H. Frazier, "Analysis of the Drag-Cup A-C Tachometer," A.I.E.E. Tech. Paper 51-348.
(643) C. C. Johnson, "A homopolar tachometer for servomechanisms," Proc. I.R.E., vol. 40, pp. 158–160; February, 1952.
(644) Shih-Ying Lee and J. F. Blackburn, "Contributions to hydraulic controls," *Trans. Amer. Soc. Mech. Eng.*, vol. 74, no. 6, pp. 1005–1016; August, 1952.

All these papers present studies of control components that are of frequent interest to designers. The paper by Lee and Blackburn presents some data and concepts concerning hydraulic-control components and helps answer a number of questions that are frequently raised by control engineers.

Applications

The published literature described only a small proportion of the many new applications of feedback-control system theory.

(645) R. N. Bretoi, "Automatic flight control—analysis and synthesis of lateral control problem," *Trans. Amer. Soc. Mech. Eng.*, vol. 74, no. 3; April, 1952.
(646) M. Cambernac and F. Lajeunesse, "Stabilization of direct current servomechanisms," *Onde Elec.*, vol. 31, pp. 434–445; November, 1951.
(647) G. Klein, "Analysis and construction of a position fixing servomechanism," *Ann. Télécomm.*, vol. 6, pp. 313–324; November, 1951.
(648) W. M. Pease, "An automatic machine tool," *Sci. Amer.*, vol. 187, pp. 101–115; September, 1952.

The last reference described an application of electronic control and servomechanism techniques that represents a significant advance in the automatic control of machine processes. The prototype machine, which is now in operation to establish the feasibility of this method, is shown in the picture below. This machine, developed at the Servomechanisms Laboratory of the Massachusetts Institute of Technology and sponsored by the U. S. Air Force, utilizes digital data, stored on punched tapes, to prescribe machine operation.

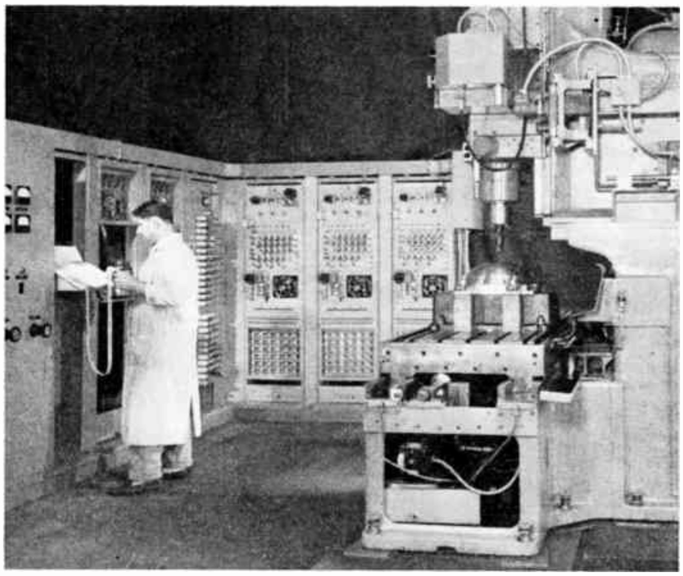

Fig. 10—Feedback control systems machine, developed at the Servomechanisms Laboratory of the Massachusetts Institute of Technology and sponsored by the U. S. Air Force, utilizes digital data, stored on punch tapes, to prescribe machine operation.

Terminology

Two professional society subcommittees have been cooperating to establish a consistent system of nomenclature and symbolism for use in this field. The results to date have been reported in the following papers

(649) Committee on Terminology of Industrial Instruments and Regulators, Amer. Soc. Mech. Eng. "Automatic control terminology," *Mech. Eng.*, vol. 74, pp. 486–489; June, 1952.
(650) Feedback Control Systems Committee, A.I.E.E. "Proposed symbols and terms for feedback control systems," *Elec. Eng.*, vol. 70, pp. 905–909; October, 1951.

A subcommittee of the I.R.E. Technical Committee on Feedback Control Systems is now active in the development of a system of terminology that will reflect adequately the current usage in the field of feedback controls and that is compatible with other fields of interest within the I.R.E.

Supporting Fields

Many of the developments stemmed from work done in other fields.

The role of electronic analog computers is particularly significant, especially in the study of nonlinear control systems where direct analytic techniques are unduly cumbersome.

Public Recognition

The *Scientific American* for September, 1952 emphasized to the lay public the importance of this professional field. That issue was devoted exclusively to articles on feedback-control systems by leading workers. Although written for a nontechnical reader, it is recommended to engineers and scientists as well.

Circuits

Linear Active Networks

The fundamental principles of feedback continued to be subjected to analysis as marginal obscurities were examined and occasionally clarified. General methods of analysis still received attention. Further progress on an approach that examines the paths of migration of the poles and zeroes of relevant functions as certain parameters are varied provides a penetrating insight into the performance of a feedback system.

Linear-Varying Parameter and Nonlinear Circuits

Developments were concerned mainly with specific problems and are covered under the appropriate fields of application, such as information theory and modulation systems and electronic computers. General theoretical work continued on operational and integral transform methods of solving linear time-varying systems.

(651) J. A. Aseltine and D. L. Trautman, "Transforms for linear time-varying network functions," presented I.R.E. National Convention New York, N. Y.; March, 1952. Summary, Proc. I.R.E., vol. 40, p. 226; February, 1952.
(652) L. A. Zadeh, "Operational analysis of variable-delay systems," Proc. I.R.E., vol. 40, pp. 564–568; May, 1952.

Transistor Circuitry

Semiconductor devices are in a stage of very rapid change and development, and it follows that transistor circuitry is itself in a rapidly changing state. This is true with particular regard to the upper limits of performance. Transistors have been viewed as low-power devices, but within the year Hall reported a transistor capable of 100-watts output. Upper-frequency limit has been raised by orders of magnitude with the announcement of a transistor television set and a junction tetrode that oscillates in the 100-mc region.

Transistor circuitry can be divided into two areas: the large-signal application in pulse devices, largely computers at the present, and the small-signal application in which linear amplification is of primary importance.

The small size and low power requirements of the transistors are primary advantages in computers requiring large numbers of elements. The types of circuit most generally used have been astable, monostable, or bistable negative resistances employing a singlepoint-contact transistor and, frequently, semiconductor diodes to improve the characteristics of the circuits. In this field the work of Felker is significant. In his circuits all amplification was derived from regenerative pulse amplifiers that, during each period of the clocking device, regenerate pulses and essentially supply new energy to replace that lost in the preceding period. Memory devices consist of these regenerative amplifiers and delay lines which restore and continually circulate the stored bits. This technique was employed earlier with vacuum tubes in the SEAC machine.

(653) J. H. Felker, "Regenerative amplifier for digital computer applications," Proc. I.R.E., vol. 40, pp. 1584–1596; November, 1952.

A number of papers describe and analyze basic negative-resistance switching circuits using point-contact transistors.

(654) B. G. Farley, "Dynamics of transistor negative-resistance circuits," Proc. I.R.E., vol. 40, pp. 1497–1508; November, 1952.
(655) A. W. Lo, "Transistor trigger circuits," Proc. I.R.E., vol. 40, pp. 1531–1541; November, 1952.
(656) A. E. Anderson, "Transistors in switching circuits," Proc. I.R.E., vol. 40, pp. 1541–1558; November, 1952.
(657) L. P. Hunter and H. Fleisher, "Graphical analysis of some transistor switching circuits," Proc. I.R.E., vol. 40, pp. 1559–1562; November, 1952.
(658) G. E. McDuffie, Jr., "Pulse duration and repetition rate of a transistor multivibrator," Proc. I.R.E., vol. 40, pp. 1487–1489; November, 1952.

The use of diode matrices to perform switching functions in a computer may involve a large number of diodes that are in parallel and the back current of even good point-contact diodes imposes a limitation on performance. New silicon-junction diodes are remarkably better in this respect, possessing reverse currents that may be as low as 10^{-10} ampere, which, coupled with their rectification ratios of 10^8, makes them ideally suited to the matrix application.

(659) G. L. Pearson and B. Sawyer, "Silicon *p-n* junction alloy diodes," Proc. I.R.E., vol. 40, pp. 1348–1351; November, 1952.

Transistor circuits that perform a number of special computing functions were reported.

(660) R. L. Trent, "A transistor reversible binary counter," Proc. I.R.E., vol. 40, pp. 1562–1572; November, 1952.
(661) R. L. Trent, "Two transistor binary counter," *Electronics*, vol. 25, pp. 100–101; July, 1952.
(662) J. R. Harris, "A transitor shift register and serial adder," Proc. I.R.E., vol. 40, pp. 1597–1602; November, 1952.

Point-contact transistors in combination with junction photocells were used to locate to 0.001 inch and record in binary form the motions of a movable element.

(663) H. G. Follingstad, J. N. Shive, and R. E. Yeager, "An optical position encoder and digit register," Proc. I.R.E., vol. 40, pp. 1573–1583; November, 1952.

Junction transistors are ordinarily considered superior to those of the point-contact variety in linear or small-signal application because of their greater uniformity of characteristics and better noise properties. The better high-frequency characteristics of the point-contact transistor has been largely overcome with the invention of the junction-transistor tetrode by Wallace. It was reported that junction tetrodes are very effective in video and IF amplifiers and in oscillators in the 10-mc range.

(664) R. L. Wallace, Jr., L. G. Schimpf, and E. Dickten, "A junction transistor tetrode for high-frequency use," Proc. I.R.E., vol. 40, pp. 1395–1400; November, 1952.

On the other hand, point-contact transistors made of suitable material with proper point spacing were applied satisfactorily in high-frequency linear amplifiers and sine-wave oscillators.

(665) B. N. Slade, "The control of frequency response and stability of point-contact transistors," Proc. I.R.E., vol. 40, pp. 1382–1384; November, 1952.
(666) G. M. Rose and B. N. Slade, "Transistors operate at 300 mc," *Electronics*, vol. 25, pp. 116–118; November, 1952.

The first applications of medium and high-power transistors were described and included a 100-watt amplifier reported by Hall.

(667) C. L. Rouault and G. N. Hall, "A high-voltage, medium-power rectifier," Proc. I.R.E., vol. 40, pp. 1519–1521; November, 1952.
(668) R. N. Hall, "Power rectifiers and transistors," Proc. I.R.E., vol. 40, pp. 1512–1518; November, 1952.
(669) R. F. Shea, "Transistor power amplifier," *Electronics*, vol. 25, pp. 106–108; September, 1952.

A number of papers described point-contact and junction transistors in amplifiers and oscillators that would ordinarily use vacuum tubes. The substitution of transistors for vacuum tubes can be made through the duality principle for point-contact transistors and directly for junction units.

(670) L. J. Giacoletto, "Junction transistor equivalent circuits and vacuum tube analogy," Proc. I.R.E., vol. 40, pp. 1490–1493; November, 1952.

However, distinctions between the two devices exist and the circuit analogy for junction transistor applications, as the case with duality for the point-contact type, must be suggestive rather than exact. Transit-time effects in junction transistors were found to be significant at frequencies just above the audio-frequency band for some connections, and this complication must be considered.

(671) R. L. Pritchard, "Frequency variations of current-amplification factor for junction transistors," Proc. I.R.E., vol. 40, pp. 1476–1481; November, 1952.
(672) D. E. Thomas, "Transistor amplifier-cutoff frequency," Proc. I.R.E., vol. 40, pp. 1481–1483; November, 1952.

Information Theory and Modulation Systems

The trend established in recent years continued. Most of the work has been based on information theory concepts rather than on conventional modulation-system approaches.

There has been considerable probing into the basic concepts of information theory, such as information itself, its definition, measurement, and relation to the thermodynamic concept of entropy. It was shown, for example, that even with the advent of micropower transistors the circuit power levels are still many orders of magnitude greater than basically required for accommodating reasonable information rates.

(673) E. Reich, "On the definition of information," *Jour. Math. Phys.*, vol. 30, pp. 156–161; October, 1951.
(674) D. A. Bell, "Physical entropy and information," *Jour. Appl. Phys.*, vol. 23, pp. 372–373; March, 1952.
(675) J. H. Felker, "A link between information and energy," Proc. I.R.E., vol. 40, pp. 728–729; June, 1952.

Shannon's theory of communication has continued to arouse a great deal of interest as evidenced by numerous articles discussing the basic concepts of information theory. The results of the theory have been reobtained by reasoning from somewhat different viewpoints. In some cases, particular aspects implicit in the theory have been examined in detail, such as the delay time needed to approach the ideal channel capacity in a practical case.

Other papers attempted to present a picture of the history and status of information theory, in some cases with a slant toward some particular branch of the communication field.

(676) P. M. Woodward and I. L. Davies, "Information theory and inverse probability in telecommunication," *Proc. I.E.E.* (London), vol. 99, pt. 3, pp. 37–44; March, 1952.
(677) K. Küpfmüller, "Channel capacity and transmission time," *Arch. Elek. Übertragung*, vol. 6, pp. 265–268; July, 1952.
(678) W. Weaver, G. E. Peterson, and H. Davis, "Information theory," *Jour. Speech and Hearing Disorders*, vol. 17, pp. 166–197; June, 1952.
(679) W. Meyer-Eppler, "Information theory," *Naturwiss*, vol. 39, no. 15, pp. 341–347; August, 1952.

Much interest was centered around practical applications of information theory. It was shown that there are inherent difficulties in approaching the theoretical maximum rate of information transmission. Drastic attempts to approach the ideal lead to excessive complication of apparatus.

(680) W. R. Bennett, "Practical significance of information theory in transmission problems," presented I.R.E. Western Convention, Long Beach, Calif.; August 26–29, 1952.

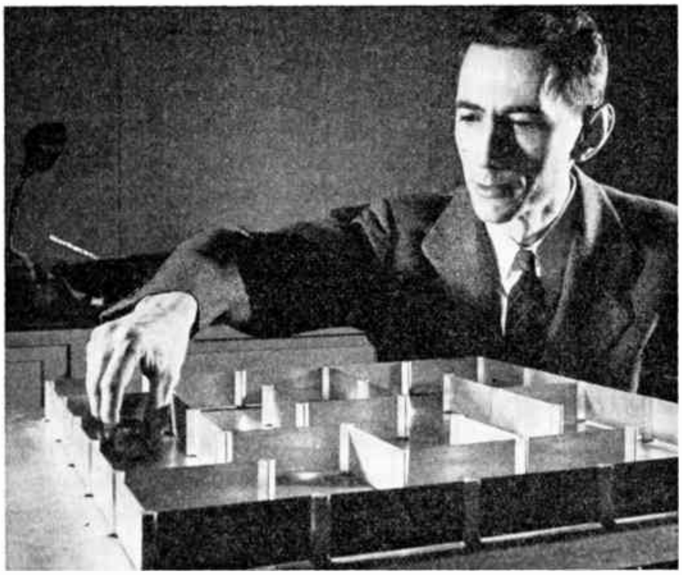

Fig. 11—Dr. Claude E. Shannon, Bell Telephone Laboratories mathematician, sets his electrical mouse down in a maze through which it will thread its way to a distant "piece of cheese" (an electrical terminal) in 12 to 15 seconds. The mouse uses for its "brain" some of the same kind of switching relays found in dial telephone systems. It was designed to provide fundamental knowledge which will help improve telephone service.

Coding is one of the processes essential to most practical applications of information theory. A number of significant contributions were made in this field. The so-called Shannon-Fano code uses short groups of symbols to designate highly probable events and proportionately long groups for improbable events, thereby minimizing the average number of symbols per event. With certain probability distributions this code may actually be optimum, but it is only near-optimum in general. A new procedure has now been devised by which the optimum code can be constructed for any probability distribution of the events to be coded.

Practical methods were described by which successive samples of a signal can be made more nearly independent so that they can be efficiently coded by using a Shannon-Fano code.

(681) B. M. Oliver, "Efficient coding," *Bell Sys. Tech. Jour.*, vol. 31, pp. 724–750; July, 1952.
(682) P. Elias, "Predictive coding," presented I.R.E. National Convention, New York, N. Y.; March 3–6, 1952.
(683) D. A. Huffman, "A method for the construction of minimum redundancy codes," Proc. I.R.E., vol. 40, pp. 1098–1101; September, 1952.

With a view towards determining how closely the ideal channel capacity can be approached, a large number of different codes have been examined, for both discrete and continuous channels. Surprisingly, all the good codes fall short of the ideal by approximately equal amounts; a signal-to-noise ratio of the order of 8 db higher than ideal is required to attain a given transmission rate. Highly complicated codes are presumed to be necessary for signaling at rates near the actual channel capacity.

(684) E. N. Gilbert, "A comparison of signaling alphabets," *Bell Sys. Tech. Jour.*, vol. 31, pp. 504–522; May, 1952.

The problem of optimum separation of signal and noise has continued to receive a great deal of attention from the information-theory viewpoint. A number of papers on this subject (as well as other subjects discussed below) were presented at the Symposium on Applications of Communication Theory, held in London, September 22–26, 1952. The proceedings of this symposium including the papers and a portion of the discussion will be issued in book form by the Butterworth press.

It was shown formally how existing means for optimum separation of a signal from white noise can be applied to other statistical types of noise, and furthermore, how a receiver can recover the most information from incoming symbols by utilizing their *a posteriori* probability distribution.

Various approaches to the problem of optimum filtering of noisy signals appeared in the literature. A few were based on the Wiener-Lee criterion, and some were based on different viewpoints, for example, on the principle of inverse probability, on the concept of existence probability, on a rather general criterion of a non-probabilistic type, or on a choice of various statistical criteria.

(685) R. M. Fano, "Communication in the presence of additive Gaussian noise," presented Symposium on Application of Communication Theory, London; September 22–26, 1952.
(686) P. M. Woodward, "Information theory and the design of radar receivers," Proc. I.R.E., vol. 39, pp. 1521–1524; December, 1951.
(687) I. L. Davies, "On Determining the presence of signals in noise," *Proc. I.E.E.* (London), vol. 99, pt. 3, pp. 45–51; March, 1952.
(688) L. A. Zadeh and J. R. Ragazzini, "Optimum filters for the detection of signals in noise," Proc. I.R.E., vol. 40, pp. 1223–1231; October, 1952.
(689) D. Middleton, "Statistical methods for the detection of pulsed radar in noise," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.

A number of papers dealt with the technique of radar detection whereby successive sweeps are stored and superposed. In one instance, superposition of 22 sweeps showed an impressive rise in signal-to-noise ratio. Detection methods based on correlation techniques, likewise introduced in recent years, were discussed to a lesser extent.

(690) P. L. Waters, "Video signal integration using a storage tube," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.

(691) J. Icole and J. Oudin, "Time analysis and filtering," *Ann. Telecomm.*, vol. 7, pp. 99–108; February, 1952.

The construction of apparatus for measuring autocorrelation and cross correlation continued to receive attention.

A new electronic analog correlator was constructed at Massachusetts Institute of Technology with the object of evaluating and displaying simultaneously several (five) pointed of the correlation curve. Such a correlator enables one to watch the correlation curve change, while the statistics of the signal vary, e.g., in music. The operation of this general-purpose correlator is largely based on pulse techniques which allows a great deal of flexibility.

Correlators for more specific applications were also built. Use was made of magnetic tape or magnetic drums to obtain the required delay. In some cases, correlation techniques were applied to problems outside the field of communications.

(692) M. J. Levin and J. P. Reintjes, "A five-channel electronic analog correlator," presented National Eelectronic Conference, Chicago, Ill.; September 29–October 1, 1952.
(693) F. E. Brooks, Jr. and H. W. Smith, "A computer for correlation functions," *Rev. Sci. Instr.*, vol. 23, pp. 121–126; March, 1952.
(694) R. A. Johnson and D. Middleton, "Measurements of auto- and cross-correlation functions of modulated carriers and noise following a non-linear device," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.
(695) V. J. Guethlein, "Correlator for low frequencies," presented I.R.E. National Convention, New York, N. Y.; March 3–6, 1952.

Measurements of correlation were made also in the application of information theory to television. Autocorrelation curves and contours of constant autocorrelation were determined for typical pictures by simple optical means. Likewise by optical means, probability distributions of the amplitudes, as well as of the amplitude changes (between adjacent picture elements) were obtained. Such statistical data furnishes an estimate of the minimum redundancy removable by simple, linear means and, hence, an estimate of the theoretically possible bandwidth reduction. The power-density spectrum of the video signal was analyzed using autocorrelation theory, and the effect of statical parameters of motion and complexity on the spectrum was studied.

Experimental work was described in which much of the linear correlation was actually removed from television signals. This was done by predicting future signal values on the basis of past values and then transmitting only the difference between the actual and the predicted signal. Since the prediction is based on a linear, weighted summation of past values, it is referred to as linear prediction. The success of such a prediction criterion is closely allied with the autocorrelation of the signal and is readily appraised by measuring the relative mean power or the amplitude distribution of the "reduced" signal.

Work was reported also on the information-theory aspects of describing simple line drawings by methods more efficient than the conventional television scan. Also, an elaborate analysis was made of the possible savings obtainable from the technique of variable-rate scanning, by which the picture detail is more uniformly distributed over the video signal. This analysis involves a quantitative measure of picture detail, which was experimentally determined for a number of typical pictures.

(696) E. R. Kretzmer, "Statistics of the television signals," *Bell Sys. Tech. Jour.*, vol. 31, pp. 751–763; July, 1952.
(697) M. B. Ritterman, "An application of auto-correlation theory to the video signal of television," *Sylv. Tech.*, vol. 5, pp. 70–75; July, 1952.
(698) C. W. Harrison, "Experiments with linear prediction in television," *Bell Sys. Tech. Jour.*, vol. 31, pp. 764–783; July, 1952.
(699) J. Loeb, "Communication theory of transmission of simple drawings," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.
(700) E. C. Cherry and G. G. Gouriet, "Some possibilities for the compression of television signals by recoding," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.

A great deal of work was reported in the field of speech, some of it barely falling within the realm of information theory but nevertheless of great interest to workers in the field.

More was learned about the identification of subjective sounds from the characteristics of the acoustic wave; identification of vowel sounds was found to be possible from the position of peaks in the spectral distribution.

A machine was constructed which recognizes, selects, and codes spoken words. The codes are then interpreted by appropriate circuits, so that no human perception is involved in the actual recognition.

The reverse process has also been instrumented in admirable fashion. Experimental apparatus has been constructed in England which makes possible the synthesis of speech from slowly varying parameters. These parameters specify the resonant frequencies of the vocal cavity system and the excitation applied to it. The synthesized speech has good intelligibility and the information content of the controlling signals is estimated to be less than one fiftieth of that of normal telephone speech signals. The input control signal consists of 150 samples per second. A second speech synthesizer was built for the United States Air Force. This equipment accepts an input telegraphic code from which it constructs speech by selecting the appropriate basic speech sounds and patching them together.

(701) G. E. Peterson, "Information bearing elements of speech," presented Symposium on Application of Communication Theory, London; September 22–26, 1952.
(702) K. H. Davis, R. Biddulph, and S. Balashek, "Automatic recognition of spoken words," presented Symposium on Application of Communication Theory, London; September 22–26, 1952.
(703) W. Lawrence, "The synthesis of speech from slowly varying parameters," presented Symposium on Application of Communication Theory, London; September 22–26, 1952.
(704) W. G. Tuller and H. H. Williams, "A speech synthesizer," presented Symposium on Application of Communication Theory, London; September 22–26, 1952.

A new theory of hearing was presented; it postulates a simple mechanism whereby vibrations traveling down the cochlear partition can create two distinct waves of neural stimulation. The theory makes it possible to explain some significant experimental data not hitherto understood.

Aimed at establishing a link between information theory, the structure of language, and, ultimately, the properties of the brain, a theory of language structure was developed. Some of the results are similar to those of Zipf, but appear to go a significant step further.

Another provocative theory which was presented during the past year is that of semantic information. In contrast to the existing statistical theory of information, this new theory decisively involves the contents of the symbols instead of merely their frequencies of occurrence. It was indicated that the statistical theory can be mapped on to the theory of semantic information, that the latter sheds new light on parts of the former, and that the semantic concept of information may ultimately lead to a better psychological concept of information than the present statistical concept.

(705) W. H. Huggins, "A theory of hearing," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.
(706) B. Mandelbrot, "An informational theory of the structure of language based upon the theory of statistical matching of message and coding," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.
(707) Y. Bar-Hillel and R. Carnap, "Semantic information," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.

Such basic topics as noise, power spectra, sampling, quantization, and companding also received their share of attention.

The spectral distribution of energy in noise and signal-modulated waves was analyzed for amplitude and angle modulation. A general analysis was made of the relations between input and output signal-to-noise power ratios in band-pass limiters. New techniques of noise analysis were described and some experimental observations on random noise were also reported.

The concept of an instantaneous power spectrum was discussed and defined mathematically. It is dependent not only on the present but also on the past history of the signal.

The sampling theorem is clear cut since it implies an ideal filter. An analysis was made of the less clear-cut situation of a nonideal low-pass filter, with the object of determining the effect of cut-off shaping and sampling frequency.

Quantization distortion, such as that experienced in pulse-code modulation, was again subjected to theoretical treatments. One of these analyses was rather general.

The practically important technique of speech companding was subjected to a thorough analysis. It was found that if compressed speech is to be transmitted without distortion over the same restricted band adequate for uncompressed speech the transmission system is subject to more severe attenuation and phase-shift requirements.

(708) D. Middleton, "On the distribution of energy in noise- and signal-modulated waves," *Quart. Appl. Math.*, vol. 9, pp. 337–354; January, 1952; vol. 10, pp. 35–56; April, 1952.
(709) W. B. Davenport, "Signal-to-noise ratios in band-pass limiters," Technical Report 234; Research Laboratory of Electronics, M.I.T., Cambridge, Mass.; May 29, 1952.
(710) R. C. Davis, "New techniques in the mathematical analysis of noise," presented I.R.E. Western Convention, Long Beach, Calif.; August 26–29, 1952.
(711) V. J. Francis, "Random noise. Rate of occurrence of peaks," *Wireless Eng.*, vol. 29, pp. 37–40; February, 1952.
(712) C. H. Page, "Instantaneous power spectra," *Jour. Appl. Phys.*, vol. 23, pp. 103–106; January, 1952.
(713) J. W. Haanstra, "Sampling and recovery of continuous information," presented I.R.E. Western Convention, Long Beach, Calif.; August 26–29, 1952.
(714) J. P. Schouten and H. W. F. van't Groenewout, "Analysis of distortion in pulse-code modulation systems," *Appl. Sci. Res.*, sec. B, vol. 2, no. 4, pp. 277–290; 1952.
(715) J. C. Lozier, "Instantaneous compandors on narrow-band speech channels," *Bell Sys. Tech. Jour.*, vol. 30, pp. 1214–1220; October, 1951.

During the period immediately following World War II the technical literature abounded with analyses aimed at evaluating the relative merits of the numerous modulation systems, particularly pulse systems. The advent of information theory has, of course, changed the complexion of this problem by making it possible to compare actual system performance to an absolute ideal performance. During the past year several authors compared the various systems from the viewpoint of information theory.

A new theoretical approach to linear multiplexing, making use of geometrical signal representation, was described in detail. Also on the subject of multiplex systems, comparisons were made, as in past years, between time and frequency sharing, and analyses were made of distortion and of cross talk in time-division multiplex systems.

(716) Z. Jelonek, "A comparison of transmission systems," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.
(717) S. Goldman, "Information theory of noise reduction in various modulation systems," presented Symposium on Applications of Communication Theory, London; September 22–26, 1952.
(718) L. A. Zadeh and K. S. Miller, "Fundamental aspects of linear multiplexing," Proc. I.R.E., vol. 40, pp. 1091–1097; September, 1952.
(719) L. J. Libois, "Use of pulse modulation for transmission in a group of telephony channels of carrier-current systems," *Onde Elec.*, vol. 32, pp. 190–196; April/May, 1952.

A number of new ideas in modulation and multiplexing were revealed during the past year. A new type of "one-unit" pulse code modulation, requiring only very simple terminal apparatus, has been developed. In this so-called system of delta modulation, changes in the signal are transmitted periodically, instead of the signal itself, by comparing the signal to a sampled quantized approximation of itself. If, at the instant of sampling, the signal value exceeds the quantized value, a pulse of fixed amplitude is sent; if not, no pulse is sent. The comparison is effected by a feedback circuit that is closed only at the sampling times. The sampling rate is made sufficiently high so that the staircase approximation of the signal reobtained at the receiver is adequate, e.g., 100 kc for speech. This makes efficient use of the bandwidth required and has the virtue of simplicity.

A class of modulation systems referred to as ambiguous-index systems was proposed, with the object of devising new systems which avoid certain defects of existing ones.

Nonsynchronous time division, a new system of multiplexing made possible by sampling randomly instead of sampling periodically, was built and tested. The samples derived from the signals of the various channels are coded into different characteristic pulse groups so that the receiver can identify each sample as belonging to a certain channel. Occasional coincidence of the randomly spaced pulse groups causes some noise, which increases with the number of channels; but on the other hand, the system has unusual flexibility. As more channels are used, no well-defined point of overload is ever reached, although the quality deteriorates.

(720) L. J. Libois, "A new method of code modulation: 'Δ-modulation'," *Onde Elec.*, vol. 32, pp. 26–31; January, 1952.
(721) J. F. Schouten, F. De Jager, and J. A. Greefkes, "Delta modulation, a new modulation system for telecommunication," *Philips Tech. Rev.*, vol. 13, pp. 237–245; March, 1952.
(722) C. W. Earp, "A recent development in communication technique," *Proc. I.E.E.* (London), vol. 99, pt. 3, pp. 181–186; July, 1952.
(723) J. R. Pierce and A. L. Hopper, "Nonsynchronous time division with holding and with random sampling," Proc. I.R.E., vol. 40, pp. 1079–1088; September, 1952.

The British Broadcasting Company, after a series of tests, has planned a frequency-modulation service for the United Kingdom. As opposed to amplitude modulation, frequency modulation was found to give approximately twice the range for the same quality of service.

Also in the field of frequency modulation, it was shown that a receiver can be made more nearly ideal (with regard to rejecting an interfering signal that is only slightly weaker than the wanted signal) by using feedback across the limiter. Furthermore, there appeared a detailed analysis of a commonly used but little understood component of frequency-modulation receivers, namely, the ratio detector.

(724) "The B.B.C. scheme for V.H.F. broadcasting," *BBC Quart.*, vol. 6, pp. 171–181; Autumn, 1951.
(725) R. M. Wilmotte, "Reduction of interference in F.M. receiver and feedback across the limiter," Proc. I.R.E., vol. 40, pp. 34–36; January, 1952.
(726) B. D. Loughlin, "The theory of amplitude-modulation rejection in the ratio detector," Proc. I.R.E., vol. 40, pp. 289–296; March, 1952.

Instrumentation

Basic Standards and Calibration Methods

A new basic unit of time (the sidereal year), supplementing and less variable than mean solar time, was adopted by the International Astronomical Union. Time reckoned in the new unit will be designated "ephemeris time." The application of atomic frequency and time standards as well as high-precision, high-frequency quartz crystal oscillators appeared most promising.

The closest approach to a basic standard was announced for accurate voltages of the order of microvolts and millivolts at all frequencies up to about 1,000 mc. This standard was a relatively inexpensive reliable constant-voltage source with its output independent of frequency. It seems to satisfy a crying need of many years standing.

(727) H. H. Skilling, "Electric Transmission Lines," McGraw-Hill Book Co., Inc., New York, N. Y., 1st ed.; 1951.
(728) F. M. Greene, "Calibration of commercial radio field-strength meters at the National Bureau of Standards," *N.B.S. Cir. 517*; December, 1951.
(729) M. C. Selby, "Accurate rf microvolts," (paper delivered at the 1952 IRE National Convention), Proc. I.R.E., vol. 40, p. 218; February, 1952.
(730) F. L. Hermach, "Thermal converters as ac-dc transfer standards for current and voltage measurements at audio frequencies," *Jour. Res. Nat. Bur. Stand*, vol. 48, pp. 121–128; February, 1952.
(731) A. L. Cullen, "Absolute power measurement at microwave frequencies," *Proc. IEE* (London), vol. 99, pp. 100–111; April, 1952
(732) A. L. Cullen, "A general method for the absolute measurement of microwave power," *Proc. IEE* (London), vol. 99, pp. 112–120; April, 1952.
(733) L. R. M. Vos de Wael, "Direct reading frequency measuring equipment for the range of 30 c/s to 30 Mc/s," Proc. I.R.E., vol. 40, pp. 807–813; July, 1952.
(734) F. K. Harris, "Electrical Measurements," John Wiley and Sons, Inc., New York, N. Y., 1st ed.; 1952.
(735) D. D. King, "Measurements at Centimeter Wavelength," D. Van Nostrand Co., Inc., New York, N. Y., 1st ed.; 1952.
(736) A. W. Warner, "High-frequency crystal units for primary frequency standards," Proc. I.R.E., vol. 40, pp. 1030–1033; September, 1952.
(737) V. H. Atree, "Precision voltage source," *Wireless Eng.*, vol. 29, pp. 226–230; September, 1952.
(738) V. J. Tyler, "A simple bolometer for dissipation measurements," *Marconi Rev.*, vol. 15, pp. 114–117; 3rd quart., 1952.
(739) H. T. Wilhelm, "Impedance bridges for the megacycle range," *Bell Sys. Tech. Jour.*, vol. 31, pp. 999–1012; September, 1952.
(740) C. C. Cook, "Calibration of commercial field-strength meters," *Tele-Tech*, vol. 11, pp. 44–46, 96, 99–101; October, 1952.
(741) H. W. Kline, "Industrial frequency standard," *Electronics*, vol. 25, pp. 130–131; November, 1952.

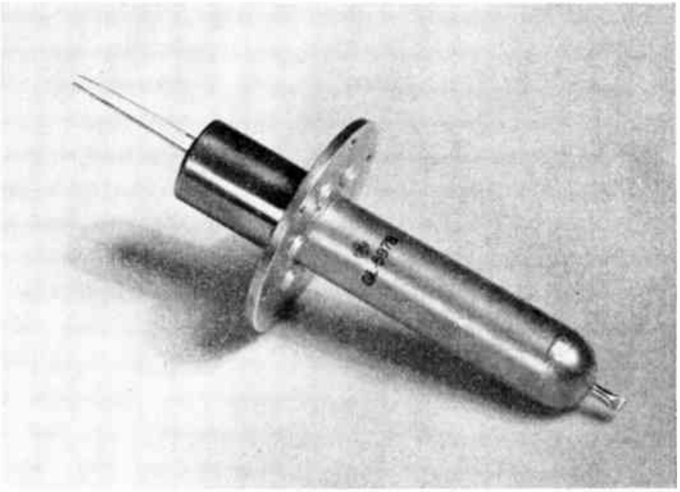

Fig. 12—"The Finger," more technically known as an ion chamber, is far smaller than other gamma-ray detectors of the same type and sensitivity which are used to detect deadly atomic rays in planes flying over A-bomb blast sites. This device was developed and built by the General Electric Company's Tube Department.

Audio-Frequency Measurements

Precision magnetic-tape recorders are being used extensively in audio-frequency measurements, particularly for acoustic noise problems. These recorders provide a permanent record of the signal, they can be used as an accessory for spectrum analysis of signals of short duration, and they aid in subjective comparisons of various types of signals. Binaural recording on magnetic tape appears to be particularly useful for this subjective comparison. One method of magnetic recording, called boundary-displacement recording, has been developed primarily for instrumentation purposes. It makes the visual display of the recorded magnetic signal possible.

(742) H. L. Daniels, "Boundary-displacement magnetic recording," *Electronics*, vol. 25, pp. 116–120; April, 1952.

Some new instruments for the measurement of power, voltage, and phase at audio frequencies were described.

(743) D. E. Garrett and F. G. Cole, "A general-purpose electronic wattmeter," Proc. I.R.E., vol. 40, pp. 165–171; February, 1952.
(744) L. A. Rosenthal and G. M. Badoyannis, "Mean square vacuum-tube voltmeter," *Electronics*, vol. 25, pp. 128–131; September, 1952.
(745) H. W. Curtis, "Measuring the mean power of varying-amplitude complex audio waves," Proc. I.R.E., vol. 40, pp. 775–779; July, 1952.
(746) G. N. Patchett, "A versatile phase-angle meter," *Electronic Eng.* (London), vol. 24, pp. 224–229; May, 1952.
(747) J. C. West, "A simple variable frequency phase measuring device," *Electronic Eng.* (London), vol. 24, pp. 402–403; September, 1952.

The work of the National Bureau of Standards in developing highly accurate methods for transferring ac current and voltage measurements to dc measurements was reported. An accuracy of 0.01 per cent in the frequency range from 25 to 20,000 cycles per second was indicated. In this development, several factors that limit the transfer accuracy of thermal converters were discovered.

(748) F. L. Hermach, "Thermal converters as ac-dc transfer standards for current and voltage measurements at audio frequencies," *Jour. Res. Nat. Bur. Stand.*, vol. 48, pp. 121–138; February, 1952.

A number of different methods are used for measuring the nonlinear distortion in audio systems. The results of such measurements, however, are not readily interpreted in terms of the distortion that can be noticed by the listener because the available psychological data are not adequate for this purpose. Two investigations recently completed supply some of this needed information. In one set of experiments a signal of two tones at an interval of a perfect fifth was compared before and after transmission through a nonlinear network. When the mean frequency of the interval was above 1 kc and the sound-pressure level was above 50 db (with respect to 0.0002 microbar), distortions greater than about one-half per cent were noticeable. For lower frequencies and lower levels, the minimum detectable distortion was, in general, appreciably higher. Further experiments also showed that nonlinear distortion made small errors of intonation more noticeable.

In the second set of experiments, the just-perceptible modulation of one tone by another was measured, an extension of work done by others. The results showed that the sensitivity to modulation increased with increasing level, and the sensitivity to amplitude modulation was a minimum for modulating frequencies in the range from 20 to 100 cps. The just-perceptible amplitude modulation in this range was about 3 per cent at an 80-db sound-pressure level. When the frequency of the modulated component was above 1 kc, the maximum sensitivity was observed for modulating frequencies between about one-fifth and two-thirds of the frequency of the modulated component. For this range of frequencies, at an 80-db sound-pressure level, an amplitude modulation of less than one-fifth of one per cent could be detected.

(749) R. Feldtkeller, "Die Hörbarkeit nichtlinearer Verzerrungen bei der Übertragung musikalischer Zweiklänge," *Akust. Beihefte*, no. 3, pp. 117–124; 1952.
(750) E. Zwicker, "Die Grenzen der Hörbarkeit der Amplitudenmodulation und der Frequenz modulation eines Tones," *Akus. Beihefte*, no. 3, pp. 125–133; 1952.

The tone-burst technique is being more generally used for audio-frequency measurements. A tone-burst is a sinusoidal oscillation that is turned on for a number of cycles and then turned on. In one measurement technique, the energy that remains in the system after the applied oscillation is turned off is used as a measure of the transient distortion. In another application the measurement is made during the time the oscillation is on in order to avoid the effects of reflected signals. A tone-burst technique was also used as one method of evaluating the acoustic properties of rooms.

(751) M. C. Kidd, "Tone-burst generator checks a-f transients," *Electronics*, vol. 25, pp. 132–135; July, 1952.
(752) R. L. Terry and R. B. Watson, "Pulse techniques for the reciprocity calibration of microphones," *Jour. Acous. Soc. Amer.*, vol. 23, pp. 684–685; November, 1951.
(753) T. Somerville and C. L. S. Gilford, "BBC pulsed-glide displays," *FM-TV*, vol. 12, pp. 22f, 43; June, 1952; and pp. 28, 30; July, 1952.

High-Frequency Measurements

Three books that devoted at least a large part of their space to high-frequency measurements were published.

(754) F. E. Terman and J. M. Pettit, "Electronic Measurements," McGraw-Hill Book Co., Inc., New York, N. Y., 2nd ed.; 1952.
(755) D. D. King, "Measurements at Centimeter Wavelength," D. Van Nostrand Co., Inc., New York, N. Y.; 1952.
(756) F. Benz, "Messtechnic für Funkingenieure," Springer-Verlag, Vienna, Austria; 1952.

The first book is a revision of Terman's 1935 "Measurements in Radio Engineering." It encompasses a broad field, but for all its breadth covers the specialized field of high-frequency measurements very well. The second book limits itself primarily to transmission-line devices and presents the methods and techniques of these measurements. The third book, covering all frequencies, is divided into five parts, the last of which deals with high-frequency measurements. Using the centimeter-kilogram-second system of units, it may be confusing to those accustomed to mks or cgs systems.

A review article on measuring technique and another on instruments were published.

(757) A. F. Harvey, "Instruments for use in the microwave band," *Proc. IEE* (London), pt. II, vol. 98, pp. 781–789; December, 1951. Discussion, pp. 789–782. *Ibid.*, summary, pt. III, vol. 99, p. 32; January, 1952.
(758) W. Druey, "High-frequency measurement technique, *Bull. schweiz. electrotech. ver.*, vol. 42, pp. 989–1000; December 15, 1951 (In German). Discussion, pp. 1000–1003 (In German and French).

Impedance Measurements

Progress in impedance measurement can be divided into four categories:

1. Sweep-frequency methods using reflected energy. 2. Other wide-band methods. 3. RF bridges. 4. New techniques required for the measurement of open waveguides and strip transmission lines or "printed microwave circuits."

Most sweep-frequency methods measure only the magnitude of the reflected wave or of the reflection coefficient, indicating the variation in the magnitude of the terminating impedance with frequency. This is a rapid measurement and allows quick modification and re-observation of results. It usually does not measure the phase of the reflection coefficient. Work was done recently on the development of instruments that measure both magnitude and phase of the reflection coefficient as a function of frequency. These results were displayed on an oscilloscope. At least one of these used an overlay of the Smith chart on the oscilloscope so that the plot was read directly. Long-distance microwave relays presented a rather special need for quick measurement techniques because of the extensive facilities that must be taken out of service during measurement. Here, sweep methods are invaluable.

(759) K. S. Packard, "Automatic Smith-chart Impedance Plotter," paper number 62 presented before the I.R.E. Convention in New York; March, 1952. Summary, PROC. I.R.E., vol. 40, p. 218; February, 1952.
(760) E. A. N. Whitehead, "A microwave swept-frequency impedance meter," *Elliot Jour.*, vol. 1, pp. 57–58; September, 1951.
(761) W. J. Albersheim, "Measuring techniques for broadband, long distance radio relay systems," PROC. I.R.E., vol. 40, pp. 548–551; May, 1952.

Several other methods, not sweep frequencies, were reported as being adaptable to use over wide frequency ranges. One used the insertion loss and phase shift of a signal when an unknown is inserted to determine its impedance. This requires the measurement of small voltage and phase shifts, but is independent of the proximity of the unknown to the measuring equipment. The heterodyne method, permitting the standards to be at an intermediate frequency when making measurements at a radio frequency has been extended. Attenuators in the intermediate frequency range have been used for some time in the measurement of insertion loss. Measurements of Q, delay, phase, and impedance are more recent developments. This technique employs a single set of standards over a very wide range of frequencies. It does, however, require the use of a high-quality mixer to preserve the accuracy of these standards. Another method of impedance measurement uses a mixer as in the heterodyne method but the same signal source for both signal and local oscillator. The magnitude of one is derived from the voltage across the unknown, and the magnitude of the other is derived from the current through the unknown. The IF output is a dc voltage whose amplitude indicates the magnitude of the resistance of the unknown. A 90-degree phase shift in either signal or local oscillator gives a dc output proportional to the reactive component of the unknown. For conductance measurements, a variation of the substitution method was reported. In this method, the resistive load need not be matched at the frequency used. The signal is rectified and the substitution element used in the dc load of the rectifier.

(762) D. A. Alsberg, "A precise sweep-frequency method of vector impedance measurement," PROC. I.R.E., vol. 39, pp. 1393–1400; November, 1951.
(763) D. A. Alsberg, "Principles and applications of converters for high-frequency measurements," PROC. I.R.E., vol. 40, pp. 1195–1203; October, 1952.
(764) H. LeCaine, "The Q of a microwave cavity by comparison with a calibrated high-frequency circuit," PROC. I.R.E., vol. 40, pp. 155–157; February, 1952.
(765) B. Salzberg and J. W. Marini, "Measurement of impedance and admittance," paper 58, presented IRE Convention, New York, N. Y.; March, 1952. Summary, PROC. I.R.E., vol. 40, p. 218; February, 1952.
(766) W. W. Freeman, Jr., "A high sensitivity method for measuring conductance and capacitance at radio frequencies," paper 30, presented IRE Convention, New York, N. Y.; March, 1952. Summary, PROC. I.R.E., vol. 40, p. 215; February, 1952.

The use of the bridged-T bridge for impedance measurements at 50–100 mc was reported. For lower frequencies, bridges for coaxial-system measurements continue to be popular.

(767) R. F. Proctor, "A bridged-T impedance bridge for the V.H.F. band," *Proc. IEE* (London), vol. 99, pt. III, p. 105; March, 1952.
(768) H. T. Wilhelm, "Impedance bridges for the megacycle range," *Bell Sys. Tech. Jour.*, vol. 31, pp. 999–1012; September, 1952.

An expanding interest in open waveguides and strip transmission lines (microwave printed circuits) has necessitated the development of different measuring techniques. A method of determining standing-wave ratio on an open waveguide was reported in which the change in input impedance due to movement of a dielectric disk along the open guide was used. Knowing the change in impedance, the standing-wave ratio is found to be the square root of the ratio of maximum and minimum impedance change.

(769) S. W. Attwood and G. Goubau, "Method for open waveguide. standing-wave measurements," paper 51, presented IRE Convention, New York, N. Y.; March, 1952. Summary, PROC. I.R.E., vol. 40, p. 217; February, 1952.

Frequency and Time

Extremely selective absorption of energy in the microwave region by certain atoms and molecules is being used for frequency and time standards. A survey of the methods and known possibilities of these properties was presented and a theoretical short-time accuracy of 1 part in 10^{12} was ascribed to the resonances in molecular and atomic beams and the absorption of microwaves by ammonia. Accuracies for longer periods are expected to average out to even better values. These then, represent our most accurate standards for time and frequency.

A more versatile, if less accurate, frequency calibrator is the crystal type. It is claimed for a recent instrument that a complete range of frequencies can be obtained from the calibrator without loss of the accuracy normally associated with the crystal.

(770) C. H. Townes, "'Atomic' clocks and frequency stabilization on microwave spectral lines," *Jour. Appl. Phys.*, vol. 22, pp. 1365–1372; November, 1951.
(771) D. Cooke, "A self-interpolating crystal calibrator for setting up and measuring radio frequencies," *Elec. Eng.* (London), vol. 24, pp. 23–25; January, 1952.

Signal Sources

Recent developments in signal sources indicate a continuation of the trend away from point-by-point measurements to the faster sweep-frequency methods. In addition, there is a trend toward the complete impedance-measuring device that includes the signal source associated with the impedance-plotting mechanism. Sweeping devices to measure other quantities are also so specialized as to require a specific signal source which is often built into the equipment.

(772) J. A. Cornell and J. F. Sterner, "Sweep-frequency generator for the U.H.F. television band," *Tele-Tech*, vol. 11, pp. 38–40, 86, 88; February, 1952.
(773) F. P. Blecher, "A wide-band sweep generator," paper 33, presented IRE Convention, New York, N. Y.; March, 1952. Summary, Proc. I.R.E., vol. 40, p. 215; February, 1952.
(774) W. F. Marshall, "Microwave generator with crystal control," *Electronics*, vol. 24, pp. 92–95; November, 1951.

Power, Detection, and Attenuation

A large amount of attention has been concentrated on the properties of microwave gyrators, circuit elements that do not obey the reciprocity theorem. The microwave gyrator has been realized by making use of the Faraday rotation in pieces of ferrite in a waveguide. It is expected that these lossless broad-band devices may become very useful tools in the field of measurements. Their properties make them suited for electrically controlled variable attenuators, modulators, microwave switches, and one-way transmission systems. A detector based on the wideband absorption of microwaves by thin layers of certain metals used in a Golay pneumatic heat detector was reported. With a detector of 12-mm diameter, signals equivalent to noise measure in the order of 10^{-8} watt. A study was made of accuracy of bolometer power-measuring devices. This study showed that at frequencies where the bolometer wire became an appreciable portion of a wavelength better accuracy is obtained with convectively cooled air-mounted wires than with vacuum-mounted units. A means of obtaining accurate and constant voltages of 1 to 100,000 μv at all frequencies to 300 mc was developed.

(775) C. L. Hogan, "The ferromagnetic Faraday effect at microwave frequencies and its application, the microwave gyrator," *Bell Tech. Jour.*, vol. 31, pp. 1–31; January, 1952.
(776) H. Theissing, H. J. Merrill, and J. M. McCue, "Measurements of millimeter radiation with the pneumatic heat detector," paper 61, presented IRE Convention, New York, N.Y.; March, 1952. Summary, Proc. I.R.E., vol. 40, p. 218; February, 1952.
(777) M. C. Selby, "Accurate RF microvolts," paper 59, presented IRE Convention, New York, N. Y.; March, 1952. Summary, Proc. I.R.E., vol. 40, p. 218; February, 1952.
(778) H. J. Carlin and M. Sucher, "Accuracy of bolometric power measurements," Proc. I.R.E., vol. 40, pp. 1042–1048; October, 1952.
(779) K. S. Machin, M. Ryle, and D. D. Vonberg, "The design of an equipment for measuring small radio-frequency noise powers," *Proc. IEE* (London), vol. 99, pt. III, pp. 127–134; May, 1952.

Video-Frequency Measurements

Recognition of the importance of the phase characteristic of television transmission apparatus is given further emphasis by the introduction of new measuring gear for point-by-point or oscillographic presentation of data. Activity is directed primarily toward accuracy of measurement and convenience of manipulation.

(780) A. Ruhrmann, "Direct reading high frequency phase measurement with frequency curve tracer," *Arch. tech. Messen*, Issue No. 190; November, 1951.
(781) C. W. Goodchild and R. C. Looser, "Apparatus for the measurement of phase delay in television transmission circuits and in associated apparatus," Inst. Elect. Engrs. Paper 1255 (Television Convention 1952).
(782) G. J. Hunt, "Group-delay Distortion-Measuring Equipment," Inst. Elect. Engrs., Paper 1250 (Television Convention, 1952).

Impedance measurements in the megacycle range is ably reviewed in a survey paper supplemented by an extensive bibliography.

(783) H. T. Wilhelm, "Impedance bridges for the megacycle range," *Bell Sys. Tech. Jour.*, vol. 31, pp. 999–1012; September, 1952.

Interference Measurements

The Central Radio Propagation Laboratory, in cooperation with the military services, is planning a worldwide network of approximately 50 atmospheric-noise-recording stations. The prototype receiver was built and arrangements are progressing for the construction and installation of the field stations.

Co-ordinated studies are being carried on at the University of Florida, the University of Pennsylvania, and several other places, both in this country and abroad, on the desirable characteristics to be measured for various kinds of radio noise.

Telemetering

The FM/FM mobile system made new gains, both in application and in performance. The use of a crystal-controlled transmitter became standard practice and several manufacturers are now in production of the two-watt version operating in the 220-Mc band. PDM/FM, PPM/AM, or PPM/FM systems are the only pulse-modulated systems in common use, and the FM/FM system has taken the place of the proposed PPM/pulsed RF as the high-performance system. Work is active on a PCM system of modulation.

An outstanding digital telemetering system was described at Long Beach, California. This system is versatile in that it can transmit one channel with 400-cycle response, or 400 channels with one-cycle response each, or any intermediate pairing. The airborne installation incorporates null sensing with servobalancing and analog-to-digital conversion. It transmits intelligence as coded beacon responses at radar repetition rates. On the ground, a microwave tracking radar receives the pulses and temporarily stores them. After checking for errors, the information is printed to three significant decimal digits.

An improved FM receiver appeared. The receiving station in the field reverted to the earlier design of a receiver and a recorder, since the magnetic tape recorder was demonstrated to possess adequate stability and frequency response. Subsequently, in a central laboratory the tapes are played back through subcarrier discriminators and the outputs of the various channels simultaneously recorded on various types of permanent recorders. Automatic analysis equipment is still under test. There are a number of semiautomatic units available.

In the field of subcarrier oscillators, very important advances in the temperature stability characteristic of several types appeared. The general assembly techniques were improved and the corresponding space occupied for a given channel function considerably reduced. Power requirements remain a problem.

The potentiometer-type pickup continued to find application for many measurements previously employing inductance-type pickups. Advances were made in the life and stability of this type of pickup, and their ability to withstand shock and vibration was increased. Strain-gauge elements are still employed, but more often these require either a special amplifier or a more complex subcarrier oscillator than the voltage-modulated units. Barium titanate pickups are widely employed, especially for vibration measurements, and several improved designs achieving higher-frequency response are now available.

The problems of over-all reliability of equipment involving chains of individual reliabilities, satisfactory vacuum tubes, and efficient low-weight power supplies still come to the fore in any general discussion among telemetering engineers.

Oscillography

General. Considerable attention was given to the evolution of the general-purpose cathode-ray oscillograph from a waveshape indicator to a measuring instrument reading amplitude and time, either directly calibrated or by substitution methods.

(784) "A true electronic voltmeter," *Oscillographer*, vol. 13, pp. 9 *et. seq.;* July–September, 1952.
(785) R. S. Mackay, "Switch provides d-c reference display," *Electronics*, vol. 25, pp. 23–124; December, 1952.
(786) "A new quantitative 10 megacycle oscillograph," *Oscillographer*, vol. 13, p. 20; January–March, 1952.

The accuracies of measurement obtained were made possible in part by the development of cathode-ray tubes made to tighter tolerances than those previously available as standard components.

(787) "Tight tolerance cathode-ray tubes," *Electronic Design*, vol. A, pp. 6–7; December, 1952.

Electron Optics for Cathode-ray Oscillograph Tubes. Simplified mathematical methods were developed for numerical ray tracing, the prediction of lens focal lengths, and other parameters from the physical dimensions and applied electrode voltages.

(788) P. Grivet, "Cardinal parameters of a new model of an electron lense," *Compt. Rend. Acad. Sci.* (Paris), vol. 234, pp. 73–75; January, 1952.
(789) J. C. Burfoot, "Numerical ray tracing in electron lenses," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 22–24; January, 1952.

A textbook was published devoted to the basic principles of storage tubes.

(790) M. Knoll and B. Kazan, "Storage Tubes," John Wiley and Sons, Inc., New York, N. Y., pp. 143; 1952.

The spurious signal on image iconoscopes was greatly reduced by a pulse-control method of maintaining mosaic bias,

(791) R. Theile and F. H. Townsend, "Improvements in image iconoscopes," Proc. I.R.E., vol. 40, pp. 146–154; February, 1952.

and by changes in design and operating conditions.

(792) J. E. Cope, L. W. Germany, and R. Theile, "Improvements in design and operation of the image iconoscope type camera tubes," *Jour. Brit. I.R.E.*, vol. 12, pp. 139–149; March, 1952.

Studies were made of second-order defocusing effects in electron beams,

(793) J. S. Hickey, Jr. and T. G. Mihran, "The spreading of an electron beam," Proc. I.R.E., vol. 40, p. 994; August, 1952.

and a method of counteracting the defocusing due to space charge by use of a magnetic field was described.

(794) M. E. Hines, "Nullification of space charge effects in a converging electron beam by a magnetic field," Proc. I.R.E., vol. 40, pp. 61–64; January, 1952.

A cathode-ray tube having distributed delay-line types of deflection plates was designed and used to record pulses having rise times of 5×10^{-10} second, and to observe 3×10^{9}-cps oscillations at useful amplitudes.

(795) S. T. Smith, R. V. Talbot, and C. H. Smith, Jr., "Cathode-ray tube for recording high speed transients," Proc. I.R.E., vol. 40, pp. 297–303; March, 1952.

A monoscope was designed for artificially duplicating controllable antenna characteristics.

(796) S. T. Smith, "A novel type of monoscope," Proc. I.R.E., vol. 40, pp. 666–668; June, 1952.

The variation in secondary emission over the target plate was obtained by using a three-dimensional target and varying the angle of the primary electrons. A number of electrostatic lenses were described, either unipotential or with low focus voltages with respect to cathode.

(797) E. Regenstreif, "An independent electrostatic lens with minimum elliptical astigmatism," *Jour. Phys. Radium*, vol. 12, pp. 760–761; July–September, 1951.
(798) C. S. Szegho, "Cathode-ray tube with low focusing voltage," Proc. I.R.E., vol. 40, pp. 937–939; August, 1952.
(799) A. Y. Bentley, K. A. Hoagland, and H. W. Grossbohlin, "Self focusing picture tube," *Electronics*, vol. 25, pp. 107–109; June, 1952.

An exceptionally stable supply suitable for cathode-ray tubes is capable of delivering 1 ma at 3 kv with a stability of one part in 10^4.

(800) J. Templeton, "A high stability high voltage power supply unit," *N. Z. Jour. Sci. Tech.*, vol. 33, pp. 218–223; November, 1951.

Cathode-Ray Oscillograph Applications. A receiving-tube-characteristics plotter producing a calibrated family of E_g-I_p-E_p curves was described.

(801) M. L. Kuder, "Electron tube curve generator," *Electronics*, vol. 25, pp. 118–124; March, 1952.

A number of other oscillographic apparatuses were developed for displaying the characteristics of transistors.

(802) P. J. W. Jochems and F. H. Stieltjes, "Apparatus for testing transistors," *Philips Tech. Rev.*, vol. 13, pp. 254–265; March, 1952.
(803) G. B. B. Chaplin, "Display of transistor characteristics on the cathode-ray oscillograph," *Jour. Sci. Inst.* (Brit.), vol. 29, pp. 142–145; May, 1952.
(804) "A Transistor Curve Tracer," RCA License Laboratory Bulletin LB 882.

A modulation method of displaying nonlinear characteristics of materials under test was described.

(805) H. E. Hollmann, "Polaresistivity and polaristors," Proc. I.R.E., vol. 40, pp. 538–545; May, 1952.

A method of photographically plotting the instantaneous mean power of complex waves using a sweep and a continuous motion camera was used for the study of audio signals.

(806) H. W. Curtis, "Measuring the mean power of varying amplitude complex audio waves," Proc. I.R.E., vol. 40, pp. 775–779; July, 1952.

By using a logarithmic amplifier in a cathode-ray oscillograph, it is possible to measure reverberation times directly on the screen.

(807) C. G. Mayo and D. G. Beadle, "The direct measurement of reverberation time," *Elec. Eng.* (Brit.), vol. 23, pp. 462–465; December, 1951.

A ten-channel amplitude distribution analyser for nuclear studies was built using a K-1059 target tube.

(808) E. Glenn, "A pulse-height distribution analyser," *Nucleonics*, vol. 9, pp. 24–28; September, 1952.

A transient recorder having sweep durations of 10^{-8} second was described.

(809) D. R. Hardy, "A high speed transient recorder," *Jour. Sci. Inst.*, vol. 29, pp. 241–242; August, 1952.

Photographic methods suitable for oscillography and television were reviewed.

(810) H. Aberdam, "Photography of oscillograms and television images," *Toute la Radio*, pp. 339–342 and 365–368; November and December, 1951.

Image converters were used as high-speed shutters.

(811) J. A. Jenkins and R. A. Chippendale, "The application of image converters to high speed photography," *Jour. Brit. IRE*, vol. 11, pp. 505–517; November, 1951.

Increasing application of cathode-ray oscillographs in the subaudio field

(812) P. S. Christaldi, "Oscillographic instrumentation for the subaudio field," *Trans. IRE*, vol. PGI-1, pp. 45–56; May, 1952.

emphasized the importance of the development of adequate transducers.

(813) C. C. Johnson, "A homopolar tachometer for servomechanism application," Proc. I.R.E., vol. 40, pp. 155–157; February, 1952.

A compendium of presently widely scattered source material on transducers and accessories useful in oscillography was made available.

(814) M. T. Nadir, "A Compilation of Analog Transducers," Allen B. Du Mont Laboratories, 1st ed., 68 pp; 1952.

Magnetics

Research and engineering in magnetic materials included, in particular, continued exploration of the ferromagnetic nonmetals, the development of miniature pulse transformers and magnetic amplifiers for computers to meet the needs of the Armed Forces, and work on substitutions for critical elements.

Considerable progress was reported on measuring the properties of magnetic materials up through microwave frequencies and on deriving a suitable correlating theory of the mechanisms of magnetism. A study of the Faraday rotation effect in ferrites at microwave frequencies and the construction of a nonreciprocal waveguide element utilizing this effect, termed the "gyrator," was announced. A conference on magnetism, with an international roster of speakers and participants, was sponsored by the Office of Naval Research at the University of Maryland on September 2–6, 1952. The papers will be published in a forthcoming issue of the *Review of Modern Physics.*

(815) 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.

(816) B. Pistoulet, "On the behavior of ferromagnetic powders up to 24,000 megacycles per second," *Ann. Telecomm.*, vol. 7, pp. 27–45; January, 1952; pp. 86–97; February, 1952, pp. 127–138; March, 1952 (In French).

(817) J. K. Galt, "Initial permeability and related losses in ferrites," *Ceramic Age*, vol. 60, pp. 29–33; August, 1952.

(818) L. F. Bates, "Some post-war developments in magnetism," *Proc. Roy. Soc. A.*, vol. 65, pp. 577–594; August 1, 1952.

Ferrites with squared hysteresis loops for magnetic amplifier and computer applications have been achieved through processing and also through the application of suitable stresses to completed cores.

(819) J. J. Went and E. W. Gorter, "Magnetic and electrical properties of Ferroxcube materials," *Philips Tech. Rev.*, vol. 13, pp. 181–193; January, 1952.

(820) V. B. Vonderschmitt, M. J. Olbert and H. B. Stott, "Ferrite applications in electronic components," *Electronics*, vol. 25, pp. 138–139; March, 1952.

(821) E. Both, "Development and utilization of magnetic ferrites," *Ceramic Age*, vol. 59, pp. 39–45; April, 1952.

(822) E. Gelbard, "Magnetic properties of ferrite materials," *Tele-Tech*, vol. 11, pp. 50–52, 82; May, 1952.

(823) W. Six, "Some applications of Ferroxcube," *Philips Tech. Rev.*, vol. 13, pp. 301–311; May, 1952.

(824) E. Newhall, P. Gomard and A. Ainlay, "Saturable reactors as r-f tuning elements," *Electronics*, vol. 25, pp. 112–115; September, 1952.

Improved thin tape magnetic cores became commercially available for small transformers. Magnetic amplifier development has taken advantage of ultra-thin tape with rectangular hysteresis loops and half-wave circuitry to achieve small size and high speed. The possibilities of subminiature magnetic amplifiers in combination with transistors for small computers appear challenging on the basis of exploratory work.

(825) E. P. Felch, V. E. Legg and F. G. Merrill, "Magnetic modulators," *Electronics*, vol. 25, pp. 113–117; February, 1952.

(826) F. E. Butcher and R. Willheim, "Some aspects of magnetic amplifier technique," Proc. I.R.E., vol. 40, pp. 261–270; March, 1952.

(827) F. Benjamin, "Improvements extend magnetic-amplifier applications," *Electronics*, vol. 25, pp. 119–123; June, 1952.

(828) A. V. Hughes and C. F. Salt, "Magnetic core materials for small power transformers," *Elec. Mfg.*, vol. 49, pp. 133–138, 324; June, 1952.

(829) W. H. Elliot, "Magnetic amplifier definitions," *Elec. Mfg.*, vol. 50, pp. 88–91, 252; July, 1952.

(830) M. F. Littmann, "Ultrathin tapes of magnetic alloys with rectangular hysteresis loops," *Commun. and Elec.*, pp. 220–223; July, 1952.

(831) C. C. Horstman, "Core materials for small transformers," *Tele-Tech*, vol. 11, pp. 40–42, 90; October, 1952.

(832) E. A. Sands, "The behavior of rectangular hysteresis loop materials under current pulse conditions," Proc. I.R.E., vol. 40, pp. 1246–1250; October, 1952.

(833) L. J. Johnson, "High speed magnetic amplifier," *Elec. Mfg.*, vol. 50, pp. 98–101, 318; November, 1952.

Design techniques for magnetic powder cores and the appraisal of such cores for military equipment received attention.

(834) H. E. Harris, "Simplified approach to toroidal inductor design," *Tele-Tech.*, vol. 11, pp. 54–56, 107; January, 1952; pp. 52–53, 70; February, 1952.

(835) S. Freedman, "Toroidal coil developments," *Radio and Telev.*, vol. 47, pp. 3–6, 31; April, 1952.

(836) G. R. Polgreen, "Production and application of magnetic powders," *GEC Jour.*, vol. 19, pp. 152–169; July, 1952.

(837) E. Both, "Magnetic powder cores for military communication equipment," *Tele-Tech.*, vol. 11, pp. 36–38, 100; August, 1952.

Two new permanent magnet materials of potential importance, especially in the event of shortages of nickel and cobalt required for Alnico, were announced. One was a bismuth-manganese alloy and the other a ceramic (ferrite) type. Further work on permanent magnets consisting of ultrafine iron powders was carried out.

(838) J. J. Went, G. W. Rathenau, E. W. Gorter and G. W. Van Oosterhout, "Ferroxdure, a class of new permanent magnetic materials," *Philips Tech. Rev.*, vol. 13, pp. 194–208; January, 1952.
(839) B. Kapelman, "Permanent magnets from ultrafine iron powders," *Elec. Eng.*, vol. 71, pp. 447–451; May, 1952.
(840) "Navy develops new permanent magnet material called Bismanol," *Steel*, vol. 131, pp. 76–77; July 28, 1952.

The general techniques of magnetic measurements and applications have advanced.

(841) R. F. Lafferty, "Extended Q-meter measurements," *Electronics*, vol. 24, pp. 126–131; November, 1951.
(842) W. Jellinghaus, "Development of the methods of testing ferromagnetic materials," *Arch. f. d. Eisenhuttenwesen*, vol. 22, pp. 401–410; November–December, 1951 (In German).
(843) P. M. Prache, "Magnetic cores and shells for communication purposes," *Cables and Trans.* (Paris), vol. 6, pp. 22–64; January, 1952; pp. 124–164; April, 1952 (In French).
(844) D. C. Dieterly and C. E. Ward, "Wide range ac bridge test for magnetic materials," *ASTM Bull.*, vol. 182, pp. 75–80; May, 1952.
(845) H. W. Lord, "Dynamic hysteresis loop measuring equipment," *Elec. Eng.*, vol. 71, pp. 518–521; June, 1952.

Piezoelectricity

Progress in the physics of this field, with ferroelectricity as the keynote for the year, is an intimate part of the rapidly developing physical picture of the solid state and represents also the most significant advance for piezoelectricity during the year. Important theoretical papers mark progress in the analyses of the behavior of the piezoelectric resonator and of the transducer and its coupled field. On the design and development side the high-frequency, thickness-shear quartz plate has attained the status of a primary standard of frequency while the split ring of quartz has invaded the audio-frequency field as a frequency standard. The large number of papers and reports in the several branches of piezoelectricity, including those on the many *applications*, bring the total number of references in piezoelectricity for the year 1952 to well over five hundred.

A fairly complete bibliography for the year 1951, which appeared in March, 1952 as an unclassified report to the U. S. Army Signal Corps, included about three hundred titles for that year. A similar bibliography for 1952 is in preparation.[1]

The following books, bibliographies, digests, and review articles are noted:

(846) R. G. Breckinridge and H. Thurnauer (editors), "Digest of the Literature on Dielectrics," National Research Council, vol. XIV (1950); September, 1951.
(847) R. F. S. Hearmon, "The elastic constants of piezoelectric crystals," *Brit. Jour. Appl. Phys.*, vol. 3, pp. 120–124; April, 1952.

[1] These bibliographies, along with reports on research in the broad field of frequency control, sponsored by the U. S. Army Signal Corps Engineering Laboratories, are available within a few months of their receipt in microcard form through the Office of Naval Research, Library of Congress, Technical Information Division.

(848) W. Shockley (editor), "Imperfections in Nearly Perfect Crystals," John Wiley and Sons, Inc., New York, N. Y., pp. 490; 1952.
(849) J. C. Slater, "The solid state," *Physics Today*, vol. 5, pp. 10–15; January, 1952.
(850) K. S. Van Dyke and O. M. H. Wall (Wesleyan University), "Bibliography of Piezoelectricity—1951," U. S. Army Signal Corps Contract DA36-039-sc-73, supplementary volume, 7th quarterly report; February 29, 1952.
(851) A. von Hippel, "Piezoelectricity, ferroelectricity and crystal structure," *Phys. Rev.*, vol. 87, pp. 200–201, abstract; July 1, 1952.

Ferroelectricity, Antiferroelectricity, and their Applications

Considerable progress was made in understanding ferroelectricity and antiferroelectricity. These are the counterparts in the dielectric field of ferromagnetism and antiferromagnetism in the magnetic field. A theory based on rotatable polar molecules was worked out (Takagi) which shows that crystals become antiferroelectric if the polarizability of the dipoles is small but ferroelectric if the polarizability of the ions becomes larger. This type of theory is applicable to materials similar to C_sCl, which may have rotatable dipoles, but not to such materials as $BaTiO_3$, whose dipoles are caused by actual displacement of the centers of charge. In the antiferroelectric state the dipoles are lined up "parallel" to a given line as in the ferroelectric state, but alternate dipoles are oppositely directed so that, strictly, antiparallelism rather than parallelism exists. A theory of antiferroelectricity that had been developed for cubic crystals by Kittel was extended to tetragonal structures by Mason.

On the experimental side, new measurements were reported on the properties of ferroelectric and antiferroelectric crystals. Frazer and Pepinsky have examined the structure of KH_2PO_4 (KDP) and showed that at the Curie temperature the PO_4 tetrahedron becomes distorted by having the phosphorus atom displaced from the center of the tetrahedron. They regard this change as being the origin of the ferroelectric dipole. The potassium atom also suffers a small displacement.

Considerable work was done in investigating the domain sizes and domain motion in ferroelectrics. Kanzig and Peter showed that there is a minimum size of about 1,500A for domains in KH_2PO_4 for which spontaneous polarization can appear. This was explained by Kanzig as being due to a balance between depolarization energy and the domain wall energy. In his investigation of the domain structure of barium titanate Merz found that in addition to 90° walls that have previously been known 180° walls also exist. No evidence has yet been obtained of domain wall motion, but new domains are seen to occur when the electric field is increased. By increasing the C-axis domain-content of the crystal, the hysteresis loop is given square corners and the coercive field is decreased.

A new ferroelectric, ammonium metaphosphate was reported. A large number of measurements were made by Japanese investigators on the properties of $BaZrO_3$, $PbZrO_3$, $PbTiO_3$, and related compounds, and it was found that they show both ferroelectric and antiferroelectric properties. For a combination of $PbZrO_3$

and $BaZrO_3$, temperature regions occur in which the material is ferroelectric. Below the region the material is antiferroelectric while above the region the material is paraelectric.

The transition in $NH_4H_2PO_4$ (ADP) occurring at 122°K was shown to be an antiferroelectric transition. This was surmised in a theory by Nagamiya and was proved by the work of Mason and Matthias, and of Wood, Merz, and Matthias, who investigated the $ND_4D_2PO_4$ modification. The change in crystal structure is consistent with the arrangement of the hydrogen or the deuterium nuclei in an antiferroelectric state.

The ferroelectric effect was applied in such devices as signal storage devices and dielectric amplifiers which promise to have very wide usage. Anderson described a ferroelectric information storage system, useful for digital computors or telephone switching systems, which has many advantages over conventional storage systems. These systems have the advantage of low power consumption, offer the possibility of storing large amounts of information in a small space, and are very fast in operation. Another device whose operation depends on the nonlinear response of a ferroelectric material is the dielectric amplifier. This device is the analogue of a magnetic amplifier and, like the magnetic amplifier, can effect a gain in the ratio of the carrier frequency to the signal frequency. Some of the fundamentals of such amplifiers were discussed (Vincent, Pipes); some experimental values were reported by Urkowitz.

(852) Y. Takagi, "Ferroelectricity and antiferroelectricity of a crystal containing rotatable polar molecules," *Phys. Rev.*, vol. 85, pp. 315–324; January, 1952.
(853) C. Kittel, "Theory of antiferroelectric crystals," *Phys. Rev.*, vol. 82, pp. 729; June 1, 1951.
(854) W. P. Mason, "Properties of a tetragonal antiferroelectric crystal," *Phys. Rev.*, vol. 88, pp. 480–484; November, 1952.
(855) B. C. Frazer and R. Pepinsky, "Structural changes in the ferroelectric transition of KH_2PO_4," *Phys. Rev.*, vol. 85, pp. 479–480; February 1, 1952.
(856) W. Kanzig, "Wall energy of ferroelectric domains," *Phys. Rev.*, vol. 87, pp. 385; July 15, 1952.
(857) W. Kanzig and M. Peter, "Critical domain size in ferroelectrics," *Phys. Rev.*, vo.. 85, pp. 940–941; March 1, 1952.
(858) W. J. Merz, "Domain properties in $BaTiO_3$," *Phys. Rev.*, vol. 88, pp. 421; October, 1952.
(859) R. Pepinsky, *et al.*, "A ferroelectric ammonium metaphosphate," *Phys. Rev.*, vol. 86, pp. 793; June 1, 1952.
(860) Nagamiya, "On the theory of the dielectric, piezoelectric, and elastic properties of $NH_4H_2PO_4$," *Prog. in Theor. Phys.*, vol. 7, p. 3; 1952.
(861) E. Sawaguchi, H. Maniwa, and S. Hoshino, "Antiferroelectric structure of lead zirconate," *Phys. Rev.*, vol. 83, pp. 1078; 1951.
(862) E. Sawaguchi, G. Shirane, and Y. Takagi, "Phase transition in lead zirconate," *Jour. Phys. Soc.* (Japan), vol. 6, pp. 333; 1951.
(863) W. P. Mason and B. T. Matthias, "Piezoelectric dielectric, and elastic properties of $ND_4D_2PO_4$," *Phys. Rev.*, vol. 88, pp. 477–479; November 1, 1952.
(864) G. Shirane and A. Takeda, "Transition energy and volume change at three transitions in barium titanate," *Jour. Phys. Soc.* (Japan), vol. 7, pp. 1–4; January–February, 1952.
(865) G. Shirane, "Ferroelectricity and antiferroelectricity in ceramic $PbZrO_3$ containing Ba or Sr," *Phys. Rev.*, vol. 86, pp. 219–227; April 15, 1952.
(866) J. R. Anderson, "Ferroelectric storage elements for digital computors and switching systems," *Elec. Eng.*, vol. 71, pp. 916–922; October, 1952.
(867) E. A. Wood, W. J. Merz, and B. T. Matthias, "Polymorphism of $ND_4D_2PO_4$," *Phys. Rev.*, vol. 87, pp. 544; August 1, 1952.
(868) A. M. Vincent, "Dielectric amplifier fundamentals," *Electronics*, vol. 24, pp. 84–88; December, 1951.
(869) L. A. Pipes, "A mathematical analysis of a dielectric amplifier," *Jour. Appl. Phys.*, vol. 23, pp. 818–824; August, 1952.
(870) H. Urkowitz, "A ferroelectric amplifier," Proc. I.R.E., vol. 40, pp. 232; February, 1952.

Resonators

A new level of performance for thickness-shear resonators of quartz has been attained in AT-cut plates in disk form with spherical surfaces, fused mountings, and scrupulous attention to surface finish, cleanliness and hermetic sealing. These plate make primary, standards of frequency in the 3- to 20-mc range. The use of long bars of quartz in flexure as audio-frequency standards has not been common because of the unavailability and high cost of quartz in large size. The straight bar now promises to be superseded by a nearly complete ring of quartz undergoing the flexure in the plane of the ring. For the same length of flexing strip (now circumference of the ring), upon which the frequency of resonance depends, the requirement as to maximum over-all dimension of the original piece of quartz rock is greatly reduced. Local internal heating of quartz plates as a limiting factor in frequency constancy for crystal-controlled oscillators, particularly if the amplitude is large and is variable, is receiving study as is also the distribution of the amplitude of vibration throughout thickness-shear quartz resonators. A recent theoretical analysis of the thickness-shear resonator has been extended to include the secondary effects of the piezoelectric properties on the stiffness and thus on the frequencies of resonance. A method is demonstrated for measuring the parameters of quartz resonators which is particularly suited to the very high-resonance frequencies. In the instrument which has been developed for such measurements, in the Signal Corps Engineering Laboratories, the deflections as crystal resonances are passed through are compared with reference deflections which are either caused by or modified by a standard capacitance. Several studies have been underway in the use of quartz as a mechanical filter. The elimination of unwanted modes in filter crystals is the subject of one of a half dozen papers (others not here listed) by Bechmann from his new location in the Radio Experimental and Development Branch Laboratories, Dollis Hill, of the British Post Office Engineering Department, these appearing mostly in the British journals and dealing largely with resonator problems.

(871) R. Bechmann, "Single response thickness-shear mode resonators using circular bevelled plates," *Jour. Sci. Instr.* (London), vol. 29, pp. 73–76; March, 1952.
(872) V. E. Bottom (Colorado A. and M. Coll.), "Mounting Techniques for Improved Heat Dissipation in Quartz Crystal Units," U. S. Army Signal Corps Contr. DA36-039-sc-5485, Quarterly Progress Report No. 1; February 28–May 30, 1951.
(873) E. A. Gerber, "Quartz-crystal measurement at 10 to 180 megacycles," Proc. I.R.E., vol. 40, pp. 36–40; January, 1952.
(874) R. D. Mindlin, "Forced thickness-shear and flexural vibrations of piezoelectric crystal plates," *Jour. Appl. Phys.*, vol. 23, pp. 83–88; January, 1952.
(875) C. R. Mingins, *et al.* (Tufts Coll.), "An Investigation of the Characteristics of Electromechanical Filters," U. S. Army Signal Corps Contr. DA36-039-sc-5402, 3rd Quarterly Report; August 1, 1952.
(876) E. J. Post, "A new crystal cut for quartz with zero temperature coefficient," *Appl. Sci. Res.*, vol. B1, pp. 420–428; 1950. Abstract: Proc. I.R.E., vol. 40, pp. 889, Ab. 1641; July, 1952.
(877) E. J. Post, "Note on safe resonator current of piezoelectric elements," Proc. I.R.E., vol. 40, pp. 835; July, 1952.
(878) J. E. Thwaites, "Quartz vibrators for audio frequencies," *Proc. IEE* (London), vol. 99, pt. IV; 1952.
(879) M. D. Waller, "Vibrations of free plates: line symmetry; corresponding modes," *Proc. Roy. Soc.*, vol. 211, pp. 265–276; February 21, 1952.

(880) A. W. Warner, "High frequency crystal units for primary frequency standards," PROC. I.R.E., vol. 40, pp. 1030–1033; September, 1952.

Transducers

Great progress has been made in the formal analysis of the piezoelectric transducer and there have been a number of reports on design and performance characteristics. New developments in recording instruments for wave propagation and viscosity measurements give promise of new measuring and testing techniques.

(881) M. Alixant, "Ultrasonic generators and their applications," *Radio Tech. Dig.* (France), vol. 5, pp. 271–278, 299–325; 1951.
(882) R. Barthel and A. W. Nolle, "A precise recording ultrasonic interferometer and its applicaton to dispersion tests in liquids," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 8–15; January, 1952.
(883) F. E. Borgnis (Calif. Inst. of Tech.), "A general theory of the acoustic interferometer for plane waves," Contract Nonr-220(02), Task No. NR384–404, Technical Report No. 3; January 25, 1952. (Submitted by W. G. Cady, Project Director).
(884) A. Skudrzyk, "The general theory of the acoustic transmitter and receiver, its use to obtain the equivalent circuit diagrams of a magnetostrictive oscillator and a quartz transducer," *Nuovo Cim.*, vol. 7, pp. 416–434 (Suppl. No. 2, 1950), in German. (*Phys. Abstr.*, vol. 55, pp. 303, AB.2533; April, 1952.)
(885) Colloquium over Ultrasonore Trillingen (International Conference on Ultrasonics—Brussels; June 7, 8, 9, 1951)—Kon. VI. Acad. Weten. Let. Sch. Kunst. Belgie; 1951. (*Jour. Acous. Soc. Amer.*, vol. 24, pp. 553; September, 1952.)

Applications of Piezoelectric Devices

There have been a number of confirmed diagnoses of cancerous tissue by ultrasonic ranging techniques using a quartz element.

(886) J. M. Reid and J. J. Wild, "Ultrasonic ranging for cancer diagnosis," *Electronics*, vol. 25, pp. 136–138; July, 1952.

Among many papers on experiment and measurement in which the piezoelectric crystal is the key tool, the following are listed as including some treatment of the piezoelectric device as well as of the findings of the investigation. In one, the quartz crystal traces the force continuously throughout the impact of the two metal bodies. The comparison of observations with theory sheds considerable light on the "flow-pressure" concept of Vincent (1900). In a second paper, a barium titanate transducer which is capable of large amplitude is used to strike and/or to cause sliding of surface on surface in the development of a technique for studying wear on telephone switching apparatus. The large part in wear which is played by sliding as compared with striking is beautifully demonstrated. Another paper extends a technique of measuring ultrasonic propagation constants to the analysis of the contribution of their lengths and of the different parts of the chains of molecules in liquid and solid polymers to their viscoelastic properties. In a fourth paper which uses pulse techniques to measure ultrasonic attenuation in steel in the 5 to 50 mc/sec range, the importance of a buffer of water between transducer and steel emerges along with the dependence of attenuation upon the heat treatment (and grain size) of the steel. In another paper, interferometric measurements of the viscosity of carbon dioxide and of ethylene at ultrasonic frequencies yield absorption coefficients one thousand-fold larger than are yielded by classical low-frequency or transpiration methods.

(887) A. W. Crook, "A study of some impacts between metal bodies by a piezo-electric method," *Proc. Roy. Soc. A*, vol. 212, pp. 377–390; May 7, 1952.
(888) W. P. Mason and H. J. McSkimin, "Mechanical properties of polymers at ultrasonic frequencies," *Bell Sys. Tech. Jour.*, vol. 31, pp. 122–171; January, 1952.
(889) W. P. Mason and S. D. White, "New techniques for measuring forces and wear in telephone switching apparatus," *Bell Sys. Tech. Jour.*, vol. 31, pp. 469–503; May, 1952.
(890) H. D. Parbrook and E. G. Richardson, "Propagation of ultrasonic waves in vapours near the critical point," *Proc. Phys. Soc. B*, vol. 65, pp. 437–444; June, 1952.
(891) R. L. Roderick and R. Truell, "The measurement of ultrasonic attenuation in solids by the pulse technique and some results in steel," *Jour. Appl. Phys.*, vol. 23, pp. 267–279; February, 1952.

Quality Control

The application of statistical quality control expanded in the electronics industry. The ever-increasing need for greater reliability in both military and commercial applications of electronics resulted in improved techniques for assessing the quality of both components and systems.

(892) F. Ennerson, R. Fleischman, and D. Rosenberg, "A production experiment using attribute data," *Indus. Quality Control*, vol. VIII, p. 41; March, 1952.
(893) E. D. Goddess, "Rating new test methods," *Electronics*, vol. 5, p. 101; April, 1952.
(894) R. D. Guild, "Correlation of conventional and accelerated test conditions for heater burnouts by the logarithmic normal distribution," *Indus. Quality Control*, vol. IX, pp. 27–30; November, 1952.
(895) R. S. Hoff and R. C. Johnson, "A statistical approach to the measurement of atmospheric noise," PROC. I.R.E., vol. 40, p. 185; February, 1952.
(896) R. McGhee, "Process control in a development laboratory," *Proc. Middle Atlantic Regional Conference*, American Society for Quality Control, p. 85; March, 1952.
(897) H. G. Romig, "Quality control techniques for electronic components," *Quality Control Conference Papers 1952*, Sixth Annual Convention, American Society for Quality Control, Syracuse, N. Y.; May 22–24, 1952.
(898) D. Rosenberg and F. Ennerson, "Production research in the manufacture of hearing aid tubes," *Indus. Quality Control*, vol. VIII, p. 94; May, 1952.
(899) B. W. Squier, Jr., "Quality control of TV tubes," *Radio and Telev. News*, vol. 47, p. 49; February, 1952.
(899A) "Inspection Bulletin on Sampling Procedures," *R.T.M.A. Eng. Bull.* No. 42; 1952.

Antennas, Waveguides, and Transmission Lines

Antenna Theory

Significant progress was made in advancing the theory of cylindrical antennas by developing new procedures and methods for solving Hallen's integral equation.

(900) A. Zinke, "A new solution for the current and voltage distributions on cylindrical, ellipsoidal, conical, or other rotationally symmetrical antennas," *Frequenz*, vol. 6, pp. 57–65; March, 1952.
(901) R. King, "An improved theory of the receiving antenna," PROC. I.R.E., vol. 40, pp. 1113–1120; September, 1952.
(902) R. King, "An Alternative Method of Solving Hallen's Integral Equation and Its Application to Antennas Near Resonance," Cruft Laboratory Technical Report No. 154; July, 1952.
(903) R. King, "Theory of electrically short transmitting and receiving antennas," *Jour. Appl. Phys.*, vol. 23, pp. 1174–1187; October, 1952; Cruft Laboratory Technical Report No. 141; March, 1952.

Coupled antennas were investigated extensively, both theoretically and experimentally.

(904) L. Lewin, "Mutual impedance of wire aerials," *Wireless Eng.*, vol. 28, pp. 352–355; December, 1951.
(905) R. King, "Self- and mutual impedance of parallel identical antennas," PROC. I.R.E., vol. 40, pp. 981–988; August, 1952.

(906) L. S. Palmer, "Radiation or diffraction patterns close to receiving antennas," *Jour. Appl. Phys.*, vol. 23, pp. 289–290; February, 1952.
(907) T. Morita and C. E. Faflick, "The measurement of current distributions along coupled antennas and folded dipoles," PROC. I.R.E., vol. 39, pp. 1561–1565; December, 1951.

Extensive theoretical and experimental work was done on the problem of scattering from cylindrical antennas. In particular, an important new experimental method for measuring back-scattering was developed.

(908) C. T. Tai, "Electromagnetic back-scattering from cylindrical wires," *Jour. Appl. Phys.*, vol. 23, pp. 909–915; August, 1952.
(909) S. H. Dike and D. D. King, "The absorption gain and back-scattering cross section of the cylindrical antenna," PROC. I.R.E., vol. 40, pp. 853–860; July, 1952.
(910) V. Twersky, "Multiple scattering of radiation by an arbitrary planar configuration of parallel cylinders and by two parallel cylinders," *Jour. Appl. Phys.*, vol. 23, pp. 407–414; April, 1952.

The problem of short electric and magnetic dipoles in and near the earth was investigated.

(911) J. R. Wait, "Magnetic dipole antenna immersed in a conducting medium," PROC. I.R.E., vol. 40, pp. 1244–1245; October, 1952.
(912) R. F. Proctor, "Input impedance of horizontal dipole aerials at low heights above the ground," *Proc. I.R.E.* (Australia), vol. 13, pp. 58–61; 1952.

Basic Antenna Types

Several papers appeared dealing with radiation patterns of antennas of different types.

(913) J. E. Storer, "Radiation pattern of an antenna over a circular ground screen," *Jour. Appl. Phys.*, vol. 23, pp. 588–593; May, 1952.

The radiation characteristics of helical antennas were analyzed. A discussion of anomalous behavior of the modes of propagation and an extensive bibliography are included in the first paper.

(914) S. Sensiper, "Electromagnetic Wave Propagation on Helical Conductors," M.I.T. Laboratory for Electronics Report No. 194, Cambridge, Mass.; May, 1952.
(915) C. C. Haycock and J. S. Ajioka, "Radiation characteristics of helical antennas of few turns," PROC. I.R.E., vol. 40, pp. 989–991; August, 1952.

The theory of the continuous-sheet model and the thin helical wire was developed and compared with experimental results on delay lines and helical antennas.

(916) E. Roubine, "Etudes des Ondes Electromagnetiques Guidee par les Circuits en Helice," *Annales des Telecommunications*, vol. 7, pp. 205–216; May, 1952; pp. 262–275; June, 1952; pp. 310–324; July–August, 1952.

A nonuniform dielectric transmission line made up of rods alternating with disks of high dielectric constant was used to radiate a broadside pattern.

(917) G. Mueller, "A broadside dielectric antenna," PROC. I.R.E., vol. 40, pp. 71–75; January, 1952.

A comprehensive study of dielectric antennas includes radiation patterns for dielectric cylinders and cones excited through holes in the broad face of a waveguide and for linear arrays of such elements. The theory of modes for dielectric cylinders with or without a central conductor was discussed together with the coupling of these cylinders to a waveguide.

(918) M. Bouix, "Contribution a l'Etude des Antennes Dielectriques," *Ann. Telecomm.*, vol. 7, pp. 217–238; May, 1952; pp. 276–295; June, 1952, pp. 336–348; July–August, 1952, pp. 350–363; September, 1952.

Many advances in the applications of antennas, particularly for microwave frequencies, were made through the use of improved techniques and increased understanding of the theory. The adaptation of antennas to meet the specific requirements of high-speed aircraft and guided missiles is significant.

A new type of microwave lens, where the artificial dielectric is made of perforated metallic plates, was reported.

(919) J. C. Simon, "Un Nouveau Type de Lentilles en Hyperfrequencies," *L'Onde Electrique Ap.*, vol. 32, pp. 181–189; May, 1952.

Microwave antennas for shaped beams continued to receive attention. Doubly curved reflectors, antenna-pattern calculations, and antenna theory were discussed.

(920) A. S. Dunbar, "On the theory of antenna beam shaping," *Jour. Appl. Phys.*, vol. 23, p. 847; August, 1952.
(921) R. J. Stegen, "Slot radiators and arrays at x-band," TRANS. I.R.E., Prof. Gp. Ant. Prop. PGAP-2, p. 62; February, 1952.

Increased activity occurred in microwave scanning antennas. Among the papers that appeared were discussions on optical theory for application to scanner design and the application of optical systems to scanners.

(922) J. E. Eaton, "Zero phase-front in microwave optics," TRANS I.R.E., Prof. Gp. Ant. Prop. PGAP-1, p. 38; February, 1952

Ferrites appear to have application to microwave scanners.

(923) A. J. Simmons and H. N. Chait, "Microwave antenna ferrite applications," *Electronics*, vol. 25, p. 156; June, 1952.

Considerable effort was devoted to the problem of flush mounting uhf and vhf antennas in high-speed aircraft.

(924) R. H. J. Cary, "The slot aerial and its application to aircraft," *Proc. IEE* (London), vol. 29, pt. III, pp. 187–196; July, 1952.
(925) J. V. N. Granger, "Design limitations on aircraft antenna systems," *Aero. Eng. Rev.*, pp. 82–88; May, 1952.
(926) R. H. J. Cary, "A survey of external and suppressed aircraft aerials for use in the high-frequency band," *Proc. IEE* (London), vol. 29, pt. III, pp. 197–213; July, 1952.
(927) R. G. Mirimanov, "The radiation resistance of a dipole near an ellipsoid of revolution of good conductivity," *C. R. Acad. Sci.* (U.R.S.S.), vol. 80, no. 2, pp. 189–192; September 11, 1951.

Several new books on antenna theory and engineering were published during the year.

(928) D. D. King, "Measurements at Centimeter Wavelength," D. Van Nostrand Co., Inc., New York, N. Y.
(929) E. A. Laport, "Radio Antenna Engineering," McGraw-Hill Book Co., Inc., New York, N. Y.
(930) S. S. Schelkunoff and H. T. Friis, "Antennas, Theory and Practice," John Wiley and Sons, New York, N. Y.
(931) S. S. Schelkunoff, "Advanced Antenna Theory," John Wiley and Sons, New York, N. Y.

Transmission Lines and Microwave Circuits

Low-loss microwave Faraday rotation was realized. In this development, a ferrite material within a waveguide and in the presence of an unvarying magnetic field accomplishes rotation of the plane of polarization. This action has promise of wide application in that (1) it provides a means of electric control of polarization within a waveguide and (2) the rotation is not reciprocal. The nonreciprocal property makes possible the construction of a gyrator, a one-way transmission system, and the like. Theory and applications were described and a related problem was discussed.

(932) 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.
(933) C. H. Luhrs, "Correlation of the Faraday and Kerr magneto-optical effects in transmission-line terms," Proc. I.R.E., vol. 40, pp. 76–78; January, 1952.
(934) S. A. Schelkunoff, "Generalized telegraphist's equations for waveguides," *Bell Sys. Tech. Jour.*, vol. 31, pp. 784–801; July, 1952.

Several groups announced advances concerning bandwidth and directivity of directional couplers. The Dolph-Tchebyscheff array distributions, as well as other tapered coupling functions, were applied to directional-coupler design with excellent results. Several papers also described directional couplers providing very tight coupling. In particular, a broad-band 3-db directional coupler was mentioned having excellent characteristics as a hybrid junction. Several novel circuit applications of directional couplers were described. In one application, impedances that are calculable from electromagnetic theory are shown to be of interest, possibly for use as standards.

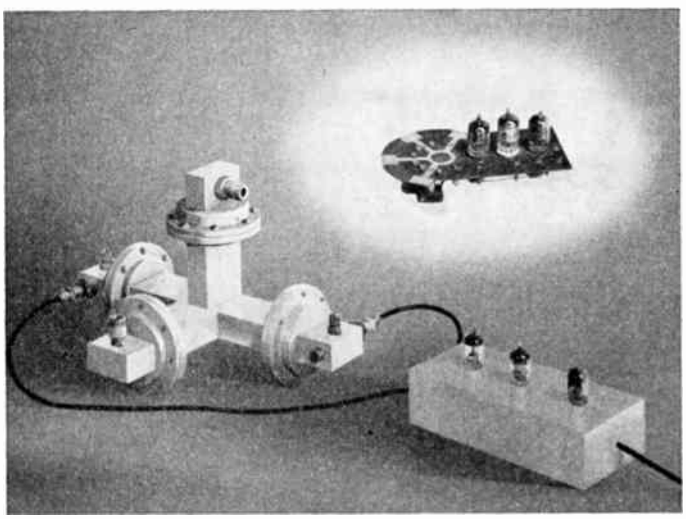

Fig. 13—Microstrip balanced crystal mixer and 3-stage preamplifier compared with the equivalent waveguide junction and conventional amplifier. (*Federal Telecommunication Laboratories*).

(935) S. E. Miller and W. W. Mumford, "Multi-element directional couplers," Proc. I.R.E., vol. 40, pp. 1071–1078; September, 1952.
(936) H. J. Riblet, "Super directivity with directional coupler arrays," Proc. I.R.E., vol. 40, pp. 994–995; August, 1952.
(937) H. J. Riblet, "The short-slot hybrid junction," Proc. I.R.E., vol. 40, pp. 180–184; February, 1952.
(938) W. C. Jakes, Jr., "Broad-band matching with a directional coupler," Proc. I.R.E., vol. 40, pp. 1216–1218; October, 1952.
(939) W. J. Van de Lindt, "Application of multi-hole coupling to the design of a variable and calibrated waveguide attenuator and impedance," *Philips Res. Rep.*, vol. 7, pp. 28–35; February, 1952.
(940) L. Lewin, "The impedance of unsymmetrical strips in rectangular waveguides," *Proc. IEE* (London), vol. 99, pt. IV, pp. 168–176; July, 1952.

A few papers appeared improving the general knowledge of aperture coupling and providing basic design information. In particular, the applicability of Bethe's aperture theory was extended.

(941) S. B. Cohn, "Microwave coupling by large apertures," Proc. I.R.E., vol. 40, pp. 696–699; June, 1952.
(942) S. B. Cohn, "The electric polarizability of apertures of arbitrary shape," Proc. I.R.E., vol. 40, p. 1069; September, 1952.
(943) I. Reingold, J. L. Carter, and K. Garoff, "Single- and multi-iris resonant structures," Proc. I.R.E., vol. 40, p. 861; July, 1952.

Several basic theoretical papers on transmission lines, transmission-line junctions, and laminated transmission lines were published.

(944) M. Namiki and H. Takahashi, "Some variational principles for problems in transmission lines," *Jour. Appl. Phys.*, vol. 23, pp. 1056–1057; September, 1952.
(945) T. Teichmann, "Completeness relations for loss-free microwave junctions," *Jour. Appl. Phys.*, vol. 23, pp. 701–710; July, 1952.
(946) S. P. Morgan, Jr., "Mathematical theory of laminated transmission lines," *Bell Sys. Tech. Jour.*, vol. 31, pp. 883–949; September, 1952.

Problems encountered in the use of multimode transmission lines were explained.

(947) A. P. King, "Dominant wave transmission characteristics of a multimode round waveguide," Proc. I.R.E., vol. 40, pp. 966–969; August, 1952.
(948) W. Kummer, "Impedance measurement technique for two-mode guides," Trans. I.R.E., PGAP-1, pp. 148–152; February, 1952.

Two papers on filters or filter-like structures appeared.

(949) E. T. Jaynes, "Concepts and measurement of impedance in periodically loaded waveguides," *Jour. Appl. Phys.*, vol. 23, pp. 1077–1084; October, 1952.
(950) H. J. Riblet, "Synthesis of narrow-band direct-coupled filters," Proc. I.R.E., vol. 40, pp. 1219–1223; October, 1952.

Theoretical and experimental procedures for determining the electromagnetic field inside a resonant cavity was proposed.

(951) I. C. Maier, Jr. and J. C. Slater, "Field strength measurements in resonant cavities," *Jour. Appl. Phys.*, vol. 23, pp. 68–77; January, 1952.
(952) J. C. Simons and J. C. Slater, "Electromagnetic resonant behavior of a confocal spheroidal cavity system in the microwave region," *Jour. Appl. Phys.*, vol. 23, pp. 29–30; January, 1952.

Novel waveguide circuits were introduced.

(953) R. H. Reed, "Modified magic tee phase-shifter," Trans. I.R.E., PGAP-1, pp. 126–134; February, 1952.
(954) A. J. Simmons, "A broadband microwave quarter-wave plate," Trans. I.R.E., PGAP-1, pp. 123–125; February, 1952; Proc. I.R.E., vol. 40, pp. 1089–1090; September, 1952.

A number of papers appeared on slotted-line measurements.

(955) H. H. Meinke, "Circular measuring lines with visual indication for frequencies from 10^8 to 3×10^{10}," *Fernmeldetechnisch Zeitschrift* (FTZ), vol. 5, pp. 583–584; September, 1952.
(956) F. Tischer, "Helical measuring line for microwaves," *Zeit. Angew. Physik*, vol. 4; September, 1952.

The problem of surface-wave transmission lines is intimately connected with that of the travelling-wave antenna. Work was done on both, but only papers concerned with the first are listed here.

(957) H. Kaden, "Fortschritte in der Theorie der Drahtwellen," *Arch. elekt. Übertragung*, vol. 5, pp. 399–414; 1951.
(958) R. Adler, "Waves on inhomogeneous cylindrical structures," Proc. I.R.E., vol. 40, pp. 339–348; March, 1952.
(959) R. B. Dyott, "The launching of electromagnetic waves on a cylindrical conductor," *Proc. IEE* (London), pt. III, vol. 99, no. 62, pp. 408–413; November, 1952.

Wave Propagation

Tropospheric Propagation

Propagation Well Beyond the Horizon. Experimental evidence continued to appear in the literature concerning the weak but apparently reliable tropospheric fields propagated several hundred miles beyond the horizon at all vhf and microwave frequencies. Reports on tests on

3,700 and 500 mc in northeastern United States in 1950–1951

(960) K. Bullington, "Radio transmission beyond the horizon in the 40–4000 mc band," Proc. I.R.E. (in press).

summarize the median fields beyond the horizon out to several hundreds of miles as being 50 to 90 db below free space but tens or hundreds of db greater than predicted by conventional theory of propagation around a smooth earth under standard refraction conditions. Antenna gains and beam widths seem to be roughly maintained, in contrast to the original predictions of the turbulent scattering theory under the assumption of blob size small compared to antenna aperture dimensions. The quality of a sound channel transmitted on a 535-mc carrier was reported limited only by noise level, rather than by multipath effects, and the pulse broadening of 1.5-μsec pulses was usually less than a few tenths of a microsecond, indicating that bandwidths of a few megacycles may be possible for this type of propagation. These tests indicate that sufficiently high power and antenna gains will make such circuits reliable for point-to-point hops of several hundred miles over difficult terrain.

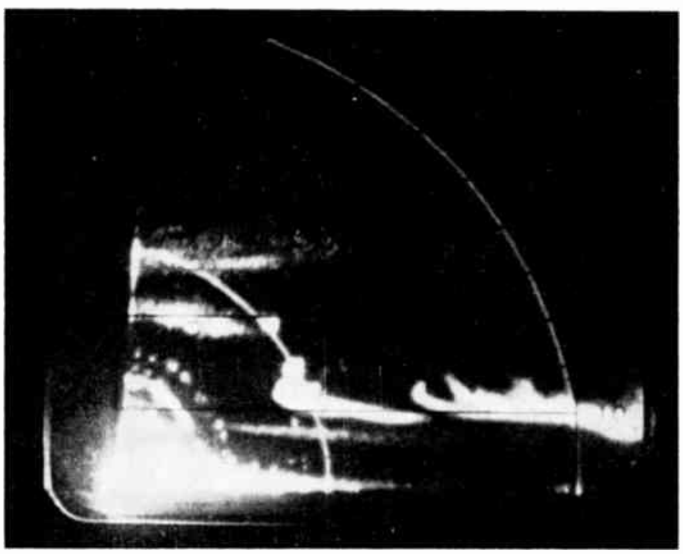

Fig. 14—Weather echoes photographed on the RHI 'scope of an AN/CPS-9 radar. The two perfect marks are 5 and 10 mile slant-range marks; 10 and 20 thousand foot elevation lines are also visible. All echoes in the first 3 miles are from ground targets. The echoes near 20 thousand feet and above are from snow clouds, those near 10 thousand feet are snow showers swept several miles horizontally by surface winds, and the weak horizontal echo at 8 thousand feet is the melting level "bright band." (*M.I.T.*)

The explanation of these reliable, though weak and fading, tropospheric fields became the center of a spirited and as yet unresolved controversy. The first suggested explanation attributed the fields to scattering by omnipresent blobs of atmospheric inhomogeneity in the upper air high over the middle of the path, caused by atmospheric turbulence. The alternative suggestion attributes the fields to a partial internal reflection from the normal atmosphere itself, which is a horizontally stratified inhomogeneous medium under normal conditions, because gravitational forces cause the index of refraction to decrease monotonically with height in the normal troposphere.

(961) T. J. Carroll, "Normal tropospheric propagation deep into the earth's shadow: the present status of suggested explanations," Trans. I.R.E., P.G.A.P., vol. 3, pp. 6–11; August, 1952.
(962) J. Feinstein, "The role of partial reflections in tropospheric propagation beyond the horizon," Trans. I.R.E. P.G.A.P., vol. 2, pp. 2–8; March, 1952; vol. 3, pp. 101–111; August, 1952.
(963) T. J. Carroll, "Internal reflection in the troposphere and propagation beyond the horizon," Trans. I.R.E., P.G.A.P., vol. 2, pp. 9–27; March, 1952; vol. 3, pp. 84–100; August, 1952.
(964) J. F. Colwell and L. J. Anderson, "Concerning the radio field due to internal reflections in the stratified troposphere," Trans. I.R.E., P.G.A.P., vol. 3, pp. 117–125; August, 1952.
(965) M. Katzin, "Tropospheric propagation beyond the horizon," Trans. I.R.E., P.G.A.P., vol. 3, pp. 112–116; August, 1952.

The ultimate decision may be largely determined by direct measurement of the actual intensity, scale, and height distribution of tropospheric turbulence at different times and places. Fortunately, the recently developed microwave refractometer measures directly and almost arbitrarily rapidly the index of refraction of a gas such as moist air, and the instrument has not been made airborne. Profiles of index of refraction versus height in the troposphere can now be directly measured, including fluctuations due to turbulence or other motions of the atmosphere affecting the index of refraction.

(966) C. M. Crain, "Directly recorded tropospheric refractive-index fluctuations and profiles," Trans. I.R.E., P.G.A.P., vol. 3, pp. 79–83; August, 1952.
(967) G. Birnbaum, H. E. Bussey, and R. R. Larson, "The microwave measurement of variations in atmospheric refractive index," Trans. I.R.E., P.G.A.P., vol. 3, pp. 74–78; August, 1952.

The first attempt to use such microwave refractometer data to estimate how intensity of turbulence decreases with height was published.

(968) W. E. Gordon, "Statistical Fluctuations in the Atmosphere," Proc. 2nd Meeting Joint Commission on Radio-Meteorology, URSI, Rue des Minimes 42, Brussels, pp. 74–77; 1951.

Microwave Fading over Optical Paths. Frequency-selective fading, caused by the presence of one or more paths that have slightly different lengths and hence different relative phases of their signals on arrival at the receiver, sets a limit to the usable bandwidth of a single communication channel. For two typical microwave overland paths in New Jersey, tropospheric path differences of the order of one to seven feet were measured directly and correspond to time delays of a few millimicroseconds. The methods employed involved both sweeping a carrier over an 11-per cent frequency range in the 4,000-mc region and the use of pulses only a few millimicroseconds long. Such fine-grained investigations mark the advent of millimicrosecond time measurements and the use of traveling-wave tubes in tropospheric propagation measurements.

Momentary deep fades on optical overwater microwave paths were observed for some years. Experimental observations from New Zealand

(969) D. G. Kiely and W. R. Carter, "An experimental study of fading in propagation at 3-cm wavelength over a sea path," *Jour. IEE* (London), vol. 99, pp. 53–60; March, 1952.

on a 39-mile microwave overwater link indicated that the explanation must lie both in the motion of the lobe interference pattern across the receiving antenna and in some additional atmospheric mechanism (such as atmospheric turbulence perhaps) that makes direct and sea-reflected signals almost exactly equal in magnitude and their resultant very small when they arrive in phase opposition at the receiving antenna.

(970) A. B. Crawford and W. C. Jakes, Jr., "Selective fading of microwaves," *Bell Sys. Tech. Jour.*, vol. 31, pp. 68–90; January, 1952.
(971) O. E. DeLange, "Propagation studies at microwave frequencies by means of very short pulses," *Bell Sys. Tech. Jour.*, vol. 31, pp. 91–103; January, 1952.

Velocity of Propagation. A new method of measurement of the velocity of propagation of 1.25-cm waves by a method analogous to the Michelson interferometer in optics gave the vacuum value of 299,792.6±0.7 km. The value confirms the general tendency of recent measurements to yield a value 13 to 20 km higher than that commonly accepted a decade ago for this fundamental physical constant.

(972) K. D. Froome, "A new determination of the velocity of electromagnetic radiation by microwave interferometry," *Nature*, vol. 169, pp. 107, 108; January, 1952.

Frequency-Spectrum Conservation. A report issued by the IRE-RTMA Joint Technical Advisory Committee contains summary chapters on propagation characteristics 30–3000 Mc by C. R. Burrows, and 3–300 KMc by G. C. Southworth.

(973) Joint Technical Advisory Committee, IRE-RTMA, "Radio Spectrum Conservation," McGraw Hill-Book Co., Inc., New York, N. Y., pp. 91–125; 1952.

These chapters aim to survey in as simple a manner as possible the broad features of propagation knowledge that must influence wise choice of frequency bands in the vast portion of the radio spectrum in which the troposphere is the dominant influence.

Radio Meteorology. Since 1945 there have been several active programs of research in radio meteorology, with particular attention directed toward microwave scattering by raindrops, snowflakes, and cloud particles. Progress was made toward a better understanding of the scattering processes that are of interest to those wishing to eliminate weather echoes from radar scopes, as well as to those who interpret weather echoes usefully, and that are of obvious importance to anyone studying tropospheric propagation. Because most of the important technical developments were described in report form, not widely available, it seems best to mention each major research project and describe its recent accomplishments.

The Signal Corps Engineering Laboratories at Belmar, New Jersey maintained a Weather Radar Section, which has engineered several unusual equipments. First was the CPS-9, a powerful X-band radar especially designed for the Air Weather Service, and now in production.

(974) E. L. Williams, "Progress Report on the AN/CPS-9 Radar Program," Proc. Third Radar Weather Conf., McGill Univ., Canada, pp. C21–24; September, 1952.

Second was a cloud base and top indicator, a powerful K-band set normally arranged to point vertically and plot the range (i.e., altitude) of any clouds or cloud layers passing overhead.

(975) F. W. Fisher, W. B. Gould, and C. L. Greenslit, "Radar cloud base and top indicator," Proc. Third Radar Weather Conf., McGill Univ., Canada, pp. E1–8; September, 1952.

Due to the very small particle size of fair-weather cumulus (less than 20 microns), some of these are not detected; most other clouds leave clear records. This type of radar also detects angels in the lower atmosphere almost continuously, but these echoes are easily distinguished from clouds.

The Signal Corps has continuously sponsored since 1946 a research project in the Meteorology Department at the Massachusetts Institute of Technology. This project has concentrated on accurate measurement of both the radar echo and meteorological paramenters of precipitation. The objectives are to learn more about the scattering process from different types of natural precipitation, as compared with idealized, uniform, spherical particles, and also to advance the usefulness of radar techniques in meteorological research an weather observation. Very careful measurements indicate that radar echoes at 10- and 3-cms wavelength from rain are consistently 6 or 7 db lower than would be anticipated from measured rain rates at the ground or from liquid water contents measured aloft by aircraft.

(976) P. M. Austin and H. E. Foster, "Note on comparison of liquid water content of air with radar reflectivity," *Jour. Met.*, vol. 7, pp. 160–161; April, 1950.
(977) P. M. Austin, "Comparison of Average Signal Intensity with Rainfall Rate," *Proc. Conf. on Water Resources*, Bul. 41, Illinois State Water Survey, pp. 227–233; October, 1951.

Both observation and theory have established that the nature of the fluctuating character of weather echoes can reveal information about the relative velocities of raindrops, turbulence, and other motions within precipitation.

(978) A. Fleisher, "The Information Obtainable from Fluctuation Measurements," *Proc. Third Radar Weather Conf.*, McGill Univ., Canada, pp. G9–14; September, 1952.

Through regular use of radar and aircraft during storms, much has been learned about the precipitation forms, processes, and flight conditions occurring within them as related to the radar information.

(979) P. M. Austin and A. C. Bemis, "A quantitative study of the 'bright band' in radar precipitation echoes," *Jour. Met.*, vol. 7, pp. 145–151; April, 1950.
(980) H. E. Foster, "The Use of Radar in Weather Forecasting with Particular Reference to Radar Set AN/CPS-9," Tech. Rep. No. 20, M.I.T. Weather Radar Research, Cambridge, Mass.; September, 1952.
(981) R. M. Cunningham, "The Distribution and Growth of Hydrometeors around a Deep Cyclone," Tech. Rep. No. 18, M.I.T. Weather Radar Research, Cambridge, Mass.; May, 1952.

The Air Force Cambridge Research Center maintains an active program in this field. Especially developed radar systems are used particularly for vertical probing through cloud systems and precipitation. Much has been learned about processes initiating precipitation, microwave attenuation due to rain, scattering from cloud particles, and scattering of polarized radiation from nonspherical particles.

(982) D. Atlas and H. C. Banks, "The interpretation of microwave reflections from rainfall," *Jour. Met.*, vol. 8, pp. 271–282; October, 1951.

(983) V. G. Plank, D. Atlas, and W. H. Paulsen, "Preliminary Survey of Cloud and Precipitation Detection at 1.25 CM," Proc. Third Radar Weather Conf., McGill Univ., Canada, pp. B13–20; September, 1952.

For three years the Air Force has sponsored some of the research in precipitation physics carried on by the Stormy Weather Group at McGill University, which includes extensive studies of the details of microwave scattering from precipitation. Emphasis there was appropriately placed on snow,

(984) J. S. Marshall and K. L. S. Gunn, "Measurement of snow parameters by radar," *Jour. Met.*, vol. 9, pp. 322–327; October, 1952.

and melting snow that creates the familiar horizontal bright band on range-height indicators.

(985) M. Kerker, P. Langleben, and K. L. S. Gunn, "Scattering of microwaves by a melting, spherical ice particle," *Jour. Met.*, vol. 8, p. 424; December, 1951.

The fluctuating character of weather echoes received interesting statistical treatment indicating that even though weather echoes are similar to noise they may be detectable well below noise level by analysis of a number of return pulses.

(986) W. Hitschfeld, "Detectability of Threshold Echoes," Proc. Third Radar Weather Conf., McGill Univ., Canada, pp. G15–18; September, 1952.

The University of Chicago, University of Illinois, and Illinois State Water Survey co-operatively operated a project particularly directed toward measuring rainfall rates by radar. They demonstrated that a properly calibrated radar can measure the rainfall rate over small areas of an acre or two with satisfactory accuracy, or total rainfall over a large area with better accuracy than ordinary rain-gauge networks.

(987) F. A. Huff and G. E. Stout, "Area-depth studies for thunderstorm rainfall in Illinois," *Trans. Amer. Geophys. Union*, vol. 33, pp. 495–498; August, 1952.

Their program is expanding.

Recent work in England and Australia,

(988) J. E. N. Hooper and A. A. Kippax, "The bright band—a phenomenon associated with radar echoes from falling rain," *Quart. Jour. R. Met. Soc.*, pp. 125–132; April, 1950.
(989) E. G. Bowen, "Radar observations of rain and their relation to mechanisms of rain formation," *Jour. Atmos. and Terr. Phys.*, vol. I, pp. 125–140; 1951.

and other groups in the United States, used radar primarily as a meteorological tool for exploration of precipitation processes. Its exceptional value in this field is clearly demonstrated.

Radio Astronomy

Solar Radio Waves. Routine measurements of solar radiations in the radio-frequency band are now being made on approximately a dozen wavelengths at various observing stations scattered throughout the world, and both instruments and methods for conducting special investigations have been improved.

Instances of the association of some of the abnormal solar radio emissions with solar and geophysical phenomena of other types (such as flares, sudden ionospheric disturbances, increases of the intensity of primary cosmic rays, and the like) continued to be reported despite the decline of sunspot activity throughout the past five years. Solar outbursts of wavelength less than 1 cm were recorded for the first time during May through September, 1951; four out of the five such bursts detected by Hagen and Hepburn on a wavelength of 8.5 mm occurred in association with flares.

(990) "American astronomers report," *Sky and Telescope*, vol. 11, pp. 169–171; May, 1952.
(991) R. E. Burgess and C. S. Fowler, "Solar activity and ionospheric effects," *Wireless Eng.*, vol. 29, pp. 46–50; February, 1952.
(992) J. P. Hagen and N. Hepburn, "Solar outbursts at 8.5-mm. wave-length," *Nature* (London), vol. 170, pp. 244–245; August 9, 1952.
(993) T. Hatanaka and F. Moriyama, "On some features of noise storms," *Rep. Ionosphere Res. Japan*, vol. 6, pp. 99–109; 1952.
(994) A. Maxwell, "Possible identification of a solar M-region with a coronal region of intense radio emission," *Observatory*, vol. 72, pp. 22–26; February, 1952.
(995) J. A. Simpson, W. Fonger, and L. Wilcox, "A solar component of the primary cosmic radiation," *Phys. Rev.*, vol. 85, pp. 366–368; January 15, 1952.

The annular and total solar eclipses of September 1, 1951 and February 25, 1952, respectively, provided radio astronomers with excellent opportunities for determining the distribution of radio emission as a function of position on the sun's disk. The earlier eclipse was observed on frequencies of 9,350 and 169 mc and the later eclipse on frequencies of 550 and 255 mc by French observers, and on frequencies of 35,000 and approximately 3,000 mc by an expedition from the United States. Observations outside the path of totality of the 1952 eclipse were also made on 169 mc by observers in France and in French West Africa. The sun was relatively "quiet" during both eclipses.

Two conclusions drawn from observation of the 1951 eclipse were 1) on 9,350 mc, the sun's disk shows limb brightening, and 2) the effective diameter of the sun's disk on 169 mc was approximately 1.4 times as great as the optical diameter. Measurements made during the 1952 eclipse confirm that the sun's disk as observed on 169 mc was very much larger than the optical disk, and indicate further that it lacks radial symmetry and has the shape of a considerably flattened ellipse whose major axis coincides with the equatorial diameter.

(996) J. F. Denisse, E. J. Blum, and J. L. Steinberg, "Radio observations of the solar eclipses of September 1, 1951, and February 25, 1952," *Nature* (London), vol. 170, pp. 191–192; August 2, 1952.
(997) M. Laffineur, R. Michard, J. C. Pecker, M. d'Azambuja, A. Dollfus, and I. Atanasijević, "Observations combinées de l'éclipse totale de soleil du 25 février 1952 à Khartoum (Soudan) et de l'éclipse partielle au radio-télescope de l'Observatoire de Meudon," *Compt. Rend.* (Paris), vol. 234, pp. 1528–1530; April 7, 1952.

Interferometer techniques continued to be widely used for locating on the solar disk the positions of sources of solar radio emissions. An instrument built at the Commonwealth Scientific and Industrial Research Organization, Australia enabled both the position and polarization of a source to be determined within a time interval of less than a second. With this instrument, the positions of the sources of some thirty noise storms were revealed and six of these studied in detail. The intensity of such a storm appeared to be more closely related to the size of the largest spot in the group of sunspots with which the storm is associated than to the size of the group as a whole, and the sense of the circular polarization of the radio emission appeared to be dependent on the polarity of the magnetic field of the associated spot. The rapid motions of the sources of six solar outbursts were followed, and it was found that in the early stages such sources usually tend to move swiftly outward toward, and sometimes even beyond, the solar limb.

(998) A. G. Little and R. Payne-Scott, "The position and movement on the solar disk of sources of radiation at a frequency of 97 mc/s. I. Equipment," *Aust. Jour. Sci. Res.*, ser. A, vol. 4, pp. 489–507; December, 1951.
(999) R. Payne-Scott and A. G. Little, "The position and movement on the solar disk of sources of radiation at a frequency of 97 mc/s. II. Noise storms," *Aust. Jour. Sci. Res.*, ser. A, vol. 4, pp. 508–525; December, 1951.
(1000) R. Payne-Scott and A. G. Little, "The position and movement on the solar disk of sources of radiation at a frequency of 97 mc/s. III. Outbursts," *Aust. Jour. Sci. Res.*, ser. A, vol. 5, pp. 32–46; March, 1952.

The occultation of the radio star in Taurus by the solar corona was observed at Cavendish Laboratory in June, 1952, with an interferometer of large resolving power. The corona was observed to affect the radiation from the radio star even when the angular distance of the radio star from the sun's center was as great as ten times the sun's optical radius.

(1001) K. E. Machin and F. G. Smith, "Occultation of a radio star by the solar corona," *Nature* (London), vol. 170, pp. 319–320; August 23, 1952.

The line spectrum of atomic hydrogen was investigated and found to include an absorption line, produced by the $2^2S_{1/2}-2^2P_{3/2}$ fine-structure transition, which may be observable in the solar spectrum at a frequency of about 10,000 mc.

(1002) J. P. Wild, "The radio-frequency line spectrum of atomic hydrogen and its applications in astronomy," *Astrophys. Jour.*, vol. 115, pp. 206–221; March, 1952.

Other recent theoretical studies of solar radio emissions dealt primarily with the interpretation of these radiations in terms of plasma oscillations.

(1003) J. F. Denisse and Y. Rocard, "Excitation d'oscillations électroniques dans une onde de choc. Applications radioastronomiques," *Jour. Phys. Rad.*, vol. 12, pp. 893–899; December, 1951.
(1004) J. Feinstein, "Condition for radiation from a solar plasma," *Phys. Rev.*, vol. 85, pp. 145–146; January 1, 1952.
(1005) R. Q. Twiss, "On Bailey's theory of amplifier circularly polarized waves in an ionized medium," *Phys. Rev.*, vol. 84, pp. 448–457; November 1, 1951.
(1006) R. Q. Twiss, "Excess radio noise from solar flares and sunspots," *Nature* (London), vol. 169, pp. 185–186; February 2, 1952.

Galactic Radio Waves. The list of frequencies of observed galactic radio-frequency radiation were considerably extended on the high-frequency side by the successful measurement of such radiation on 255, 1,210, and 3,000 mc per second. Contour lines giving the distribution of the 255-mc radiation over the sky were deduced. The first detailed measurements at a frequency (18.3 mc) near the opposite end of the observable range were also reported, and contour lines showing the distribution of equivalent temperature at this frequency in a zone of the sky centered at declination $-34°$ were derived. The observed temperatures were found to be much higher, and the ratio of maximum to minimum much lower, at 18.3 mc than at 100 mc.

(1007) I. Atanasijević, "Mesures du rayonnement de la Voie Lactée sur 255 mc/s.," *Compt. Rend.* (Paris), vol. 235, pp. 130–132; July 16, 1952.
(1008) J. H. Piddington and H. C. Minnett, "Observations of galactic radiation at frequencies of 1210 and 3000 mc/s.," *Aust. Jour. Sci. Res.*, ser. A, vol. 4, pp. 459–475; December, 1951.
(1009) C. A. Shain, "Galactic radiation at 18.3 mc/s.," *Aust. Jour. Sci. Res.*, ser. A, vol. 4, pp. 258–267; September, 1951.

Two Australian scientists published the first contours showing the distribution on the sky of a galactic-line emission in the radio spectrum. The emission line in question, which occurs at 1,420 mc and results from a hyperfine-structure transition of hydrogen, was found in certain directions to consist of two components. If the separation is an effect of galactic rotation, as seems reasonable to assume, the measurement of the displacements of the components will yield a determination of the distances of the sources. A powerful method for the investigation of the structure of the galaxy is therefore suggested.

(1010) W. N. Christiansen and J. V. Hindman, "21 cm line radiation from galactic hydrogen," *Observatory*, vol. 72, pp. 149–151; August, 1952.

A survey of the southern sky on a frequency of 101 mc revealed the presence of 77 discrete sources of radio emission. Although the more intense of these sources are concentrated toward the galactic equator, the weaker ones tend to be randomly distributed. The number of known discrete sources now exceeds 100. Attempts to identify them as a group with a particular type of astronomical object were unsuccessful, but identifications of a number of individual sources were made. Within the past year, for example, several external galaxies, two clusters of galaxies, and the remnants of Tycho Brahe's supernova of 1,572 were all identified as sources of radio-frequency radiation. Attempts to use an interferometer of high precision for the measurement of parallaxes or proper motions of four of the prominent radio stars yielded negative results.

(1011) R. H. Brown and C. Hazard, "Extra-galactic radio-frequency radiation," *Phil. Mag.*, vol. 43, pp. 137–152; February, 1952.
(1012) R. H. Brown and C. Hazard, "Radio-frequency radiation from Tycho Brahe's supernova (A.D. 1572)," *Nature* (London), vol. 170, pp. 364–365; August 30, 1952.
(1013) B. Y. Mills, "The distribution of the discrete sources of cosmic radio radiation," *Aust. Jour. Sci. Res.*, ser. A, vol. 5, pp. 266–287; June, 1952.
(1014) F. G. Smith, "An attempt to measure the annual parallax or proper motion of four radio stars," *Nature*, vol. 168, pp. 962–963; December 1, 1951.

Among the discrete sources that were recently studied in particular detail are the Andromeda Nebula, the Cygnus radio star, and a diffuse source near the latter. The 158.5-mc radiation from the Andromeda Nebula was observed with a 218-foot paraboloidal antenna whose beam width to half power is only 2° at this frequency. The measured intensity of the radiation agreed well with the intensity predicted on the assumption that the Andromeda Nebula is similar to our galaxy. A prominent discrete source with an angular extent of around 10° was discovered in Cygnus, and spectrum curves for this radio nebula and for the Cygnus radio star were derived from observations on half a dozen frequencies in the range from 60 to 3,000 mc. The spectrum of the extended source differs from both that of the radio star and that of the general galactic radiation, and the source was tentatively identified with the bright galactic nebulas surrounding γ Cygni.

(1015) R. H. Brown and C. Hazard, "Radio emission from the Andromeda Nebula," *Mon. Not. R. Astr. Soc.*, vol. 111, pp. 357–367; 1951.
(1016) R. H. Brown and C. Hazard, "A radio survey of the Cygnus region. I. The localized source Cygnus (1)," *Mon. Not. R. Astr. Soc.*, vol. 111, pp. 576–584; 1951.
(1017) J. H. Piddington and H. C. Minnett, "Radio-frequency radiation from the constellation of Cygnus," *Aust. Jour. Sci. Res.*, ser. A, vol. 5, pp. 17–31; March, 1952.

An analysis of the 100-mc galactic radiation indicated that a single spheroidal source distribution cannot account for the observed intensities in the direction away from the galactic plane.

(1018) J. G. Bolton and K. C. Westfold, "Galactic radiation at radio frequencies. IV. The distribution of radio stars in the galaxy," *Aust. Jour. Sci. Res.*, ser. A, vol. 4, pp. 476–488; December, 1951.

Ionospheric Propagation[2]

The ionosphere comprises all of the upper atmosphere beyond about 60 km. It is perhaps this simple matter of definition which makes its study so broad in scope and which currently produces several hundred new papers annually.

Radio wave propagation in the ionosphere is dependent upon the physical state of the ionosphere at the particular time and place. Thus the radio engineer must inevitably become concerned with matters which are more properly the concern of the scientist.

It is not an easy matter to describe progress in a categorical and neatly classified way because of the interdependeace of most of the subjects of investigation. Neither is it possible in the space available here to treat a comprehensive list of subjects. However, topics selected from the agenda of Commission 3 (ionospheric radio wave propagation), of the Tenth General Assembly of the International Scientific Radio Union (URSI) held in Sydney, Australia, in August, 1952, will serve to point out some of the most significant matters under investigation by leading researchers.

A meeting was held at the National Bureau of Standards in Washington, D. C. in April, 1952, which was jointly sponsored by URSI and the IRE Professional Group on Antennas and Propagation. The papers presented at this meeting were abstracted in the PROCEEDINGS OF THE I.R.E. in June, 1952. The complete proceedings of the meeting, including some nonscheduled papers, are available in the TRANSACTIONS OF THE I.R.E., PGAP-3, in August, 1952, issued by the Professional Group.

[2] This account is an abridgement of the paper, M. G. Morgan, "Progress in ionospheric research during 1952."
D.S.I.R. Abstracts refer to those prepared by the Department of Scientific and Industrial Research in London and carried monthly in PROC. I.R.E.
R.I.R.J. Abstracts refer to those carried in Report of *Ionospheric Research in Japan* (approximately quarterly; in English).

A new edition (second) of S. K. Mitra's book, "The Upper Atmosphere" (The Asiatic Society, 1 Park St., Calcutta), has been published this year. This book is by far the most comprehensive treatment of the subject available. The appearance of the second edition, only five years after the first, is a manifestation of the speed with which our knowledge of the upper atmosphere is increasing.

Movements of the Ionosphere. It is now generally recognized that there exist in the ionosphere, in addition to motions due to tides, motions due to pressure gradients caused by temperature inequalities. In the F region, large-scale movement is certainly profoundly affected by additional forces arising from the motion of the charged particles in the geomagnetic field. D. F. Martyn pointed out at the URSI Assembly that, though the tidal motions are mainly horizontal, the ions and electrons are constrained to move along the terrestrial magnetic lines of force. This motion has, in general, a vertical component except at the equator. This behavior explains many of the known anomalies of the F_2 layer and the small but significant departures of the E and F_1 regions from the ideal Chapman region. A further consequence of these considerations is that the usual methods of measuring the recombination coefficient from observations of the diurnal variation of ionization need to be modified.

Martyn pointed out that a polarization field is developed by the motion of the charged particles across the magnetic field (Hall effect) and that this also gives rise to vertical drifts of ions and electrons.

(1019) O. Lindberg, "Hall effect," PROC. I.R.E., vol. 40, pp. 1414–1419; November, 1952.

There are, in addition, traveling disturbances of smaller scale (the order of a few km) which can be observed as the transit of some characteristic feature of the ionization, such as a hump in the virtual-height versus frequency curve, from one observatory to another. There is the possibility that these may not always represent actual transport of charged particles although recombination rates would have to be very high in some cases if they were not.

The speed and direction of the movements are observed to have diurnal, seasonal, and height dependences. Horizontal velocities are of the order of hundreds of meters per second and vertical velocities of the order of 5.

L. A. Manning has pointed out that "average wind velocity," to be significant, must include a definition of the domain thickness and the nature of the turbulence. R. Gallet has gone so far as to suggest that the continuing enigma of sporadic ionization in the E region may be accounted for by turbulence wherein fluctuations of atmospheric density produce electron concentration without invoking additional ionization. (See the discussion herein of "sporadic-E ionization" under the section title *Miscellaneous.*)

The following selected references are about one-third of the number which have appeared in the past year on this subject.

(1020) G. J. Phillips "Measurements of winds in the ionosphere," *Jour. Atmos. Terr. Phys.*, vol. 2, pp. 141–154; 1952. D.S.I.R. Abstract 1916.

(1021) R. E. Jones, G. H. Millman, and R. J. Nertney, "Turbulence in the lower ionosphere as deduced from increments in absorption and phase path at 150 kc/s," TRANS. I.R.E., PGAP-3, p. 139; August, 1952. (Abstract.) Also abstracted in PROC. I.R.E., vol. 40, p. 744 (paper no. 43); June, 1952.

(1022) A. Hewish, "The diffraction of galactic radio waves as a method of investigating the irregular structure of the ionosphere," *Proc. Roy. Soc. A*, vol. 214, pp. 494–514, October, 1952. See also *ibidem*, vol. 209, pp. 81–96, October, 1951. D.S.I.R. Abstract 1284.

(1023) J. S. Greenhow, "A radio echo method for the investigation of atmospheric winds at altitudes of 80–100 km," *Jour. Atmos. Terr. Phys.*, vo.. 2, pp. 282–291; 1952. D.S.I.R. Abstract 3083.

(1024) L. A. Manning, O. G. Villard, Jr., and A. M. Peterson, "Double-Doppler study of meteoric echoes," *Jour. Geophys. Res.*, vol. 57, pp. 387–404; September, 1952.

(1025) J. Feinstein, "On nature of the decay of a meteor trail," *Proc. Phys. Soc. B*, vol. 65, p. 741; September, 1952. (Correspondence.)

Effective Conductivity of the Ionosphere. At the URSI Assembly, W. G. Baker and D. F. Martyn presented their paper with the above title. They pointed out that the height-integrated conductivity of the ionosphere need not be greater than about 5 to 10×10^{-8} emu to satisfy the rsquirements of the dynamo theory. The best and most recent study of ionospheric conductivity indicates a value no greater than about 4.5×10^{-9} emu.

(1026) D. R. Bates and H. S. W. Massey, "The negative ion concentration in the lower ionosphere," *Jour. Atmos. Terr. Phys.*, vol. 2, pp. 1–13; 1951. D.S.I.R. Abstract 983. See also *ibidem*, pp. 253–254; 1952. (Correspondence.) D.S.I.R. Abstract 2796.

The ionospheric conductivity thus appears to be deficient by a factor of at least 12.

It was shown by Baker and Martyn that the ionosphere, considered as a thin sheet in which vertical currents are prohibited by polarization, has height-integrated Hall conductivity, at right angles to the electric field, some 3 to 3.5 times greater than the direct conductivity. Combining the direct conductivity and the Hall conductivity suitably, they show that the effective conductivity is 5×10^{-8} as required by the dynamo theory. Within a few degrees of the magnetic equator, the Hall conductivity diminishes rapidly, but the direct east-west conductivity increases rapidly. This results in an effective conductivity, in a narrow strip at the equator, about 2.4 times that over the rest of the earth, thus explaining the equatorial enhancement of the daily magnetic variation. Since the current is nearly at right angles to the electric field over most of the earth, but parallel to it at the magnetic equator, the electric field must undergo a rapid phase shift of nearly $\pi/2$ within a few degrees of the equator. In this region the current will be centered at 100 km $\pm$10 km, but in higher latitudes should be mainly between 120–150 km.

Essentially the same observations have apparently been made by M. Hirono.

(1027) M. Hirano, "On the influence of the Hall current to the electrical conductivity of the ionosphere," *Rep. Ionospheric Res.* (Japan), vol. 6, pp. 44–45. Also, under the same title, pt. I, *Jour. Geomag. Geoele.* (Japan), vol. 2, p. 1; 1950. R.I.R.J. Abstract no. I-1. pt. II, *ibidem*, vol. 2, p. 113; 1950. R.I.R.J. Abstract no. I-2.

J. A. Ratcliffe has shown that many of the anomalies of *F*-layer critical frequencies vanish when one considers instead the height-integral of electron density. He and J. M. Kelso have presented different, rapid means of obtaining the true height distribution of electron density from virtual height versus frequency records.

(1028) J. A. Ratcliffe, "Some regularities in the F2-region of the ionosphere," *Jour. Geophys. Res.*, vol. 56, pp. 487–507; December, 1951. D.S.I.R. Abstracts 1294. Also, "A quick method for analyzing ionospheric records," *ibidem*, pp. 463–485. D.S.I.R. Abstract 1292.

(1029) J. M. Kelso, "A procedure for the determination of the vertical distribution of the electron density in the ionosphere," *Jour. Geophys. Res.*, vol. 57, pp. 357–368; September, 1952.

Ionospheric Storm Phenomena. D. F. Martyn has analyzed ten years of hourly F_2-region virtual height and critical frequency records taken from selected latitudes. He has found that diurnal disturbance variations of these quantities exist which closely parallel those of the magnetic field. A correspondence is also found on a "storm-time" scale. Previous theories of these F_2-region disturbances attribute them to bombardment of the region by particles from the sun. Martyn finds such theories invalid and proposes that they are due, like tidal variations, to electric fields in the ionosphere. The fields, he believes, are created by the intense current systems in the auroral zones, and are spread over the earth according to Laplace's theorem. Over most of the earth, the drift is such as to raise the average height of the F_2-region, and to spread out its ionization, thus reducing the critical frequency on the average. Near the equator, however, the drift due to the electric field of the magnetic disturbance counteracts that due to the normal "quiet-day" field (refer to preceding discussion on Hall conductivity) and leads on the average to increased critical frequency since it counteracts the normal spreading out of the ionization in the vertical direction. In the early morning, the effect of storms is enormous, since it prevents the F_2-region from falling into the recombination "sink" at about 200 km, and this is generally noted in critical frequency data as the onset of the storm. The Hall conductivity is invoked to account for some six hours phase difference between the phase of the solar diurnal magnetic variation (S_D) at the equator and in the auroral zone. The onset is simultaneous over the world, but is most noticeable at locations where the local time of magnetic storm commencement occurs at the time of steepest slope of the S_D curve.

The effect of a storm lasts about three days, since this is the time necessary for the F_2-region to settle to "steady-state" variation under the "quiet-day" tidal influence. The early behavior of the critical frequency in "storm-time" depends markedly on the local time of occurrence of the sudden commencement. If the magnetic storm commences at a local time when the S_D versus critical-frequency curve is near its maximum positive value, the critical frequency is immediately depressed. If the storm commences at a time when the critical frequency is increasing, the critical frequency is raised. There is no evidence of a time progression of disturbance from the polar zones; disturbance in the F_2-region is simultaneous throughout the world. However, the local time effect described may give rise to false impressions of such a progression owing to the time phase change with latitude, ascribed to the Hall conductivity, of the onset. Storms commencing near sunset exhibit only a negative phase (depressed critical frequency) whereas those commencing near sunrise exhibit first a positive phase (enhanced critical frequency) and then a negative phase in a day or so. In general, storms cause a tendency towards summer conditions and amplified tidal oscillations.

This model of ionospheric storms was presented by Martyn at the URSI Assembly in Australia and represents the progress in his thinking since the presentation of his theory of magnetic storms and auroras at the URSI Assembly in Zurich in 1950 and reported last year in these pages.

(1030) D. F. Martyn, "The theory of magnetic storms and auroras," *Nature*, vol. 167, p. 92; January, 1951. See also the note, T. Nagata, "On the position of the auroral zone," *Rep. Ionospheric Res.* (Japan), vol. 6, pp. 159–161; September, 1952.

Although not yet assured of survival, Martyn's thoughts on magnetic storms, auroras, and ionospheric storms are some of the best ideas available today.

J. H. Meek has analyzed data from Canadian and other high latitude stations and found that disturbances appear first in one part of the auroral zone and then move around the earth with the sun for several days. Maximum depressions (of F_2 critical frequency) occur in the southern part of the auroral zone at 60 to 65° N geomagnetic latitude. Absorption is very high in the auroral zone and extends southward in a manner similar to the geographical distribution of critical frequency depression. Blackouts usually come during the morning hours, but in severe disturbances may be effective continuously for several days. Few occur during winter.

(1031) J. H. Meek, "Ionospheric disturbances in Canada," *Jour. Geophys. Res.*, vol. 57, pp. 177–190; June, 1952. D.S.I.R. Abstract 2805.

R. Lindquist has studied polar blackouts in Sweden and finds strong correlation with magnetic measurements, the aurora, and a type of sporadic-E designated N_1. Lindquist finds a tendency for blackouts to reappear at the same time for two or more days.

(1032) R. Lindquist, "Polar blackouts recorded at the Kiruna observatory," *Acta. Polyt.* (Stockholm), no. 85, 25 pp.; 1951. D.S.I.R. Abstract 783.

The Japanese have been particularly active in the matter of investigating ionospheric storm phenomena. It is not considered necessary to review their work in detail here because of the agreement for the most part with the preceding account. However, the reader who is interested in delving further into this subject will want to review the Japanese literature, including their documents which were transmitted in considerable number to the URSI Assembly in Australia.

The ionospheric prediction services of a number of countries are issuing routine storm warnings with increasing success. The warnings are based upon the observations of co-operating solar observatories. The problem of learning what solar events produce geomagnetic and ionospheric storms is one of the challenging frontiers of solar physics.

Radio Propagation by Scattering. An account of the propagation of vhf signals by scattering from the regular ionosphere, as described in these pages last year, has been published by the authors of that work.

(1033) D. K. Bailey, R. Bateman, L. V. Berkner, H. G. Booker, G. F. Montgomery, E. M. Purcell, W. W. Salisbury, and J. B. Wiesner, "A new kind of radio propagation at very high frequencies observable over long distances," *Phys. Rev.*, vol. 86, pp. 141–145; April 15, 1952.

J. C. W. Scott stated at the URSI Assembly that steady backscatter is obtained from the ionosphere at Saskatoon from 100-km height at 50 mc and 400-km range. It is not seen at 100 mc. Investigators at Cornell University are now completing instrumentation intended to detect vertical backscatter of vhf.

Long-distance backscatter of hf has received a great impetus now that it is realized that detectable signals can be obtained with low power (hundreds of watts) by using pulses of the order of milliseconds. The usefulness of such experiments is also greatly enhanced by the discovery that the backscatter is almost entirely from the ground, via the ionosphere, and not from the ionosphere itself. It is a surprising fact that there is negligible difference in the effectiveness of ground and water as scattering regions. There appears to be every likelihood that this technique will greatly augment vertical incidence measurements in oblique path-propagation evaluation.

(1034) W. G. Abel and L. C. Edwards, "The source of long distance backscatter," Proc. I.R.E., vol. 39, pp. 1538–1541; December, 1951. D.S.I.R. Abstract 1082.
(1035) J. T. deBettencourt, "Instantaneous prediction of ionospheric transmission circuits by the communication zone indicator (COZI)," Trans. I.R.E., PGAP-3, pp. 202–209; August, 1952.
(1036) O. G. Villard, Jr. and A. M. Peterson, "Scatter-sounding: A technique for study of the ionosphere at a distance," Trans. I.R.E., PGAP-3, pp. 186–201; August, 1952. Abstracted in Proc. I.R.E., vol. 40, p. 746 (paper no. 57); June, 1952. Also, "Instantaneous prediction of radio transmission paths," *QST*, vol. 36, pp. 11–19; March, 1952. Also, "Scatter-sounding: A new technique in ionospheric research," *Science*, vol. 116, pp. 221–224; August 29, 1952.

The aurora will reflect vhf radio signals. Its irregular and changing nature constitutes a somewhat unusual scattering medium. The quality of radio signals reflected from the aurora is poor, and K. L. Bowles has found the power-spectrum of the fading to have frequency components of roughly equal strength from zero to a cut-off frequency of 100 to 200 c.

(1037) R. K. Moore, "Theory of radio scattering from the aurora," Trans. I.R.E., PGAP-3, pp. 217–229; August, 1952. Abstracted in Proc. I.R.E., vol. 40, p. 747 (paper no. 65); June, 1952.
(1038) K. Bowles, "The fading rate of ionospheric reflections from the aurora borealis at 50 mc/s," *Jour. Geophys. Res.*, vol. 57, pp. 191–196; June, 1952. D.S.I.R. Abstract 2876.

LF and VLF Ionospheric Propagation. There has been further reporting on the extensive oblique path program of investigation on these frequencies at the Cavendish Laboratory at Cambridge University.

In passing from the range 90–200 km, to 535 km, at 16 kc, the following facts are noted:

1. At short distances the reflection coefficient is about 0.15 by day and 0.50 at night in summer; the corresponding values at 535 km are 0.3 and 0.55.

2. At distances from 90 to 535 km the waves are reflected from an apparent height of about 74 km at midday and about 92 km at night. The way in which the height varies with the inclination of the sun's rays is markedly different for the two paths.

3. At 535 km, sid produces a lower reflection height but little change in amplitude of the downcoming wave. During and after severe magnetic storms the diurnal variation of the signal amplitude is abnormal, the abnormality persisting for as long as 38 days.

At 70–128 kc, significant changes are also noted in passing to longer distances. Information is available at 100 km and from 350–950 km and the following facts are noted:

1. At 100 km the absorption shows marked solar control, increasing about one hour before ground sunrise. At greater distances, the reflection coefficient is found to increase steadily with distance. At midday in summer on 70 kc it is found to be 0.02 at 300 km and 0.09 at 800 km. It is found to be less on higher frequencies, and in winter the values are roughly doubled.

2. At 100-km range, the apparent height of reflection on a summer day is about 70 km. It increases, on the average, 7–8 km from day to night. The change commences at about ground sunrise rather than an hour before as with absorption. Results at 350-km range were nearly identical, but at 850–950-km range it was found that both the absorption and apparent height change about one hour before ground sunrise at the midpoint of the path. The daytime apparent height of reflection is 70 km as for the shorter ranges, but the increase at night is of the order of 20 km.

3. At 100 km, the effect of sid is to reduce the amplitude of the sky wave by a factor of about 0.01 and to decrease the apparent height by as much as 10 km. At 850–950 km, sid causes the amplitude of the sky wave to increase by as much as five times and sometimes to reach its nighttime value.

(1039) R. N. Bracewell, "The ionospheric propagation of radio waves of frequency 16 kc/s over distances of about 200 km," *Proc. IEE* (London), vol. 99, pt. IV, pp. 217–228; July, 1952. D.S.I.R. Abstract 2870.

(1040) W. C. Bain, R. N. Bracewell, T. W. Straker, and C. H. Westcott, "The ionospheric propagation of radio waves of frequency 16 kc/s over distances of about 540 km," *Proc. IEE* (London), vol. 99, pt. IV, pp. 250–259; July, 1952. D.S.I.R. Abstracts 2871.

(1041) K. Weekes and R. D. Stuart, "The ionospheric propagation of radio waves with frequencies near 100 kc/s over short distances," *Proc. IEE* (London), vol. 99, pt. IV, pp. 29–37; April, 1952. D.S.I.R. Abstract 3533.

(1042) K. Weekes and R. D. Stuart, "The ionospheric propagation of radio waves with frequencies near 100 kc/s over distances up to 1000 km," *Proc. IEE* (London), vol. 99, pt. IV, pp. 38–46; April, 1952. D.S.I.R. Abstract 3534.

The construction of a sweep-frequency recorder covering the range 50–1,000 kc has been described and sample records taken. Results so far have been good throughout most of the frequency range at night, but daytime records are not complete, especially in the summer months.

(1043) J. C. Blair, J. N. Brown, and J. M. Watts, "A sweep frequency ionosphere recorder for the low frequencies," TRANS. I.R.E., PGAP-3, p. 185; August, 1952. (Abstract.) Also abstracted in PROC. I.R.E., vol. 40, pp. 745–746 (paper no. 56); June, 1952.

J. A. Pierce has completed what will surely be a most valuable document for the radio-propagation engineer. The chapter titles are perhaps the most effective way of conveying the nature of this report. They are: (1) the unabsorbed intensity of a single sky-wave component; (2) the unabsorbed intensity of all possible sky-wave components; (3) transmission losses; (4) observations of low-frequency field strength in 1951; and (5) noise, signal-to-noise ratio, and required power.

(1044) J. A. Pierce, "Sky-Wave Field Intensity: (I) Low and Very Low Radio Frequencies," Tech. Rpt. No. 158, Cruft Laboratory, Harvard University, Cambridge, Mass.; September 1, 1952.

Miscellaneous. It will be expedient to discuss a number of remaining matters under this title.

The nature and cause of the "sporadic-*E*" effect still go largely unanswered. As mentioned under *Movements of the Ionosphere*, R. Gallet has made the interesting suggestion that it can be accounted for entirely by turbulence and not through the agency of additional ionization.

(1045) R. Gallet, "The nature of the sporadic-E layer and turbulence in the upper atmosphere," *Compt. Rend. Acad. Sci.* (Paris), vol. 233, pp. 1649–1650; December 19, 1951. D.S.I.R. Abstract 1912.

Two authors have published attempted correlations with the aurora, but the correlations are not strong and the two papers are somewhat contradictory. (However, Lindquist finds correlation of polar blackouts with aurora and a certain type of sporadic-*E*. Thus a correlation of this type of sporadic-*E* with aurora may be inferred. See section on *Ionospheric Storm Phenomena.*) A correlation of the motion of sporadic-*E* clouds with geomagnetic variations has also been discussed. It has been pointed out that the new hf backscatter technique provides an excellent method of tracking sporadic-*E* clouds. (See discussion herein under section title *Radio Propagation by Scattering.*) K. Rawer and others have published papers on high-frequency absorption. Measurements on different frequencies reveal an important contribution to selective absorption occurring in the *E*-layer which can be calculated by assuming a parabolic distribution of electron density and an exponential variation of collisional frequency. A graphical method is described which gives the separate contributions of the *E*- and *D*-layers. The values of *D*-layer absorption are lower than those obtained by the usual method in which *E*-layer absorption is neglected. The *E*-layer contribution is fairly constant. It is concluded that the *E*-layer collisional frequency is certainly less than 10^4/s, a value in agreement with recent temperature and pressure data at 125 km. In another paper, collisional frequencies were deduced in the conventional way using the observed diminution of multiple echoes. For the *F*-layer, measurements were made at four frequencies at night for about six months. For the *E*-layer, measurements were made at five frequencies at midday for two years. Values of 2×10^2/s and $6–7\times10^3$/s were obtained for the collisional frequencies at the middle of the *F*- and *E*-regions, respectively.

(1046) K. Bibl and K. Rawer, "The contributions of the D- and E-regions in measurements of ionospheric absorption," *J. Atmos. Terr. Phys.*, vol. 2, pp. 51–65; 1951. (In French.) D.S.I.R. Abstract 985.
(1047) K. Rawer, K. Bibl, and E. Argence, "Determination of the number of collisions in the ionosphere E- and F-regions," *Compt. Rend. Acad. Sci.* (Paris), vol. 233, pp. 667–669; September 17, 1951. D.S.I.R. Abstract 987.

H. W. Wells reported *F*-region effects of the solar eclipse observed at sunrise on September 1, 1951 with three high-speed recorders on an east-west line 12 minutes apart in local time. He concludes that from the moment when two-thirds of the sun was covered, through the maximum phase (94 per cent), and until one-third of the sun was uncovered, no ionization was produced.

(1048) H. W. Wells, "Ionospheric effects of solar eclipse at sunrise, 1 September 1951," *Jour. Geophys. Res.*, vol. 57, pp. 291–304; June, 1952. D.S.I.R. Abstract 2800. See also: "F-region effects of solar eclipse at sunrise, 1 September 1951," TRANS. I.R.E., PGAP-3, p. 210; August, 1952. (Abstract.) Also abstracted in PROC. I.R.E., vol. 40, p. 746 (paper no. 58); June, 1952.

Oblique path pulses experiments have been described. Several of these are now on a sweep-frequency basis. So far, no particularly unexpected results have been reported. The importance of the "high ray" is apparent.

(1049) W. Dieminger, "Echo sounding of the ionosphere at oblique incidence," *Z. Angew. Phys.*, vol. 3, pp. 90–96; March/April, 1951. D.S.I.R. Abstract 674.
(1050) M. Mayumida, C. Ouchi, and T. Yoshida, "Sweep frequency pulse test of oblique incidence," *Proc. Semi-Annual Meet. Central Radio Wave Obs.* (Japan), no. 2, p. 128; 1951. R.I.R.J. Abstract no. R-9.
(1051) R. Silberstein, "Interpretation of high-frequency cw field-intensity records with the aid of simultaneous pulse data," PROC. I.R.E., vol. 40, pp. 974–976; August, 1952. D.S.I.R. Abstract 3219.
(1052) P. G. Sulzer and E. E. Ferguson, "Sweep-frequency oblique-incidence ionosphere measurements over a 1150 km path," PROC. I.R.E. (Correspondence), vol. 40, p. 1124; September, 1952. D.S.I.R. Abstract 3530.

The suppression of magneto-ionic rays by transmitter polarization control has been investigated further and attenuations of as much as 50 db obtained. The statistical nature of the fading of a single magneto-ionic component at oblique incidence has been investigated and found to be log-normal in character.

(1053) M. G. Morgan, "Polarization control and measurement in ionosphere vertical incidence echo ranging," TRANS. I.R.E., PGAP-3, pp. 33–41; August, 1952. Abstract in PROC. I.R.E., vol. 40, p. 740 (paper no. 14); June, 1952.
(1054) H. P. Hutchinson, "Short period sky-wave fading of cw emissions," TRANS. I.R.E., PGAP-3, pp. 12–18; August, 1952. Abstracted in PROC. I.R.E., vol. 40, p. 739 (paper no. 11); June, 1952. Also presented at I.R.E. Western Electronic Show and Convention, Long Beach, California; August 26–29, 1952.

An outline of the effects of all the layers in calculating received hf field strength, going somewhat beyond present methods, has been presented.

(1055) K. Rawer, "A calculation method for sky-wave field strength," PROC. I.R.E., vol. 40, p. 973; August, 1952. (Abstract.) The full paper has been published as "Calculation of sky-wave field strength," *Wireless Engr.*, vol. 29, pp. 287–301; November, 1952. D.S.I.R. Abstract 199.

J. C. W. Scott has presented much needed information on solar control of the *E*- and F_1-layers at high latitudes. He finds that, whereas both follow the Chapman law, the sensitivity of the *E*-layer to solar angle is very small in the auroral zone. It recovers north of the zone. The F_1-layer is found to have rather low sensitivity at all latitudes.

(1056) J. C. W. Scott, "The solar control of the E- and F1-layers at high latitudes," *Jour. Geophys. Res.*, vol. 57, pp. 369–386; September, 1952.

C. M. Minnis has discussed the longitude effect found in F_2-region parameters and suggests that prediction services use a set of hourly charts each of which would show the distribution at a fixed value of zero meridian time.

(1057) C. M. Minnis, "The graphical representation of the longitude effect in F2-region," *J. Atmos. Terr. Phys.*, vol. 2, pp. 261–265; 1952. D.S.I.R. Abstract 3081.

Conclusion. The references in the foregoing account represent about 15 per cent of those which have appeared on ionospheric matters in the literature of the free world in the past twelve months, not to mention approximately one hundred Commission 3 documents transmitted to the URSI Assembly in Australia. Mitra's book, whose text is of great value, is of at least equal value as a key to the great mass of accumulated periodical literature.

Designers and operators of communication circuits utilizing ionospherically propagated signals will find the new book "Radio Spectrum Conservation" (McGraw-Hill Book Co., Inc., New York, N. Y.) of very considerable value. This book, published in May, 1952 was prepared by the Joint Technical Advisory Committee under the sponsorship of IRE and RTMA. Nearly half of it consists of Chapter 2, entitled "Propagation Characteristics of the Radio Spectrum." It was prepared as follows: Sec. 1, *General*, J. H. Dellinger; Sec. 2, *10–200 kc/s*, (Mrs.) M. L. Phillips; Sec. 3, *0.2–2 mc/s*, W. S. Duttera; Sec. 4, *2–30 mc/s*, T. N. Gautier; Sec. 5, *30–3000 mc/s*, C. R. Burrows; and Sec. 6, *3–300 kmc/s*, G. C. Southworth.

Acknowledgment

The individual sections of this report were prepared by the Technical Committees of the IRE, who made assignments to individuals or groups to carry on the investigations necessary to make a comprehensive review of the particular field of activity assigned to them.

These reporters are thanked for their diligence in this preparation. All of the reports were reviewed by the members of the Annual Review Committee Editorial Board, and the reports correlated as to style and content. The membership of this Editorial Board and the names of the engineers who prepared the sections of the report follow:

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Correction

Olof Lindberg, author of the paper, "Hall Effect," which appeared in the November, 1952 issue of the Proceedings of the I.R.E., has brought the following error to the attention of the editors:

On page 1419, column 1, the second equation following the first paragraph should read,

$$V_N = B \sin \omega_2 t,$$

and not

$$V_H = B \sin \omega_2 t.$$

Standards on Sound Recording and Reproducing: Methods of Measurement of Noise, 1953*

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1. INTRODUCTION

1.1 General Description

Noise is a limiting factor in any system which stores information because it limits the signal-to-noise ratio and hence the total quantity of stored data. This applies in the field of sound recording and reproducing, as well as in any information storage system.

1.2 Definitions

1.2.1 Noise

As applied to a sound recording and reproducing system, any output power which tends to interfere with the utilization of the applied signals except for output signals which consist of harmonics and subharmonics of the input signals, intermodulation products, and flutter or wow.

* Reprints of this Standard, 53 IRE 19 S1, may be purchased while available from The Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y., at $0.50 per copy. A 20 per cent discount will be allowed for 100 or more copies mailed to one address.

1.2.2 Spectral-Noise Density

The limit of the ratio of the noise output within a specified frequency interval to the frequency interval, as that interval approaches zero.

Note—This is approximately the total noise within a narrow frequency band divided by that bandwidth in cycles per second.

1.2.3 System Noise

The noise output which arises within or is generated by the system or any of its components, including the medium.

1.2.4 Equipment Noise

That noise output which is contributed by the elements of the equipment during recording and reproducing, excluding the recording medium, when the equipment is in normal operation. Equipment noise usually comprises hum, rumble, tube noise, and component noise

1.2.5 The Zero-Modulation State of a Recording Medium

The state of complete preparation for playback in a particular system except for omission of the recording signal.

Note 1—Magnetic recording media are considered to be in the zero-modulation state when they have been subjected to the normal erase, bias and duplication printing fields characteristic of the particular system with no recording signal applied.

Note 2—Mechanical recording media are considered to be in the zero-modulation state when they have been recorded upon and processed in the customary specified manner to form the groove *with no recording signal applied.*

Note 3—Optical recording media are considered to be in the zero-modulation state when all normal processes of recording and processing, including duplication, have been performed in the customary specified manner, but *with no modulation input* to the light modulator.

1.2.6 Medium Noise

That noise which can be specifically ascribed to the medium.

1.2.7 Zero-Modulation Medium Noise

That noise which is developed in the scanning or reproducing device during the reproducing process when a medium is scanned in the zero-modulation state.

Note—For example, zero-modulation medium noise is produced in magnetic recording by undesired variations of the magnetomotive force in the medium, which are applied across the scanning gap of a demagnetized head, when the medium moves with the desired motion relative to the scanning device. Medium noise can be ascribed to nonuniformities of the magnetic properties, and to other physical and dimensional properties of the medium.

1.2.8 Modulation Noise

Noise which exists only in the presence of a signal and is a function of the instantaneous amplitude of the recorded signal. (The signal is not to be included as part of the noise.)

Note—This type of noise results from such characteristics of a recording medium as light transmission in a film, slope of a groove, magnetism in a wire or tape, etc.

1.2.9 Signal-to-Noise Ratio

The ratio of the signal power output to the noise power in the entire pass band.

1.2.9.1 Single-Frequency Signal-to-Noise Ratio

The ratio of the single-frequency signal power output to the noise power in the entire pass band.

2. BASIC METHODS OF MEASUREMENT

2.1 Noise

The noise from any source is the noise output power as measured by any power meter which correctly loads the source and which is effective throughout the specified range of frequencies. Any voltmeter or ammeter which indicates correct root-mean-square values may be used in combination with the correct load termination resistor in lieu of a wattmeter. Wave filters should be used, as required, to limit the measured noise to a specified spectral band and to eliminate spurious signals not considered as noise.

Note—At this time the industry is largely equipped with meters which are rated as average reading voltmeters. The apparent power computed from the indicated voltage of a full-wave rectifying meter may be used in lieu of the true rms voltage if the meter type or characteristic is specified.

2.2 Spectral-Noise Density

This measurement is a determination of the spectral distribution of the noise power as a function of frequency. The noise power accepted by a measuring device of narrow bandwidth (a wave analyzer, for instance) is plotted as a function of frequency, in terms of the power per cps. It is necessary to omit from such plots any noise, such as that derived from hum pickup, which is in the nature of discrete spectral lines of bandwidth less than that of the wave analyzer. Such responses must be plotted strictly as spectral lines of indicated amplitude.

2.2.1 Weighted Spectral-Noise Density

The spectral-noise density data may be weighted in relative importance as a function of frequency to conform with experimental curves obtained by measurements of human-hearing characteristics, if it is desired to relate the data to the hearing characteristic.

2.2.2 Photographic Recording of Noise

It is also possible to record photographically either the instantaneous noise voltage or current amplitude versus time from the face of a cathode-ray tube with a phosphor of appropriately rapid light-amplitude decay time. A strip of the resultant record lends itself to analysis in terms of transient functions and noise amplitude probability.

2.3 System Noise

It is desirable to determine the noise of a complete system[1] in one or more ways that indicate the objective and subjective performance of the system. In general high-frequency noise components and low-frequency hum from power-supply equipment constitute the most objectionable portions of the noise. Therefore, measurements should be made to evaluate these two noise sources separately. Weighted measurements which are based upon the sensitivity characteristic of the ear, as a function of frequency, may also be valuable, as stated in Section 2.2.1.

The noise levels of magnetic recording and reproducing systems are in general much lower than those of other recording systems. The difficulties encountered in attempting to measure the true noise level are therefore considerably greater.

It should be noted that in magnetic recording and reproducing systems, care should be exercised in the elimination of the magneto-strictive introduction of mechanical noise into the reproducing system. Mechanical damping of the core structure of the reproducing head, and design to allow smooth, quiet, passage of the record medium over the pole pieces may usually be done sufficiently well to allow one to neglect these effects.

The objective over-all performance of a system requires a noise measurement over the entire specified frequency range of the system. Several different types of noise measurements are possible.

The system noise measurements should be made with the entire system in operation, in accordance with either Section 2.1 or 2.2, or both.

2.4 Equipment Noise

The measurement of equipment noise poses some special problems. In general, it is necessary to consider all noise components introduced during recording and reproducing. An appropriate and quite simple method, from which the over-all process may be evaluated, involves the measurement of the output noise with the motion of the medium arrested. A necessary assumption for the success of this procedure is that the noise introduced in the recording system is negligible in comparison with that introduced in the reproducing system. This may be tested by operating the entire system in the normal recording condition, with the recording medium in motion, but with *no input signal applied*, and intermittently turning on and off all the apparatus associated with the recording amplifier.[2] If there is *no apparent* difference between the noise levels of the reproduced signal under the two conditions, when the medium is in a state equivalent to its zero-modulation condition, then it is safe to assume that the recorded noise may be neglected. This condition is fulfilled by many well-designed recording systems.

[1] It is necessary that the apparatus to be included in the "system" be specified.

[2] In magnetic recording, sources of bias and erase current and their power supplies are considered as parts of the associated apparatus. Switching transients must be minimized and readings taken when their effects are not present.

Under these conditions, the noise from the playback portion of the equipment may be considered to be the noise of the entire equipment. It is that output signal which is produced when the entire system (recording and playback) is excited in the normal playback condition, but with no recording input signal applied and with the recording medium removed from proximity to the reproducing device. The latter condition may be fulfilled by simply removing the recording medium and running the drive mechanism in the normal fashion. In mechanical recording the reproducing device is maintained in contact with an unmodulated groove. A low-pass filter is inserted to allow rumble measurements to be made.

The equipment output noise should be measured by noise power indicating apparatus as stated in Section 2.1 and 2.2. It may be analyzed as in Section 2.3.

2.5 The Zero-Modulation State of a Recording Medium

This condition, as defined, requires no measurement other than a zero-reading of the recording signal, except that in magnetic recording the bias condition must be measured as for a normal recording operation.

2.6 Medium Noise

The definitions divide medium noise into two separate categories, Section 1.2.7 (Zero-Modulation Medium Noise) and Section 1.2.8 (Modulation Noise), the second of which depends upon the presence of a modulation signal. It is best to consider these effects separately. At the present time there appears to be no reliable method by which the noise of the medium can be accurately measured, unless the medium noise exceeds the equipment noise. If the equipment noise is sufficiently low, it is possible to measure the system noise and the equipment noise, and then to compute from these values the equivalent medium noise.

2.7 Zero-Modulation Medium Noise

There are major reasons why this noise cannot *always* be measured reliably. First, the noise voltages generated in the reproducing device can be, in some instances, of such small magnitude that available measuring equipment has sufficient intrinsic noise to make the readings ambiguous. Second, the measured medium noise is so closely related to the operating characteristics of the scanning device that all measurements must be evaluated in terms of the specific geometrical and physical conditions of the reproducing (playback) device. Third, in mechanical recording and reproducing, it is difficult to secure rumble-free test records.

It is possible to produce a standard precision medium-scanning device which has superior characteristics, and which may be used as a reference for the comparison of all available types of recording media of essentially equivalent geometrical configuration. It seems wise at this time, however, to delay the fixing of such standards until additional work has been done, so that there is assurance that the standard will not suffer early obsolescence. In the interim one may choose a temporary standard for his personal tests, so that tentative relative comparisons of media may be made. If this procedure is followed, and if the output noise power from the reproducing or playback system with the medium in place and in normal relative motion is somewhat greater than the output-noise power from the same system, with the medium either removed or by-passing the reproducing device, then it is possible to compute the zero-modulation medium noise as the difference between the two noise powers. If desired, the noise spectrum of the medium may be plotted as the difference between the system and the equipment noise spectra. In either instance it seems advantageous to measure or to convert the final values for statement as terminal voltages at the output of the scanning device. The reactance parameters of this scanning device must be of known value and so related that either the electrical resonance effect is negligible or its effects are accountable.

In a magnetic recording system part of the zero-modulation medium noise may result from the application of erase or bias signals containing dc or even-number harmonic components which cause asymmetry of the erase or bias waveforms and which cannot be neglected.

2.8 Modulation Noise

The modulation noise introduced by certain recording media is of sufficient relative amplitude to make its presence easily detectable by ear in the acoustic output derived from a well-designed system. Nevertheless, when measurements are attempted it is found that a number of difficulties are encountered. The modulation noise intensity is found to be a function of the amplitude of the recorded signal and to exist, by definition, only in the presence of that signal. Therefore, it is necessary to separate the output signal from the modulation noise without affecting that noise, in order that one may make a measurement of only the noise. A series of sharply-tuned filter devices (of bandwidth consistent with the flutter and wow of the system) seems to be indicated for removal of the fundamental frequency and its important harmonics. Extremely narrow band-rejection filters are needed for this measurement because there is a possibility that the noise may be concentrated within the spectrum which is closely adjacent to the frequencies of the causative modulating signals. These conditions impose additional difficulties in their requirements of extremely accurate regulation of the speed of the medium as it passes the scanning device.

3. MEASUREMENT PROCEDURE

3.1 Noise

System and equipment noise and signals should be measured in the correctly terminated output circuit of the equipment. For measuring noise which has considerable fluctuations, it is recommended that the meter shall have approximately the dynamic characteristics of the standard vu meter. This meter may be used to measure the noise voltage across the terminating load resistor. If the noise fluctuations are small, it is desirable to measure the noise power directly by means of any reliable thermal-type power indicating meter (thermocouple, hot wire, bolometer, or certain vacuum tube devices, for instance) which provides the correct output termination.

The calibration of the measuring equipment should be sufficiently accurate throughout the useful pass band of the system or equipment to be measured so that the specified accuracy of the result may be assured. Beyond the frequency limits of the pass band the sensitivity of the meter may be cut off as required to suppress the pickup of undesired signals, but in a manner which avoids introduction of undesirable transient effects.

Note—See note after 2.1.

3.2 Broadband Noise Measurements

3.2.1. System Noise Measurements

The recording portion of the system may be improved rather easily to an extent sufficient to prevent the introduction of detectable recorded noise from this source. It is, therefore, to be assumed that the recording signal channel is free from noise which may be recorded at any level above that of the medium noise. It is also to be assumed that in magnetic recording the erase and bias current waves are symmetrical about the axis of zero current, within less than 0.5 per cent, so that excessive medium noise will not be caused by the resultant effective recorded unbalanced dc components.

The recording medium is to be passed through the normal recording processes, with zero recording signal and correct input termination, and then reproduced in the usual way. The output terminals of the reproducing (or playback) system are connected to the correct terminating load resistance (R), and the true rms current (I) which passes through that resistor is indicated or recorded by a thermal ammeter or other equivalent device. The noise power output (P) may be computed from the relation

$$P = I^2R. \quad (1)$$

As an optional method, it is permissible to measure the true rms voltage (E) across the load resistor (R) and to compute the power output from the relation

$$P = E^2/R. \quad (2)$$

Another satisfactory method involves the use of a bolometer device of the correct terminating resistance (R) in which the output noise power is dissipated and compared with an adjustable indicated power dissipated from a source of metered dc or sinusoidal ac energy. Any of these devices may be calibrated in combination with the load resistor to indicate power or to indicate decibels with respect to 1 mw (dbm).

After the noise power output has been measured, the maximum signal output may be measured by applying an input signal which produces not more than the maximum allowable distortion, at any specified frequency, and making a measurement of the output signal level by a procedure similar to that employed in making the noise measurement. The signal-to-noise ratio of the system may be computed in accordance with the definition 1.2.9.

3.2.2. Equipment Noise Measurement

The equipment noise is measured by removing the recording medium and repeating the system noise measurement with all portions of the equipment activated in the normal manner, so that the adjustments are the same as those used for the system noise measurement.

3.2.3. Medium Noise Computation

The equipment noise power output (P_{en}) measured in accordance with Section 3.2.2 is subtracted from the system noise power output (P_{sn}) measured under the same conditions. The result is the medium noise power output (P_{mn}). Thus,

$$P_{mn} = P_{sn} - P_{en}. \qquad (3)$$

Subtraction of the total noise power output of the system (P_{sn}) from (P_{ss}), the power of the combined specified single-frequency-signal and noise, yields (P_{ms}), the power of the signal from the medium. Hence,

$$P_{ms} = P_{ss} - P_{sn}. \qquad (4)$$

The ratio (P_{ms}/P_{mn}) is the single-frequency-signal to noise power ratio of the medium, so that

$$(S/N)_m = P_{ms}/P_{mn} = (P_{ss} - P_{sn})/(P_{sn} - P_{en}). \quad (5)$$

The latter ratio may be converted to the decibel scale in the normal way.

3.3 Unweighted High-Frequency Noise Measurements

A 250 cps high-pass filter, with 18 db per octave attenuation below 250 cps, is connected between the output terminals of the equipment and the load and measuring device. All measurements outlined under "Broadband Noise Measurements" may be repeated to obtain the signal-to-noise ratio corresponding to the portion of the spectrum, which is essentially free of the low-frequency vacuum tube "flicker" noise of the playback preamplifier input stage and hum of the power-line frequency and its major harmonics.

3.4 Noise Spectrum Analysis

The noise spectrum may be analyzed by insertion of a very narrow band pass filter of variable frequency (a number of interchangeable filters with a series of fixed central frequencies may be inserted, one at a time, as a substitute) between the output terminals of the equipment (or the output metering terminals) and the power-measuring equipment. All measurements outlined under "Broadband Noise Measurements" may be repeated for each of a series of frequencies throughout the pass band of the system. The results, in terms of power, are then divided by the equivalent bandwidth for a continuous spectrum of the filter system at each test frequency. Plots of these values as functions of frequency may then be made to indicate the spectral-noise density of the system (Section 3.2.1), the equipment (Section 3.2.2), and the medium (Section 3.2.3).

It is necessary that discrete single-frequency spectral lines (from power frequency sources, incompletely erased tone recordings, and the like) be treated separately. Readings of the power output of such interfering signals may be utilized by subtracting from them the mean of the power readings of two similar unaffected adjacent noise spectral bands, spaced at an equal frequency interval on opposite sides of the spectral line. The resultant value should *not* be divided by the bandwidth of the filter, but should be plotted as a spectral line of the indicated amplitude.

Reasonably satisfactory measurements of this sort may be made by connecting a standard narrow-band wave analyzer across the output load resistor. In this case the error indication for continuous spectrum noise signals must be corrected by comparison with a simple power-indicating meter, which may be connected to the output via a single narrow-band filter.

3.5 Weighted Noise Measurement

Appropriate contour curves may be used as a basis for establishing a weighted response. It should be noted that when the ultimate use of the reproduced signal is to actuate some mechanism such as the human ear a different weighting characteristic must be substituted. Weighted measurements are particularly valuable in conjunction with studies of the relative operational effects with different system noise conditions. They should therefore be applied in a measurement procedure similar to that of the Section 3.2 "Broadband Noise Measurements."

3.6 Instantaneous Noise Voltage Measurements

The instantaneous voltage may be caused to deflect the electron beam of a cathode-ray oscilloscope so that the position of the spot of light on the screen is proportional to the voltage. A continuously moving photographic film or tape may be passed through a camera at an appropriate speed to resolve the recorded transverse movement and so to plot the noise voltage as a function of time. Short record intervals of this sort may be utilized for determining the various characteristics of the noise output. This method may be applied for both system and equipment noise measurement.

Reliability of Airborne Electronic Components*

B. G. BROMBERG† AND R. D. HILL, JR.†

Summary—A review of typical electronic component failures shows that failures occur because of insufficient reliability per component, combined with the multiplicity of components utilized in typical electronic assemblies. Further, it is shown that failures do not occur in a manner described by the classical Gaussian description but rather by an exponential description which indicates a decreasing number of failures per unit time with time. Means for increasing reliability of components are discussed, with emphasis on mechanical ruggedness and resistance to severe environments. Replacement of electronic tubes by transistors and magnetic amplifiers is also discussed.

I. Status of Reliability

A. Statistics

IT IS WELL KNOWN throughout the aircraft and guided missile industry that electronic equipment needs vast improvement in reliability. Because of the generally poor reputation attributed to electronic equipment many key engineers in these and other industries have a tendency to use most any means other than electronic to achieve a certain design function. Yet, it is inconceivable that certain functions now performed electronically can be handled in any other way. Thus, the present state of electronic science is that, on one hand, it holds the key to achieving what is now impossible in any other way and, on the other hand, it requires extensive effort to raise the level of reliability to that of mechanical and hydraulic applications.

All electronic equipment contains a multiplicity of various components. In determining which components contribute most to the label of unreliability it is highly informative to examine the large amount of statistical data which is being accumulated by various government agencies and firms engaged in the manufacture or use of electronic equipment. Table I is a composite summary of faults found in typical production runs of guidance receivers for a guided missile, of radar units for airplanes, and airborne automatic control equipment. It is immediately apparent from Table I and other similar data that the principal component, but by no means the only culprit, which has caused repeated and unexpected failures is the electron tube. The seriousness of this situation is all the more emphasized when it is realized that the individual tubes were selected and completely tested prior to installation in the airborne equipment.

The statistics of electron tube failures observed in a variety of equipment show that, in spite of the relatively long-average tube life, the number of hours of operation of the equipment between tube failures is remarkably low. Typical values are that average tube life in reasonably well-designed equipment can range from 1600 to 6500 hours, with the number of operational hours between failures ranging from 14 to 30 hours.

The over-all reliability of a piece of equipment is a function of its complexity and reliability of its components. The complexity of an equipment is difficult to indicate in anything but comparative terms. In electronic equipment complexity may be designated by the number of electron tubes which must operate simultaneously if the total equipment is to perform its desired function. Since the electron tube is the chief component contributing to failure, the theory of probability utilizing the reliability and number of electron tubes can indicate some useful trends. Before presenting this analysis, it should be pointed out that it is not rigorously true that an analysis based on electron tubes only is valid in all cases; for a more general solution, the relative reliabilities and numbers of other electronic components such as condensers, resistors, transformers, potentiometers should be evaluated.

TABLE I

Distributuon of Faults in Production Run of Typical Airborne Electronic Systems

Item	Per Cent of Total Faults
1. Electron tubes	64.0
2. Resistors	8.8
3. Condensers	7.2
4. Wiring errors	6.2
5. Dry rectifiers	4.5
6. Mechanical items	2.4
7. Burn-outs	1.1
8. Miscellaneous	5.8
	100.0

Since the reliability of each component of an assembly can reasonably be considered to be independent from each other, the total reliability of the assembly can be stated exactly the same as the well-known probability of simultaneous occurrence, namely,

$$R_{\text{Total}} = R_1 \cdot R_2 \cdot R_3 \cdots R_n, \tag{1}$$

where R_{Total} = reliability of assembly, and $R_1, R_2 \cdots R_n$ are the reliabilities of each component.

From this expression the curves of Fig. 1 can be obtained by assuming that the reliability of each compo-

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nent is equal. The curves of Fig. 1 bring out vividly that the reliability of components comprising a moderately complex assembly must be several orders greater than that expected of the assembly. Another conclusion that can be seen easily from (1) is that a small group of less reliable components operating in conjunction with a group of highly reliable components will strongly control the reliability of the composite.

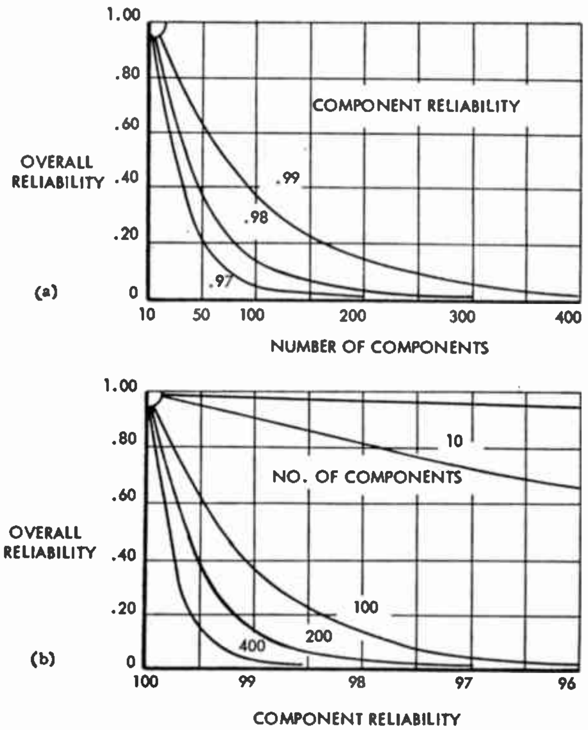

Fig. 1—Reliability dependence on (a) number of components and (b) individual component reliability.

The records of failure of components in service indicate another interesting fact. The failures of components, and this is not restricted only to electron tubes, do not show a failure history that in any way resembles the typical probability curve shown in Fig. 2. The distribution of failures indicated in Fig. 2 is called the normal or

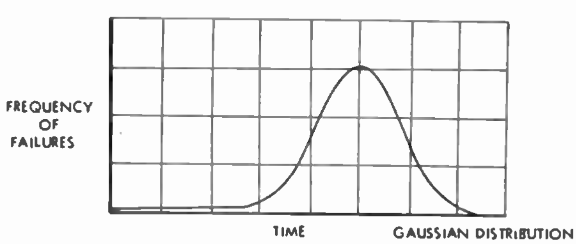

Fig. 2—Classical probability distribution.

Gaussian distribution, and it can be observed in the laboratory by subjecting a number of individual components to a typical life test and plotting the number of failures occurring during certain, consecutive intervals of time. This is the type of histogram which is obtained in the usual life test run on incandescent lamps. However, the history of tube failures in service does not show a normal-type distribution.

LaGasse and Dean[1] have shown the number of aircraft radio tubes rejected in each 100-hour interval of life for a group of 1,912 tubes. These records show that

(a) more failures occurred in the first interval of time than in any other,
(b) for each succeeding interval of time, a smaller number of failures occurred,
(c) although certain tubes lived for over 3,000 hours of operation, the mean time for failure was 583 hours.

A graph of LaGasse and Dean's records is shown in Fig. 3. The curve of failures appears to be a hyperbola asymptotic to both axes or an exponential curve. This type of histogram for electron tubes has been substantiated by a large majority of the statistics which deal with tubes in actual service conditions.

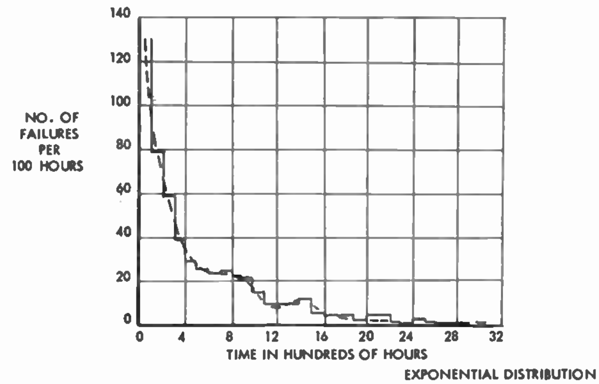

Fig. 3—Observed failure distribution.

B. Means of Increasing Reliability

The actual problem of reliability lies basically in the mechanical design of the package with emphasis on the following categories: (1) general mechanical ruggedness, (2) design for shocks, (3) design for vibration, (4) moisture proofing, (5) heat dissipation, (6) pressure changes and (7) temperature changes.

Although these seven design aspects are all important in the reliability makeup of any electronic system, it has been observed that shock and vibration are probably the most important failure-causing environment. This can be seen by examining the reliability figures of ground, shipborne, and airborne equipment. The order of reliability falls definitely into three orders of magnitude, with stationary ground equipment being the most reliable of the three types and airborne equipment being the least reliable. It can be expected by extrapolation that electronic equipment in guided missiles, which generally subject their contents to vibration and shock several orders of magnitude greater than that of inhabited aircraft, needs special attention if reliability is to be achieved.

[1] J. E. M. LaGasse and W. W. H. Dean, "Tubes at work," *Electronics*, vol. 14, p. 56; November, 1941.

The purpose of this paper is to emphasize the need for reliability and to indicate several ways of obtaining improvements in reliability. It is not practicable to make this an exhaustive account of such means, but rather a provocative listing of certain attacks which have been considered by the authors. Based on the statistics and probability studies indicated previously, the following methods of improving the reliability of electronic equipment appear logical:

(*a*) improvement in reliability of electron tubes,
(*b*) use of redundant circuits,
(*c*) elimination of all or some of the electron tubes by more reliable components,
(*d*) design for shock and vibration environments.

These four methods are discussed in the following sections.

C. Improvement in Reliability of Electron Tubes

Basically, an electron tube is a mechanical structure which, among other things, depends on maintenance of its geometry for proper functioning. In addition, the reliability of electron tubes requires reasonable uniformity of the thermionic property of the cathode throughout the life of the tube. Failures in tubes can be attributed almost exclusively to failures in these two aspects.

The Aeronautical Radio Incorporated (ARINC) inaugurated in 1946 a program with certain tube manufacturers to improve the life of a small number of commonly used tube types. The basic goal of the program was the improvement of existing tube structures and manufacturing techniques to the point where a much higher degree of reliability than previously available could be expected. Cost considerations of such an improvement program were of secondary significance.

The ARINC tubes and the more recently offered reliable tubes manufactured by Raytheon are designed to withstand shock and vibration by minimizing the length of the internal elements and by having all parts designed as fixed end columns and beams. Dimensions are held to much closer tolerances than had been used before; for example, critical grid dimensions are held to ± 0.0005 inch. Exhaustive inspection techniques sometimes involving binocular microscopes are utilized. After manufacture each tube is given a burning-in period of 50 hours under normal operating conditions. The burning-in period serves to stabilize the electrical characteristics and, more important, has been found to reduce the number of early-life failures.

To improve the probability of increasing the reliability of electron tubes, the ARINC program was purposely limited to a small number of tube types—namely, ten.

The statistics of the ARINC tubes in active service show a reliability equivalent to airborne failures of not more than 2.5 per cent in the first 1,000 hours of operation. This rate of failure is to be compared to a rate as high as 30 per cent in the first 1,000 hours for the best equivalent tubes available before the ARINC tubes. In a run of about 1,500 tubes of the type 5654, which is the 6AK5 equivalent, it was observed that there was one failure in the first 1,000 hours and only 32 failures in a total of 3,950,000 hours of operation.

From this data it is obvious that ARINC tubes should be used whenever possible. In most cases the ARINC tubes are directly interchangeable with their JAN equivalents, and in the case of three tubes the substitution can be made by considering only the effect of a slight increase in cathode heater current.

On the surface it might appear desirable to extend the ARINC techniques to all tube types. Such an undertaking would undoubtedly dilute the ARINC effort and might well lead to little or no improvement over existing JAN types. An example of this was the recent effort by the government services to obtain ruggedized versions of many of the JAN types. These will be recognized as the as the 6SN7Ws, 6AQ5Ws, 6X4Ws, and so forth.

D. Use of Redundant Circuits

In addition to increasing the reliability of components comprising an assembly, the theory of probability points to another means of obtaining a high degree of over-all reliability. This is the use of a duplicate system in parallel with the original, wherein the functioning of either one of the parallel systems results in successful operation of the assembly. This fact can be expressed mathematically.

$$R_{\text{Total}} = 1 - (1 - R_p)^n, \tag{2}$$

where

R_{Total} = reliability of the over-all system,
R_p = individual reliability of the component system which is paralleled by similar systems,
n = number of systems being paralleled.

An example to clarify this equation is: If a subsystem has a reliability of 80 per cent, and 3 of these systems are paralleled, the over-all reliability has increased from 80 per cent to 99.2 per cent.

The use of redundant systems may also permit installation in aircraft of each system in a different orientation or in a different location (as compared to the other systems comprising the redundancy) so as to minimize the effects of known or unknown environments as extreme temperatures, vibration, moisture, and so forth.

E. Elimination of Electron Tubes

As stated earlier, electron tubes have been found to be the cause of about 64 per cent of the failures of electronic equipment; hence, elimination of this troublesome item should allow a large increase in reliability of the over-all electronic system. In general, there are about three satisfactory substitutes for electron tubes. These are the transistor, the magnetic amplifier and the selenium rectifier.

Transistors are a recent development which utilizes semiconducting materials to provide control over the flow of electrons. Until the end of World War II these devices were germanium diodes, and were limited to such functions as rectification and pulse-shaping operations. Early postwar developments produced the emitter-collector type transistor which could perform some of the functions of the triode. These early transistors, however, were extremely noisy and could not be produced with consistent characteristics. More recent developments have led to the *n-p-n* and *p-n-p* type transistors, and it appears that these types are much improved from the noise standpoint and can be produced with consistent characteristics.

Table II, which was derived from work by Wallace and Pietenpol,[2] gives some pertinent characteristics of the latest *n-p-n* types.

TABLE II

N-P-N Transistor Characteristics

Noise figure	10–20 db at 1,000 cps
Power gain	40–50 db per stage
Efficiency	48% for Class A
Power consumption	0.6 μw for an audio oscillator
Frequency response	<5 kc with full gain

As can be seen from the table, the transistor's weak features are its noise figure and its frequency response. These features naturally limit the substitution of transistors for vacuum tubes.

The magnetic amplifier is certainly not a new device to the electronic field. Until the last three to five years, however, the magnetic amplifier was limited to power-amplifier and voltage-regulator applications. Developments in the field of regenerative magnetic amplifiers have made these devices more adaptable for replacing vacuum tubes.[3] It is now possible to obtain power gains of up to 50,000 with an input level of 10^{-9} watts. With gains of this order available, it is possible to control a relay with the signal from photo cells, thermo couples, and so forth, amplified only by a magnetic amplifier.[4]

The major advantages of the magnetic amplifier are its efficiency, high power gain, resistance to shock and vibration and, particularly, its reliability.

Application of the selenium rectifier to electronic systems as a replacement for power rectifiers and bias supplies is well known and will not be elaborated on here. It is interesting to note, however, that recent developments in hermetic sealing of selenium rectifiers have overcome many of their former disadvantages, such as susceptibility to humidity and salt-spray exposure. Improvements have also been made in the reliability of selenium rectifiers in relatively high ambient temperatures.

Conclusion

It is well recognized that the problems involved in the design and production of reliable airborne electronic equipment are tremendous, but with a continued effort to improve vacuum tubes—such as the ARINC and individual tube manufacturers' programs, by the replacement of tubes with transistors, magnetic amplifiers and selenium rectifiers where possible, by redundant design, and by a greater concentration of effort on the mechanical design of electronic equipment, the challenge can be met and we can produce reliable airborne electronic equipment.

[2] R. L. Wallace and W. J. Pietenpol, "Some circuit properties and applications of npn transistors," *Bell Sys. Tech. Jour.*, vol. XXX, p. 530; July, 1951.

[3] "Magnetic Amplifier Design Handbook," Bulletin 2000, Vickers Electric Division, Vickers, Inc., St. Louis, Mo.; 1949.

[4] "Application of magnetic amplifiers," Section of *Proc. NEC*, Chicago, Ill., 1951, vol. VII, pp. 235–262; February 15, 1951.

Fluctuation Noise in a Microwave Superregenerative Amplifier*

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Summary—A brief review of superregenerative (sr) operation is followed by the substitution of Rice's Fourier series representation for noise current into the expression for the output of an SR amplifier. Expressions are derived for the noise figure. It is then shown how a reflex klystron can be used as the active element. Expressions for the noise figure in terms of the klystron parameters are derived. Calculation for a hypothetical, but realistic, case shows that low noise figures are obtainable if certain conditions are met. In particular, it is shown that deliberate introduction of beam current, with its consequent shot noise, during the quiescent interval provides a smaller over-all noise figure.

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The Superregenerative Principle

Superregenerative amplifiers have been treated extensively in the literature.[1,2] The superregenerative (sr) amplifier under consideration in this paper is one for microwave application. It may be considered to be a tuned circuit containing an inductance, capacity, and a shunt conductance which

[1] W. E. Bradley, "Superregenerative detection theory," *Electronics*, vol. 21, September, 1948. Also Philco Corporation Research Report No. 32 "Theory of the Superregenerative Receiver," Philadelphia, Pa.; 1947.

[2] L. Riebman, "Theory of the superregenerative amplifier," Proc. I.R.E., vol. 37, p. 29; January, 1949. This article contains a bibliography.

varies with time. Physically, the tuned circuit may be a resonant cavity. A simplified circuit of the sr amplifier is shown in Fig. 1.

A signal current, $i(t)$, is fed into the tuned circuit, and a voltage, $e(t)$, is obtained. A quench generator controls $g(t)$, the varying conductance shunting the tuned circuit. This conductance is composed partly of the losses of resonant cavity or inductor-capacitor combination, and partly of a negative conductance contributed by an electron tube periodically energized by the quench generator. In the case of a microwave amplifier, the negative conductance may be contributed by the bunched electron beam of a reflex klystron, and controlled by a quench voltage on the control grid (or, in the absence of a control grid, on the cathode) of the klystron to quench the beam.

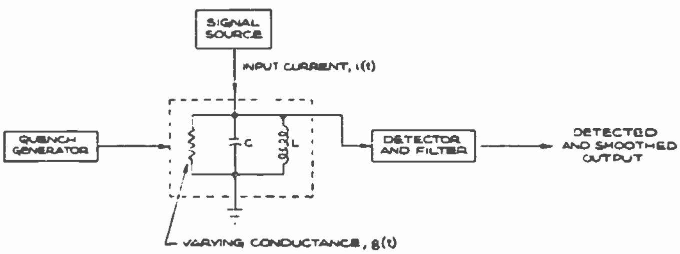

Fig. 1—Simplified superregenerative amplifier.

The sr obtains its amplification by a sequential series of operations. Oscillations are caused to build up in the resonant circuit when the negative conductance is introduced under the control of the quench waveform. The amplitude to which oscillations build up at any time is dependent upon the strength of oscillations in the circuit caused by an input signal even prior to the time of introducing the negative conductance. After the signal has built up several orders of magnitude, the negative conductance is removed by the quench generator turning off the klystron electron beam or introducing positive conductance, and oscillations are quenched. The quench cycle is then repeated to cause periodic buildup and decay.

The instantaneous output, $e(t)$, of Fig. 1 is thus not only a function of the instantaneous $i(t)$ and $g(t)$, but also of the past history of $i(t)$ and $g(t)$. Consequently, $e(t)$ is a function of the waveform of $g(t)$ as well as its instantaneous value. If the so-called "ideal" quench waveform[3] is used, the operation of the sr amplifier may be divided into three phases, as shown in Fig. 2. During the listening interval the sr amplifier is most sensitive to an input $i(t)$, and the electron tube may be turned off or there may be a small beam current to make the listening conductance small. The beam current is suddenly turned to a high value at the end of the listening interval, and oscillation, determined by the signal across the tuned circuit, begins to build up. Before overload takes place heavy damping is applied to remove the built-up signal and to prepare the tuned circuit for reception of a new signal. Thus, it is seen that the output of the sr amplifier is a sequence of sampling pulses.

[3] W. S. Percival, U. S. Patent No. 2,171,148; 1939.

The expression for the detection output of the sr amplifier which will be used is the one developed by Bradley.[1,2] Other expressions have been used by other writers.[4] Bradley's expression is

$$E(t) = \frac{1}{j\omega_0 C} \int_{-\infty}^{t} F(t, \tau) e^{-j\omega_0 \tau} i'(\tau) d\tau, \tag{1}$$

where

C = shunt capacity of the tuned circuit,
$\omega_0 = (LC)^{-1/2}$, the resonant angular frequency,
$i(t)$ = the input driving current,
$i'(t) \equiv$ the derivative of $i(t)$,

and $F(t, \tau)$ is the "time aperture function" defined by

$$F(t, \tau) = \begin{cases} \exp\left[-\frac{1}{2C}\int_{\tau}^{t} g(t)dt\right], & \text{for } t > \tau \\ 0, & \text{for } \tau < t. \end{cases} \tag{2}$$

In (2) $g(t)$ is the time-varying conductance of the oscillator circuit. The ideal quench waveform of Fig. 2 is used, and it is assumed that quenching is so severe that no appreciable energy comes through the network during the quench interval. It is further assumed that amplification is great enough that the amount of energy getting through the network during the listening interval $(-t_2, 0)$ is negligible compared to the built-up signal level at the end of the build-up interval. Thus, in the output it is necessary to consider only the output function between $t=0$ and $t=t_1$. These assumptions simplify the calculations but are not so radical as to depart seriously from practice. $F(t, \tau)$ will now be computed. Defining $P(t)$ by $g(t)/C$, one has (see Fig. 2),

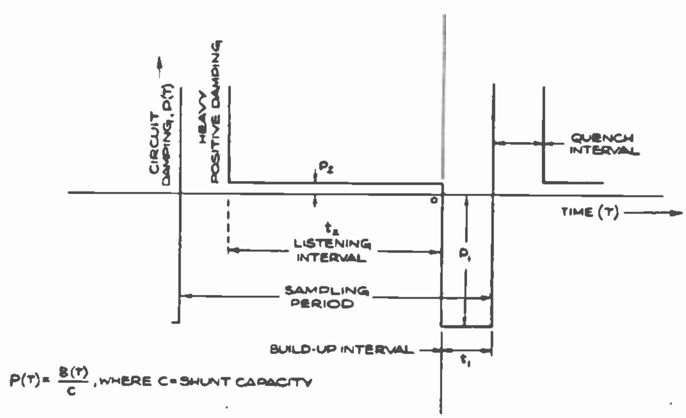

Fig. 2—Ideal quench waveform.

$$F(t, \tau) = \exp\left[\frac{P_2\tau}{2} + \frac{P_1 t}{2}\right], \quad \text{for } -t_2 < \tau < 0$$

$$= \exp\left[\frac{P_1}{2}(t - \tau)\right], \quad \text{for } 0 < \tau < t. \tag{3}$$

[4] L. A. Zadeh, "Band-pass low-pass transformation in variable networks," Proc. I.R.E., vol. 38, p. 1339; November, 1950. The expression given by Zadeh is similar to that derived by Bradley. In "Correlation functions and power spectra in variable networks," *op. cit.*, p. 1342, Zadeh gives a method for treating the effect of noise upon variable networks. The approach in the present paper may be considered an alternative to Zadeh's.

Noise Input

For the input noise current, the representation of Rice[5] will be used.

$$i(t) = \frac{1}{2} \sum_{n=-\infty}^{\infty} C_n \exp [\omega_n t - \phi_n]. \qquad (4)$$

In this representation the ϕ_n are random phase angles, with a uniform probability density function in the interval $(0, 2\pi)$. Also

$$C_n^2 = 2F(f_n)\Delta f,$$
$$\omega_n = 2\pi f_n,\ f_n = n\Delta f,$$
$$C_{-n} = C_n,$$
$$\phi_{-n} = -\phi_n,$$
$$\lim_{N\to\infty} \frac{1}{2} \sum_{n=-N}^{N} F(f_n)\Delta f = \int_0^\infty F(f)df \equiv \overline{i^2(t)}. \qquad (5)$$

Here, $F(f)$ is the noise power spectrum, and $\overline{i^2(t)}$ is the mean square noise current, or total average power for a load of 1 ohm. Substituting (4) into (1) and using (3), and assuming that $\exp [P_1 t_1/2] \gg 1$ and that $P_1 \gg P_2$ (these assumptions are the same as those made before), there is obtained

$$E(t) = \frac{1}{C} \exp\left[\frac{P_1 t}{2}\right] \sum_n C_n \exp [-j\phi_n] \times \frac{1 - \exp\left[-\frac{P_2 t_2}{2} + j\omega_0 t_2 - j\omega_n t_2\right]}{\frac{P_2}{2} + j(\omega_n - \omega_0)}. \qquad (6)$$

To find the mean square value of $E(t)$, (this is commonly called the average power) $E(t)$ is multiplied by $E^*(t)$, its conjugate, and then the product averaged. Two averages must be taken; one with respect to ϕ_n, the random phase angle, and the other with respect to t over the period, T, of a quench cycle.

$$\text{ave.}\ \{E(t)E^*(t)\} = \frac{1}{2\pi T} \int_0^{2\pi} \int_0^{t_1} E(t)E^*(t)dtd\phi_n, \qquad (7)$$

or

$$\overline{E^2(t)} = \frac{-\exp [P_1 t_1]}{C^2 P_1} \sum_n C_n^2 \times \frac{1 + \exp [-P_2 t_2] - 2\exp\left[-\frac{P_2 t_2}{2}\right] \cos (\omega_n - \omega_0) t_2}{\frac{P_2^2}{4} + (\omega_n - \omega_0)^2}. \qquad (8)$$

Now, from (5),

$$C_n^2 = 2F(f_n)\Delta f = 2F(\omega_n) \frac{\Delta\omega}{2\pi} = \frac{1}{\pi} F(\omega_n)\Delta\omega.$$

[5] S. O. Rice, "Mathematical analysis of random noise," *Bell. Sys. Tech. Jour.*, vol. 24, p. 125; January, 1945.

The series in (8) can be approximated by an integral in which ω_n becomes ω and $\Delta\omega \to d\omega$. Now suppose that $F(\omega)$ is flat and equals F_0. Then (8) becomes

$$\overline{E^2(t)} = \frac{2 \exp [P_1 t_1] F_0}{T P_1 P_2 C^2} (1 - \exp [-P_2 t_2]). \qquad (9)$$

It is of interest now to compute the output power spectrum of the noise since this noise may be passed through other circuitry. To find the output power spectrum, the autocorrelation function is first computed. Then the power spectrum is found by taking the Fourier transform of the autocorrelation functions. This is Wiener's theorem.[6] Written as a Fourier series with period T, (6) has the form

$$E(t) = \sum_{m=-\infty}^{\infty} a_m \exp\left[j \frac{2\pi m t}{T}\right] \sum_{n=-\infty}^{\infty} C_n f(\omega_n), \qquad (10)$$

where

$$a_m = \frac{1}{CT} \int_0^{t_1} \exp\left(\frac{P_1 t}{2} - \frac{2\pi j m t}{T}\right) dt.$$

Now the autocorrelation function of $E(t)$ is

$$R(\tau) \equiv \text{ave.}\ \{E(t)E^*(t+\tau)\}$$
$$= A_0 \sum_n |a_n|^2 \exp\left[\frac{2\pi j n \tau}{T}\right], \qquad (11)$$

where

$$A_0 = \frac{2F_0}{P_2}(1 - \exp [-P_2 t_2]), \qquad (12)$$

for $F(\omega) = F_0$, a constant. Taking the Fourier transform to get the power spectrum,

$$F_1(\omega) = \int_{-\infty}^{\infty} R(\tau) \exp [-j\omega\tau] d\tau$$
$$= A_0 \sum_n |a_n|^2 \delta\left(\omega - \frac{2\pi n}{T}\right), \qquad (13)$$

where $\delta[\omega - (2\pi n/T)]$ is the Dirac delta function in the frequency domain. Equation (13) indicates a discrete spectrum, with components at harmonics of the quench frequency.

Now suppose that the highest modulating frequency to be amplified is f_a. The quench rate must then be as least $2f_a$. This is a statement of the general theorem that a time function containing no frequencies higher than f_a is completely specified by a set of discrete ordinates occurring at a frequency $2f_a$.[7] Then the detector of the sr amplifier will be followed by a low-pass filter which cuts off above f_a, but below $1/T$, the quench frequency.

[6] H. M. James, N. B. Nichols, and R. S. Phillips, "Theory of Servomechanisms," MIT Rad. Lab. Series No. 25, McGraw-Hill Book Co., Inc., New York, N. Y., p. 273, 1947.
[7] B. M. Oliver, J. R. Pierce, and C. E. Shannon, "The philosophy of pcm," Proc. I.R.E., vol. 36, p. 1324; November, 1948.

Therefore, the only component of the noise spectrum in (29) which is passed by this filter is the dc component, which is the component for $n=0$. This is $A_0|a_0|^2$. Under our assumption that $\exp[P_1t_1/2]\gg 1$,

$$\overline{E_0^2(t_1)} = \frac{8F_0 \exp[P_1t_1](1-\exp[-P_2t_2])}{C^2T^2P_1^2P_2}. \quad (14)$$

The noise power spectrum F_0 is the total noise spectrum from any source. Of course thermal noise is always present, and there may be shot noise present, too, if the electron tube is used to introduce a small negative conductance during the listening interval. It will be shown later that some advantage may be obtained from this procedure. Thus we write

$$F_0 = F_1 + F_2, \quad (15)$$

where F_1 = thermal noise power spectrum and F_2 = shot noise power spectrum. One can write F_0 as a simple sum since thermal noise and shot noise are independent.

At the end of the listening interval, conditions change radically. A large negative conductance is introduced. This usually means an increase in the shot noise during the build-up interval. The noise contributed during the build-up interval in this way can be calculated as before. It turns out to be

$$\overline{E^2(t_1)} = \frac{\exp[P_1t_1]}{\pi T P_1 C^2}\int_{-\infty}^{\infty}\frac{F'(\omega)d\omega}{\frac{P_1^2}{4}+(\omega-\omega_0)^2}, \quad (16)$$

where $F'(\omega)$ is the power spectrum of the shot noise introduced during the build-up interval. For $F'(\omega)=F_0'$, a constant, and after passing through the video filter, this becomes

$$\overline{E_1^2(t_1)} = \frac{8F_0'\left(\exp\left[\frac{P_1t_1}{2}\right]-1\right)^2}{C^2T^2P_1^3} \approx \frac{8F_0'\exp[P_1t_1]}{C^2T^2P_1^3}. \quad (17)$$

The total noise power output is the sum of (14) and (17).

Consider now the problem of the noise figure of a superregenerative amplifier. Noise figure is commonly defined as

$$NF = \frac{\frac{S}{N}\text{in}}{\frac{S}{N}\text{out}}, \quad (18)$$

where S stands for the available signal power, and N stands for the available noise power. Now the available power gain of the amplifier is usually defined as $G=S_{out}/S_{in}$, so that (18) becomes

$$NF = \frac{N_{out}}{GN_{in}}. \quad (19)$$

Thus the noise figure is the ratio of the actual available noise power to the available output noise power of an ideal (no noise sources) network with the same gain characteristics. The external noise is assumed to be entirely thermal noise, and the internal noise is assumed to be due entirely to shot noise.

GN_{in} can be interpreted as the noise through the amplifier, due to the external source. This is given by (14) with F_1 of (15) substituted for F_0. Then

$$NF = 1 + \frac{F_2}{F_1} + \frac{F_0'P_2}{F_1P_1(1-\exp[-P_2t_2])}. \quad (20)$$

This has a minimum value for $P_2=0$. In this case

$$NF_{min} = 1 + \frac{F_2}{F_1} + \frac{F_0'}{F_1P_1t_2}. \quad (21)$$

Equation (21) assumes that the other quantities are unaffected when $P_2\to 0$.

The Use of a Relex Klystron

It was stated earlier that a reflex klystron[8–11] could be used in a microwave sr amplifier. The structure of a reflex klystron is shown in Fig. 3. The accelerating potential for the electron beam is usually applied to the cavity resonator. A small negative potential applied to the repeller reflects electrons back to the gap. If there exists a sinusoidal voltage across the gap, the electron beam will be velocity modulated. The result of this velocity modulation is to "bunch" the electron beam.

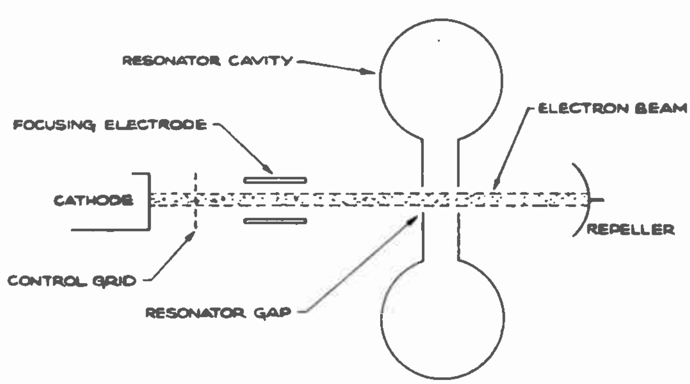

Fig. 3—Structure of a reflex klystron.

"This bunching causes the electrons that are returned toward the anode (cavity) by the repeller to return through the anode gap in bursts or pulses, one each cycle. When these pulses pass through the gap at such a time that the electrons in the pulses are slowed down as a result of the alternating voltage existing across the gap at the instant of their return passage, energy will

[8] J. R. Pierce, "Reflex oscillators," Proc. I.R.E., vol. 33, p. 112; February, 1945.
[9] E. L. Ginzton and A. E. Harrison, "Reflex klystron oscillators," Proc. I.R.E., vol. 34, p. 97; March, 1946.
[10] D. R. Hamilton, J. K. Knipp and J. B. H. Kuper, "Klystrons and Microwave-Triodes," MIT Rad. Lab. Series No. 7, McGraw-Hill Book Co., Inc., New York, N. Y.; 1948.
[11] K. R. Spangenburg, "Vacuum Tubes," McGraw-Hill Book Co., Inc., New York, N. Y., p. 571, 1948.

be delivered to the oscillations in the resonator and will thereby assist in maintaining these oscillations."[12] This condition results from a transit time from resonator gap to repeller and back of approximately $n+3/4$ cycles, where n is an integer or zero. This action is equivalent to introducing a negative conductance in the cavity. The exact value of negative conductance which is introduced is proportional to the beam current. If the beam current is large enough, all the losses may be overcome and oscillations will build up until overload takes place, or the beam current is reduced, or the value of repeller voltage is changed. This is just the action desired in a superregenerative amplifier. It is possible for the beam current to damp the cavity, too. There is always some loading effect due to the beam absorbing energy from the cavity on the first passage. When the repeller voltage is of such a value as to cause the returned electron bunches to introduce negative conductance, the losses are reduced or overcome, but if the repeller voltage is of such a value as to introduce positive conductance, then the beam loading effect is enhanced and severe damping may result. A large Q during the listening interval may be obtained by allowing sufficient beam current to make $P_2 \to 0$. $P_2=0$ means infinite Q.

It is possible to write equations for the noise figure in terms of klystron parameters. To do this we use the small-signal theory as described by Spangenburg[11] and Terman[12] from which the formulas to be used are obtained. First the following symbols are defined:

ω_0 = rf angular frequency, resonant angular frequency of cavity.
t_g = time an electron spends in the gap space, in seconds.
t_d = time an electron spends in the drift space, the space between repeller and gap, in seconds.
$\theta_g = \omega_0 t_g$ = gap transit angle, in radians.
$\theta_d = \omega_0 t_d$ = drift space transit angle, in radians.
$M = (\sin[\theta_g/2])/\theta_g/2$ = beam coupling coefficient.
I (with appropriate subscripts) = direct beam current in amperes.
V_0 = beam potential (accelerating potential), in volts.
G_B = beam loading conductance in mhos (always positive).
G_e = electronic transconductance, in mhos (negative for buildup).
G_{LR} = equivalent shunt conductance of load and resonator cavity, in mhos.
G_T = total conductance in mhos.
K = Boltzmann's constant $= 1.38\times10^{-23}$ joules per degree K.
T_0 = Kelvin temperature, degrees.
ϵ = electronic charge $= 1.6\times10^{-19}$ coulombs.
C = shunt capacity, in farads.

[12] F. E. Terman, "Radio Engineering," McGraw-Hill Book Co. Inc., New York, N. Y., 3rd ed., p. 444, 1943.

The following three formulas may therefore be obtained.

$$G_T = G_{LR} + G_B - |G_e|. \tag{22}$$

$$G_B = \frac{I}{2V_0}\left(M^2 - M\cos\frac{\theta_g}{2}\right). \tag{23}$$

$$|G_e| = \frac{IM^2\theta_d}{V_0}\left[\frac{J_1(X)}{X}\right]|\sin\theta_d|. \tag{24}$$

Here

$$X = \frac{MV_1\theta_d}{2V_0}, \tag{25}$$

where $J_1(X)$ is the Bessel function of first kind and first order, and V_1 is the amplitude of the signal voltage. We shall assume that $J_1(X)/X$ is adjusted to have its maximum value of one half, although actually this is impossible in practice because the signal strength changes during build-up. Defining the quantity B by

$$-B = \frac{M^2 - M\cos\frac{\theta_g}{2} - \frac{M^2}{2}\theta_d|\sin\theta_d|}{V_0}, \tag{26}$$

substituting (23) and (24) into (22), and using (26), there is obtained

$$G_T = G_{LR} - IB. \tag{27}$$

Let I_1 = beam current during the listening interval,
I_2 = beam current during build-up,
G_{T1} = total conductance during listening,
and G_{T2} = total conductance during build-up.

Then recalling that $P(t) = g(t)/C$,

$$P_2 = \frac{G_{LR} - BI_1}{C}, \tag{28}$$

$$P_1 = \frac{BI_2 - G_{LR}}{C}. \tag{29}$$

The thermal noise spectrum is given by[13]

$$F_1 = KT_0. \tag{30}$$

The power spectrum of shot noise is $2\epsilon I$,[14] for a temperature-limited cathode. For space-charge limited current, the shot noise is less. However, at high frequencies, the smoothing effect of space charge is reduced. Therefore, it will be somewhat pessimistically assumed that the shot effect has the spectrum $2\epsilon I$ for the reflex klystron. All of this shot noise current is not effect across the resonator gap, because the coupling between beam and cavity is not perfect. The power that is coupled from the beam to the cavity is proportional to M^2. Therefore, the shot noise spectra during listening and during buildup, respectively, are

$$F_2 = 2\epsilon I_1 M^2, \tag{31}$$

$$F_0' = 2\epsilon I_2 M^2. \tag{32}$$

[13] S. Goldman, "Frequency Analysis, Modulation, and Noise," McGraw-Hill Book Co., Inc., New York, N. Y., p. 390; 1948.
[14] *Ibid.*, p. 362.

We shall write the noise figures for two cases.

1. The beam current during listening is zero. This means that $P_2 \neq 0$ and that, in (20), $\exp[-P_2 l_2] \ll 1$. Also $F_2 = 0$.

2. Enough beam current is allowed during the listening interval so that the losses in the cavity are just cancelled, making $P_2 = 0$. This means we must use (21) for this case.

We have then, the following, using (20), (21), (28), (30) and (32),

Case 1:

$$NF_1 = 1 + \frac{2\epsilon G_{LR} M^2 I_2}{KT_0(BI_2 - G_{LR})}. \tag{33}$$

Case 2:

$$NF_2 = 1 + \frac{2\epsilon M^2 I_1}{KT_0} + \frac{2\epsilon CM^2 I_2}{KT_0 l_2(BI_2 - G_{LR})}. \tag{34}$$

It should be noted that I_2 is always large enough so that oscillations build up during the build-up interval. It is seen that this means

$$I_2 > \frac{G_{LR}}{B}. \tag{35}$$

Equations (33) and (34) have no meaning for $I_2 < (G_{LR}/B)$. A minimum noise figure is approached asymptotically. For Case 1, this minimum is

$$NF_{1M} = 1 + \frac{2\epsilon G_{LR} M^2}{KT_0 B}, \tag{36}$$

and for Case 2,

$$NF_{2M} = 1 + \frac{2\epsilon I_1 M^2}{KT_0} + \frac{2\epsilon CM^2}{KT_0 l_2 B}. \tag{37}$$

A question of particular interest is whether it is ever advantageous to introduce beam current, and therefore shot noise, during the listening interval to make $P_2 = 0$. The answer is yes, if it is desired to get a lower noise figure. We have considered a hypothetical, but realistic, case in which numbers were substituted into (33) and (34). In fact, the numbers chosen are actually approximated in a QK205 reflex klystron. The conditions were as follows:

resonator gap spacing	$= 0.020$ inch
resonant frequency	$= 10{,}000$ mc
cold Q of cavity and load	$= 500$
shunt capacity	$= 1$ $\mu\mu$f
beam potential	$= 1{,}000$ volts
listening time	$= 0.2$ μsec.

The mode of operation considered was $\theta_d = (23/4)(2\pi)$ radians ($5\frac{3}{4}$ cycle mode). From the conditions above, all the necessary parameters may be calculated to find the noise figure. Results for the $5\frac{3}{4}$ cycle mode are shown in Fig. 4. In this figure, the independent variable is incremental beam current, which is that in excess of the current necessary to produce oscillation. Thus

$$\Delta I = I_2 - \frac{G_{LR}}{B}.$$

Fig. 4 clearly shows the advantage obtained by allowing enough beam current during the listening interval to cancel the cavity losses. The following conclusions may be drawn for obtaining low noise figure.

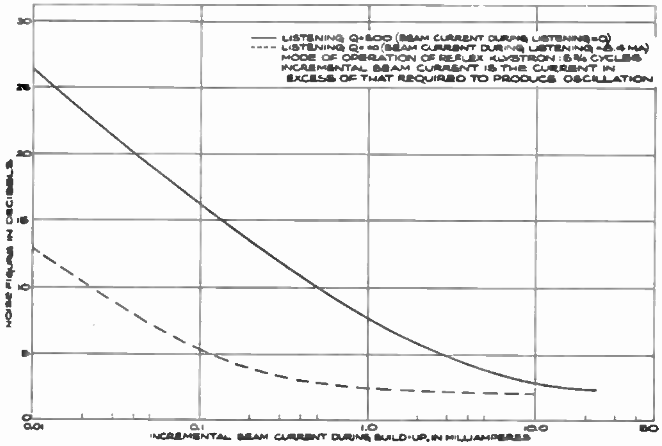

Fig. 4—Incremental beam current during build-up, in ma. Noise figure of a hypothetical superregenerative amplifier.

1. The listening interval should be as long as possible.
2. The cold listening Q should be as high as possible.
3. The direct beam current during build-up should be as high as possible consistent with operation in the linear mode (no overload). If the build-up interval is kept short, high beam current may be used.
4. It is profitable to allow sufficient beam current during the listening interval to make $P_2 = 0$.
5. A high mode of operation will allow low noise figures to be obtained with smaller beam current.

Acknowledgment

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The Use of Admittance Diagrams in Oscillator Analysis*

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Summary—**Much useful general information concerning the behavior of oscillators may be obtained by means of a graphical analysis based upon curves of electronic and circuit admittance. A curve of electronic susceptance versus electronic conductance and a curve of circuit susceptance versus circuit conductance are plotted in the same diagram. At points of intersection of the two curves the electronic and circuit admittances are equal in magnitude and phase. These points therefore indicate possible equilibrium values of frequency and amplitude. This method of analysis explains observed oscillator phenomena, such as amplitude and frequency hysteresis, dominance of one mode of oscillation over other modes, pulsing, and electronic tuning. The function of this paper is to present a summary of information previously found only scattered throughout the literature on oscillators.**

Introduction

THE ANALYSIS to be presented in this paper is helpful in explaining many aspects of oscillator behavior. It is not ordinarily directly applicable to the quantitative prediction of the operating characteristics of oscillators of known parameters, although it may occasionally serve as a guide in oscillator design. Most of the ideas contained in the paper are not new, but may be found scattered throughout the technical literature on oscillators.

Two-terminal and Four-terminal Oscillators

Electronic oscillators may be classified as two-terminal and four-terminal types. A two-terminal electronic oscillator is one that consists of a two-terminal oscillatory circuit shunted by some form of two-terminal electronic device capable of transferring power to the oscillatory circuit from the source of direct voltage. The electronic element must exhibit an admittance between its terminals that has a negative conductive component, i.e., the application of an alternating voltage to the terminals must result in the flow current in opposition to the applied voltage. Oscillation can occur if the magnitude of the electronic conductance is equal to or exceeds the conductance of the oscillatory circuit shunted across the element. In microwave devices the electronic admittance results from the presence of moving electrons within a gap across which the voltage is impressed. At lower frequencies, as in dynatron and transitron oscillators, secondary emission or other phenomena may be involved. The reflex klystron is an excellent example of a two-terminal microwave oscillator.

In four-terminal oscillators, the electronic device is a four-terminal element. Application of alternating voltage between one pair of terminals results in the flow of alternating current through a circuit connected across the other pair. In other words, the device has a transadmittance. Oscillation is obtained with such a device only when the output terminals are connected to the input terminals through a suitable feedback network. Triode, tetrode, and pentode feedback oscillators and two-resonator klystrons are examples of four-terminal oscillators.

Electronic admittance and transadmittance are ordinarily essentially independent of frequency over the frequency range covered by a tunable oscillator. They are, however, dependent upon amplitude. Although their magnitudes may increase with voltage amplitude at low amplitude, a value of amplitude is always reached beyond which the magnitude of electronic admittance or transadmittance falls with increase of amplitude. This characteristic is essential to limitation of amplitude of oscillation, and results from nonlinearity of the electronic device.

Two-terminal Oscillatory Circuit

The oscillatory circuit connected across the electronic element of a two-terminal oscillator ordinarily consists of some type of resonator to which an external load is coupled. At frequencies up to several hundred megacycles per second, the resonator usually takes the form of a lumped-element circuit. In the microwave range, however, the characteristics of lumped-element circuits are unsatisfactory and other types of resonators, such as cavity resonators or sections of transmission lines must be employed. Although microwave resonators do not in general behave like simple parallel resonant circuits, in the vicinity of a resonance frequency they may ordinarily be represented by an equivalent parallel combination of constant-lumped inductance, capacitance, and conductance, the values of which are different for different modes of resonance.

In many oscillator circuits the external load is connected to the output resonator through a transmission line. At the lower frequencies the line is usually short in comparison with the wavelength and the effect of the line is negligible. In microwave tubes, on the other hand, a length of line large in terms of the wavelength is usually an integral part of the tube structure, and

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cannot be eliminated. The coupling line must, therefore, in general be taken into consideration in an equivalent circuit of the oscillator. The general form of the equivalent circuit of a two-terminal oscillator is shown in Fig. 1, in which Y_e represents the electronic admittance between the electrodes across which the resonator is shunted, and G_r, C_r, and L_r represent the equivalent resonator conductance, capacitance, and inductance

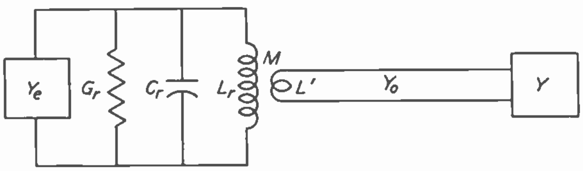

Fig. 1—Equivalent circuit of a two-terminal oscillator.

in the vicinity of a resonance frequency. M represents the mutual inductance between the coupling coil or loop and the resonator, and L' represents the self-inductance of the coupling coil or loop. Y is the admittance of the load in which the transmission line is terminated, and Y_0 is the characteristic admittance of the line. In low-frequency circuits, Y may be considered to be connected directly across the coupling coil.

The transmission line, loaded at the far end by the admittance Y, may be replaced by the equivalent admittance Y_l' measured between its input terminals. By well-known methods, the combination of the coupling loop and Y_l' may be replaced by an equivalent admittance Y_l shunted across the resonator admittance. The equivalent circuit may then be drawn in the form of Fig. 2, in which $Y_r = G_r + j\omega C_r - 1/j\omega L_r$.

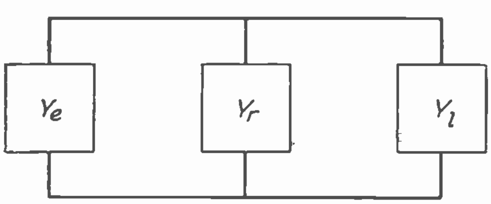

Fig. 2—Simplified equivalent circuit of a two-terminal oscillator.

Although the electronic susceptance B_e is essentially independent of frequency throughout the tuning range of most oscillators, at any oscillation frequency it may be considered to result from an equivalent inductance L_e or capacitance C_e. Fig. 2 may, therefore, be drawn in the equivalent form of Fig. 3, in which G, C, and L have values given by the relations

$$G = G_e + G_r + G_l \quad (1)$$

$$C = C_e + C_r + C_l \quad (2)$$

$$L = 1/(1/L_e + 1/L_r + 1/L_l) \quad (3)$$

Electronic inductance L_e and capacitance C_e are not present simultaneously in the equivalent circuit.

In the analysis that follows, the total circuit admittance, conductance, and susceptance will be represented by the symbols Y_c, G_c, and B_c. The circuit admittance is the sum of the resonator and load admittances, as stated by the relations:

$$\begin{aligned} Y_c &= Y_r + Y_l \\ G_c &= G_r + G_l \\ B_c &= B_r + B_l = \omega(C_r + C_l) - (1/\omega L_r + 1/\omega L_l). \end{aligned} \quad (4)$$

An exact analysis of the equivalent circuit of Fig. 3 is complicated by the dependence of G_e upon voltage amplitude. For this reason the assumption will first be made that G_e is constant, and the effect of variation of G_e upon the behavior of the oscillator will be made subsequently. The dependence of B_e upon amplitude causes some change of frequency as the amplitude of oscillation builds up, but the change is normally so small that B_e may also first be assumed to be constant in making the analysis.

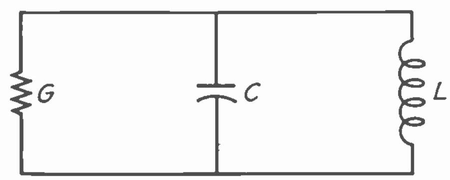

Fig. 3—Simplified equivalent circuit of a two-terminal oscillator.

Variation of Y_e with amplitude is an indication that the relation between the electronic gap current and the voltage which produces it is not linear. Since one consequence of nonlinearity of circuit elements is the generation of harmonics in the current and voltage, it follows that variation of Y_e with amplitude is always associated with the presence of harmonics. A strictly rigorous analysis would have to take harmonics into account or else show that the presence of harmonics has negligible effect upon the steady-state frequency and amplitude, even at large values of amplitude. Because the complexity of a complete analysis tends to complicate an interpretation of the results, and because the following treatment is intended to be of value principally in explaining qualitatively some of the observed characteristics of oscillator behavior, harmonics will be neglected. The simplified analysis is valid at small amplitudes of oscillation; its application at large amplitudes is justified by the fact that the phenomena which it predicts are observed experimentally.

Under the assumption that all parameters in the circuit of Fig. 3 are constant and linear, summation of the currents at one of the nodal points yields the following differential equation for the voltage V across the elements:

$$\frac{d^2V}{dt^2} + \frac{G}{C}\frac{dV}{dt} + \frac{V}{LC} = 0 \quad (5)$$

in which G, C, and L are given by (1) to (3). The solution of (5) is

$$V = V_0 \epsilon^{\alpha t} \sin (\omega t + \phi) \tag{6}$$

in which

$$\alpha = -G/2C = -(G_e + G_r + G_l)/2C$$
$$= -(G_e + G_c)/2C \tag{7}$$

$$\omega = \sqrt{\frac{1}{LC} - \frac{G^2}{4C^2}} = \sqrt{\frac{1}{LC} - \alpha^2} \tag{8}$$

and the constants V_0 and ϕ are the amplitude and phase angle of the voltage at the instant when $t=0$.

Equation (8) shows that the voltage can be sinusoidal only if $|G| < 2\sqrt{C/L}$. Examination of (6) and (7) discloses that, since the resonator and load conductances G_r and G_l are positive, sustained sinusoidal oscillation is possible only if the electronic conductance G_e is negative and equal to or greater in magnitude than G_c. If G_e is negative and equal in magnitude to G_c, α is zero and the oscillation is of constant amplitude. If G_e is negative and greater in magnitude than G_c, the amplitude of oscillation theoretically increases continuously. Actually, however, the dynamic value of G_e varies with the amplitude of oscillation and, although it may remain constant or increase in magnitude over some ranges of amplitude, there is always some amplitude above which it decreases. Eventually, therefore, an equilibrium amplitude is reached at which the dynamic value of G_e is equal to G_c. This amplitude is evidently dependent upon the manner in which G_e varies with amplitude, upon the resonator losses, and upon the load.

Equation (6) indicates that oscillation cannot take place unless it is started in some manner. In any actual circuit, the random thermal motion of electrons sets up random current pulses of sufficient magnitude to initiate the oscillation if the static value of G_e, i.e., the value of G_e at zero amplitude, is negative and greater in magnitude than G_c.

Physically, a negative value of G_e is an indication that the motion of electrons through the electric and magnetic fields within the tube results in a conversion of energy from the source of direct voltage to the source of alternating voltage across the electrodes. In an oscillator, the source of alternating voltage is the resonator.

Admittance Diagrams for Two-terminal Oscillators

Equations (6) and (7) show that under equilibrium conditions α must be zero and

$$G_e = -(G_r + G_l) \equiv -G_c. \tag{9}$$

When α is zero, (8) reduces to the relation

$$\omega C - 1/\omega L = 0. \tag{10}$$

Since ωC and $1/\omega L$ represent the capacitive and inductive components of the total susceptance $B_e + B_r + B_l$ of the circuit of Figs. 2 and 3, (10) is satisfied only if

$$B_e = -(B_r + B_l) \equiv -B_c. \tag{11}$$

Equations (9) and (11) represent the criteria for steady-state oscillation.

Since G_e and B_e may ordinarily be considered to be functions of amplitude alone, and G_c and B_c of frequency alone, the solution of the simultaneous equations (9) and (10), expressed in terms of amplitude and frequency, should indicate the equilibrium values of amplitude and frequency. The functional expressions for Y_e and Y_c are usually so complex, however, that an analytical treatment is difficult, if not impossible, and for some oscillators the functional relation between Y_e and amplitude is not known. Much useful general information concerning the behavior of oscillators may be obtained from a graphical analysis, nevertheless, even when the exact forms of the expressions for Y_e and Y_c are not known. The graphical method consists in plotting the conductive and susceptive components of Y_e and $-Y_c$ at various frequencies in rectangular coordinates of admittance and susceptance, i.e., in plotting B_e versus G_e and $-B_c$ versus $-G_c$ in the same diagram. Since the curves intersect at points where (9) and (11) are satisfied, the points of intersection indicate possible equilibrium values of amplitude and frequency.

The presence of the term α^2 in (8) indicates that during the build-up and decay of oscillation the frequency of oscillation is less than the value at which B_e and B_c are equal in magnitude. Since α^2 is usually small in comparison with $1/LC$, however, the following treatment will be simplified by the assumption that B_e and B_c are equal in magnitude not only under steady-state oscillation, but also during transient periods. Under this assumption, the ordinate of the admittance point on the $-Y_c$ curve in the admittance diagram must be equal to the ordinate of the admittance point on the Y_e curve at all times.

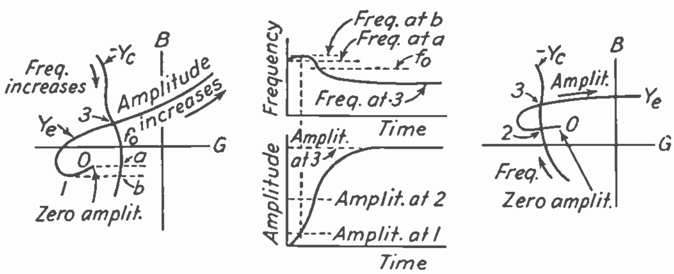

Fig. 4—(a) Admittance diagram for a two-terminal oscillator. (b) Variation of frequency and amplitude during buildup of oscillation. (c) Admittance diagram; oscillation not self-starting.

Fig. 4(a) shows an admittance diagram in which the curves of circuit admittance and electronic admittance are of arbitrary form. Equilibrium oscillation obtains for values of frequency and amplitude corresponding to point 3, since (9) and (11) are satisfied at this point. The zero-amplitude electronic-admittance point is at 0. Under the assumption that $B_e + B_c = 0$ during the build-up of oscillation, the circuit admittance and frequency at zero amplitude correspond to point a on the curve of $-Y_c$. Because the magnitude of the electronic conductance at point 0 exceeds that of the circuit conductance at point a, α is positive in (6) and any initial disturbance, such as circuit or tube noise, initiates an oscillation of increasing amplitude. As the amplitude increases, the electronic-admittance point moves toward point 1 and the circuit-admittance point moves toward point b. Inasmuch as the frequency increases along the circuit-admittance curve from a to b, increase of amplitude from 0 to 1 is accompanied by increase of frequency of oscillation. With increase of amplitude beyond that corresponding to point 1, the electronic-admittance point moves back toward the conductance axis, the displacement being accompanied by an equal displacement of the circuit-admittance point and consequently by a decrease of frequency. The amplitude continues to increase and the frequency to decrease until the amplitude reaches the value corresponding to the intersection at 3. This point is stable, inasmuch as further increase of amplitude would cause the magnitude of G_e to become less than G_c and the amplitude therefore to decrease.

The rate at which the amplitude increases during the build-up of oscillation to the stable value corresponding to point 3 is at every instant proportional to the difference in magnitudes of the electronic and circuit conductances. In the foregoing example, the greatest difference between the magnitudes of G_e and G_c occurs for an amplitude corresponding to a point on the Y_e-curve not far from that at which G_e has its greatest magnitude. Fig. 4(b) shows the general manner in which the amplitude and frequency vary with time during the growth of oscillation. The frequency f_0 is that at which the circuit susceptance is zero, and is therefore the resonance frequency of the resonator alone.

If the electronic conductance at zero amplitude is smaller in magnitude than the circuit conductance, as in Fig. 4(c), α is negative at zero amplitude and oscillation cannot start spontaneously. Should the circuit be driven, however, to an amplitude equal to or greater than that at point 2, the amplitude will increase to the equilibrium value at point 3.

Under certain conditions, oscillation may start simultaneously at more than one frequency.[1] The manner in which the oscillation builds up is then complicated by the fact, shown both theoretically and experimentally, that when voltages of two different frequencies are impressed simultaneously across a gap, the electronic admittance for either voltage is changed by the presence of the other voltage. An example of an admittance diagram that predicts simultaneous starting at two frequencies is shown in Fig. 5(a), in which the circuit admittance is that of a section of transmission line. The curve of input susceptance versus input conductance of a section of transmission line of characteristic admittance Y_0, terminated in a load that results in a voltage standing-wave ratio S is a circle with its center on the conductance axis and passing through points on the conductance axis at which the conductance is equal to Y_0S and Y_0/S. Increase of frequency causes the admittance point to be displaced along the circle in a clockwise direction. (Equal intervals along the circle do not correspond to equal frequency increments, the rate of change of position with respect to frequency being least at the point of minimum conductance and greatest at the point of maximum conductance.)

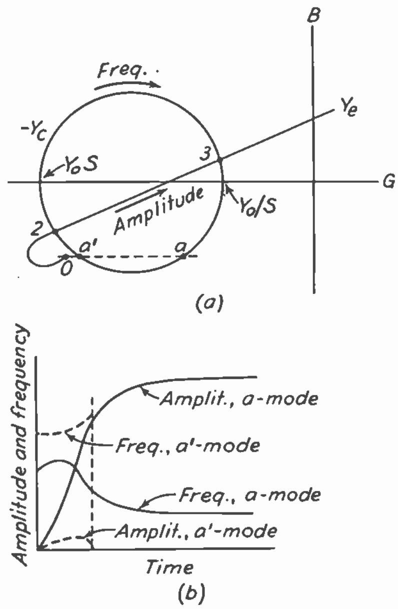

Fig. 5—(a) Admittance diagram of a two-terminal oscillator capable of oscillating in more than one mode. (b) Variation of frequency and amplitude in two modes of oscillation during buildup of oscillation.

In Fig. 5(a), the zero-amplitude electronic conductance is greater in magnitude than the circuit conductance of both point a and point a'. Oscillation therefore starts at the frequencies corresponding to both of these points. Because of the lower magnitude of G_c at point a than at point a', however, the oscillation corresponding to point a builds up much more rapidly than that corresponding to point a' and eventually reaches equilibrium at point 3. The electronic conductance for the a'-frequency is reduced not only as the result of increase of amplitude of the a'-oscillation, but also as the result of the rapidly increasing amplitude of the a-oscillation. At some time before the amplitude of the a-oscillation reaches that corresponding to point 3, G_e for the a'-oscillation falls below the corresponding magnitude of G_c, and the a'-oscillation therefore dies out. Fig. 5(b) shows general manner in which amplitude and frequency of the two modes of oscillation vary with time.

[1] W. H. Huggins, Proc. I.R.E., vol. 35, p. 1518; December 1947; vol. 36, p. 624; May 1948.

Under certain conditions oscillations may exist simultaneously in two frequencies under equilibrium conditions.[2] Oscillation may also take place alternately in two modes, one dying down as the other builds up.

The particular curves discussed in the foregoing examples were chosen only because they are convenient in explaining important points in the analysis. The graphical analysis based upon an admittance diagram may be applied to any type of oscillator, regardless of the type of energy-converting device, type of resonator, or type of loading. The shape and position of the electronic-admittance curve depends upon the type of electronic device and the operating voltages and currents; the shape and position of the circuit-admittance curve depends upon the characteristics of the resonator and the extent and manner in which it is loaded.

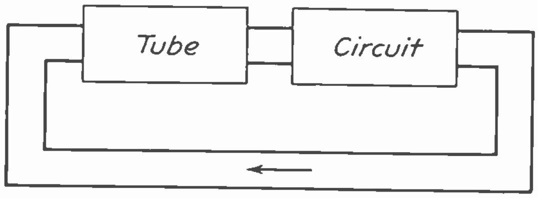

Fig. 6—Block diagram of a four-terminal oscillator.

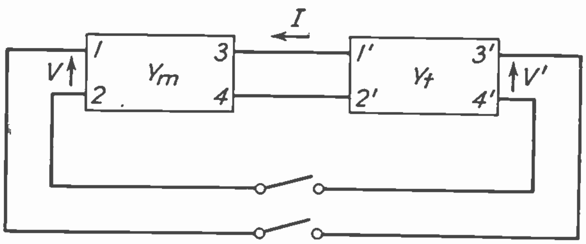

Fig. 7—Equivalent circuit of a four-terminal oscillator.

Admittance Diagrams for Four-terminal Oscillators

In four-terminal oscillators, the output of an electron tube is coupled back to the input through a four-terminal circuit, as in Fig. 6. If the tube is represented by a transmittance Y_m and the circuit by a transfer admittance Y_t, the circuit becomes that of Fig. 7. The electronic element is assumed to be unilateral; that is, application of an alternating voltage to terminals 1–2 results in the flow of alternating current through terminals 3–4, but the application of voltage to, or the flow of current through, terminals 3–4 has no effect upon the voltage or current of terminals 1–2. The electronic transadmittance Y_m is defined as the ratio of the current into terminal 3 to the voltage applied to terminal 1 relative to terminal 2. The circuit transfer admittance Y_t is defined as the ratio of the impressed current flowing *into* terminal 1′ to the resulting voltage of terminal 3′ relative to terminal 4′. On the basis of these definitions, the voltage V' produced between terminals 3′–4′ by the application of a voltage V to the terminals 1–2 is given by the relation $V' = -Y_m V/Y_t$.

If V' is equal to V in phase and magnitude, i.e., if $Y_m = -Y_t$, the voltages and currents in the network will not be affected if the impressed voltage V is replaced by the output voltage V' by closing the switch. In other words, the closed circuit will oscillate with constant amplitude. Since V' must be identical with V in the closed system, oscillation can occur only at a frequency that makes Y_m and $-Y_t$ equal in phase. If the magnitude of Y_m is less than that of Y_t, V' is less than V in the open system, and the amplitude of oscillation must die down when the system is closed. If the magnitude of Y_m is greater than that of Y_t, on the other hand, the amplitude of oscillation in the closed system increases.

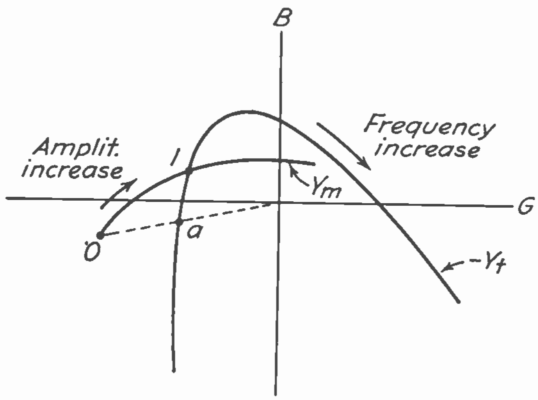

Fig. 8—Admittance diagram of a four-terminal oscillator.

The foregoing discussion indicates that four-terminal oscillators can be analyzed with the aid of transfer-admittance diagrams. As in admittance diagrams for two-terminal oscillators, curves of B_m versus G_m and $-B_t$ versus $-G_t$ are constructed in the same diagram. Fig. 8 shows a diagram in which the curve of Y_e is of arbitrary form and that of Y_m is typical of coupled two-resonator oscillator circuits. Point 0 on the Y_m curve corresponds to zero amplitude. Oscillation starts at the frequency corresponding to point a, at which the phase angle of $-Y_t$ is equal to that of Y_m. Because the magnitude of Y_m at zero amplitude is greater than that of $-Y_t$, the amplitude increases and the electronic-admittance point moves toward point 1. Displacement of the electronic-admittance point with increase of amplitude is accompanied by displacement of the circuit-admittance point, the two points always lying on the same radius vector. The increase of amplitude of oscillation is consequently accompanied by change of frequency. The amplitude continues to increase, with an accompanying change of frequency, until point 1 is reached. This point corresponds to steady-state oscilla-

[2] Schaffner, Hans, "Some Notes on Simultaneous Oscillations in Systems with Two Degrees of Freedom," E.E. Res. Lab., Eng. Exp. Sta., U. of Ill.

tion, since further increase of amplitude would cause the magnitude of Y_m to become less than that of $-Y_t$ and the amplitude to decrease.

Long-line Effect

As an example of the application of admittance diagrams to the analysis of oscillators, admittance diagrams will be used to explain a frequency- and amplitude-hysteresis effect that is observed when load is coupled to an oscillator resonator through a line that is long in comparison with the wavelength, as in the circuit of Fig. 1. In the vicinity of one of the frequencies of resonance, the shunt conductance of a resonator is essentially constant, and the susceptance proportional to the frequency. The admittance curve is a straight line parallel to the susceptance axis. The input admittance of a line terminated in an unmatched load is a circle, as in Fig. 5(a). The transformer formed by the resonator inductance and the coupling loop changes the magnitude

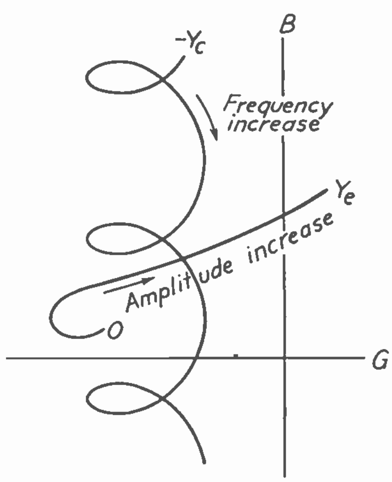

Fig. 9—Admittance diagram of a two-terminal oscillator loaded by a long transmission line terminated in an unmatched load.

of the equivalent admittance shunting the resonator, and the self-inductance of the loop adds some series susceptance. The general form of the circuit-admittance curve, which is the resultant of the curve of the resonator admittance and that of the equivalent load admittance, is of the general form shown in Fig. 9. The size of the loops depends upon the degree of mismatch of the load and the line, the length of the line, and the tightness of coupling to the resonator.

Change of tuning of the resonator causes a vertical displacement of the loops in the circuit-admittance curve of Fig. 9. Because tuning of the resonator has a negligible effect upon the electronic-admittance curve, the loops move relative to the electronic-admittance curve. For ease of explanation, however, the loops may be assumed to remain stationary and the Y_e curve to move relative to the $-Y_c$ curve, as in Fig. 10. Suppose that the oscillator parameters have been adjusted so that the frequency and amplitude of oscillation are those corresponding to point *a*. Change of tuning of the resonator causes a displacement of the $-Y_c$ curve, indicated in Fig. 10 by an upward displacement of the Y_e curve. The intersection moves toward *b*, with continuously decreasing frequency and amplitude. Further change in tuning causes the intersection to jump abruptly from *b* to *c*, with a corresponding abrupt decrease

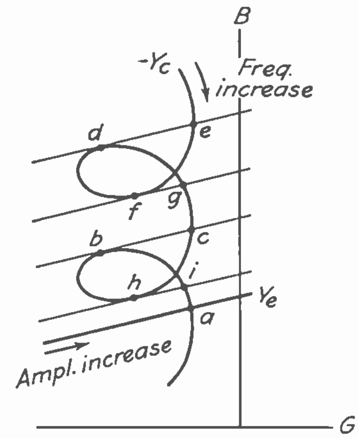

Fig. 10—Admittance diagram used in the analysis of the long-line effect.

in frequency and increase of amplitude.[3] From *c* to *d* the frequency and amplitude decrease continuously and at *d* the frequency again decreases abruptly and the amplitude increases abruptly to values corresponding to point *e*. Change in parameters in the opposite direction, so as to move the Y_e curve downward relative to the $-Y_c$ curve, results in similar abrupt changes in frequency and amplitude at *f* and *h*.

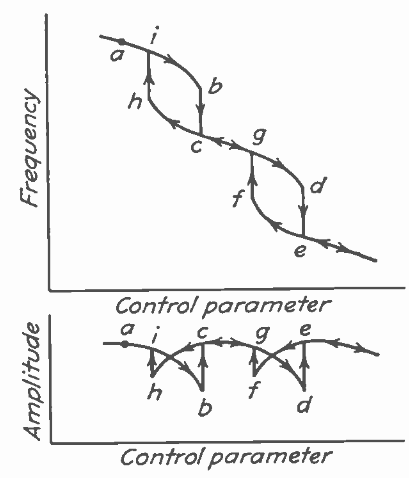

Fig. 11—Amplitude and frequency hysteresis produced by the long-line effect.

The general manner in which the frequency and amplitude might be expected to vary with resonator tuning

[3] Above the point at which the Y_e curve crosses itself, values of G_e of the portion of the curve on which *c* lies are smaller than those of the portion on which *b* lies. Oscillation may therefore build up in the new mode and suppress that in the original mode even before the intersection reaches point *b*. Where the jump takes place depends upon the relative values of G_e in the two modes.

is illustrated in Fig. 11. Examination of Figs. 10 and 11 discloses that frequencies lying between points b and h and between d and f are not observed as the tuning is changed back and forth. Other ranges of frequency are observed only when the tuning is changed in one direction or the other. These abrupt changes of frequency and amplitude, observed when a load is coupled to an oscillator through a long line, are called the long-line effect. A similar analysis may be made for four-terminal oscillators.

A detailed analysis shows that the loops in the circuit-admittance curves may be eliminated and that the long-line effect should consequently be avoided by (1) matching the load to the line, (2) making the line short in comparison with the wavelength, or (3) reducing the coupling of the line to the resonator. These predictions are in agreement with observed behavior.

Conclusion

The principal value of the method of analysis presented in this paper lies in its ability to explain observed oscillator phenomena and characteristics. Although it is applicable to oscillators operating in all frequency ranges, it is particularly useful in the analysis of some types of microwave oscillators, such as klystrons.[4] Because of limitations imposed by assumptions made in the mathematical treatment upon which the method is based, and because of the difficulty in predicting the exact form of the electronic-admittance curves of some oscillators, it is not in general very useful in the quantitative predetermination of oscillator characteristics.

[4] J. R. Pierce, "Reflex Oscillators," Proc. I.R.E., vol. 33, p. 112; 1945; Radiation Laboratory Series, Vol. 7, Sec. 11-5, D. Van Nostrand Co., Inc., New York, N. Y.; 1948; H. J. Reich, P. F. Ordung, H. L. Krauss, and J. G. Skalnik, "Microwave Theory and Techniques," Chaps. 12 and 13, D. Van Nostrand Co., Inc.; New York. N. Y.; 1953.

Transfer Characteristics and Mu Factor of Picture Tubes*

Kurt Schlesinger†, senior member, i.r.e.

Summary—**An attempt is made to explain, analytically, the observed shape of the characteristic of kinescopes, which seems to follow a simple power law with an exponent between 2 and 2.5. The difference from Langmuir-Childs law is due to the fact that the active-cathode area varies with grid voltage according to another power law.**

The theory is applied to the modulator section of a conventional TV picture tube and also to various structural modifications thereof. As to the emission characteristic, gamma is consistently found to lie between 2.4 and 2.5 and seems to be little affected by structural alterations. The mu factor, on the other hand, is strongly influenced by any one of the changes in the four system parameters.

An experimental tube was built to check some of the predictions of the above theory. For the cathode current, a gamma value of 2.43 was observed. The useful screen current followed a power law with an exponent of 1.9. The mu factor of this tube was found to fall within two per cent of the value computed from (15) of this paper.

Introduction

It is well known that the conventional type of television picture tube has a nonlinear brightness-transfer characteristic, which can be expressed by a simple power law with an exponent of approximately 2.5. An accurate way to measure this figure, also called the brightness-transfer constant or gamma-exponent has been given by Baldwin.[1] The influence of this nonlinearity on halftone rendition and the need for an inverse-power correction, or "rooter" operation, in the transmitter has been outlined in a fundamental paper by Oliver.[2] It was further recognized at an early date that the receiver nonlinearity has important bearing on the visibility of noise in the picture. For a given transmitter power the apparent signal-to-noise ratio can be much improved by the use of root-and-power response in sender and receiver, respectively.

The problem of picture tube nonlinearity has assumed additional importance with the advent of color television. There, the display of constant hue regardless of brightness depends in a large measure on the correct amount of gamma control in the color transmitter. Accordingly, the NTSC has included in its tentative proposal for color-television standards[4] the recommendation that the transmitter should employ a rooter network corresponding to a receiver gamma of 2.75 ± 0.25. This design center is somewhat higher than the five-halves power law assumed in earlier papers, and values for gamma of 3:1, and even higher figures, were quoted during recent sessions of the NTSC.

While most phosphors saturate at high energy levels, a linear relationship between light output and beam current is reported[5] for the lower current densities ($<100\ \mu a/cm^2$). Within this range it seems justified, therefore, to focus attention on the triode structure of

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[1] M. W. Baldwin, "Measurement method for picture tubes," *Electronics*, vol. 22, pp. 104–105; November, 1949.

[2] B. M. Oliver, "Tone rendition in television," Proc. I.R.E., vol. 38, pp. 1288; November, 1949.

[3] Report by R. D. Kell, RCA. D. G. Fink, "Television Standards and Practice," McGraw Hill Book Co., Inc., New York, N. Y., pp. 189–194; 1943.

[4] NTSC—Color Field Test Specifications, Supplement #75, *Telev. Dig.*, Wyatt Bldg., Washington 5, D. C.; December 1, 1951.

[5] H. W. Leverenz, "Luminescence of Solids," John Wiley & Sons, New York, N. Y. Fig. 112, p. 358, pp. 349–362; 1950. Also G. F. J. Garlick, *Elec. Eng.*, pp. 287–291; August, 1949.

the cathode-ray tube including its cathode, aperture-grid, and first anode. A theory might then predict the form of the cathode-current versus grid-voltage characteristic and should reveal that this is indeed a simple power law. It should also yield the value of its gamma exponent and indicate how gamma depends on the system parameters.

It should be borne in mind, however, that the beam current reaching the fluorescent screen of picture tubes is only a fraction of that emitted from their cathode. The electron-gun efficiency has a tendency to decrease at the higher currents because of increasing beam spread ahead of limiting apertures. This tends to reduce the gamma of the light-output characteristic below the value computed for the modulation section alone. A pertinent example is given in the experimental section of this paper.

Langmuir's Law for Variable Cathode Area

The analysis that follows acknowledges the emission limitation imposed by space charge but it does not take into account its retroaction on the original field distribution in front of the cold cathode. The cold field is found as a solution of Laplace's equation. Poisson's equation should be used at higher-beam currents. It has been found, however, that the simplified approach checks with experience up to a point where more than one-third of the total cathode area is active. This covers a range of current amplitudes most commonly encountered in picture reception.[6]

Thermionic emission in a conventional triode is proportional to the 1.5th power of the grid-from-cutoff voltage:

$$I = P[e_g - e_c]^{3/2}, \tag{1}$$

where P is the perveance constant.[7] Child's law may be re-written in terms of current density from a segment of the cathode and the field strength $\overline{E}$ normal to it.

$$i = K \cdot \overline{E}^{3/2}. \tag{1a}$$

In a tube whose cathode area is not constant, but depends on grid voltage, and where the field distribution across the cathode area is not uniform, the over-all characteristic does not necessarily follow a power law. It will do so, however, if (1) The area function is itself a power law of the type

$$A = \text{const. } (e_g - e_c)^m, \tag{2}$$

and if (2) The expression for the total cathode current takes the form of a product of (1(a)) and (2). If these two conditions are met the over-all characteristic is a power law with a gamma of

$$\gamma = 3/2 + m. \tag{3}$$

It can be shown that the second condition is met if the potential gradient at the cathode surface decreases with the square of the radius off axis. This holds to a first approximation in axially symmetric fields, where the potential $V_{(r,z)}$ at any point is tied down to the axial potential by the relation

$$V_{(z,r)} = \phi_z - \frac{r^2}{4}\cdot\phi^{(2)} + \frac{r^4}{64}\phi^{(4)} - \cdots. \tag{4}$$

The cathode gradient then reads

$$\text{grad } V_{(0,r)} = \phi^{(1)} - \frac{r^2}{4}\phi^{(3)} + \frac{r^4}{64}\phi^{(5)} - \cdots, \tag{5}$$

and since it vanishes at a critical radius r_k,

$$\begin{aligned} 0 &= \text{grad } V_{(0,r_k)} \\ &= \phi^{(1)} - \frac{r_k^2}{4}\phi^{(3)} + \frac{r_k^4}{64}\phi^{(5)} - \cdots. \end{aligned} \tag{5(a)}$$

We obtain by subtraction of (5(a)) from (5),

$$\text{grad } V_{(0,r)} = (r_k^2 - r^2)\frac{\phi^{(3)}}{4} - (r_k^4 - r^4)\frac{\phi^{(5)}}{64} + \cdots,$$

or approximately

$$\text{grad } V_{(0,r)} \sim \frac{d^3\phi}{dz^3}(0, 0)\cdot\frac{r_k^2 - r^2}{4}. \tag{6}$$

The total cathode current may now be found by integrating the contributions of concentric rings, each emitting under the influence of a field given by (6), out of the radius r_k, where the field goes through zero. From (1(a)) and (6) we get:

$$\begin{aligned} I_{\text{tot}} &= k\int_{r=0}^{r_k}[\text{grad } V_{0,r}]^{3/2}\cdot 2\pi r dr \\ &= 2\pi k\left(\frac{\phi^{(3)}}{4}\right)^{3/2}\cdot\int_{r=0}^{r_k}(r_k^2 - r^2)^{3/2} r dr. \end{aligned}$$

There results

$$I_{\text{tot}} = \tfrac{2}{5}\cdot K\cdot\overline{E}^{3/2}(\pi r_k^2) = \text{const. } (e_g - e_c)^{3/2}\cdot A_K. \tag{7}$$

This is 40 per cent of the emission of an equivalent diode with the cathode area A_K and plate voltage $e_g - e_c$.

We will now show that the cathode area is a power of the grid voltage (2) so that the over-all gamma of a kinescope can be obtained from (3).

Electrostatic Fields in the Grid-Cathode Region of Picture Tubes

Fig. 1(a) shows a cross section along the axis, through the modulator region of a conventional picture tube. The structure is symmetrical around the Z-axis and comprises a cathode surface K, a grid G which

[6] Since this paper was prepared, a thorough analysis of the cathode-ray triode including space charge effects has been published elsewhere: M. Ploke, "Zeitschrift fuer angewandte Physik," Springer, Berlin, pt. 1, vol. 3, pp. 441–449, December, 1951; pt. II, vol. 4, pp. 1–12; January, 1952. The results of that paper are in perfect agreement with those presented here.

[7] K. R. Spangenberg, "Vacuum Tubes," McGraw Hill Book Co., Inc., New York, N. Y., and London, pp. 186–187; 1948.

consists of an aperture $2R$ in a plane sheet of metal of thickness T, and a first anode A. For our purposes, there are four variables: d_1, d_2, l_{AK} and R. We made the following assumptions:

1. The anode may be replaced by a plane through point P connected to anode bias V_a.
2. On the surface of a coaxial cylinder through the grid hole the boundary potential has constant gradients between electrodes and assumes the values zero, V_g, and V_a respectively at cathode, grid and anode. (See Fig. 1(b)).

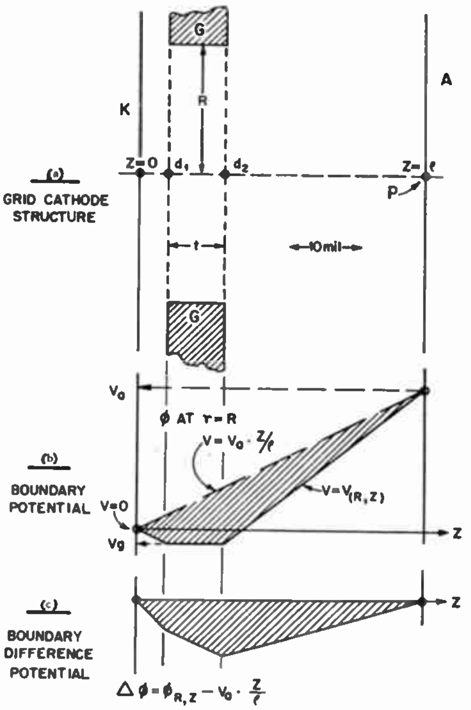

Fig. 1—(a) Grid cathode structure, (b) boundary potential, (c) boundary difference potential.

The Laplace equation for axial symmetry reads

$$\frac{\partial^2 V}{\partial z^2} + \frac{1}{r}\frac{\partial}{\partial r}\left(r\cdot\frac{\partial V}{\partial r}\right) = 0. \tag{8}$$

A solution which meets the above boundary conditions is

$$\phi_{rz} = \frac{V_a}{l}\cdot z + \sum a_n \sin\left(\frac{\pi n z}{l}\right)\cdot I_0\left(j\frac{\pi n r}{l}\right). \tag{9}$$

Here, I_0 is the modified Bessel function of zero order of the argument $(\pi n r/l)$.[8] The coefficients a_n follow from a Fourier analysis of the boundary difference potential,

$$\Delta\phi_{R,z} = \phi_{R,z} - V_a\cdot\frac{z}{l}, \tag{10}$$

shown in Fig. 1(c). To find a_n, we compute

$$a_n = \frac{1}{I_0\left(j\pi n\frac{R}{l}\right)}\cdot\frac{2}{l}\cdot\int_0^l \Delta\phi\cdot\sin\left(\pi n\frac{z}{l}\right)dz. \tag{11}$$

If this integration is performed, we find that

$$\pi n a_n = \frac{2}{I_0\left(j\pi n\frac{R}{l}\right)}\left[V_g\frac{\sin(\pi n\delta_1)}{\pi n\delta_1} + \frac{\delta_2}{1-\delta_2}(V_g - V_a) + \frac{\delta_2}{1-\delta_2}\cdot(V_g - V_a)\frac{\sin(\pi n\delta_2)}{\pi n\delta_2}\right]. \tag{12}$$

Here, $\delta_1 = d_2/l$ are inter-electrode spacings in term of system length l. We can now find the field strength normal to the cathode surface by forming $\partial\phi/\partial z$ in (9) and using (12).

$$\text{grad}\,\phi_{(r_10)} = \frac{V_a}{l} + \frac{2}{l}\sum\frac{I_0\left(j\pi n\frac{r}{l}\right)}{I_0\left(j\pi n\frac{R}{l}\right)}\left[V_g\frac{\sin(\pi n\delta_1)}{\pi n\delta_1} + (V_g - V_a)\cdot\frac{\delta_2}{1-\delta_2}\cdot\frac{\sin(\pi n\delta_2)}{\pi n\delta_2}\right]. \tag{13}$$

At this point we may derive, as a by-product, a formula for the amplification factor μ of picture tubes which is quite accurate.

μ is defined as the grid cut-off voltage in terms of the first anode voltage,

$$\mu = -V_a/V_c. \tag{14}$$

Cutoff occurs when the gradient at cathode center disappears. From (13):

$$0 = V_a + 2\sum\frac{1}{I_0\left(j\pi n\frac{R}{l}\right)}\left[V_c\cdot\frac{\sin(\pi n\delta_1)}{\pi n\delta_1} + (V_c - V_a)\frac{\delta_2}{1-\delta_2}\cdot\frac{\sin(\pi n\delta_2)}{\pi n\delta_2}\right]. \tag{13a}$$

From (13(a)) and (14) there results

$$1 + \mu = \frac{1 + 2\sum_{n=1}\frac{1}{I_0\left(j\pi n\frac{R}{l}\right)}\cdot\frac{\sin(\pi n\delta_1)}{\pi n\delta_1}}{1 - \frac{\delta_2}{1-\delta_2}\cdot 2\sum_{n=1}\frac{1}{I_0(j\pi nR/l)}\cdot\frac{\sin(\pi n\delta_2)}{\pi n\delta_2}}. \tag{15}$$

Applications of this expression for practical tube types will be given later. We now proceed to our primary task of finding the active cathode area as a function of grid voltage. The radius r_k of the active section is defined as the distance off axis for which the potential gradient passes through zero. From (13) for $r = r_k$,

[8] Tabulated in: Jahnke and Emde, "Tables of Functions," Dover Publications, New York, N. Y., pp. 226 and 228; 1943.

$$0 = V_a + 2\sum \frac{I_0(j\pi n r_k/l)}{I_0(j\pi n R/l)}\left[V_g\cdot\frac{\sin(\pi n\delta_1)}{\pi n\delta_1} + (V_g - V_a)\frac{\delta_2}{1-\delta_2}\cdot\frac{\sin(\pi n\delta_2)}{\pi n\delta_2}\right]. \tag{13b}$$

By subtracting (13(b)) from 13(a) we obtain

$$\frac{V_g - V_c}{V_a} = \frac{1-\Delta F_{02}}{F_{01}+\Delta F_{02}} - \frac{1-\Delta F_{k2}}{F_{k1}+\Delta F_{k2}} = G_0 - G_k. \tag{16}$$

In this expression, F_0 and F_k stand for

$$F_0 = 2\sum \frac{1}{I_0\left(j\pi n\frac{R}{l}\right)}\cdot\frac{\sin(\pi n\delta)}{\pi n\delta}, \tag{17}$$

$$F_k = 2\sum \frac{I_0(j\pi n r_k/l)}{I_0(j\pi n R/l)}\cdot\frac{\sin(\pi n\delta)}{\pi n\delta}, \tag{18}$$

respectively, while

$$\Delta = \frac{d_2}{l-d_2} = \frac{\delta_2}{1-\delta_2}. \tag{19}$$

Equation (16) contains implicitly the desired information about the active cathode area. To find the relation $r_k=f(V_g)$ we compute G_0-G_k for a few selected values of r_k/R and plot the results on double-logarithmic graph paper. If these points lie on a straight line this proves the existence of a simple power law between cathode area and grid voltage of the type anticipated in (2). The exponent m is then found as $m=2\cdot\tan\alpha$. The factor 2 accounts for the fact that the abscissa in Fig. 2 is in diameter ratios, whereas m in (2) refers to cathode area. The over-all gamma of the tube is then found by adding three-halves to m, as called for by (3).

Practical Applications of the Theory

The expressions for μ and gamma derived above were applied to a television picture tube type 17GP4. Numerical data for the four structural parameters listed in Fig. 1(a) were obtained from direct inspection of a gun of this type, prior to its use on the production line. The standard data thus obtained were:

$d_1=4$ mils, $R=18$ mils,
$t=8$ mils, $l=40$ mils.

Fig. 2 shows four points of (16) computed for active cathode radii of 1R/10 2R/10 3R/10 5R/10 respectively. All of these points lie smoothly on a straight line with a slope of 26° 45′. *This indicates that the active cathode radius grows very nearly as the square root of the grid-to-cut-off voltage.* The area-exponent is 1.008, yielding an over-all gamma, for this tube, of 2.508. (See (3).) The μ-factor for the 17GP4 results from (15) as $\mu=5.9$. Handbook data[9] listing the cut-off voltages for this tube indicate mu-factors within the limits of 3.9 and 9.1, around a design center of 6.0.

In order to show how these constants depend on the mechanical dimensions of the gun-structure, the same analysis was repeated in three more cases, changing only one of the four parameters at a time. In case no. 2 the thickness of the grid metal was reduced from 8 to 4 mils. In case no. 3 the grid-cathode spacing was doubled. In case no. 4 the grid diameter was reduced by 22 per cent.

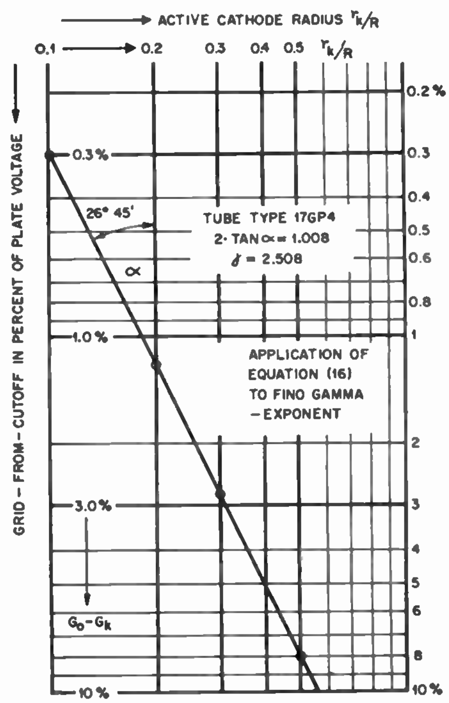

Fig. 2—Application of (16) to find gamma exponent.

The results of these analyses are summarized in Table I. The general trend seems to indicate that the μ-factor is affected by every one of the system variations, while on the other hand the value of the gamma exponent seems to be remarkably stable. In fact, none of the structural changes seems to have much influence on gamma, which stays within 7 per cent of a mean value of 2.43. These results hold for a total system length of 40 mils,

TABLE I
INFLUENCE OF SYSTEM PARAMETERS ON GAMMA AND MU

Analysis No.	Condition	μ-factor	γ-exponent
1	standard tube type 17GP4	5.9	2.508
2	grid-metal thickness: 4 mil [standard: 8 mil]	3.17	2.46
3	grid-cathode spacing: 8 mil [standard: 4 mil]	9.6	2.34
4	grid-hole: 28 mil [standard: 36 mil]	11.9	2.41

[9] RCA Handbook, vol. 1-2, Tube Dept., Harrison, N. J.

but they may be extended to any value of l, using the principle of similitude[10] inherent in (15) and (16).

An Experimental Confirmation

In order to obtain an experimental check on the theory as outlined, an electron gun was built with the following data: $R=18$, $d_1=4$, $d_2=12$, $l=324$ (mils). This tube was equipped with a separate collector electrode so that the actual beam current and the total cathode emission could be measured individually. Inserting the structural data into (15) and using 20 terms thereof to obtain better than 2 per cent accuracy, a mu-factor of 66.3 was computed.

The experiment revealed that cut-off occurred at -35 v with a first anode voltage of 2,400 v, thus indicating a mu-factor of 68.6.

Measured data of cathode and beam current are plotted in Fig. 3 on double-log paper, using the grid-from-cut-off voltage as ordinate. Both curves seem to follow simple power laws with a gamma exponent of 2.43 for the cathode, but only 1.9 for the collector characteristic. Guns with higher over-all efficiency may not exhibit as much of a gamma reduction as the sample. However, the test serves to indicate that accidental electron interception within the gun may have a strong influence on the over-all transfer-constant of a kinescope serving as a transducer from signals into light.

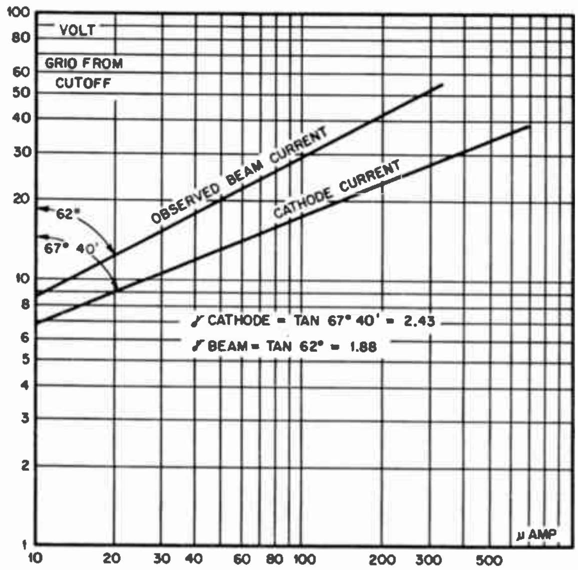

Fig. 3—Characteristic of experimental tube.

[10] H. Moss, "Advances in Electronics," Academic Press, New York, N. Y., vol. 2, pp. 32–36; 1950.

Optimum Linear Shaping and Filtering Networks*

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Summary—**Optimum transmitter and receiver transfer characteristics are obtained for linear communication systems under assumptions of fixed power levels and fixed over-all distortion of message signal. Two separate criteria of performance are used as the basis for optimization: (a) the mean-square value or variance of the receiver output noise component and (b) the probability that the noise component of receiver output exceeds a preassigned tolerance value at least once during some finite period of observation.**

1. Introduction

The problem considered in this paper is the formulation of the joint optimization of transmitter and receiver transfer characteristics of a given communication system as illustrated in Fig. 1. The specific type of system studied is a linear one, in which the noise adds directly to the signal in the channel. The following quantities are considered as fixed:

1. Average noise power spectrum $\overline{S}_n(\omega)$.
2. Desired message signal power or energy spectrum $S_m(\omega)$.
3. The distortion present in the system between input signal and receiver output signal.
4. Transfer characteristics of the channel $\underline{Y}_c(\omega)$.
5. Message signal power levels at all stages of the system.

While the general problem of constructing networks to minimize the effects of noise has been attacked quite extensively in the literature,[1–4] the present work differs in the following respects:

a. Most of the previous work was concerned with constructing a signal filter to separate noise from a given mixture of signal and noise, whereas here we consider that the signal itself can also be modified by a suitable linear shaping network at the transmitter.

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[1] N. Wiener, "The Extrapolation, Interpolation, and Smoothing of Stationary Time Series with Engineering Applications," Report of the Services 19, Research Project DIC-6037, M.I.T., Cambridge, Mass.; February, 1942. Also available as a book, printed by the Technology Press, M.I.T., Cambridge, Mass., and John Wiley and Sons, New York, N. Y.; 1949.

[2] R. B. Blackman, "The design of prediction circuits with data smoothing," *Bell Tel. Labs. Tech. Mem.*; February 23, 1944.

[3] R. S. Phillips and F. R. Weiss, "Theoretical Calculation on Best Smoothing of Position Data for Gunnery Prediction," Radiation Lab., M.I.T., Cambridge, Mass.; February, 1944.

[4] H. W. Bode and C. E. Shannon, "A simplified derivation of linear least-square smoothing and prediction theory," Proc. I.R.E., vol. 38, pp. 417–425; April, 1950.

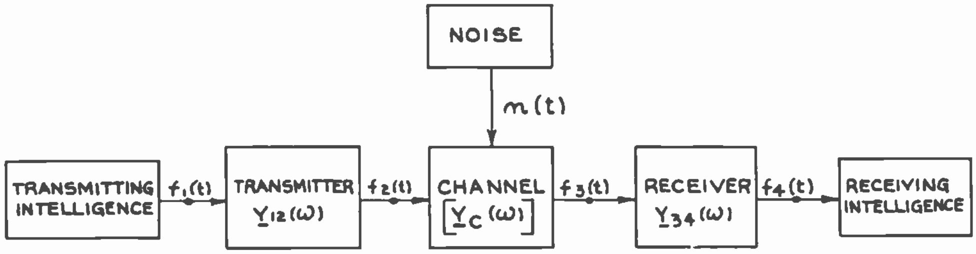

Fig. 1

b. In previous studies signal distortion as well as noise in the system output were considered as variables subject to over-all minimization. The idea here is to obtain optimum filters that can be added to a given system so that the effect of the noise is minimized without affecting the inherent distortion of the message signal.

c. As a direct result of item b above, it is possible to use as optimization criteria properties of the noise component of the receiver output alone, rather than the usual mean-square error. In this paper two separate optimization formulations are obtained using the following two criteria.

1. The mean-square value or variance of the receiver output noise component.

2. The probability that the noise component of the receiver output exceeds a preassigned tolerance value at least once during some designated period of observation.

Which criterion would best apply to a particular system is dependent on the mechanism by which the receiving intelligence converts the receiver output into information. Thus, if one's decisions are based on the value of the receiver output at specific instants, criterion 1 would be applicable. Criterion 2 would apply in cases where gated triggering is used, e.g., decisions being based on the maximum value attained during a fixed observation period. It can be shown that in certain cases the above criteria are in addition monotonically related to the equivocation or loss of information[5–7] due to noise of such systems. Thus, while the optimizations to be performed are by no means a minimization of equivocation in the general sense, they can be thought of in these cases as giving the best results attainable within the limitations of the practical considerations that are assumed.

2. General Considerations

Consider the block diagram of Fig. 1. We assume that the messages transmitted $f_1(t)$ are of finite duration so that the Fourier transforms $\underline{F}_1(\omega)$ exist. We define $r(t)$ and $m(t)$ as the corresponding message components of the signals which appear at the input and output of the receiver, having Fourier transforms $\underline{R}(\omega)$ and $\underline{M}(\omega)$, respectively.

Some basic relationships can be written down as follows:

$$\underline{F}_4(\omega) = \underline{Y}_{34}(\omega)\underline{N}(\omega) + \underline{M}(\omega) \tag{1}$$

$$f_3(t) = r(t) + n(t) \tag{2}$$

$$\underline{R}(\omega) = \underline{M}(\omega)/\underline{Y}_{34}(\omega) = \underline{Y}_c(\omega)\underline{Y}_{12}(\omega)\underline{F}_1(\omega). \tag{3}$$

The assumption that the distortion in the system is fixed is equivalent for the linear system under study to the statement that the ratio of $\underline{M}(\omega)$ to $\underline{F}_1(\omega)$ is a constant, determined in practice by component design considerations. Hence, (3) gives us a necessary definite relation between the linear shaping network characteristics $\underline{Y}_{12}(\omega)$ and $\underline{Y}_{34}(\omega)$. The procedure to be followed will be to use $\underline{Y}_{34}(\omega)$ as the variable for optimization, $\underline{Y}_{12}(\omega)$ then being given by

$$\underline{Y}_{12}(\omega) = \frac{1}{\underline{Y}_{34}(\omega)\underline{Y}_c(\omega)} \cdot \frac{\underline{M}(\omega)}{\underline{F}_1(\omega)} \cdot \tag{4}$$

A constraint on the possible variation of $\underline{Y}_{34}(\omega)$ is imposed by the fact that the power levels of the message signal at the various parts of the system are assumed fixed by practical design consideration. This constraint is most conveniently expressed by the following equation for the power or energy of the message signal component at the *input* of the receiver:

$$I_r = \frac{I_m}{A_{rm}} = \frac{1}{2\pi}\int_{-W}^{W} S_m(\omega)/Y_{34}^2(\omega)d\omega,^8 \tag{5}$$

where

$$I_m = \frac{1}{2\pi}\int_{-W}^{W} S_m(\omega)d\omega,$$

W = maximum angular frequency of message signal

and

A_{rm} = power gain of receiver.

[5] C. E. Shannon, "A mathematical theory of communication," *Bell. Sys. Tech. Jour.*, vol. 27, pp. 379–423, 623–656; July and October, 1948.

[6] C. E. Shannon, "Communication in the presence of noise," Proc. I.R.E., vol. 37, pp. 10–21; January, 1949.

[7] R. M. Fano, "The Transmission of Information," Research Lab. of Electronics, Technical Report No. 65, M.I.T., Cambridge, Mass.; March 17, 1949.

[8] Note that "$Y(\omega)$" not underlined is used as the magnitude of "$\underline{Y}(\omega)$."

P_{n0}, the variance of the noise component of the receiver output, is given by

$$P_{n0} = \frac{1}{2\pi}\int_{-\infty}^{\infty} Y_{34}^2(\omega)\overline{S}_n(\omega)d\omega, \tag{6}$$

where

$$\overline{S}_n(\omega) = \text{average spectrum of noise.}$$

3. Noise Variance Measure

For our first measure of system performance, we proceed to find the receiver transfer characteristic magnitude $Y_{34}(\omega)$ that will minimize P_{n0} and still satisfy (5). In the first place, it is evident that $Y_{34}(\omega)$ should be zero for ω greater in magnitude than W. Using standard variational techniques,[9] we obtain for $|\omega| < W$ a value $Y_{34}'(\omega)$ that yields minimum output noise variance, as outlined in Appendix I. The result is

$$Y_{34}'^2(\omega) = \frac{A_{rm}I_{nm}}{I_m}\sqrt{S_m(\omega)/\overline{S}_n(\omega)}, \tag{7}$$

where

$$I_{nm} = \frac{1}{2\pi}\int_{-W}^{W}\sqrt{S_m(\omega)\overline{S}_n(\omega)}d\omega. \tag{8}$$

The expression for the resultant minimum variance of the receiver output noise is

$$P_{n0}' = \frac{A_{rm}I_{nm}^2}{I_m}. \tag{9}$$

It will be noted that this optimization places no restriction on the phase angle of the receiver transfer characteristic. An important feature of these results is the fact that the optimum shaping and filtering networks obtained in this manner are independent of the amplitude of the channel noise, being dependent only on its relative frequency distribution.

Several examples of the application of the above results are shown in Fig. 2. In the first two columns are shown some representative combinations of signal and noise spectra. The parameter x is the ratio of ω to W, the message signals' maximum angular frequency component. The resultant optimum magnitude of the receiver transfer characteristic is in the third column. The last column shows the ratio of the minimum value of noise variance obtained to the value which would result if the receiver characteristic were flat in the pass band. As expected, the relative improvement increases as the linear correlation of signal and noise spectra decreases.

4. Probability Tolerance Measure

The second type of measure to be applied is the probability that the deviation at the receiver output exceeds some given tolerance value at least once during a given period of time. Here we assume that the noise is Gaussian.

There are two ways in which the tolerance value can be exceeded during the observation time:

a. The noise *is greater than* the tolerance value for the *whole* of the observation time.
b. The noise *passes through* the tolerance value *at least once* during the observation time.

We assume in this discussion that the former contingency is not significant due to the duration of the observation time. This is done because of the mathematical difficulty involved in accounting for *both* contingencies. Thus the problem reduces, at least approximately, to minimizing the expected number of positive slope crossings per unit time of the tolerance value, given by the expression[10]

$$E_d = \frac{1}{2\pi}\sqrt{\frac{-\psi_0''}{\psi_0}}\exp(-d^2/2\psi_0), \tag{10}$$

where

$$\psi_0 = \frac{1}{2\pi}\int_{-\infty}^{\infty}\overline{S}(\omega)d\omega = P_{n0} \tag{11}$$

$$\psi_0'' = \frac{-1}{2\pi}\int_{-\infty}^{\infty}\omega^2\overline{S}(\omega)d\omega \tag{12}$$

and

$$\overline{S}(\omega) = Y_{34}^2(\omega)\overline{S}_n(\omega), \text{ or zero if } |\omega| > W. \tag{13}$$

	$S_m(\omega)$	$\overline{S}_n(\omega)$	$[Y_{34}'(\omega)]^2$	P_{no}'/P_{no}''
1	$S_m(\omega)$ ARBITRARY	ZERO (NO NOISE)	ARBITRARY	NONE
2	$S_m(\omega)$ ARBITRARY	$\overline{S}_n(\omega) = k S_m(\omega)$	A_{rm} = CONST.	1
3	$a^2(1-x)$	b^2	$\frac{4}{3}A_{rm}\sqrt{1-x}$	$\frac{8}{9} = .889$
4	$a^2(1-x)^2$	b^2	$\frac{3}{2}A_{rm}(1-x)$	$\frac{3}{4} = .75$
5	$a^2(1-x)$	b^2x	$\frac{2\pi}{8}A_{rm}\sqrt{\frac{1-x}{x}}$	$\frac{\pi^2}{16} = 0.617$
6	$a^2(1-x)^2$	b^2x^2	$\frac{1}{2}A_{rm}\frac{1-x}{x}$	$\frac{1}{4} = .25$

Fig. 2

As before, we set $Y_{34}(\omega)$ equal to zero outside the message band. Applying variational techniques[9] to find extremes of E_d under the constraint of (5), we obtain (see Appendix II) results as follows:

[9] H. Margenau and G. M. Murphy, "The Mathematics of Physics and Chemistry," D. Van Nostrand Co., Inc.; New York, N. Y., chap. 6; 1943.

[10] S. O. Rice, "Mathematical analysis of random noise," *Bell Sys. Tech. Jour.*, vol. 23, pp. 282–332; July, 1944; vol. 24, pp. 46–156; January, 1945.

$$I_1(u) = \frac{1}{\pi}\int_0^W \sqrt{\frac{S_m(\omega)\bar{S}_n(\omega)}{u^2\omega^2 + W^2}}\,d\omega \tag{14}$$

$$I_2(u) = \frac{1}{\pi}\int_0^W \omega^2\sqrt{\frac{S_m(\omega)\bar{S}_n(\omega)}{u^2\omega^2 + W^2}}\,d\omega \tag{15}$$

$$I_3(u) = \frac{1}{\pi}\int_0^W \sqrt{S_m(\omega)\bar{S}_n(\omega)(u^2\omega^2 + W^2)}\,d\omega \tag{16}$$

$$d^2 = d'^2(u) = \frac{I_1(u)I_3^2(u)}{u^2I_2(u)I_r} \tag{17}$$

$$Y_{34}^2(\omega) = \frac{I_3(u)}{I_r}\sqrt{\frac{S_m(\omega)}{\bar{S}_n(\omega)(u^2\omega^2 + W^2)}}\,. \tag{18}$$

For a specific problem, it is first necessary to obtain numerical expressions for integrals I_1, I_2, and I_3 in terms of the parameter u. Then it is necessary to solve expression (17) for u in terms of d, the deviation tolerance value. Using this value of u, the "optimum" value of $Y_{34}^2(\omega)$ is given by (18). It is seen that this value differs from the previous result which simply minimizes the noise variance, in the inclusion of a factor $u^2\omega^2+W^2$ in the denominator. This factor tends to deemphasize the higher frequency components of the noise, thus decreasing the likelihood of short pulses exceeding the tolerance value.

The crux of this method is the solution of (17) for u in terms of the tolerance level d. It is necessary to plot $d'^2(u)$ given by (17) versus u, then to select graphically the desired solutions, at which $d'^2=d^2$. This of course has the advantage that we can use the same plot for a variety of values of the tolerance d.

Resultant expressions for ψ_0, ψ_0'', and the value of E_d, all expressed as functions of u, which result when the receiver transfer characteristic magnitude is given by expression (18), are as follows:

$$\psi_0 = \frac{I_1(u)I_3(u)}{I_r} \tag{19}$$

$$-\psi_0'' = \frac{I_2(u)I_3(u)}{I_r} \tag{20}$$

$$E_d = \frac{1}{2\pi}\cdot\sqrt{\frac{I_2(u)}{I_1(u)}}\exp\frac{-d^2I_r}{2I_1(u)I_3(u)}\,. \tag{21}$$

Examination of the above expressions enables us to draw certain inferences as to their behavior when the parameter u varies. These are outlined in Table I.

In the case where $S_m(0)\bar{S}_n(0)=k>0$, we see that d'^2 approaches infinity for both of the limiting extremes of u. Hence, the equation $d'^2=d^2$ (solving for u) must have in general an even number of solutions. If d^2 is less than some minimum value, there is no solution. These solutions signify the extreme values of E_d. Now we know that E_d is finite for $u=0$, zero for $u\to\infty$. Hence, the solutions of $d'^2=d^2$ will be alternate minima and maxima, the first being a minimum and the last being a maximum. For system design purposes, the fact that $E_d\to 0$ as $u\to\infty$ is not significant, since in this case ψ_0 becomes infinite; this means that while the noise signal will cross the value d very seldom, the magnitude of the noise will be greater than d most of the time.

In any event, it turns out that the solution of $d'^2=d^2$ for which the value of u is smallest is the one that should be used as a design value.

TABLE I

Quantity	$u\to\infty$: $S_m(0)\bar{S}_n(0)=k>0$	$u\to\infty$: $S_m(0)\bar{S}_n(0)=0$	$u\to 0$
ψ_0	approaches ∞ as log $2u$	finite limits	finite limits, system equivalent to "minimum noise variance" system
ψ''_0	finite limits	finite limits	finite limits, system equivalent to "minimum noise variance" system
E_d	approaches zero as $\frac{1}{\sqrt{\log 2u}}$	finite limits	finite limits, system equivalent to "minimum noise variance" system
d'^2	approaches ∞ as log $2u$ (becomes equal to ψ_0)	approaches the same finite limit as ψ_0	approaches ∞ as $1/u^2$

We take as an example the case of constant signal and noise spectra. Thus,

$$S_m = a^2;\quad \bar{S}_n = b^2,\ \text{in}\ -W < \omega < W \tag{22}$$

$d'^2(u)$, $Y_{34}^2(\omega)$, ψ_0 and ψ_0'' are as follows:

$$d'^2(u) = P_nA_{rm}\cdot\frac{v(\sinh 2v + 2v)^2}{4\sinh 2v(\sinh 2v - 2v)} \tag{23}$$

$$Y_{34}^2(\omega) = A_{rm}\frac{\sinh 2v + 2v}{4\sinh v}\cdot\frac{W}{\sqrt{u^2\omega^2 + W^2}} \tag{24}$$

$$\psi_0 = P_nA_{rm}\cdot\frac{v\sinh 2v + 2v}{4\sinh^2 v} \tag{25}$$

$$-\psi_0'' = W^2P_nA_{rm}\cdot\frac{\sinh^2 2v - 4v^2}{16\sinh^4 v} \tag{26}$$

$$v = \sinh^{-1} u,\quad P_n = \frac{b^2W}{\pi}\,. \tag{27}$$

For a given tolerance value d, optimum design values of u or v are obtained by solving the equation $d'^2(u)=d^2$. For this example, this process is illustrated by the curves on Fig. 3.

Here we have normalized plots (on a log-log scale) of d'^2, ψ_0, and $-\psi_0''/\psi_0$, as functions of the parameter v. The value of d'^2, starts out at infinity, then passes through a minimum, after which point it merges with the ψ_0 curve. If the square of the tolerance value d is less than about 1.6, the value of this minimum, the expected number of crossings E_d will have no extreme value. For values of d^2 greater than this minimum, two values of v will satisfy the equation $d'^2=d^2$, the first being a minimum and the second a maximum.

On Fig. 4 we have plotted the variation of E_d with v for two such values of the tolerance parameter d, namely $d^2=2.0$ and 2.5. In both cases, E_d is seen to become a minimum at the first point where $d'^2=$ the given value of d^2 on the graph of Fig. 3. We can call this the "optimum" value of v in each case since, even though E_d

becomes smaller than this minimum value for sufficiently large values of v, we will remember that the variance of the receiver output noise ψ_0 is considerably larger than our tolerance value d^2 at these values of v. Hence, E_d is small only because the noise signal is greater than the prescribed tolerance most of the time, an undesirable error-producing result.

Returning to Fig. 3 we see that the optimum or de-

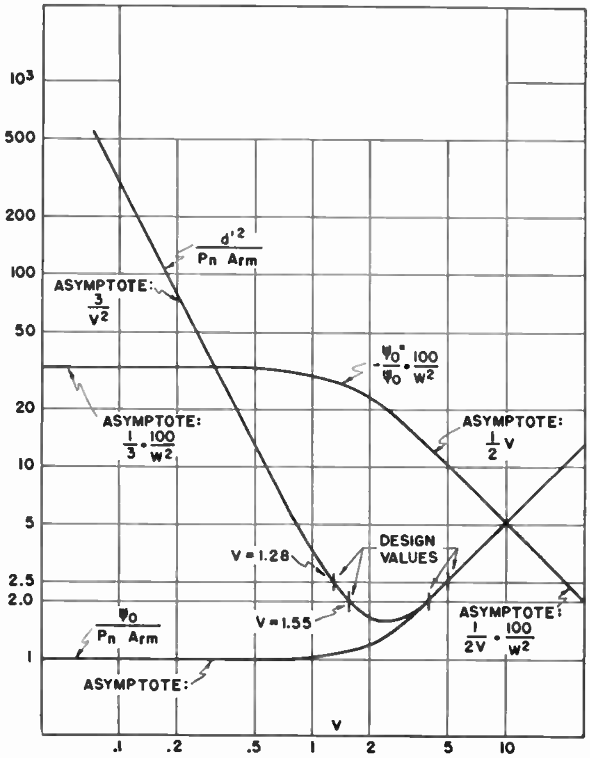

Fig. 3—Design curves.

sign value of v is the smaller value at which the d'^2 curve crosses the specified value d^2. It is seen from the E_d curves that the decrease in E_d from the minimum noise variance case ($v=u=0$) is rather small. This will usually be the case. Such an optimization device will usually be practical only for those marginal systems where every last ounce of performance possible is needed.

Appendix I

Derivation of Results for Minimization of Output Noise Variance

The "optimum" receiver characteristic magnitude of (7) is obtained by determining the minimum value of P_{n0} (6) using (5) as a constraint. Applying variational techniques[9] we find that P_{n0} is extreme when

$$\overline{S}_n(\omega)Y_{34}(\omega) - kS_m(\omega)/Y_{34}{}^3(\omega) = 0 \qquad (28)$$

for all ω less than W. We designate this "optimum" value of $Y_{34}(\omega)$ as $Y_{34}'(\omega)$; k may be determined from (5) as being given by

$$\sqrt{k} = A_{rm}I_{nm}/I_m; \qquad (29)$$

thus expressions (7) results for $Y_{34}'(\omega)$. Substitution of $Y_{34}'(\omega)$ into (6) gives the extreme value P_{n0}' given by (9).

To show that this extreme, being unique, is a minimum, we compare P_{n0}' with P_{n0}'', the noise variance which would result if $Y_{34}(\omega)$ were constant in the band $-W<\omega<W$.

This yields

$$\frac{P_{n0}'}{P_{n0}''} = \frac{\left\{\int_{-W}^{W} S_m(\omega)\overline{S}_n(\omega)d\omega\right\}^2}{\int_{-W}^{W} S_m(\omega)d\omega \int_{-W}^{W} \overline{S}_n(\omega)d\omega}. \qquad (30)$$

By Schwartz's inequality,[11] this ratio is always less than or equal to unity. Hence the unique extreme value P_{n0}' must be a minimum.

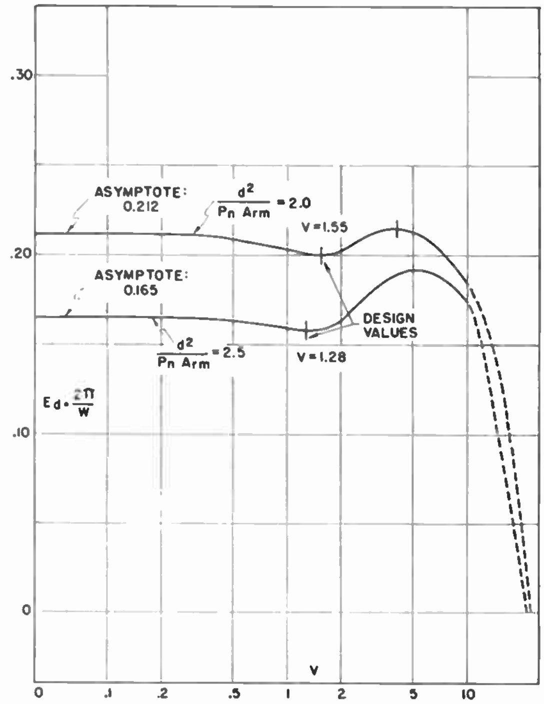

Fig. 4—E_d versus v. $d^2/P_nA_{rm}=2.0$, 2.5.

Appendix II

Derivation of Results that Minimize Expected Crossings of Given Tolerance Value

Here the procedure is to find extremes of E_d (10), again using (5) as a constraint.[9] Equating the variation of E_d to zero, we obtain, after eliminating common factors,

$$\psi_0{}^2\delta\psi_0'' + (d^2 - \psi_0)\psi_0''\delta\psi_0 = 0. \qquad (31)$$

Using (11), (12), and (13), this becomes

$$\int_0^W (A\omega^2 + B)\overline{S}_n(\omega)Y_{34}(\omega)\delta Y_{34}(\omega)d\omega = 0, \qquad (32)$$

[11] H. Cramer, "Mathematical Methods of Statistics," Princeton University Press; Princeton, N. J.; 1946.

where A and B are positive constants, independent of ω, satisfying

$$A = \psi_0^2; \qquad B = -\psi_0''(d^2 - \psi_0). \tag{33}$$

Introducing the constraint of (5) on the $\delta Y_{34}(\omega)$, there results

$$(A\omega^2 + B)\overline{S}_n(\omega)Y_{34}(\omega) - \lambda S_m(\omega)/Y_{34}^3(\omega) = 0 \tag{34}$$

which must be satisfied for all $|\omega| < W$.

From here on, the algebra consists of substituting $Y_{34}(\omega)$ as determined by (34) into (5) to determine λ, then the use of (33) to establish values for A and B in terms of the known quantities. Defining the parameter u by the equation

$$B = A^2W^2/u^2, \tag{35}$$

(17) and (18) result, where $I_1(u)$, $I_2(u)$ and $I_3(u)$ are as determined by expressions (14), (15), and (16).

Determination of Voltage, Current, and Magnetic Field Distributions together with the Self-Capacitance, Inductance and HF Resistance of Single-Layer Coils*

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Summary—**A theoretical investigation for quantitative evaluation of voltage, current, and magnetic field distribution along single-layer coils is presented herein. The magnitudes and the number of harmonics present in the distribution are obtained for the first time. From the voltage and current distributions, the self-capacitance and inductance of coils have been obtained. The self-capacitance depends mostly on the length to diameter ratio; it slightly depends on the amount of harmonics as well as the pitch to wire-diameter ratio. The harmonics mainly rely on the number of turns, the operating frequency, the coil diameter, and the length to diameter ratio. From the magnetic field distribution, the HF coil resistance is obtained. Experimental results extracted from previous authors are in good agreement with the theoretical predictions.**

I. List of Principal Symbols

a = mean coil diameter, cms.
b = coil length, cms.
D = distance between adjacent turns (pitch), cms.
d = wire diameter, cms.
N = number of turns of coil.
L_c = coil inductance, μH
C_s = coil self-capacitance, cms. (e.s.u.).
R_{dc} = dc resistance of coil.
R_{ac} = ac resistance of coil.
$\omega/2\pi$ = operating frequency.
$\omega_r/2\pi$ = self-resonant frequency of coil.

II. Introduction

A great deal of theoretical and experimental work has been published concerning HF single-layer coils. The most important published comprehensive theoretical work for the determination of HF coil resistance is due to Butterworth.[1–3] His main formula for single-layer solenoids of very many turns is

$$R_{ac}/R_{dc} = \alpha(1 + F) + (\beta u_1 + \gamma u_2)\frac{d^2}{D^2}G.$$

F and G are functions of t and $t^2 = 2\pi^2 f\mu d^2/\rho$; u_1 and u_2 are functions of b/a, and ρ and μ are the resistivity and the permeability of the wire material, respectively; α, β, and γ are functions of d/D and t. All are tabulated in Butterworth's paper. Afterwards, Butterworth modified his formula to suit very short coils as follows:

$$R_{ac}/R_{dc} = 1 + F\left(1 + \frac{1}{8}W_n\frac{d^4}{D^4}\right) + U_nG\frac{d^2}{D^2}\left(1 + \frac{1}{2}V_n\Phi_1\frac{d^2}{D^2}\right),$$

where, U_n, V_n, and W_n are functions of N, and ϕ_1 is a function of t. Butterworth did not consider the case where the current is not uniformly distributed along the coil. Butterworth's formulas are also not suitable for coils of intermediate lengths, which was clearly indicated experimentally by Jackson.[4] Unfortunately, most HF coils are of intermediate lengths.

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[1] S. Butterworth, "Eddy-current losses in cylindrical conductors, with special applications to the alternating current resistance of short coils," *Phil. Trans.* (London), A 222, p. 57; 1922.
[2] S. Butterworth, "Alternating current resistance of single layer coils," *Proc. Roy. Soc. A.*, A 107, p. 693; 1925.
[3] S. Butterworth, "Effective resistance of inductance coils at radio frequencies," *Exper. Wireless and Wireless Eng.*, vol. 3, pp. 203, 302, 417, and 483; 1926.
[4] W. Jackson, "Measurements of the high frequency resistance of single layer solenoids," *Jour. IEE* (London), vol. 80, p. 844; 1937.

According to the authors' knowledge, there are no previous publications which give the voltage, current, and field distributions along HF coils. Howe,[5] in determining the self-capacitance of single-layer coils, assumed the current distribution to be a sine curve superposed on a rectangle. He mentioned that the calculation of the magnetic field even with this assumption is practically impossible. Palermo,[6] in deriving his formula for the self-capacitance of single-layer coils, considered only the capacitances between adjacent turns to be responsible for the charging currents. He did not contemplate the capacitances between the different turns and a point in the coil estimated at zero potential which form the important portion of the self-capacitance. Palermo's formula is

$$C_s = \pi a/3.6 \cosh^{-1} \frac{D}{d}\ \mu\mu f.$$

Medhurst[7] showed experimentally that C_s is practically independent of the spacing ratio D/d for a coil having $b/a=1.0$

Recently, Moullin[8,9] attacked the problem of an infinitely long solenoid in which the current flow was circumferential and had a density which varied harmonically along the axis. Using Bessel functions, he then calculated the self inductance of single-layer coils.

III. Current and Voltage Distributions

In calculating the current and voltage distributions along the coil, it is assumed that the ac resistance of every turn and the conductance between turns are negligible. It is also assumed that the interaction of electric currents in the different turns is instantaneous, which is very approximately true so long as the coil dimensions b and a are small compared with the wavelength in free space corresponding to the operating frequency. Accordingly, the currents in the different turns will be in time phase.

Steady sinusoidal conditions with respect to time will be assumed. Symbolic notations will be adopted. Root-mean-square values will be used.

We are going to consider first the case where the coil is not earthed at either end; it may then be earthed at its center.[10]

The charging currents are those shown in Fig. 1. There are other charging currents between adjacent and nonadjacent turns which are very small and can be neglected. This is clarified in Appendix A.

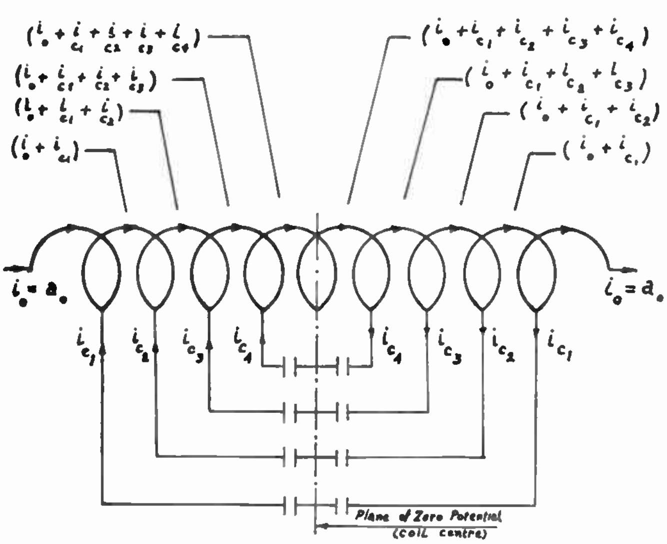

Fig. 1

A. Calculation of Potential Due to Magnetic flux

Consider a turn at a distance x from center (Fig. 2).

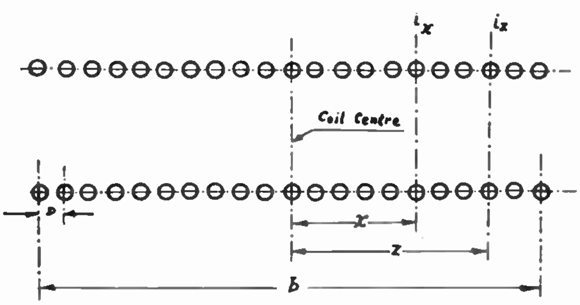

Fig. 2

Let the current in that turn $=i_x$, its charge $=q$, and its potential with respect to the coil center (considered of zero potential) $=v$. The current in the adjacent turn distant $x+D$ equals $i_x+\Delta i=i_x+j\omega q$, giving

$$q = \Delta i/j\omega = (D/j\omega)di/dx. \qquad (1)$$

The potential of the adjacent turn $=v+\Delta v$, and $\Delta v = Ddv/dx$ = voltage drop across a turn at a distance x. Thus, Δv = voltage drop due to the turn's self-inductance l+sum of voltage drops due to the mutual inductance M between the turn in question and any other turn of the coil $=j\omega l i_x + j\omega \sum M i_z$. (2)

Maxwell's formula for the self inductance of a single turn is

$$l = 2\pi a\left\{\left(1+\frac{3}{16}\frac{d^2}{a^2}\right)\log_e\frac{8a}{d} - \left(2+\frac{1}{16}\frac{d^2}{a^2}\right)\right\} \times 10^{-3}\ \mu H. \qquad (3)$$

The mutual inductance M between two turns distant z apart can be obtained from tables in footnote refer-

[5] G. W. O. Howe, "Inaugural address to the wireless section," *Jour. IEE* (London), vol. 60, p. 67; 1922.

[6] A. J. Palermo, "Distributed capacity of single layer coils," Proc. I.R.E., vol. 22, p. 897; 1934.

[7] R. G. Medhurst, "H.F. resistance and self-capacitance of Single Layer Solenoids," *Wireless Eng.*, vol. 24, pp. 35 and 80; 1947.

[8] E. B. Moullin, "The field of a coil between two parallel metal sheets," *Jour. IEE* (London), vol. 94, p. 78; 1947.

[9] E. B. Moullin, "The use of Bessel functions for calculating the self-inductance of single layer solenoids," *Jour. IEE* (London), vol. 96, p. 133; 1949.

[10] The case where the coil is earthed at one end can be directly obtained, and it is given in Appendix C.

ence 11. Plotting M/a to a base of y/a and remembering that $M(y)=M(-y)$, Fig. 3 is obtained, where y is the distance between the two turns which require M. The interesting values of M/a are those starting from $y=D$. At $y=0$, the ordinate is l/a. The summation in (2) should be carried out turn-by-turn. However, unless the number of turns is small, the same result can be satisfactorily obtained by an integration process. Therefore, (2) reduces to

$$\Delta v = j\omega l i_x + j\frac{\omega}{D}\int_{x+D}^{b/2} M i_z dz + j\frac{\omega}{D}\int_{-b/2}^{x-D} M i_z dz$$

$$= j\frac{\omega}{D}\int_{-b/2}^{b/2} M_1 i_z dz. \quad (4)$$

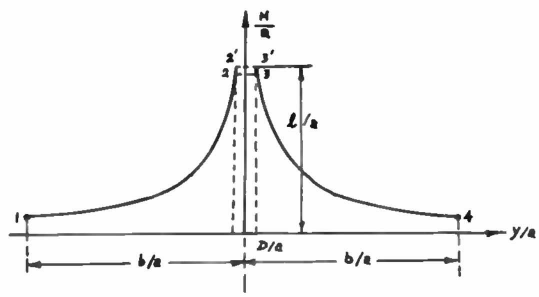

Fig. 3

M_1 is the curve 1 2 2′ 3′ 3 4 (Fig. 3).

From the nature of the problem, i_z can be represented as

$$i_z = a_0 + \sum_{n=1} a_n \cos(n\pi z/b) \quad (5)$$

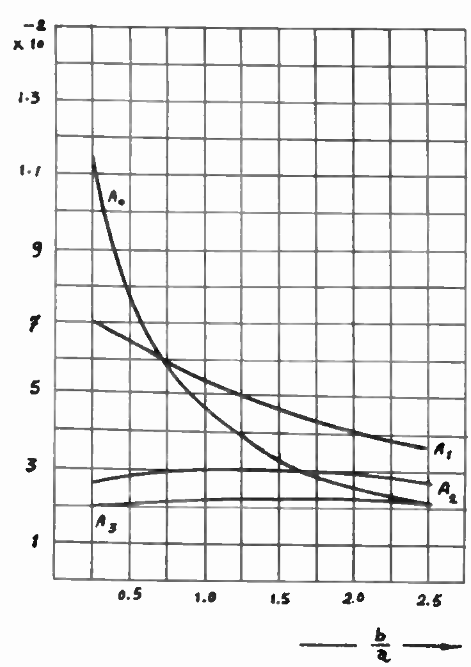

Fig. 4

[11] F. E. Terman, "Radio Engineering Handbook," McGraw-Hill Book Co., Inc., New York, N. Y.; 1943.

where n is an odd integer. The upper limit of the summation will be given later in the paper. A convenient representation of the characteristic, Fig. 3, is a trigonometric polynomial by means of Fourier analysis with $2b/a$ as its fundamental period.

$$M_1/a = A_0 + \sum_{m=1} A_m \cos(m\pi y/b). \quad (6)$$

The upper limit of the summation in (6) depends on the number of terms in the expansion required for satisfactory representation. A_0 and A_m are to be determined from Fourier analysis. It is clear that A_0 and A_m depend on D/a, b/a, and d/a.

In order to have the same $M_1/a \rightarrow y/a$ characteristic for all practical coils, a value of 0.005 for D/a and a value of 0.01 for d/a will be assumed. For other ratios, the representation of the characteristic will be practically unaffected (Appendix B).

Fig. 4 shows a chart of A_0, A_1, A_2, and A_3 against b/a ranging from 0.25 to 2.5 including almost all practical coils. Substitution of (5) and (6) in (4) gives

$$\Delta v = D\frac{dv}{dx}$$

$$= j\omega a_0 \frac{b}{D}\frac{a}{\pi}\int_{\theta=-\pi/2}^{\pi/2}\left\{A_0 + \sum_{m=1} A_m \cos m(\theta-\phi)\right\} d\theta$$

$$+ j\omega\frac{b}{D}\frac{a}{\pi}\int_{\theta=-\pi/2}^{\pi/2}\left[\left(A_0\sum_{n=1} a_n \cos n\theta\right)\right.$$

$$+ \sum\frac{a_n A_m}{2}\{\cos((m+n)\theta - m\phi)$$

$$\left. + \cos((m-n)\theta - m\phi)\}\right] d\theta, \quad (7)$$

where $\theta=\pi z/b$, $\phi=\pi x/b$, $\theta-\phi=\pi(z-x)/b=\pi y/b$.

The first part of (7), which is

$$(b/D)(2a/\pi)\left(\frac{\pi}{2}A_0 + \sum_{n=1} j^{n-1}\frac{A_n}{n}\cos n\pi x/b\right)$$

gives the inductance m_x between a turn at a distance x and all other turns of the coil, the integration of which along the coil gives L_c.

$$L_c = \frac{b^2}{D^2}\frac{4a}{\pi^2}\left(\frac{\pi^2}{4}A_0 + \sum_{n=1} A_n/n^2\right)\mu H. \quad (8)$$

TABLE 1

b/a	L_c/N^2a (Authors')	L_c/N^2a (Nagaoka)	Discrepancy per cent
0.25	1.419×10^{-2}	1.435×10^{-2}	1.14%
0.50	1.019×10^{-2}	1.035×10^{-2}	1.60%
1.00	$0.65\ \times10^{-2}$	0.697×10^{-2}	4.25%

L_c is calculated by (8) for several coils having different dimensions, and the results are in good agreement with those of Nagaoka (Table 1). Integration of (7) gives,

$$v = j\omega \frac{b^2}{D^2} a \frac{a_0}{\pi^2}\left\{\pi^2 A_0 \frac{x}{b} + 2\sum_{n=1} j^{n-1}\frac{A_n}{n^2}\sin n\phi\right\}$$
$$+ j\omega \frac{b^2}{D^2}\frac{a}{\pi^2}\left[\left(2A_0\sum_{n=1} j^{n-1}\frac{a_n}{n}\right)\frac{\pi x}{b}\right.$$
$$+\left\{\sum_{n=1} a_n \sum_{m=2} j^{m+n-1}\frac{A_m}{m(m+n)}\sin m\phi\right\}_{(m+n)\text{odd}}$$
$$+\left\{\sum_{n=1} a_n \sum_{m=2} j^{m-n-1}\frac{A_m}{m(m-n)}\sin m\phi\right\}_{(m-n)\text{odd}}$$
$$\left.+\left\{\frac{\pi}{2}\sum_{n=1}\frac{a_n A_m}{m}\sin m\phi\right\}_{m=n}\right]. \quad (9)$$

If the current were uniformly distributed and of value a_0, the potential would not be uniform and would be given by

$$v = j\omega a_0 \frac{b^2}{D^2}\frac{a}{\pi^2}\left\{\pi A_0 \frac{\pi x}{b} + 2\sum_{n=1}\frac{A_n}{n^2} j^{n-1}\sin(n\pi x/b)\right\}.$$

The voltage at the coil end is obtained from (9) by putting $\phi=\pi/2$. The terminal voltage V_{ter} is twice the end voltage.

$$V_{ter} = j\omega a_0 L_e + j\omega \frac{b^2}{D^2}\frac{a}{\pi} a_1 \sum_{n=1} j^{n-1}\frac{a_n}{n a_1}(2A_0 + A_n). \quad (10)$$

B. Calculation of Potential Due to Electric Charges

The potential at the point P due to a ring having a charge q (Fig. 5) is given by

$$v_p = \int_{\alpha_1=0}^{2\pi}\frac{q\,d\alpha_1}{2\pi\sqrt{(y^2+a^2) - a^2\cos^2\alpha_1/2}}$$
$$= \frac{2p}{\pi a} q \int_{\gamma_1=0}^{\pi/2}\frac{d\gamma_1}{\sqrt{1-p^2\cos^2\gamma_1}} = \frac{2}{\pi a} qpK(p), \quad (11)$$

where

$$\gamma_1 = \alpha_1/2, \qquad p = 1/\sqrt{1+y^2/a^2},$$

and $K(p)$ is the complete elliptic integral of the first kind with modulus p.

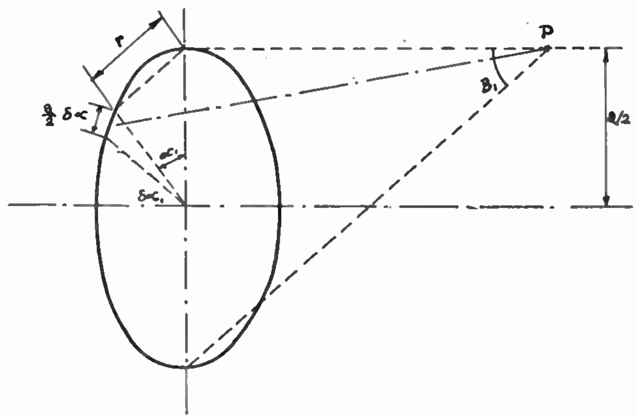

Fig. 5

It should be noted here that the charge on any turn except the two end turns could be considered satisfactorily concentrated on a circle, even if the pitch of winding is of the order of the wire diameter. The charge distribution on the cross section of any turn is mainly due to adjacent turns; nonadjacent turns have practically no effect due to the screening action of the adjacent ones. Any turn, except the central one and the two end turns, can therefore be satisfactorily considered as if it were a central wire of three equidistant coplanar long wires having nearly the same charges, neglecting second-order effects. The charge in the central wire will therefore be considered as if it were concentrated at its center. There is practically no charge on the central turn of the coil. Therefore, the potential due to any turn of the coil except the end turns could be calculated as if it were an isolated charged ring. It is clear that correction for the two end turns must be carried out if the number of turns is very small; such correction is evidently dependent on the pitch to diameter ratio. However, for a large number of turns, the correction is very small and the potential distribution as well as the self-capacitance C_s will be practically independent of pitch to wire-diameter ratio.

Following the same lines as in part A of this section, the potential v at a turn distant x from the center is given by

$$v = \frac{2}{\pi a}\frac{1}{D}\left\{\int_{-b/2}^{b/2} pK(p)q\,dz - \int_{x-D}^{x+D} pK(p)q\,dz\right\}$$

+ potential due to charge on turn under question. (12)

Equation (12) can also be reduced as in part A to

$$v = \frac{2}{\pi a}\frac{1}{D}\int_{-b/2}^{b/2} pK(p)q\,dz. \quad (12a)$$

Using tables of footnote reference 12, $pK(p)$ can be plotted to a base of y/a in the same way as M/a in part A.

Therefore,

$$pK(p) = B_0 + \sum_{m=1} B_m \cos(m\pi y/b) \quad (13)$$

where B_0, B_m are to be determined from Fourier analysis. Fig. 6 shows a chart for B_1 against b/a.

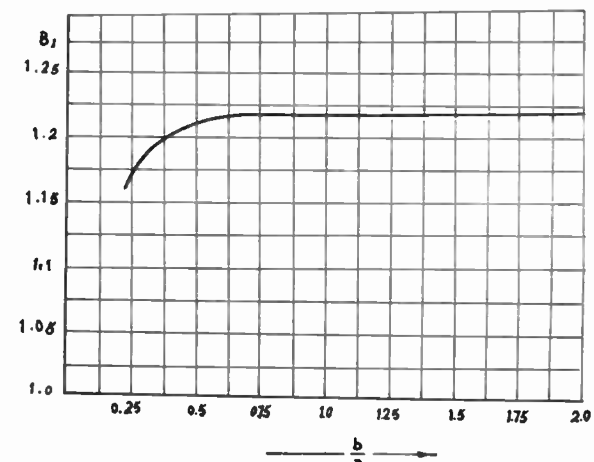

Fig. 6

[12] H. B. Dwight, "Mathematical Tables, and Other Mathematical Data," Macmillan Co., New York, N. Y.

Substitution of (1), (5), and (13) in (12a) gives

$$v = \frac{1}{j\omega}\frac{2}{\pi a}\left\{-\frac{\pi}{2}\sum_{n=1} n a_n B_n \sin n\phi + \sum_{n=1} n a_n \sum_{m=2,4,\cdots} j^{n+m-1}\frac{B_m}{m+n}\sin m\phi - \sum_{n=1} n a_n \sum_{m=2,4,\cdots} j^{m-n-1}\frac{B_m}{m-n}\sin m\phi\right\}. \quad (14)$$

Terminal voltage

$$= 2v(\phi = \pi/2) = -\frac{1}{j\omega}\frac{2}{a}\sum_{n=1} j^{n-1} n a_n B_n. \quad (15)$$

IV. Determination of Magnitudes and Number of Harmonics

The two potentials due to magnetic flux and electric charges must be equal at any turn of the coil. Therefore, (9) and (14) are equal at

$$x = 0,\ x = D,\ x = 2D, \cdots, x = \frac{N-1}{2}D\left(= \frac{b}{2}\right).$$

There will be $(N-1)/2$ equations giving $(N-1)/2$ harmonics in terms of the input current a_0. Therefore, the harmonics in (5) must not exceed $(N-1)/2$. From these $(N-1)/2$ simultaneous equations, a_1/a_0, a_3/a_0, a_5/a_0, $\cdots$, a_{N-2}/a_0 can be obtained, and it is clear that they depend on b/a, $\omega/2\pi$, a, and N. Calculation for a coil having $N=13$ and $b/a=0.5$ gives $A_0=0.751$, $A_1=0.643$, $A_2=0.2855$, $A_3=0.2085$, $A_4=0.1426$, $B_0=2.811$, $B_1=1.217$, $B_2=0.406$, $B_3=-0.0128$, and $B_4=0.172$. When the coil is resonating ($a_0=0$), the current distribution is

$$i_z = a_1\{\cos(\pi z/b) - 0.0628\cos(3\pi z/b) + 0.02\cos(5\pi z/b) + \cdots\}. \quad (16)$$

It is clear that the magnitudes of the harmonics are small and the series forming them is convergent.

V. Determination of Coil Self-Capacitance

When the coil is self-resonating, $a_0=0$, and $\omega=\omega_r=1/\sqrt{L_cC_s}$. Equating (10) and (15) and putting $a_0=0$, and $\omega^2=\omega_r^2=1/L_cC_s$, gives

$$C_s = \frac{a}{2}\,\frac{\dfrac{\pi}{4}\,\dfrac{\sum_{n=1} j^{n-1}\dfrac{a_n}{na_1}(2A_0+A_n)}{\dfrac{\pi^2}{4}A_0+\sum_{n=1}A_n/n^2}}{\sum_{n=1} j^{n-1} n\dfrac{a_n}{a_1}B_n}$$

$$= \frac{a}{2}\,\frac{\dfrac{\pi}{4}\,\dfrac{(2A_0+A_1)-\dfrac{a_3}{3a_1}(2A_0+A_3)+\cdots}{\dfrac{\pi^2}{4}A_0+A_1+\dfrac{A_3}{9}+\cdots}}{B_1-3\dfrac{a_3}{a_1}B_3+\cdots}. \quad (17)$$

The coil self-capacitance, therefore, depends mainly on A_0, A_1, A_3, A_5, $\ldots$ B_1 and B_3, B_5, $\ldots$, located on the coil length to diameter ratio. It depends slightly on the harmonics present, which latter rely on the length to diameter ratio as well as on N, provided the frequency $=\omega_r/2\pi$. For any other frequency, the harmonics depend also on the operating frequency $\omega/2\pi$ and on a. For the coil along which the current distribution was previously given by (16), the effect of harmonics is to increase C_s by about 2 per cent.

The self-capacitance depends slightly on the frequency at which measurement is made. Medhurst[7] reported, in Table 2 of his paper, the following measurements: At Frequencies between 0.72 and 3.0 mc/s, the self-capacitance ranges from 2.14 to 2.17 uuf; however, at frequencies between 6.0 and 18.0 mc/s, the self-capacitance varies between 2.27 and 2.37 uuf (the natural frequency of the measured coil was about 15.0 mc/s).

TABLE 2

λ	$b/a=0.625$, $d/D=0.745$, $f=1000$ kc, $d=0.1016$	$b/a=0.333$, $d/D=0.652$, $f=800$ kc, $d=0.0508$
Experimental	2.71	1.795
Authors'	2.74	1.765
Butterworth	3.32	2.00

If the harmonics were neglected, the coil self-capacitance could be obtained from (17) by putting $a_3=0=a_5=\cdots$. In this case,

$$C_s = a\frac{\pi}{8}\cdot\frac{1}{B_1}\frac{2A_0+A_1}{\dfrac{\pi^2}{4}A_0+A_1+\dfrac{A_3}{9}+\dfrac{A_5}{25}+\cdots}$$

$$= \frac{a^2b^2}{D_2}\frac{1}{2\pi B_1}\frac{2A_0+A_1}{L_c}. \quad (18)$$

Equation (18) is a satisfactory one for calculating the coil self-capacitance, provided the number of turns is not very small as stated before. Equating (10) and (15) and putting $a_3=0=a_5=\cdots$ and using (8), the fundamental component, a_1 of the current can be satisfactorily obtained.

$$a_1 = a_0\frac{L_c}{\left(\dfrac{\omega_r^2}{\omega^2}-1\right)\dfrac{a}{\pi}\dfrac{b^2}{D^2}(2A_0+A_1)}. \quad (19)$$

VI. Magnetic Field Distribution

At any turn along the coil, there are two magnetic fields, the self-produced field which is due to the current in the turn itself, and the mutual field which is due to the current in the other turns. The latter may be resolved into two components, axial and radial.

A. Self-Produced Field

If a unit current is flowing in a certain turn of diameter a, it will be accompanied by a flux ϕ linking the turn. Assuming a to be increased to $a+\delta a$ (Fig. 7(a)), ϕ will therefore be increased to $\phi+\delta\phi$. The self-inductance l will also be increased to $l+\delta l$, where

$$\delta l = \delta\phi = \pi a \frac{\delta a}{2} B_{s_1}$$

and

$$B_{s_1} = \frac{2}{\pi a}\frac{dl}{da} = \text{self produced magnetic field due}$$

to unit current.

It is considered axial. The mean value of

$$B_{s_1} = B_{s_1\text{mean}} = \frac{1}{2} B_{s_1} = \frac{1}{\pi a}\frac{dl}{da}.$$

It is acting over the cross section.

The self-produced field due to current i flowing in the turn under consideration will, therefore, be given by

$$B_{s\text{mean}} = \frac{i}{\pi a}\frac{dl}{da}. \tag{20}$$

The value of dl/da is obtained from (3).

B. "Axial Component B_y" of Mutual Field

Consider two turns distant y apart and having the same diameter a (Fig. 7(b)). If the diameter of the turn at which the field is required is increased to $a+\delta a$, the axial flux linking this turn due to a unit current flowing in the other will be increased from Φ_y to $\Phi_y+\delta\Phi_y$. The mutual inductance will therefore increase from M to $M+\delta M$, where

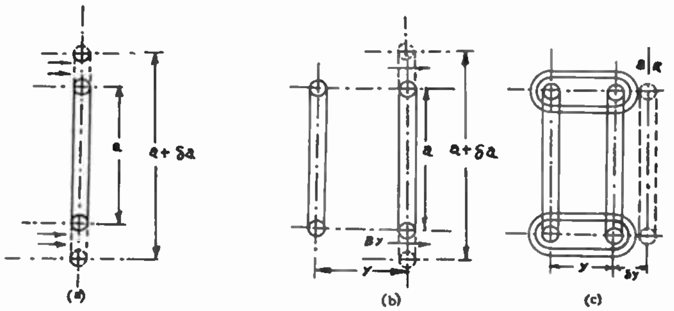

Fig. 7

$$\delta M = \delta\Phi_y = \pi a \frac{\delta a}{2} B_{1y},$$

giving

$$B_{1y} = \frac{2}{\pi a} = \frac{dM}{da} = \text{axial field component}$$

due to a unit current passing in the other turn. The mean value of $B_{1y}(=\frac{1}{2}B_{1y})$ gives the axial field component acting on the cross section.

If a current i is flowing in the other turn,

$$B_y = \frac{1}{2}\frac{2i}{\pi a}\frac{dM}{da} \cong \frac{1}{2}\frac{2i}{\pi a}\frac{dM_1}{da}.$$

Substitution of (6) gives

$$B_y = \frac{i}{2}\cdot\frac{2}{\pi a}\left\{\frac{d(aA_0)}{da} + \sum_{m=1}\frac{d(aA_m)}{da}\cos(m\pi y/b)\right\}. \tag{21}$$

It should be noted that $d(aA_m)/da$ is a function of b/a only, since

$$\frac{d(aA_m)}{da} = A_m - \frac{b}{a}\frac{dA_m}{d(b/a)}.$$

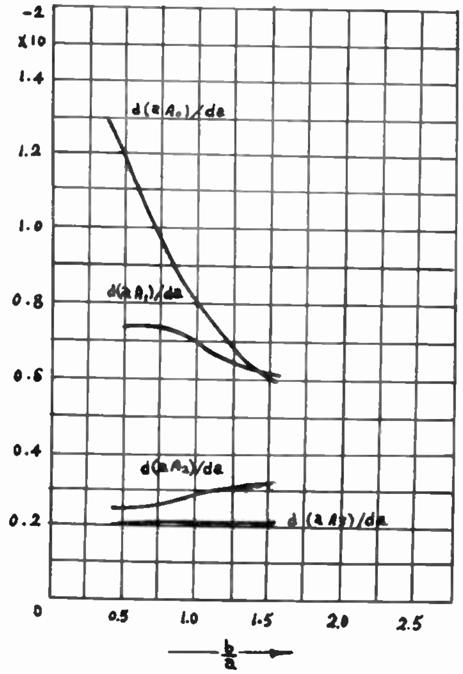

Fig. 8

Fig. 8 shows a chart for

$$\frac{d(aA_0)}{da}, \quad \frac{d(aA_1)}{da}, \cdots \text{ against } b/a.$$

C. Radial Component B_R of the Mutual Field

Let the turn at which the field is required be displaced axially a distance δy (Fig. 7(c)), the mutual radial flux due to a unit current flowing in the other turn will be decreased from Φ_R to $\Phi_R-\delta\Phi_R$. The mutual inductance will be reduced from M to $M-\delta M$, where

$$-\delta M = \pi a\delta y\cdot B_{1_R}, \text{ giving } B_{1_R} = -\frac{1}{\pi a}dM/dy.$$

The radial field component due to a current

$$i \text{ in other turn} = B_R = -\frac{i}{\pi a}\frac{dM}{dy} \cong -\frac{i}{\pi a}\frac{dM_1}{dy}.$$

Substitution of (6) gives

$$B_R = \frac{i}{b}\sum_{m=1} mA_m \sin(m\pi y/b). \tag{22}$$

From (5), (20), (21), and (22), and by following the same lines as in part (3), the axial and radial magnetic field components B_{z_t} and B_{R_t}, respectively, acting over the cross section of a turn distant x will be given by

$$B_{x_t} = \frac{1}{2}\frac{1}{D}\frac{2}{\pi a}\int_{-b/2}^{b/2} i_z \frac{dM}{da}\,dz$$
$$= \frac{a_0}{2}\frac{2}{\pi^2}\frac{b}{a}\frac{2}{D}\left\{\frac{\pi}{2}\frac{d(aA_0)}{da} + \sum_{n=1} j^{n-1}\frac{1}{n}\frac{d(aA_n)}{da}\cos n\phi\right\}$$
$$+ \frac{1}{2}\frac{2}{\pi^2}\frac{b}{a}\frac{1}{D}\left[\left\{2\frac{d(aA_0)}{da}\sum_{n=1}\frac{a_n}{n}\sin\frac{n\pi}{2}\right\}\right.$$
$$+ \left\{\sum_{n=1} a_n \sum \frac{\dfrac{d(aA_m)}{da}}{m+n} j^{m+n-1}\cos m\phi\right\}_{m\ \text{even}}$$
$$+ \left\{\sum_{n=1} a_n \sum \frac{\dfrac{d(aA_m)}{da}}{m-n} j^{m-n-1}\cos m\phi\right\}_{m\ \text{even}}$$
$$\left. + \left\{\frac{\pi}{2}\sum_{n=1} a_n \frac{d(aA_m)}{da}\cos m\phi\right\}_{m=n}\right], \tag{23}$$

and

$$R_{R_t} = \frac{1}{D}\int_{-b/2}^{b/2} i_z\left\{\frac{1}{b}\sum_{m=1} mA_m \sin\left(m\pi\frac{z-x}{b}\right)\right\}dz$$
$$= -\frac{1}{\pi D}2a_0\sum_{n=1} j^{n-1}A_n\sin(n\pi x/b)$$
$$-\frac{1}{\pi D}\left[\sum\sum m\frac{a_nA_m}{2}\left\{\frac{\cos((m+n)\theta - m\phi)}{m+n} + \frac{\cos((m-n)\theta - m\phi)}{m-n}\right\}_{m\neq n}\right.$$
$$\left. + (\theta\sin m\phi)\right]_{\theta=-\pi/2}^{\pi/2}. \tag{24}$$

If the current were uniformly distributed and equal to a_0, (23) and (24) would reduce, respectively, to

$$B_{xt_0} = \frac{a_0}{2}\frac{2}{\pi^2}\frac{b}{a}\frac{2}{D}\left\{\frac{\pi}{2}\frac{d(aA_0)}{da} + \sum_{n=1} j^{n-1}\frac{1}{n}\frac{d(aA_n)}{da}\cos(n\pi x/b)\right\} \tag{25}$$

and

$$B_{Rt_0} = -\frac{2}{\pi D}\sum_{n=1} j^{n-1}A_n\sin(n\pi x/b). \tag{26}$$

VII. Determination of HF Coil Resistance

The coil losses are mainly copper losses due to skin and proximity effects. The losses due to skin effect have been satisfactorily obtained by various authors. Loss per cm length of a straight circular conductor carrying a current I (rms), given by Butterworth, equal to $I^2R_0(1+F)$, where R_0 = dc resistance per cm length, F is a function of t, given in Butterworth's paper, and $t^2 = 2\pi^2 fd^2\mu/\rho$. Therefore, loss along whole coil due to skin effect $= W_s = \dfrac{1}{D}\displaystyle\int_{-b/2}^{b/2} i_z^2\pi aR_0(1+F)dx.$

Substitution of (5) for i_z gives

$$W_s = a_0^2\left\{1 + \frac{4}{\pi}\sum_{n=1} j^{n-1}\frac{a_n}{na_0} + \frac{1}{2}\sum_{n=1}\frac{a_n^2}{a_0^2}\right\}(1+F)R_{dc}, \tag{27}$$

where

$$R_{dc} = \pi a\frac{b}{D}R_0.$$

Considering the fundamental only,

$$W_s = a_0^2\left(1 + \frac{4}{\pi}\frac{a_1}{a_0} + \frac{1}{2}\frac{a_1^2}{a_0^2}\right)(1+F)R_{dc}$$
$$\cong a_0^2\left(1 + \frac{4}{\pi}\frac{a_1}{a_0}\right)(1+F)R_{dc}. \tag{28}$$

It is clear from (28) that W_s is increased by the ratio

$$\left(1 + \frac{4}{\pi}\frac{a_1}{a_0}\right)$$

due to the non-uniformity of current distribution. Substitution of (18) and (19) gives

$$\frac{4}{\pi}\frac{a_1}{a_0} = 2\left\{2A_0 + \frac{8}{\pi^2}\left(A_1 + \frac{A_3}{9} + \cdots\right)\right\} \Big/ \left\{\frac{2\pi B_1}{a^2\omega^2}\frac{D^2}{b^2} - (2A_0 + A_1)\right\}. \tag{29}$$

If the current were uniformly distributed and the coil were shunted with C_s, the ratio with which the loss increases would be equal to

$$\left\{\frac{1}{1 - \dfrac{\omega^2}{\omega_r^2}}\right\}^2 \cong 1 + \frac{2C_s}{C} = 1 + 2\Big/\left\{\frac{1}{\omega^2 L_c C_s} - 1\right\}.$$

Substitution of (18) gives

$$2\Big/\left\{\frac{1}{\omega^2 L_c C_s} - 1\right\} = 2(2A_0 + A_1)\Big/\left\{\frac{2\pi B_1}{a^2\omega^2}\frac{D^2}{b^2} - (2A_0 + A_1)\right\}. \tag{30}$$

Now, numerators of (29) and (30) are nearly equal, indicating that the increase in skin loss can be approximately obtained as if the coil were shunted by C_s, provided $\omega/2\pi$ is far from $\omega_r/2\pi$.

For the determination of the losses due to proximity effect, two cases will be considered. One case is when the coil turns are not too closely wound. The other case is when the coil turns are closely wound. In the first case, the magnetic field at any point along the coil could be considered uniformly distributed over the cross section. The problem, therefore, reduces to the determination of the losses in a cylindrical conductor per cm length when cut by a uniform magnetic field B perpendicular to its axis and which was given by Butterworth as $25R_0B^2d^2G$, where G is a function of t given in Butterworth's paper. Therefore, losses along whole coil due to proximity effect are

$$W_p = \frac{1}{D}\int_{-b/2}^{b/2} 25\pi a R_0(B_{xt}^2 + B_{Rt}^2)d^2G dx.$$

Substitution of (23) and (24) for B_{xt} and B_{Rt}, respectively, gives the following:

$$W_p = a_0^2R_{dc}\frac{d^2}{D^2}G\{(K_1 + K_2) + (f_1 + f_2)\}, \qquad (31)$$

where

$$K_1 = 25\,\frac{2}{\pi^2}\sum_{n=1} A_n^2 = \text{function of } b/a \text{ (Fig. 9).}$$

$$K_2 = 25\,\frac{4}{\pi^4}\,\frac{b^2}{a^2}\left[\frac{\pi^2}{4}\left\{\frac{d^2}{da}(aA_0)\right\}^2 + \frac{1}{2}\left\{\sum_{n=1}\left(\frac{d}{da}\left(\frac{aA_n}{n}\right)\right)^2\right\} + 2\,\frac{d(aA_0)}{da}\sum_{n=1}\frac{d}{da}\left(\frac{aA_n}{n^2}\right)\right]$$

= another function of b/a (Fig. 9).

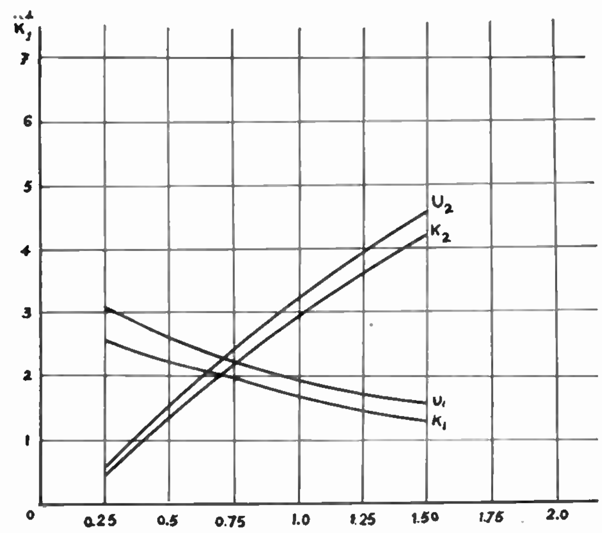

Fig. 9

f_1 and f_2 are functions of $(a_n/a_0,\ b/a)$ and are given in Appendix D.

K_1+f_2 = contribution of total radial component of magnetic field.

K_2+f_2 = contribution of total axial component of magnetic field.

If the current were uniformly distributed, (i.e., $a_n=0$), $f_1=0=f_2$.

For the sake of comparison, the radial and axial field contributions u_1 and u_2, given by Butterworth in his equation, are also shown in Fig. 9.

The total coil copper loss = $W_s + W_p$.

If the turns of the coil are closely wound, the magnetic field components at any conductor cross section of the coil can no longer be considered uniformly distributed over the cross section. The form of field variation depends on the position of the cross section along the coil as well as on whether the field component is axial or radial. It should be noted that the form of field variation is mainly due to adjacent turns, and hence it can be approximately considered the same along the coil except at the two end turns. In this way, the problem reduces to the determination of the losses in a solenoid when subjected to a mean-square value of two field components, one radial and the other axial.

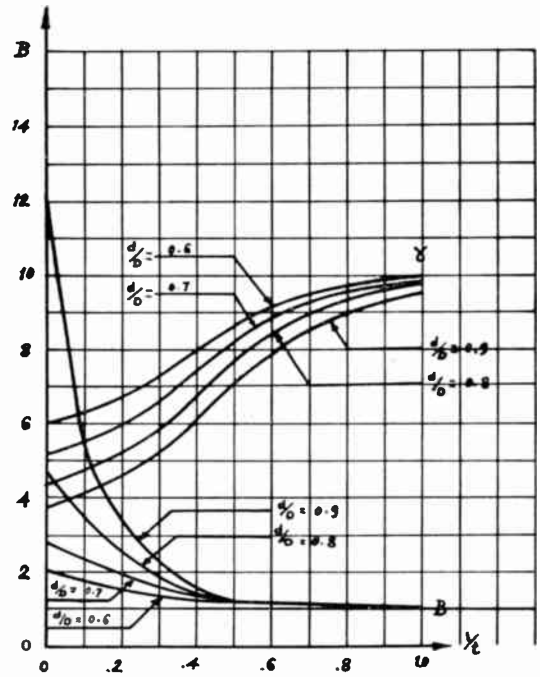

Fig. 10

Following Butterworth's work, the modifying factors for the radial and axial field contributions could be taken as β and γ given in Butterworth's equation; therefore,

$$W_p = a_0^2R_{dc}\frac{d^2}{D^2}G\{(\beta K_1 + \gamma K_2) + (\beta f_1 + \gamma f_2)\}. \qquad (32)$$

Hence,

$$R_{ac}/R_{dc} = \left\{1 + \frac{4}{\pi}\sum_{n=1} j^{n-1}\frac{a_n}{na_0} + \frac{1}{2}\sum_{n=1}\frac{a_n^2}{a_0^2}\right\}(1+F) + \{(\beta K_1 + \gamma K_2) + (\beta f_1 + \gamma f_2)\}\frac{d^2}{D^2}G \qquad (33)$$

β and γ are functions of d/D and t, and are given in Fig. 10, which is extracted from Butterworth's paper.

If the current were uniformly distributed, $a_n=0=f_1=f_2$, and the resistance ratio would be given by,

$$R_{ac}/R_{dc} = (1+F) + (\beta K_1 + \gamma K_2)\frac{d^2}{D^2}G. \qquad (33a)$$

It should be noted that although the increase in skin and proximity losses due to the nonuniformity of current distribution is approximately equal to the increase in loss if the current were uniformly distributed and the coil shunted by C_s, this is not so if $\omega/2\pi$ is near $\omega_r/2\pi$, even if the harmonics a_3, $a_5, \cdots$, were neglected. This can be clarified by the following example:

Consider a coil having $b/a=1.0$, $a=9.7$, $d=0.0508$, and $d/D=0.67$. Therefore, $C_s=2.97$ $\mu\mu$f, $L_c=1040$ μh, $\omega_r/2\pi=2.86$ mc/s. If $a_3=0=a_5=\cdots$, and approximations up to A_3 are only considered, then, at a frequency equal to 0.5 $\omega_r/2\pi$, $a_1/a_0=0.465$, $f_1=2.91$, $f_2=2.587$. Substitution in (33) gives $R_{ac}/R_{dc}=10.0$. If the current were uniformly distributed and the coil shunted with C_s, the resistance ratio, obtained from (33a) and multiplied by

$$\left\{1\bigg/\left(1-\frac{\omega^2}{\omega_r^2}\right)\right\}^2,$$

would equal 8.9. Therefore, the effect of nonuniformity of current distribution is to increase the resistance ratio by about 11 per cent over the case if the current were uniformly distributed and the coil shunted with C_s. However, at a frequency equal to 0.3 $\omega_r/2\pi$, the percentage increase is only about 4 per cent. Therefore, the experimental determination of the HF resistance by the reactance variation method at frequencies near the natural frequency of the coil requires modification.

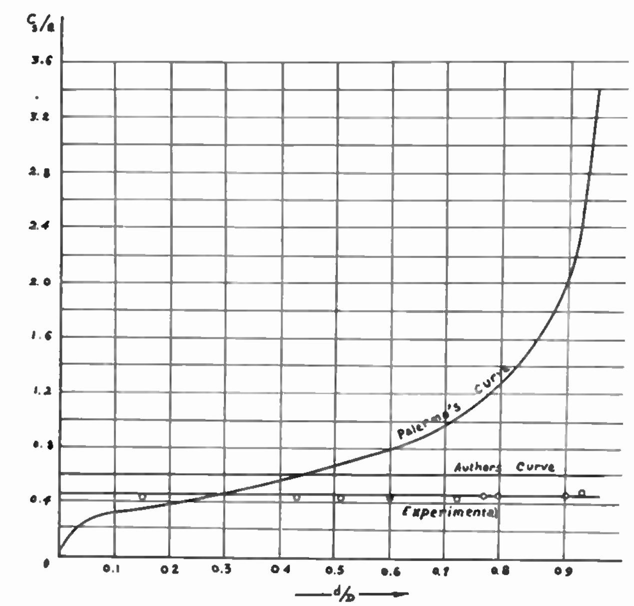

Fig. 11

VIII. Experimental Verification (Extracted from Previous Authors)

A. Self-Capacitance Verification

Self-capacitance is practically independent of the number of turns and the spacing ratio, contradicting Palermo's theory. An experimental curve extracted from Medhurst's paper for $b/a=1.0$, d/D ranging from 0.15 to 0.95 and a ranging from 2.6 to 6.4 cm, is given (Fig. 11). Curves calculated from (18) and from Palermo's formula are also depicted. Fig. 12 shows C_s/a against b/a, extracted experimentally from Medhurst's paper as well as the theoretical curve calculated from (18). Satisfactory agreement is indicated for coil lengths ranging from $0.2a$ to a. As Medhurst's experiments were carried out on coils earthed at one end, the conception in Appendix C was adopted.

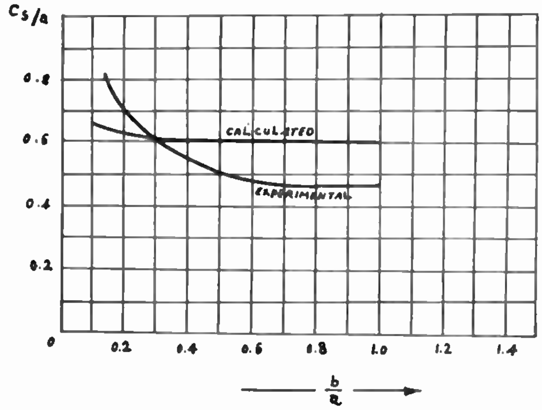

Fig. 12

B. Verification for the Resistance Ratio

The coiling effect λ, which is the ratio of the ac coil resistance to the resistance at the same frequency of the same length of straight wire

$$\left\{=\frac{R_{ac}}{R_{dc}(1+F)}\right\}$$

was calculated with equation (33a) for several ratios of b/a and for values of d/D ranging from 0.6 to 0.9. Tables 2, 3, and 4 give experimental as well as theoretical values of λ; the experimental results in Tables 3 and 4 are extracted from Medhurst's paper,[7] while those in Table 2 are taken from a paper by Palermo and Grover.[13] For the sake of comparison, the theoretical values obtained by using Butterworth's equation are also given in the tables.

TABLE 3

$b/a=1.0$, $t=10$

d/D	0.6	0.7	0.8	0.9
λ (experimental)	1.94	2.47	3.17	4.10
λ (Authors')	1.80	2.18	3.07	4.76
λ (Butterworth)	2.06	2.61	3.61	5.57

TABLE 4

$b/a=0.4$, $t=8.0$

d/D	0.6	0.7	0.8	0.99
λ (experimental)	1.83	2.28	2.97	3.99
λ (Authors')	1.79	2.257	3.31	5.24
λ (Butterworth)	1.95	2.62	3.88	6.02

[13] A. J. Palermo and F. W. Grover, "Study of the high frequency resistance of single layer coils," Proc. I.R.E., vol. 18, p. 2041; 1930.

IX. Appendices

A. *Effects of Charging Currents other than Those between the Different Turns and the Datum of Zero Potential*

As each turn of the coil is at a different mean potential from every other turn, there will be capacitances between each pair of adjacent as well as nonadjacent turns (Fig. 13). The capacitances between adjacent

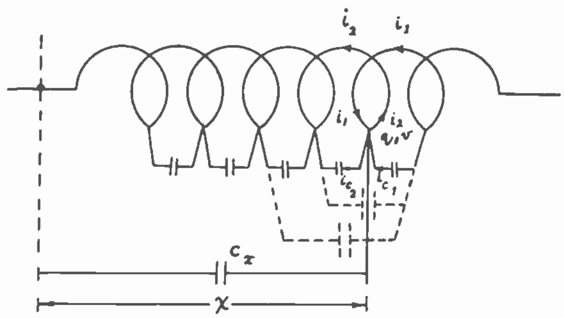

Fig. 13

turns are only important due to their screening effect.

Let Δi = variation of current, at a distance x, between two successive turns. If the capacitances between adjacent turns are only considered,

$$\Delta i = i_{c_2} - i_{c_1} = j\omega C\{(\Delta v)_1 - (\Delta v_2\} = j\omega CD^2 d^2 v/dx^2 \quad (34)$$

where C = capacitance between two adjacent turns $= \pi a/3.6 \cosh^{-1} D/d$ $\mu\mu$f; the adjacent turns considered as if they were two parallel cylinders.

However, if C_x is only considered,

$$\Delta i = j\omega q = j\omega C_x v. \quad (35)$$

Although C_x is generally small compared with C, v is large compared with Δv. On the average, $C_x v$ could be considered of the same order as $C \cdot \Delta v$. Therefore, Δi obtained from (34) could be considered as a small correcting term for Δi given by (35). Accordingly, the change of current between successive turns is, to a good degree of approximation, due to the capacitances C_x.

B. *Effect of Using Ratios for D/a and d/a other than 0.005 and 0.01, Respectively*

The effect of using a value for D/a other than 0.005 will be first considered. The pitch to diameter ratio in almost any practical coil is not less than 0.005, which is the value considered in the text. If the summation process is carried out turn-by-turn, the result will not therefore be affected by any other value for D/a. However, if an integration process is adopted, the result will be slightly affected. As the representation of Fig. 3 is a Fourier one, the summation can be easily carried out. As an example,

$$\sum_{m=0}^{n-1} \sin mD = \frac{\sin\left(\frac{n-1}{2}D\right)\cdot \sin\frac{nD}{2}}{\sin D/2}$$

while

$$\frac{1}{D}\int_0^{nD} \sin D dD = \left(\sin\frac{nD}{2}\right)^2 \bigg/ \frac{D}{2},$$

which is practically the same provided the number of turns is not very small ($nD/2 = \pi/2$). Therefore, for large number of turns, the integral in (4) and the like could be considered practically unaffected by varying the ratio D/a provided N is large.

The effect of using a value for d/a other than 0.01 can also be practically neglected, and can be clarified as follows: In determining A_0, A_m in the text, the 48-ordinate scheme was adopted. Let A_0, A_m be the coefficients at the given ratio of d/a, and A_{0_1}, A_{m_1} be the corresponding values at another ratio $(d/a)_1$. Then,

$$A_{0_1} = A_0 + \frac{(l/a)_1 - (l/a)}{48}$$

and

$$A_{m_1} = A_m + \frac{(l/a)_1 - (l/a)}{24},$$

where (l/a) and $(l/a)_1$ are the values at the ratios (d/a) and $(d/a)_1$, respectively. The discrepancy is in general very small. For $d/a = 0.01$, $l/a = 2.95 \times 10^{-2}$ μh/cm, $A_0 = 0.751 \times 10^{-2}$, $A_1 = 0.643 \times 10^{-2}$ μh/cm. For a value of d/a, so that l/a is increased by 50 per cent, the coefficients A_0 and A_1 will be given by 0.75×10^{-2} and 0.70×10^{-2} μh/cm, respectively. In any case, the correction can be easily included as illustrated.

C. *Coil Earthed at One End*

When a coil is earthed at one end, the charge distribution and hence the self-capacitance depend on the position of the coil (its inclination and distance) with respect to an equivalent conducting plane at earth potential.

To simplify the matter, consider the case where a conducting plane is at the earthed end of the coil (Fig. 14). Such consideration, although different from earth-

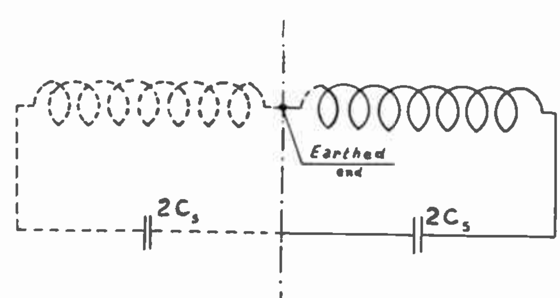

Fig. 14

ing the end of the coil, should give qualitative and even quantitative approximations. The charge distribution on coil and the induced charges at the conducting plane must be such that potential of the latter is zero. By applying the method of images, the coil and its image (shown dotted) will be treated as in the case where neither end is earthed. The self-capacitance of the coil will therefore be twice the self-capacitance of a coil with neither end earthed and of same diameter but of double length.

D. f_1 and f_2 Functions

$$f_1 = \frac{25}{\pi^2}\Bigg[4\,\frac{a_1}{a_0}\Bigg\{\frac{\pi}{4}A_1^2 + A_2\left(\frac{2}{3}+\frac{6}{5}\frac{a_3}{a_1}-\frac{10}{25}\frac{a_5}{a_1}-\cdots\right)\left(\frac{8}{3\pi}A_1-\frac{8}{3\pi}A_3-\frac{8}{12\pi}A_5-\cdots\right)$$

$$+A_4\left(-\frac{2}{15}+\frac{6}{7}\frac{a_3}{a_1}+\frac{10}{9}\frac{a_5}{a_1}+\cdots\right)\left(-\frac{32}{15\pi}A_1+\frac{32}{15\pi}A_3+\frac{32}{9\pi}A_5-\cdots\right)+\cdots\Bigg\}$$

$$+\frac{a_1^2}{a_0^2}\Bigg\{\frac{\pi^2}{8}A_1^2+2A_2^2\left(\frac{2}{3}+\frac{6}{5}\frac{a_3}{a_1}-\frac{10}{21}\frac{a_5}{a_1}+\cdots\right)^2$$

$$+\frac{9\pi^2}{8}A_3^2\frac{a_3^2}{a_1^2}+8A_4^2\left(-\frac{2}{15}+\frac{6}{7}\frac{a_3}{a_1}+\frac{10}{9}\frac{a_5}{a_1}-\cdots\right)^2+\frac{25\pi^2}{8}A_5^2\frac{a_5^2}{a_1^2}+\cdots$$

$$+\frac{8}{3}A_1A_2\left(\frac{2}{3}+\frac{6}{5}\frac{a_3}{a_1}-\frac{10}{21}\frac{a_5}{a_1}+\cdots\right)-\frac{32}{15}A_1A_4\left(-\frac{2}{15}+\frac{6}{7}\frac{a_3}{a_1}+\frac{10}{9}\frac{a_5}{a_1}+\cdots\right)$$

$$+\frac{24}{5}A_2A_3\frac{a_3}{a_1}\left(\frac{2}{3}+\frac{6}{5}\frac{a_3}{a_1}-\frac{10}{21}\frac{a_5}{a_1}+\cdots\right)-\frac{40}{21}A_2A_5\frac{a_5}{a_1}\left(\frac{2}{3}+\frac{6}{5}\frac{a_3}{a_1}-\frac{10}{21}\frac{a_5}{a_1}+\cdots\right)$$

$$+\frac{96}{7}A_3A_4\frac{a_3}{a_1}\left(-\frac{2}{15}+\frac{6}{7}\frac{a_3}{a_1}+\frac{10}{9}\frac{a_5}{a_1}-\cdots\right)-\frac{160}{9}A_4A_5\frac{a_5}{a_1}\left(-\frac{2}{15}+\frac{6}{7}\frac{a_3}{a_1}+\frac{10}{9}\frac{a_5}{a_1}-\cdots\right)+\cdots\Bigg\}\Bigg].$$

$$f_2 = \frac{25}{\pi^4}\frac{b^2}{a^2}\Bigg[4\,\frac{a_1}{a_0}\Bigg[\frac{d}{da}(aA_0)\left(1-\frac{1}{3}\frac{a_3}{a_1}+\frac{1}{5}\frac{a_5}{a_1}+\cdots\right)\Bigg\{\pi\frac{d}{da}(aA_0)+\frac{4}{\pi}\frac{d}{da}(aA_1)+\frac{4}{9\pi}\frac{d}{da}(aA_3)$$

$$+\frac{4}{25\pi}\frac{d}{da}(aA_5)+\cdots\Bigg\}+\frac{\pi}{2}\frac{d}{da}(aA_0)\left\{\frac{d}{da}(aA_1)-\frac{1}{3}\frac{a_3}{a_1}\frac{d}{da}(aA_3)+\frac{1}{5}\frac{a_5}{a_1}\frac{d}{da}(aA_5)-\cdots\right\}$$

$$+\frac{1}{2}\left\{\frac{d}{da}(aA_1)\right\}^2+\frac{d}{da}(aA_2)\left(\frac{1}{3}+\frac{3}{5}\frac{a_3}{a_1}-\frac{5}{21}\frac{a_5}{a_1}+\cdots\right)\Bigg\{\frac{4}{3\pi}\frac{d}{da}(aA_1)-\frac{4}{5\pi}\frac{d}{da}(aA_3)$$

$$-\frac{8}{105\pi}\frac{d}{da}(aA_5)-\cdots\Bigg\}+\frac{d}{da}(aA_4)\left(-\frac{1}{15}+\frac{3}{7}\frac{a_3}{a_1}-\frac{5}{21}\frac{a_5}{a_1}+\cdots\right)\Bigg\{-\frac{4}{15\pi}\frac{d}{da}(aA_1)$$

$$-\frac{4}{7\pi}\frac{d}{da}(aA_3)+\frac{4}{9\pi}\frac{d}{da}(aA_5)-\cdots\Bigg\}+\cdots\Bigg]$$

$$+\frac{a_1^2}{a_0^2}\Bigg[\left\{2\frac{d}{da}(aA_0)\right\}^2\left(1-\frac{a_3}{3a_1}+\frac{a_5}{5a_1}+\cdots\right)^2+\frac{\pi^2}{8}\left\{\frac{d}{da}(aA_1)\right\}^2$$

$$+\frac{2}{9}\left\{\frac{d}{da}(aA_2)\right\}^2\left(1+\frac{9a_3}{5a_1}-\frac{15}{21}\frac{a_5}{5a_1}+\cdots\right)^2+\frac{\pi^2}{8}\frac{a_3^2}{a_1^2}\left\{\frac{d}{da}(aA_3)\right\}^2$$

$$+\frac{2}{225}\left\{\frac{d}{da}(aA_4)\right\}^2\left(-1+\frac{45}{7}\frac{a_3}{a_1}+\frac{75}{9}\frac{a_5}{a_1}-\cdots\right)^2+\frac{\pi^2}{8}\frac{a_5^2}{a_1^2}\left\{\frac{d}{da}(aA_5)\right\}^2+\cdots$$

$$+4\frac{d}{da}(aA_0)\left(1-\frac{a_3}{3a_1}+\frac{a_5}{5a_1}-\cdots\right)\left\{\frac{d}{da}(aA_1)-\frac{a_3}{3a_1}\frac{d}{da}(aA_3)+\frac{a_5}{5a_1}\frac{d}{da}(aA_5)-\cdots\right\}$$

$$+\frac{4}{9}\frac{d}{da}(aA_1)\frac{d}{da}(aA_2)\left(1+\frac{8}{5}\frac{a_3}{a_1}-\frac{15}{21}\frac{a_5}{a_1}+\cdots\right)+\frac{4}{225}\frac{d}{da}(aA_1)\frac{d}{da}(aA_4)\left(1-\frac{45}{7}\frac{a_3}{a_1}-\frac{75}{9}\frac{a_5}{a_1}+\cdots\right)$$

$$+\frac{4}{5}\frac{d}{da}(aA_2)\frac{d}{da}(aA_3)\left(1+\frac{9}{5}\frac{a_3}{a_1}-\frac{5}{7}\frac{a_5}{a_1}+\cdots\right)\frac{a_3}{a_1}$$

$$-\frac{20}{63}\frac{d}{da}(aA_2)\frac{d}{da}(aA_5)\left(1+\frac{9}{5}\frac{a_3}{a_1}-\frac{5}{7}\frac{a_5}{a_1}+\cdots\right)\frac{a_5}{a_1}$$

$$-\frac{4}{35}\frac{d}{da}(aA_3)\frac{d}{da}(aA_4)\left(1-\frac{45}{7}\frac{a_3}{a_1}-\frac{75}{9}\frac{a_5}{a_1}+\cdots\right)\frac{a_3}{a_1}$$

$$-\frac{4}{27}\frac{d}{da}(aA_4)\frac{d}{da}(aA_5)\left(1-\frac{45}{7}\frac{a_3}{a_1}-\frac{25}{3}\frac{a_5}{a_1}+\cdots\right)\frac{a_5}{a_1}+\cdots\Bigg]\Bigg].$$

Correspondence

"Instantaneous" Frequency*

In a paper published recently,[1] the term "Instantaneous Frequency" is mentioned repeatedly. Many authors have already referred to this term as being fallacious and misleading, especially in the discussion of frequency modulation.[2,3] It is intended, in the following discussion, to show why this term is inapplicable, with the hope of banishing it forever from the dictionary of the communication engineer.

A simple sinusoidal waveform is expressible as, $A \sin (\omega t+\phi)$, or as the real part of $A \exp (j\omega t)$; in both cases, the *constant* ω is the angular frequency of the waveform. The usual accepted extention of this treatment is to regard a nonperiodic function as $A \sin \phi$ or the real part of $A \exp (j\phi)$, where ϕ is a real function of the time t, and to define an "instantaneous angular frequency" as $d\phi/dt$. Thus, Marique[1] treats a function $e(t)=\exp [j(\omega_0\theta+\epsilon\theta^2)]$, and says, "then the instantaneous angular frequency is $\Omega=(\omega_0+2\epsilon\theta)$."

When a real function is expressed as the real part of $A \exp (j\phi)$, with both A and ϕ as functions of t, the choice of A and ϕ is not unique. The imaginary part of the function is arbitrary, although some choices lead to simpler expressions for A and ϕ. If then the rate of change of ϕ is regarded as the "instantaneous angular frequency," this is not a unique function of t. A simple amplitude-modulated wave, usually expressed by $\text{Re}[A(t) \exp (j\omega t)]$ with a constant ω, may also be expressed as $\text{Re}[A \exp \{j\psi(t)\}]$, where A is a constant whose absolute magnitude is at least as high as the highest amplitude of the wave, and $\phi(t)$ is a (nonlinear) function of t. Therefore, it is possible to regard the wave as having constant amplitude and a complicated "instantaneous frequency" function; this representation is as legitimate as the usual one, of constant frequency and variable amplitude.

It appears that the only mathematically precise, in contrast to "intuitive," approach to such a term is by a limit process of the same type that is used to define the slope or the curvature of a curve at any point. This process is outlined as follows.

A sine curve $A \sin (\omega t+\phi)$ may be fitted to any three points on a given curve $f(t)$. Three points are necessary, although sometimes insufficient or incompatible, to define the three independent constants A, ω and ϕ. $f(t)$ is supposed to be single valued, continuous, and twice differentiable.

Let us find the sine curve that passes through the points of $f(t)$ whose abscissas are $t-\Delta t$, t and $t+\Delta t$.

$$
\begin{aligned}
f(t) &= A \sin (\omega t + \phi),\\
f(t \pm \Delta t) &= A \sin (\omega t + \phi \pm \omega\Delta t)\\
&= A \sin (\omega t + \phi) \cos \omega\Delta t\\
&\quad \pm A \cos (\omega t + \phi) \sin \omega\Delta t\\
&= f(t) \cos \omega\Delta t\\
&\quad \pm \sqrt{A^2 - [f(t)]^2} \sin \omega\Delta t.
\end{aligned}
$$

We will use the following short notations:

$$
\begin{aligned}
f &= f(t)\\
f(+) &= f(t + \Delta t)\\
f(-) &= f(t - \Delta t),
\end{aligned}
$$

then

$$
\left.
\begin{aligned}
f(+) &= f \cos \omega\Delta t + \sqrt{A^2 - f^2} \sin \omega\Delta t\\
f(-) &= f \cos \omega\Delta t - \sqrt{A^2 - f^2} \sin \omega\Delta t
\end{aligned}
\right\}. \quad (1)
$$

Solving (1) for the functions of $\omega\Delta t$,

$$
\left.
\begin{aligned}
\sin \omega\Delta t &= \frac{f(+) - f(-)}{2\sqrt{A^2 - f^2}}\\
\cos \omega\Delta t &= \frac{f(+) - f(-)}{2f}
\end{aligned}
\right\}. \quad (2)
$$

By division,

$$
\tan \omega\Delta t = \frac{f(+) - f(-)}{f(+) + f(-)} \times \frac{f}{\sqrt{A^2 - f^2}}. \quad (3)
$$

The second factor may be found by squaring (2) and adding, giving after some algebraic manipulations,

$$
\frac{f^2}{A^2-f^2} = \frac{[2f+f(+)+f(-)][2f-f(+)-f(-)]}{[f(+)-f(-)]^2}. \quad (4)
$$

After (4) is substituted in (3), the result is

$$
\tan \omega\Delta t = \frac{\sqrt{[2f+f(+)+f(-)][2f-f(+)-f(-)]}}{f(+)+f(-)}. \quad (5)
$$

This is a transcendental equation that gives the "average" angular frequency of the function $f(t)$ for $t-\Delta t<t<t+\Delta t$. We now pass to the limit $\Delta t \to 0$.

$$
\begin{aligned}
\tan \omega\Delta t &= \omega\Delta t + \cdots\\
f(\pm) &= f \pm \Delta t f' + \tfrac{1}{2}(\Delta t)^2 f'' + \cdots
\end{aligned}
$$

where primes denote differentiation with respect to t. Equation (5) then reduces to

$$
\omega\Delta t = \frac{\sqrt{(4f) \times (-[\Delta t]^2 f'')}}{2f}
$$

$$
\omega = \sqrt{-\frac{f''}{f}}. \quad (6)
$$

The ω in (6) is a function of t, and may be used as an "instantaneous angular frequency." This frequency is real only for points where the curvature of the graph of $f(t)$ is directed towards the t-axis; at points on the t-axis itself the frequency is undefined, unless the curve has an inflection at that point. The expression (6) is evidently true for the simple case where $f=A \sin (\omega t+\phi)$.

Suppose now that $f(t)=\sin g(t)$, then

$$
\begin{aligned}
f' &= g' \cos g\\
f'' &= g'' \cos g - (g')^2 \sin g.\\
\omega &= \sqrt{(g')^2 - g'' \cot g}. \quad (7)
\end{aligned}
$$

The last value is quite different from the "intuitive" $\omega=g'$. (Both values would be the same only if $g''=0$, but then g is a linear function of t, and ω is constant.)

The frequency defined by (7) may have some value in discussing nonperiodic waves; but the "intuitive" value, nevertheless, is wrong. Thus, it is easy to understand the apparent paradoxes in statements like the following:

"The maximum of the response of a tuned RLC circuit to a voltage of varying frequency does not occur when the instantaneous frequency coincides with the resonant frequency of the tuned circuit"; or, "The spectrum of a frequency-modulated wave is much wider than the range of variation of the instantaneous frequency."

These are erroneous statements, based on an "intuitive"—but erroneous—interpretation of a term.

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* Original manuscript received by the Institute, October 6, 1952.

[1] J. Marique, "The response of RLC resonant circuits to EMF of sawtooth varying frequency," Proc. I.R.E., vol. 40, p. 945; August, 1952.

[2] N. L. Harvey, M. Leifer, and N. Marchand "The component theory of calculating radio frequency spectra, with special reference to frequency modulation," Proc. I.R.E., vol. 39, p. 648; June, 1951.

[3] W. C. Vaughan, "Spectrum of a frequency modulated wave," *Wireless Engineer*, vol. 29, p. 217; August, 1952.

More on Direction Finders*

Hansel's letter on polarization errors in direction finders[1] raises some interesting points of nomenclature which merit careful consideration. The work of Ross[2] in relation to Adcock-type direction finders is also relevant.

Let us suppose that a direction finder, designed to give correct indications with vertically polarized waves, is set up on a uniform, unobstructed site. If the incoming radiation has a horizontally polarized component, an error will in general be observed and, because of this, it is natural and convenient to refer to this component as "unwanted." The more weakly the instrument responds to this component, that is, the smaller the pick-up factor for horizontally polarized waves relative to that for the vertically polarized component, the *smaller* the error. It is therefore rather confusing that the term "unwanted" should also be applied, as Hansel proposes, to a component which, although producing no actual error on a clear site, excites only a weak or zero response.

I agree, however, that it would perhaps be an unfortunate residual characteristic of a hypothetical instrument if the pick-up

* Received by the Institute, March 27, 1952.

[1] P. G. Hansel, "Polarization errors of radio direction finders; a proposed classification," Proc. I.R.E., vol. 39, p. 970; 1951.

[2] W. Ross, "The specification and measurement of polarization errors in Adcock-type direction finders," *Proc. IEE* (London), vol. 96, pt. III, p. 269; 1949.

Correspondence

factor for one polarization component were much larger than the other, both components being assumed to give correct bearings on an unobstructed site; for, in certain cases of operation on an imperfect site, large errors might thereby result. Nevertheless, in my opinion, confusion can best be avoided by applying the term "unwanted" to the component which introduces errors when the direction finder is operated on a uniform unobstructed site rather than by allowing it to embrace the wider connotation suggested by Hansel.

Since the additional errors which arise when the instrument is set up in imperfect surroundings are special to each site, it is preferable, as Hansel proposes, to regard these as polarization-sensitive or polarization-dependent site errors.

The distinction between the primary and secondary classes of instrumental polarization errors, put forward by Hansel, is not clearly drawn. It is difficult to see how errors resulting from re-radiation from essential conductors of the direction finder differ from errors of the first class, since both are due to the response of the system as a whole to the unwanted component of the field. When, therefore, polarization errors are measured under controlled conditions on a uniform unobstructed site, I suggest that they should be considered as instrumental characteristics without attempting further subdivision as part of a *general* nomenclature. It must be borne in mind that even these instrumental errors will, in general, depend upon the height of the system above ground and on the ground constants.

The work described above was carried out as part of the program of the Radio Research Board, and this note is published by permission of the Department of Scientific and Industrial Research.

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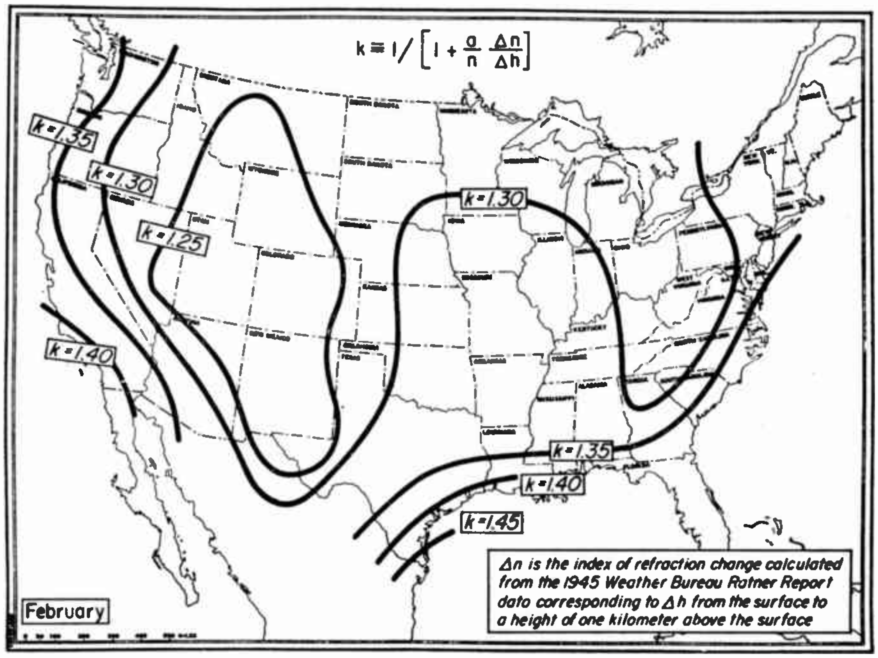

Fig. 1—Effective earth's radius factor, *k*, for February.

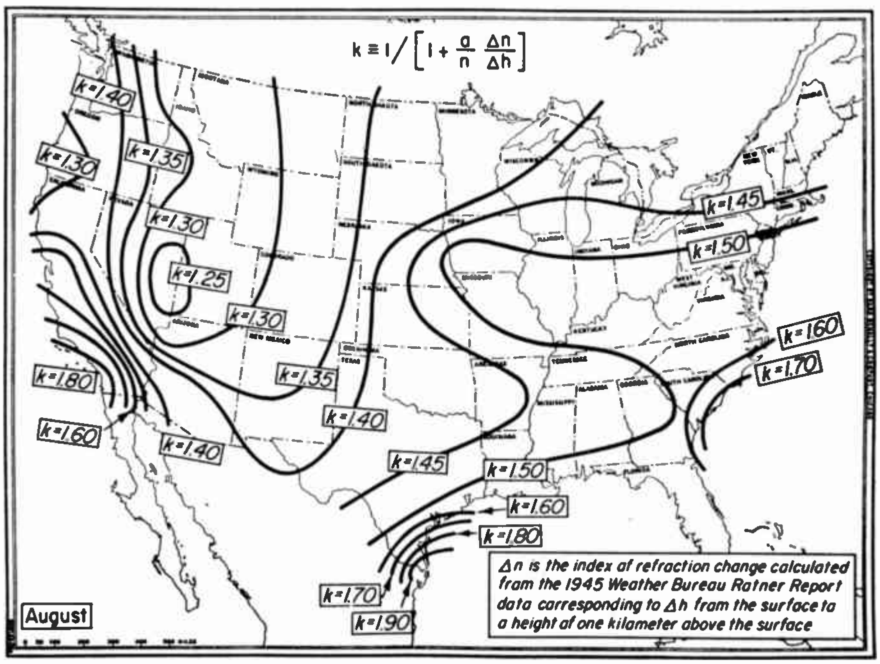

Fig. 2—Effective earth's radius factor, *k*, for August.

The Geographical and Height Distribution of the Gradient of Refractive Index*

Summary

Charts are presented of the February and August distribution of the effective earth's radius factor over the United States. Also included is a chart showing the distribution of refractive-index gradient for warm, temperate, and cold climates.

Since the presentation of the theory of internal partial reflections by Feinstein,[1] there has been increased interest in the normal geographical and height distribution of the refractive-index gradient. In view of this interest, the following preliminary charts are presented.

Some work has been done[2] to show the geographical distribution over the United States of effective earth's radius but none over a uniform height increment above the earth's surface. Figs. 1 and 2 are charts of the effective earth's radius factor, *k*, for the months of February and August, respectively. The height interval of these charts is from the surface to 1 km above the surface.

Chart 3 is an illustration of the climatic variation of the gradient of refractive index to the height of 90,000 feet above sea level. San Juan in July is chosen as an example of a warm, humid climate, Washington, D. C. in October as a temperate or median climate, and Fairbanks, Alaska, in February as

* Original manuscript received by the Institute, May 13, 1952.

[1] J. Feinstein, *Jour. Appl. Phys.*, vol. 22, p. 1952; 1951.

[2] R. J. Wagner, Jr., RCA Engineering Report F-43-116; 1951.

Correspondence

a dry, cold climate. The basis for extending the curves above the tropopause is the assumption of an isothermal stratosphere[3] of −65.3°C as used by Schulkin.[4]

All data are from the 1945 Weather Bureau Report, "Upper Air Average Values of Temperature, Pressure and Relative Humidity over the United States and Alaska," by Benjamin Ratner. These observations were taken between 2200 and 0100, 75th meridian time.

The values of effective earth's radius, factor, given on Figs. 1 and 2 are obtained from the relationship:

$$k = 1.\left[1 + \frac{a}{n}\frac{\Delta n}{\Delta h}\right],$$

where a = earth's radius = 6,370 km
n = mean radio refractive index of the interval
$\Delta n/\Delta h$ = gradient of refractive index of the interval.

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[3] F. L. Whipple, *Bull. Amer. Met. Soc.*, vol. 33, p. 13; 1952.
[4] M. Schulkin, Average Radio Refraction in the lower atmosphere, *Proc. IRE*, 40, pp. 544–561.

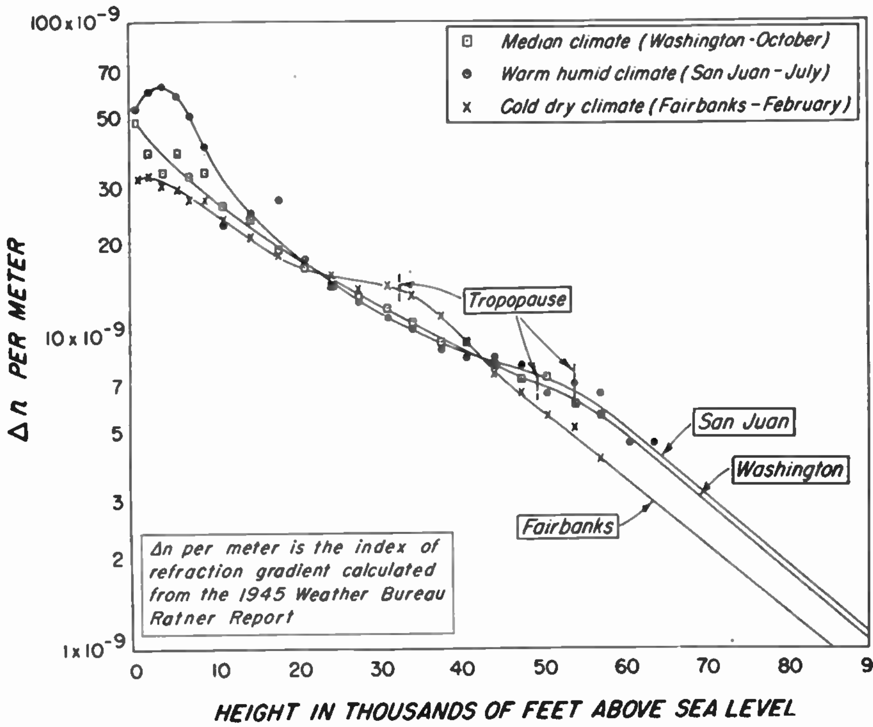

Fig. 3—Average refractive index, gradient.

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Dr. Berkowitz attended the Moore School of Electrical Engineering, University of Pennsylvania, receiving the M.S. degree in February, 1948. From July, 1947 until the present he has been on the research and teaching staffs of the Moore School, where he has been concerned with the theory of fire-control equipment and also the interference effect of various types of noise on communication systems. He received the Ph.D. degree in June, 1951.

Dr. Berkowitz is a member of Sigma Xi and an associate member of AIEE. He is also helping to organize the Society for Industrial and Applied Mathematics.

❖

B. G. Bromberg was born in New York, N. Y. on February 14, 1915. He obtained a B.S. degree in mechanical engineering in 1936 and a M.S. degree in 1937, both from New York University. He entered the aircraft industry in 1937 and became chief technical engineer for Consolidated-Vultee Aircraft Corporation in 1943. After World War II Dr. Bromberg was employed as a research associate at Massachusetts Institute of Technology, and received his Sc.D. degree there in 1947. Since 1947 he has been employed at McDonnell Aircraft Corporation, Missile Engineering Division. He started as head of the guidance and control department and is now chief engineer.

B. G. BROMBERG

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❖

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T. S. GEORGE

From 1938 to 1945 Dr. George served as instructor and assistant professor of mathematics at the University of Florida. From 1942 to 1945 he was on military leave as a Naval electronics officer, leaving the Navy with the rank of lieutenant commander. During this time, he served at sea as radar officer aboard a carrier and later in the Bureau of Aeronautics where he was in charge of development of electronic bombing and fire-control devices.

At the end of World War II Dr. George

Contributors to Proceedings of the I.R.E.

became a consulting engineer in the research division of the Philco Corporation, doing theoretical work in a variety of electronic problems until 1952. He is now at Patrick Air Force Base, Cocoa, Fla.

❖

M. Kamal Gohar was born in Cairo, Egypt on February 1, 1923. He received the B.Sc. degree in June, 1944 and the M.Sc. degree in January, 1948, both in electrical engineering from Fouad I University, in Egypt. In July, 1949 he was the recipient of the Ph.D. degree from Alexandria University.


M. K. Gohar

Dr. Gohar has held the posts of a demonstrator and lecturer at Fouad University. He is now a senior lecturer and, at the same time, assists in the research activities of Fouad I University's electrical department. He has recently been selected by the Technical Committee of the Egyptian Ministry to act as a consultant for their Electric Power activities.

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❖

Raymond D. Hill, Jr. was born in St. Louis, Mo. in 1921. He received the B.S. degree in electrical engineering from Washington University in St. Louis in 1943.


R. D. Hill

Mr. Hill has been closely associated with the aviation and electronics industries since 1940. He has held a private flying license since 1941. From 1944 to 1946, he served in the U. S. Naval Reserve as an electronic specialist officer.

After returning to civilian life in 1946, Mr. Hill joined the engineering staff of the McDonnell Aircraft Corporation, where he is now serving as chief of electronics in the Missile Engineering Division. He has since been continuously involved in the design and development of guidance and control systems for Navy and Air Force guided missiles and of other aircraft electronic systems. He is now completing work on the M.S. degree in electrical engineering at Washington University.

Abd El-Samie Mostafa (SM'51) was born in Cairo, Egypt on April 27, 1917. He received the B.Sc. degree in June, 1937 and the Ph.D. degree in 1946, both in electrical engineering from Fouad I University, in Egypt.


A. E. Mostafa

Dr. Mostafa has held the posts of teaching assistant and lecturer at Fouad University, and was promoted to assistant professor in 1948. He is now professor of radio engineering, associated with the research section in radio and tele-communication work at Alexandria University.

Dr. Mostafa was elected an associate member of the IEE (London) in June, 1948, and was awarded the Fouad El-Awal prize for science in Egypt for 1950.

❖

Herbert J. Reich (A'26–M'41–SM'43–F'49) was born on Staten Island, N. Y., on October 25, 1900. He received the M.E. degree from Cornell University in 1924, and the Ph.D. degree in physics in 1928. In 1929 he joined the department of electrical engineering at the University of Illinois, where he became assistant professor, associate professor, and professor, successively, of electrical engineering. In January, 1944, he was granted leave of absence to join the staff of the Radio Research Laboratory at Harvard University. In January, 1946, Professor Reich was appointed professor of electrical engineering at Yale University, where he is at present.


Herbert J. Reich

Dr. Reich has specialized in the fields of electron tubes and electron-tube circuits, having published numerous papers on these and related subjects in various technical journals. He is the author of "Theory and Applications of Electron Tubes," and "Principles of Electron Tubes," as well as co-author of "Ultra-High-Frequency Techniques," and "Microwave Theory and Techniques" which is soon to be published. Dr. Reich is also editor of the Van Nostrand Series in Communications Engineering.

Dr. Reich has served on numerous IRE committees, and is a member of the American Institute of Electrical Engineers, the American Association for the Advancement of Science, the American Society for Engineering Education, and is a Fellow of the American Physical Society.

Kurt Schlesinger (A'41–SM'51) was born in Berlin, Germany in 1906. After receiving the Ph.D. degree in engineering in Berlin in 1929, he joined the Radio Research Laboratory of von Ardenne, where he was engaged in development of oscilloscope tubes and circuits.


K. Schlesinger

From 1931 until 1938, Dr. Schlesinger was chief engineer in the television research department of Loewe Radio Berlin. During that period a complete television system was developed. From 1938 through 1940, he worked in Paris as a consultant to Radio Gramont, and built equipment for infra-red telephony for the French army.

In the United States, Dr. Schlesinger was with RCA Laboratories at Purdue University, from 1941 through 1944. During that time he developed a system for television sound multiplexing, which employed frequency modulated wave bursts during the picture retrace.

From 1944 until 1947, Dr. Schlesinger was consulting engineer in the Color Television Department of CBS. He has since been executive engineer in charge of television research with Motorola Inc., Chicago.

During Dr. Schlesinger's twenty years of activity in television research he has received more than two hundred U. S. patents, and has authored numerous technical articles and publications. He has, also, served on the NTSC committees, working on television problems.

❖

Harry Urkowitz (S'48–A'49) was born on October 1, 1921 in Philadelphia, Pa. and educated in the public schools there. He was graduated from the Drexel Institute of Technology, Philadelphia, Pa. in 1948 with the B.S. degree in electrical engineering.


H. Urkowitz

After graduation Mr. Urkowitz was employed by the Philco Corporation in their Philadelphia research division, where he has been to the present. He is now an acting project engineer with Philco. During World War II he served in the Army Air Forces from 1942 to 1945 as a radar bombardier-navigator.

Mr. Urkowitz is a member of Phi Kappa Phi, Tau Beta Pi, and Eta Kappa Nu.

Institute News and Radio Notes

Calendar of COMING EVENTS

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 23–24

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

High Frequency Communication Symposium, IRE Professional Group on Communications Systems, Long Lines Auditorium, 32 Avenue of the Americas, New York, N. Y., June 11–12

Symposium on Microwave Optics, McGill University, Montreal Canada, June 22–24

IRE Western Convention and Electronic Show, Civic Auditorium, San Francisco, Calif., August 19–21

International Sight and Sound Exposition and Audio Fair, Palmer House, Chicago, Ill., September 1–3

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 A. G. Jensen, the **Standards** Committee met on January 8. Chairman Jensen reported on his letter to Charles Dawes concerning ASA C42 subcommittee activities and the scheduling of a sectional committee meeting in the near future. Professor Dawes had reported that the committee was studying the status of its various groups and that the overlapping in definitions work within subcommittees 1, 13, and 14 might be solved by a meeting of the chairmen before the sectional committee meeting. Mr. Jensen commented on the over-all question of frequency-band nomenclature and the progress made by CCIR Study Group XIV on the proposed standardization of frequency-band designations. The proposed Standard on Electron Devices: Methods of Measuring Noise, which was submitted by the Electron Devices Committee, was discussed and minor revisions recommended by the Standards Committee. The standard was approved. There was a recommendation to change the name of Committee 26 from the Committee on Servo-Systems to the Committee on Feedback-Control Systems; the change was approved.

On February 5, the **Audio Techniques** Committee met under the Chairmanship of C. A. Cady. The Committee completed the proposed revision to ASA C16.5.

The **Electron Devices** Committee met on January 9, under the Chairmanship of G. D. O'Neill. Chairman O'Neill reported on the klystron definitions now on the Grand Tour. The comments received indicate that no changes are needed; the definitions will be considered by the Standards Committee in the future. M. E. Hines reported on the Ad Hoc Committee on Reorganization of Committee 7. H. L. Owens inquired when the Solid State Definitions report would be available. Chairman O'Neill suggested R. M. Ryder be contacted concerning these definitions. S. F. Kaisel has accepted an invitation to serve on the Committee and his appointment has been approved by the IRE Executive Committee.

On January 14 the **Measurements and Instrumentation** Committee met in Washington, D. C., under the Chairmanship of F. J. Gaffney. W. D. George reported on the activities of Subcommittee 25.1. This Subcommittee has accumulated definitions on voltage measurements which will be submitted to the Committee. The Subcommittee also is working on a standard for voltage measurement applicable for signal-generator output, and it is estimated that it will be available in approximately four months. J. H. Muncy reported for J. G. Reid, Jr., on the activities of Subcommittee 25.14. Harold Dinger reported on the work of the new Subcommittee 25.8 on Interference Measurements whose first meeting was held on January 29. As a preliminary action the more important and fundamental terms in the field will be defined. H. M. Joseph attended the Measurements and Instrumentation meeting as representative of P. S. Christaldi, and discussed the work of the Subcommittee on Oscillography. A written report on the activities of Subcommittee 25.13 on Telemetering was given.

Under the Chairmanship of P. C. Sandretto the **Navigation Aids** Committee met on January 16. The Committee completed consideration of the third section of Harry Davis' list of terms.

New England Radio Engineering Meeting

A Radio Engineering Meeting sponsored by the North Atlantic Region of the IRE is to be held April 11 at the University of Connecticut, Storrs, Conn. Morning and afternoon sessions will be held in the Student Union Building.

Guest speaker is to be D. E. Noble, a former professor at the University now vice president and director of research of Motorola, Inc. Dr. Noble was influential in introducing frequency modulation. Six papers are to be given.

Last Call for Western IRE Convention Papers

Authors are invited to submit prospective papers for the IRE part of the 1953 Western Electronic Show and Convention to be held in San Francisco, Calif., on August 19–21. The dealine is May 1.

Papers in the fields of antennas and propagation, circuits, communication theory, computers, control and instrumentation, electronic devices, uhf and microwave techniques, nuclear electronics, transistors, and non-vacuum tube electronics are particularly desired, but no paper should be withheld if it does not fall into one of these categories. In general, the time allowed will be 30 minutes per paper.

The following should be submitted to B. M. Oliver, Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.: (1) name, address, and affiliation of author, (2) title and 100 word abstract, (3) the paper, or a summary of 500 words.

Automatic Control Courses Offered

The University of Michigan, College of Engineering, has announced two intensive courses in automatic control. The classes are scheduled for June 15–20 and June 22–25, 1953, and are intended for engineers who wish to obtain a basic understanding of the field.

The courses are built around the principles and application of measurement, communication, and control, and will include some fundamental work in nonlinear systems. The role of analog computing methods also will be emphasized.

The deadline for registration is April 15, 1953. Further information may be obtained from: Professor M. H. Nichols, Room 1523, East Engineering Building, University of Michigan, Ann Arbor, Mich.

Professional Group News

Airborne Electronics

The Professional Group on Airborne Electronics sponsored a symposium on "Electronic Control and Stabilization of Aircraft," and a technical session on the "Import of Electronic Trends on Aircraft Design" at the annual meeting of the Institute of Aeronautical Sciences, held January 28, 1953, the Hotel Astor, New York, N. Y. The IRE session was presided over by General P. C. Sandretto of International Telephone and Telegraph Corporation and Federal Telecommunications Laboratories.

General Sandretto made the following remarks in opening the session:

"While the Wright Brothers demonstrated powered flight in 1903, it was several years before the airplane had reached the stage of development where it could be regarded as a means of transportation and had acquired unique navigational problems. By one of those coincidences which have had a profound effect on the course of history, radio development paralleled in time that of the airplane. It was in 1902 that John Stone obtained a patent on the first device applying radio to navigation, and in 1910 when the airplane was in need of navigational equipment, James McCurdy transmitted a radio message from the air. Radio and the aeronautical sciences were therefore united to bring forth air transportation.

"The joining of radio and aeronautics, was, however, a union of convenience rather than love because two more incompatible equipments than the airplane and the radio set could hardly be found.

"Flight's greatest obstacle is weight and radio equipment is heavy. Radio equipment is delicate and dislikes a vibrating ambient. Yet all aircraft have pronounced vibration characteristics. Any protusions reduce the efficiency of an airplane, yet all radio installations operate best with large protruding antennas. And so on, and on, we could mention the incongruity of applying radio to aviation.

"For years the problems of incompatibility were largely ignored. It was not until 1936 that the first aircraft had radio equipment engineered into it at the time of its inception. The radio engineers did little better in approaching the problem from their end."

Walter Robinson, research supervisor and assistant professor of mechanical engineering at Ohio State University presented a paper on the systematic cooling of airborne electronic equipment. He described seven methods which were applied to cooling a power supply unit having a heat dissipation of 330 watts. Tests were conducted on large tubes with noncylindrical shell.

Another paper, by William Sichak, J. J. Nail, and A. G. Kandoian, of Federal Telecommunications Laboratories, concerned the problem of obtaining satisfactory patterns from uhf antennas mounted on large aircraft. After extensive work to determine the patterns which could be expected from antennas mounted in various places in the aircraft, the authors concluded that multiple antennas must be used. Applying the multiple antenna system to give suitable pattern for distance measuring or radar beacon purposes was relatively easy, but there were problems to be solved before it could be used for other applications.

H. F. McKenney in his paper, "What Magnetic Amplifiers Can Do to Increase Aircraft Reliability," stressed that the advantages of magnetic amplifiers were (1) no warm-up time, and (2) no cooling problems. After describing design criteria, applications to converters, turret drives, auto pilot, and pulse generator were discussed. He stated that pulses with time durations of the order of three microseconds had been obtained.

Applying electronics to aircraft engine control was discussed in a paper by J. D. Peterson and R. W. Curran. The cumbersomeness of the present cable and pulley system of throttle and mixture controls was compared to one using a servo amplifier consisting of a five pound servo motor and a five pound servo amplifier per engine. Only two tubes are used in the magnetic amplifiers, and in 2,000 hours of operation there had been no failure. A number of provisions were made to take care of the most prominent failures that might occur.

The Dayton Chapter of the group met recently at the Biltmore Hotel, under the chairmanship of Maurice Jacobs. David Weber of the Collins Radio Company spoke about "Modular Airborne Electronic Design," illustrating his remarks with diagrams and a model of a commercial airline transmitter receiver.

Audio

The Milwaukee Chapter of the Professional Group on Audio met recently at the Engineers Society of Milwaukee Building. D. E. Mereen presided and N. C. Pickering, Pickering Corporation, spoke on "Pickups and Preamps for High-Quality Audio." Mr. Pickering placed special emphasis on the possibility of overloading the first audio tube by the signal induced from the pickup head.

The Philadelphia Chapter of the group held two meetings recently at the Edison Building Auditorium of the Philadelphia Electric Company. W. E. Kock, director of acoustics research, Bell Telephone Laboratories, gave a paper entitled, "The Physics of Music and Hearing," with demonstrations. He outlined the physical concepts of hearing and reviewed the spectral content of musical instruments. He also discussed electrical means for reproducing and imitating existing orchestral instruments. A motion picture, "Action Pictures of Sound," was also shown. At the second meeting, F. H. Slaymaker, Stromberg-Carlson Company, gave a paper entitled, "Performance Criteria of Loudspeakers."

Broadcast and Television Receivers

Stephen Bushman presided over a recent meeting of the Chicago Chapter of Professional Group on Broadcast and Television Receivers, held in the Western Society of Engineers Auditorium.

L. H. Horn, Underwriter Laboratories, Inc., presented a paper titled "Underwriters Laboratories View Connections of UHF and Color-Adapters to VHF-TV Receivers." Mr. Horn reviewed problems of receiver replaceable-and-attachable devices from the pre-war era to the present. He classified adapters into two categories, those which can be safely installed by the customer, and those much must be installed by servicemen.

S. W. Jacobson, director of research, E. I. Guthman & Company, spoke on "A New Television Horizontal Output Transformer." He showed how early TV receiver horizontal-deflecting systems, using 9-kv high voltage and 53-degree deflection with 390-volt Bt, have been improved through the use of ceramic transformer cores, high perveance tubes, high inductance yokes, and improved drive circuitry. Such systems now give a high efficiency performance of 15½-kv and 70-degree deflection with 140-volt Bt and 11½-watts input.

Circuit Theory

The Chicago Chapter of the Professional Group on Circuit Theory met recently at the Western Society of Engineers Auditorium, L. E. Pepperberg as Chairman. Speaker C. A. Stone of the Armour Research Foundation spoke on electronics in nucleonics.

Vehicular Communications

The Los Angeles Chapter of the Professional Group on Vehicular Communications met in February at the Institute of Air Sciences Building. M. E. Kennedy was the Chairman.

W. A. Miller, Radio Division of the Pacific Telephone and Telegraph Company, presented a paper called, "The Use of Vehicular Communication Equipment in the Telephone Plant." It concerned the development of telephone communication to mobile units in that area. Many technical problems were discussed in adjacent channel operation, intermodulation, and selective-dial calling.

Electronic Computers

Over 700 people attended the Western Computer Conference held on February 4–6, Hotel Statler, Los Angeles, Calif., sponsored by the Joint Computer Conference Committee representing the IRE Professional Group on Electronic Computers, the American Institute of Electrical Engineers, and the Association for Computing Machinery.

Reports were given on commercial applications of computers, applications to aircraft and missile design, and new developments in digital and analog computer equipment. There was also a panel discussion on the relative merits and applications of analog and digital computers. Products and services of twenty-two organizations were displayed.

Proceedings of this Western Computer Conference will be available from the IRE and can be ordered for $3.50 from: L. G. Cumming, Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y.

1953 Convention Record of the I.R.E.

Join the IRE Professional Groups to Receive Convention Papers

All available papers presented at the 1953 IRE National Convention will appear in a new publication, the CONVENTION RECORD OF THE I.R.E., to be published in June. The CONVENTION RECORD will be issued in ten Parts, with each Part devoted to one general subject.

Instructions on Ordering

1. If you are a member of an IRE Professional Group and have paid the Group assessment by April 30, 1953, you will automatically receive, free of charge, that Part of the CONVENTION RECORD pertaining to the field of interest of your Group, as indicated in the chart below.
2. If you are not a member of an IRE Professional Group, or if you are a member but have not paid an assessment, pay the group assessment listed below and receive, without additional charge, not only the corresponding Part of the CONVENTION RECORD but all publications issued by the Group during the assessment Period. To join a Group, you must be an IRE member.
3. In addition, CONVENTION RECORD Parts may be purchased at the prices listed in the chart below. Orders must be accompanied by remittance, and, to guarantee delivery, must be received by April 30, 1953, at the Institute of Radio Engineers, 1 East 79 St., New York 21, N. Y.

Group Assessments

Airborne Electronics	$2.00
Antennas and Propagation	$4.00
Audio	2.00
Broadcast and Television Receivers	2.00
Broadcast Transmission Systems	2.00
Circuit Theory	2.00
Communications Systems	2.00
Electron Devices	2.00
Electronic Computers	2.00
Engineering Management	1.00
Industrial Electronics	2.00
Information Theory	2.00
Instrumentation	1.00
Medical Electronics	1.00
Microwave Theory and Techniques	2.00
Nuclear Science	none
Quality Control	2.00
Radio Telemetry and Remote Control	1.00
Vehicular Communications	2.00

CONVENTION RECORD OF THE I.R.E.

Part	Title	Free to Paid Members of Following IRE Professional Groups	Other IRE Members	Nonmembers	Public Libraries and Colleges
1	Radar and Telemetry Sessions: 6, 12, 37, 43	Airborne Electronics Radio Telemetry & Remote Control	$1.00	$3.00	$2.40
2	Antennas & Communications Sessions: 1, 7, 13, 18, 28	Antennas & Propagation Communications Systems Vehicular Communications	1.25	3.75	3.00
3	Audio Sessions: 25, 31, 38	Audio	1.00	3.00	2.40
4	Broadcasting & Television Sessions: 2, 8, 23, 29, 35, 41	Broadcast Transmission Systems Broadcast & TV Receivers	1.50	4.50	3.60
5	Circuit Theory Sessions: 3, 9, 15, 21	Circuit Theory	1.25	3.75	3.00
6	Electron Devices— Engineering Management Sessions: 16, 20, 24, 26, 39	Electron Devices Engineering Management Quality Control Industrial Electronics	1.00	3.00	2.40
7	Electronic Computers Sessions: 4, 10, 14	Electronic Computers	1.00	3.00	2.40
8	Information Theory Sessions: 22, 27, 33, 40	Information Theory	1.25	3.75	3.00
9	Instrumentation— Nucleonics— Medical Electronics Sessions: 5, 11, 17, 32, 34	Instrumentation Nuclear Science Medical Electronics	1.25	3.75	3.00
10	Microwaves Sessions: 30, 36, 42	Microwave Theory & Techniques	1.00	3.00	2.40
	Complete Convention Record (All Ten Parts)		11.50	34.50	27.60

1953 Electronic Components Symposium

April 29–May 1, Pasadena, Calif.

An attendance of over 1,500 scientists, engineers, and executives is indicated for the 1953 Electronic Components Symposium, April 29–May 1, Shakespeare Club, Pasadena, Calif.

The three-day meeting, which is sponsored by the IRE Professional Group on Instrumentation, American Institute of Electrical Engineers, Radio Television Manufacturers Association, and West Coast Electronic Manufacturers Association, will feature the theme "Critical Problems Being Faced by the Electronic Industry in Meeting Industrial and Military Demands."

Sessions will be open to the public and registration may be made by writing to: The Symposium Headquarters of the Stanford Research Institute, Los Angeles Division, 621 South Hope, Los Angeles 17, Calif.

The symposium program follows:

Wednesday, 9:45 A.M., April 29

Welcome

Chairman, A. M. Zarem, 1953 Electronic Components Symposium, Stanford Research Institute, Los Angeles, Calif.

Wednesday, 10:00 A.M., April 29

Session 1—General

Chairman, Simon Ramo, Hughes Aircraft Co., Culver City, Calif.

"The Development of Industry Standards by the RTMA," R. R. Batcher, Radio Television Manufacturers Assn., New York, N. Y.

"Inferences from Tests of Electronic Ordnance," B. P. Ramsay, U. S. Naval Ordnance Lab., Silver Spring, Md.

"A Critical Compilation of Electronic Information," Richard Larson, Vitro Corporation of America, Silver Spring, Md.

"The Component Problem in Industrial Electronics," E. D. Cook, General Electric Co., Schenectady, N. Y.

Wednesday, 12:00, April 29

Luncheon

Luncheon Address, Speaker and Subject to be announced

Wednesday, 1:45 P.M., April 29

Session 2—Environment and Packaging

Chairman, A. W. Rogers, Signal Corps Electronics Lab., Fort Monmouth, N. J.

"Protective Coatings for Etched Circuit Wiring," Morris Weinberg and L. J. Martin, Hughes Aircraft Co., Culver City, Calif.

"Review of Component Progress for Auto-Sembled Electronic Equipments," V. J. Kublin and R. A. Gerhold, Squier Signal Lab. and Signal Corps Engineering Lab., Fort Monmouth, N. J.

"Components for Mechanized Production of Electronic Equipment," L. K. Lee and F. M. Hom, Stanford Research Institute, Stanford, Calif.

"Recommended Temperature Measuring Techniques and Ratings for Electronic Parts," J. P. Walsh, Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y.

"The Behavior of Component Parts in High-Intensity Short-Duration Environments," C. R. Gates and F. A. Paul, California Institute of Technology, Pasadena, Calif.

"Temperature-Pressure Derating of Electron Tubes," Bernard Smith, Wright Air Development Center, Dayton, Ohio

Wednesday, 6:30 P.M., April 29

Dinner

Dinner Address, Speaker and Subject to be announced

Thursday, 9:30 A.M., April 30

Session 3—Tubes and Tube Reliability

Chairman, To be announced

"Electron Device Reliability vs. Post-War Equipment Complexity," J. E. Gorham, Evans Signal Lab., Fort Monmouth, N. J.

"Statistical Control of Electron Tube Reliability," A. J. Heitner, Sylvania Electric Products Inc., Emporium, Pa.

"Performance of Vacuum Tubes in Military Applications," E. R. Jervis and R. Madison, Aeronautical Radio, Inc., Washington, D. C.

"Reliability—Tubes vs. Transistors," C. W. Martel, Raytheon Manufacturing Co., Newton, Mass.

"Improving Equipment Reliability by Tube Aging and Inspection," R. E. Colander, Bendix Aviation Corp., North Hollywood, Calif.

Thursday, 12:00, April 30

Luncheon

Luncheon Address, Speaker and Subject to be announced

Thursday, 1:45 P.M., April 30

Session 4—Reliability

Chairman, M. B. Carlton, Research and Development Board, Washington, D. C.

"The Case of Reliability vs. Defective Components et al.," R. M. C. Greenidge, Bell Telephone Lab., Murray Hill, N. J.

"The Necessity of Statistical Experimental Design in Testing for Component Reliability," J. L. Blair, Consolidated Vultee Aircraft Corp., San Diego, Calif.

"Rudiments of Good Circuit Design," N. H. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

"Reliability of Transistors," R. M. Ryder and W. R. Sittner, Bell Telephone Lab., Murray Hill, N. J.

Thursday, 4:00 P.M., April 30

Round Table on Reliability

Participants, The authors of the papers in day's sessions, and R. R. Carhart, The Rand Corp., Santa Monica, Calif.; R. Lusser, Los Angeles Ordnance District Office, Pasadena, Calif.

Friday, 9:30 A.M., May 1

Session 5—Resistors, Capacitors and Dielectrics

Chairman, Louis Kahn, Aerovox Corp., New Bedford, Mass.

"Characteristics and Applications of Voltage Sensitive Dielectrics," George S. Shaw and J. L. Jenkins, Radiation, Inc., Melbourne, Fla.

"Some Characteristics and Limitations of Capacitor and Resistor Components," Julian K. Sprague and Leon Podolsky, Sprague Electric Co., North Adams, Mass.

"New Developments in General Purpose Ceramic Dielectric Capacitors," A. K. Das Gupta and W. G. Delp, Solar Manufacturing Corp., Los Angeles, Calif.

"Recent Developments in Dielectric Materials Related to Component Development," G. T. Kohman, Bell Telephone Labs., Murray Hill, N. J.

"Quality Components and Improved Dielectrics," A. J. Warner, Federal Telecommunication Laboratories, Inc., Nutley, N. J.

Friday, 2:00 P.M., May 1

Session 6—Devices and Materials

Chairman, Reuben Lee, Westinghouse Electric Corp., Baltimore, Md.

"New Ferritic Materials," Ephraim Gelbard, General Ceramics and Steatite Corp., Keasbey, N. J.

"Ferro-Resonant Devices," Hugo Woerdemann, Magnetic Research, Inc., El Segundo, Calif.

"Transformer Design Limitations," R. M. Hanson, Transonic, Inc., Bakersfield, Calif.

"Selenium Rectifier Characteristics and Limitations," G. B. Farnsworth, General Electric Co., West Lynn, Mass.

"Contact Phenomena as Related to Miniaturization," Frank Spayth, P. R. Mallory & Co., Inc., Indianapolis, Ind.

IRE People

James L. Hollis (S'37–A'40–M'44–SM'46) has joined the E. C. Page Company Consulting Radio Engineers of Washington, D. C.

J. L. Hollis

Mr. Hollis was born in Omaha, Neb., in 1916, and received the B.S. degree in electrical engineering from Kansas State College, in 1938. He spent one year with First National Television, Incorporated, of Kansas City, and in 1939 joined the broadcast engineering staff of the Crosley Corporation, Cincinnati, Ohio.

In 1947, Mr. Hollis joined the Collins Radio Company, in Cedar Rapids, Iowa, and was a project and group engineer in charge of high-frequency transmitter development for six years. He also was responsible for the development of a line of high-power air-cooled communications and international broadcast transmitters.

Mr. Hollis has been active in the Cedar Rapids IRE Section and their 1952 Conference on Communications. He is a member of the National Society of Professional Engineers and Kappa Eta Kappa.

❖

Melvin Maller (M'50) electronics engineer with the National Bureau of Standards, Corona, Calif., died recently. He was 34 years of age.

A native of New York, Mr. Maller received the B.S. and M.E.E. degrees from New York University in 1939 and 1948, respectively. He also took advanced work at the Polytechnic Institute of Brooklyn.

In 1941 Mr. Maller became affiliated with the Signal Corps Engineering Laboratory in Red Bank, N. J. From 1946–1950 he was a member of the Watson Laboratory in Red Bank, where he became chief of the systems instrumentation unit.

Mr. Maller transferred to the National Bureau of Standards in Washington, D. C., and in 1951 he moved to Riverside, Calif., with the NBS missile development division. He was leader on a classified missile development project, and acted as consultant to the engineering section on microwave designs and test equipment specifications. He also was in charge of special transformer design and specifications.

Mr. Maller was a member of the American Society of Mechanical Engineers.

Joseph M. Conroy (A'23–SM'51) has been named director of engineering of Canadian Aviation Electronics, Montreal, Canada. He will be responsible for advising the president on general engineering matters, for long-term planning of product development, and for the solution of special engineering problems. He joined the company in 1951 as chief engineer.

J. M. Conroy

Mr. Conroy was born in Ottawa, Canada, and received the B.S. degree in electrical engineering from McGill University in Montreal.

For over twenty-five years, Mr. Conroy has occupied engineering administrative positions in the electronic industry in Canada. He has been associated with such companies as Canadian General Electric, Canadian Marconi, and RCA Victor.

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John Van Nuys Granger (S'42–A'45–M'46–SM'51) has been honored by the Eta Kappa Nu Association as its choice of "The Outstanding Young Electrical Engineer of 1952."

J. V. N. Granger

A native of Marion, Iowa, Dr. Granger received the B.A. degree in 1941, from Cornell College, and the M.S. degree from Harvard University in 1942, where he worked in the Radio Research Laboratory on development of homing systems for missiles and airborne vhf direction finders.

During World War II, Dr. Granger joined the American-British Laboratory at Great Malvern, England, to become group leader of the antenna group and a technical observer with the United States Air Corps. Later he was a technical advisor to the First Tactical Air Force (French-American) in France, and helped plan and evaluate the radar counter measures program.

After the war, Dr. Granger returned to Harvard University as antenna group leader of the Electronics Research Laboratory, and received his Ph.D. degree there in 1948. In 1949 he joined the Stanford Research Institute, where he is presently assistant chairman of the engineering department and head of its Aircraft Radiation Systems Laboratory.

Dr. Granger is a member of the panel on antennas and propagation of the Committee on Electronics—a division of the government's Research and Development Board, and, in 1951, was named chairman of the subpanel on airborne antennas. He is a member of the International Scientific Radio Union and the Institute of Aeronautical Sciences.

❖

Group Captain E. A. D. Hutton (M'46), Commanding Officer of RCAF Station, Clinton, Ontario, died recently.

E. A. D. Hutton

Born February 16, 1909, in Manchester, England, G/C Hutton was educated at the Polytechnic Institute in London, and engaged in the operation and maintenance of commercial radiotelegraph stations before enlisting in the RCAF as an airman in 1934.

Captain Hutton was active in Air Force signals work and co-operated with the De Havilland Aircraft Company in developing the first RCAF radio-trainer aircraft. He was an instructor until assigned to RAF Bomber Command Headquarters in England as signals training officer. For this work he was on the King's Honours List for 1945.

Appointed to the Canadian Joint Staff in Washington, D. C., Captain Hutton served as chief signals officer until 1948 when he became director of telecommunications operations.

He was a member of the British Institute of Electrical Engineers.

❖

W. W. MacDonald (A'31–SM'52) has been appointed editor of *Electronics* by the McGraw-Hill Publishing Co., Inc., New York, N. Y. Mr. MacDonald became associate editor of the publication in 1941, managing editor in 1944, and executive editor in 1952.

W. W. MacDonald

Mr. MacDonald was born in Brooklyn, N. Y., and studied at Columbia University. After two years as a field engineer, he joined McGraw-Hill in 1926, and then spent a year supervising communications equipment installations in Central and South America.

Before becoming associated with *Electronics* in 1941, Mr. MacDonald was successively managing editor of *Electrical Merchandising* and editor of *Radio Retailing*.

Harold E. Gumbart (A'45), senior sales engineer for New Products Division of Corning Glass Works, has been appointed Western district sales representative, located in Los Angeles, Calif.

Born in Illinois, Mr. Gumbart received a B.S. degree in electrical engineering from the Carnegie Institute of Technology and did graduate work in business law at Columbia University.

From 1916 to 1928 Mr. Gumbart was in the export department of Standard Oil Company of New York, then with Brown Company of Portland, Me. In 1933 he became assistant to the president of the Fibre Conduit Company, and in 1936 sales manager. Since 1941 he has been with the Corning Glass Works.

❖

Russell A. Berg (A'37–M'45) has been promoted to the position of chief engineer at the New London Instrument Company, New London, Conn.

R. A. Berg

Mr. Berg was born in 1914 in New York. He received the B.E. degree from Yale University in 1936 and did graduate work at the Polytechnic Institute of Brooklyn.

In 1936 Mr. Berg was a student engineer with the Underwood Elliott Fisher Company, and later transferred to RCA Communications, Inc. He subsequently worked for the Westinghouse Electric Company as a tester and radio operator, and the Hammerlund Manufacturing Company as a tester and wireman.

During World War II, Mr. Berg was a radio engineer at the Coles Signal Corps Laboratory, Red Bank, N. J. Prior to his present position he was with the Trad Television Corporation.

❖

William L. Foss (A'49), consulting engineer and a pioneer in radio electronics, died recently at his home in Washington, D. C.

A native of Maine, Mr. Foss studied law in addition to engineering and received a legal degree from the American University. He started his professional career as a director of engineering and operational work for a chain of New England radio stations.

From 1928–1941, Mr. Foss was a consulting engineer in Washington, D. C., and from 1941–1945 he worked with Army Signal Corps and Air Force communications. In 1951–1952 he was a liaison between the United States and Canada for a joint radar warning system.

Mr. Foss was a member of Radio Pioneers and the Society of Motion Picture and Television Engineers.

E. A. Nicholas (A'14–SM'46), an executive of the International Telephone and Telegraph Corporation, died recently at the age of 59.

Long a leader in the manufacture of television, radio, and phonograph equipment, Mr. Nicholas directed the patent contract department of IT&T. He was president of the Farnsworth Radio and Television Corporation from 1938 to 1949, when it merged with IT&T, and transferred to that organization.

A native of Ohio, Mr. Nicholas attended the Cleveland School of Commerce and New York University. He began his career with the United Wireless Company in Cleveland. Subsequently, he became a wireless operator, manager of the Marconi Company wireless station in Cleveland, and chief operator and inspector of the Great Lakes Division.

Mr. Nicholas served as assistant to the vice president and general manager of the Radio Corporation of America in Indiana, and sales manager of the Eastern division; manager, then vice president, of RCA Radiola division. Next he assumed the presidency of E. A. Nicholas, Inc., became vice president in charge of sales for RCA Victor, manager of its licensing division, and a member of the advisory board.

Mr. Nicholas was a director of the Radio and Television Manufacturers Association, and a life member of the Veteran Wireless Operators Association, which in 1944 presented him its Marconi Memorial Commemorative Medal of Achievement.

❖

Benedict V. K. French (A'24–M'30–SM'43) has been appointed Chicago manager of the General Instrument Corporation.

B. V. K. French

Mr. French began his 31 years in the electronic field as a development engineer with Federal Telegraph and Telephone Company. Subsequently, he held positions with the American Bosch Company, RCA License Division Laboratory, P. R. Mallory Company, and the Allen B. DuMont Laboratories, Inc. He was responsible for the introduction of push-button station selection and waveband switching.

During World War II, Mr. French served on the joint Army-Navy Standardization Board; he also supervised, at Mallory, research in developing a mercury-type dry battery, extensively used in armed forces radio equipment.

Mr. French has served as Chairman of the IRE Connecticut Valley and Indianapolis Sections, and is a member of the IRE Professional Group on Airborne Electronics and the Radio Club of America.

❖

Glen B. Ransom (M'45) has been appointed assistant engineering staff manager of the long lines department of the American Telephone and Telegraph Company, New York, N. Y.

G. B. Ransom

Mr. Ransom, a native of Marengo, Iowa, received the B.S. degree in electrical engineering from the University of Minnesota in 1922. He then joined AT&T as a technical engineer, and in 1927 became district plant engineer in Indianapolis, and division transmission engineer in Cleveland in 1928. In 1930, he transferred to the engineering headquarters in New York. Recently he has been an engineer of plant extension.

Mr. Ransom is a fellow of the American Institute of Electrical Engineers and Eta Kappa Nu.

❖

Kenneth A. Giffin (M'52) has been appointed district sales manager for the Los Angeles tube department of the General Electric Company.

Mr. Giffin was born in Bellaire, Ohio, on January 15, 1911, and graduated from Purdue University in 1937. From 1937–1939, he was associated with the Bendix Radio Division as a receiver and aircraft radio systems engineer. From 1939–1951, he worked with the American Airlines as a communications representative. Before joining General Electric, he was a service engineering manager for Aeronautical Radio, Inc., in Washington, D. C.

Mr. Giffin is a member of the Armed Forces Communications Association.

❖

Philip D. Doersam (S'40–M'46–SM'50) has been named manager of East coast operations of the Univox Corporation, Los Angeles, Calif.

Mr. Doersam was born in Pennsylvania, in 1917, and received the B.S. degree in electrical engineering from Columbia University in 1942. He studied advanced radar at the Massachusetts Institute of Technology.

From 1942–1945, Mr. Doersam was a staff member at the MIT Radiation Laboratory, and in 1946, he became the acting head of the electronics laboratory at the Glenn L. Martin Company, Baltimore, Md. From 1947–1949, he was senior engineer and group leader at the Douglas Aircraft Company, Santa Monica, Calif. In 1949, he joined the Hughes Aircraft Company where he was chief, flight test engineering, until his recent appointment.

Books

High Frequency Transmission Lines by J. de France

Published (1952) by the Bayside Publishers, 36-35 206 St. Bayside L. I., N. Y. 40 pages, paper bound. 34 figures. 6½×10. $0.90.

J. de France is head of the department of electric technology, State University of New York, Brooklyn, N. Y.

This is a booklet written to explain the physical behavior of high-frequency transmission lines to beginners who do not possess more than an elementary knowledge of mathematics.

The first chapter describes the main electrical quantities involved in the propagation of waves on an infinite line; the second deals with reflection on terminating loads. Following this is a review of the usual types of lines and applications and a brief introduction to waveguides.

The text is in everyday, nontechnical words and will be useful to the class of readers for which it is planned. It also will be of some interest to students with more technical background, for here we find an easily readable explanation of the elementary facts underlying the mathematical treatment of wave transmission along lines. Other presentations of this are sometimes unnecessarily abstruse and theoretical, and the author has eliminated this effect.

A. G. Clavier
Federal Telecommunications Labs., Inc.
Nutley, N. J.

Handbook of Engineering Fundamentals Edited by Ovid W. Eshbach

Published (1952) by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 1262 pages+52-page index+x pages. Tables and figures. 5¼×8¾. $10.00.

Ovid W. Eshbach is the dean of Northwestern Technological University, Evanston, Ill.

This book is a revised edition of a 1936 publication. Upon approaching it with, "what function does this book serve, and hence of what use is it," the reviewer feels that the material performs a very useful purpose for the engineer and technical man. It illuminates those areas of engineering that border on chemistry and physics; areas that are apt to be considered pure theory by the practical man.

The book embraces the fields of mathematics, mechanics, aerodynamics, engineering thermodynamics, electricity and magnetism, radiation, light, acoustics, chemistry, metallic materials, nonmetallic materials, and finally, a valuable section on engineering law. How completely these subjects are covered may depend upon the size of the book; this text is of reasonable size and coverage.

Some may question the utility of an encyclopedic type of book, but to a person who is familiar with the subjects, such a style can furnish a brief and useful review of material basic to his activity, thus saving him from wading through one or more weighty texts on the subject. Moreover, these articles have reasonably complete and up-to-date bibliographies that enable the reader to make further investigations.

Particularly noteworthy to the reviewer were the sections on "Mathematics," by O. W. Eshbach; "Physical Units and Standards," by Ernst Weber; and "Engineering Thermodynamics," by Milton C. Stuart. Although the section on mathematics is necessarily brief, the presentation is clear and adequate, as are the other sections.

The reviewer noticed a few errors which may have escaped the eyes of the proof reader. On page 2-201, (a possible typographical error) is given the limit value of $\frac{\infty}{\infty}$ as $\lim_{x \to a}$ instead of $\lim_{x \to a} \frac{\phi'(x)}{\Psi'(x)}$. On page 9-59, in the electrical section, we do not find the compensation theorem mentioned; it deserves notice. On page 10–49, we note, "The parabolic horn . . . is being widely used in connection with sound motion pictures. The exponential horn . . . is often used in loudspeaker units for public-address systems."

One matter which may affect the size of the book but which merits improvement is the size of the type. It is too small, not only in the normal portions of the book, but much too small in the sections devoted to illustrative examples and the like.

The book does fill a need of the average engineer, and deserves a special place in his library. It is an excellent handbook, and contains interesting reading material as well.

Albert Preisman
Capitol Radio Engineering Institute
Washington, D. C.

Theory of Electromagnetic Waves, A Symposium Sponsored by the Geophysical Research Directorate, Air Force Cambridge Research Laboratories, and the Institute for Mathematics and Mechanics, New York University

Published (1951) by Interscience Publishers, Inc., 250 Fifth Ave., New York, N. Y. 1,393 pages+viii pages. 72 figures. 6¼×10. $6.50.

This book, which is a record of a symposium on electromagnetic waves held at New York University, June, 1950, presents the newest developments in electromagnetic theory on a scientific level, and reviews the more important, unsolved problems in the field.

A number of the papers deal with problems in diffraction and reflection. S. A. Schelkunoff gives an excellent review of the approximations involved in Kirchhoff's formula, and shows that it is not possible to obtain any improvement in the result by repeated applications of the formula. Approximate solutions based on the author's induction and field equivalence theorems do not suffer from this disadvantage. A paper by Levine and Schwinger discusses the diffraction of a plane wave by an aperture in an infinite screen. Two variational expressions are obtained for the far field, and it is shown that they yield approximate results which are valid over a much wider frequency range than most of the commonly used approximations. An interesting paper by Kellar and Frank gives a simple answer in closed form for the diffraction and reflection of a pulse by a wedge or corner.

The propagation of waves in nonhomogeneous media is considered by a number of authors. S. A. Schelkunoff draws attention to the fact that in determining the reflection coefficient for a finite inhomogeneous layer, difficulties can arise in approximating the finite layer with an infinite layer of apparently similar nature. N. Marcuvitz discusses the various representations of the field in a spherically stratified region. B. Friedman treats the propagation of waves in an inhomogeneous atmosphere where the dielectric constant is stratified in the radial direction. The problem of the reflection of waves from rough surfaces has been discussed by S. O. Rice and solutions obtained for slightly rough surfaces.

The book is of interest mainly to research engineers in the field of wave propagation. Due to the wide range of topics covered and use of higher mathematics, some engineers may find the book to be incoherent and difficult to read.

George Sinclair
Sinclair Radio Labs. Ltd.
Toronto, Ont., Canada

Radio Spectrum Conservation, A Report of the Joint Technical Advisory Committee, IRE-RTMA

Published (1952) by McGraw-Hill Book Company, Inc., 330 West 42 St., New York 36, N. Y. 198 pages+10-page bibliography+8-page appendix +5-page index+xi pages. 7 figures. 8×5¼. $5.00.

This book was prepared by a group of experts and consultants under the direction of a subcommittee of the Joint Technical Advisory Committee. It is designed both as an aid and an exhortation to those concerned with the planning and administration use of a limited and extremely valuable natural resource, the radio spectrum. For this purpose, it treats briefly in successive chapters the history of allocation, the propagation characteristics of the various bands of frequencies, an idealized allocation based on a proper co-ordination between radio propagation characteristics and service requirements, and a critical discussion of the present allocation. The book concludes with a proposed program of "dynamic conservation," in which the planning will be done with such foresight and the administration with such flexibility as to obtain the maximum utilization of the spectrum.

In general, the treatment of the various topics is adequate for the purpose of the book and the style is suitable to those for whom the book is intended. However, differences in style are readily apparent, particularly between the various sections of the chapter on radio propagation characteristics. Some of these sections contain passages which may be somewhat difficult for the lay reader. There are some omissions and some errors, inconsistencies and duplication have been found. Space also has been devoted to certain characteristics or anomalies which are believed to be more of scientific interest than of administrative importance. These failings are neither numerous nor fatal to the purposes of the book, and are readily understandable in view of the scope and complexity of the subject matter and the extreme difficulty of preparing a brief, but complete summary thereof. It may be said that this is a good, informative summary, and for those who wish to pursue the subject in greater detail, sufficient references are provided.

In the idealized allocation developed in chapter 3, the propagation characteristics appear to have been correctly applied, to provide the kinds of communications needed in the various services. However, little information is given to justify the amounts of space assigned to each service, other than certain general considerations related to present occupancy. It would appear that this allocation should be viewed as a recommendation of the suitability of the various frequency bands of the spectrum for the several services, rather than a recommendation for spectrum allocations at the locations and in the amounts indicated. In the critique of the present allocations (chapter 4) a complete and well rounded discussion is presented with the good and bad features of the present allocation, together with the reasons for the present situation. Chapter 5, on dynamic conservation, analyzes the problems incident to the substantial achievement of ideal spectrum utilization. It recognizes, at the outset, that to be effective, and in order to avail itself of changing knowledge and provide for new demands and services any program of management must be dynamic and flexible. Nine deterrents to full occupancy are discussed briefly. One other deterrent, that of present spectrum occupancy by spurious signals generated by non-ideal equipment, is not treated at this point, although the problem of harmonic emissions is included in the later discussion of technical measures by which improvements may be effected.

In summary, although one may disagree with specific passages in the book, the overall objective is good, and the subject in the main is expertly handled. It fills a need in an area which has been all too foreign to the general public and to those whose support is needed if the program is to be successful. It is to be hoped that the book will be widely read and that it will be studied and retained for reference by all who are responsible for assuring that effective use is made of this essential resource.

EDWARD W. ALLEN, JR.
Federal Communications Commission
Washington, D. C.

The Oxide-Coated Cathode Volume One—Manufacture by G. Herrmann and S. Wagener

Published (1951) by Chapman & Hall Ltd., Anglobooks, 475 Fifth Avenue, New York, N. Y. 143 pages+4-page index+viii pages. 78 figures. 5¾×8¾. Set of two volumes $15.00.

G. Herrmann is an electrical engineer, Berlin, Germany. S. Wagener is a member of the Post Office Research Station, London, England.

This is the first of a two-volume book previously published in 1944 in Germany. In the English translation, Dr. Wagener presents a revised book with modern views and methods; references include papers published in 1950.

Of particular interest is a statement occurring in the description of the book, printed inside the jacket: "A review of the oxide cathode is complicated by the *close interdependence between manufacture on the one hand and scientific investigation on the other*. Many of the measures taken during manufacture can only be understood by virtue of their effect on the physical mechanism, *whilst investigation of the physical phenomena must be based on a thorough knowledge of how to make a good cathode*. If this latter point is not taken into account, phenomena may be investigated which are certainly interesting but of little importance for the cathodes which are actually used in commercial valves."[1]

The importance of this statement can hardly be overemphasized, and it is evident in reading the complete two-volume work that this thought has been a guiding principle in the writing of the book.

Volume I contains five chapters, the first being a brief but interesting historical review with a general discussion of the types of oxide-coated cathodes.

Chapter 2, entitled, "The manufacture of the cathode before mounting in the envelope," is concerned with core-metal properties, preparation and application of the coating suspension, and a description of indirect heaters. Tables and charts are used in discussing core materials which include typical compositions of various commercial alloys used in the United States. The views expressed concerning the use of pure, unplated tungsten as a base metal are at variance with American experience; the reaction between W and BaO at normal operating temperatures is not great enough to prevent manufacture of tubes having a commercial life expectancy. Discussion of such topics as the precipitation of the carbonates, preparation of the suspension, coating methods, sintering, etc., are valuable and well handled.

Chapter 3, entitled, "Further processing of the cathode after mounting in the envelope," covers in outline the essential facts concerning the breakdown of the carbonate and activation of the cathode. Since the theory of activation is covered in Volume II, the discussion of this topic in Volume I is naturally limited to a brief description of practical procedures.

"The characteristics of the oxide cathode" are discussed in chapter 4, which contains sections on the measurement of temperature and thermal properties, measurement and comparison of emission values, actual values of emission and efficiency obtainable, undesirable features of the oxide cathode, and life. The section "ascertaining the saturated current from the retarding field current" seems a bit unrealistic to one who has spent much time pursuing this idea experimentally, in view of the temperature gradient along the typical cathode; the description of actual tests for emission seems rather brief. Apart from these criticisms, the chapter is very useful; the sections on sparking and the effects of impurities are particularly interesting.

The final chapter describes, briefly, special cathodes that have been proposed for certain applications, including thoria and core-activated cathodes. There is a section of eleven pages on oxide cathode for gas-discharge devices that is especially good.

Despite the fact that some topics might profitably have been discussed in somewhat greater detail, physicists and engineers on experimental or production control work will find this book to be an extremely worthwhile source of information.

Volume II has previously been reviewed in the PROCEEDINGS.[2]

GEORGE D. O'NEILL
Sylvania Electric Products Inc.
Bayside, N. Y.

[1] The italicizing is the reviewer's.

[2] G. D. O'Neill, "The Oxide-Coated Cathode," by G. Herrmann and S. Wagener Volume II, PROC. I.R.E., vol. 40, pp. 880; July, 1952. Correction, PROC. I.R.E., vol. 40, pp. 1741; December, 1952.

Dictionary of Conformal Representations by H. Kober

Published (1952) by Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. 201 pages+4-page index+3-page bibliography+xvi pages. 447 figures. 6⅛×9¼. $3.95.

Conformal mapping is a utilization of the mathematical simplicity and peculiarities of the complex variable in the analysis and synthesis of the corresponding physical peculiarities of two-dimensional fields of steady flow or static flux. It is a powerful tool in many fields such as the fluid dynamics of airfoils and the electromagnetic plane waves guided by parallel conductors. In the field of electrical engineering, it is most simply applied to conduction and to separate electric and magnetic fields, all of which are examples of orthogonal potential and flux.

The fundamentals of conformal mapping have been duplicated in a number of textbooks, while the more specialized aspects have been spread over various periodicals and collected volumes. There has been a dire need for some comprehensive list and pictorial illustrations of the many problems amenable to the techniques of conformal mapping. Like integrals, there is no limit to the number of variations that would be helpful for reference.

The author of this volume has gone far toward filling this need. His compilation has the benefit of joint efforts first reported in 1944–1948, among the scientific research groups of the British Admiralty. It is a great credit to the individuals, the organization, and the publisher that this collection is now made available at a low cost to the many scientists who need it in their life work. It is bound to stimulate more application of these techniques and more original work to this end.

The book is divided into five parts. The first part is devoted entirely to the bilinear transformation and its important special cases which are completely, sometimes redundantly, treated. The remaining four parts deal with mappings obtained from algebraic functions, exponential functions, functions composed of the Schwarz-Christoffel transformation and higher transcendental (especially elliptic) functions. Proofs are omitted for brevity, while the limitations and peculiarities of each transformation are painstakingly placed in evidence. In most cases, the corresponding regions and their boundaries are shown in carefully lettered diagrams of the type which may be familiar from Appendix II of Churchill's "Introduction to Complex Variables and Applications."

In ordering the material within this dictionary, it may be unfortunate that the author, as he notes in the foreword, does not use one system exclusively. Instead, he classifies usually according to the functional form of the transformation and sometimes according to the geometry of the regions involved. The inclusion of the Topological Index may be in recognition of the physical importance of a completely geometrical system of classification.

An excellent list of special notations and nomenclature is placed in the front of the book. A large number of references are given; however, the practice of collecting these at three different points in the book may be questioned.

The minor objections noted above should not obscure the over-all usefulness of this large collection of mappings, gathered from many sources and presented in a uniform notation. The Dictionary of Conformal Representations is highly recommended to engineers, scientists, and applied mathematicians who deal with the problems of two-dimensional fields.

HAROLD A. WHEELER
WALTER K. KAHN
Wheeler Laboratories
Great Neck, N. Y.

TV Troubleshooting and Repair Guide Book Volume I by Robert G. Middleton

Published (1952) by John F. Rider Publisher, Inc., 480 Canal St. New York 13, N. Y. 201 pages+3-page index. 194 figures. 8½×11. Paper bound.

In the last five years or so, much has been written on television receiver troubles and their diagnosis. A considerable portion of this information pertains only to specific problems and is widely scattered in various texts and trade journals.

This book, written primarily with the average television technician in mind, attempts to include as much practical information of this nature as possible under one cover. It is a book convenient for use in the service shop, and should be of considerable help in solving troubleshooting.

There are ten chapters in all, presented in an easy-to-read style. The text is well illustrated with picture-tube patterns illustrating receiver faults and applicable waveforms, together with troubleshooting charts for diagnosis and correction.

The author has tried to avoid any extensive theoretical explanations, presenting only as much theory as deemed necessary to assist in practical troubleshooting, rather than a complete theoretical analysis of the circuits involved.

The first chapter points out, generally, the variations in circuitry which the television technician might expect to encounter in one manufacturer's receiver to another. Included are photographs of normal operating waveforms taken on specific receivers from several different manufacturers.

The remaining chapters cover possible faults which might develop in various portions of the receiver. It gives the procedure for proper diagnosis, pointers on visual alignment techniques, test equipment kinks and the problem of external interference.

The sections dealing with visual alignment procedures and the description of oscilloscope probes and their use should be particularly helpful to the uninitiated.

KENNETH FOWLER
General Electric Company
Syracuse, N. Y.

Advances in Electronics, Volume IV, Edited by L. Marton

Published (1952) by Academic Press, Inc., Publishers, 125 E. 23 St., New York 10, N. Y. 329 pages +14-page index+x pages. 118 figures. 6×9. $7.80.
L. Marton is associated with the National Bureau of Standards, Washington, D. C.

The fourth annual edition of this excellent series of papers is unchanged in purpose and format. It is regrettable, however, that the preface to volume one was not reprinted in the succeeding volumes. It states, among other things, that the book does not concern itself with electronic circuitry but with physical electronics and the principal components of electronic devices.

The seven papers contained in this edition are listed as follows:

1. "Electron Scattering in Solids," by H. S. W. Massey (68 pages). This mathematical paper discusses elastic, inelastic, and multiple scattering, also, electron energy loss and mobility concepts. It should be of considerable interest to scientists who deal with such things as electron microscopes and secondary emission problems.
2. "The Scintillation Counter," by G. A. Morton (37 pages). This device, which evolved from the early spinthariscope, counts the scintillations (flashes) produced by nuclear radiation on a phosphor crystal. The components and applications of the counter are discussed.
3. "Fluctuation Phenomena," by Aldert Van Der Ziel (44 pages). This paper deals with "spontaneous fluctuations of electricity," which is more commonly and perhaps imprudently called noise. A mathematical discussion is presented of some of the more important problems.
4. "Electronic Digital Computers," by Charles V. L. Smith (28 pages). The author gives in some detail the components and information channels of digital computers. The SEAC and the whirlwind computers are described. Due to the nature of the science, the general information was up-to-date at the time the paper was written but is presently out of date.
5. "Modulation of Continuous-Wave Magnetrons," by J. S. Donal (67 pages). The various types of modulation, except pulse modulation, are presented.
6. "The Magnetic Airborne Detector," by Winfield E. Fromm (41 pages). This material describes the method used during World War II to locate submarines with airborne equipment.
7. "Multichannel Radio Telemetering," by M. G. Pawley and W. E. Triest (28 pages). This paper gives some of the advances in the art of radio telemetering that were made during World War II. The applications are primarily of flight testing pilotless aircraft.

There is evidence that some of the papers were written in great haste. For example the Smith paper outlined the order in which it would discuss the various storage tubes, and then discussed them in a different order. Frequent use of the first person plural is found in several papers. Also, the mathematical papers could have been improved by including tables of symbols and a more judicious selection of type to distinguish vectors from scalars.

Although the papers lack polish in various ways, they do present a hard core of valuable information on a wide scale. The Massey paper may not be of interest to matriculates but most of the others are readable for those delving in various subjects. Students who participate in seminars and declamation contests will do well to investigate these papers as a possible source of subject material.

PAUL K. HUDSON
University of Illinois
Urbana, Ill.

The Electromagnetic Field by Max Mason and Warren Weaver

Published (1952) by Dover Publications, Inc.' 1780 Broadway, New York 19, N. Y. 328 pages+44-page appendixes+18-page indexes+xiii pages. 61 figures. 5⅜×8. $1.85 paperbound. $3.95 clothbound.
Max Mason is associated with the Rockefeller Foundation and Warren Weaver with the University of Wisconsin.

This treatise on the fundamental ideas of the electromagnetic field was originally published in 1929 by the University of Chicago Press and has now been made available in a reasonably priced paperbound edition by Dover Publications. As the authors specifically state in the introduction, they wanted to arrive at the field equations of Maxwell "in a way which will excite, rather than dull, curiosity, and which tends to produce that attitude toward fundamentals which must prevail before a real electron theory of electricity replaces the present electrical theory of electrons."

This is indeed the key to the organization of the book. It is assumed that Coulomb's law is essentially a statistical law applying between complexes of charges, and that its validity for two isolated charges is not established irrevocably. To build up electrostatic field concepts for ponderable bodies requires, then, very cautious examination of limits, of "conditions" at points in space where no charge is present. The concepts of continuous field vectors, charge densities, potential values, forces, and the like are critically examined. In a similar manner is treated the topic of magnetostatics as dealing basically with charges in motion; starting from the fundamental aspects of Ampere's law of force action between two currents, the vector potential is established for complexes of moving charges. Again, a critical examination is made of the concept of continuous field vectors, potential values, forces, and the like. Very brief treatment is given to actual current flow in conductors. In introducing the field equations, the authors again examine critically the continuous concepts such as the Poynting vector, and the energy densities. The theory is only carried to the establishment of the retarded potential functions and the radiation field of moving electrons.

The book is very well written, in a challenging manner, fully bearing out the intent of the authors. It is of great value to all scholars interested in the extension of the electromagnetic field concepts to a real electron theory of ponderable matter. It is, however, not in the purview of this book to give actual practical applications and we will therefore find little of direct interest to the radio engineer.

ERNST WEBER
Polytechnic Institute of Brooklyn
Brooklyn, N. Y.

Abstracts and References

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research, London, England, and Published by Arrangement with that Department and the *Wireless Engineer*, London, England

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 I.R.E.

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The Annual Index of 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

534.15 599
Analysis of Air Vibrations in a Pipe with Internal Discontinuities—J. Guittard. (*Acustica*, vol. 2, no. 5, pp. 231–236; 1952. In French.) A method of investigating the effect of various types of discontinuity, such as cross-section variation, using fine powder as indicator.

534.26+535.43 600
On a Multiple Scattering Theory of the Finite Grating and the Wood Anomalies—Twersky. (See 695.)

534.26 601
The Diffraction of Sound Pulses by an Oscillating Infinitely Long Strip—P. J. Berry. (*Quart. Jour. Mech. Appl. Math.*, vol. 5, part 3, pp. 324–332; September, 1952.) A solution is obtained for the case of a plane pressure pulse incident normally on an infinitely long strip of finite width, capable of motion as a spring-supported rigid body. Numerical results are given for the case of a sharp-fronted pulse of constant unit pressure, with graphs showing how the mobility of the strip affects the pressure distribution on the back of it.

534.26 602
The Diffraction of a Sound Pulse by a Nonrigid Semi-infinite Plane Screen—F. J. Berry. (*Quart. Jour. Mech. Appl. Math.*, vol. 5, part 3, pp. 333–343; Sept. 1952.) Analysis is given for the two-dimensional diffraction of a plane-fronted pulse, incident normally on the screen. Two methods of finding the pressure change across the screen are described, both involving successive approximations. Graphs illustrate the results obtained by one method for several types of screen material.

534.321.9 603
Aspects of the Concentration of Ultrasonic Energy—A. Barone. (*Acustica*, vol. 2, no. 5, pp. 221–225; 1952.) For another account see 3309 of 1952.

534.321.9:534.845 604
Ultrasonic Absorption and Relaxation Mechanism—A. K. Dutta. (*Indian Jour. Phys.*, vol. 26, pp. 279–282; June 1952.) Discussion leading to the conclusion that the absorption of elastic waves in liquids is mainly due to a frictional relaxation mechanism.

534.614 605
The Velocity of Sound in Air—J. M. A. Lenihan. (*Acustica*, vol. 2, no. 5, pp. 205–212; 1952.) Pulses derived from a 13.5-kc/s transmitter and a microphone receiver were displayed together on a double-beam cro. Coincidence of the pulses could be obtained by movement of the transmitter toward or away from the microphone, the motion being effected by means of an accurate screw of length 1.8 m. Transmitter positions were noted for the 1st–5th and the 41st–45th coincidences, to obtain five readings for the value of 40 wavelengths. Corrections were applied for the effects of temperature, humidity, and other less important factors. The final value deduced for the velocity of 13.5-kc sound waves in dry air at 273.16°K and 1013.2 mb is 331.45 ±0.04 mc.

534.84 606
Review of Methods and Apparatus for Room-Acoustics Measurements—L. Keidel. (*Arch. tech. Messen*, no. 200, pp. 193–196; Sept. 1952.)

534.84:621.396.712.3 607
The 'Pierre Bourdan' Low-Frequency [broadcasting] Centre, Paris—Conturie. (See 825.)

534.845.1/.2 608
Sound Insulation by means of Rubber and Steel Springs—M. L. Exner. (*Acustica*, vol. 2, no. 5, pp. 213–221; 1952. In German.) Good agreement was obtained between theory and experiment in measurements on combinations of rubber and steel springs. The high internal damping of the rubber, whose loss factor is about 10 times that of steel springs, results in good insulation over the whole frequency range investigated, 20 cps-2 kc. Mechanical filters, consisting of masses with intervening springs, were also investigated; they were found better than simple systems above a certain critical frequency, but had disadvantages at low frequencies.

534.845.1/.2 609
The Mechanism of Sound Transmission through Single-Leaf Partitions, investigated using Small-Scale Models—A. Schoch and K. Fehér. (*Acustica*, vol. 2, no. 5, pp. 189–204; 1952.) A summary is given of Cremer's results (2904 of 1951) for transmission through plates of infinite area, and the effect of the boundaries is discussed qualitatively for the case of finite plates. Measurements are reported, using small-scale models with corresponding high-frequency plane waves in an echo-free box of dimensions 150×80×80 cm. Results for plates of various materials, for both normal and oblique incidence, are shown graphically and discussed.

534.846 610
Auditorium Specifically Designed for Technical Meetings—D. M. Beard and A. M. Erickson. (*Jour. Soc. Mot. Pic. Tele. Eng.*, vol. 59, pp. 205–211; Sept. 1952.) Description of the auditorium, seating 550, at the Naval Ordnance Laboratory, White Oak, Md. The effects of poly-cylindrical sections, absorbent plaster, serrated rear wall, and padded seats, combine to give excellent acoustic characteristics. Additional facilities include 21 microphones distributed about the room, controlled lighting, optical-projection booth, and an adequate telephone communication system.

534.861.4:621.395.623.7 611
The Environment of High-Quality Reproduction—F. H. Brittain. (*Wireless World*, vol. 59, pp. 2–5; Jan. 1953.) A survey of reproducer circuit requirements and auditorium conditions to be satisfied in order to obtain the full benefit of good loudspeaker performance.

621.395.6:621.396.712 612
Speech Input Systems for Broadcast Transmitters—Hill. (See 824.)

621.395.61 613
On the Directivity of Spherical Microphones—W. Kuhl. (*Acustica*, vol. 2, no. 5, pp. 226–231; 1952.) The directivity patterns of microphones with plane circular diaphragms on the surface of a sphere were measured for 10 frequencies and compared with the patterns computed by Schwarz (2992 of 1945) for point microphones. Uniform response for all angles of incidence can be obtained by adding the voltages derived from two point microphones located at opposite ends of a diameter of a sphere. A frequency-response curve is calculated for a capacitor microphone with spherical diaphragm.

621.395.623.7 614
Friction-driven Loudspeaker—(*Wireless World*, vol. 59, pp. 27–28; Jan. 1953.) A loudspeaker whose operation depended on the attraction between a metal surface and a poor conductor (e.g. agate) was designed by Johnsen and Rahbek over 30 years ago. A modern commercial public-address loudspeaker using the same principle is described, in which a metal band attached to the diaphragm is held in contact with a rotating cylinder coated with

a semiconductor. The power output is comparable with that of an amplifier-driven loudspeaker of similar size.

621.395.623.8 615
P.A. [public-address] Systems in Generating Plants—S. C. Bartlett. (*Radiotronics*, vol. 17, pp. 159–164; Oct. 1952.) The special conditions encountered in power stations are discussed, and the design is considered of suitable equipment to provide adequate speech coverage to all personnel, with reply or break-in from any point of the system.

789.983 616
The Chord Organ—A. Douglas. (*Electronic Eng.*, vol. 24, pp. 562–566; Dec. 1952.) Description of a Hammond instrument which produces, if desired, a chord when any single note is pressed. Tone controls are also provided.

ANTENNAS AND TRANSMISSION LINES

621.315.2/.3 617
New Cables and Conductors of the I.K.A. [Verwaltung für Installationen, Kabel, Apparate]—H. Göttlich and H. J. Franz. (*Deutsche Elektrotech.*, vol. 6, pp. 429–432; Sept. 1952.) Data and illustrations of various cables, including flexible types, for counter-circuit, television, HF and UHF applications.

621.392+621.315.212].018.44 618
Mathematical Theory of Laminated Transmission Lines: Part 2—S. P. Morgan, Jr. (*Bell Sys. tech. Jour.*, vol. 31, pp. 1121–1206, Nov. 1952.) Part 1 (25 of January) dealt mainly with Clogston-1 lines; the present paper deals mainly with Clogston-2 lines, which are composed entirely of laminated material; both parallel-plane and coaxial lines are considered. Formulae are also derived for the general case of a line with arbitrary fractions of space occupied by the main dielectric and the laminations. Analysis is given for the principal and higher modes, assuming infinitesimally thin laminae; the effect of finite thickness is considered subsequently. The influence of nonuniformity of the laminations is examined; to achieve an attenuation constant of the order of a tenth that of a conventional line, nonuniformities must be smaller than a few parts in 10,000. Dielectric and magnetic losses are discussed; their magnitude is directly proportional to frequency provided the loss tangents do not vary with frequency.

621.392.21 619
Calculation of Transmission-Line Constants—R. O. Kapp. (*Engineering, Lond.*, vol. 174, pp. 315–316; Sept. 5, 1952.) Approximate formulae are derived for the three line constants, usually represented by the symbols **A**, **B** and **C**. Errors involved in the use of these formulae are $<0.7\%$ for either the real or the imaginary component of any of the constants for line lengths up to about 600 miles. The formulae do not involve hyperbolic functions.

621.392.21.09 620
Application Possibilities of a Surface-Wave Mode—W. F. Gunn. (*Marconi Rev.*, 4th Quarter, vol. 15, no. 107, pp. 145–166; 1952.) A summary is given of recent work on surface waves, together with a short account of experiments carried out in 1951 on a go-and-return system of total length about 130 ft. Relevant analysis from various sources is included in appendices.

621.392.21.029.64 621
Microstrip—A New Transmission Technique for the Kilomegacycle Range—D. D. Grieg and H. F. Engelmann. (PROC. I.R.E., vol. 40, pp. 1644–1650; Dec. 1952.) A general description and background theory are given for transmission lines comprising a single wire conductor arranged parallel to a ground plane and for flat-strip lines of the type dealt with in 2705 of 1952 (Barrett). Practical methods of making such lines include printing and embossing.

621.392.21.029.64 622
Simplified Theory of Microstrip Transmission Systems—F. Assadourian and E. Rimai. (PROC. I.R.E., vol. 40, pp. 1651–1657; Dec. 1952.) An analysis is made of TEM-mode propagation in a line comprising a wire or a finite-width strip immersed in a uniform dielectric and arranged parallel to a ground plane. Characteristic impedance, power flow and losses are considered. Numerical calculations based on the theory indicate the practicability of lines of this type at microwave frequencies.

621.392.21.029.64:621.317.3 623
Microstrip Components—J. A. Kostriza. (PROC. I.R.E., vol. 40, pp. 1658–1663; Dec. 1952.) Standing-wave detectors are described suitable for making measurements on lines of the single-conductor-and-ground-plane type dealt with in above. The deviations from pure TEM-mode propagation for different constructions are assessed on the basis of the measured values of guide wavelength. Dispersion and r.f. impedance are also discussed. Voltage s.w.r. measurements are reported on components for effecting transitions to coaxial lines. Attenuator pads and loads, crystal mounts, directional couplers etc. using the same constructional basis are described.

621.392.26 624
Calculation of the Propagation Constants of an Inhomogeneously-Filled Waveguide—J. A. Bradshaw and L. G. Chambers. (*Brit. Jour. Appl. Phys.*, vol. 3, pp. 332–333; Oct. 1952.) Comment on 2114 of 1952 and author's reply.

621.392.26 625
Diffraction of Guided Waves at Plane Diaphragms—R. Müller. (*Z. Naturf.*, vol. 5a, pp. 617–621; Nov. 1950.) The problem of diffraction at a plane diaphragm is formulated for the general case of a waveguide of arbitrary cross-section. For the special case of a coaxial aperture in a circular cylinder, a wave suffers no transformation from E to H mode or vice versa if incident parallel to the axis, but does suffer transformation if incident in any other direction.

621.392.26 626
The Concept and Measurement of Impedance in Periodically Loaded Wave Guides—E. T. Jaynes. (*Jour. Appl. Phys.*, vol. 23, pp. 1077–1084; Oct. 1952.) The theory of the node-shift method of investigating transmission-line problems is reviewed. A definition of impedance in a form applicable to the disk-loaded waveguide is developed from ordinary circuit theory by expressing the em field in terms of a set of independent component fields. An extension of the node-shift technique for measuring impedance is described which involves a determination of the parameters of a coupling system.

621.396.67 627
Mutual Radiation Resistance of Aerials and Arrays—L. Lewin. (*Wireless Eng.*, vol. 30, pp. 24–25, Jan. 1953.) Comment on 32 of January (Knudsen).

621.396.67 628
Theory of Electrically Short Transmitting and Receiving Antennas—R. King. (*Jour. Appl. Phys.*, vol. 23, pp. 1174–1187; Oct. 1952.) Centre-driven cylindrical aerials of length $\leq\lambda/\pi$ are considered; complete quantitative solutions are obtained by determining the distributions of current that actually satisfy the integral equations. Components of current in phase and in quadrature with the driving voltage are evaluated, together with the impedance, the effective length and the gain. Quite accurate results are obtained even in a first-order solution when the King-Middleton method of solving Hallén's integral equation by iteration is applied correctly. The newly determined values are combined with the King-Middleton second-order results to obtain more accurate values for aerials of length $\leqq 1.4\ \lambda/\pi$.

621.396.67 629
Cylindrical Aerials—R. W. P. King. (*Wireless Eng.*, vol. 30, p. 24; Jan. 1953.) Comment on 2715 of 1952 (Storm).

621.396.67:621.317.336 630
An Antenna Impedance-Measuring Instrument—J. F. Cline. (PROC. I.R.E., vol. 40, pp. 1686–1689; Dec. 1952.) An indicating instrument is described which has a small capacitive loading effect when connected directly to the terminals of an aerial. This is achieved by isolating those conductive components which are not part of the RF-cap circuit and operating the aerial as a receiving aerial, so that the signal generator is some distance away and not incorporated in the measuring instrument.

621.396.67:621.397.6 631
The WJZ-TV Auxiliary Antenna—J. Preston. (*Tele-Tech*, vol. 11, pp. 38–39; Oct. 1952.) The emergency WJZ television aerial array consists of four asymmetrical corner reflectors, with $\lambda/2$-dipole feed, uniformly spaced round the conical portion at the top of the Empire State Building and set askew in order to prevent the occurrence of deep nulls in the radiation pattern.

621.396.67:621.397.6 632
Aerials of Modern High-Power Television Stations—G. Rutelli. (*Alta Frequenza*, vol. 21, pp. 215–216; Aug./Oct. 1952.) Short discussion of the radiation characteristics of the aerials at the Sutton Coldfield and Holme Moss stations, with reference to the theory of that type of antenna previously published by the writer (3331 of 1941 and 436 of 1942.)

621.396.67.001.11:517.948.32 633
Difficulties with Present Solutions of the Hallén Integral Equation—S. H. Dike. (*Quart. Appl. Math.*, vol. 10, pp. 225–241; Oct. 1952.) Dike and King (2716 of 1952) have found serious discrepancies between experimental values of broadside absorption gain and back-scattering cross-section and those calculated by the King-Middleton modification (1453 of 1946) of Hallén's first-order solution for a cylindrical aerial. These discrepancies are here discussed in detail and the problem is re-examined, reference being made to the published results of many investigators. A theory which lends itself to practical computation of the complete characteristics of a simple dipole aerial does not at present seem to exist. It is significant that the results of Van Vleck *et. al.* (3035 of 1947) for the back-scattering cross-section of a shorted dipole agree more closely with experiment than the first-order solutions of Hallén, King and Middleton, or Gray (1931 of 1944). Variational methods of solving Hallén's equation have given results which are not satisfactory in some respects. It is considered that it might be worth while to follow up a suggestion made by Brillouin (790 of 1945) that the known function and the kernel of the integral equation be expanded in Fourier series with known coefficients, and that the unknown function for the current be expanded likewise with unknown coefficients. Term-by-term integration would then lead to a set of simultaneous equations for determining the coefficients. Results of such an approach do not appear to have been published.

621.396.676:623.74 634
Flush-Mounted Antennas for Military Aircraft—(*Tele-Tech*, vol. 11, pp. 58–59, 111; Oct. 1952.) Illustrations of zero-drag types of aerial developed for jet-driven fighters and high-speed bombers and operating at frequencies from 100 mc to 1.25 kmc. Their functions include distance measurement, communications, landing approach, navigation, and interrogation.

621.396.677 635
Approximate Determination of Aerial Gain—S. Giustini. (*Alta Frequenza*, vol. 21, pp. 204–214; Aug./Oct. 1952.) When side lobes are negligible, the field-strength distribution of a directive aerial can be represented by a single lobe generated by rotation of the polar curve $E=E_0e^{-h}\phi^2$, where E_0 is the maximum field strength and h a matching parameter. The following approximate expressions are derived for the gain: $G\approx 8h$: $G\approx 2.75/(\phi')^2$, where ϕ' is the angle (in radians) corresponding to a field strength of $E_0/\sqrt{2}$.

621.396.677.029.62 636
U.S.W. Wide-Band Directive Aerial—H. Bosse. (*Fernmeldetech. Z.*, vol. 5, pp. 437–439; Oct. 1952.) Description of an aerial system consisting of a vertical stack of four pairs of horizontal $\lambda/2$ dipoles. The dipoles of each pair are arranged in line, and behind the whole system at a distance of about 0.3 λ is a polarizing reflector grid of 20 horizontal rods. Effective bandwidth is 27 mc, centred on 54.5 mc.

621.396.67 637
Antennas: Theory and Practice. [Book Review]—S. A. Schelkunoff and H. T. Friis. Publishers: J. Wiley and Sons, New York, 1952, 593 pp., $10. (Proc. I.R.E., vol. 40, p. 1742; Dec. 1952.) A complete text, intended for students, radio engineers and applied mathematicians and physicists; the mathematics does not go beyond the calculus.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.014.1:537.311.2 638
Ohm's Law for Build-up Phenomena—V. Kussl. (*Funk u. Ton*, vol. 6, pp. 527–533; Oct. 1952.) In the case of 2-pole networks, the Laplace transformation is applied in the form of a Fourier integral of the input waveform. Doetsch's symbolic notation for asymmetrical transformations (3450 of 1948) is used, and the equality sign of Ohm's law is replaced by the Doetsch transformation sign. The variation with time of a current through a complex impedance is given by the Laplace transform product of the susceptance and the applied-voltage spectrum. Application of the transformation in quadripole theory is described. By formulating the quadripole equation in chain-matrix form, transient-response parameters can be roughly estimated. Application of the theory to the determination of transient distortion in communication systems and to the stability testing of amplifiers is outlined.

621.3.015.7:621.387.4 639
Pulse-Amplitude Analysis in Nuclear Research—A. B. Van Rennes. (*Nucleonics*, vol. 10, pp. 20–27, 22–28, 32–38 and 50–56; July–Oct. 1952.) Various voltage-discrimination techniques are discussed in detail and descriptions are given of a simple type of analyser and a moderate-precision and a high-precision analyser. Analysers are also discussed in which pulse-height selection is effected either by mechanical means or by use of diode valves, trigger circuits, sorting-ladder circuits, or beam-deflection techniques. Other types of analyser described include those in which height selection is accomplished (*a*) by an expander-amplifier driving a chain of discriminators, (*b*) by conversion of pulse amplitude to pulse duration, (*c*) by means of information-storage devices. 55 references.

621.314.25 640
Low-Cost Variable Phase Shifter—S. Wald. (*Electronics*, vol. 25, pp. 168, 180; Dec. 1952.) The basis of the circuit is a linear resistance potentiometer divided by tappings into four equal sections, neighbouring sections being fed, by a pair of transformer secondaries, with voltages phase-separated by 90°. The value of the potentiometer resistance is not critical, providing it is large compared with the impedance of the transformer secondaries.

621.314.7:621.396.6 641
Dynamics of Transistor Negative-Resistance Circuits—B. G. Farley. (Proc. I.R.E., vol. 40, pp. 1497–1508; Nov. 1952.) A general method is presented for calculating approximately the characteristics of nonlinear circuits. The region of operation is divided into subregions, within each of which the circuit may be considered as nearly linear. The method is applied to (*a*) analysis of a high-speed switching circuit using a point-contact transistor, (*b*) discussion of negative-resistance relaxation oscillations, (*c*) calculation of waveforms and rise times of a regenerative transistor amplifier [769 below (Felker)].

621.314.7:621.396.6:512.831 642
Matrix Representation of Transistor Circuits—J. Shekel. (Proc. I.R.E., vol. 40, pp. 1493–1497; Nov. 1952.) Transistor circuits are discussed in terms of measurable quantities only. Once the admittance matrix of the grounded-base transistor has been determined, the matrices of the grounded-emitter and grounded-collector transistors can easily be derived. Matrix representation also provides a direct method for analysis of stages in cascade.

621.314.7:621.396.6:621.396.822 643
Transistor Noise in Circuit Applications—H. C. Montgomery. (Proc. I.R.E., vol. 40, pp. 1461–1471; Nov. 1952.) Problems of linear circuits involving multiple noise sources can be handled by familiar methods with the aid of certain noise-spectrum functions, which are described. Several theorems of general interest in circuit work, dealing with noise spectra and noise correlation, are derived. The noise characteristics of transistors can be described in terms of the spectrum functions for simple but arbitrary configurations of equivalent noise generators. From these, the noise figure can be calculated for any external circuit. Numerical results for a number of *n-p-n* transistors are given in a table and many curves.

621.314.7.012.8 644
Junction-Transistor Equivalent Circuits and Vacuum-Tube Analogy—L. J. Giacoletto. (Proc. I.R.E., vol. 40, pp. 1490–1493; Nov. 1952.) A comparison is made between the operating characteristics of a *p-n-p*-junction transistor and a triode tube, using a Π network to represent the transistor.

621.316.8+621.318+621.319.4].001.8 645
Nonlinear Circuit Elements in High-Frequency and Low-Frequency Technology—H. E. Hollmann. (*Arch. elekt. Übertragung*, vol. 6, pp. 434–440, 478–486 and 520–531; Oct.–Dec. 1952.) A review of the properties and applications of nonlinear inductors, capacitors and resistors of many different types. See also 3039 of 1952.

621.316.842:621.316.7 646
New Commercial Barretters—J. Sommer. (*Funk u. Ton*, vol. 6, pp. 520–526; Oct. 1952.) The characteristics of two tungsten-coil barretters are given. The resistances when cold are respectively 50Ω and 100Ω; a current of about 5mA doubles the resistance in each case. Tests to determine the cooling characteristics and the effect of ambient-temperature changes are described.

621.318.4 647
Coil Winding Data—L. Knight. (*Wireless World*, vol. 59, p. 22; Jan. 1953.) Charts give the number of turns required in conjunction with various values of capacitance for tuning over the frequency ranges 2–70 mc and 70 kc/s-3 mc, using standard formers with dust cores.

621.318.57 648
New Bistable High-Speed Multi-Purpose [switching] Device—Y. Druet (*C.R. Acad. Sci., Paris*, vol. 235, pp. 494–496; Aug. 1952.) Operating conditions for an Eccles-Jordan circuit using two Type-ECH42 triode-hexode valves are noted. With suitable diode limiting, consistent operation is maintained at pulse rates $>2\times10^6$/sec.

621.318.57:621.3.015.7 649
Arithmetical Counters for Pulses—A. Dauphin. (*Onde élect.*, pp. 459–463; Nov. 1952.) A list is given of 51 relevant publications, with short notes indicating their scope.

621.318.57:621.314.7 650
A Transistor Reversible Binary Counter—R. L. Trent. (Proc. I.R.E., vol. 40, pp. 1562–1572; Nov. 1952.) The counter is built of elementary transistor packaged units. The mechanism used to achieve reversibility and the circuit for each type of building block are described.

621.318.57:621.314.7 651
Transistor Trigger Circuits—A. W. Lo. (Proc. I.R.E., vol. 40, pp. 1531–1541; Nov. 1952.) Analysis is presented for transistor trigger circuits which permits prediction as to whether operation will be monostable, bistable or astable (oscillatory) and also of the amplitude and waveform of the output. Practical pulse circuits for various purposes are described which are so designed that their operation is not affected by reasonable variations of circuit parameters, bias voltages, transistor characteristics, or ambient temperature.

621.318.57:621.314.7 652
Transistors in Switching Circuits—A. E. Anderson. (*Bell Sys. Tech. Jour.*, vol. 31, pp. 1207–1249. Proc. I.R.E., vol. 40, pp. 1541–1558; Nov. 1952. Correction, *ibid.*, vol. 40, pp. 1732–1733; Dec. 1952.) Analysis of transistor trigger circuits is based on an approximate representation of the negative-resistance characteristic by three straight lines. Circuits using point-contact transistors for waveform generation, level restoration, delay, storage, and counting are described, and their properties and limitations are discussed in detail.

621.318.57:621.314.7:518.4 653
Graphical Analysis of Some Transistor Switching Circuits—L. P. Hunter and H. Fleisher. (Proc. I.R.E., vol. 40, pp. 1559–1562; Nov. 1952.) Methods are described for generating the entire input characteristics for the various terminals of a transistor, and graphical methods of analysis are applied to (*a*) a base-input amplifier, (*b*) a collector-to-emitter direct-coupled switching circuit, (*c*) a collector-to-base direct-coupled circuit.

621.318.572 654
Electronic Switch—K. R. Sturley. (*Wireless World*, vol. 59, pp. 11–14; Jan. 1953.) A switching circuit for two-waveform display with a single-beam cro uses a conventional multivibrator for generating the switching voltages.

621.392 655
Network Analysis by Repeated Voltage Superposition—J. E. Parton. (*Electronic Eng.*, vol. 24, pp. 570–574; Dec. 1952.) A method of analysis is described, with worked-out examples, which reduces considerably the number of simultaneous equations to be solved for an *m*-mesh network. The method essentially involves successive applications of Thévenin's theorem, each application reducing by one the number of meshes in the network considered, with a corresponding reduction of the number of simultaneous equations to be solved. A similar method has been described by Tasny-Tschiassny (3365 of 1948), who used "residual" current generators at the final nodes instead of residual voltage generators in the final branches, and whose method differs from the present method in other details.

621.392 656
Synthesis of Cascaded Three-Terminal

RC Networks with Minimum-Phase Transfer Functions—P. F. Ordung, F. Hopkins, H. L. Krauss and E. L. Sparrow. (PROC. I.R.E., vol. 40, pp. 1717–1723; Dec. 1952.) For the realization of a particular transfer function including complex zeros, the method of synthesis presented yields a network with fewer elements, simpler configurations and higher level of transmission than previous methods (e.g. 1605 of 1950).

621.392.1 657

The Practical Significance of Complex Frequencies in Electrical Communication Engineering—J. Peters. (*Arch. elekt. Übertragung*, vol. 6, pp. 401–413; October 1952. Correction, *ibid.*, vol. 6, p. 514; Dec. 1952.) A concise general introduction tothesubject. Complex frequencies are complex quantities whose real part represents the gain of a system and whose imaginary part represents the frequency in the usual sense. The application of the Laplace transform in analysis of transmission problems is explained and the properties of the complex plane and its poles and zeros are described. The use of the poles and zeros for representation of the transmission characteristics of a linear network is considered. Analogues of the complex plane, such as that obtainable with a stretched elastic membrane, are discussed and their applications illustrated.

621.392.4/.5 658

Anode-Follower Derivatives—A. W. Keen. (*Wireless Eng.*, vol. 30, pp. 5–9; Jan. 1953.) "Low output-impedance stages characterized by anode output and feedback of the entire output voltage are derived from the basic 'anode-follower' by substitution of a tube impedance for the shunt resistor of the feedback path, or of a comparator stage for the entire input-feedback potential divider, and by replacement of the output tube by a series-connected push-pull pair. These developments suggest the possibility of obtaining an anode-follower analogue of each cathode-follower derivative, thereby increasing the number of circuit variants available for practical use."

621.392.4/.5:512.972 659

Applications of Tensor Theory to Linear Electronic Circuits—A. Kaufmann. (*Radio tech. Dig.* (France), vol. 6, nos. 2, 3 and 4, pp. 67–76, 157–168 and 199–209; 1952.) An explanation of tensor concepts and their general application to tube circuits, with examples illustrating the determination of input impedance and gain of feedback, cathode-follower, and grounded-grid circuits.

621.392.5 660

On the Approximation Problem in Network Synthesis—A. D. Bresler. PROC. I.R.E., vol. 40, pp. 1724–1728; Dec. 1952.) A method of synthesis is presented in which a desired frequency-response characteristic is replaced by an approximation consisting of a sequence of rectilinear segments. The method is illustrated by application to the design of attenuation equalizers with constant-resistance ladder sections.

621.392.5 661

The Parallel-T Resistance-Capacitance Network—L. G. Cowles. (PROC. I.R.E., vol. 40, pp. 1712–1717; Dec. 1952.) Analysis is given for the general case of finite source and load resistances. When these two resistances are appropriately related the network loss is the same at low and high frequencies; the transfer characteristic is then a circle in the complex plane. This "symmetrical" network is equivalent to a simple series-resonant circuit as regards its transfer characteristic.

621.392.5 662

RC Cathode-Follower Feedback Circuits—S. C. Dunn. (*Wireless Eng.*, vol. 30, pp. 10–19; Jan. 1953.) When certain *RC* circuits are associated with a cathode-follower circuit, a voltage gain can be obtained over a band of frequencies. A number of prototype and derived *RC* circuits which can be used in this way are analysed and their response curves are determined. The matrices of the derived networks can be formed easily from those of the corresponding prototypes. The effect of circuit termination on response is discussed and the use of these circuits as feedback elements in amplifiers is considered in some detail. Experiments in confirmation of the theory are mentioned.

621.392.5 663

Resistance-Capacitance Networks with Over-Unity Gain—W. Bacon and D. P. Salmon. (*Wireless Eng.*, vol. 30, pp. 20–23; Jan. 1953.) Longmire (2702 of 1947) and Epstein (2940 of 1951) have described *RC* circuits with greater output than input voltage. A method of increasing the voltage gain by feeding the output voltage of one network into a second network is described. The process cannot be extended indefinitely, the voltage gain attainable being limited by the impedance increase necessary at each stage. Experiments confirmed the theory. Such networks can be used with a cathode follower to construct oscillators in which the valve gain is less than unity. An experimental circuit is described.

621.392.5 664

Response of a Linear Network to an Input with Linearly Variable Frequency as obtained in Sweep-Frequency Testing—H. Ekstein and T. Schiffman. (*Proc. nat. Electronics Conf., Chicago*, vol. 7, pp. 454–471; 1951.) Application of an input voltage with linearly increasing frequency to a linear network produces an output curve which, for very slow frequency variation, is an image of the admittance plotted as a function of frequency. When the rate of frequency variation is not negligible, the response curve is a distorted image of the admittance. The nature of this distortion is investigated. A quantitative approximation method is presented which uses the theory of functions for evaluation of an integral. The result is expressible in terms of elementary functions. Explicit expressions are given for the dynamic corrections to be applied to the "observed" resonance frequencies and peak admittances. The method is applied to several simple circuits in addition to the *LCR* circuit which has been previously treated by other authors.

621.392.52 665

Fundamentals of Filter Theory and Technique—K. H. Haase. (*Funk u. Ton*, vol. 6, pp. 505–519; Oct. 1952.) Description of the application of the wave theory and the operating-parameter theory in the design and calculation of different basic types of filter.

621.392.52 666

Formulas for Ladder Filters—H. J. Orchard. (*Wireless Eng.*, vol. 30, pp. 3–5; Jan. 1953.) Four related sets of explicit formulas for the elements of a basic low-pass filter network are presented with a common notation. Three of the sets have been published previously [2900 of 1937 (Norton); 1543 of 1952 (Bosse); 1541 of 1952 (Belevitch)], the fourth being new; all have reference to the image-parameter theory due to Norton and Darlington (1361 of 1940). If corresponding formulae could be found for a general type of filter with response depending on Jacobian sn elliptic functions, they would represent a considerable contribution to filter-design technique.

621.392.52 667

A Nonlinear Statistical Filter—A. W. Sullivan and J. M. Barney. (*Proc. Nat. Electronics Conf., Chicago*, vol. 7, pp. 85–91; 1951.) A method is described for using the statistical differences between a periodic rectangular pulse (the wanted signal) and the envelope of fluctuation noise (the interfering signal), for the purpose of discriminating between the two signals. Expressions are derived for the density distribution probability of noise and of signal plus noise. A description is given of a practical filter which was checked experimentally under conditions when the signal was completely masked by the noise, both aurally and visually, but could be reliably detected by means of the statistical filter. Possible application to secret-transmission systems is discussed.

621.392.52:518.12 668

Numerical Calculation of Filter Circuits with Tchebycheff Characteristics after the Method of W. Cauer—V. Fetzer. (*Arch. elekt. Übertragung*, vol. 6, pp. 419–431; Oct. 1952.) Formulas for Tchebycheff-type filters are derived from those previously given for filters with generalized parameters (1545 of 1952.) Three types of antimetrical filter are considered. The formulas necessary for numerical calculation of both symmetrical and antimetrical normalized filters are derived and applied to examples. By suitable frequency transformation the normal type of Tchebycheff filter can be dealt with. A complete set of curves is provided for evaluation of the required parameters.

621.392.52:621.315.212 669

Coaxial Transmission-Line Filters—D. E. Mode. (PROC. I.R.E., vol. 40, pp. 1706–1711; Dec. 1952.) Analysis for coaxial-line band-pass filters is given based on TEM-mode transmission. The influence of the nature and spacing of the obstacles on the bandwidth is discussed. Measurements on filters of various constructions support the theoretical results. A TE-mode high-pass filter is also discussed. For narrow-band applications this type of filter is inferior to the cavity type.

621.392.52:621.396.49 670

Nonlinear Filtering and Waveshape Multiplexing—R. E. Scott, S. Fine and A. Macmullen. (*Electronics*, vol. 25, pp. 146, 148; Dec. 1952.) A method of providing two channels on one carrier consists of differentiating the combined signal, clipping to remove one component, and re-integrating to restore the other. The removed component is recovered by subtracting the retained component from the original input. Experimental circuits and waveforms obtained are illustrated, the two components being respectively a sine wave and a square wave.

621.394/.396].6:003.63 671

Functional Circuit Diagrams—C. E. Williams. (*Wireless World*, vol. 59, pp. 19–21; Jan. 1953.) Shortened version of paper abstracted in 63 of January.

621.396.6:621.314.7:629.13 672

Transistors in Airborne Equipment—O. M. Stuetzer. (PROC. I.R.E., vol. 40, pp. 1529–1530; Nov. 1952.) Discussion of the advantages of using transistors instead of valves in aircraft equipment.

621.396.6:621.317.755 673

Slow-Speed Circular Timebase—(*Radio Tech. Dig.* (France), vol. 6, no. 4, pp. 179–193; 1952.) French version of paper by Hardie and Thomas (2755 of 1952) supplemented with references and a note on earlier types of sine-cosine potentiometer.

621.396.6.002.2:621.314.7 674

Printed Circuitry for Transistors—S. F. Danko and R. A. Gerhold. (PROC. I.R.E., vol. 40, pp. 1524–1528; Nov. 1952.) The auto-sembly technique [355 of February (Danko)] is suggested as a simple and effective method for the production of compact transistor circuits.

621.396.611.1 675

Resonance Curves—"Cathode Ray." (*Wireless World*, vol. 59, pp. 29–33; Jan. 1953.) Deviations encountered in practical circuits from the ideal conditions dealt with in elementary theory are simply explained.

621.396.611.1:621.396.822 676

Spontaneous Voltage Fluctuations in a Resonant Circuit—E. Paolini. (*Alta Frequenza*, vol. 21, pp. 199–203; Aug./Oct. 1952.) The rms value of voltage fluctuations, of thermal origin, at the terminals of a parallel *RLC* circuit, is determined for the unusual case where the frequency range in question is not negligible in comparison with the bandwidth of the resonant circuit. Curves are given to facilitate numerical calculation.

621.396.615+621.396.645]:621.314.7 677

A Junction-Transistor Tetrode for High-Frequency Use—R. L. Wallace, Jr., L. G. Schimpf and E. Dickten. (PROC. I.R.E., vol. 40, pp. 1395–1400; Nov. 1952.) Application of suitable bias to a fourth electrode connected to the *p*-type central section of an *n-p-n*-junction transistor causes a considerable reduction of the base resistance. This reduction enables the transistor to be used at frequencies over ten times the normal limit. Circuits are given for a variable-frequency tuned amplifier, a band-pass amplifier, and a sine-wave oscillator for 40–115 mc.

621.396.615:621.314.7 678

Transistor Oscillators—W. Herzog. (*Arch. elekt. Übertragung*, vol. 6, pp. 398–400; Oct. 1952.) The characteristics of transistor oscillators are established by analysis in which the conductance form of the transistor equations is used. The following circuits are considered: (*a*) transistor with frequency-determining quadripole and overall feedback; (*b*) as in (*a*) but with transformer coupling between transistor and quadripole; (*c*) transistor oscillator with a Π-arrangement of three parallel-connected tuned circuits.

621.396.615.029.4:621.314.7 679

Low-Drain Transistor Audio Oscillator—D. E. Thomas. (PROC. I.R.E., vol. 40, pp. 1385–1395; Nov. 1952.) Description of the design and performance of a 130-c/s oscillator using a Western Electric Type-A1768 point-contact transistor supplied from a single 6-V battery, the power drain from which does not exceed 35 mW.

621.396.615.11 680

A Low-Frequency Function Generator—R. H. Brunner. (*Electronics*, vol. 25, pp. 114–117; Dec. 1952.) Description of a relaxation oscillator capable of giving a constant-amplitude output of sine, square or triangular waveform, in the frequency range 0.01 cps–1 kc.

621.396.615.12.078 681

Automatic Tuning Control of H.F. Generators with Varying Load—H Hertwig. (*Electronic Appl. Bull.*, vol. 13, pp. 9–18; Jan. 1952.) The phase relation between the primary voltage and the secondary current of the output transformer of a crystal-driven 40-mc 500-W generator is used for automatic control of the tuning of the output circuit under varying load conditions. Control is effected via a bridge type of phase-measurement unit using a pair of Type-EQ80 enneodes, which acts on a control unit using a pair of Type-PL21 thyratrons. Circuit details, photographs and performance figures are given.

621.396.615.17:621.314.7 682

Pulse Duration and Repetition Rate of a Transistor Multivibrator—G. E. McDuffie, Jr. (PROC. I.R.E , vol 40, pp 1487–1489; Nov. 1952.) Expressions are derived for the pulse duration and repetition rate of an astable (oscillatory) multivibrator circuit using a point-contact transistor. The formulas are confirmed experimentally for repetition rates from 200 to 10,000 per sec and pulse durations from 30 to 900 μs.

621.396.619.13:621.318.4 683

Variable Inductance and its Application in Frequency-Sweep Oscillators—W. Lange. (*Funk u. Ton*, vol. 6, pp. 534–540; Oct. 1952.) The modulation principle described consists in varying the voltage across an inductor L_1 while the current through it is maintained constant. Alternations of the control-grid voltage of a pentode cause anode and screen-grid currents to vary in magnitude, developing a voltage variation across an anode inductor L_2, coupled to the inductor L_1 in the cathode circuit. The current through L_1 is maintained constant by an alternating voltage applied to the suppressor grid. A frequency shift of ±20% around 470 kc is attainable. The use of the method for f.m. and frequency-sweep tuning is indicated.

621.396.622.7:621.396.619.13 684

Double-Counter FM and AFC Discriminator—J. J. Hupert, A. Przedpelski and K. Ringer. (*Electronics*, vol. 25, pp. 124–125; Dec. 1952.) A frequency discriminator with large bandwidth and good stability comprises a pair of pulse-counter circuits, each preceded by mixer and pulse-forming circuits, with their outputs connected in series.

621.396.645+621.396.615 685

Vacuum-Tube Circuits without Plate Supplies—P. B. Clark. (*Electronics*, vol. 25, pp. 192, 199; Dec. 1952.) The existence of thermal emf and contact potential makes circuit operation possible without application of voltage to tube anodes. A limiter, a low-gain amplifier, a multivibrator and an oscillator circuit are described.

621.396.645 686

Volume Compression and Expansion—B. D. Corbett: G. J. Pope. (*Electronic Eng.* vol. 24, p. 580; Dec. 1952.) Comment on 365 of February and author's reply.

621.396.645:621.313.2.026.441/.442]-9 687

Calculations for a Power Amplifier for a D.C. Motor—J. Zakheim. (*Onde elect.* vol. 32, pp. 455–458; Nov. 1952.) The design is considered of valve circuits for driving low-power motors (5–15W), such as are often used in control or telemetry equipment.

621.396.645:[621.314.7 688

Transistor Operation: Stabilization of Operating Points—R. F. Shea. (PROC. I.R.E., vol. 40, pp. 1435–1437; Nov. 1952.) The provision of optimum emitter and collector bias currents for a transistor amplifier is discussed, and a relation between the values of resistors and voltages is derived which should be satisfied if stable operation is to be achieved.

621.396.645:621.314.7 689

Transistor Amplifier Cut-Off Frequency—D. E. Thomas. (PROC. I.R.E., vol. 40, pp. 1481–1483; Nov' 1952.) The effect of the positive feedback associated with the internal base resistance of a transistor on its cut-off frequency is analysed. Expansion of the expression for current gain α in a Taylor series shows that only the phase shift in α is important in reducing the cut-off frequency.

621.396.645:621.314.7 690

Frequency Variations of Current-Amplification Factor for Junction Transistors—R. L. Pritchard. (PROC. I.R.E., vol. 40, pp. 1476–1481; Nov. 1952.) In a grounded-emitter or grounded-collector connection of a junction-type transistor, the effective current amplification is proportional to $1/(1-\alpha)$, where α is the current gain of the transistor. As a result of the phase shift associated with α, the value of $1/(1-\alpha)$ decreases rapidly with increasing frequency, so that the upper frequency limit of the grounded-emitter or grounded-collector arrangements may be considerably lower than has been expected. Results of measurements of the frequency variation of α for several fused-impurity *p-n-p*-junction transistors developed by Saby (877 below) are shown graphically.

621.396.645:621.387.4 691

The Reproduction of Voltage Pulses by means of a Proportional Amplifier—U. Cappeller. (*Z. angew. Phys.*, vol. 4, pp. 330–343; Sept. 1952.) Analysis of an amplifier for nuclear-physics investigations is based on Laplace transformations. A characteristic transmission function is introduced which completely describes the transmission properties of the amplifier and represents the combined pulse-distorting influences of the individual circuit elements. The transmission functions of single-stage and multistage amplifiers are derived and a detailed exposition is given of the distortion experienced by a typical exponential decay pulse. Optimum reproduction of such a pulse requires a particular relation between pulse duration and the time constants of the amplifier circuits. Improvement of time-resolution involves closer restriction of this relation and greater complexity of circuits. Use of negative feedback offers advantages; a two-stage feedback amplifier is a useful unit in a large amplifier system. The transmission function can alternatively be determined from the response of the amplifier to steady alternating voltage; a suitable method of measurement is described.

621.396.645.371.029.45 692

A Photocell Amplifier for Infra-Red Spectroscopy—D. A. H. Brown. (*Jour. Sci. Inst.*, vol. 29, pp. 292–294; Sept. 1952.) Description of a highly linear amplifier for use at a chopping frequency of 800 c/s. Gain variation is $<\frac{1}{3}\%$ for 10% variation of supply vloltage.

621.396.822 693

Symposium on Noise. General Introduction—H. B. G. Casimir. (*Tijdschr. ned. Radiogenoot.*, vol. 17, pp. 199–206; Sept./Nov. 1952.) Discussion of the mathematical representation of noise.

GENERAL PHYSICS

534.01+538.56]:621.319.55 694

A Coherent Theory of Relaxation Phenomena—E. Hiedemann and R. D. Spence. (*Z. Phys.*, vol. 133, pp. 109–123; Sept. 5, 1952.) The theory presented is based on the theory of functions. General formulas are derived and the particular case of elastic relaxation oscillations is discussed. Conditions for the occurrence of discrete and of continuous relaxation spectra are determined and a formula is derived for the distribution function of the continuous spectrum.

534.26+535.43 695

On a Multiple Scattering Theory of the Finite Grating and the Wood Anomalies—V. Twersky. (*Jour. Appl. Phys.*, vol. 23, pp. 1099–1118; Oct. 1952.) The problem is treated by applying the solution previously obtained (2685 of 1952) for multiple scattering from an arbitrary configuration of parallel cylinders. Both the transmission grating and the reflection grating comprising semicylindrical bosses on a perfectly conducting plane are considered. The complete expression for the scattered wave is given for the case of grating width small compared with distance to observation point and cylinder spacing large compared with λ. The case of radii≪λ is investigated in detail; bright and dark hands in the intensity curves, similar to the grating anomalies found by Wood in 1902, are related to the magnitudes and phases of the various orders of scattering. The theory is extended to gratings with elements other than cylinders.

535.42.001.11 696

Removal of Inconsistency in the Theory of Diffraction—D. S. Jones. (*Proc. Camb. Phil. Soc.*, vol. 48, part 4, pp. 733–741; Oct. 1952.) In certain cases the integral equations involved in analysis of the diffraction of small-amplitude acoustic or e.m. waves give a solution which does not satisfy the boundary conditions imposed, but which agrees with the solution found by other means. This inconsistency is removed if different boundary conditions are imposed in the formulation of the problem; this is illustrated by discussion of two-dimensional diffraction of a plane e.m. wave by a perfectly conducting semi-infinite plane.

537.12 697
The Rydberg Constant and the Atomic Mass of the Electron—E. R. Cohen. (*Phys. Rev.*, vol. 88, pp. 353–360; Oct. 15, 1952.) Re-evaluation of the spectroscopic data pertinent to the Rydberg constant and the mass of the electron yields the values $R_\infty = 109737.326 \pm 0.014$ cm^{-1} and $m = (54.895 \pm 0.008) \times 10^{-5}$ atomic mass units. From microwave measurements $m = (54.8785 \pm 0.0019) \times 100^{-5}$ a.m.u. and $R_\infty = 109737.311 \pm 0.012$ cm^{-1}. Houston's and Chu's data can be brought into agreement with those of Drinkwater, Richardson and Williams by assuming differences in the wavelength standards used.

537.226.2/.3:541.135 698
Dielectric Dispersion in Pure Polar Liquids at Very High Radio Frequencies: Part 3—The Effect of Electrolytes in Solution—J. A. Lane and J. A. Saxton. (*Proc. Roy. Soc. A*, vol. 214, pp. 531–545; Oct. 1952.) A description is given of measurements, at mm and cm wavelengths, of the absorption of electrolytic solutions, of concentrations up to 3N, water and methyl alcohol being used as solvents. The results obtained are analyzed in terms of Debye's theory of dispersion in a polar dielectric, and modifications of the theory necessary to take account of the ionic conductivity of an electrolyte are indicated. Measurements on aqueous solutions of NaCl are discussed in relation to Hückel's theory of electrolytic solutions. Part 2: 3400 of 1952.

537.228.1:548.0 699
Piezoelectricity, Ferroelectricity, and Crystal Structure—A. von Hippel. (*Z. Phys.*, vol. 133, pp. 158–173; Sept. 15, 1952. In English.) By visualizing polar crystals as a network of permanent dipole moments, the piezoelectric and ferroelectric properties of dielectrics may be deduced from considerations of molecular symmetry. This approach is used to clarify the relation between the sphalerite (cubic) and wurtzite (hexagonal) structures, the ferroelectric feedback effect in $BaTiO_3$, aspects of domain formation, and the interrelation between ferroelectiricity and piezoelectricity.

537.311.1:538.632 700
Carriers of Electricity in Metals exhibiting Positive Hall Effects—S. Brown and S. J. Barnett. (*Phys. Rev.*, vol. 87, pp. 601–607; Aug. 1952.) Measurements on samples of Mo and Zn, made by an inertia method, showed the sign of the charge:mass ratio of the carriers to be negative, the mean value of over 100 measurements being within 3% of the value for free electrons.

537.523/.527 701
Electrical Discharges in Gases—F. J. Jones. (*Nature, Lond.*, vol. 170, pp. 601–603. Oct. 1952.) A summarized account of six papers, with discussion, presented at a meeting of Section A (Mathematics and Physics) of the British Association, Belfast, September 1952.

537.523/.525]:546.292:538.56.029.63 702
High-Frequency Breakdown in Neon—A. D. MacDonald. (*Phys., Rev.*, vol. 88, p. 420; Oct. 1952.) Preliminary report of the results of measurements of breakdown fields for cylindrical cavities of heights 0.317 and 0.634 cm. over the pressure range 0.5–300 mm of Hg. A detailed report is to be published in the *Canadian Journal of Physics*.

537.525 703
An Explanation of the Extremely Low Normal Running Potential of a High-Frequency Discharge between Plane Plates—F. Schneider (*Z. angew. Phys.*, vol. 4, pp. 324–325; Sept. 1952.) A tentative explanation is provided by taking account, in the equation of electron motion, of a restoring force indicated by plasma diffusion theory.

537.533.75 704
Chromatic Losses of Electrons in Passage through Matter—G. Möllenstedt. (*Optik, Stuttgart*, vol. 9, No. 10, pp. 473–480; 1952.) An account of investigations of the velocity distribution of electrons after passage through various gases and solid materials.

537.533.8 705
The Theory of Secondary Emission—J. F. Marshall. (*Phys. Rev.*, vol. 88, pp. 416–417; Oct. 1952.) Preliminary note; to be treated in detail in a forthcoming paper.

538.113/.114 706
Antiferromagnetism—Ochsenfeld. (*Z. angew. Phys.*, vol. 4, pp. 350–360; Sept. 1952.) A comprehensive review of the subject, with 42 references.

538.3 707
A Simplified Form of the Relativistic Electromagnetic Equations.—N. W. Taylor. (*Aust. Jour. Sci. Res., Ser. A*, vol, 5, pp. 423–429; Sept. 1952.) Maxwell's equations are expressed in the form of a single four-vector density equation, in which the field tensor has only three distinct complex components. The number of equations is reduced, but all the usual classical formulas may be obtained by separating the real and imaginary parts.

538.521 708
The Induction of Electric Currents in a Uniformly Conducting Circular Disk by the Sudden Creation of Magnetic Poles—A. A. Ashour. (*Quart. Jour. Mech. Appl. Math.*, vol. 5, part 3, pp. 379–384; Sept. 1952.) Using toroidal coordinates, a Riemann space of two regions is constructed, as in Sommerfeld's method of multiform potentials, and the Riemann potential for a single magnetic pole is determined. Jeans' treatment of uniform finite plane current sheets is applied to the case of the circular disk, numerical results being given for a particular example.

538.56+535.14 709
Hertzian Waves and Photons—L. de Broglie. (*Onde élect.*, vol. 32, pp. 393–396. Oct. 1952.) Discussion of the implications, in physical theory, of an uncertainty relation between (*a*) the number of particles of the Bose-Einstein type associated with a wave and (*b*) the phase of that wave.

538.566:535.42 710
Diffraction of Electromagnetic Waves by Apertures in Plane Conducting Screens—J. P. Vasseur. (*Ann. Phys.* (*Paris*), vol. 7, pp. 506–563; July/Aug. 1952.) See 2184 of 1952.

538.566:535.42 711
Diffraction by an Edge and by a Corner—D. S. Jones. (*Quart. Jour. Mech. Appl. Math.*, vol. 5, Part 3, pp. 363–378; Sept. 1952.) Conditions are given which are sufficient to ensure that the current density normal to an edge is zero at the edge and that there is no line distribution of charge on the edge. An extra condition is given which makes the components of the field parallel to the edge finite. The solution is then shown to be unique. Simpler conditions are given for two-dimensional fields. The agreement of various known solutions with the conditions here determined is discussed. Certain simple types of current and charge distribution lead to a unique solution for the diffraction by corners formed by flat surfaces.

538.566:537.562 712
Propagation of Electric Waves in Stratified and Continuously Variable Plasmas—W. O. Schumann. (*Z. Naturf.*, vol. 5a, pp. 612–617; Nov. 1950.) For a plasma of sandwich structure, with the denser medium inside, there are two possible frequency ranges for propagation in which the phase velocity falls from the value *c* at the lower limiting frequency to zero at the upper limiting frequency. When the density varies linearly towards the interior to an arbitrarily high value, the wave is strongly concentrated at the plane for which $\epsilon = 0$ and the phase velocity tends to zero. For a plasma of uniform density and natural frequency ω_0, with outer layers in which density falls off linearly, propagation is possible only when $\omega < \omega_0^2/2$. The more the wave is concentrated at the region $\epsilon = 0$, and the smaller its phase velocity, the nearer ω^2 approaches to $\omega_0^2/2$.

538.632 713
Hall Effect—O. Lindberg. (Proc. I.R.E., vol. 40, pp. 1414–1419; Nov. 1952.) Discussion of the Hall, Ettingshausen, Nernst, and Righi-Leduc effects.

539.234:537.311.1 714
Mean Free Paths of Electrons in Evaporated Metal Films—F. W. Reynolds and G. R. Stilwell. (*Phys. Rev.*, vol. 88, pp. 418–419; Oct. 1952.) Estimates of the mean free paths of the conduction electrons in Cu and Ag films, based on resistivity measurements on films of thickness from 100 to 1500 μ, are found to be in good agreement with values calculated from Dingle's theory (2189 of 1950).

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.746/.75 715
Sunspot Areas, Flares and Filaments observed at the Stockholm Observatory in the Years 1950 and 1951—Y. Ohman and L. O. Lodén. (*Tellus*, vol. 4, pp. 241–248; Aug. 1952.)

523.755:523.78 716
Comparison of Photographs of the Corona obtained at the Eclipse of 1952, February 25, with Simultaneous Observations by Lyot Coronagraphs—H. von Klüber. (*Observatory*, vol. 72, pp. 207–209; Oct. 1952.) Photographs of the solar corona taken at Khartoum are reproduced and discussed in relation to routine estimates of the intensity of the green corona line λ5303. Possible correlation of particular features of the corona with geomagnetic effects is noted.

523.85:621.396.822 717
The Positions of Six Discrete Sources of Cosmic Radio Radiation—B. Y. Mills. (*Aust. Jour. Sci. Res., Ser. A.* vol. 5, pp. 456–463; Sept. 1952.)

523.854:621.396.822.029.63 718
A Preliminary Survey 1420-Mc/s Line Emission from Galactic Hydrogen—E. N. Christiansen and J. V. Hindman. (*Aust. Jour. Sci. Res., Ser. A.* vol. 5, pp. 437–455; Sept. 1952.) Report of measurements on a radiation source having the form of a band of varying intensity along the galactic equator.

551.510.52 719
The Ionic Equilibrium of the Lower Atmosphere and Recombination Theories—B. Vitale. (*Ann. Geofis.*, vol. 5, pp. 257–271; April 1952.)

551.510.535 720
A Note on Ionospheric Wind Measurements at 150 kc/s—G. H. Millman. (*Ann. Géophys.*, vol. 7, pp. 272–274; Oct./Dec. 1951 In English.) Report of measurements made in Pennsylvania, using a three-receiver technique similar to that of Mitra (96 of 1950).

551.510.535 721
The Ionization of the E Layer: its Measure-

ment and Relation to Solar Eruptions—K. Bibl. (*Ann. Géophys.*, vol. 7, pp. 208–214; Oct./Dec. 1951.) Criteria for distinguishing between normal and abnormal layers are discussed. Relatively thin layers are classed as abnormal; their ionization distribution corresponds to a power law with index >2. A definition of f_0E is given which remains valid for complex layers; f_0E is the highest critical frequency of a normal layer preceding or coinciding with the first discontinuity between the E and F echoes. Application of this definition to the evaluation of ionosphere observations made at Freiburg during 1950 and 1951 leads to greater constancy of the daily variations and monthly means of f_0E. Examination of the values of f_0E for three summer months indicates that all deviations >0.2 mc above the monthly mean are attributable to sudden ionospheric disturbances.

551.510.535:523.854:621.396.822 722
The Diffraction of Galactic Radio Waves as a Method of Investigating the Irregular Structure of the Ionosphere—A. Hewish. (*Proc. Roy. Soc. A*, vol. 214, pp. 494–514; Oct. 1952.) An account of an investigation of ionospheric characteristics by observation of changes in the diffraction pattern of radio waves from the galaxy. Ionospheric irregularities cause irregular changes of phase in the galactic waves passing through them. Observations at two stations about 1 km apart indicate that such ionospheric irregularities may have a lateral extent of 2–10 km and a variation of electron density of about $5\times10^9 e/cm^3$; their height is about 400 km. they are most pronounced about midnight, and they show little annual variation. Such portions of the ionosphere have a wind-like motion with velocities of the order of 100–300 m/s. The velocity decreases after midnight, and large velocities are associated with periods of geomagnetic disturbances.

551.510.535:546.21–1:537.56 723
Production of the E-Layer in the Oxygen-Dissociation Region in the Upper Atmosphere—D. C. Choudhury. (*Phys. Rev.*, vol. 88, pp. 405–408; Oct. 1952.) The probable value of the absorption cross section of O_2 for the ionization causing the E layer is calculated, using the O_2 height-distribution data obtained by Moses and Wu (129 of 1952). Discussion indicates that the pre-ionization by solar radiation in the range 900–1000 Å suggested by Nicolet (420 of 1947) and ionization by high-energy photons emitted from the solar corona [Hoyle and Bates (388 of 1949)] are both operative in producing E-layer ionization. The former produces the normal E layer and the latter is responsible for the fine structure of the E layer recently reported by Naismith and Bramley (473 of 1952).

551.410.535:621.3.087.4 724
A New Ionosphere Sounder—K. Bibl. (*Ann. Géophys.*, vol. 7, pp. 265–267; Oct./Dec. 1951.) Frequency-sweep apparatus covering the range 1–16 Mc/s is described. The antenna circuit is eliminated, the high-impedance rhombic aerial being directly matched to the power valves. The frequency range is covered in the other circuits in two wavebands each with a 1:4 ratio; quick waveband changing is achieved by means of carbon brushes rotating with the variable capacitors. The transmitter and receiver have a common oscillator. The power-supply arrangements are particularly described; the unit is of small size.

551.510.535:621.087.4 725
Improvements to the Berkner-Wells-Seaton Type of Ionosphere Sounder—E. Harnischmacher. (*Ann. Géophys.*, vol. 7, pp. 262–264; Oct./Dec. 1951.)

551.510.535:621.317.083.7 726
High-Altitude Research—E. Burgess. (*Engineer. Lond.*, vol. 194, pp. 338–340 and 370–373; Sept. 1952.) An account of methods and equipment used with rockets for investigations at heights up to 250 miles; physical phenomena observed include the ion and electron densities in the inosphere. A description is given of a 23-channel telemetering system transmitting at 1 kmc with a peak power of 1 kW.

551.510.535:621.396.11.039.55 727
Ionospheric Measurements at Oblique Incidence over Eastern Australia—Strohfeldt, McNicol and Gipps. (See 807.)

551.594.5:621.396.9 728
Localization of Aurorae with 10-m High Power Radar Technique, using a Rotating Antenna—G. Hellgren and J. Meos. (*Tellus*, vol. 4, pp. 249–261; Aug. 1952.) Radar equipment with a peak pulse power of 100 kW, pulse width 40 μs, and 3-element Yagi aerial rotating at 2 r.p.m., has been used since May 1951 at Kiruna Geophysical Observatory for the location of aurorae. Preliminary results of the observations indicate good correlation between auroral activity, geomagnetic activity, and the appearance of the N_1 layer, a special type of sporadic-E ionization often appearing in connection with magnetic bays. The distribution in range and bearing of the recorded aurorae agrees with the simple theory that most of the radio-wave scattering comes from those points where the radar beam is perpendicular to the surface of the auroral discharges. The calculated height distributions of the reflection centers have maxima around 120 km.

551.594.6:538.566.029.45/.51 729
Propagation of Very Long Electromagnetic Waves, and the Wave Spectrum of Lightning—Schumann. (See 802.)

LOCATION AND AIDS TO NAVIGATION

621.396.9 730
Commercial Radar System—W. F. Johnson. (*Elec. Mfg*, vol. 47, pp. 72–77; Feb. 1951.) General description of navigational radar equipment for merchant ships. Both 3-cm and 10-cm wavelengths are catered for and a standard 16-in. television CR-tube provides a satisfactory display. Accessibility of the various units to facilitate maintenance work is a special feature of the design. The reflectors for the aerial systems consist of expanded metal attached to a suitable framework.

621.396.9:621.677.088.22 731
Scanning Aberrations of Radio Lenses—T. C. Cheston and D. H. Shinn. (*Marconi Rev.*, 4th Quarter vol. 15, No. 107, pp. 174–184; 1952.)

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215:546.472.21 732
Photoelectric Measurements on ZnS Single Crystals—J. Krumbiegel. (*Naturwissenschaften*, vol. 39, p. 447; Oct. 1952.) Measurements on a number of specimens, using monochromatic irradiation of wavelength ranging from 450 to 2000 mμ in steps of 50 mμ, indicated two peaks of photoconductivity, at about 750 and 1150 mμ respectively. Time lag of the photocurrent was observed in all cases.

535.215:546.883 733
Photoconduction in Anodic Ta_2O_5—L. Apker and E. A. Taft. (*Phys. Rev.*, vol. 88, pp. 58–59; Oct. 1952.) Observations show that fundamental optical absorption occurs for $h\nu>4.6$ eV. The resultant photoconduction between electrolyte and Ta substrate shows a quantum yield near 0.5 when the field in the film is of the order of 10^7 V/cm.

535.376 734
Light Emission and Destruction of Phosphors due to Electron and Ion Impact—W. Hanle and K. H. Rau. (*Z. Phys.*, vol. 133, pp. 297–308; Sept. 15, 1952.) Measurements were made of the light emission from ZnS-Ag, ZniSiOi-Mn and $MgWO_4$ phosphors under excitation by Hi, He, Ne, Ar and Xe canal rays. The emission depends only to a very slight extent on the energy of the ions and is independent of the ion density. With increase of ion mass the emission decreases, with a jump in passing from He to Ne ions. Destruction of the three phosphors by canal-ray bombardment was found to increase with ion mass and to follow a simple law; it was about 10 times more rapid for ZnS than for the other two phosphors. Organic phosphors were found to undergo deterioration when bombarded by electrons, the effect being correspondingly smaller than in the case of ion bombardment.

537.228.1 735
Voltage Measurements on Rochelle Salt under Compressive Stress—B. Püschel. (*Arch. tech. Messen.*, pp. 197–198; Sept. 1952.) A 50-g weight was dropped from different heighst on to a Rochelle-salt crystal contained between brass plates 1 mm thick. Voltages up to 600 V were developed.

537.311.33 736
Electronic States in Crystals under Large Over-All Perturbations—P. Feuer. (*Phys. Rev.*, vol. 88, pp. 92–100; Oct. 1952.) Solutions of the three-dimensional Schrödinger equation are discussed for a potential which is the sum of a potential with the periodicity of the crystal lattice plus a disturbing potential. General theory developed for large perturbations is applied to a one-dimensional crystal in a uniform electric field, using the narrow-band approximation; the probability for an electron to cross a forbidden energy band is calculated. The results are considered in relatio nto the observations of McAfee et al. (164 of 1952) on Ge *p-n* junction.

537.311.33 737
On the Electrical Properties of Porous Semiconductors—E. B. Hensley. (*Jour. Appl. Phys.*, vol. 23, pp. 1122–1129; Oct. 1952.) Calculations are made of the component of conductivity due to the presence of an electron gas in the pores of a semiconductor, such as the oxide coating of a cathode, on the basis of simplified pore models. The conditions are indicated for which this component can become an appreciable part of the total conductivity. The thermoelectric power is also investigated.

537.311.33:[546.28+546.289 738
Properties of Silicon and Germanium—E. M. Conwell. (Proc. I.R.E., vol. 40, pp. 1327–1337; Nov. 1952.) The latest available information on the fundamental properties of Ge and Si is presented in tables and curves. Electrical properties, especially carrier density and mobility, are treated in greatest deaial.

537.311.33:546.289 739
P-N Junctions by Impurity Introduction through an Intermediate Metal Layer—L. D. Armstrong. (Proc. I.R.E., vol. 40, pp.1341–1342; Nov. 1952.) Indium is melted on to a gold-plated area on the surface of a Ge *n*-type crystal and diffuses into the Ge to form a *p-n* junction with a well-defined area.

537.311.33:546.289 740
Lifetime of Injected Carriers in Germanium—D. Navon, R. Bray and H. Y. Fan. (Proc. I.R.E., vol. 40, pp. 1342–1347; Nov. 1952.) Carrier lifetime was determined from measurements of the variation of the conductance of the test piece after production of excess carriers by applying a voltage pulse. The effect of heat treatment was also investigated.

537.311.33:546.289 741
Measurement of Minority-Carrier Lifetime in Germanium—L. B. Valdes. (Proc. I.R.E., vol. 40, pp. 1420–1423; Nov. 1952.) Equipment is described in which the carriers are liberated optically on a flat face of a crystal,

their concentration then being measured as a function of distance from the point of liberation. Lifetimes from a few to several hundred microseconds can be determined.

537.311.33:546.289 742

Activation Energy of Heat-Treatment-Introduced Lattice Defects in Germanium—R. M. Baum and C. S. Hung. (*Phys. Rev.*, vol. 88, pp. 134–135; Oct. 1952.) Hall-coefficient and resistivity measurements are reported on two single crystal samples converted from *n*-type to *p*-type by heat treatment. The values deduced for the thermally produced acceptors, viz. 0.058 and 0.047 eV respectively, are considerably higher than for chemically produced acceptors; this result is in general agreement with that of Dunlap (*Phys. Rev.*, 1st July 1952, Vol. 87, No. 1, p. 190.)

537.311.33:546.289 743

***p-n* Junctions produced by Growth-Rate Variation**—R. N. Hall. (*Phys. Rev.*, vol. 88, p. 139; Oct. 1952.) More than 100 uniformly spaced *p-n* junctions have been formed in an ingot of Ge by periodically varying the rate of growth of the crystal from the melt. The process depends on the presence in the melt of two impurities of opposite type, eg Sb (*n* type) and Ga or In (*p* type), whose segregation constants vary at different rates with rate of growth.

537.311.33:546.289:548.55 744

Preparation of Germanium Single Crystals—L. Roth and W. E. Taylor. (PROC. I.R.E., vol. 40, pp. 1338–1341; Nov. 1952.) Description of two methods, using a vacuum furnace with HF induction heating. In the first method the crystal is grown in the crucible by controlling the rate of cooling; in the second, a seed crystal is gradually withdrawn from the surface of the melt.

537.311.33:621.314.632 745

Cadmium-Sulfide Crystal Rectifiers—(*Electronics*, vol. 25, pp. 189, 192; Dec. 1952.) Long hexagonal *n*-type CdS crystals were tested for rectifier properties; the influence of orientation, mounting, and impurities was investigated. Point-contact rectifiers were obtained, optimum rectification occurring at 7 V. Transistor action was not obtained, but is thought to be possible.

537.311.33:621.314.7 746

Transistor Electronics: Imperfections, Unipolar and Analog Transistors—W. Shockley. (PROC. I.R.E., vol. 40, pp. 1289–1313; Nov. 1952.) A detailed discussion of the physics of transistors, particularly as regards the properties of holes and electrons and the effects of impurities, together with a description of transistor action and of a new class of unipolar transistors, some of which, from their similarity to tubes, are termed analogue transistors.

537.311.33:621.396.822 747

Current Noise in Semiconductors. A Reexamination of Bernamont's Data—D. A. Bell. (*Phil. Mag.*, vol. 43, pp. 1017–1111; Oct. 1952.) The results obtained by Bernamont (1715 of 1937) on thin metal films, here regarded as semiconductors, indicated that current noise varied approximately inversely with frequency over the range 96 cps–162 kc. On adjusting his results to make allowance for Johnson noise and for the supposed loss of a factor of 10 in the calculations, the noise from his resistor "B" closely follows the inverse-frequency law for all current densities.

537.311.33:621.396.822 748

Current Noise in Semiconductors—D. A. Bell. (*Wireless Eng.*, vol 30, pp. 23–24; Jan. 1953.) Discussion of the law relating the frequency spectrum of the noise voltage with the current in a semiconductor.

538.114 749

Magnetic Domains—H. J. Williams. (*Bell Lab. Rec.*, vol. 30, pp. 385–396; Oct. 1952.) The domain structure of magnetic materials is shown by numerous microphotographs and diagrams, and electron-spin changes and domain-boundary movement under the action of a magnetic field are illustrated by diagrams and models.

538.221 750

Applications and Properties of Ferroxcube—(*Electronic Appl. Bull.*, vol. 13, pp. 44–58; March/April 1952.) Tables and numerous curves are given which show the properties and operating characteristics of the various available types and grades of ferroxcube, so that the material most suitable for a particular application can easily be selected.

538.221 751

Ferromagnetic Properties of Hexagonal Iron-Oxide Compounds with and without a Preferred Orientation—G. W. Rathenau, J. Smit and A. L. Stuyts. (*Z. Phys.*, vol. 133, pp. 250–260; Sept. 15, 1952, In English.) An account of ferroxdure, a ceramic material with the composition $BaO.6Fe_2O_3$, has previously been given [2824 of 1952 (Went et al.)]. Materials of about this composition are here discussed. The variation of the magnetization with the strength of the applied field is shown graphically. The formation of Bloch walls results in irregularities in the crystal structure. With regular crystal distribution and crystals above a certain critical size, demagnetization by Bloch-wall displacement can occur for positive field strengths of about $4\times I_s$, where I_s is the saturation magnetization. When crystal-orientation processes are applied to ferroxdure materials, BH_{max} values of 3×10^6 gauss.oersted can be reached. An improvement of the texture of these ceramics is obtained by increase of grain size.

538.221 752

A New Method of Melting Ferromagnetic Semiconductors. $BaFe_{18}O_{27}$, a New Kind of Ferromagnetic Crystal with High Crystal Anisotropy—H. P. J. Wijn. (*Nature* (London), vol. 170, pp. 707–708; Oct. 1952.) An account is given of the HF method used in melting a mixture of Fe_3O_4 and $BaCO_3$ in an atmosphere of N_2; an alumina crucible was used, with a lid of Rh or Ir to give additional surface heating. From one melt a crystal with the composition $BaFe_{18}O_{27}$ was obtained. This has a structure resembling that of $BaFe_{12}O_{19}$ [2824 of 1952 (Went et al.)] and exhibits very high crystal anisotropy.

538.221:548.0 753

Coercive Force and Crystal Energy—W. Gerlach. (*Z. Phys.*, vol. 133, pp. 286–290; Sept. 15, 1952.) Sintered Ni rods show an increase of coercive force with decreasing temperature proportional to the square root of the crystal energy. Wires of solid Ni annealed for a long time at a moderate temperature show a similar effect, but sintered Fe and Co rods exhibit anomalous effects.

538.221:548.1.023 754

Crystal Structure of $BaFe_{18}O_{27}$—P. B. Braun. (*Nature* (*London*) vol. 170, p. 708; Oct. 25, 1952.) Results are tabulated of an X-ray investigation of the crystal mentioned by Wijn (752 above).

538.221:621.392.26 755

Magnetic Double Refraction at Microwave Frequencies—M. T. Weiss and A. G. Fox. (*Phys. Rev.*, vol. 88, pp. 146–147; Oct. 1952.) Magnetic double refraction has been observed at 24 and 9 kmc, evidenced by a conversion from linear to elliptical polarization of a dominant *TE* wave in a circular waveguide filled with ferrite and subjected to a dc magnetic field transverse to the direction of propagation and at 45° to the initial direction of polarization. The double refraction is attributed to the difference between the RF permeability parallel to and transverse to the field.

538.23 756

A Relation between Hysteresis Coefficient and Permeability—M. Kornetzki. (*Z. angew. Phys.*, vol. 4, pp. 343–345; Sept. 1952.) Assuming for simplicity that the magnetization curves of various materials, measured in closed magnetic circuits, are distinguished from one another only by different scale factors, it is shown that the relative hysteresis coefficient is proportional to the initial permeability and inversely proportional to the saturation induction. Measurements on Ni-Zn ferrites with initial permeabilities of 30–1500 indicate hysteresis coefficients differing among themselves by a factor of 50, though the ratio of hysteresis coefficient to initial permeability varies only by a factor of 3.

538.242 757

A New Gyromagnetic Effect in Permalloy and Iron—S. J. Barnett and L. A. Giambomi. (*Phys. Rev.*, vol. 88, pp. 28–37; Oct. 1, 1952.) Experiments were made with long cylinders of compressed powder material magnetized axially nearly to saturation and subjected to a weak transverse alternating magnetic field of period much greater than the relaxation time. A transverse magnetization was observed perpendicular to the applied alternating field. Measured values of the effect are in substantial agreement with results of earlier experiments.

539.234 758

The Contamination in Evaporated Films by the Material of the Source—O. S. Heavens. (*Proc. Phys. Soc.*, vol. 65, pp. 788–793; Oct. 1952.) A microchemical and a radioactive-tracer method were used to investigate contamination of Ag and Ge films by the boats or filaments used in the vaporization process. One or two parts of W or Mo in 10^7 can be detected by the tracer method. Minimum contamination attainable was of the order of a few parts in 10^6.

546.431.824–31:539.11 759

Domain Properties in $BaTiO_3$—W. J. Merz. (*Phys. Rev.*, vol. 88, pp. 421–422; Oct. 1952.) Short account of investigations of the arrangements and movements of the ferroelectric domains in single crystals of $BaTiO_3$ under the influence of an electric field. Only so-called 90° walls have hitherto been reported, but the smaller 180° walls constituting the true domain boundaries have now been observed. The average width of these antiparallel domains, as measured by means of a microscope, is from 0.1 μ to about 10 μ. Observations were made of domain movements corresponding to each step of a hysteresis loop. More detailed studies of the number of domains, their velocities and relaxation times, are being made by applying very short rectangular electrical pulses.

621.3.042.143:538.221 760

Ultrathin Magnetic Alloy Tapes with Rectangular Hysteresis Loops—M. F. Littmann. (*Elec. Eng., N.Y.*, vol. 71, pp. 792–795; Sept. 1952.) Text of paper presented at A.I.E.E General Meeting, June 1952. Report of an experimental study of high-permeability and high-resistivity tapes, suitable for cores for hf applications. Thicknesses range from $\frac{1}{8}$ to 1 mil.

621.314.2.042.143 761

Core Materials for Small Transformers—C. C. Horstman. (*Tele-Tech*, vol. 11, pp. 40–42, 90; Oct. 1952.) Discussion of the reduction in transformer weight and electrical losses effected by the use of hypersil cores produced from strip material of thickness 1–5 mil. A recent development is the forming of longitudinal grooves in the thin strip prior to winding into a core. This results in increased rigidity and higher stability under temperature cycles. Improvements in Ni-alloy materials are also noted, such as the production of strip materials of thickness only 1 mil, with retention of high permeability and low coercive force.

621.318.1.042.15 762
The Production and Application of Magnetic Powders—G. R. Polgreen. (*G. E.C. J.*, vol. 19, pp. 152–169; July 1952.) A description is given of modern methods and equipment for the manufacture of Fe and Cu-Ni-Fe-alloy (Gecalloy III) powders; the chemical methods used result in reduced losses and improved stability. The properties of these powders and of the resulting cores are compared with corresponding properties of commercially available sheet materials and ferrites.

MATHEMATICS

517.511 763
The Decomposition of Functions—J. W. Head. (*Proc. Camb. Phil. Soc.*, vol. 48, part 4, pp. 742–743; Oct. 1952.) Discussion of functions of the step-voltage type. If $f(t)$ approaches asymptotically the value $tn\ e^{-t}$ when the time scale is suitably chosen, $f(t)$ can be decomposed into a series of Laguerre functions which are mutually orthogonal over the range $0-\infty$. The coefficients in this series are here obtained in terms of the various Laguerre functions and of $f(t)$ and $dL_n(t)/dt$ when the Laguerre function $L_n(t)$ has a zero. An explicit formula is derived involving functions which can be calculated and tabulated.

517.942.82 764
General Rules for Laplace Transformation U. Kirschner. (*Funk u. Ton*, vol. 6, pp. 541–547; Oct. 1952.) A statement of general relations applying in different mathematical operations.

681.142 765
MONECA—A New Network Calculator for Motor Performance Calculations—C. G. Veinott. (*Elec. Eng. N.Y.*, vol. 71, pp. 795–801; Sept. 1952.) Text of paper presented at A.I.E.E. General Meeting, January 1952. Description of an analogue computer for calculations on single-phase induction motors.

681.142:621.314.7 766
An Optical Position Encoder and Digit Register—H. G. Follingstad, J. N. Shive and R. E. Yaeger. (PROC. I.R.E., vol. 40, pp. 1573–1583; Nov. 1952.) Transistor circuits are used in a small unit which performs the operations of 6-digit photoelectric encoding, pulse regeneration, digit storage, reflected-to-natural binary translation, and digit shifting.

681.142:621.314.7 767
A Transistor Shift Register and Serial Adder—J. R. Harris. (PROC. I. R.E. vo.. 40, pp. 1597–1602; Nov. 1952.) Equipment is described which can store a pair of binary numbers, add them, and produce the sum a digit at a time. The equipment is constructed from primary transistor units including a flip-flop circuit, pulse amplifiers with and without delay, and diode gate circuits.

681.142:621.395.625.3 768
On Two Problems in Potential Theory and their Application to the Design of Magnetic Recording Heads for Digital Computers—A. D. Booth. (*Brit. Jour. Appl. Phys.*, vol. 3, pp. 307–308; Oct. 1952.) Both theory and experiment indicate that the field outside the gap depends very little on the particular shape of pole-piece.

681.142:621.396.645:621.314.7 769
Regenerative Amplifier for Digital Computer Applications—J. H. Felker. (PROC. I.R.E. vol. 40, pp. 1584–1596; Nov. 1952.) An amplifier using a point-contact transistor is used to regenerate digital information at a rate of 10^6/sec and to develop pulses with rise times $<0.05\ \mu s$.

MEASUREMENTS AND TEST GEAR

531.76 770
A Combined Timer and Cycle Counter—P. Huggins. (*Electronic Eng.*, vol. 24, pp. 578–579; Dec. 1952.) Description, with full circuit details, of a unit which combines the functions of timer and cycle counter (2841 of 1952) within the range 0.02–2.64 sec. Two 12-position dekatron tubes are used which provide visual indication of the time, in steps of 1/50 sec, as the apparatus operates. Conversion from timer to cycle counter is effected by a simple switch.

531.76:621.318.57:621.317.755 771
A Dekatron C.R.O. Time Marker—J. H. L. McAuslan. (*Electroinc Eng.*, vol. 24, pp. 567–569; Dec. 1952.) Description, with detailed circuit diagram, of equipment using Type-Gc10B dekatrons to provide longer time-markers on the screen of a cro at each tenth pulse, with additional negative markers for each hundredth pulse.

621.316.8(083.74) 772
Gold-Chromium Standard Resistors—A. Schulze and H. Eicke. (*Z. angew. Phys.*, vol. 4, pp. 321–324; Sept. 1952.) Experiments during the last 15 years have shown standard resistors made of Au-Cr alloy to be superior to those made of manganin. New constructions are described in which the resistance coil is housed in an argon-filled glass envelope; these types are suitable for measurements of the greatest precision, and are designated principal standard resistors.

621.317.328.089.6 773
Calibration of Commercial Field-Strength Meters—C. C. Cook. (*Tele-Tech*, vol. 11, pp. 44–46. 99; Oct. 1952.) An account of the service provided by the National Bureau of Standards, with an outline of the methods of calibration of meters operating in the ranges 10 kc–30 mc and 30–300 mc.

621.317.336.029.64 774
The Determination of Impedance with a Double-Slug Transformer—R. C. Ellenwood and E. H. Hurlburt. (PROC. I.R.E., vol. 40, pp. 1690–1693; Dec. 1952.) Formulae are derived by means of which the required impedance can be determined from a knowledge of the length, spacing, position and "effective" dielectric constant of the slugs. A method of determining the "effective" dielectric constant experimentally is described. Results of accuracy comparable with those given by a precision slotted-line method have been obtained.

621.317.337:621.396.611.1 775
***Q*-Factor Measurements**—A. G. Wray (*Marconi Instrumentation*, vol. 3, pp. 118–123; Oct. 1952.) The Q factors of single reactive components and of complete oscillatory circuits are discussed. The principles of measurement methods are outlined, and resistive, inductive and capacitive methods of injecting the necessary small test emf are considered.

621.317.351:534.442.2 776
Audio-Frequency Spectrum Analysis—W. Sagajiblo: S. V. Soanes. (*Electronic Eng.*, vol. 24, p. 581; Dec. 1952.) Comment on 3171 of 1952 and author's reply.

621.317.352:621.395 777
Reference-Level Test Equipment with Direct Indication, and its Importance for the Improvement of Telephony—K. Braun and H. Koschel. (*Fernmeldetech. Z.*, vol. 5, pp. 447–455; Oct. 1952.) Description of apparatus, including artificial mouth and artificial ear, suitable for tests on complete telephone circuits or on individual items of equipment.

621.317.7.029.6:621.396.615.141.2 778
Microwave Devices for Magnetron Production Testing—M. Nowogrodzki. (*Tele-Tech*, vol. 11, pp. 36–37, 111; Oct. 1952.) Outline description of (*a*) a cavity-resonator type of wavemeter using a neon lamp for visual indication of resonance, (*b*) equipment for measurement of output power, using a water load, (*c*) a rf power monitor for use in life tests.

621.317.7.029.62/.63:621.392 779
Helical Measuring Line for Microwaves—F. Tischer. (*Z. angew. Phys.*, vol. 4, pp. 345–350; Sept. 1952.) A line of considerably reduced length and of characteristic impedance 50 Ω comprises a helical conductor wound in a groove in an insulating sleeve on an axial conductor, the whole being enclosed in a coaxial tube with a slot through which projects as inductive probe of a type previously described (3048 of 1951). When the parameters are correctly chosen, phase and amplitude fluctuations along the line are $<1\%$ over the frequency range 250 mc–2 kmc. The accuracy of measurements made with this line is equal to that with a medium-quality straight line.

621.317.725.088.22:621.385.2 780
Diode Tube-Voltmeter Errors—G. D. Morgan. (*Electronic Eng.*, vol. 24, pp. 575–577; Dec. 1952.) Discussion based on experience with a voltmeter using a Type-VR78 (Mazda-D.1) diode, of the magnitude of the possible errors in diode voltmeters.

621.317.733:621.317.374 781
New Method for the Measurement of Dielectric Loss Angle—L. Schnell (*Elektrotechnika, Budapest*, vol. 45, pp. 264–268. Discussion, pp. 268–269; Sept. 1952.) A bridge arrangement is described in which the voltage across the meter diagonal is a nearly linear function of tan δ.

621.317.733.029.51/.63:621.317.335 782
A Measurement Bridge for 0.1–1000 Mc/s—H. Voigt. (*Arch. elekt. Übertragung*, vol. 6, pp. 414–418; Oct. 1952.) The four capacitors constituting the arms of the bridge are formed by a set of parallel disks within a cylindrical screen. A flat test sample of a material whose dielectric properties are to be determined is introduced between one end plate and the removable end of the screen. The other end plate has a micrometer adjustment for balancing the bridge. A rectifier and tube voltmeter serve as balance indicator. A cylindrical type of construction is also shown that is suitable for measurements on liquid dielectrics. Typical results for the variation of dialectric constant and loss angle of PVC with the amount of softening agent and with frequency are shown in diagrams.

621.317.737.088.22:621.3.012.3 783
***Q*-Meter Correction Chart for *Q*-Voltmeter Loading**—R. Lafferty. (*Tele-Tech*, vol. 11, p. 43; Oct. 1952.) An abac is given for correcting errors due to the shunting effect of the input resistance of the tube voltmeter used in the measurements.

621.317.755:621.314.7.012 784
Oscilloscopic Display of Transistor Static Electrical Characteristics—N. Golden and R. Nielsen. (PROC. I.R.E., vol. 40, pp. 1437–1439; Nov. 1952.) Description, with schematic circuit diagram, of cro equipment permitting rapid comparison with a standard.

621.317.755:621.396.6 785
Slow-Speed Circular Timebase—(See 673.)

621.317.78.029.6 786
A Laboratory Power Meter—E. F. Schelisch. (*Marconi Rev.*, vol. 15, pp. 167–173; 4th Quarter 1952.) Two cartridge-type Si-crystal diodes are connected as shunt elements $\lambda_0/4$ apart in a coaxial line, a matching transformer being fixed between them. Power measurement to within 0.1 db is achieved over a range of 40 db or more in the microwave band. Possible uses of the device as a FM discriminator, an

a.m. demodulator, or a frequency multiplier, are illustrated and discussed.

621.396.645.35 787

A High-Sensitivity Direct-Voltage Amplifier with High Input Resistance—W. Kroebel. (*Z. Phys.*, vol. 133, pp. 30–40; Sept. 1952.) A new type of contact breaker is described which uses a flexural type of double quartz plate as its vibrator. A type of construction is used in which the contact gap is completely screened from the exciting voltage applied to the crystal. Application is made to the amplification of direct voltages from sources of very high internal resistance. Full circuit details of an amplifier are given with which, for a bandwidth of 1 c/s and input resistance of 100 MΩ, a power of about 5×10^{-20} W can be measured.

621.396.822.029.64:621.327.3 788

The Design of Microwave-Noise Generators—P. M. Ratcliffe. (*Marconi Instrumentation*, vol. 3, pp. 124–127; Oct. 1952.) Mumford (929 of 1950) showed that an ordinary Hg-vapor discharge lamp mounted in a waveguide acts as a good noise source for the 6-cm band. Similar sources have now been produced for the S and X bands at 10 cm and 3.2 cm. The new tubes are about 9 in. long and $\frac{3}{8}$ in. in diameter, and are filled with a Hg-vapor and Ar mixture at a pressure of 30 mm Hg, the dc power consumption for reliable operation being about 10 W. A filament is fitted at each end, one being heated by ac to assist in starting the discharge. Matching of the source to the waveguide is effected for the X-band mounting by insertion of the tube in the E plane of the waveguide at an angle of 10° to the waveguide axis. For the S-band mounting an H-plane fitting is used with the tube at right angles to the narrow walls of the waveguide. The generators deliver a noise-power output about 15 db above zero level.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

53.087.55:771.4 789

Photographic-Exposure Timers providing Compensation for Supply-Voltage Variations—R. J. Hercock and D. M. Neale. (Proc. I.R.E., vol. 99, pp. 507–515; Part II, Oct. 1952.) Description of a circuit giving exposure times, at the nominal supply voltage, continuously adjustable from 1 sec to 1 min or more, with an intensity-time product constant to within ±5% for supply-voltage variations from +15% to −20%.

534.1.08 790

Vibration Measurements—R. Winslade. (*Electronic Eng.*, vol. 24, pp. 553–557; Dec. 1952.) Description of a pickup unit, with spring-supported coil moving in a magnetic field, for measuring vibration amplitudes, velocities and accelerations.

621.315.3.001.41 791

Continuous Measurement of Cable Diameters—E. C. R. Scarfe. (*Elect. Times*, vol. 122, pp. 399–401; Sept. 1952.) The extruded cable runs between a pivoted tungsten-carbide stylus and a rotating anvil. Movement of the stylus varies the air gap between a fixed quartz crystal and one of its electrodes. The frequency variations derived from the capacitance change modulate a 100-kc carrier. The direct voltage obtained via conventional discriminator and output circuits is applied to a meter, calibrated in thousandths of an inch, which shows deviations from a preset nominal diameter.

621.316.7:621.314.7 792

Control Applications of the Transistor—E. F. W. Alexanderson. (Proc. I.R.E., vol. 40, pp. 1508–1511; Nov. 1952.) The possibility is examined of using transistors for control functions at present performed by magnetic amplifiers, amplidynes and thyratrons. A transistor controlled by auxiliary transistors can function in a manner similar to that of a phase-controlled rectifier, and has certain definite advantages.

621.317.083.7:551.510.535 793

High-Altitude Research—Burgess. (See 726.)

621.384.6:621.317.083.7 794

A Telemetering System for a Large Electrostatic Accelerator—C. W. Johnstone, J. F. Kalbach and H. J. Lang. (Proc. I.R.E., vol. 40, pp. 1664–1674; Dec. 1952.) Description of the 16-channel pulsed-light-beam system used for monitoring and controlling the ion source, focusing and belt charging in the 12-MeV es accelerator nearing completion at Los Alamos.

621.385.833 795

Electron-Optical Properties of Electrostatic Lenses—W. Lippert and W. Pohlit. (*Optik, Stuttgart*, vol. 9, no. 10, pp. 456–462; 1952.) Results of experimental investigations are presented as families of curves from which the electron-optical properties of an e.s. lens of the symmetrical 3-electrode type can be determined from the parameters of the electrode system.

621.387.4 796

Self-Quenching Parallel-Plate Vapour-Filled Counters with Operating Voltages below the Static Breakdown Field Strength—J. Christiansen. (*Z. angew. Phys.*, vol. 4, pp. 326–329; Sept. 1952.)

621.397.424 797

Geiger Counter Tubes—N. B. Balaam. (*Electronic Eng.*, vol. 24, pp. 558–561; Dec. 1952.) Description of the construction and characteristics of a series of counter tubes for various specific purposes. All are of the cylindrical gas-filled type, with halogen or organic quenching agent.

621.387.424:537.525.92 798

Remark on the Space-Charge Sheath of the Geiger Counter—D. H. Wilkinson. (*Rev. Sci. Instr.*, vol. 23, pp. 463–464; Sept. 1952.) The popular notion of the Geiger-counter space-charge sheath as a thin expanding shell requires modification. Owing to the considerable charge transported in the sheath, it grows in thickness as it crosses to the cathode and may occupy more than half the total volume of the counter. The attendant wide spread in arrival time of the positive ions at the cathode may explain, to some degree, the time distribution of spurious counts.

621.387.424:539.26 799

A [Geiger-Müller] Counter Arrangement for X-Ray Interference Measurements—R. Berthold and A. Trost. (*Schweiz. Arch. angew. Wiss. Tech.*, vol. 18, pp. 277–282; Sept. 1952.)

621.791.3:534.321.9 800

Ultrasonic Tinning Techniques for Aluminum—A. E. Crawford. (*Electronics*, vol. 25, pp. 102–105; Dec. 1952.) The ultrasonic iron described uses a self-driving longitudinally excited magnetostriction element made of Co-Fe alloy laminations and operated as a λ/2 resonator. The frequency is about 20 kc. A proposed plant for continuous tinning of Al wire is also described.

621.791.3:534.321.9 801

Ultrasonic Tinning of Aluminum—P. Wenk and H. Boljahn. (*Z. Metallkde*, vol. 43, pp. 322–324; Sept. 1952.) Description of an ultrasonic soldering tool using a 20-kc Ni magnetostriction oscillator, with illustrations of tests on sheet Al, using pure Sn as solder.

PROPAGATION OF WAVES

538.566.029.45/.51:551.594.6 802

Propagation of Very Long Electromagnetic Waves, and the Wave Spectrum of Lightning—W. O. Schumann. (*Naturwiss.*, vol. 39, pp. 475–476; Oct. 1952.) Regarding lightning as a Dirac current pulse, a formula derived for the wavelength of maximum intensity (λ_m) shows that λ_m increases as the square of the distance from the point where the flash occurs. The impulse received at a distance from the flash is the Fourier integral of the spectral components of the wave, a formula for which is given. The actual pulse shape for a lightning flash probably favors the lower frequencies in the spectrum. A detailed account of the investigation is to be published in *Z. angew. Phys.*

538.566.2 803

A Method of Solving the Wave Equation in a Region of Rapidly Varying Complex Refractive Index—J. J. Gibbons and R. L. Schrag. (*J. Appl. Phys.*, vol. 23, pp. 1139–1142; Oct. 1952.) The equation for wave propagation in an ionized medium is transformed into an integro-differential equation with only one real dependent variable, thus avoiding the need to solve two simultaneous differential equations. The solution yields one of the two wave functions directly, the second being derived from the first by direct integration. The method is illustrated by computing the reflection coefficient for a region where the refractive index passes through a sharp peak.

621.396.11 804

Scattering of Electromagnetic Energy in a Randomly Inhomogeneous Atmosphere—H. Staras (*Jour. Appl. Phys.*, vol. 23, pp. 1152–1156; Oct. 1952.) First-order perturbation theory is used to derive an integral representing the scattered power at a receiver resulting from random inhomogeneities in the propagating medium. The expression obtained corresponds with that used by Booker and Gordon (1757 of 1950), but instead of the space-correlation function of refractive index used by them a time-correlation function is introduced which permits evaluation of the time average of the scattered power; this time-correlation function is directly measurable. For small-scale turbulence the average scattered power is not affected by the particular model of atmospheric turbulence chosen; for large-scale turbulence the results depend on the particular time-correlation function chosen and on particular assumptions regarding the scattering bodies.

621.396.11 805

Effect of Magnetic Field in Oblique Propagation over Equatorial Region—B. Chatterjee. (*Indian J. Phys.*, vol. 26, pp. 297–312; June 1952.) Curves of the Booker type (422 of 1939) are presented for the case of propagation across an equatorial region, and the phenomenon of lateral deviation is discussed. Propagation curves are also given for the particular transmission paths Calcutta-Bandoeng and Calcutta-Bombay. The calculations were made for the case of a flat stratified layer over a flat earth, so that correction factors are required to take account of the earth's curvature.

621.396.11.029.51:551.510.535 806

The Polarization of Vertically Incident Long Radio Waves—J. M. Kelso, H. J. Nearhoof, R. J. Nertney and A. H. Waynick. (*Ann. Géophys.*, vol. 7, pp. 215–244; Oct./Dec. 1951, In English.) Analytical expressions relating the distribution of electron concentration and collision frequency in the ionosphere to the polarization characteristics are derived, the wave being treated as a single magneto-ionic component. Measurements made on a frequency of 150-kc are reported and interpreted. A model of the D and E layers is assumed which gives theoretical results in good agreement with experimental observations. See also 517 of February (Gibbons and Nertney).

621.396.11.029.55:551.510.535 807

Ionospheric Measurements at Oblique Incidence over Eastern Australia—M. Strohfeldt, R. W. E. McNicol and G. de V. Gipps. (*Aust. Jour. Sci. Res., Ser.*, vol. 5, pp. 464–472; Sept. 1952.) An account of attempts made to identify night-time ionosphere reflecting layers by measuring apparent path lengths of pulsed transmissions on 5.8 mc over a baseline of 763 km, using responder technique. The characteristics of beacon triggering are discussed in relation to the type of echo received. Correlation was established between occurrences of E_s observed at oblique incidence and at vertical incidence near the mid-point of the trajectory. Unusual records of Pedersen rays are shown, and sudden height increases and diffuseness of F_2 echoes are discussed. A check on the oblique-incidence theory, using a Millington transmission curve in conjunction with vertical-incidence *h'f* records, yielded resonable agreement between measured and deduced reflection heights. A rough analysis of oblique-incidence pentrations showed that the average frequency separation of the ordinary-ray and the extraordinary-ray m.u.f. was about half the gyromagnetic frequency.

621.396.81 808
A Comparison of C.W. Field Intensity and Backscatter Delay—W. L. Hartsfield and R. Silberstein. (Proc. I.R.E., vol. 40, pp. 1700–1706; Dec. 1952.) The relation between back-scatter and skip phenomena was investigated by comparing the intensity of the 15-mc WWV signals, received at White Sands in New Mexico, with the recorded delay times for the back-scatter received at Sterling, Virginia, from a pulse transmitter operating at about the same frequency. Rapid variations in the back-scatter records for disturbed days correspond in order of magnitude with previously observed motions of ionosphere irregularities.

621.396.81.029.62 809
Field Strengths Recorded on Adjacent F.M. Channels at 93 Mc/s over Distances from 40 to 150 Miles—G. S. Wickizer and A. M. Braaten. (Proc. .R.E., vol. 40, pp. 1694–1699; Dec. 1952.) Analysis of records of the field strength received from stations KE2XCC (93.1 mc, Alpine, N. J.) and WBZ-FM (92.9 mc, Boston, Mass.) over a period of more than a year at two places on Long sland. For the evening hours there is a seasonal trend towards higher intensities in summer. The over-all variations were larger for the longer transmission paths. The hourly distribution curves are discussed in relation to possible modes of propagation.

RECEPTION

621.396.62 810
Receiver Production of the VVB-RFT—A. Blaha. (*NachrTech.*, vol. 2, pp. 261–264; Sept. 1952.) Short descriptions of the special features of some of the best types of receiver produced by this East German nationalized industry in 1952.

621.396.62(083.7) 811
Standards on Receivers: Definitions of Terms, 1952—(Proc. I.R.E., vol. 40, pp. 1681–1685; Dec. 1952.) Standard 52 RE 17.S1.

621.396.621:621.396.662 812
A Method of Band-Spreading—C. A. Parry. (Proc. I.R.E., vol. 13, no. 10, pp. 365–369; Oct. 1952.) Analysis of a capacitive type of circuit for use in communication receivers shows that it is possible to obtain frequency bands of equal width and constant gain with simple circuits, certain requirements being imposed on the tuning inductors used on each range. Errors due to stray capacitance increase with frequency and cannot be neglected beyond a certain limit, but this limit can be made to lie above the highest operating frequency by suitable circuit design. A suggested design procedure is outlined.

621.396.621.54:621.385.5 813
Application of the DK92 Tube on 30 Mc/s—H. H. van Abbe and J. Jager. (*Electronic Appl. Bull.*, vol. 13, pp. 1–7; January, 1952.) Full circuit details are given of a frequency changer for the ranges 3.3–10 mc and 8.8–30 mc. A single Type-DK92 heptode is used; this is a 50-mA miniature heptode with a variable-μ characteristic making it suitable for agc.

621.396.621.54:621.396.82 814
Microphony in Superhet Oscillators—H. Stibbé. (*Wireless World*, vol. 58, pp. 504–506; vol. 59, pp. 35–38; Dec. 1952 and Jan. 1953.) Microphony in the oscillators of superheterodyne receivers is caused by a frequency-discriminator action of the IF amplifier plus detector when the tuning is not quite correct. It can be prevented in some circumstances by using an over-critically coupled IF amplifier, thus permitting a greater degree of detuning before the discriminator action starts. A numerical calculation is made of the effect of vibration of tuning-capacitor plates for a typical case; the figures indicate that the highest possible degree of rigidity and symmetry are required in the assembly of this component. Methods are described for mounting it with good mechanical insulation. Measurements of the microphony-free output of a receiver are also described.

621.396.822:621.396.62 815
Noise in Receivers and Amplifiers—S. Gratama. (*Tijdschr. ned. Radiogenoot.*, vol. 17, pp. 207–247; Sept./Nov. 1952.) The various causes of noise in receivers are surveyed. The physical mechanisms of shot effect, induced grid noise and total-emission noise in valves are explained. Practical use can be made of the correlation which exists between induced grid noise and shot effect to reduce the noise caused by the latter. 59 references.

621.396.822:621.396.621 816
A Note on the Approach of Narrow-Band Noise after a Nonlinear Device to a Normal Probability Density—G. R. Arthur. (*Jour. Appl. Phys.*, vol. 23, pp. 1143–1144; Oct. 1952.) From the integral equation derived by Kac and Siegert (3645 of 1947) for the output of a low-pass filter preceded by a nonlinear device excited by a noise source, the first three central moments of the probability density of the output signal are obtained and the approach of these moments to those of a Gaussian density is demonstrated.

621.396.822.029.62 817
V.H.F. Radio Noise—E. G. Hamer. (*Wireless World*, vol. 59, p. 43; Jan. 1953.) Total-noise measurements were made at typical sites, during the latter part of 1950, at frequencies of 77 and 172 mc. The noise level was much less in the country and in residential areas than in industrial areas; there was no noticeable difference between the levels obtaining with horizontal and with vertical polarization. The variation of noise level with distance from a main road was also investigated. The general atmospheric noise level was greater in all cases than that due to thermal noise alone, but was less at the higher frequency; in an industrial area the net result might be appreciably better reception at 172 than at 77 mc.

621.396/.397].828 818
Radio Interference Suppression [Book Review]—G. L. Stephens. Publishers: Iliffe & Sons, London, 132 pp., 10s 6d; 2nd ed. 1952. (*Electronic Eng.*, vol. 24, no. 298, p. 585; Dec. 1952.) A practical guide to the various methods of eliminating interference with radio and television reception.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11:519.272 819
Contribution to the Statistical Study of Communications—S. Malatesta. (*Alta Frequensa*, vol. 21, pp. 163–198; Aug./Oct. 1952.) An introduction to the application of statistical methods in network theory, making use of the spectral-density and correlation functions and a criterion of network efficiency based on distortion. The statistical method is applied to the optimum noise filter of Wiener.

621.395.521.3:621.396.97 820
A Variable Equalizer for Broadcast-Programme Circuits on Trunk Lines—C. M. Hall. (*Telecommun. Jour.* (Australia), vol. 8, pp. 311–313; Oct. 1951.) Description of equipment designed to facilitate the work involved in equalizing trunk routes in Queensland, where several circuits are over 800 miles in length and two exceed 1000 miles. The equalizer finally adopted includes three units, one for correction of the low-frequency slope of the response curve, the next for the response hump usually occurring at about 150 c/s, and the last section for the high-frequency response. Plug-in attenuation pads are provided so that any reasonable degree of equalization can be obtained in each section.

621.396.333+621.396.5]:621.396.71 821
Navy V.L.F. Transmitter will radiate 1000 kW.—T. D. Hobart. (*Electronics*, vol. 25, pp. 98–101; Dec. 1952.) Description of transmitter sited at Jim Creek Valley, near Arlington, Washington, and planned to provide both cw and frequency-shift teleprinter communication with ships throughout the Pacific area, including submerged submarines. The twin 500-kW power amplifiers use a push-pull arrangement of Type-5831 water-cooled triodes, with 6-V thoriated tungsten filaments taking about 13 kW of heating power, and 11.5 kV anode voltage; each amplifier feeds half of the aerial. The tuning range is 14.5–35 kc. The aerial is suspended between two 3000-ft mountain ridges, and comprises a horizontal zig-zag of ten spans, arranged in two groups of five, with a 900-ft down-lead at the mid-point of each span. Facilities for a 46-man staff are provided on the 7000-acre site.

621.396.4 822
A Beam Radio System with Pulse-Phase Modulation for 12- and 24-channel Telephony Transmission—E. Hölzler and H. Holzwarth; H. Holzwarth and W. Arens; E. Schulz, G. Piefke and E. Seibt; W. Wild, U.v. Kienlin and H. Simon. (*Fernmeldetech. Z.*, vol. 5, pp. 397–405 and 456–467; Sept. and Oct. 1952.) Section A, Survey, by Hölzler and Holzwarth, outlines the general characteristics of the system, whose 4-mc frequency band can be selected at will in the range 2.45–2.7 kmc.

Section B, Modulation Equipment, by Holzwarth and Arens, describes in detail the modulation and demodulation arrangements for the two 12-channel groups.

Section C, High-Frequency Equipment, by Schulz, Piefke and Seibt, gives an account of the transmitters and receivers, and of the ring-modulator type of mixer used at the receiver input. One transmitter, with a power of 0.5 W, uses a disk-seal triode, Type 2C40, the other, with an output of 5 W, uses a Type-2C39A valve. Tuning is effected by varying the length of the grid cylinder. Control and monitoring equipment is also noted.

Section D, Aerial System, by Wild, v. Kienlin and Simon, describes the lens-type and parabolic aerials used, and also the filter and feeder arrangements. The radiation diagram of a parabolic aerial 3 m in diameter is shown and the operating characteristics of aerials respectively 3m, 2m and 1.2m in diameter are compared.

621.396.5:621.396.8 823
Comparison of Mobile Radio Transmission at 150, 450, 900, and 3700 mc—W. R. Young, Jr. (*Bell Sys. Tech. Jour.*, vol. 31, pp. 1068–1085; Nov. 1952.) An account is given of tests conducted in and around New York City. Sufficient test locations were used to give a statistical indication of the trend of performance with frequency variation. Variations of

aerial gain and frequency stability with frequency variation are taken into account. The transmitter power required to achieve the same coverage at different frequencies depends on the variation with frequency of both path loss and strength of signal required to produce satisfactory communication. The combination of these factors fixes a broad optimum-frequency band at about 500 mc; this frequency band is more suitable than all the others for a mobile radiotelephone service. The 900-mc band may be preferable to the 150-mc band if full use is made of aerial gain, but above 900 mc performance falls off rapidly.

621.396.712:621.395.6 824

Speech Input Systems for Broadcast Transmitters—S. Hill. (*Jour. Brit. I.R.E.*, vol. 12, pp. 533–541; Oct. 1952.) Text of paper presented at 1951 Radio Convention, London. Technical and economic factors involved in the design of the a.f. equipment are considered. Layout and switching requirements are reviewed. Microphones, amplifiers, level indicators, faders, mixers and recording arrangements are discussed.

621.396.712.3:534.84 825

The "Pierre Bourdan" Low-Frequency [broadcasting] Centre, Paris—L. Conturie. (*Onde élect.*, vol. 32, pp. 397–410; Oct. 1952.) A detailed account of the general lay-out of the establishment, the various studios and control and recording rooms, with particular reference to the methods of construction giving good sound insulation between the studios and their surroundings, and to the treatment of studio walls, ceilings, etc., to obtain the desired acoustic properties for faithful recording or high-quality transmission of programmes. See also 3318 of 1952 (Pujolle).

621.396.712.3:621.396.6 826

Broadcasting-Studio Installations and the New S.F.R. Equipment—J. Cordonnier and M. Bernard. (*Onde élect.*, vol. 32, pp. 411–422; Oct. 1952.) The relative merits of centralized and decentralized installations are discussed and descriptions are given of new equipment units, developed by the Société Française Radioélectrique, which are economical in use and retain all the essential advantages of the mixed type of installation. The units have been designed so that various combinations can be adopted to meet the requirements of different studios; they include microphone and line amplifiers, attenuators, etc., which can be assembled into monobloc programme consoles. Performance data are tabulated and illustrations are given of typical units and assemblies, including sound-pickup consoles and consolettes.

621.396.822:621.395.44 827

Intermodulation Noise—J. L. Bordewijk. (*Tijdschr. ned. Radiogenoot.*, vol. 17, pp. 261–279; Sept./Nov. 1952.) Intermodulation noise in multichannel telephony systems increases as the signal level rises, in contrast to noise from other sources, which becomes more noticeable as the signal level decreases. An optimum signal/total-noise ratio generally occurs at the point where intermodulation noise and noise due to other causes are about equal. The intermodulation-noise spectrum can be calculated either from the intermodulation products or by using correlation functions.

621.396.822:621.396.619.1 828

Signal/Noise Ratio for Various Modulation Systems—F. L. Stumpers. (*Tijdschr. ned. Radiogenoot.*, vol. 17, pp. 249–260; Sept./Nov. 1952.) Comparison is made between the two broad groups of modulation methods respectively using (*a*) nonquantized and (*b*) quantized signals. The signal/noise ratio in the output of the different systems is related to the signal/noise ratio in the transmission channel and to the required bandwidth. When nonquantized signals are used the effects of noise in the successive stages of the system are cumulative; when quantized signals are used (as in p.c.m. and delta modulation) noise is introduced by the initial quantization process but the system is nearly immune to channel noise. For ratios of useful energy to noise energy in the transmission channel greater than a threshold value of about 20 db, the quantized system is practically fault-free.

621.396.93 829

Maritime Distress Frequency—W. Blow. (*Wireless World*, vol. 59, p. 16; Jan. 1953.) The frequency of 1.65 mc hitherto used in European waters is to be replaced by 2.182 mc from 1st May 1953; this will be a world-wide distress and calling frequency.

SUBSIDIARY APPARATUS

621-526 830

Servomechanisms, a Survey—G. R. Arthur. (*Jour. Brit. I.R.E.*, vol. 12, pp. 507–516; Oct. 1952.) Design techniques discussed include frequency and time analysis and statistical methods; an indication is given of problems not yet solved. 55 references.

621-526 831

Nonlinear Servomechanisms—J. Loeb. (*Onde élect.*, vol. 32, pp. 431–437; Nov. 1952.) The various factors limiting the application of the linear theory of servomechanisms are discussed, the theory of "filtered" systems using relays, developed independently by Dutilh (743 of 1951) and Kochenburger (*Elect. Eng., N. Y.*, Aug. 1950), is outlined, and two new criteria applicable to all "filtered" servomechanisms are established. The first criterion is concerned with the possibility of hunting taking place and includes the criteria of Nyquist and Kochenburger as special cases. The second criterion determines the stability of such oscillations of the system. See also

621-526.001.11 832

A Formula for an Integral occurring in the Theory of Linear Servomechanisms and Control Systems—H. Bückner. (*Quart. Appl. Math.*, vol. 10, pp. 205–213; Oct. 1952.)

621.311.6:621.396.615:621.314.7 833

Application of Transistors to High-Voltage Low-Current Supplies—G. W. Bryan, Jr. (PROC. I.R.E., vol. 40, pp. 1521–1523; Nov. 1952.) A transistor oscillator is used to develop the hv required for such devices as Geiger-Müller counters. The oscillations have a sawtooth waveform, the flyback being used for shock excitation of the hv transformer.

621.314.632:546.289]+621.314.7 834

Power Rectifiers and Transistors—R. N. Hall. (PROC. I.R.E., vol. 40, pp. 1512–1518; Nov. 1952.) Power rectifiers with rectification ratios as high as 10^7 can be made by fusing donor and acceptor contacts to the opposite faces of a Ge wafer. Analysis of the characteristics of such rectifiers gives results in good agreement with experimental values. The properties of transistors prepared in a similar manner, and capable of outputs as high as 100 W, are described. At present the operation of these power units is limited to about 20 kc by transit-time effects.

621.314.632:546.289 835

A High-Voltage, Medium-Power Rectifier—C. L. Rouault and G. N. Hall. (PROC. I.R.E., vol. 40, pp. 1519–1521; Nov. 1952.) A description is given of the operating characteristics of *p-n*-junction rectifiers prepared by fusing impurity metals to Ge wafers. The addition of cooling fins enables higher powers to be handled.

621.314.65 836

The "Nevitron" Mercury-Arc Rectifier—(*Engineering* (London), vol. 174, no. 4521, p. 373; Sept. 19, 1952. *Overseas Eng.*, vol. 26, p. 163; Dec. 1952.) Description of a new type of rectifier with the Hg pool in a Mo cup with external Al cooling fins. Provided the Mo cup is wetted by the Hg to give a concave meniscus, the cathode spot runs in a continuous line round the edge of the Hg. The cooling system ensures no excessive emission of vapor. An auxiliary electrode, lifted from the Hg by means of a solenoid, serves to start the arc. The voltage drop across the arc is 12.5V. The weight of a 50-A 500-V Nevitron is only 2.5 lb, excluding the ignition solenoid. Types with grid control have also been tested. The power required in the grid circuit for full control is only one-thousandth of that for a multianode rectifier.

621.316.722.1:621.387 837

Improved Stabilization from a Voltage-Regulator Tube—M. D. Armitage. (*Electronic Eng.*, vol. 24, pp. 568–569; Dec. 1952.) By using a suitable barretter in place of the resistor usually connected in series with a voltage-regulator tube, a definite improvement in performance is obtained. The barretter type of circuit is most useful when the load current is relatively high.

621.316.722.1.027.3 838

Stabilizer for Control of High Direct Voltages—J. Serny. (*Rev. gén. élect.*, vol. 61, pp. 411–420; Sept. 1952.) The development and performance of a stabilizer for direct voltages of the order of several thousands of volts are described. The application of the stabilizer to voltages of any value (*a*) using as variable resistor a large number of triode valves in series, (*b*) suppressing the voltage-divider bridge generally used to control the regulator system, is also discussed. Rectifier ripple can be eliminated, so that a simple type of filter can be used.

621.318.435.3:621 311.62 839

The Transbooster—A. H. B. Walker. (*Electronic Eng.*, vol. 24, pp. 546–550; Dec. 1952.) Description of circuits in which a transductor is used for regulation of the output voltage of a rectifier, fed from ac mains, under varying load conditions. If the transductor is connected on the dc side of the main rectifier, a smaller transductor can be used, since it will only have to handle the total boost voltage required to cover rectifier regulation and mains-voltage variation.

621.316.7:621-526 840

Automatic Feedback Control [Book Review]—W. R. Ahrendt and J. F. Taplin. Publishers: McGraw-Hill, New York, 1951, 412 pp., 64s. (*Electronic Eng.*, vol. 24, p. 584; Dec. 1952.) Theory and applications of servo control systems.

TELEVISION AND PHOTOTELEGRAPHY

621.397 841

A High-Speed Direct-Scanning Facsimile System—C. R. Deibert, F. T. Turner and R. H. Snider. (*Elect. Eng. N. Y.*, vol. 71, p. 784; Sept. 1952.) Digest of paper presented at A.I.E.E. General Meeting, January 1952. A description is given of the Western Union system, which handles copy up to 8½ in. by 15 in. at the rate of 2½ in.²/sec. Using d.s.b. transmission, the required bandwidth is 30 mc. The transmitter comprises two identical scanning units, which are used alternately to save time while copy is changed. The copy-holding cylinder rotates at 1800 *r.p.m.*, and the controls are partly electromechanical and partly electronic, with tuning-fork frequency standards for synchronization.

621.397.5 842

Television Program Origination: The Engineering Technique—D. C. Birkinshaw. (*Proc. IEE*, part IIIA, vol. 99, pp. 43–73. Discussion, pp. 174–178; April/May 1952.) A comprehensive review of the development of the BBC. television service, including discussion of apparatus and techniques for studio and outside broadcasts and for telecine and telefilm recording.

621.397.5 843
Television Program Production Problems in Relation to Engineering Technique—I. Atkins. (*Proc. IEE*, part IIIA, vol. 99, pp. 74–81. Discussion, pp. 174–178; April/May 1952.) Discussion of production planning camera technique and lighting problems.

621.397.5 844
Determination of the Number of Lines to be chosen for a Television System, as dependent on the Size of the Receiver Screen—P. Stroobants. (*Onde élect.*, vol. 32, pp. 438–444; Nov. 1952.) See 3245 of 1952.

621.397.5:061.4(443.611) 845
The Second Television Salon—(*Onde élect.*, vol. 32, pp. 464–466; Nov. 1952.) Discussion of design trends for receivers, cr tubes, aerials and feeders, as exemplified in the equipment on show at the 1952 Salon. For other accounts see *Télévision*, Nov. 1952, No. 28, pp. 255–258; *TS et TV*, Nov. 1952, vol. 28, no. 289, pp. 333–335; *Toute la Radio*, Nov. 1952, vol. 19, no. 170, pp. 398–402; *Radio Télév. prof., Paris*, Oct. 1952, vol. 21, no. 210, pp. 14–15 . . . 20.

621.397.5:534.86 846
Problems of Sound in Television Programmes—R. F. A. Pottinger. (*Proc. IEE*, Part IIIA, vol. 99, pp. 145–149. Discussion, pp. 174–178; April/May 1952.)

621.397.5:778.5 847
Television Recording—W. D. Kemp. (*Proc. IEE*, part IIIA, vol. 99, pp. 115–127. Discussion, pp. 174–178; April/May 1952.) Various methods of photographic recording on film, with intermittent or continuous motion of the film are discussed and the two methods now used by the BBC are described in some detail.

621.397.5(091) 848
The History of Television—G. R. M. Garratt and A. H. Mumford. (*Proc. IEE*, part IIA, vol. 99, pp. 25–40. Discussion, pp. 40–42; April/May 1952.) A review of developments in various countries. 45 references.

621.397.6:535.317.5 849
A 5:1 Television Zoom Lens—H. H. Hopkins. (*Proc. IEE*, part IIIA, vol. 99, pp. 109–, 112. Discussion, pp. 174–178; April/May 1952.) Performance requirements of zoom lenses for television are discussed and a lens system satisfying the requirements, designed for the BBC, is described. The aberrations of such lens systems are considered and methods of correction are outlined.

621.397.6:621.385.832 850
The Monoscope—R. D. Nixon. (*Proc. IEE*, part IIIA, vol. 99, pp. 132–135. Discussion, pp. 174–178; April/May 1952.) Discussion of the operating principles and factors affecting the design of cr tubes for generating a stationary-picture signal. The picture is printed on a conducting plate, usually Al, using printing material finally converted to carbon with a low secondary-emission ratio. Since Al has a relatively high secondary-emission ratio at low voltages, scanning of the picture by the cr beam results in a picture signal being produced in the lead connecting the Al plate to the final accelerator electrode. Such devices have recently been used by the BBC for test-card transmission. See also 2865 of 1938 (Burnett).

621.397.6:778.5 851
A Continuous-Motion System for Televising Motion-Picture Films—H. E. Holman and W. P. Lucas. (*Proc. IEE*, part IIIA, vol. 99, pp. 95–108. Discussion, pp. 174–178; April/May 1952.) Detailed description of BBC equipment for 35-mm film and of the special equipment required for 16-mm film on account of the increased magnification from film to viewing screen. The flying-spot system is used.

621.397.611:778.5 852
The Development of a High-Quality 35-mm Film Scanner—T. C. Nuttall. (*Proc. IEE*, (London), part IIIA, vol. 99, pp. 136–144. Discussion, pp. 174–178; April/May 1952.) Detailed description of BBC equipment using the flying-spot system.

621.397.611.2 853
A Small High-Velocity-Scanning Television Pickup Tube—J. E. I. Cairns. (*Proc. IEE*, (London), part IIIA, vol. 99, pp. 89–94. Discussion, pp. 174–178; April/May 1952.) The tube described, scaled down from one of the super-emitron type [756 of 1951 McGee)], has a superior performance and is two or three times as sensitive as its predecessor. This superiority is due to increased mosaic storage, which reduces the shading signal but increases the picture lag. The lag is unnoticeable except for very rapidly moving objects.

621.397.611.2 854
The Influence of Tube Characteristics and other Factors on Camera Design—L. H. Bedford. (*Proc. IEE* (London), part IIIA, vol. 99, pp. 82–88. Discussion, pp. 174–178; April/May 1952.) The principal types of camera tube are discussed and their transfer characteristics are shown graphically. Factors affecting camera design are considered and the principal features of eight modern cameras are tabulated.

621.397.611.2 855
An Investigation into the Use of Secondary-Electron Signal Multipliers in Image Iconoscopes—R. Theile and H. McGhee. (*Proc. IEE*, part IIIA, vol. 99, pp. 159–165. Discussion, pp. 174–178; April/May 1952.) By using an electron-transmissive screen in front of the first multiplier dynode, complete collection and sufficient acceleration of the secondary electrons leaving the target can be accomplished. Further, with a suitable geometrical arrangement of the multiplier and target, uniform picture generation can be achieved over the whole target area. A practical assembly is described and its performance discussed.

621.397.611.2 856
Design Features of a Television Camera with a Single-Lens Optical View-Finder—T. Worswick and J. L. Bliss. (*Proc. IEE* (London), part IIIA, vol. 99, pp. 166–173. Discussion, pp. 174–178; April/May 1952.) Detailed description of a BBC camera, of relatively small size and weight, with an optical view-finder located on top of the camera. A servo focusing-control system is used.

621.397.62 857
Intercarrier-Sound Television Receivers—A. Boekhorst. (*Electronic Appl. Bull.*, vol. 13, pp. 21–33; Feb. 1952.) The basic principles of the intercarrier-sound system are described and the requirements imposed on the transmitter and on the response curve of the receiver are discussed. Three methods of separating the video and intercarrier signals are considered and a detailed description is given of (*a*) the detector and video amplifier, (*b*) the sound channel of a receiver supplying a large signal to the picture tube.

621.397.62:621.385.3 858
Stable Oscillator for U.H.F. TV Receivers—Loofbourrow and Morris. (See 900.)

621.397.62:621.396.67 859
Community Antennas bring TV to Fringe Areas—J. M. Carroll. (*Electronics*, vol. 25, pp. 106–111; Dec. 1952.) A system representative of many operating in the U.S.A. is described. Signals in the various vhf channels are received by separate high-gain aerials mounted on high towers, and are passed through preamplifiers mounted high up the towers. Signals from odd and even channels respectively are combined and transmitted via coaxial cables to the tower base, where they are redistributed to separate-channel amplifiers, shifted from high-band to low-band channels, and fed to subscribers by a transmission-line system. Suitable aerials and amplifiers are discussed.

621.397.621 860
Reactive Time Bases—A. B. Starks-Field. (*Jour. Brit. I.R.E.*, vol. 12, pp. 519–532. Discussion, p. 532; Oct. 1952.) Text of paper presented at 1951 Radio Convention, Cambridge. High-efficiency line-deflection circuits for large-screen television tubes are discussed. Various methods are described for recovering the energy in the deflecting field at the end of the scan; this energy can either by returned to the h.v. line or used to boost the voltage of the driver stage. The design of booster circuits is discussed with reference to efficiency, linearity and convenience of operation from h.v. supplies of the order of 200 V. Particular attention is paid to the design of the transformer, which may be either an autotransformer or a multi-winding type. A system for operating directly on to high-impedance deflection coils is briefly mentioned.

621.397.621.029.63 861
One-Channel Converter for U.H.F. Television—Wen Yuan Pan. (*Electronics*, vol. 25, pp. 134–138; Dec. 1952.) Printed inductors and Ge-diode mixers are used in a commercially available converter for shifting signals from any given uhf channel to a selected channel in the lower vhf band. The whole of the uhf television band is covered by the grounded-anode oscillator circuit.

621.397.621.2:621.318.2 862
A New Focusing Unit for Television Picture Tubes—P. van Tilburg and J. A. Verhoef. (*Electronic Appl. Bull.*, vol. 13, pp. 37–43; March/April 1952.) The properties of ferroxdure which make it particularly suitable for use in magnetic focusing units are described and details are given of a unit which uses two annular ferroxdure magnets. The strength of the focusing field is adjusted by variation of the separation of the two rings, which can be varied from 1 mm to 12 mm to cover a range of beam voltages from 5 kV to 20.5 kV.

621.397.7:621.316.7 863
Television Control-Room Lay-Out—R. D. Chipp. (*Tele-Tech*, vol. 11, pp. 48–51; Oct. 1952.) Separate arrangements for audio, video, and direction control result in greater efficiency of operation. Suggested plans for large, medium, and small studios are presented and discussed.

621.397.7:628.972 864
Television Studio Lighting Equipment—S. L. Johnson. (*Proc. IEE*, part IIIA, vol. 99, pp. 113–114. Discussion, pp. 174–178; April/May 1952.)

621.397.7:628 972 865
Television Lighting Technique—H. O. Sampson. (*Proc. IEE*, part IIA, vol. 99, pp. 150–158. Discussion, pp. 174–178; April/May 1952.) An account of arrangements adopted in BBC studios.

621.397.7:628.972:621.327.4 866
Discharge Lamps for Television Studios—E. H. Nelson and W. A. Price. (*Proc. IEF*, part IIIA, vol. 99, pp. 128–131. Discussion, pp. 174–178; April/May 1952.)

621.397.82:621.396.621 867
The Maximum Permissible Interference Radiation from U.S.W. Receivers—(*Radio Tech.* (Vienna), vol. 28, pp. 425–426; Oct. 1952.) With the introduction of television in Germany, principally on frequencies in the band 174–216 mc, interference from the second harmonic of the local oscillator of s.w. f.m. broadcasting receivers has been experienced. It has been decided that such in-

terference must be reduced below the level of 30 μV/m at a distance of 30 m from an aerial connected to a receiver. Equipment suitable for making the necessary measurement is noted.

621.397.822 868
Noise Measurements on Television Transmissions—R. Rasch. (*Fernmeldetech. Z.*, vol. 5, pp. 440–444; Oct. 1952.) Noise voltages of amplifiers are usually measured in terms of effective values, while for television picture signals peak values are used. Equipment is described for cro comparison of peak and effective values of noise voltages. A correction of 15 db should be applied when comparing effective values with peak-to-peak values. A method of determining the permissible noise level in a television transmission system is outlined and illustrations are given of the effect on picture quality of a progressive reduction of the signal/noise ratio.

621.396/.397].828 869
Radio Interference Suppression [Book Review]—Stephens. (See 818.)

TRANSMISSION

621.396.61:621,396.611.3:621.396.67 870
Transmitter Combining Circuits—A. R. A. Rendall and G. A. Hunt. (*Electronic Eng.*, vol. 24, pp. 550–552; Dec. 1952.) Description of typical circuits used at BBC. unattended stations for coupling two or more transmitters, operating on a common frequency, to a single aerial. For transmitter powers <1 kW a special hybrid coil, wound on an iron-dust core, has been developed. The circuits used include both hybrid and bridged-T circuits.

TUBES AND THERMIONICS

621.314.6/.7:621.396.822 871
On the Theory of Noise in *P-N* Junctions and Related Devices—R. L. Petritz. (Proc. I.R.E., vol. 40, pp 1440–1456; Nov. 1952.) Noise resulting from fluctuations inherent in the electronic system of a *p-n* junction is investigated and found to be a result of fluctuations of the concentration of the minority carriers. A noise theory based on a lumped-parameter representation of a *p-n* junction is developed, and an equivalent circuit, with appropriate noise generator, is derived. Noise characteristics of *p-n*-junction rectifiers and transistors are analyzed. The available noise power of a *p-n*-junction rectifier is voltage dependent, its equation resembling that of Weisskopf for point-contact rectifiers. The noise figures of *p-n*-junction transistors are of the order of unity and are independent of size and current density. A comparison is made, as regards noise, between point-contact and *p-n*-junction rectifiers and transistors, using the Wisskopf noise formula (M.I.T. Rad. Lab. Series, No. 133, 1943) for the point-contact devices. A relation between the noise spectrum and the admittance of a *p-n*-junction is obtained. Fluctuation noise constitutes only a part of the measured noise of point-contactand *p-n*-junction rectifiers and transistors. Another source of noise, connected with control of mean current, is required to account for (*a*) the noise figures of *p-n*-junction and point-contact transistors being appreciably greater than unity, (*b*) the large difference between the noise figures of *p-n*-junction and point-contact transistors, (*c*) the $1/f$ law of the frequency spectrum of the measured noise.

621.314.63:546.289 872
On Some Transients in the Pulse Response of Point-Contact Germanium Diodes—M. C. Waltz. (Proc. I.R.E., vol. 40, pp. 1483–1487; Nov. 1952.) To explain the hole-storage effect noted by Michaels and Meacham (1817 of 1950) a hypothesis is proposed which postulates the presence of traps in the Ge *p* layer near the point electrode. Measurements and calculations indicate trap densities of the order of $10^{16}/cm^3$, trap depths in the energy band of about 0.3 eV, and capture cross-section diameters of about 0.3 Å.

621.314.7 873
Present Status of Transistor Development—J. A. Morton. (Proc. I.R.E., vol. 40, pp. 1314–1326; Nov. 1952.) Reprint. See 2651 of 1952.

621.314.7 874
Effects of Space-Charge-Layer Widening in Junction Transistors—J. M. Early. (Proc. I.R.E., vol. 40, pp. 1401–1406; Nov. 1952.) Some effects of the dependence of the thickness of the collector barrier on collector voltage are analyzed. The thickness of the base layer decreases as collector voltage increases, resulting in an increase of the current-gain factor α and a decrease of the emitter voltage required to maintain any given emitter current. These effects lead to the introduction of two new elements in the small-signal equivalent circuit: (*a*) the collector conductance, which is proportional to emitter current and varies inversely with collector voltage; (*b*) the voltage-feedback factor, which is independent of emitter current but varies inversely with collector voltage.

621.314.7:537.311.33 875
Transistor Electronics: Imperfections, Unipolar and Analog Transistors—Shockley. (See 146.)

621.314.7:546.289 876
A Developmental Germanium *P-N-P* Junction Transistor—R. R. Law, C. W. Mueller, J. I. Pankove (Pantchechnikoff) and L. D. Armstrong. (Proc. I.R.E., vol. 40, pp. 1352–1357; Nov. 1952.) A transistor of the *p-n-p* junction type can easily be made in the laboratory by diffusing indium into opposite faces of a single-crystal *n*-type Ge wafer. The characteristics of such units are illustrated by experimental curves obtained in tests of over 100 units.

621.314.7:546.289 877
Fused-Impurity P-N-P Junction Transistors—J. S. Saby. (Proc. I.R.E., vol. 40, pp. 1358–1360; Nov. 1952.) Transistors of the *p-n-p*-junction type were produced by fusion of acceptor impurities so as to create *p*-type areas on opposite faces of a wafer of *n*-type Ge. The power dissipation of such units can be increased by the addition of metal cooling fins. The current multiplication factor α is nearly constant at about 0.95 up to 120°C and decreases slightly above this temperature. The power gain is high and noise figure low.

621.314.7:546.289 878
Four-Terminal P-N-P-N Transistors—J. J. Ebers. (Proc. I.R.E., vol. 40, pp. 1361–1364; Nov. 1952.) A *p-n-p*-junction transistor and one of the *n-p-n*-junction type can be interconnected in such a way as to have an equivalent circuit identical with that of a *p-n-p-n* transistor. A simplified equivalent circuit is obtained for the case where the *p-n-p-n* transistor is used as a grounded-base hook-collector transistor.

621.314.7:546.289 879
A Unipolar "Field-Effect" Transistor—W. Shockley. (Proc. I.R.E., vol. 40, pp. 1365–1376; Nov. 1952.) The field-effect transistor consists of a layer of *p*-type material sandwiched between two layers of heavily doped *n*-type material, termed *n*+. The working current is carried by hole conduction in the *p*-type layer, between terminals consisting of heavily doped *p*+ inserts. With reverse bias across the *p-n* junctions, the current flows in a channel of *p*-type material bounded by two space-charge regions with negligible carrier concentration. A theory of the action of such devices is presented, the new terms used for the various electrodes are defined, and design calculations are made for a unit made from Ge.

621.314.7:546.289 880
Junction Fieldistors—O. M. Stuetzer. (Proc. I.R.E., vol. 40, pp. 1377–1381; Nov. 1952.) A description is given, with theory, of an amplifying device with high-impedance input and low-impedance output, which uses an auxiliary electrode close to a *p-n* junction to control the surface conductivity in the neighbourhood of the junction. The arrangement is similar to those previously described (3198 of 1950). A frequency cut-off in the AF range will limit the application of the device in its present form.

621.314.7:546.289 881
Theory of Alpha for P-N-P Diffused-Junction Transistors—E. L. Steele. (Proc. I.R.E., vol. 40, pp. 1424–1428; Nov. 1952.) Equations are developed for the emitter and collector currents for *p-n-p*-junction transistors, and the current-gain factor α is deduced. The IF value of α and its HF cut-off value are markedly dependent on the thickness of the *n*-type "base" region, the HF characteristics being better when this thickness is small. In grounded-emitter applications the HF characteristics depend more directly on the lifetime of holes, and show only second-order dependence on the base thickness; the shorter the lifetime the higher the cut-off frequency.

621.314.7:546.289 882
Effect of Electrode Spacing on the Equivalent Base Resistance of Point-Contact Transistors—L. B. Valdes. (Proc. I.R.E., vol. 40, pp. 1429–1434; Nov. 1952.) An expression for the equivalent base resistance r_b is derived and is checked experimentally Electrode spacing, and the thickness and resistivity of the Ge slice, have major effects on the value of r_b.

621.314.7:546.289:536.49 883
Variation of Transistor Parameters with Temperature—A. Coblenz and H. L. Owens. (Proc. I.R.E., vol. 40, pp. 1472–1476; Nov. 1952.) Measurements were made of the variations with temperature of the parameters of 20 Western Electric Type-1698 and Type-1768 transistors over the range 25–85°C. The results are shown graphically and indicate that these transistors can operate satisfactorily for many small-signal applications up to about 60°C, the gain, e.g., being decreased by only about 2 db at this temperature.

621.314.7:621.3.016.352 884
The Control of Frequency Response and Stability of Point-Contact Transistors—B. N. Slade. (Proc. I.R.E., vol. 40, pp. 1382–1384; Nov. 1952.) Satisfactory stability and frequency characteristics have been obtained by control of the point-contact spacing and the resistivity of the Ge used. By means of the methods outlined, transistors have been produced that can oscillate at frequencies considerably higher than 100 mc, one reaching 300 mc.

621.314.7+[621.314.632:546.289 885
Power Rectifiers and Transistors—Hall. (See 834.)

621.314.7:[621.396.615+621.396.645 886
A Junction-Transistor Tetrode for High-Frequency Use—Wallace, Schimpf and Dickten (See 677.)

621.314.7:621.396.822 887
An Experimental Investigation of Transistor Noise—E. Keonjian and J. S. Schaffner. (Proc. I.R.E., vol. 40, pp. 1456–1460; Nov. 1952.) Transistor noise is discussed and methods of measuring it are described. Experimental results give noise figures for point-contact transistors of about 50 db, while for *p-n*-junction transistors the values may be as low as 10 db at 1 kc. The noise figure of point-

contact transistors was found relatively independent of the dc operating point, but for junction transistors the noise figure may vary considerably with collector voltage and to some extent with emitter current.

621.383.5 888

New Photoelectric Devices utilizing Carrier Injection—K. Lehovec. (PROC. I.R.E., vol. 40, pp. 1407–1409; Nov. 1952.) The devices described are: (*a*) the photomodulator, which permits modulation of a light beam by the change in absorption due to injected carriers; (*b*) the graded-seal junction, which is prepared by fusing together two materials at a temperature intermediate to their two melting points, with subsequent slow cooling. A theory of the phenomenon of electroluminescence [1341 of 1951 (Payne *et al.*)] is proposed which is based on the injection of minority carriers.

621.383.5 889

Properties of the M-1740 P-N Junction Photocell—J. N. Shive. (PROC. I.R.E., vol. 40, pp. 1410–1413; Nov. 1952.) Description of a cell evolved from the practical unit described by Pietenpol (2302 of 1951) and the work of Goucher *et al.* (1669 of 1951). The cell is only $\frac{3}{8}\times\times\frac{1}{8}3/16$ in., has low dark current, low noise and high sensitivity.

621.383.5:546.289:621.397.611.2 890

Use of the Flying-Spot Scanner to Study Photosensitive Surfaces—J. I. Pantchechnikoff, S. Lasof, J. Kurshan and A. R. Moore. (*Rev. Sci. Instr.*, vol. 23, pp. 465–467; Sept. 1952.) Variations of photosensitivity over the surface of a large-area Ge photocell [2656 of 1952 (Pantchechnikoff)] are investigated by scanning with a flying spot from a cr tube and using the output of the photocell, after amplification, to control the beam intensity of a second cr tube.

621.385:621.396.822 891

A New Method of Calculating Microwave Noise in Electron Streams—J. R. Pierce. (PROC. I.R.E., vol. 40, pp. 1675–1680; Dec. 1952.) The approach to the problem is essentially the same as that of North (3420 of 1940). Linearized equations are used to calculate a frequency component of the noise excited in an electron beam by a charge having a velocity different from the mean velocity of the beam. Noise maxima and minima are found for a beam traversing a drift space. Results agree with values calculated by the Rack-Llewellyn-Peterson method (see "Traveling-Wave Tubes," J. R. Pierce, Chap. 10).

621.385.032.21:061.3(47) 892

Conference on Cathode Electronics—I. Dykman. (*Zh. tekh. Fiz.*, vol. 22, pp. 175–182; Jan. 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

621.385.032.213:546.431.221 893

The Electronic Properties of Barium Sulfide—W. Grattidge and H. John. (*Jour. Appl. Phys.*, vol 23, pp. 1145–1151; Oct. 1952.) Results are reported of measurements made of the electron emission from BaS used as cathode coatings in planar diodes. For the most active of the samples used, the emission at temperatures of 900° K and over was comparable with that from pure BaO. Work function, conductivity and thermoelectric power were determined and the effect of Fe as an impurity was studied. The evaporation rate was found to be much less than that of BaO.

621.385.032.216:537.311.32 894

Conductivity of Oxide Emitters—R. C. Hughes and P. P. Coppola. (*Phys. Rev.*, vol. 88, pp. 364–368; Oct. 15, 1952.) Measurements of the electrical conductivity of a (BaSrCa)O emitter over a range from room temperature to 1100°K indicate the existence, in well activated cathodes, of a low-temperature conduction mechanism with an activation energy as low as 0.05 eV. A high-temperature conduction mechanism of 1-*e*V activation energy is noted for the temperature at which appreciable electron emission can be drawn. Exposure to Xe at a pressure of 25 atm causes a marked decrease of conductivity in the high-temperature range. These results are considered to confirm Loosjes and Vink's hypothesis (3208 of 1950) that in the high-temperature range conduction takes place mainly through space currents in the pores in the material. The low activation energy of the low-temperature conduction mechanism indicates that this conduction probably occurs in a monolayer of Ba on the surface of the oxide.

621.385.032.216:537.533.8 895

Secondary Electron Emission from Barium Oxide—J. Woods and D. A. Wright. (*Brit. Jour. Appl. Phys.*, vol. 3, pp. 323–326; Oct. 1952.) Report of an experimental investigation of the influence on the secondary-emission coefficient, δ, of the methods of preparing and operating the BaO layers. Variation of δ with temperature is small between room temperature and 600°C. For evaporated films under steady bombardment at 240 V the value of δ is about 3 for thickness 10^{-6} cm and about 2 for thickness 10^{-6} cm; with pulsed operation δ is considerably larger. For sprayed coatings the value of δ is about 2 for both steady and pulsed operation. Over a long period of operation the value of δ falls and decomposition of the oxide occurs.

621.385.032.216:546.431/.432]-31 896

Electrical Conductivity and Thermoelectric Power of (BaSr)O and BaO—J. R. Young. (*Jour. Appl. Phys.*, vol. 23, pp. 1129–1138; Oct. 1952.) Report of an investigation of the temperature dependence over the range 1100°–300°K of the properties of oxide-cathode coatings at different states of activation and with Ni bases of different purities. Details are given of experimental procedure. No significant differences were found between the properties of BaO and (BaSr)O. Thermoelectric-power /temperature curves confirm theory developed by Hensley (737 above). Results cannot be explained on the basis of a simple one- or two-level semiconductor model, but give general support to the pore-conduction theory.

621.385.032.216:621.386 897

A Study of the Oxide-Coated Cathodes by X-Ray Diffraction Method: Part 1—E. Yamaka. (*Jour. Appl. Phys.*, vol. 23, pp. 937–940; Sept. 1952.) See 1158 of 1952.

621.385.032.216.2 898

Latest Disc-Cathode Developments—(*Electronics*, vol. 25, pp. 236 . . 252; Nov. 1952.) C.r.-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.

621.385.032.24:537.533 899

Origin of Thermal Grid Emission and Investigations on its Elimination—H. Köppen. (*Nachr Tech.*, vol. 2, pp. 246–247; Aug. 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.

621.385.3:621.397.62 900

Stable Oscillator for U.H.F. TV Receivers—K. E. Loofbourrow and C. M. Morris. (*Electronics*, vol. 25, pp. 118–121; Dec. 1952.) The Type-6AF4 acorn oscillator triode is described. The influence of construction details on operating parameters is discussed. Power output is increased by silver-plating the leads; an increase from about 90 to 150 mW is observed for samples operating at about 1 mc. Use of the tube in a receiver with an IF of 41.25–45.75 mc is discussed; the required oscillator frequency range (in the region of 930 mc) is obtained by using the tube with a $\lambda/2$ external line. Circuits are suggested capable of holding the drift to 500 kc in intercarrier-sound receivers.

621.385.832 901

The Optimum Space-Charge-Controlled Focus of an Electron Beam—D. L. Hollway. (*Aust. Jour. Sci. Res., Ser. A*, vol. 5, pp. 430–436; Sept. 1952.) A theoretical investigation is made of the defocusing of a beam of circular cross-section due to space charge; expressions for the condition of optimum focus are derived from the equations of the beam profile. Over a wide range of tubes of spot radius the optimum-focus expressions may be replaced by simpler formulae useful for dealing with electron-beam design problems.

621.387 902

The Thyratron as Switching and Control Tube and its Industrial Application Possibilities—R. Hübner. (*Bull. schweiz. elektrotech. Ver.*, vol. 43, pp. 760–764; Sept. 20, 1952.)

621.387.032.212 903

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 surprisingly high values of apparent inductance and appreciable values of effective resistance. The origin of the quadrature current in such tubes is discussed.

621.396.615.141.2 904

Oscillations in a Nonslotted Magnetron in connection with Amplification by Space-Charge Waves—R. Warnecke, H. Huber, P. Guénard and O. Doehler. (*C.R. Acad. Sci.* (Paris), vol. 235, pp. 493–494; Aug. 25, 1952.) A formula for the frequency of oscillations in a whole-anode magnetron is confirmed experimentally. From a "diocotron" oscillator of this type in which the frequency can be changed within wide limits by adjustment of the anode voltage, about 50mW power has been obtained over a frequency band of more than an octave around 800 Mc/s.

621.396.622.6:546.28 905

Silicon P-N Junction Alloy Diodes—G. L. Pearson and B. Sawyer. (PROC. I.R.E., vol. 40, pp. 1348–1351; Nov. 1952.) Acceptor or donor impurities are alloyed with *n*- or *p*-type Si to produce *p-n*-junction diodes with reverse currents as low as 10^{-10} A, rectification ratios as high as 10^8 at 1 V, stable Zener voltage which can be fixed, during the production process, at a value between 3 V and 1 kV, and ability to operate at temperatures as high as 300°C.

621.396.822 906

Symposium on Noise. General Introduction—Casimir. (See 693.)

621.396.822:621.385.13 907

Valve Noise at Very High Frequencies—G. Diemer. (*Tijdschr. ned. Radiogenoot.*, vol. 17, pp. 281–301; Sept./Nov. 1952.) At frequencies $>10^8$ cps, for which electron transit times are not negligible, the finite duration and particular shape of current pulses induced by the individual electrons give rise to additional noise; total-emission noise increases considerably and space-charge smoothing becomes less effective. The correlation between the various causes of noise is emphasized, and the difference between the transmission process through the tube for signal and for noise is indicated. Various triode circuits are discussed in relation to noise factor, the value of which is affected by the feedback in the circuit.

MISCELLANEOUS

621.396.822 908

Symposium on Noise. Historical Introduction—J. L. van Soest. (*Tijdschr. ned. Radiogenoot.*, vol. 17, pp. 197–198; Sept./Nov. 1952.) The subject is traced from Brown's investigations in 1827 of the movements of particles. In present-day electrical engineering the greatest emphasis is laid on signal/noise ratio, on account of its importance in relation to the transmission of information.

621.396/.397 909

Electronics for Communications Engineers [Book Review]—J. Markus and V. Zeluff. Publishers: McGraw-Hill, New York, 601 pp., $10. (Proc. I.R.E., vol. 40, p. 1741; Dec. 1952.) A collection of papers published in *Electronics* during the past five years on the design of communication, broadcasting, television and radar equipment.

Whenever circuits call for precision and high resolution in compact space ...

There's a 10-turn Helipot to meet your requirements

With the development of the original HELIPOT—the *first* multi-turn potentiometer—an entirely new principle of potentiometer design was introduced to the electronic industry. It made possible variable resistors combining high resolution and high precision in panel space no greater than that required for conventional single-turn potentiometers.

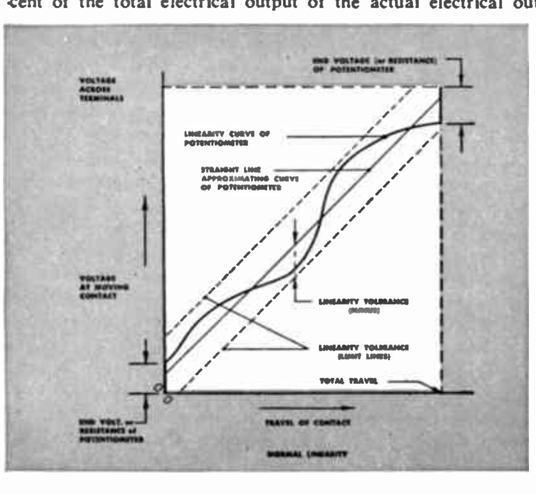
The Helipot Principle... *High resolution and precision settings require a long slide wire. But by coiling a resistance element into a helix, it is possible to gain desired resolution and precision without wasting panel space. This principle is applied in various Helipot models with slide wires ranging from 3 to 40 helical turns.*

Advantages are immediately apparent. In the case of the widely-used 10-turn Model A Helipot, for example, a 45" long slide wire—coiled into ten helical turns—is fitted into a case 1¾" in diameter, and 2" in length. Another advantage of the 10-turn pot is that, when equipped with a turns-indicating RA Precision DUODIAL, slider position can be read directly as a decimal, or percentage, of total coil length traversed.

10-TURN HELIPOT MODELS—CONDENSED SPECIFICATIONS

	Model A	Model AN	Model AJ
No. of turns	10	10	10
Resistance Range	10 ohms to 300,000 ohms	100 ohms to 250,000 ohms	100 ohms to 50,000 ohms
Resistance Tolerance: Standard	±5%	±5%	±5%
Best	±1%	±1%	±3%
*Linearity Tolerance: Standard	±0.5%	±0.5%	±0.5%
Best	±0.05% (1K ohms and above)	±0.025% (5K ohms and above)	±0.1% (above 5K ohms)
Power rating @ 40°C	5 watts	5 watts	2 watts
Mechanical Rotation	3600° +4° −0°	3600° +1° −0°	3600° +12° −0°
Electrical Rotation	3600° +4° −0°	3600° +1° −0°	3600° +12° −0°
Starting Torque	2 oz. in.	1.0±.3 oz. in.	.75 oz. in.
Running Torque	1.5 oz. in.	0.6±.3 oz. in.	.60 oz. in.
Net Weight	4 oz.	4 oz.	1 oz.

*i.e. INDEPENDENT LINEARITY. The above linearity tolerances are based on the following definition recently proposed to clarify and standardize nomenclature related to precision variable resistors.... "Independent linearity is the maximum deviation in percent of the total electrical output of the actual electrical output at any point from the best straight line drawn through the output versus rotation curve. (This line shall be measured through the extent of the effective electrical angle.) The slope and position of the straight line from which the linearity deviations are measured must be so adjusted as to minimize these deviations."



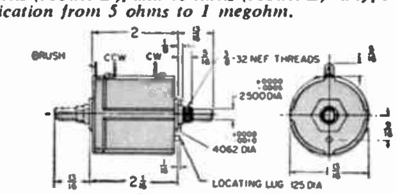
10-Turn Helipot Highlights

From the basic Helipot principle, model variations have been developed to meet new requirements:

Model A Helipot

the original 10-turn Helipot—provides a resolution from 12 to 14 times that of conventional single-turn potentiometers of same diameter (1¾"), linearities as close as ±0.05% in resistances as low as 1K ohms.

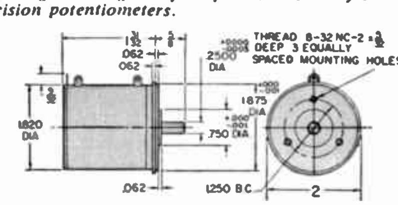
The same multi-turn principle is also available in 3 turn units (Model C), and larger-diameter units of 15 turns (Model B), 25 turns (Model D), and 40 turns (Model E)—a type for every application from 5 ohms to 1 megohm.



Model AN Helipot

an ultra-precision version of the basic 10-turn Helipot. Produced in volume to extremely close electrical and mechanical tolerances, this unit features precision ball bearings (Class 5), servo mounting lid, plus linearity tolerance as close as ±0.025% as low as 5K. A 3-turn unit (Model CN) is also available.

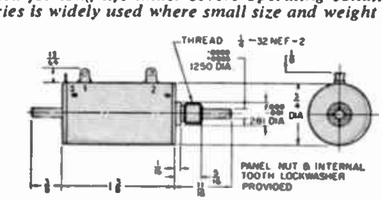
Models AN and CN are particularly recommended for precise servo-mechanism applications and represent the most advanced design and highest quality available today in the field of precision potentiometers.



Model AJ Helipot

a 10-turn *miniature* Helipot only ¾" in diameter, weighs 1 oz., has slide wire 18" long. Also available with servo mounting (Model AJS) and servo mounting with *ball* bearings (Model AJSP). Linearities as close as ± 0.1% as low as 5K.

Designed for long life under severe operating conditions, the AJ Series is widely used where small size and weight are vital.



Design details on above units are subject to change without notice. Certified drawings available upon request.

Only Helipot is able to supply—in volume—multi-turn helical potentiometers *with special features to meet your particular needs* . . . Special Shafts, Extra Spot Welded Taps at any position, Ganged Assemblies (except AJ), Special Temperature Coefficients, etc. Send us your requirements!

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Industrial Engineering Notes[1]

Television News

The Italian government is buying a considerable amount of television equipment from a British firm for use in its studios at Rome and Milan, according to reports reaching the Department of Commerce. Medium-power transmitting equipment also is being purchased for use at Rome and Pisa. The equipment is expected to be used to expand the services of the present experimental station of the official Italian broadcasting corporation, Radio Audizione Italiana (R.A.I.), into a full-scale network. When completed, most of Italy would receive television service from transmitters located in nine main population areas. A two-way radio link is proposed between Rome and Milan, with programs originating in these two cities. . . . Speaking before the National School Boards Association Convention last week in New Jersey, **Paul A. Walker, Chairman of the FCC, said that now was the time for educators, school board members, trustees, legislators and governors to take definite and timely action to support plans in the respective communities for the utilization of the 242 channels for non-commercial educational television stations.** Chairman Walker pointed out that the end of the one-year reservation period for educational TV channels is June 2, 1953, and that these channels set aside by the FCC for educational TV cannot be held indefinitely beyond this deadline. . . . **A total of 6,174,505 television sets were shipped to dealers during 1952, RMTA has estimated.** This compares with 1951 TV set shipments to dealers of 5,095,563 units. . . . **The FCC granted construction permits for new television stations recently to bring the total authorizations since the lifting of the "freeze" last summer to 254.** Authorized since January 28 have been:

Fort Dodge, Northwest Television Co., Channel 21.

Madison, Wis., Bartell Television Corp., Channel 33.

Roswell, N. Mex., John A. Barnett, Channel 8.

Salem, Ore., Lawrence A. Harvey, Channel 24.

Johnson City, Tenn., WJHL, Inc., Channel 11.

Memphis, Tenn., Harding College, Channel 13.

Temple, Texas, Bell Publishing Co., Channel 6.

Tyler, Texas, Jacob A. Newborn, Jr, Channel 19.

Charlottesville, Va., Barham & Barham, Channel 64.

Lansing, Mich., Lansing Broadcasting Co., Channel 54.

Billings, Mont., The Montana Network, Channel 2.

(Continued on page 72A)

[1] The data on which these NOTES are based were selected by permission from *Industry Reports*, issues of February 6, 13, 20, and February 27, published by the Radio-Television Manufacturers Association, whose co-operation is gratefully acknowledged.

New! Broad Applicability!

New -hp- 522B ELECTRONIC COUNTER

...a small precision instrument that makes more kinds of measurements faster and more easily than any comparable device ever offered!

REVOLUTIONARY FEATURES SAVE TIME, MONEY; SPEED RESEARCH AND MANUFACTURING

Measures .00001 to 100,000 events per second

Measures time 10 microseconds to 27.8 hours

Accurate within 1 part in 100,000

Ideal for remote measurements, monitoring

Lowest cost completely versatile counter

No extra-cost modification required

Easily used by anyone, no training needed

Reads direct in cps, kc, seconds, milliseconds

Decimal point automatically indicated

Displays results instantly, accurately

Work-bench size; weighs just 45 pounds

Unlimited uses in research, production

-*hp*- dependability — quality construction — quality components

In an ever-increasing variety of manufacturing and research measurements, electronic counters provide greater speed, higher accuracy and broader usefulness than previously available measuring equipment.

The new -*hp*- 522B is a *versatile* low-priced counter offering you frequency, period and time interval measurement over a broad range. The instrument is completely contained in a small, bench-size unit, and no extra-cost modification is required to perform all functions. Results are displayed instantly and automatically in direct-reading form. Unskilled personnel can use the equipment immediately—no training or technical background is needed.

WIDE RANGE

Frequency range is .00001 cps to 100 kc, and the counter may be read direct from 10 cps to 100 kc. Counting is available over periods of 1/1000, 1/100, 1/10, 1 and 10 seconds, or multiples of 10 seconds. Time of display can be varied at will, counts are automatically reset, and action is repetitive. For period measurement, the unknown controls the opening and closing of the gate while the instrument's decade counters record the number of cycles of an internal standard frequency. Depending on the frequency selected, the instrument reads direct in seconds and milliseconds. By this means, frequencies down to .00001 cps may be measured.

Time intervals are measured by a similar procedure except that the gate time is controlled by a "start" and "stop" signal generated by the device under measurement or by transducers. Time intervals ranging from 10 microseconds to 100,000 seconds (27.8 hours) can be measured; and again results are

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displayed on the panel (in seconds and milliseconds). The count may be started or stopped from common or independent sources by using either positive or negative "going" waves. The level of trigger voltage is continuously adjustable for each channel from −100 to +100 volts.

GENERAL DESCRIPTION

Model 522B consists of five decade counters, a wide range time base, and gating and auxiliary circuits applying counters and time base to the broadest possible variety of measurements. The unknown is applied to the counters through a gate circuit. This circuit remains open for a precise interval controlled by an oven-housed quartz crystal. Stability of this crystal is at least 5/1,000,000 per week, and may be standardized against WWV.

-*hp*- 522A ELECTRONIC COUNTER

For applications where wide-range frequency and period measurements are desired, -*hp*- 522A is offered. Frequency counting facilities of this instrument are identical with -*hp*- 522B, except that gate time for frequency measurement is 1 second or any multiple of 1 second, and the standard frequency counted for period measurement is 100 kc. The automatic illuminated decimal point is omitted. -*hp*- 522A does not include time interval measuring circuits. $775.00 f. o. b. factory.

BRIEF SPECIFICATIONS—MODEL 522B

FREQUENCY MEASUREMENT:

Range: 10 cps to 100 kc.
Accuracy: ± 1 count ± stability (5/1,000,000 per week).
Registration: 5 places. Output pulse available to actuate trigger circuit for mechanical register to increase count capacity.
Input Requirements: 2 volts peak minimum.
Input Impedance: Approx. 1 megohm, 50 μμfd shunt.
Gate Time: .001, .01, .1, 1, 10 seconds. Extendable to multiples of 1 or 10 seconds by manual control.
Display Time: Variable .1 to 10 seconds in steps of gate time selected. Display can be held indefinitely.

PERIOD MEASUREMENT:

Range: .00001 cps to 10 kc.
Accuracy: ± .03% ± stability (for measurement over a 10 cycle period).
Gate Time: 1 or 10 cycles of unknown. Extendable to any number of cycles by manual control. (For frequencies under 50 to 60 cps).
Standard Freq. Counted: 1, 10, 100 cps; 1, 10, 100 kc; or external.

TIME INTERVAL MEASUREMENT:

Range: 10 μsec to 100,000 seconds (27.8) hrs.
Accuracy: ± 1/std. freq. counted ± stability.
Input Requirements: 2 volts peak minimum.
Input Impedance: Approx. 250,000 ohms, 50 μμfd shunt.
Start and Stop: Independent or common channels.
Trigger Slope: Pos. or neg. on start and/or stop channels.
Trigger Amplitude: Continuously adjustable on both channels from −100 to +100 volts.
Standard Freq. Counted: 1, 10, 100 cps; 1, 10, 100 kc; or external.
Price: $900.00 f. o. b. factory.

IS YOUR MEASURING PROBLEM HERE?

FREQUENCY

Production quantities
Nuclear radiations
Power line frequencies to high accuracy
R. P. S. and R. P. M.
Weight, pressure, temperature and acceleration—at remote points
Very low frequencies
Frequency stability
Oscillator calibration
Pulse repetition rates

TIME INTERVAL

Elapsed time between impulses
Pulse lengths
Camera shutter speed
Projectile velocity
Relay operating times
Precise event timing
Interval stability
Frequency ratios
Phase delay

The broad applicability of -*hp*- electronic counters makes them of greatest usefulness in any laboratory or factory. In many cases, one counter will make all your important measurements itself, and give you accuracy unavailable with other equipment. In other applications, standard transducers may be required. See your -*hp*- sales representative for help in applying Model 522B to your measurement problem.

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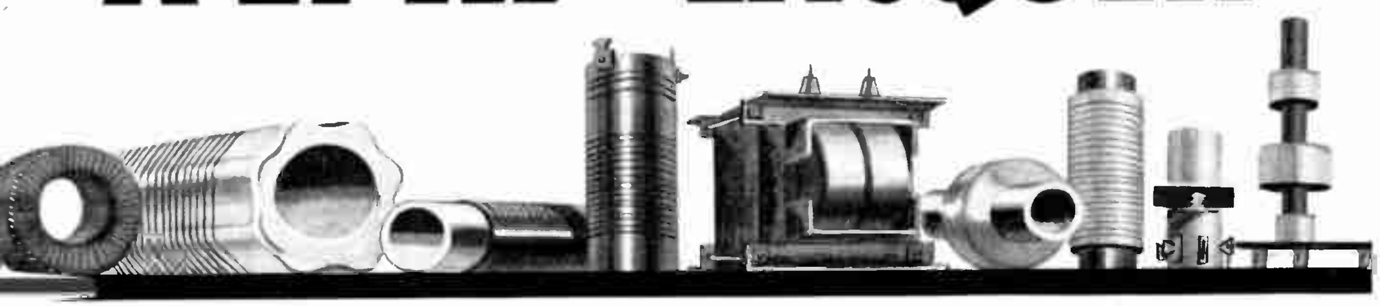

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is chemically engineered to meet the specific requirements of the industry

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Industrial Engineering Notes

(Continued from page 66A)

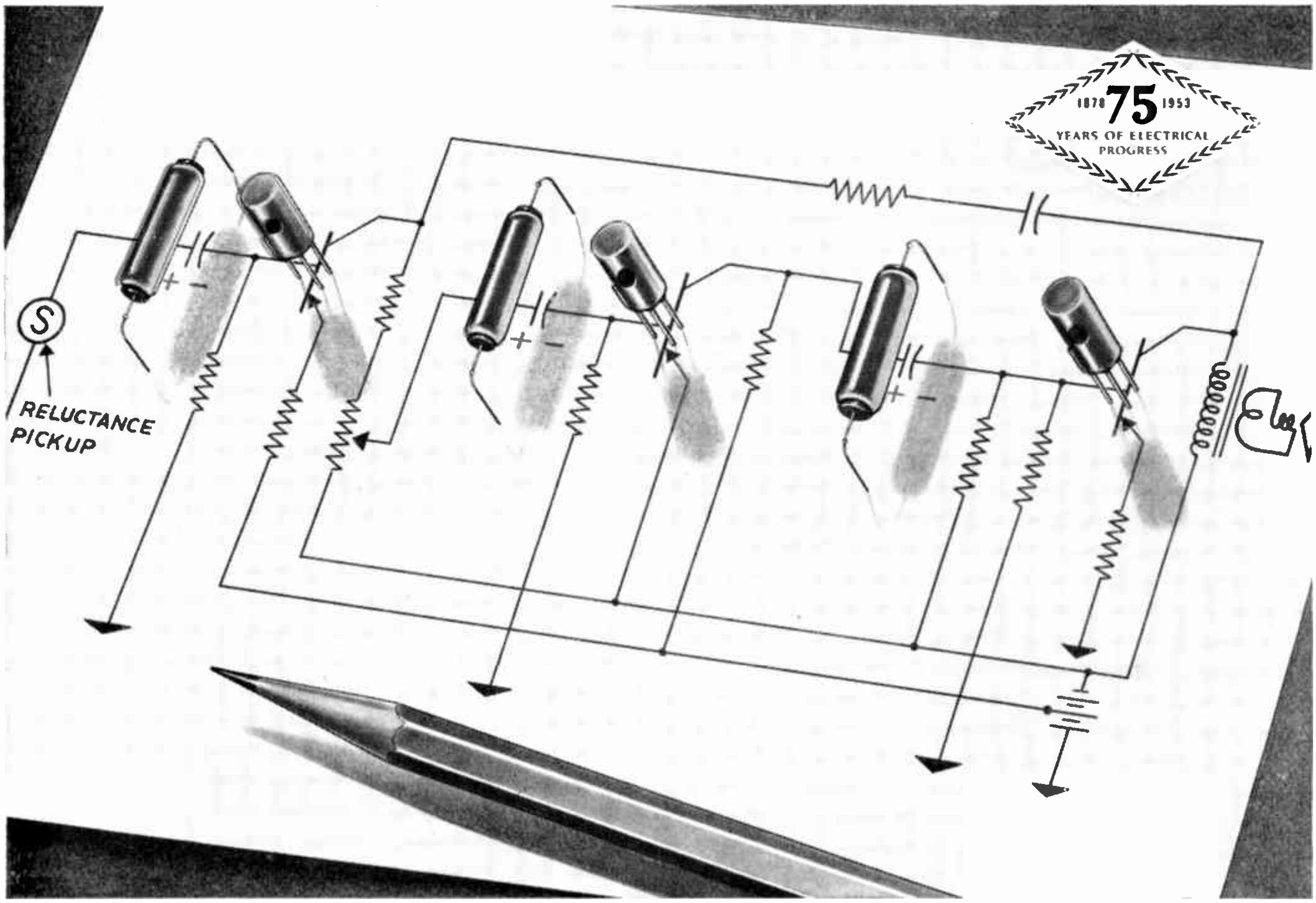
Winston-Salem, N. C., Winston-Salem Broadcasting Co., Inc., Channel 26.
Ashtabula, Ohio, WICA, Inc., Channel 15.
Texarkana, Texas, KCMC, Inc., Channel 6.
Longview, Texas, East Texas Television Co., Channel 32.
Hampton, Va., Peninsula Broadcasting Corp., Channel 15.
Newport News, Va., Eastern Broadcasting Corp., Channel 33.
Milwaukee, Wis., Midwest Broadcasting Co., Channel 25.
Mesa, Ariz., Harkins Broadcasting, Inc., Channel 12.
Eureka, Calif., Redwood Broadcasting Co., Inc., Channel 3.
Rome, Ga., Coosa Valley Radio Co., Channel 9.
Wichita, Kan., The C.W.C. Company, Inc., Channel 16.
New Orleans, La., Supreme Broadcasting Co., Inc., Channel 61.
North Adams, Mass., Greylock Broadcasting Co., Channel 74.
Portland, Me., Portland Telecasting Corp. Channel 53.
Gulfport, Miss., WGCM Television Corp., Channel 56.
Hannibal, Mo., Courier-Post Publishing Co., Channel 7.
Minot, N. D., Rudman Television Co., Channel 10 and North Dakota Broadcasting Co., Inc., Channel 13.
Oklahoma City, Okla., Oklahoma County Television & Broadcasting Co., Channel 25.
McAllen, Texas, Texas State Network, Inc., Channel 20.
Salinas, Calif., Salinas Broadcasting Corp., and Monterey Radio-Television Co., Channel 8.

The grant to Salinas Broadcasting Corp. and Monterey Radio-Television Co. was the first share-time television operation authorized by the FCC. The same Channel 8 transmitter will be used by both stations on an equal-time basis and both stations will maintain their own studios in the two cities.

FCC Actions

The FCC issued a Report and Order this week relaxing its operator license requirements to permit the remote control operation of certain low-power AM, FM, non-commercial FM broadcast stations. "The marked improvement and reliability of transmitter equipment" and "the successful operation by non-technical personnel of many electronic devices of a complex nature," it was pointed out, were among the factors considered by the Commission in reaching its decision. . . . **The FCC recently finalized its proposed rule making of May 10, 1952, to open a section of the amateur frequency band—21,000–21,450 kc—for the use of radio-telephony by amateurs,** beginning last month. This band is allocated to amateurs in accordance with the international table of frequency allocations (Atlantic City, 1947). The radio-telephone

(Continued on page 74A)



TRANSISTORS . . . TANTALYTIC CAPACITORS

teamed in 100-milliwatt tubeless amplifier

General Electric engineers at Electronics Park, Syracuse, have developed a new tubeless audio amplifier circuit that utilizes three junction transistors and three Tantalytic capacitors.

Although still experimental, this 3-stage amplifier promises significant advances in miniaturized equipments. It has a power output of 100 milliwatts—less than 10% distortion—and a power gain of 70 db.

Tantalytic capacitors were a "natural" for interstage coupling in the circuit because of their small size, large capacitance and low leakage current. They match the transistors in ruggedness and long operating life. And they will operate over a wide temperature range (−55°C to +85°C with at least 65% capacitance at −55°C). Other features include light weight, long shelf life, and hermetic sealing.

If you have a capacitor application where you need small size and superior performance, it will pay you to investigate Tantalytic capacitors. They're available in polar and non-polar construction and in ratings from 175 muf at 5 VDC to 12 muf at 150 VDC. For additional information use the convenient coupon below.

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General Electric Co., Section K 407-313
Schenectady 5, New York

Gentlemen: Please send me a copy of your free Bulletin(s)

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GENERAL ELECTRIC

Industrial Engineering Notes

(Continued from page 72A)

segment of this band is designated from 21.25 to 21.45 mc. The frequency space for Novice operation is provided at 21.10–21.25 mc. The previously proposed segment for amateur F-1 (radio-teleprinter operation) has been shifted to 21.0–21.25 mc. In general, these amendments to the amateur rules (Part 12) are designed to provide maximum usefulness of the new amateur band in the interests of the various types of amateur operation, FCC reported. A request of the Maritime Mobile Amateur Radio Club to permit amateur mobile operation in the 21 amateur band outside the continental limits of the United States will be considered separately, the Commission said. . . . **The FCC at present will not consider applications for FM stations contemplating a "functional service" program schedule.** This was revealed in a letter released by the Commission and sent to Chicago Skyway Broadcasting Co., Inc., Chicago, applicant for an FM station there. It was pointed out that "the Commission is currently reviewing the legality and general desirability of 'Storecasting' and similar 'Functional Music' operations. Until this study is completed, the Commission is of the opinion that additional 'Storecasting' operations should not be authorized pending the resolution of the policy questions presented by such operations."

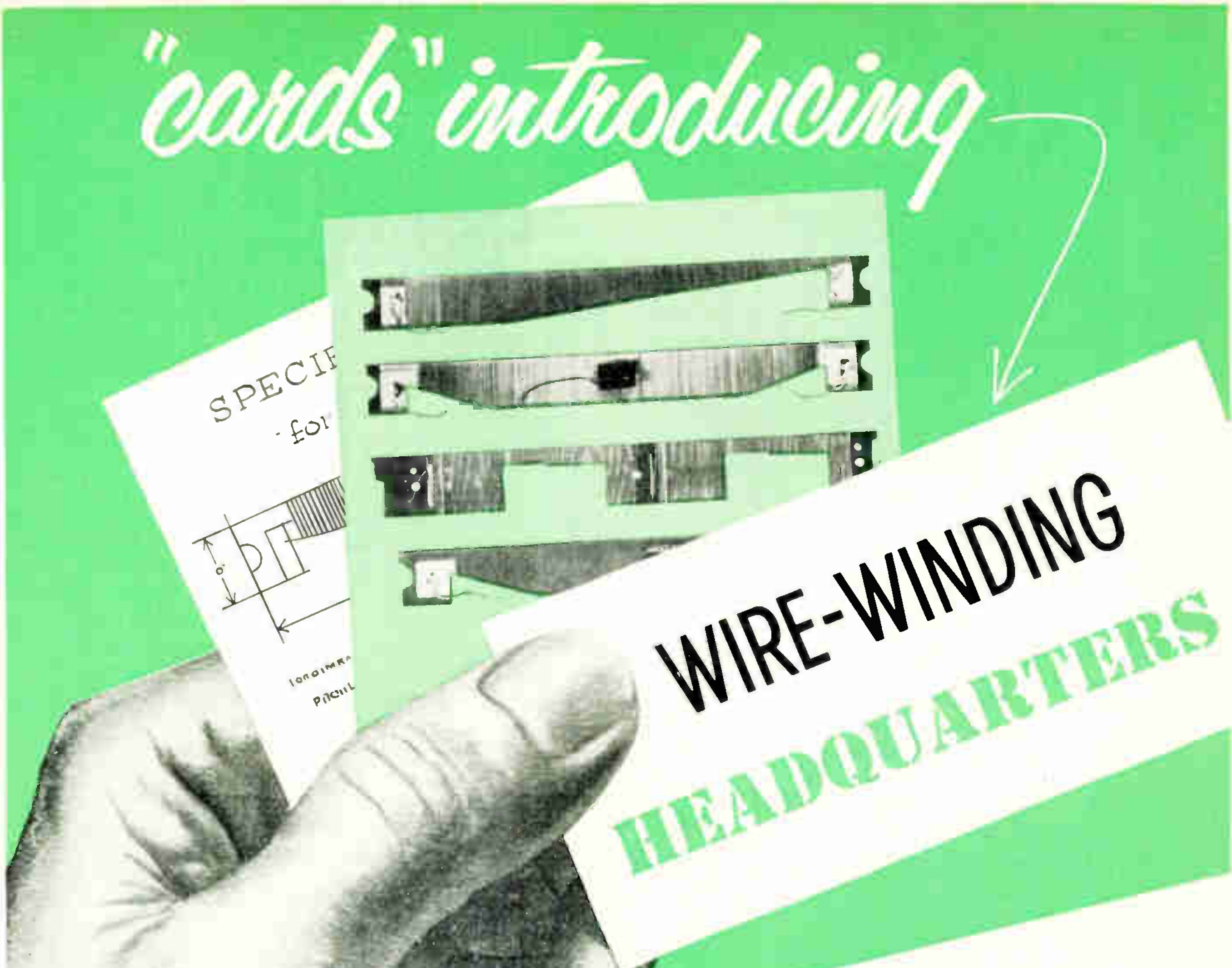
Radiation Measuring Device

A report describing methods for producing better atomic radiation measuring devices was issued by the Office of Technical Services, Department of Commerce. In developing the methods, Naval Research Laboratory scientists used rapidly-recurring, brief voltage pulse instead of a continuous high voltage on the electrodes in the Geiger tube. By not applying continuous high voltage, the scientists obtained these desirable characteristics: (1) A greater measuring range by combining continuous and pulsed voltage operation; (2) useful counter operations at higher intensity levels; (3) meter reading increases in direct proportion to the increase in radiation intensity; and (4) a wider choice of filling gas. The report, "Pulsed Geiger Tube Operations" PB 111035, is available at the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. for 50 cents per copy.

Reorganization of RTMA Urged

The RTMA Board of Directors yesterday accepted in principle recommendations of a special committee of the Technical Products Division calling for broad expansion and reorganization of the Radio-Television Manufacturers Association to provide greater recognition for manufacturers in the advanced electronics field. The action climaxed a three-day industry conference in February at the Roosevelt Hotel, New York. The major recommendations of the committee were that: (1)

(Continued on page 76A)



Draw the wire-wound control curve you need: Clarostat winds the "card" to match it. Specify tolerances: Clarostat meets them. Order any quantity: Clarostat delivers piece after piece, always *uniform*, always *dependable*, always *economical*.

All because Clarostat-designed and built winding machines, manned by skilled winding specialists, handle any kind and size of wire on any kind and shape support. Intricate control curves are met with tapered or notched supporting strips, by variable spacing of turns, by different wire sizes. From 0.032" down to 0.0009" dia. and finer, Clarostat winds to your precise requirements.

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Send us that control spec, regardless how "special". Our engineering collaboration, quotations and delivery schedules, are yours for the asking.

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Industrial Engineering Notes

(Continued from page 74A)

RTMA change its name to the Electronics Manufacturers Association, or some similar name; (2) a division for manufacturers of advanced electronics products be established within the Association, and (3) the Engineering Department be expanded and technical products in the military and commercial sales areas. . . . **Formation of an engineering committee on Internation Components Standards under the Chairmanship of Leon Podolsky, of Sprague Electric Co., was announced recently by Dr. W. R. G. Baker, Director of the RTMA Engineering Department.** The function of this new Committee is to recommend material for international standardization and to review proposals on components submitted by Technical Committee 12-3 of the Internation Electrotechnical Commission. The Committee also will give guidance to the RTMA representative on the IEC. Other members of the Committee are: R. J. Biele, General Electric Co.; Jesse Marsten, Internation Resistance Co.; J. D. Heibel, Erie Resistor Corp.; J. W. Maxwell, P. R. Mallory & Co., Inc.; J. D. Stacy, General Electric Co.; and Fred G. Weber, F. W. Sickles Division.

Materials

Interior Secretary Douglas McKay announced recently that the Bureau of Mines in the Pittsburgh region has started research to find additional sources of germanium for use in radar and other electronic equipment of the Armed Forces. The project is being conducted at the request of and in co-operation with the Signal Corps Engineering Laboratories, Fort Monmouth, N. J. A good method to obtain germanium is to extract it from the ash resulting from the burning of coal; hence, the search is being concentrated in ash pits and smoke stacks of large industrial coal consumers, the Bureau reported. Chemists with the Bureau also plan to make studies of gas producers and blast furnaces as possible sources of germanium. Germanium is now produced in small quantities as a by-product of zinc refining. Annual output is only 6,000 pounds, it was pointed out.

New Crystal Oscillator

As part of its program devoted to the improvement of measuring and calibrating standards, the National Bureau of Standards recently developed a crystal oscillator that is small, portable, dependable and accurate over long periods of time. The new oscillator unit was developed by Peter G. Sulzer of the NBS staff. This new crystal oscillator utilizes a junction transistor as the source of driving power for a high-stability quartz crystal unit. All components of the circuit, including the power supply, fit into a metal tube less than 2 inches in diameter and about 7 inches long. With the device it becomes possible to make available a readily-portable, continuously-oscillating frequency standard that may be carried to all parts of the world, NBS re-

(Continued on page 78A)

Industrial Engineering Notes

(Continued from page 76A)

ported. Complete details on the precision transistor oscillator will appear in a future NBS Technical Bulletin.

Electronic Flowmeter

A new type of electronic flowmeter, capable of measuring the air currents in a still room or the rapid flow of fluids in pipes, has recently been developed at the National Bureau of Standards. It was designed by Henry P. Kalmus of the NBS staff. This new device utilizes the change in velocity of sound waves as a measure of fluid flow. It has a very fast response and does not obstruct the fluid currents to make the measurement. In addition, the signal-to-noise ratio is sufficiently high to permit the measurement of extremely small velocities. Complete details on the electronic flowmeter appeared in the NBS Technical News Bulletin for February.

Circuitry "Packages"

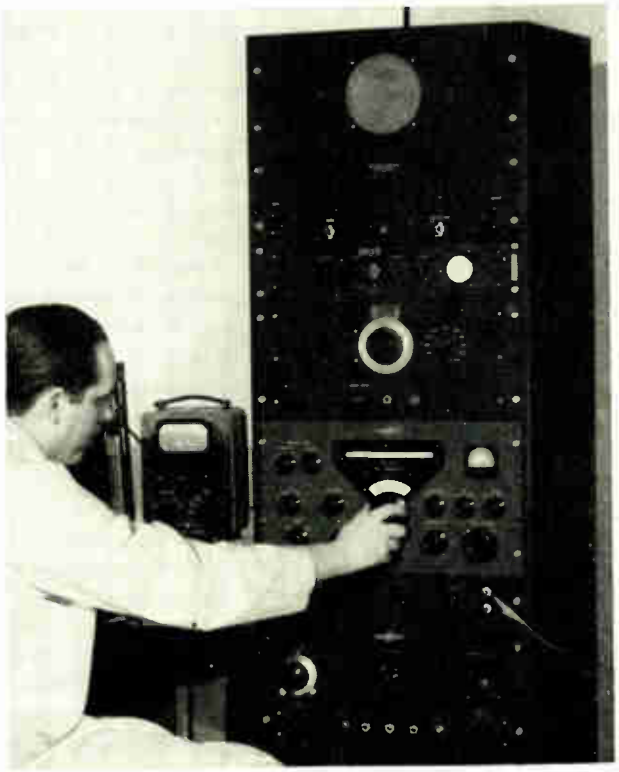
The National Bureau of Standards has recently developed an improved system of standardized plug-in circuitry "packages" for use in the construction of electronic equipment. This NBS system reportedly is an extension of similar improvements under development by industry. Each new circuit package has a large number of connections brought out to connector pins. A test jack at the top of each package helps locate defective units, making it easy to replace trouble-causing with trouble-free packages. A distinctive feature is the general similarity of most of the circuit stages. A single basic tube circuit is adapted to the great majority of requirements, and the same basic circuit serves as a low-impedance pulse driver, as a flip-flop, and for a number of gating functions. These rapidly repleaceable units, if adopted by manufacturers, promise to combine reduced manufacture and repair costs with improved reliability, the Bureau said. Complete details of the new circuit packages appeared in the NBS Technical News Bulletin for March.

Mobilization

With the view of bridging any gaps which may exist between industry and government, the U. S. Department of the Navy recently sponsored a symposium on electron tube reliability. The one-day session was held February 12 in the Department of Commerce Auditorium, Washington. The program included discussions on the following topics: Design Features of Reliable Tubes, R. E. Moe; Production Aspects of Reliable Tubes, L. B. Davis; and Quality Control Procedures for Reliable Tubes, J. A. Davies, all of the General Electric Co. Specifications for Reliable Tubes, A. J. Heitner; Missile Tube Applications, P. R. Erdle, both of Sylvania Electric Products, Inc. Determining Tube

(Continued on page 80A)

Unexcelled for Accuracy and Dependability



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Communications Receiver

The Collins 51J Communications Receiver in addition to its outstanding performance in the communications field, is being widely used in industrial laboratories as a sensitive and accurate measuring instrument. Write today for complete details and specifications.

Condensed Specifications

FREQUENCY RANGE: .54 to 30.5 megacycles.

CIRCUIT: Double Conversion Superheterodyne.

CALIBRATION: Direct reading in megacycles and kilocycles. One turn of main tuning dial covers 100 kilocycles on all bands.

TUNING: Linear, divided into 30 one-megacycle bands. Each dial division represents one kc.

FREQUENCY STABILITY: Overall stability within 1 kc under normal operating conditions.

SELECTIVITY: 5.5 to 6.5 kilocycles at 6 db down. 17 to 20 kilocycles at 60 db down.

AUDIO OUTPUT: 4 and 600 ohms impedance. 1½ watts at 1000 cps with less than 15% distortion overall. "S" meter may be switched to read audio output.

RF INPUT: High impedance single-ended. Break-in relay mounted internally. Antenna trimmer will resonate input circuit when used with any normal antenna.

POWER REQUIREMENTS: 85 watts 45/70 cps, 115 volts or 230 volts.

DIMENSIONS: Panel — 10½ inches high, 19 inches wide, notched for rack mounting. Optional metal cabinet — 21-1/8 inches wide, 12-¼ inches high and 13-1/8 inches deep. Speaker available in metal cabinet 15 inches wide, 10-5/8 inches high and 9-1/8 inches deep.

Your inquiries will receive prompt attention

COLLINS RADIO COMPANY

Cedar Rapids, Iowa

Industrial Engineering Notes

(Continued from page 78A)

Reliability in Operational Equipments, E. F. Jahr; and Statistical Aspects of Tube Reliability, G. R. Herd, of Aeronautical Radio Inc. . . . **The outlay for scientific research and development totaled more than $3.5 billion in 1952, of which almost half was financed by the government, according to a report prepared jointly by the Bureau of Labor Statistics and the Research and Development Board of the Defense Department.** The report, based on a nationwide survey of 2,000 companies and covering some 85 per cent of the total industrial research in 1951, aimed at finding out what industry was doing in the field of research and development. The companies responding to the RDB survey accounted for almost $2 billion of research, with electronics accounting for 27.3 per cent of this amount, or around $500 million. Some 94,000 research engineers and scientists were employed in January 1952 by companies replying to the RDB survey, and 23.2 per cent of them were in the field of electronics. The average research cost per research employee, including both professional and non-professional worker, was $8,900 in 1951. Copies of "Industrial Research and Development" can be had by writing to the Research and Development Board, Department of Defense, Washington 25, D. C.

Research

The Office of Technical Services, Department of Commerce, has announced the release of its January Bibliograph of Technical Reports. The monthly publication, which lists available reports on scientific and technical research done by the government or with government aid, includes the following of interest to the electronics industry: "Improved Magnetic Materials" (PB 107813), available from the Photoduplication Section, Library of Congress, for $2.75 in microfilm and $7.50 in photostat form. "Improved Magnetic Materials" (PB 107815), Photoduplication Section, Library of Congress, for $2.50 in microfilm and $6.25 in photostat form. "Investigations of Methods of Increasing Life and Capacity of Lead Acid Storage Batteries. I. Preliminary Study of Methods for Evaluating the Corrosion Resistance of Positive Grid Materials" (PB 107841), Photoduplication Section, Library of Congress, Microfilm, $3.75, photostat, $11.25. "Simplified Methods for the Evaluation of Transients in Linear Systems," (PB 107950), Photoduplication Section, Library of Congress, microfilm $2.25, photostat, $5.00. "Television Recording Project" (PB 111-072), available from the Office of Technical Services, Department of Commerce, Washington 25, D. C. for $1.00.

SECTION MEETINGS

Akron

Student paper competition; January 13, 1953.

"Future Prospects of Ultrahigh Frequency Television," by Dr. Wen Yuan Pan, Radio Corporation of America; January 20, 1953.

Atlanta

"Communications in Civil Defense," by Stark Totman, Federal Civil Defense Administration; election of officers; January 23, 1953.

Baltimore

"Ultrasonics," by Dr. Patrick Conley, Westinghouse Electric Corporation; January 14, 1953.

"Space Travel, When?" by Dr. Wernher von Braun, Ordnance Guidance Missile Center, Huntsville, Ala.; February 12, 1953.

Boston

"The Modern Flight Simulator," by W. W. Wood, Jr., Link Aviation, Inc., and "An Automatic Ground Controlled Approach System," by R. C. Kelner; November 20, 1953.

"Physics of Transistor Electronics," by Dr. W. H. Brattain, Bell Telephone Laboratories and "Problems in the Fabrication of Point Contact Transistors," by R. S. Fallows, Sylvania Electric Products, Inc." December 18, 1953.

"A Wide-Range Pulse Generator for Laboratory Applications," by R. W. Frank, General Radio Company, and "Basic Systems for the Measurement and Generation of Phase Relationships," by J. C. Looney, Technology Instrument Corporation; January 22, 1953.

Buffalo-Niagara

"Minaturized Components and Their Applications in Transistor Electronics," by P. S. Darnell, Bell Telephone Laboratories; January 21, 1953.

Central Florida

"A Novel Electronic Multiplexing System," by P. M. G. Toulon, Radiation, Inc.; November 20, 1952.

"Electric Amplifiers," by Dr. H. E. Hollman, Naval Air Missile Test Center; December 17, 1952.

Chicago

"A Review of Transistor Progress in 1952," by R. F. Shea, General Electric Company; January 16, 1953.

Cleveland

"The Present Status of Transistor Development," by J. A. Morton, Bell Telephone Laboratories; January 15, 1953.

Columbus

"Advantages and Disadvantages of Big and Small Business," by G. Foster, Industrial Nucleonics; L. Moore, Columbus and Southern Electric Co.; R. W. Masters, The Ohio State University and J. Audi, Line Material Co.; January 13, 1953.

Connecticut Valley

"The Problem of High Fidelity Audio Reproduction in the Home," by Dr. L. L. Beranek, Massachusetts Institute of Technology; January 15, 1953.

Dallas-Ft. Worth

"Switching Circuits for Automatic Control," by William Keister, Bell Telephone Laboratories; February 11, 1953.

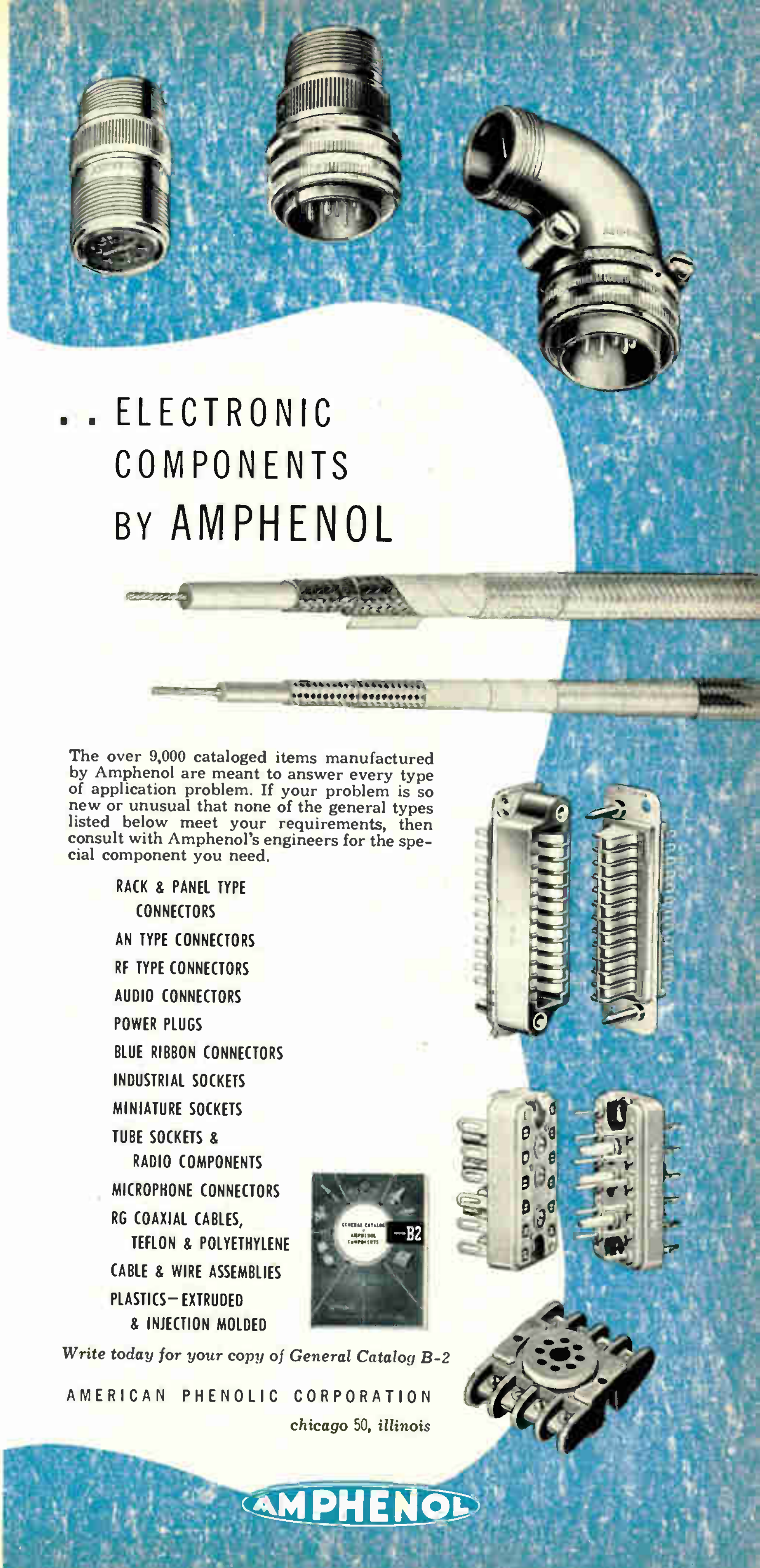
Dayton

"Servomechanisms," by Donald McDonald, Cook Research Corp.; February 12, 1953.

Des Moines-Ames

"Highlights and Sidelights of Engineering," by C. A. Scarlott, Editor of "Westinghouse Engineer"; January 27, 1953.

(Continued on page 82A)



SECTION MEETINGS

(Continued from page 81A)

FT. WAYNE

"Advance Study and Your Engineering Future," by C. J. Poling, Purdue University; February 5, 1953.

HAMILTON

"A Color TV Receiver for N.T.S.C. System," by K. Farr, Westinghouse Electric Corporation; January 26, 1953.

"VHF and UHF Measurement Techniques," by W. A. Cumming, National Research Council; February 16, 1953.

INYOKERN

"Frequency Meter Design Techniques," by Leonard Cutler, Gertch Products, Inc.; January 27, 1953.

KANSAS CITY

"Aurora Magnetic Storms and Radiation," by Dr. R. K. Moore, Sandia Corp.; January 20, 1953.

"Telemetering—Instruments, Systems, Techniques," by M. V. Kieber, Jr., Bendix Aviation Corp.; February 10, 1953.

LITTLE ROCK

"Transistor Manufacturing Techniques," by A. D. Evans, Texas Instrument Co.; January 22, 1953.

"Binaural Recording and Reproduction Sound," by C. G. Barker, Magnecord, Inc.; February 10, 1953.

LONDON

"A Synopsis of Tape Recording Systems and Standards," by G. Robitaille, Chief Engineer, Radio C.F.P.L.; January 20, 1953.

LOS ANGELES

"Remote Recording of Brain Potentials," by Dr. J. A. Gengerelli, Faculty, University of California at Los Angeles; February 3, 1953.

LOUISVILLE

"Application of Radio Isotopes to Medical Research and Therapy," by Drs. M. I. Schwalbe and Morris Nataro; February 12, 1953.

MILWAUKEE

"Pickups and Pre Amps," by N. C. Pickering, Pickering Corp.; January 23, 1953.

"Design of Switching Circuits for Automatic Control," by S. H. Washburn, Bell Telephone Laboratories; February 4, 1953.

MONTREAL

"Modern Glasses and Their Applications," by Dr. W. W. Shaver, Corning Glass Works; November 12, 1952.

"High Fidelity Audio Reproduction," by Dr. J. T. Henderson, Regional Director of Region 8, and R. H. Tanner, Northern Electric Company; December 10, 1952.

NEW YORK

"Recent Industrial Applications of Magnetic Amplifiers," by V. H. Krummenacher, Bogue Electric Manufacturing Company; January 7, 1953.

NORTH CAROLINA-VIRGINIA

"The Next Era in Electronics," by Dr. I. G. Wolff, Radio Corporation of America; January 30, 1953.

OKLAHOMA CITY

"Theory and Application of Transistors," by O. K. Garriott, Student, Oklahoma University; January 13, 1953.

OMAHA-LINCOLN

"New Facilities Now Being Installed in New Building of Lincoln Telephone and Telegraph Company," by C. C. Donley, Lincoln Telephone and Telegraph Company; January 26, 1953.

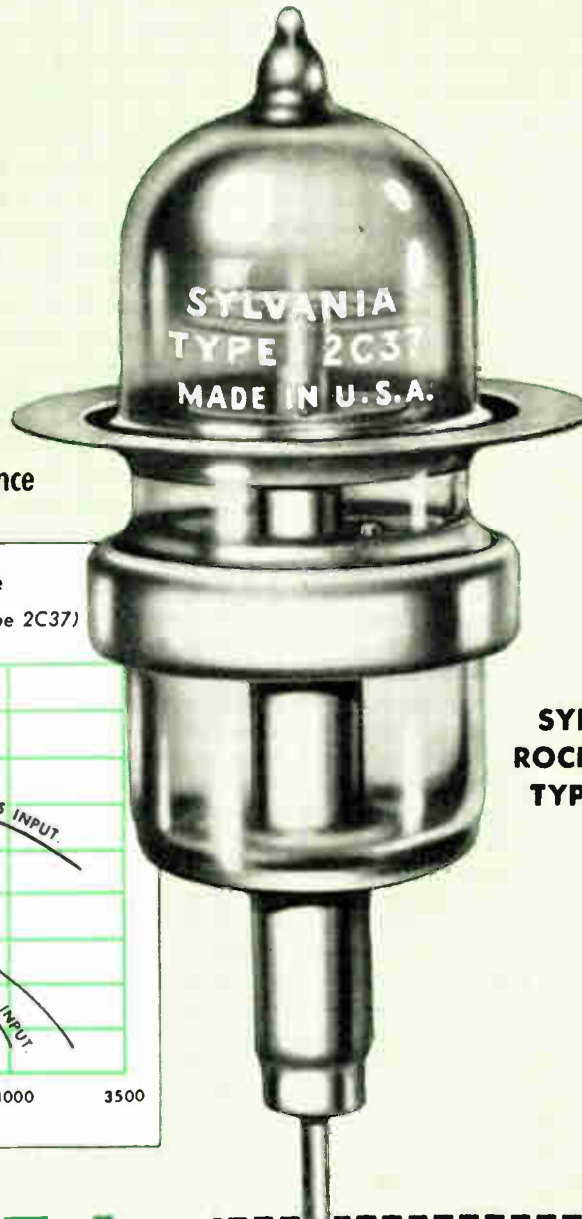
(Continued on page 84A)

Here's how to get

GOOD USABLE POWER AT UHF

Sylvania Rocket Tube Type 2C37 supplies 450 Mw at 3300 Mc.

Because of their high power throughout the UHF spectrum, Sylvania rocket tubes are especially recommended for service as pulsed oscillators, cw oscillators, rf amplifiers and frequency multipliers . . . this is one more reason why it will pay you to specify SYLVANIA.



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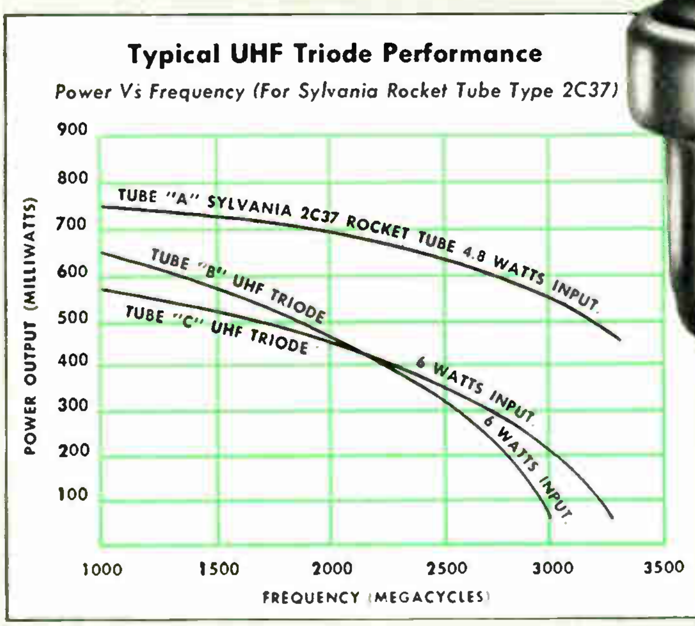

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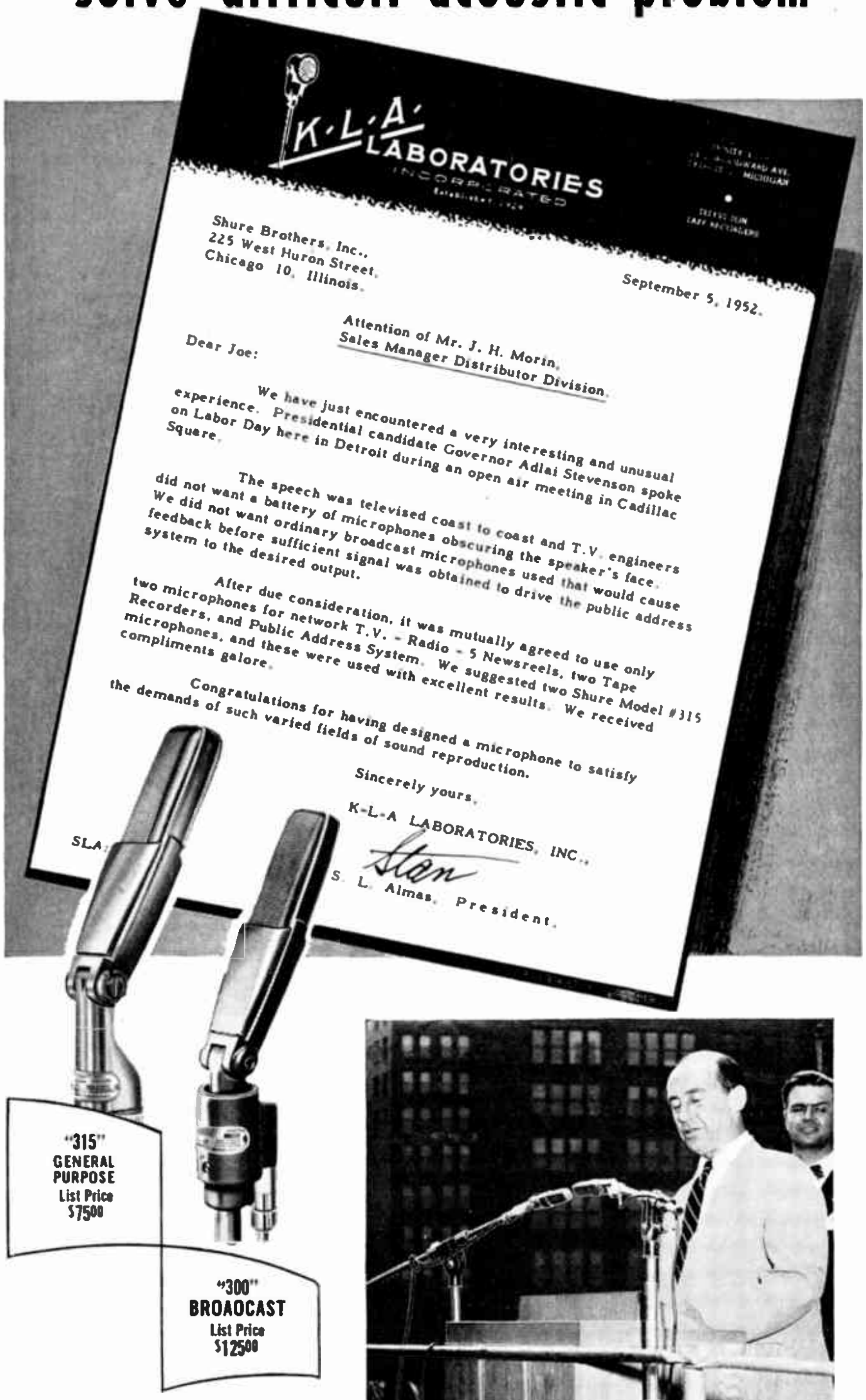


K·L·A LABORATORIES INCORPORATED

Shure Brothers, Inc.,
225 West Huron Street,
Chicago 10, Illinois.

September 5, 1952.

Attention of Mr. J. H. Morin,
Sales Manager Distributor Division.

Dear Joe:

We have just encountered a very interesting and unusual experience. Presidential candidate Governor Adlai Stevenson spoke on Labor Day here in Detroit during an open air meeting in Cadillac Square.

The speech was televised coast to coast and T.V. engineers did not want a battery of microphones obscuring the speaker's face. We did not want ordinary broadcast microphones used that would cause feedback before sufficient signal was obtained to drive the public address system to the desired output.

After due consideration, it was mutually agreed to use only two microphones for network T.V. - Radio - 5 Newsreels, two Tape Recorders, and Public Address System. We suggested two Shure Model #315 microphones, and these were used with excellent results. We received compliments galore.

Congratulations for having designed a microphone to satisfy the demands of such varied fields of sound reproduction.

Sincerely yours,

K-L-A LABORATORIES, INC.,

S. L. Almas, President.

SLA:

Former Governor Stevenson of Illinois, pictured as he addressed Detroit audience on Labor Day, during the 1952 presidential campaign.

SECTION MEETINGS

(Continued from page 82A)

Philadelphia

"The Human Centrifuge," by T. F. Pierce and C. E. Brooks, Aviation Medical Acceleration Laboratory, Naval Air Development Center; November 6, 1952.

"Field Emission Microscopy," by Dr. E. A. Muller, Faculty, Pennsylvania State College; January 8, 1953.

"Principles and Applications of Magnetic Amplifiers," by Dr. H. L. Goldstein, Bell Telephone Laboratories; February 4, 1953.

Pittsburgh

"Generalized Servomechanism Evaluation," by W. M. Kaufman, Student, Carnegie Institute of Technology; February 9, 1953.

San Francisco

"Electronics in the Oil Industry," by D. J. Pompeo, Shell Development Company; E. E. Harison, Standard Oil of California; V. N. Smith, Shell Development Co. and Dr. D. Hull, California Research Corp. Moderator, O. J. M. Smith. January 14, 1953.

Syracuse

"Solid State Luminescence," by Dr. Williams, General Electric Company; February 5, 1953.

Toledo

"Single-Sideband Transmission by Envelope Elimination and Restoration," by L. R. Kahn, consulting firm; February 12, 1953.

Toronto

"High Efficiency TV Horizontal Sweep Systems" and "Dissipation Determination," by C. E. Torsch, General Electric Company; January 26, 1953.

Tulsa

"Electronics in Aviation," by W. J. Weldon, American Airlines, Inc.; January 21, 1953.

Vancouver

Student's Night. Speakers: H. J. Goldie, B. P. Hildebrand and H. Palmer, Students, University of British Columbia; January 19, 1953.

Washington

"Microwave Propagation on Dielectric Rods in Ferromagnetic Media," by A. G. Fox, Bell Telephone Laboratories, Inc. and "A New Transistor for High Frequency Use," by R. I. Wallace, Bell Telephone Laboratories, Inc.; January 15, 1953.

"The Transmission of Speech by Narrow Band Signals," by W. G. Tuller and H. M. Williams, Melpar, Inc.; February 9, 1953.

Williamsport

"The Design of Receiving Tubes for Use in UHF TV Service," by L. R. Maguire and R. W. Slinkman and E. H. Boden, Sylvania Electric Products Inc.; January 28, 1953.

SUBSECTIONS

Lancaster

"Practical Television Antennas for Ultra-High Frequency Reception," by E. O. Johnson, RCA-Victor; January 14, 1953.

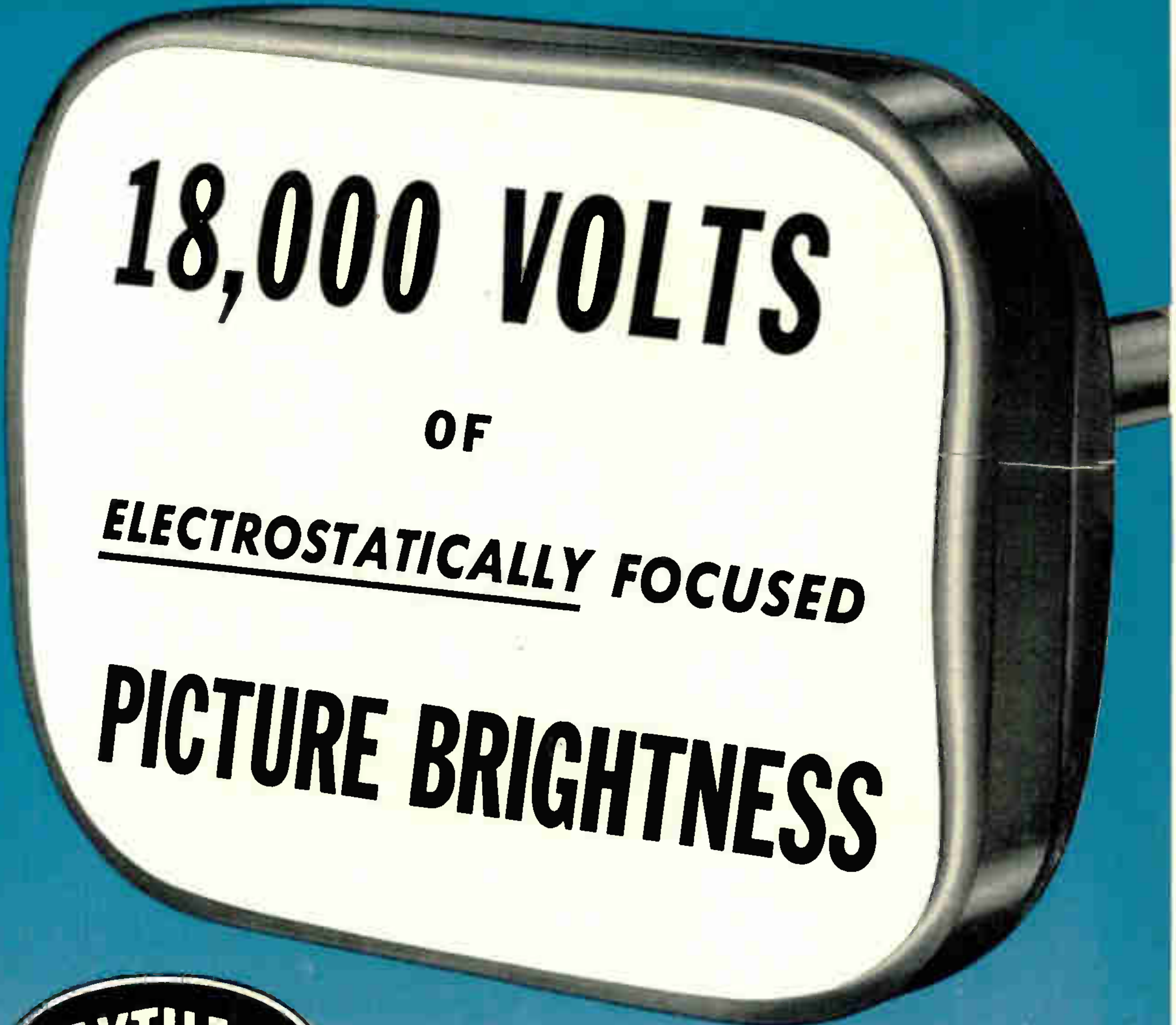
Long Island

"Low Temperature Physics," by Dr. C. A. Swenson, Massachusetts Institute of Technology; January 13, 1953.

Northern New Jersey

"Theseus, A Maze-Solving Machine," by Dr. Claude Shannon, Bell Telephone Laboratories, Inc.; January 14, 1953.

(Continued on page 86A)


18,000 VOLTS
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PICTURE BRIGHTNESS

SECTION MEETINGS

(Continued from page 84A)

PALO ALTO

"Basic Concepts of Information Theory," by Dr. B. M. Oliver, Hewlett-Packard Company; January 20, 1953.

ROME

"Miniaturization of Electronic Equipment," by Gustave Shapiro, National Bureau of Standards; January 19, 1953.

WINNIPEG

"Technical Aspects of TV," by J. E. Hayes, C.B.C.; December 4, 1952.

STUDENT BRANCH MEETINGS

AGRICULTURAL & MECHANICAL COLLEGE OF TEXAS, IRE-AIEE BRANCH

"Can Machines Think?" By Mr. Keister, Bell Telephone Laboratories; February 9, 1953.

UNIVERSITY OF AKRON, IRE-AIEE BRANCH

Student Papers: "A Two Speed Synchronous Motor and Its Controls," by Curtis Ivey. "Power Factor Meter," by Raymond Miller, and "A.M. Detector," by Robert Savoy, Students, University of Akron; January 13, 1953.

UNIVERSITY OF ALBERTA, IRE-AIEE BRANCH

"Telephone Connections in Alberta," by Mr. Schmidt, Alberta Research Council; January 19, 1953.

"Industrial Welding," by T. J. Jacobs, Jacobs Welding Engineering School; February 2, 1953.

BRITISH COLUMBIA, IRE-AIEE BRANCH

General Meeting; February 6, 1953.

BROWN UNIVERSITY, IRE-AIEE BRANCH

General Business Meeting; December 9, 1953.

Field Trip to WPRO-Providence; February 5, 1953.

Film, "Radio Frequency Heating"; February 18, 1953.

CALIFORNIA STATE POLYTECHNIC COLLEGE, IRE BRANCH

"The Fundamentals of Transistors and their Applications," by Walter Sterling, Consolidated-Vultee Aircraft Company; January 14, 1953.

UNIVERSITY OF DENVER, IRE-AIEE BRANCH

General Meeting; February 5, 1953.

STATE UNIVERSITY OF IOWA, IRE BRANCH

Films, "Navy and National Bureau of Standards Research and Development Laboratories of California" and "United States Naval Ordinance Test Station—Inyokern"; November 5, 1952.

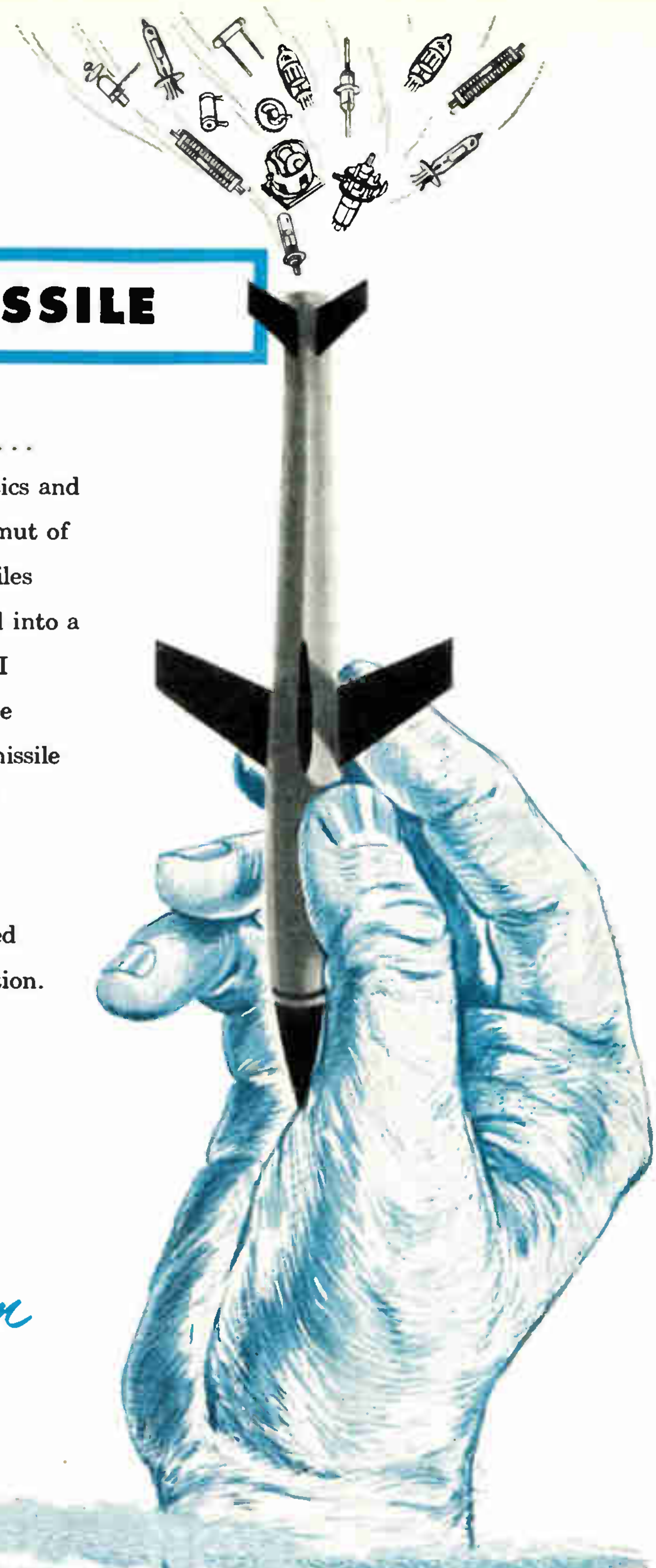
Open Discussion on "Seminar Field Trips"; November 12, 1952.

"Underground Transmission Power Cables," by W. J. Anciaux and "380 KV Overhead Transmission System of Sweden," by E. H. Berentsen, both students, University of Iowa; November 19, 1952.

"SUI Radio Amateur Club," by J. E. Frankhauser, Faculty, State University of Iowa; December 3, 1952.

"Work Experiences at Collins Radio Co." by W. J. Streib, Faculty, State University of Iowa; December 17, 1952.

(Continued on page 90A)



MAKINGS OF A MISSILE

Many things go into the Makings of a Missile . . . electronic tubes, rocket motors, metals, plastics and creative engineering talent running the whole gamut of the engineering specialties. Fairchild's Guided Missiles Division has this engineering talent—welded into a team by experience going back into World War II when Fairchild was prime contractor for one of the earliest guided missiles. For its experienced missile engineering and production organization, which has produced missiles for all three branches of the Armed Services, Fairchild recently completed this country's first privately built plant devoted exclusively to missile development and production.

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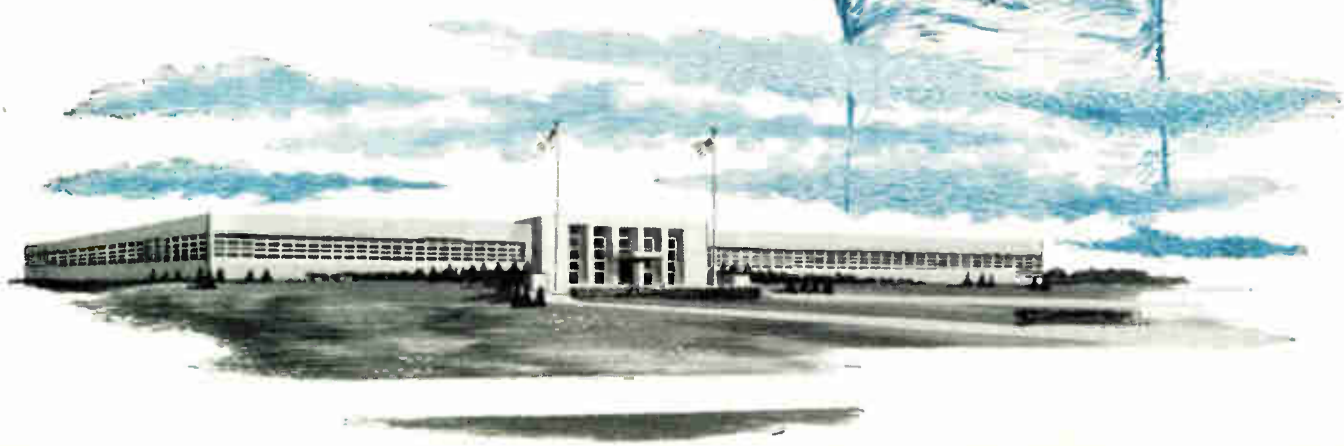

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TORKRITE has no hole nor perforations through the tube wall. This eliminates possibility of cement leakage locking the cores.

TORKRITE allows use of lower torque as it is completely independent of stripping pressure.

With TORKRITE torque does not increase after winding, as the heavier wall will not tend to collapse and bind the core.

Available in lengths 3/4" to 3 1/8" to fit a 1/4-28 core.

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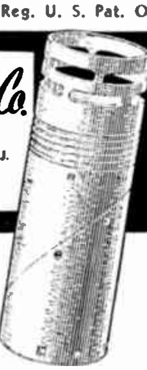

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STUDENT BRANCH MEETINGS

(Continued from page 86A)

"Direct Projection Television," by D. W. Thomas and "Sinusoidal Pulse Generator," by J. E. Madison, students, State University of Iowa; January 7, 1953.

"Electroencephalograph," by J. W. Baum, Student, State University of Iowa and open Discussion on "Student Engineers Lounge Plans"; January 14, 1953.

"Walkie-Talkie," by E. J. Tillo, Student, State University of Iowa, and open Discussion on "Possible Solutions to Practical Problems Encountered in Measurements in the Field of Medical Research"; January 21, 1953.

"Bell Telephone Laboratories," by H. A. Wells, Bell Telephone Laboratories; January 28, 1953.

LOUISIANA STATE UNIVERSITY, IRE-AIEE BRANCH

"Recent Developments in Power," by D. L. Chesnut, General Electric Company; November 12, 1952.

Film and General Meeting; December 9, 1952.

"Traffic Signals," by J. A. Loupe and "The Applications of A.C. Series Motors in Locomotives," by F. V. Warner; December 12, 1952.

"Engineering at Oak Ridge," by Gibson Morris, Carbide and Carbon Chemicals Company of Oak Ridge, Tenn.; January 6, 1953.

UNIVERSITY OF MAINE, IRE BRANCH

"Development of the Traveling Wave Tube," by Roger White, Federal Telecommunications Laboratories; February 10, 1953.

UNIVERSITY OF MARYLAND, IRE-AIEE BRANCH

Binaural Sound Demonstration by Frank McIntosh, McIntosh Laboratories and Capt. Robert Hathaway, USAF; November 5, 1952.

"Transistors," by Dr. William Deurig, Johns Hopkins Institute; December 3, 1952.

"Telemetering of the V-2 Rocket," by Representative of Johns Hopkins Institute; January 7, 1953.

"The Control System of the Viking Rocket," by N. E. Felt, Jr., Glenn L. Martin Company; February 11, 1953.

UNIVERSITY OF MASSACHUSETTS, IRE-AIEE BRANCH

"The Use of Copper in the Electrical Industry," (Illustrated with two films), by I. T. Hook, American Brass Company; January 14, 1953.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, IRE-AIEE BRANCH

Election of officers and business meeting; January 20, 1953.

MICHIGAN COLLEGE OF MINING & TECHNOLOGY, IRE-AIEE BRANCH

"My Recent Tour of Duty in the West Pacific as Navy Radio Operator," by D. I. Fales, Student, Michigan College of Mining and Technology; January 13, 1953.

"Radio Station Management," by A. Payne, Radio Station WHDF; January 28, 1953.

"Technical Operating Procedure at WHDF," by George Burgan, Radio Station WHDF; February 10, 1953.

NEWARK COLLEGE OF ENGINEERING, IRE BRANCH

Tour of RCA Electron Tube Plant in Harrison, N. J.; February 3, 1953.

COLLEGE OF THE CITY OF NEW YORK, IRE BRANCH

Election of officers; January 8, 1953.

(Continued on page 92A)

STUDENT BRANCH MEETINGS

(Continued from page 90A)

NEW YORK UNIVERSITY (EVE. DIV.), IRE-AIEE BRANCH

"Recent Developments in TV Picture Tubes," by Robert Scott, Dumont Laboratories, Inc.; January 23, 1953.

NORTH DAKOTA STATE COLLEGE, IRE-AIEE BRANCH

General meeting; December 3, 1952.

Films, "Atomic Power" and "Atomic Energy"; January 26, 1953.

NORTHWESTERN UNIVERSITY, IRE-AIEE BRANCH

Student paper competition and talk by Dr. J. F. Calvert, Faculty, Northwestern University; January 13, 1953.

Films; January 20, 1953.

Film, "Electrical Proving Ground"; January 27, 1953.

OHIO STATE UNIVERSITY, IRE-AIEE BRANCH

Field trip to National Electric Coil Company; January 29, 1953.

Field trip to Ohio State University Cyclotron Laboratory; February 12, 1953.

OKLAHOMA AGRICULTURAL & MECHANICAL COLLEGE, IRE-AIEE BRANCH

"Low Voltage Metal Inclosed Switchgear for Industrial Power Distribution," by F. R. Summers, Westinghouse Electric Corp.; February 9, 1953.

UNIVERSITY OF PENNSYLVANIA, IRE-AIEE BRANCH

Election of officers; February 5, 1953.

RENSSELAER POLYTECHNIC INSTITUTE, IRE-AIEE BRANCH

"Recent Developments of Klystron Tubes," by C. E. Rich, Sperry Gyroscope Company; February 10, 1953.

RUTGERS UNIVERSITY, IRE-AIEE BRANCH

"Patent Law and the Engineer," by Morton Amster, counselor of law; February 10, 1953.

Business meeting; February 17, 1953.

THE UNIVERSITY OF SOUTHERN CALIFORNIA, IRE-AIEE BRANCH

"The Instrument Story," by J. E. Berring, Weston Instrument Corp.; February 10, 1953.

STANFORD UNIVERSITY, IRE-AIEE BRANCH

Field trip to Lenkurt Electric Company; February 13, 1953.

UNIVERSITY OF TEXAS, IRE-AIEE BRANCH

"Cybernetics," by W. T. Guy, Professor of Applied Mathematics; February 2, 1953.

UNIVERSITY OF TOLEDO, IRE-AIEE BRANCH

"Helpful Hints in TV Servicing," by D. F. Davey and E. E. Swartz, Students, University of Toledo; December 5, 1952.

UNIVERSITY OF TORONTO, IRE-AIEE BRANCH

"Sound System for Opera Performances," by Mr. Goldin, Consulting Engineer; November 14, 1952.

"Professional Organization," by Roy Harmer, Lecturer at Ryerson Institute of Toronto; December 5, 1952.

"Computers," by V. G. Smith, Faculty, University of Toronto; January 16, 1953.

TUFTS COLLEGE, IRE-AIEE BRANCH

Business meeting; February 18, 1953.

(Continued on page 93A)

STUDENT BRANCH MEETINGS

(Continued from page 92A)

UNIVERSITY OF UTAH, IRE-AIEE BRANCH

"Electrical Engineering in the Bureau of Reclamation," by G. R. Derrick, U. S. Bureau of Reclamation; December 4, 1952.

"What Industry Expects from Engineers," by S. S. Kistler, Dean, University of Utah College of Engineering; January 22, 1953.

"Underwater Sound and Detection Devices," by Dr. Fred Huber, Naval Electronic Laboratory; January 29, 1953.

UTAH STATE AGRICULTURAL COLLEGE IRE BRANCH

"Forest Service Communication," by Francis Woods, U. S. Forest Service; January 28, 1953.

"Television on a Mountain Top or the Rise and Fall of KSL T.V.," by V. E. Clayton, KSL Television; February 11, 1953.

UNIVERSITY OF VIRGINIA, IRE-AIEE BRANCH

"Design of Broadcast Consolettes for Announcer Use," by L. F. Goeller, Jr., Student, University of Virginia; February 17, 1953.

VIRGINIA POLYTECHNIC INSTITUTE, IRE-AIEE BRANCH

Business meeting; January 13, 1953.
Business meeting; January 20, 1953.
Business meeting; February 10, 1953.

UNIVERSITY OF WASHINGTON, IRE-AIEE BRANCH

"The Northwest Power Problem," by F. D. Robbins, Faculty, University of Washington; January 15, 1953.

General meeting and film, "Watts in Glass"; January 29, 1953.

WAYNE UNIVERSITY, IRE-AIEE BRANCH

"Instrumentation of Resistance Welding Machine Schedules," by A. R. Satullo, Instructor, Wayne University; January 9, 1953.

MEMBERSHIP

The following transfers and admissions were approved to be effective as of April 1, 1953:

Transfer to Senior Member

Alexander, W. G., 6 Maguire Rd., Cochituate, Mass.
Ayer, W. E., 95 Hilltop Dr., San Carlos, Calif.
Bargellini, P. L., 15 Yale Sq., Morton, Pa.
Bauer, B., 1089 Forest Ave., Palo Alto, Calif.
Berglund, E. B., 56 Roosevelt St., Garden City, L. I., N. Y.
Ebert, J. E., 478 Whitehall St., Lynbrook, L. I., N. Y.
Franklin, C. S., 228 Lewiston Rd., Dayton 9, Ohio
French, H. A., 16 Howard Pl. Waldwick, N. J.
Guida, J. A., 2904 Newcastle Ave., Silver Spring, Md.
Gulden, E. V., 140 Oak Knoll Dr., Dayton 9, Ohio
Haggerty, P. E., 5322 Falls Rd., Dallas 9, Tex.
Hassler, E. B., 5879 N. Kolmar Ave., Chicago 30, Ill.

(Continued on page 94A)

MEMBERSHIP

(Continued from page 93A)

Heister, C. F., 3200 Federal Office Bldg., Kansas City 6E, Mo.
Holbrook, R. O., 405 Southwest Dr., Silver Spring, Md.
Ivers, J. H., 552 S. Border Rd., Winchester, Mass.
Jaeger, J. H., 361 Oakland Park Ave., Columbus 14, Ohio
Kadet, J., 19 Shute Path, Oak Hill Pk., Newton, Mass.
King, S., Electrical Engineering Department, University of Tennessee, Knoxville, Tenn.
Lundquist, C. R., 6686 DeAnza Ave., Riverside, Calif.
McKesson, L. J., 405 Upper Blvd., Ridgewood, N. J.
McRae, A. H., 1623 Hearthstone Dr., Dayton 10, Ohio
Meyer, E. G., 45 Cumberland Ave., Great Neck, L. I., N. Y.
Millard, A. M., Southern New England Telephone Co., 227 Church St., New Haven 6, Conn.
Murphy, C. H. S., Bureau of Aeronautics Representative, McDonnell Aircraft Corp., Box 516, St. Louis 3, Mo.
Pickens, D. H., 7518 S. Thomas Ave., Bridgeview, Chicago 38, Ill.
Podolsky, L., 18 Lexington Pkwy., Pittsfield, Mass.
Powell, D. S., 3415—38 St., N.W., Washington 16, D. C.
Richardson, G. A., Electrical Engineering Department, Iowa State College, Ames, Iowa
Stubbs, W., Telecommunications Department, Kuala Lumpur, Malaya
Thulin, C. W., Bell Telephone Laboratories, Inc., Murray Hill, N. J.
Van Valkenburg, M. E., Engineering Hall, University of Utah, Salt Lake City 1, Utah
Weinschel, B. O., 10015 Woodland Dr., Silver Spring, Md.
Wieland, E. S., 1203 Salem Ave., Dayton 6, Ohio
Wilson, R. T., 426 Essex Dr., Lexington Park, Md.
Witkin, E., 6801 N. 11 St., Philadelphia 26, Pa.

Admission to Senior Member

Ball, K. E., 2619 General Bradley, N. E., Albuquerque, N. Mex.
Bundy, C. W., USS MacKenzie (DD836), Fleet Post Office, San Francisco, Calif.
Cederbaum, I., Box 1, Kiryat-Motzkin, Israel
Coapman, J. W., 240 Laurie St., Eau Gallie, Fla.
Comins, A. W., 1708 Windsor Ave., Lancaster, Pa.
Fenyves, F. L., Basle (Switzerland) 75 Austr., Basle, Switzerland
Foster, L. W., 43 Cottage Hill Rd., Glens Falls, N. Y.
Hasley, A. D., 53 Cherry La., Basking Ridge, N. J.
Hawthorne, E. I., Moore School of Electrical Engineering, 200 S. 33 St., Philadelphia 4, Pa.
Hearn, R. B., 463 West St., New York 14, N. Y.
Holborn, F., 15 Eastwood Pl., Cedar Grove, N. J.
McPherson, J. C., 590 Madison Ave., New York 22, N. Y.
Means, W. J., 35 Whittredge Rd., Summit, N. J.
Nichols, N. B., Manager of Research Division, Raytheon Manufacturing Co., Waltham 54, Mass.
Plummer, D., 3116 Elm Ave., Manhattan Beach, Calif.
Raney, J. J., 140 W. Center College St., Yellow Springs, Ohio
Schisel, J., 105 New England Ave., Apt. F-8, Summit, N. J.
Schneider, S. S., Canadian Westinghouse Co., Ltd., Longwood Rd., Hamilton, Ont., Canada
Scott, J. E., 325 S. Central Ave., Fairborn, Ohio
Sheldon, J. L., 179 Dodge Ave., Corning, N. Y.
Sutinen, C. P., 317 W. Third St., Moorestown, N. J.
Thomas, J. E., Jr., 49 Kendal Common Rd., Weston 93, Mass.
Wynn, R. T. B., British Broadcasting Corp., Broadcasting House, London W.1, England

(Continued on page 98A)

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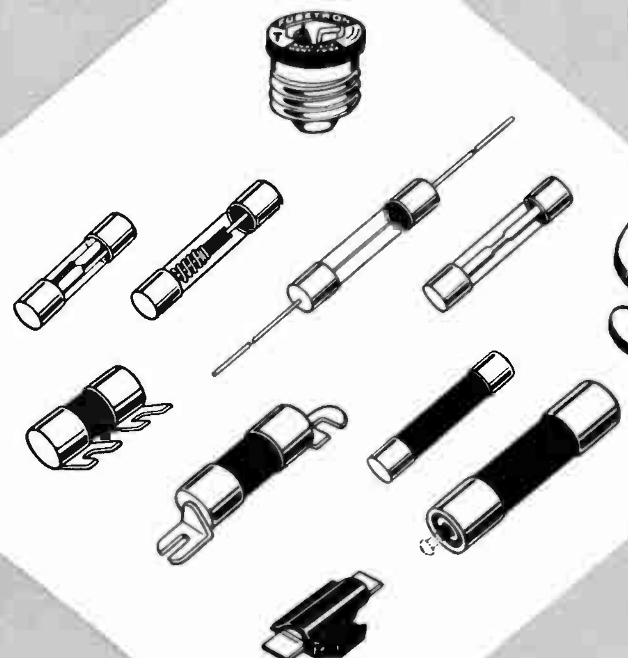

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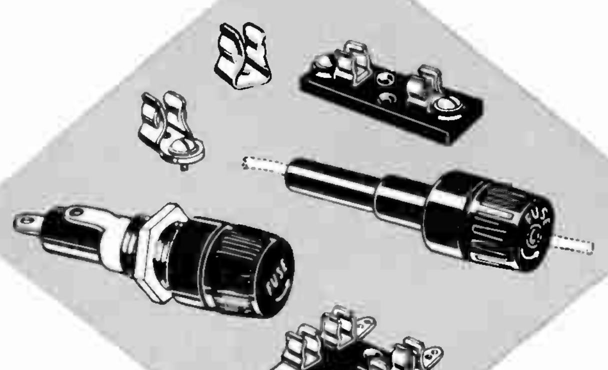

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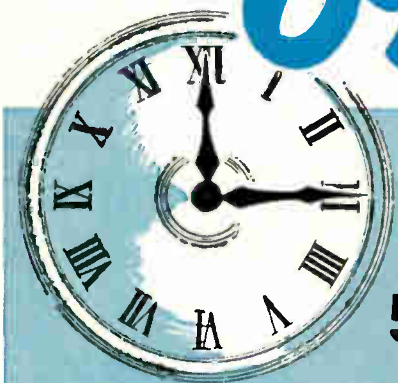

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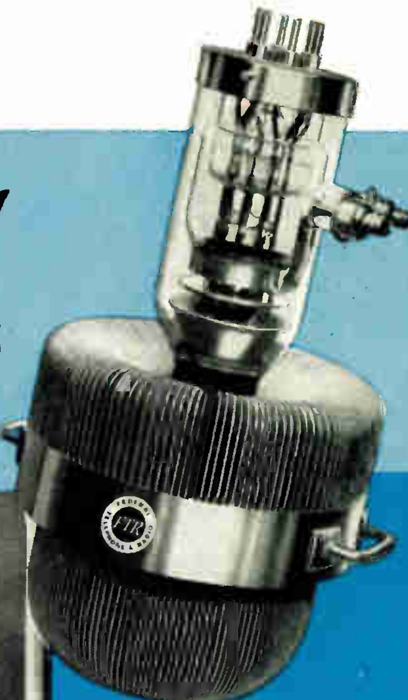

Federal F-9C31 22,255 HOURS Still in Service	Federal F-9C29 21,015 HOURS Now used as a Spare	Federal F-9C31 25,629 HOURS Still in Service

THORIATED Tungsten Filaments in Federal's F-9C31 · F-9C29 SAVE POWER EQUAL TO THE PRICE OF A NEW TUBE PER YEAR!

THIS is the life story of 3 of numerous Federal power triodes used by the Canadian Broadcasting Corporation at station CBX, Lacombe, Alberta: Since October, 1948, to recent date, these tubes have served for 69,000 hours. Both F-9C31's appear to have full emission and capability of many more hours. The F-9C29—used in modulator unit—is on standby after 21,015 hours.

Behind the long performance of these 3 tubes is Federal's pioneering in the *multi-strand thoriated tungsten filament,* which permits hairpins to expand *individually* . . . eliminates stresses which might be conducive to filament warping.

Cathodes of this type provide lower operating temperatures . . . keep components cooler, more durable. Because *less* filament power is consumed, tube life is *longer* . . . operating costs are *lower*. The power saved per-tube-per-year equals the price of a *new* tube!

For full information on Federal's F-9C31 and F-9C29, or Federal quality-controlled tubes of any power output, write Dept. K-137.

Federal always has made better tubes"

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Federal Telephone and Radio Corporation

VACUUM TUBE DIVISION **100 KINGSLAND ROAD, CLIFTON, N. J.**

In Canada: Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors: International Standard Electric Corp., 67 Broad St., N. Y.


Xb BAND 3/4" x 1 1/2"
SMALL X BAND 1/2" x 1" WAVE
Titeflex
MICROWAVE COMPONENTS
designed,
built,
and inspected
to insure superior
performance
S BAND 1 1/2 x 3 WAVEFLEX
L BAND 6 1/2" x 3 1/4" WAVEFL

MEMBERSHIP

(Continued from page 94A)

Transfer to Member

Attack, H. G., 579 James St., S., Hamilton, Ont., Canada
Bailey, W. R., Texas Instruments, 6000 Lemmon Ave., Dallas 9, Tex.
Bauer, R. E., U. S. Naval Postgraduate School, Monterey, Calif.
Bennett, R. C., 2239 Marconi Ave., Sacramento 21, Calif.
Brock, F. A., 5422 Druid La., Dallas 9, Tex.
Cook, M. F., 6307 Tecumseh Pl., College Park, Md.
D'Arcy, E. W., 7045 Osceola Ave., Chicago 31, Ill.
Finn, D. L., School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.
Gagnon, L. A., Box 166, 235 Second Ave., Port Alfred, Que., Canada
Hansen, H. M., 1314 Walden Rd., Walnut Creek, Calif.
Healey, D. J., III, Shawan Rd., Cockeysville, Md.
Helland, J. C., 24 Flannery Ave., Poughkeepsie, N. Y.
Hensel, W. G., 265 Washington Ave., Chatham, N. J.
Khouri, A. S., Centralab, a Division of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 11, Wis.
McCarter, G. B., 8310—16 St., Apt. 116, Silver Spring, Md.
Moore, A. D., 604 East 23 Ave., Vancouver 10, B. C., Canada
Nelson, R. T., 94 Pershing Ave., Valley Stream, L. I., N. Y.
North, R. C., Jr., 2844 East 26, Tulsa, Okla.
Nylin, M. E., 454 Douglas Ave., Toronto 12, Ont., Canada
Page, F. E., Jr., 1116 Post St., Houston, Tex.
Post, R. F., 1004 N. Kedzie Ave., Chicago 51, Ill.
Quint, A. S., 55 Lee St., Cambridge 39, Mass.
Richman, H. R., Box 658, R.F.D. 2, Fairfax, Va.
Schroeder, K. R., 43-28 Byrd St., Flushing 55, L. I., N. Y.
Scroggins, C. M., 4154 Prescott Ave., Dallas 9, Tex.
Shainis, M. J., 99 Featherbed La., New York, 52, N. Y.
Snow, J. E., Far East Air Logistic Force, APO 323, c/o Postmaster, San Francisco, Calif.
Stachiewicz, B. R., 926 E. Hastings St., Vancouver 4, B. C., Canada
Stewart, G. L., 25 Thursfield Cresc., Toronto 17, Ont., Canada
Villadamigo, R. D., Apartado Nacional No. 765, Barranquilla, Colombia, S. A.
Stewart, J. L., 315 Apt. No. 6 Stanford Village, Stanford, Calif.
Swierczak, P. C., 6716 Harvey Ave., Merchantville 8, N. J.
Trebby, F. J., 4128 S. Garfield St., Spokane 36, Wash.
Weis, C. F., 57 N. Bromfield Rd., Dayton 9, Ohio

Admission to Member

Allen, D. H., 2180 Colorado Ave., Santa Monica, Calif.
Atchison, F. S., 6197 Palm Ave., Riverside, Calif.
Brumbach, J. F., 9736 Johanna Ave., Franklin Park, Ill.
Brunson, R. A., R.F.D. 1, 10 Elm St., Florham Park, N. J.
Byrnes, W. P., Teletype Corp., 1400 W. Wrightwood Ave., Chicago 14, Ill.
Cammer, H. R., 231 Argyle Rd., Brooklyn 18, N. Y.
Campbell, A. A., 4812 Southern Ave., S. E., Albuquerque, N. Mex.
Cornell, W. A., 27 Forest Rd., Murray Hill, N. J.
Dawson, L. R., 432 A Kalama St., Lanikai, Hawaii
Doxey, W. L., 239 Albert Pl., Elberon, N. J.

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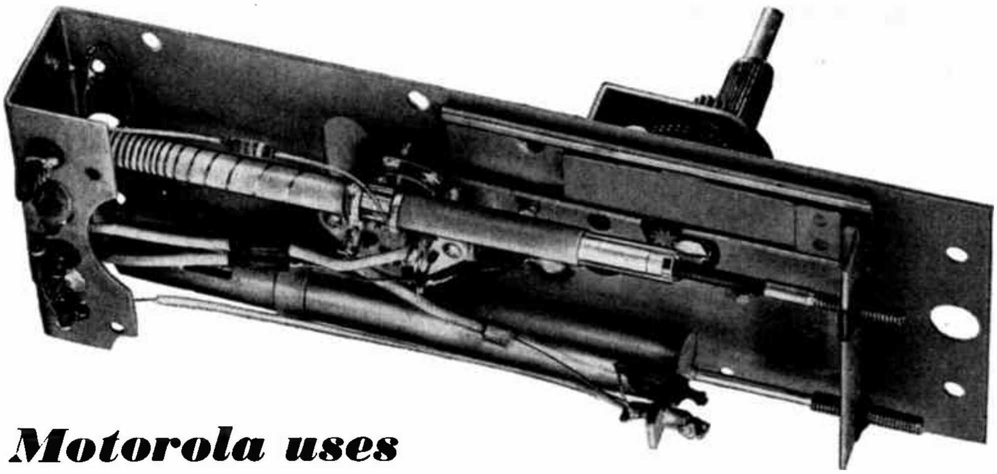
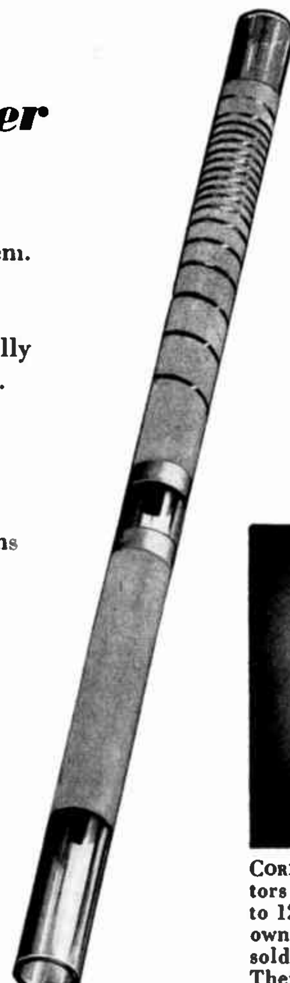


Why Motorola uses Corning Metallized Glass Inductances in new UHF converter

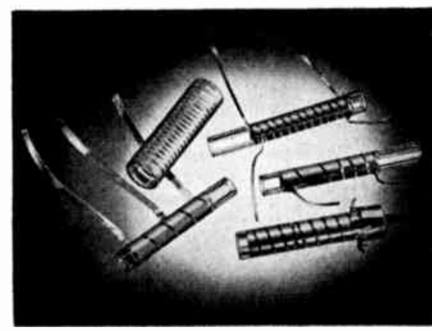


UHF converters present a tough design problem. Not only must they tune an unusually broad band, stability is extremely important.

Motorola solved their problem with a specially designed CORNING metallized glass inductance. As can be seen from the illustration, the tuning elements are a combination of distributed capacitance and inductance. The variable pitch winding tailors the unit to the desired tracking curve. One end of the turns is broadened to provide termination surface. The accuracy and rigidity of the glass assure stable, noiseless tuning.

The exceptionally high electrical stability and low temperature coefficient of CORNING metallized glass inductances are a result of the integral contact of the fired-on metallizing with the dimensionally stable glass coil forms. Drift is negligible, even under unusually variable ambient temperatures. High Q is inherent.

CORNING metallized glass inductances may well be the answer to your problem. All it takes to find out is a letter to us. Our engineers are ready to go to work for you.



CORNING Metallized Glass Inductances can be designed to fit your requirements exactly. Uniform, variable or double pitch windings are as easily manufactured as are fixed tuned, permeability tuned or permeability tuned inductance-trimmer combinations. Once a design has been approved, it can be accurately duplicated on automatic machinery to very close tolerances and in any quantity.

CORNING Metallized Glass Trimmer Capacitors are available in standard types from .3 to 12 u.u.f. or can be designed to meet your own particular needs. They are simple to solder, rugged and easy to tune critically. Their superior electrical characteristics are similar to CORNING inductances.

Corning Glass Works

New Products Division · CORNING, N. Y.

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Please send me literature on
☐ Metallized Glass Inductances, ☐ Metallized Glass Trimmer Capacitors.

Name .... Title ....

Company ....

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

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(Continued from page 98A)

Ellen, S. T., Smith Ave., R.F.D. 7, Baltimore 9, Md.
Fraser, F. S., 1777 West Third Ave., Vancouver, B. C., Canada
Fricks, W. H., 909 Borum Pl., Oklahoma City 10, Okla.
Gaunt, R. P., 8430 Lennox Ave., Van Nuys, Calif.
Godsey, W. J., 1023 Eastern Ave., Baltimore 21, Md.
Harden, C. M., 78 Pierce Rd., Watertown, Mass.
Heimlich, I. R., 2209 Graham St., Grand Prairie, Tex.
Horn, C. H., Rm. 210, 1401 Arch St., Philadelphia 2, Pa.
Hunter, W. O., 2732 N. Serrano Ave., Los Angeles 27, Calif.
Johnston, W. A., Jr., Fairchild Guided Missiles Division, Wyandanch, L. I., N. Y.
Jose, R. S., R.F.D. 2, Rancocas Woods, Mt. Holly, N. J.
Keating, J. J., 3112 Chadwick Dr., Los Angeles 32, Calif.
Kelton, M. R., Box 146, Montreal, Que., Canada
Knowlton, R. F., R.F.D. 5, 1502 E. Alta, Wichita 15, Kans.
Low, A. R., 578 Broadway Ave., Toronto 17, Ont., Canada
Mentzer, P. K., 3201 Wooster Rd., Rocky River 16, Ohio
Minidis, A., 9544 Lenore St., Detroit 28, Mich.
Morris, H. N., 213 Beverly Rd., Cocoa, Fla.
Newnan, H. L., 420 Market St., San Francisco 11, Calif.
Perry, F. M., 2000 Pyle Rd., Schenectady 3, N. Y.
Rae, J. R., 171 Riverview Ave., Tarrytown, N. Y.
Ralph, J. T., 2027 S. Newton Ave., Park Ridge, Ill.
Ross, R. M., Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Sperber, A. O., 7407—64 Pl., Glendale 27, L. I., N. Y.
Stelmak, J. P., Westinghouse Electric Corp., Box 284, Elmira, N. Y.
van der Lee, A. C., 707M Lima, Buenos Aires, Argentina
Warner, F. C., 12 High St., Bethel, Conn.
Zomber, G. L., 22 Dartmouth St., Garden City, L. I., N. Y.

The following elections to Associate grade were approved to be effective as of March 1, 1953:

Adair, R. J., 19 Proctor Blvd., Hamilton, Ont., Canada
Adams, H. E., Qtrs. W 15, NRL, CBA, Chesapeake Beach, Md.
Adamson, W. V., 306 W. Mayfield Blvd., San Antonio, Tex.
Albert, D. E., 918 Hamilton Ave., Latrobe, Pa.
Allard, L. C., Jr., Box 3024, Wright-Patterson AFB, Dayton, Ohio
Allen, D. F., 7 Alcott St., Allston 34, Mass.
Ambrogi, J. N., Jr., 319 Lincoln Ave., Lansdowne, Pa.
Anderson, W. L., 127—96 St., San Antonio 4, Tex.
Anlage, J. J., 52 Winding Way, Haddonfield, N. J.
Avella, P. S., 2155 N. Mobile Ave., Chicago 39, Ill.
Barr, F. M., 1380 North Ave., Elizabeth 3, N. J.
Barr, H. J., 813 E. Seventh St., Plainfield, N. J.
Bass, C. F., 350 Saxon Rd., Latham, N. Y.
Bazydlo, H. A., 4737 Plumer St., Detroit 9, Mich.
Beaver, M. W., 712 Crown St., Brooklyn 13, N. Y.
Beck, C., 5838 Cedar Ave., Philadelphia, Pa.
Becker, H. R., 20-04 Woodbine St., Ridgewood, L. I., N. Y.
Behringer, N. C., 29 Deer La., Wantagh, L. I., N. Y.
Bellingham, L. C., Natvar Corp., Box 67, Rahway, N. J.

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MEMBERSHIP

(Continued from page 100A)

Benway, R. E., 1641 Old Phila Pike, Lancaster, Pa.
Bernard, D. T., 126 Cedar St., Wethersfield, Conn.
Blicher, A., 535 W. 110 St., New York 25, N. Y.
Bloom, I., 3509 Virginia Ave., Baltimore 15, Md.
Bolay, C. E., c/o Two-Way Radio Communication Co., 505 N.W. Second, Oklahoma City, Okla.
Bowe, J. J., 6 Bunton St., East Milton 86, Mass.
Brumley, C. H., 183 Collingsworth Dr., Rochester 10, N. Y.
Buchinger, M. J., 74 N. Fourth St., Paterson, N. J.
Bunnell, N. R., 1410 Delaware Ave., Wyomissing, Pa.
Burr, G. S., Instron Engineering Corp., 2 Hancock St., Quincy 71, Mass.
Busteed, P. E., 25 Irving Ter., Cambridge, Mass.
Callegari, P. B., 12331 S. Yale Ave., Chicago 28, Ill.
Campani, L. M., 116 W. Merrick Rd., Freeport, L. I., N. Y.
Cape, K. E., 3040 S. Emerald Ave., Chicago, Ill.
Carroll, L. R., 925 E. Baseline Rd., Claremont, Calif.
Cervantes, H. T., Jr., E73, ER Division, U.S.S. Tarawa (CVA-40), c/o FPO, New York, N. Y.

Chase, W. R., 368 Burkedale Blvd., San Antonio 10, Tex.
Chiappinelli, B. A., 10790 Calvin St., Culver City, Calif.
Chinn, F. T., 2917 West 71 St., Kansas City 13, Mo.
Cichanowice, H. J., 550 Deeds Ave., Dayton 4, Ohio
Clark, A. R., 25 Wanamassa Point Rd., Wanamassa, N. J.
Cohen, F., 330 W. Johnson St., Philadelphia 44, Pa.

(Continued on page 102A)

MEMBERSHIP

(Continued from page 101A)

Cohen, M., 3855 Nautilus Ave., Brooklyn 24, N. Y
Cole, W. M., Jr., 908 N. Wayne St., Apt. 305, Arlington, Va.
Conlin, H. T., 1002 W. Market, Sandusky, Ohio
Cook, K. W., 5818 Access Rd., Dayton, Ohio
Corey, J. F., Box 1619, Balboa, Canal Zone
Cox, J. A., 1922 Winton Ave., Indianapolis 24, Ind
Croom, W. J., 1426 West 40 St., Norfolk 8, Va.
Cutler, M. A., Bradley, Plainville, Conn.
Da Grosa, V., c/o Shallcross Manufacturing Co., Jackson & Pusey Aves., Collingdale, Pa.
Davies, R. W., 457-B Allenhurst Rd., Buffalo 23, N. Y.
Davis, C. J., 1634 S. 51 St., Cicero 50, Ill.
Dehm, R. E., 87 Englewood Ave., Buffalo 14, N. Y
Dehmlow, L. L., 1318 S. Walnut Ave., Freeport, Ill.
Denyer, J. H. N., 736 Goulding St., Winnipeg, Man., Canada
Dew, C. D., c/o The Ohio Bell Telephone Co., 42 E. Gay St., Columbus 15, Ohio
Digenova, F., 12 Carobene Ct., Newburgh, N. Y.
Dill, J. M., 12215 Victoria St., Los Angeles, Calif.
Dinunno, J. J., Cedar Lane, Ednor, Mo.
Donovan, R. F., 136 State St., West Lafayette, Ind.
Douglas, J. H., 211 Buto, San Antonio, Tex.
Doyle, W. A., Box 3124, USAFIT, Wright-Patterson AFB, Dayton, Ohio
Drenchko, J. D., c/o Naval Air Development Center, Johnsville, Pa.
Drukaroff, I., 602 Seventh St., Lakewood, N. J.
Edwards, D. E., 1214 Ransom St., Sandusky, Ohio
Eisenbach, M. E., 16727—39 Ave., N. E., Seattle 55, Wash.
Elfman, R. S., 4706 N. Magnolia Ave., Chicago 40, Ill.
Elston, J. A., 271 Harbor St., Conneaut, Ohio
Euler, L. J., Jr., 5055 Franklin Ave., Los Angeles, Calif.
Eve, D. R., Box 72, AA & GM Branch, TAS, Fort Bliss, El Paso, Tex.
Farrell, R. L., I. A. Pak. Ltd., David Sassoon Bldg., McLeod Rd., Karachi 2, Pakistan
Fellhauer, H. E., 5841 El Monte Dr., Mission, Kans.
Fiebich, E. C., Heath Co., Benton Harbor, Mich.
Field, G. R., 211 Harding Ave., Collingswood 7, N. J.
Fitzsimmons, T. J., Round Hill Field Station, South Dartmouth, Mass.
Fleischer, A., 2912 Second St., S.E., Washington 20, D. C.
Flynn, J. E., 6625 McCallum St., Philadelphia, Pa.
Foley, T. J., County Line Rd., Hatboro, Pa.
Forte, S. S., Electrical Engineering Department, The University, Leeds 2, Yorks, England
Freedman, L. M., 10651½ Ashton Ave., Los Angeles 24, Calif.
Freyberg, J. A., 529 Pearl St., Sandusky, Ohio
Fried, G., 17 Normandy Dr., Bethpage, L. I., N. Y.
Fujiki, S., 1-73 Shin-Machi, Setagaya-Ku, Tokyo, Japan
Gagnon, R. L., 36 Ocean Ave., Salem, Mass.
Gaskell, R. J., 32 Barker Ave., Eatontown, N. J.
Gaskill, R. A., University of Michigan, Willow Run Research Center, Ypsilanti, Mich.
Gert, E. B., 8738 N. Peninsular, Portland 17, Ore.
Getty, J. N., Hq. 1125 FAG, Box 9531 ATIC Wright-Patterson AFB, Ohio
Gibbons, J., Price Waterhouse & Co., 56 Pine St. New York, N. Y.
Gillespie, L. H., 125 W. Weinert St., Seguin, Tex.
Goldfarb, J., 3521 Cedarbrook Rd., University Heights, Ohio
Granoff, N. H., 73-31—187 St., Flushing 66, L. I., N. Y.
Greene, R. L., 418 Morton St., Sharon, Pa.
Grossman, F. J., 39 Sickles St., New York 34, N. Y.
Habermann, C. L., 3309 Columbus Ct., Apt. 11, Columbus 9, Ohio

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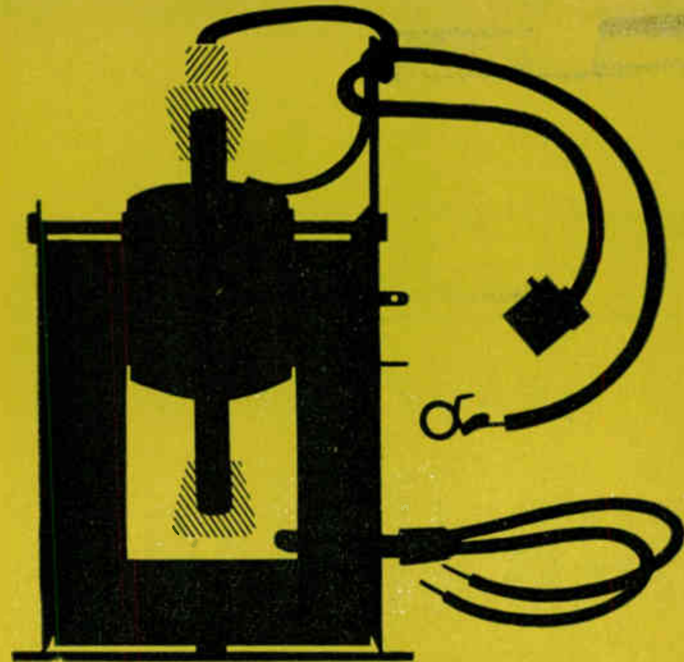


high voltage ARC INHIBITOR by Guthman

When TV manufacturers discovered that higher voltages of the new 27 and 21-inch television receivers rendered existing wax corona ring sweep transformers inadequate, they brought the problem to Guthman.

In a cooperative program with these TV engineers, a flyback transformer with a cast resin corona ring was developed—the perfect answer to this difficulty.

Your problems in the development of coils and transformers are welcome at ***Edwin I. Guthman & Company, Inc.***, 15 South Throop St., Chicago 7, Telephone: CH 3-1600, also Attica, Indiana.

THEY HAD A PROBLEM . . .

Burton browne advertising

WHAT ABOUT THE Wattage Rating OF *PRECISION WIREWOUND* RESISTORS?

The wattage rating of precision wirewound resistors is often expressed in two forms—the manufacturer's commercial catalog rating, and the JAN-R-93 or MIL-R-93A rating. Exceptions are the many resistors smaller than JAN and MIL dimensions not rated under JAN or MIL specifications.

THE BASIS FOR WATTAGE RATINGS: Production resistors are wound with resistance wire insulated with either or both enamel and a silk or nylon covering which deteriorates rapidly above 105°C.

JAN and MIL wattage ratings are based on an ambient temperature of 85°C. The wattage rating is limited to the power dissipation which will cause not more than a 20°C temperature rise. This results in a temperature of not more than 105°C at the hottest point ("hot-spot") on the winding.

Shallcross commercial ratings are based on an ambient of 25°C. Wattage rating is limited to the power dissipation which will cause not more than a 20°-40°C rise. Although higher, these ratings are based on hot-spot temperatures of only 45°-65°C.

VOLTAGE DERATING AND RESISTANCE: Above about 50 per cent of the cataloged maximum resistance, the Shallcross commercial wattage rating must be derated by the maximum voltage tabulated in the catalog. Lower thermal efficiency of the small diameter wire used for higher resistance values causes a higher temperature rise for the same dissipation, and the potential gradient in the winding must be held to a safe proportion of the breakdown voltage.

Computation using JAN-MIL wattage ratings, maximum resistances, and voltage limitations, reveals that voltage derating is seldom necessary up to 99% or more of JAN-MIL maximum resistance values.

TOLERANCE DERATING: JAN, MIL, and Shallcross commercial wattage ratings are based on resistors with 1% tolerance. For closer tolerances, the following MIL derating system is a good one to use:

Resistor Tolerance—%	Per Cent of Nominal Wattage
1	100
0.5	75
0.25	50
0.1	50

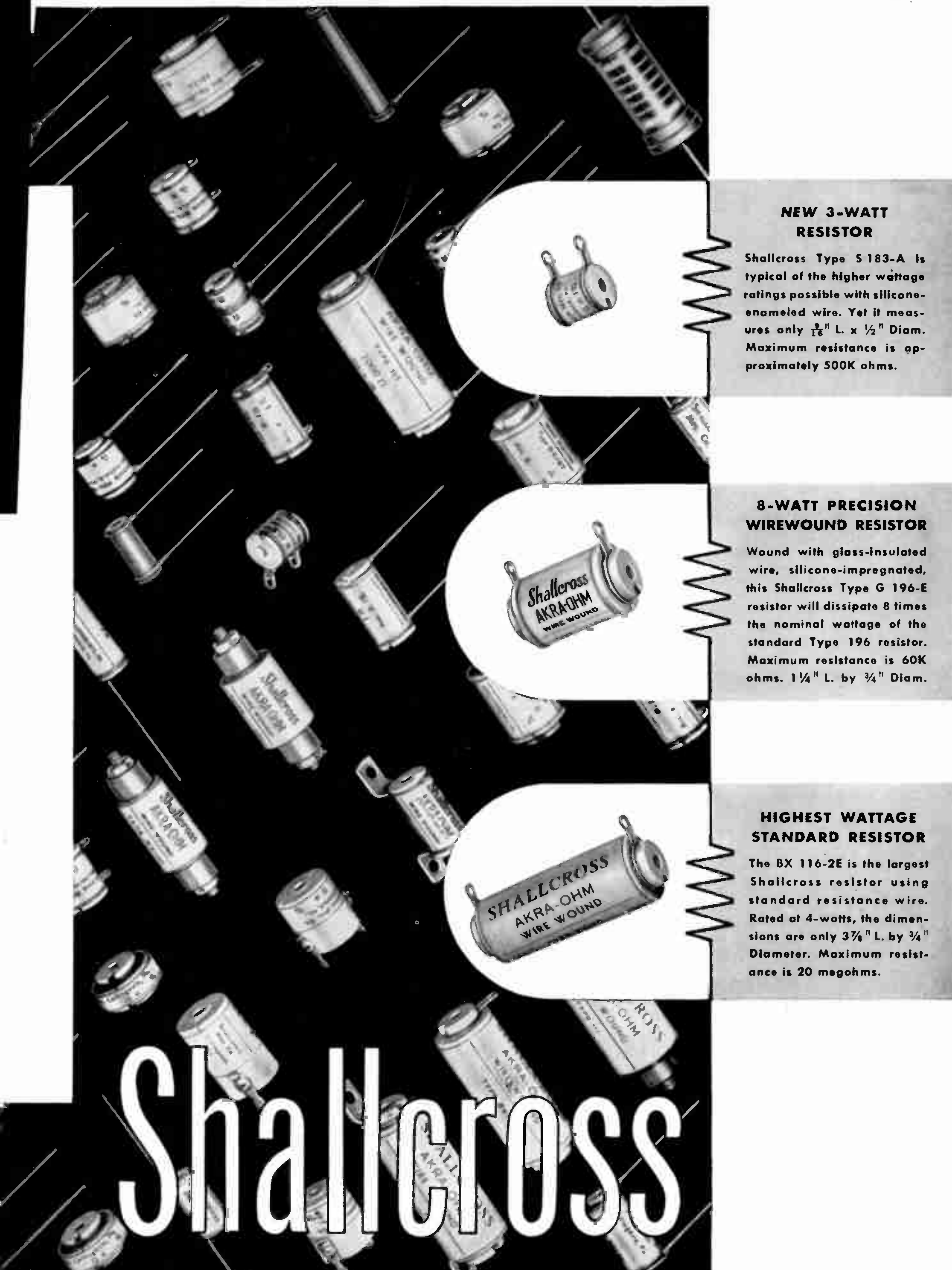
SPECIAL HIGH WATTAGE RESISTORS: Shallcross also offers non-inductive, precision wirewound resistors rated 5 to 10 times higher than the usual commercial wattage ratings. These "G" type resistors are wound with glass-insulated, low T.C. wire, silicone varnished. They are rated on a 150°C temperature rise above an ambient of 25°C. Their hot-spot temperature is 175°C.

Shallcross also supplies "S" type resistors wound with silicone-enameled low T.C. wire. Better insulation permits these resistors to operate at higher than normal hot-spot temperatures. Exact ratings are still being established, but they can be expected to approach those of "G" resistors while permitting higher maximum resistance values.

Further details on Wattage Ratings and other resistor characteristics are available in Shallcross Bulletin R-3C.

SHALLCROSS MANUFACTURING COMPANY • 524 PUSEY AVENUE, COLLINGDALE, PA.

The third of a series to promote a better understanding of the performance characteristics of precision wirewound resistors.


NEW 3-WATT RESISTOR
Shallcross Type S 183-A is typical of the higher wattage ratings possible with silicone-enameled wire. Yet it measures only 9/16" L. x 1/2" Diam. Maximum resistance is approximately 500K ohms.
8-WATT PRECISION WIREWOUND RESISTOR
Wound with glass-insulated wire, silicone-impregnated, this Shallcross Type G 196-E resistor will dissipate 8 times the nominal wattage of the standard Type 196 resistor. Maximum resistance is 60K ohms. 1 1/4" L. by 3/4" Diam.
Shallcross
AKRA-OHM
WIRE WOUND
HIGHEST WATTAGE STANDARD RESISTOR
The BX 116-2E is the largest Shallcross resistor using standard resistance wire. Rated at 4-watts, the dimensions are only 3 7/8" L. by 3/4" Diameter. Maximum resistance is 20 megohms.
SHALLCROSS
AKRA-OHM
WIRE WOUND
Shallcross

MEMBERSHIP

(Continued from page 102A)

Hall, O. C., 1001 Wedgewood Rd., Baltimore 29, Md.
Hanks, W. R., 2365 Ardmore Ter., Winston-Salem, N. C.
Harkless, E. T., 435 Myrtle Ave., Scotch Plains, N. J.
Harms, A. D., Jr., 6806 Quincy St., Philadelphia, Pa.
Hauptli, J. T., 1111 Rice Ave., Bellwood, Ill.
Herman, H. F., 3223 Reynolds St., Dallas, Tex.
Hines, T. H., 1512 Ruth Ave., Cuyahoga Falls, Ohio
Hobbs, W. D., Jr., 11741 Stamy Rd., Whittier, Calif.
Hochman, D., 239C Haddon Hill Apts., Haddonfield, N. J.
Holmquist, J. A., 2108 Ottilia St., Utica, N. Y.
Holt, T., 443 West 71 St., Los Angeles 3, Calif.
Hom, S., 1178 Pacific Ave., San Francisco 11, Calif.
Horwitz, J. D., 3128 Diamond St., Philadelphia, Pa.
Houston, R. W., Far East Network Kyushu, Fenco, 8313 Army Unit, APO 3, c/o Postmaster, San Francisco, Calif.
Hurford, A. C., 96 Lakeside Dr., Levittown, Pa.
Husenita, J., 21 Palmer Rd., Yonkers, N. Y.
Jones, J. F., 4401 Hanover St., Dallas 5, Tex.
Jordan, E. I., 440 N. Broadway, Yonkers, N. Y.
Karney, T., Jr., 722 Third St., Box 253, Harvey, La.
Kazarian, R., c/o Ohio Crankshaft Co., 3800 Harvard Ave., Cleveland 1, Ohio
Kean, P. M., Sr., 3570 W. Granville Rd., Worthington, Ohio
Kelley, L. M., 109 Follen Rd., Lexington 73, Mass.
Kelly, R. J., 515—30 St., Union City, N. J.
Keough, D. D., 12224 Allengrove St., Philadelphia 24, Pa.
Kephart, E. T., 4309 Willis Ave., Merchantville 8, N. J.
Kimball, L. R., 2 Curve La., Levittown, L. I., N. Y.
King, L. G., Navy 961, Box 29, c/o FPO, San Francisco, Calif.
Klein, M. S., 3130 Brighton Sixth St., Brooklyn, N. Y.
Klucarich, S., 131 Beaver St., Fallston, New Brighton, Pa.
Knudsen, D. F., 347 Adelaide St., W., Toronto, Ont., Canada
Kravitz, J. S., 4630 N. Beacon St., Chicago 40, Ill.
Kumm, W. H., Air ARM Division, IDF, Westinghouse Electric Corp., Friendship International Airport, Baltimore, Md.
Kundler, H. H., 1 East 57 St., Rm. 701, New York, N. Y.
LaCoste, L. J. B., 3810 Speedway, Austin, Tex.
Ladouceur, C., 1193 Notre-Dame, Joliette, Que., Canada
Lahanes, C. J., 275 Massachusetts Ave., Cambridge, Mass.
Lamartin, F. H., Apt. 1-4, U. S. Naval Academy, Annapolis, Md.
Landow, I. S., 103 Neptune Ave., Brooklyn 35, N. Y.
Lane, J. W., 7420 Reeds La., Overland Park, Kans.
Larkin, W. E., 5001 Blanco St., El Paso, Tex.
LaRocca, J. J., 4255 N. Bernard St., Chicago 18, Ill.
Lawler, E. D., 268 Bowman Ave., Merion Station, Pa.
Laws, C. R., 511 Leffingwell, Kirkwood 22, Mo.
Lebid, J., 1088 Parkside Ave., Buffalo 14, N. Y.
Lehfeldt, H. J., Bldg. 92, Rm. 226 OL, National Bureau of Standards, Washington 25, D. C.
Lenz, H. G., 612 Home St., Winnipeg, Man., Canada
Lesko, N. J., NRL CBA, Chesapeake Beach, Md.
Linden, A. E., 6738 Wyncote Ave., Philadelphia 38, Pa.

(Continued on page 108A)

the pioneer is the leader

PANORAMIC

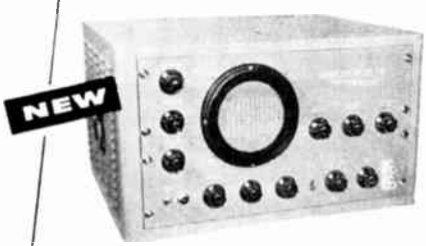
PANORAMIC IS THE PIONEER in the transformation of spectrum content into visual spectographic displays . . . known as the "Panoramic Method" by the entire electronic field.

PANORAMIC LEADS the industry in producing instruments unexcelled for every application requiring high speed spectrum or waveform analysis. Whatever yonr problem, a Panoramic Analyzer solves it quickly, accurately.

PANORAMIC leads again with

Signal Switcher—SW1

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 Type T-100

Designed specifically for applications requiring extreme resolution or demanding measurement of levels of signals spaced very closely in frequency or widely divergent in amplitude.

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- Maximum Resolution—10CPS
- Sweep Rates—30cps, 5 cps, 1 cps and 1 scan in 10 seconds

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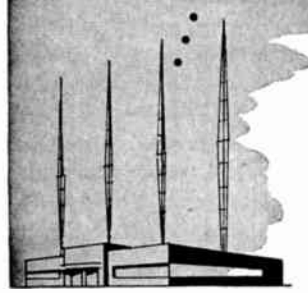
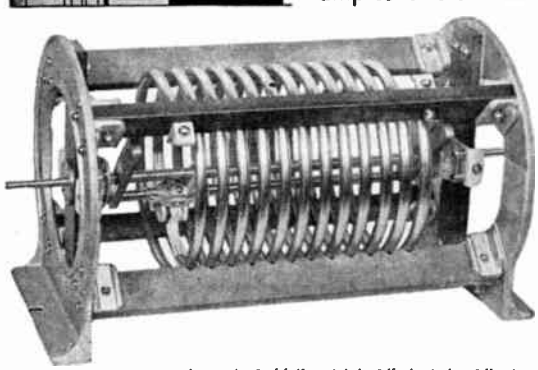
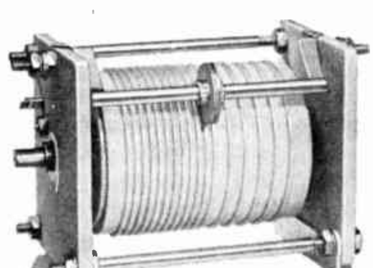


To meet the needs of RF power equipment manufacturers, JOHNSON builds a most diverse line of variable inductors. These range from 3 to 50 amperes current capacity, inductance to 300 microhenries in standard types. Characteristics of all models are: high frequency insulation grade L4 or better, low contact resistance, rigid construction. Two typical examples of JOHNSON variable inductors are:



224-2-1

Variable inductor for high power applications. Winding is 1/2" copper tubing rated to 50 amperes current. Inductance continuously variable to 16.5 microhenries. Spring loaded silver plated roller contact permits adjustment with full power applied. Insulators are glass bonded mica; cast aluminum end frames are slotted to minimize Eddy current losses. Overall dimensions: length 21 1/8", width 9", height 9". Available in eight standard models, maximum inductances 10 thru 110 microhenries. Variations from standard units such as special inductances, dual inductors for push-pull applications can be readily furnished in production quantities.



229-201

10 microhenry rotary inductor for 100 watt applications. Winding is #14 tinned copper wire with variable pitch for efficient extended frequency range. Beryllium copper tension springs maintain rolling contact. Overall size: length 4 1/2", width 2 1/2", height 3". Other inductors in the same series utilizing #12 and #16 tinned copper windings, maximum inductance 37 to 300 microhenries.

In addition to these illustrated types, the JOHNSON line includes many other variable and fixed inductors for low, medium and high power applications. Fixed inductors are available with single or multiple windings, fixed or variable coupling windings and with electrostatic shields.

For further information on all types of JOHNSON inductors, write for catalog 973—yours on request.

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(Continued on page 110A)

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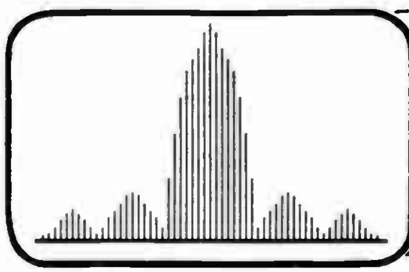
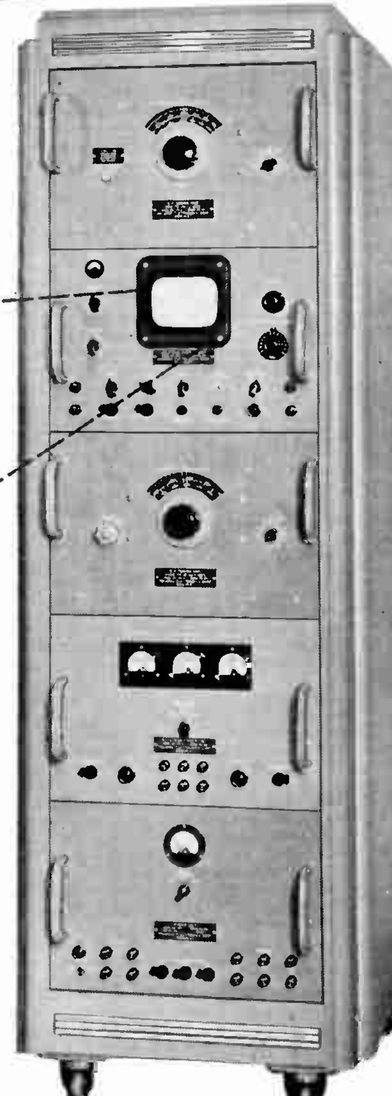
SPECTRUM ANALYZER

10 MCS TO 21,000 MCS

Polarad's Model LSA Spectrum Analyzer 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 r.f. signal.





- Continuous tuning.
- One tuning control.
- Resolution is 5KC when dispersion is 5MC per inch per sec.
- 250 KC to 25 MCS display at all frequencies.
- Tuning dial frequency accuracy 1%.
- No Klystron modes to set.
- Broadband attenuators supplied with equipment from 1 to 12 KMC.
- Frequency marker for measuring frequency differences 0-25 MCS.
- Only four tuning units required to cover entire range.
- Microwave components use latest design non-contacting shorts for long mechanical life.
- Maximum frequency coverage per dollar invested.
- 5 inch CRT display.

Where Used:

Model LSA Spectrum Analyzer is a laboratory instrument used to provide a visual indication of the frequency of distribution of energy in an r.f. signal in the range 10 to 21,000 MCS.

Other uses are:

1. Observe and measure sidebands associated with amplitude and frequency modulated signals.
2. Determine the presence and accurately measure the frequency of radio and/or radar signals.
3. Check the spectrum of magnetron oscillators.
4. Measures noise spectra.
5. Check and observe tracking of r.f. components of a radar system.
6. Check two r.f. signals differing by a small frequency separation.

THE INSTRUMENT CONSISTS OF THE FOLLOWING UNITS:

Model LTU—1 RF Tuning Unit—10 to 1000 MCS.
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Model LTU—3 RF Tuning Unit—4460 to 16,520 MCS.
Model LTU—4 RF Tuning Unit—15,000 to 21,000 MCS.
Model LDU—1 Spectrum Display Unit.
Model LPU—1 Power Unit.
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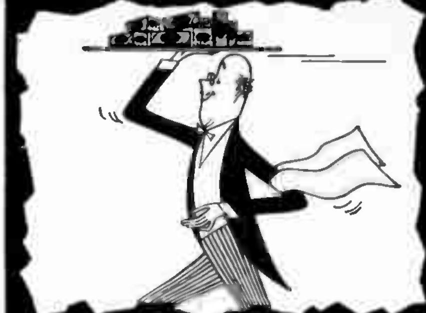
(Continued on page 114A)



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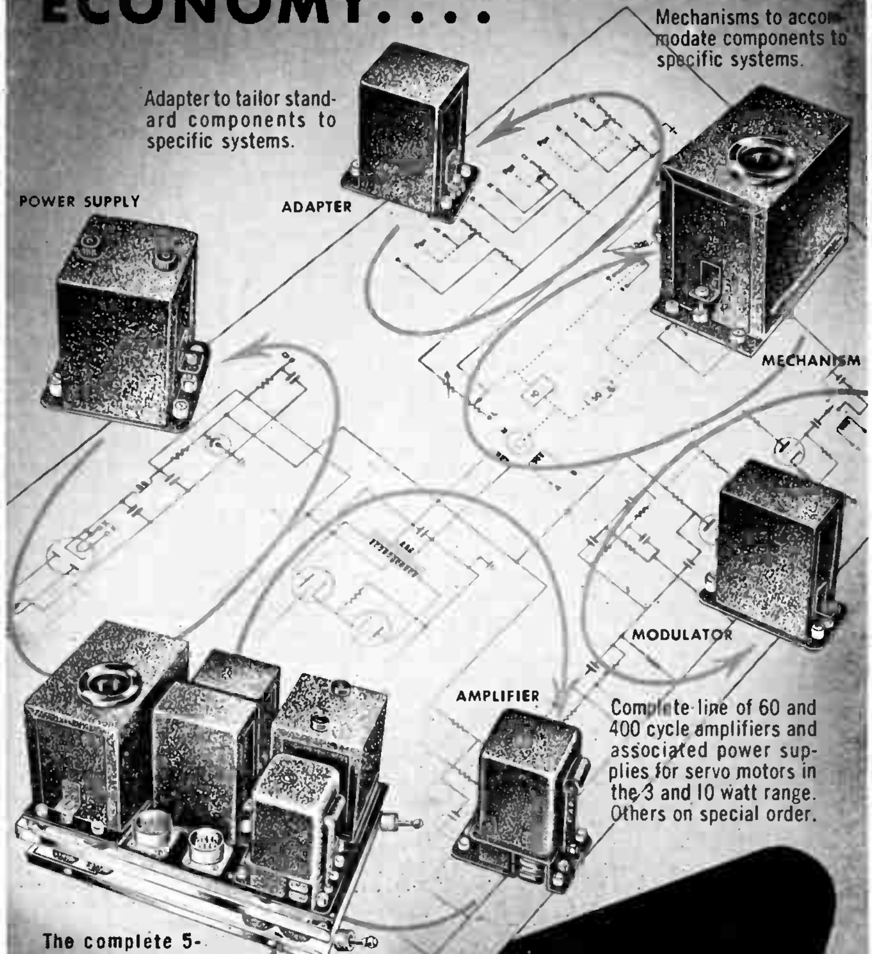

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NEW HIGH QUALITY MINIATURIZED "DIME-SIZE" CIVILIAN CONTROL—*Performance Fully Equals Larger Types.*

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.

YPE C2-45

TYPE C2-35

TYPE C2-252

TYPE C2-25

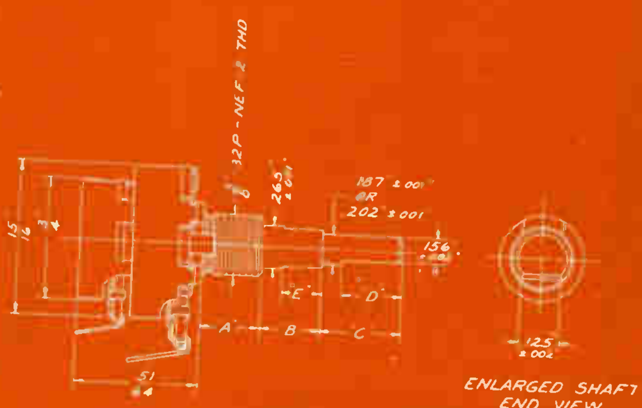
PE GC-45, 15/16" diameter variable mposition resistor. Wattage rating: 2 watt for resistances through ,000 ohms, 1/3 watt for resistances er 10,000 ohms through 100,000 ms, 1/4 watt with 500 volts maximum across end terminals for resistances over 100,000 ohms. Available h or without illustrated attached itch and in concentric shaft tandem nstruction 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 resister. 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 resister. 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

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TYPE 45, (JAN-R-94, Type RV2)
1/4 watt, 15/16" diameter variable composition resistor. Also available with other special military features not covered by JAN-R-94 including concentric shaft tandem construction. Attached switch can be supplied.

TYPE 35, (JAN-R-94, Type RV3)
1/2 watt, 1 1/8" diameter variable composition resistor. Also available with other special military features not covered by JAN-R-94 including concentric shaft tandem construction. Attached switch can be supplied.

TYPE 252, (JAN-R-19, Type RA20)
2 watt, 1 17/64" diameter variable wirewound resistor. Also available with other special military features not covered by JAN-R-19 including concentric shaft tandem construction. Attached switch can be supplied.

TYPE 25, (JAN-R-19, Type RA20)
(May also be used as Type RA25)
4 watt, 1 17/32" diameter variable wirewound resistor. Also available with other special military features not covered by JAN-R-19 including concentric shaft tandem construction. Attached switch can be supplied.

TYPE 65, (Miniaturized)
1/2 watt 70°C, 3/4" diameter miniaturized variable composition resistor.

TYPE 90
1 watt 70°C, 15/16" diameter variable composition resistor. Attached switch can be supplied. Also available in concentric shaft tandem construction.

TYPE 95, (JAN-R-94, Type RV4)
2 watt 70°C, 1 1/8" diameter variable composition resistor. Also available with other special military features not covered by JAN-R-94 including concentric shaft tandem construction. Attached switch can be supplied.

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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 55A)

G.E. to Double Germanium Diode Production

The General Electric Co., Electronic Park, Syracuse, N. Y., will double its production of germanium diodes this year, to meet the rising demand of television manufacturers.

Their principal use is in home television receivers, where they perform as video detectors, according to James H. Sweeney, germanium products sales manager.

Each of the 6.5 million TV sets expected to be built by the industry next year will incorporate as many as three of the tiny devices.

(Continued on page 116A)

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

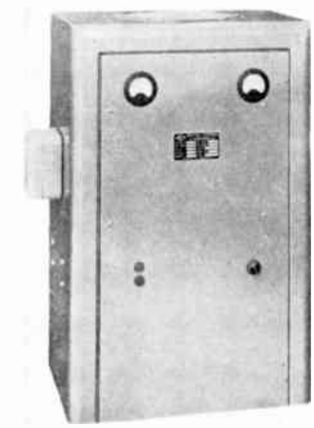
(Continued from page 114A)

Sweeney said the recent allocation by the Federal Communications Commission of 70 new TV channels in the ultra-high frequencies is largely responsible for the production increase. Tuners and converters to permit reception of the uhf channels each require one or two germanium diodes, he explained.

Nearly every TV set now manufactured for receiving very-high-frequency stations (channels 2 through 13) also incorporates one of these devices.

Power Supply

A new and highly precise high-power direct-current source, designed for digital and analogue computers, business machines and other complex electronic devices, has recently been developed by **Inet, Inc.**, 8655 S. Main St., Los Angeles 3, Calif.



This magnetic amplifier-selenium rectifier dc power supply, provides dynamic regulation of better than 0.2 per cent with wide load and alternating current line changes. Steady state regulation proved to be less than 0.15 per cent from no load to full load, with ±10 per cent ac line voltage. RMS ripple can be filtered as low as 0.01 per cent; with 0.5 per cent as standard.

Inet's precision power supply is said to require about half the space of many types of equipment with comparable performance, and is housed in a single compact cabinet, or can be built with dimensions to customer's specifications.

The selenium rectifier-magnetic amplifier design eliminates thyratrons or ignitions. Thus the equipment is designed to require the minimum of maintenance and parts replacement. Because of its high efficiency (approximately 75 per cent), the unit has sufficiently cool operation to reduce refrigeration requirements in office-installed computers.

(Continued on page 118A)

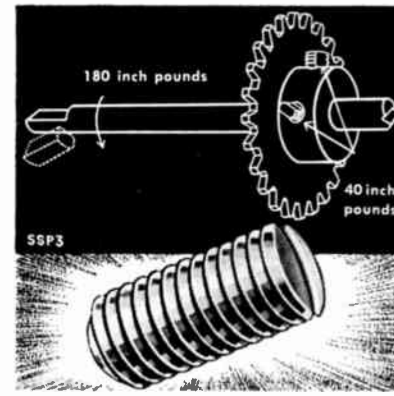
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 116A)

New Set Screw

Set Screw & Mfg. Co., 422 Main St., Bartlett, Ill., announces a new type of set screw, the "Nu-Cup."



The cup point of "Nu-Cup" is designed so that the user obtains increased holding power with the same amount of setting torque. The diameter of the cup circle is larger than that of the standard cup point, which makes a fuller contact possible and a deeper impression into the shaft, offering greater resistance to reversal, with the same setting torque. "Nu-Cup" distribution pressure is spread over a wider area, 20 to 25 per cent greater than conventional set screws.

"Nu-Cup" Set Screws are particularly suited to applications in which the shaft is soft, or is small in relation to the contact arc of the screw cup. The new set screws are made of an alloy steel, specially selected for hardness and offering exceptional capacity for pressure. They are available in slotted headless and slabbed type set screws only. A catalog is available by request.

Rotary Exhaust Tube Sealer

Consolidated Vacuum Corp., Rochester 4, N. Y., formerly the Vacuum Equipment Department of **Eastman Kodak's Distillation Products Industries**, announces the availability of a radically new high vacuum, high speed, exhaust and sealing machine for miniature and sub-miniature electron tubes.

There is no traditional slide valve at the center of the machine through which the tubes are vacuum pumped. Rather, pumping is accomplished by an easily demountable packaged unit consisting of mechanical pump, diffusion pump, valves, and compression port. This unit will produce a pressure of 1 micron or lower at the port in the positions immediately ahead of the tip-off.

Also, the machine is not indexing, that is, there are no starting and stopping motions. Once started up, the turret turns

(Continued on page 120A)

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 118A)

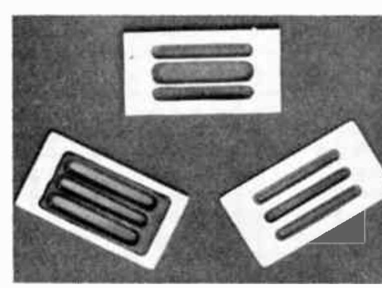
continuously, and sealing in of envelopes to base, transfer to pumping position, and finally tip-off are accomplished smoothly and automatically. Also, the continuous motion permits production rates 25 to 30 per cent greater than for conventional equipment.

In addition, only two large electric motors and one small are involved, thus greatly reducing maintenance. One large motor drives all the mechanical vacuum pumps through planetary gearing and clutch engagement. Another motor drives the turret, and a third is used to move the tube stems from the port after tip-off.

The machine can be made to index by adding several pieces which are designed to bolt into the base. No major redesign or alteration is necessary. It is normally supplied with 16 pumping and sealing heads, but this can be increased to 32 if a larger production rate is required.

Wide Band Microwave Window

Microwave Associates, Inc. 22 Cummington St., Boston 15, Mass., has a new microwave window which features the widest bandwidth of any glass-metal type heretofore used in the electronics industry. It covers a bandwidth of 4 per cent in the frequency range of 8,200–12,500 mc at a vswr less than 1.25. The vswr frequency characteristic behaves like a single resonant circuit with a minimum value of 1.03 in the neighborhood of 9,800 mc. The doubly loaded *Q* of the unit is approximately 0.25.



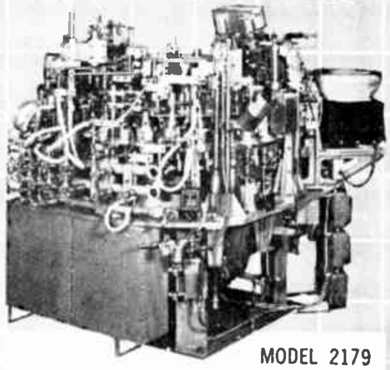
The window blank consists of three parallel slots stamped in a thin blank of kovar 0.600×1,100 inches O.D. to which is sealed a rectangular blank of low-gloss glass. The windows are copper and silver plated and may be soft soldered into a UG-39/U flat flange. It is necessary to mill out the flange to accommodate the window dimension and to break the inside edges of the waveguide at the flange connection to avoid cracking of the glass in the seal.

The windows may be used in pressurizing applications and will withstand pressures up to 30 pounds per square inch absolute.

Development of the window is an outgrowth of work done at S-band by a group at the Camp Evans Signal Laboratory under the direction of Kenton Caroff.

(Continued on page 124A)

ANOTHER milestone in production techniques ANOTHER instance of "built-in know-how"



MODEL 2179

AUTOMATIC BUTTON STEM MACHINE

- Kahle Engineering Company has added one more outstanding piece of equipment to their constantly growing list of production equipment.
- A new 24 head Button Stem Machine No. 2179 for making one inch button stems with 8 wires and tubulation for T-9 tube sizes.
- Machine incorporates automatic lead wire feed, automatic tubulation feed, automatic glass bead feed, automatic unload. These, combined with automatic rejection and head cleanout in case any component fails to feed, make this machine unique.
- Such a machine is ideal for other similar stems such as cathode ray stems with 6, 8 or 10 wires.

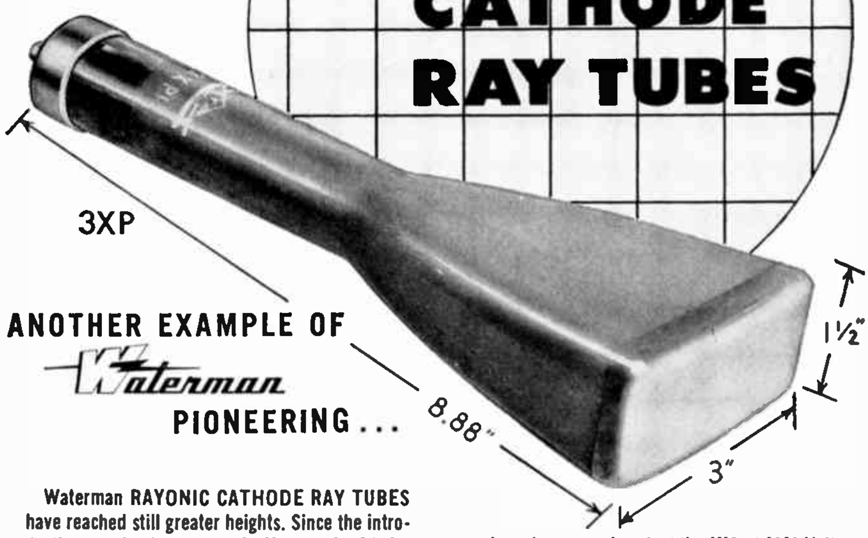
This is not just another stem machine. It is a completely automatic stem machine with 24 heads and precision high speed index. The machine illustrated embodies all the improved techniques and mechanisms that Kahle engineers could find from their own and their customers' experience.

This problem involved glass tubulated stems for radio tubes. However, Kahle has solved many other problems neither associated with glass or connected with electronics.

If your problem requires special techniques or processes; if you need custom machinery; or, if you need relief from expansion projects, Kahle engineers will work with you to achieve "customer satisfaction" from "Built-In Know-How."

Kahle
ENGINEERING COMPANY
1312 SEVENTH STREET
NORTH BERGEN, N. J.

the Waterman RAYONIC® CATHODE RAY TUBES



ANOTHER EXAMPLE OF Waterman PIONEERING...

Waterman RAYONIC CATHODE RAY TUBES have reached still greater heights. Since the introduction of the Waterman RAYONIC 3MP1 for miniaturized oscilloscopes and the Waterman developed rectangular 3SP CATHODE RAY TUBE, scientists in our laboratories have diligently searched for a more perfect answer to the perplexing problem of trace brightness versus deflection sensitivity. The 3XP RAYONIC CATHODE RAY TUBE is their answer to providing a brilliant and sharply defined trace and high deflection sensitivity at medium anode potentials. When the 3RP or 3SP tubes are operated at 1000 Volts second anode and compared against the 3XP at 2000 Volts on the second anode, the results are astonishing. For the same size spot, the 3XP light output is improved by a factor of 4 and its vertical sensitivity is improved by a factor of 2, with the horizontal sensitivity remaining equal to that of the other tubes. Because the 3XP is enclosed in a shorter envelope and is equivalent to the 3RP and 3SP with respect to interelectrode capacities, it lends itself readily for high frequency video work, as well as for low repetitive operation.

3XP TECHNICAL DATA

SIZE:	
FACE	1½ x 3 inches
LENGTH	8.875 inches
BASE	Loctal
TYPICAL OPERATING CONDITIONS	
FILAMENT	6.3 Volts
	0.6 Amps.
ANODE # 2	2000 Volts
	Max. 2750 Volts
ANODE # 1	400 to 690 Volts
GRID # 1	−22.5 to −67.5 Volts
DEFLECTION FACTOR IN VOLTS/INCH	
D 1 to D2	68 to 92
D3 to D4	25 to 35

AVAILABLE in P1, P2, P7, and P11 Phosphorf

WATERMAN PRODUCTS CO., INC.

PHILADELPHIA 25, PA.

CABLE ADDRESS: POKETSCOPE

MEMO... Write for details today!

WATERMAN PRODUCTS INCLUDE

3JP1 & 3JP7	JAN RAYONIC CR TUBES
3JP2 & 3JP11	RAYONIC CR TUBES
3MP7 & 3MP11	RAYONIC CR TUBES
3RP1, 2, 7, 11	RAYONIC CR TUBES
3SP1, 2, 7, 11	RAYONIC CR TUBES

POCKETSCOPES PULSESCOPES

RAKSCOPES

And Other Associated Equipment

WATERMAN PRODUCTS

OPTICAL SYSTEMS

INDUSTRIAL PERISCOPES

DESIGN

DEVELOPMENT

MANUFACTURE

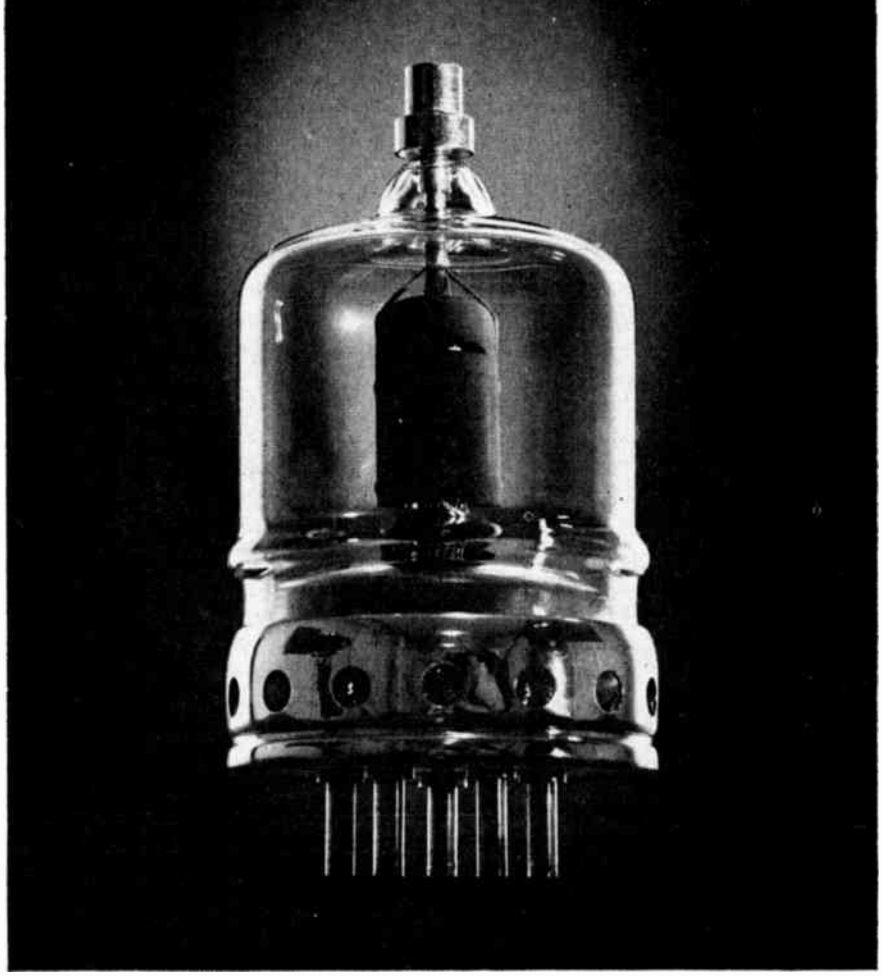
For nearly half a century Kollmorgen has designed, developed and manufactured precision optics and optical systems for industry and the military.

We have the engineering "know-how", the design personnel and the manufacturing capacity to help you solve your optical problem.

KOLLMORGEN Optical CORPORATION

Plant: 347 King Street • Northampton, Mass.
New York Office
30 Church Street
New York 7, N.Y.

TIME-TRIED TETRODE



LOS GATOS 4D21/4-125A

MODERN in every respect—with exclusive Sintercote black-body high-dissipation anode and emission-free grids—the Los Gatos 4D21/4-125A provides a new source of supply for a widely-applied tetrode type. Check Los Gatos for your requirements in other types with emphasis on long service life.

LEWIS and KAUFMAN, Ltd.

LOS GATOS 2 CALIFORNIA

LOS GATOS LONG LIFE

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 120A)

Low Force Switches

A new series of snap-action switches, designed for actuating forces as low as ½ ounce, is announced by **Micro-Switch**, a division of **Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

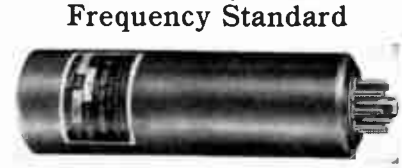
The switches are provided with rigid-lever integral actuators which adapt them to actuation by cams or by straight-line motion.

The new series is particularly useful in low-force, cam-actuated applications on timing clock motors, instruments, and meters. The switches also are widely used in rotary switch assemblies, in sequence switching gangs, and in general limit switch applications.

Type "W80" has a flat lever actuator designed for operation by straight-line motion or slow-moving cams. "W80" switches can be operated by a force as low as ½ ounce. Type "W82" switch has a hardened steel roller on the end of the lever for reducing friction in cam actuation. Type "W822" has a short roller lever actuator designed for fast cam actuation or for applications in which compactness and maximum resistance to vibration are required.

Each of these three types is available with solder lug or screw terminals. They are listed by Underwriters' Laboratories for 15 amperes, 125, 250 or 460 volts ac; ½ ampere, 125 volts, dc; ¼ ampere, 250 volts, dc.

Hermetically Sealed Frequency Standard



American Time Products, Inc., 580 Fifth Ave., New York 36, N. Y., has developed a Type 2007 frequency standard which contains a shock mounted miniature high Q tuning fork, a sub miniature double triode tube and all circuitry. Output frequencies available are 400 or 500 cps with an accuracy of ±1 part in 50,000 from −15° to +35°C and ±1 part in 5000 from −65° to +85°C. Sealed in octal base container 1½ inch diameter×4½ inch high, weighing less than 10 ounces. Power required, 75 to 200 volts, dc at 1 to 5 ma and 6.3 volts at 300 ma. Designed to withstand MIL environment.

(Continued on page 125A)

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 124A)

Selenium Rectifier

Two high voltage selenium rectifiers, Type V-75HF and Type V100HF, have been developed by **International Rectifier Corp.**, El Segundo, Calif., for use in TV equipment in which long life and reliability are of importance.

The units are designed with ferrule terminals for insertion into standard 30-ampere fuse clips. The diameter of the units is $\frac{7}{16}$ inch. The Type V75HF is $3\frac{1}{4}$ inches long and the Type V100HF is $4\frac{5}{32}$ inches long. Both units are designed to deliver 5 milliamperes into a capacitive load at a dc output voltage of 1500 and 2000 volts respectively. These cartridge rectifiers are designed to meet JAN humidity, altitude, vibration and shock specifications. Both units have been incorporated into the horizontal oscillator circuit of video cameras.

(Continued on page 140A)

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.

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, mathematical analysis, circuit design, and solid state physics. Applicants should be citizens and have at least a BA 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.

(Continued on page 128A)

Pleasant Working Conditions

So we're exaggerating a little! If you want to get technical about it (and you probably do) your life at our company won't be quite this cushy. We can promise this though—even the sky's not the limit for future opportunity. You work with a congenial group of engineers. People will listen to your ideas. The boss's door is always open.

Who you are—You're an Electronic or Mechanical Engineer. You're experienced in air communication and navigation circuitry and development. You have worked with low or high frequency circuits, instrumentation, component utilization or associated problems.

What you do now—Simple! Just contact:

Arthur E. Harrison, Vice President, Engineering

wilcox **Electric Company, Inc.**

Fourteenth & Chestnut, Kansas City 27, Mo.

ELECTRONIC ENGINEERS

EE or ME degree, minimum 3 years' experience in research and development work involving circuitry, servo-mechanisms, analogue computers, radar, and related equipment.

FIELD REPRESENTATIVES

A few openings for graduate engineers only with backgrounds similar to above. Continental U.S.A.

What You Can Expect at General Precision Laboratory

A progressive group of young, successful men, firmly established as designers and developers of electronic equipment . . . a medium-sized staff in which you receive individual recognition . . . a policy of promotion-from-within that helps qualified men move ahead swiftly . . . a modern laboratory located in a pleasant suburban community ideal for family living.

Expenses will be paid for qualified applicants who come for interviews. Please submit complete resume to: Mr. H. F. Ware

GENERAL PRECISION LABORATORY

INCORPORATED

A Subsidiary of General Precision Equipment Corporation

63 BEDFORD ROAD, PLEASANTVILLE, NEW YORK

POSITIONS OPEN

(Continued from page 126A)

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.

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 PhD 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 resume. Box 718.

ENGINEERS OR PHYSICISTS

A midwestern manufacturer of electrical resistors, rheostats and allied components, is looking for experienced engineers or physicists in-

(Continued on page 130A)

STAVID ENGINEERING, INC.

has openings for

GRADUATE ELECTRONIC and MECHANICAL ENGINEERS

Experience in design and Development of Radar and Sonar necessary.

Broad knowledge of Search and Fire Control Systems; Servo Mechanisms, Special Weapons, Microwave, Antennas and Antenna Mounts, etc.

Mechanical Engineer should also have experience in packaging of Electrical Equipment to Gov't specifications including design of complex cabinets, shock mounts and sway brace structures.

FIELD ENGINEERS

Qualified to instruct in the operation and supervise installation, maintenance and repair of Radar, Sonar and allied electronic equipments in the Field.

A chance to grow with a young and progressive company; salary and advancement commensurate with ability; liberal vacation, sick leave, 9 paid holidays, group life, sickness and accident insurance plans, and a worthwhile pension system.

Personnel Office, 312 Park Avenue

Plainfield, N.J.—Tel. Pl. 6-4806

MAKE THIS YOUR HOME FOR IMPORTANT WORK UNDER IDEAL CONDITIONS

- TV RECEIVER DESIGN ENGINEERS
- ELECTRONICS ENGINEERS
- FIELD ENGINEERS
- TEST & INSPECTION ENGINEERS
- COMPONENTS ENGINEERS

NEEDED TO WORK ON: Radar, G.C.A., Mobile Radio, Auto Radio, Airborne Communication & Navigation Equipment, Television, Antennas, Microwave Equipment, Servo Mechanisms and Guided Missiles.

YOU BENEFIT AT BENDIX RADIO:
from high wages, a modern, air-conditioned plant, paid vacations and holidays, group insurance and a good chance for advancement.

Housing immediately available in the beautiful suburban and country areas that surround the Bendix Radio plant.

Write, Wire or phone
MR. E. O. COLE, DEPT. M **Bendix Radio**
DIVISION OF BENDIX AVIATION CORPORATION
BALTIMORE-4, MD. Phone: TOWSON 2200

Makers of the World's Finest Electronic Equipment

POSITIONS OPEN

(Continued from page 128A)

terested 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.

ELECTRONIC ENGINEER—PHYSICIST

Electronic engineer or physicist to contribute to instrument development program of major petroleum refiner in Chicago area. Prefer MS with servo training. Age 25-35. Reply with details of education, experience and salary requirements. Replies will be held confidential. Box 721.

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 resume to Instrumentation Laboratory, 68 Albany St., Cambridge 39, Mass., Att: M. Phillips.

(Continued on page 132A)

ELECTRONIC ENGINEERS & PHYSICISTS

OUR STEADILY EXPANDING LABORATORY OPERATIONS ASSURE PERMANENT POSITIONS AND UNEXCELLED OPPORTUNITY FOR PROFESSIONAL GROWTH IN

RESEARCH & DEVELOPMENT

GUIDED MISSILES
RADAR
ELECTRONIC NAVIGATION
SOLID STATE PHYSICS
VACUUM TUBES
TELEVISION

THE EMPLOYMENT DEPT.

ADDRESS INQUIRIES TO: **CAPEHART FARNSWORTH CORP.**
FORT WAYNE, IND.

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

EXPERIENCED RADAR AND COMPUTER ENGINEERS

in one or more of the following fields:

- General radar and computing systems
- Servomechanisms
- Radar transmitter-modulators
- Generalized systems analysis
- Indicator systems
- Wide band I F amplifiers and receivers
- General pulse circuits
- Electro-mechanical design

UNUSUAL OPPORTUNITIES IN LONG-TERM DEVELOPMENT OF RADAR AND RELATED EQUIPMENT

SINCE 1912 A LEADER IN RESEARCH DEVELOPMENT AND PRODUCTION

Gilfillan Bros., Inc.

1815 Venice Blvd., Los Angeles 6, California

Representatives at Waldorf Astoria Hotel, March 23-26

An Opportunity

is offered for intelligent, imaginative engineers and scientists to join the staff of a progressive and self-sustaining, university-affiliated research and development laboratory. We are desirous of expanding our permanent staff in such fields as electronic instrumentation, missile guidance, microwave applications, design of special-purpose electronic computers, and in various other applied research fields of electronics and physics.

Salary structure and benefit programs are on a par with industry. In addition, there are many tangible advantages, such as our self-sponsored internal research policy, of interest to men with ingenuity and initiative.

CORNELL AERONAUTICAL LABORATORY, INC.

BUFFALO 21, NEW YORK

A NEW Bendix Division!
A NEW Electronic Product!
NEW JOB OPPORTUNITIES

In our modern plant at York, Pennsylvania, this new division of Bendix Aviation Corporation is producing a new electronic product. This division has a big future; and this is *your* opportunity to get in on the ground floor, with excellent possibilities for rapid advancement. We need the following:

- **ELECTRONICS ENG.**
- **MECHANICAL ENG.**

Also We have many openings for men qualified by education or experience in all phases of electronics.

YOU BENEFIT With the Bendix York Division, you will benefit from high wages, paid vacations and holidays and ideal living conditions in a beautiful suburban area.

Write, Wire or Phone Department Y-2

Bendix

AVIATION CORPORATION YORK DIVISION

Phone: York 5521 York, Penna.

POSITIONS OPEN

(Continued from page 130A)

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. Position are permanent. Starting salary $4,205 to $7,040 depending on qualifications. Opportunity for graduate study. Also summer vacancies. Address: Weapon Systems Laboratory, Room 211, Bldg. 328, Aberdeen Proving Ground, Maryland.

ENGINEERS PHYSICIST

A new Florida firm has an opening for an engineer or physicist with at least 2 years experience for development work on application of radioactive batteries. Some ordnance experience preferbale but not required. Adddress: Radiation Research Corp., Box 8126, West Palm Beach, Florida.

CIRCUIT ENGINEERS

Electronic engineers are required for development in the field of color and monochrome television, UHF, and transistor applications. Needed are Senior and Intermediate Engineers to direct projects, also Junior Engineers. Work is in a well-equipped laboratory in mid-town New York City. Liberal employee benefits, security and opportunity to advance. Salary commensurate with education and training. Send resume to or call in person at RCA Laboratories, 711 Fifth Ave., New York 22, N.Y.

PHYSICISTS AND ENGINEERS

Southwest Research Institute has several permanent staff positions for physicists and engineers with B.S. or advanced degrees and 2 to 5 years of experience in accoustics, H.F. and V.H.F. antenna design, electomechanical transducer research, optical instruments, and pulse circuits. Send statement of qualifications and interests in industrial and defense research to: Physics Department, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas.

QUARTZ CRYSTALS ENGINEERS

World's largest producer of crystals needs additional project engineers. Applicants should have a working knowledge of crystal manufacturing. Send complete resume: age, education, experience, salary expected. Midland Manufacturing Co., 3155 Fiberglass Road, Kansas City 15, Kansas.

PHYSICISTS

Physicists for Acoustics Research and Development—Research and development work in transducer design, directionality problems, underwater sound characteristics, sound transmission and attenuation problems and noise reduction problems. Required M.S. or PhD. in physics. Opportunities for graduate work. Salary open. Send personal data to: Arnold Addison, Personnel Director, Ordnance Research Laboratory, Box 30, State College, Pennsylvania.

TRANSFORMER ENGINEER

Transformer engineer with experience in design and development of transformers for electtronic applications, and capable of assuming the position as head of a design section on this type of equipment. All replies will be held confidential and should include details of education, experience and salary desired. Box 726.

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.

ENGINEER

SBEE, M.I.T. 1939. Varied development, design, and standards experience. Most recently, product design for 3½ years. Familiar with Government specifications. Signal Corps Inspector Agency for 3 years. Desires responsible position in design and development. Box 592 W.

ENGINEER

BEE 1951. Ex-Navy ETM (Naval Research Lab.) 1 year design and development work in radio interference suppression. Age 24, married. Desires non-military work with a future in New York metropolitan area. Box 617 W.

ENGINEER

Electronics engineer, 5 years post-war design, production and administration experience. U. S. citizen, Navy veteran. Knowledge of several foreign languages. Interested in a position in a large city in western Europe. Box 618 W.

ELECTRONIC ENGINEER

USAF Guided Missile Officer. Age 25, married. BSEE, communications option with honors. BS in commerce. Graduate of USAF Airborne Electronics, Guided Missile Guidance, and control schools. Guided missile and radar field experience. 1 year industrial experience. Interested in production, administration and development. Available March 1953. Box 619 W.

ENGINEER

BS Industrial Arts. 10 years teaching and administration in radio and allied arts, 2 years Air Force radio. Age 30, married, 1 child. Willing to locate anywhere. Box 621 W.

ELECTRONIC ENGINEER

Navy electronics officer who was released in Feb. 1953 desires position in management or sales. Age 25, single. BSEE. Radiotelephone 1st class license; 3 years practical electronics experience. Will relocate. Box 622 W.

ELECTRONIC ENGINEER

Electronic engineer graduate Queen's University, post graduate work McGill University. Canadian Civil Servant with 12 years experience in systems engineering, project engineering, radar and pulse technique and fully conversant with implementation of Canadian Government defense contracts, desires suitable position in industry. Available 2 or 3 months after submitting resignation. Box 623 W.

(Continued on page 136A)

Positions Wanted

(Continued from page 134A)

ENGINEER

SB-MIT 1945. Age 28, married, 2 children. Varied experience in servomechanisms, digital computers, helium liquefaction, and project engineering. Now on active duty with the U.S. Navy. Available April 1953. Desires technical liaison, sales, or administrative position in England or Europe. Box 630 W.

ENGINEER

BSEE 1950. Age 29, married. VHF-UHF receiver development and product design. Desires position in research and development in same field. Box 631 W.

ENGINEER

Radio Engineer, Communications—Radar; Physics, Mathematics 1937. Age 35, married, 1 child. 10 years experience. Desires research or design-development. Prefers non-classified because still alien; will accept other if given good opportunity. Box 632 W.

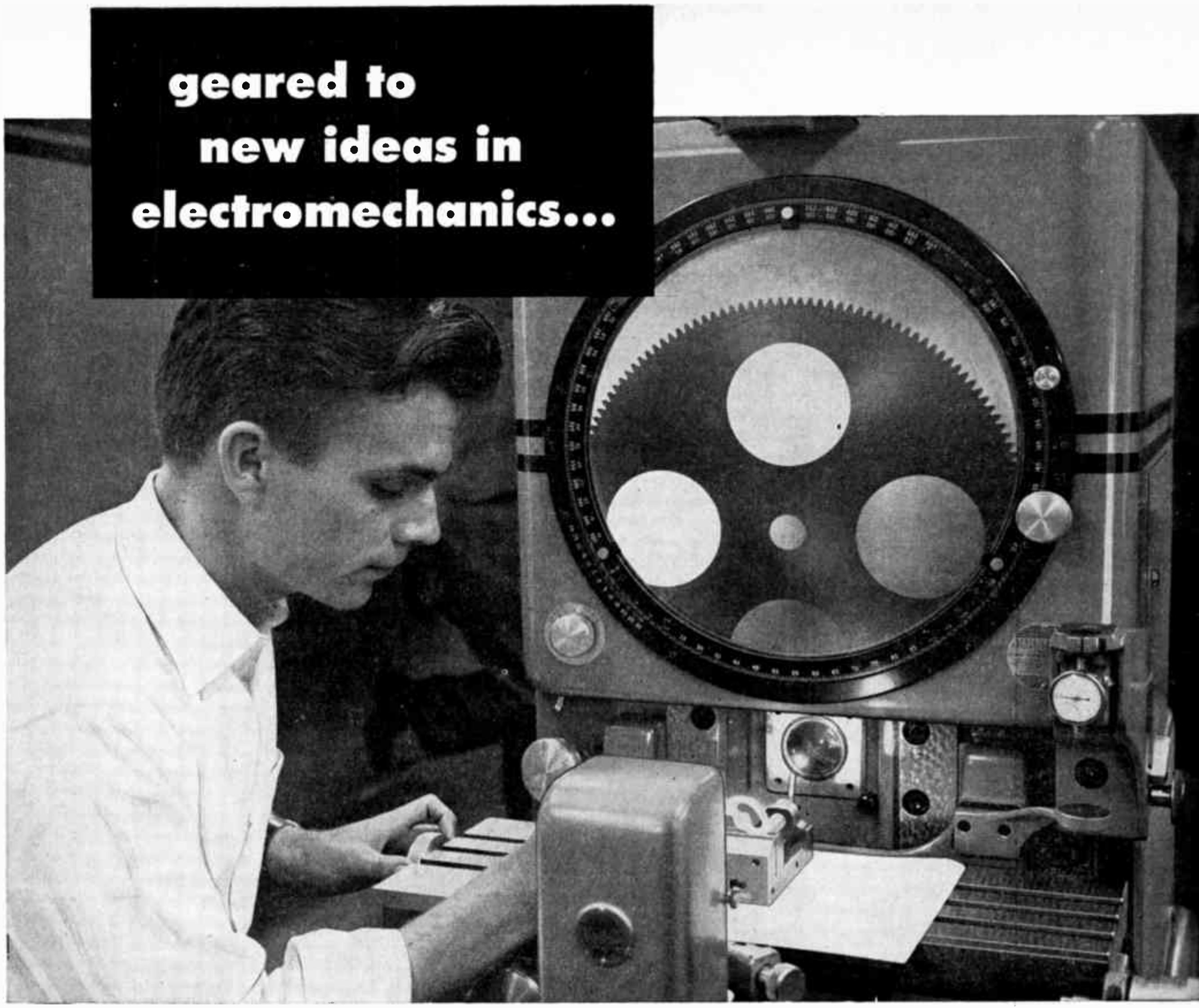
ENGINEER

BEE City College of New York 1951. Was discharged from U.S. Army March 1953, and will be available for employment in communications and allied electronic fields. Please forward inquires to Box 633 W.

ENGINEER

AB Physics 1949, MSEE Stanford University, 1951. Age 27. Married. 2 years Instructor in electrical engineering. Electronics speciality. Engineering education primary interest. Desires Assistant Professorship at smaller western university. Varied background in research and practical electronics. Box 634 W.

(Continued on page 138A)



AT NORTH AMERICAN AVIATION

One of the big reasons for the success of North American Aviation's Electromechanical Department is its painstaking attention to small details—like the millionth of an inch on a gear or the hairline accuracy of the tiny part shown on the contour projector. These small details are some of the factors contributing to the complex missile guidance and automatic control systems which are being designed and developed by this department for projects which stagger the imagination.

North American's fine reputation for pioneering in far-reaching technical fields is part of the answer to the question: "Why do so many talented engineers choose North American as a place to work?" Another is the extremely advanced equipment — much of it invented and built by North American itself — available to the engineers who work here.

In addition to North American's popularity as a place to work, there are always fine career openings for imaginative scientific minds. If you like theory, you will discover an exciting and secure future in the fields of operations analysis, advanced dynamics, kinematics, noise, error or information theory, systems engineering, statistical quality control or servo analysis.

If research, development, or design is your specialty, you'll find attractive opportunities in radar and communications systems, analogue and digital computers, automatic guidance systems or optics.

Why not write for complete information, giving us your education and experience?

NORTH AMERICAN AVIATION, INC.

Engineering Personnel Section, Missile and Control Equipment Operations

12214 Lakewood Boulevard, Dept. 93-R, Downey, California

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD

ELECTRONICS ENGINEER

To carry out research on electronic telecommunications equipment; to design and develop specialized electronic equipment as required; to carry out technical liaison duties.

Honours degree in physics, engineering physics or electrical engineering with specialized training in electronics required. Must have interest and ability in circuit design; must have interest in or experience with electronic computers. Research experience in circuit work would be useful.

Initial salary up to $5200 per annum depending on experience and qualifications. Preference will be given to Canadian applicants.

Apply by mail, giving full details of qualifications and experience to:

Chief, Personnel Branch

NATIONAL RESEARCH COUNCIL

Ottawa, Ontario, Canada

Airline Radio Technician

Large corporation requires the services of an airline radio technician to coordinate sales engineering department dealing with overseas airlines and governments. Occasional foreign travel. Please send resume in first letter.

Box 728
Institute of Radio Engineers
1 E. 79th Street
New York 21, N.Y.

ELECTRONICS ENGINEERS

Project • Design • Group • Field • Junior • Senior

AIRCRAFT ARMAMENTS' development engineering program in the fields of radar, fire control and associated equipment has provided more openings for men at all levels of experience.

If you are considering a change and are looking for a young, growing company with a continuing program of development work, we would appreciate receiving your resume and would welcome the opportunity of providing you with information about our company.

D. J. WISHART
Director of Personnel

AIRCRAFT ARMAMENTS INC.
4415-17 REISTERSTOWN ROAD
BALTIMORE 15, MD.

FLORIDA CALLS ELECTRONIC ENGINEERS

Graduate engineers for R & D in microwave components and receivers, SONAR, transistors, nonlinear circuitry and computers.

Ideal sports, living and working conditions with excellent pay, unusual employee benefits and profit sharing.

Write for application to:

RADIATION, INC.
MELBOURNE, FLORIDA

Positions Wanted

(Continued from page 136A)

ENGINEER

Degree 1948. 2 years design experience in aircraft electronic systems. 2 years design development of special equipment related to production of vacuum tubes. 1 year experience in field, lecturing and technical demonstration of television and test equipment. 3 years Army, telephone equipment and administration. Desires position in engineering administration. Box 635 W.

ENGINEER

BS physics June 1953. Sigma Pi Sigma, age 36. Entire college degree earned in part-time since marriage, 1 child. 3 years Army officer. Continuous employment in commercial/Army communications since 1935 (2 employers), 5 years marine operator, last 4 years TV broadcast with some supervisory work, remainder AM. Like TV but will consider allied fields. Box 636 W.

SENIOR ELECTRONIC ENGINEER

BS, Communications Major. M.I.T. 1950. Experience in development of multiplex microwave communication equipment, and also airborne radar equipment. Desires responsible position with challenging assignments. Locate in N.Y.—N.J. or New England area. Box 646 W.

ENGINEER

BEE and BBA June 1953. 4½ years USNR, CRM. HAM. 2 years pulse circuitry. Married, age 35. Desires electronic development position leading to management. Prefer west coast. Box 647 W.

ENGINEER

Ms in EE. Most significant experience in administration as Naval officer. Expect release from active duty March 1953. Desires position involving general administrative engineering, or as junior engineer. Single, age 28. Prefer San Francisco area. Box 648 W.

MATHEMATICAL STATISTICIAN

MA, Columbia. 5 years in electronics, radar, guided missiles, AA fire control, tracking systems. Age 38, married, child. Prefer non-classified work, analysis and evaluation of electronic systems. Box 649 W.

ENGINEER

Former Director of large trade school (electronics, electricity, radio & TV, radar, etc.) 12 years electrical engineering, teaching and management experience. Can initiate or join employee training programs for technicians or engineers. Box 650 W.

ELECTRONICS ENGINEER

BSEE University of California 1945. 1½ years gun-fire control systems; 1½ years lamp development (one patent); 3 years application of statistics to aircraft instrument manufacture.' Member ASQC, TBII. Desires engineering or statistical quality control. Prefer west coast. Box 651 W.

ELECTRONIC ENGINEER

Electronic Engineer. Age 28. 3 years experience in design of electro-medical research equipment including AC and DC low-level amplifiers, stimulators, transducers and related equipment. Box 652 W.

ELECTRONICS ENGINEER—ADMINISTRATIVE

BSEE; SM, IRE; communications engineer, radio and telephone, 11 years; Navy electronics officer, electronics training administrator, laboratory supervisor, instructor, 6 years. Age 39, married. Desires adminstrative or supervisory position. Minimum salary $8500. Box 653 W.

News—New Products

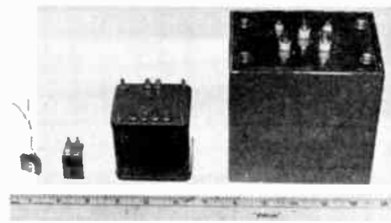
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 125A)

Mil-T-27 Transformers

A.J.F. Industries, Inc., 852–858 Monroe St., Brooklyn 21, N. Y., is now producing in quantity hermetically-sealed transformers to MIL-T-27 specifications.

Facilities for complete in-plant-testing are available so that sample transformers do not have to be sent to government laboratories for test, thus saving considerable time.



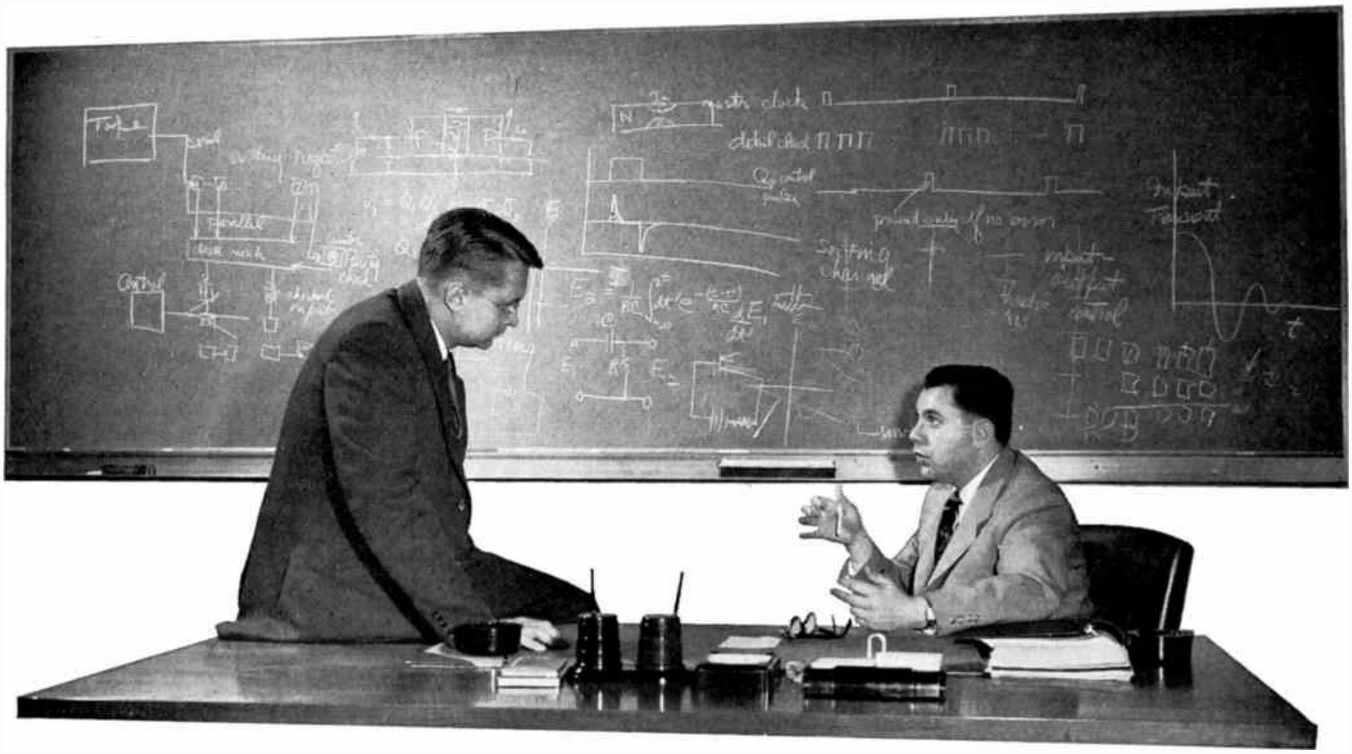
A.J.F. has ASESA prototype approvals on many types of transformers. Therefore, in most cases MIL-T-27 approvals on new transformers may be obtained simply by comparing similarity to previously approved prototypes.

Sizes range from the sub-sub-miniature (less than ¼ ounce) to 1 kv for the audio, power, plate, and filament for temperature rise of 40°C at 65°C ambient and are made grade 1 with can and also encapsulated without the can.

(Continued on page 142A)

PLANNING THE RIGHT ANSWERS

The complexity of modern air defense—extreme aircraft speeds, highly complex weapons, new combat strategies, the advanced state of today's technology—poses serious problems for the scientist and engineer.



One significant solution lies in the extensive use of airborne automatic equipment, including electronic digital computers, to augment or replace the human element in aircraft control.

AT HUGHES Research and Development Laboratories each problem is attacked basically, beginning with systems planning and analysis. This consists of an exhaustive examination of the requirements of a problem, together with an evaluation of the best means for satisfying these requirements. The objective is to design the simplest possible mechanization consistent with a superior performance.

These techniques, employing many special talents, are responsible at Hughes for the successful design, development *and* production of complexly interacting automatic systems for all phases of electronic control of interceptor navigation, flight control, and fire control. Similar accomplishments may be pointed to in the guided missile field.

Methods of systems planning and analysis responsible for achievements in the military area are also being applied at Hughes to adapt electronic digital computer techniques for business data processing and industrial controls.

Dr. E. C. Nelson (left), Head of Computer Systems Department, and J. H. Irving, Head of Systems Planning and Analysis Department, discuss a problem in the systems planning and analysis stage.

PHYSICISTS AND ENGINEERS

Hughes activities in the computer field are creating some new positions in the Systems Planning and Analysis Department. Experience in the design and application of electronic digital computers is desirable, but not essential. Analytically inclined physicists and engineers with a background in systems work are invited to apply.

Address:
SCIENTIFIC AND ENGINEERING STAFF

HUGHES
Research and Development Laboratories

CULVER CITY,
LOS ANGELES COUNTY,
CALIFORNIA

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 140A)

Also, A.J.F. Industries is manufacturing high temperature 200°C transformers which are made hermetically sealed, and, too, are presently constructing pulse transformers ranging in size from trigger and blocking oscillator units of 300 volt peak secondary, to pulse units of 80 kw peak power and 10 kv peak volts.

Samples of most of power, audio, and filament types, built to customers' specifications, can be delivered in approximately three weeks and quantity deliveries can start in approximately six weeks after approval of samples.

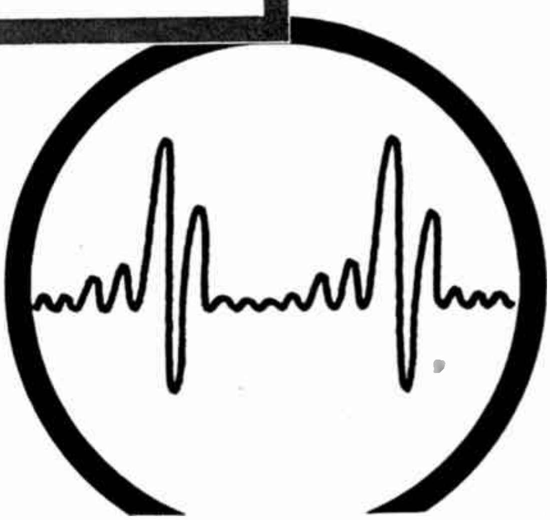
For immediate action all inquiries should be marked for the attention of M. Clifford Agress.

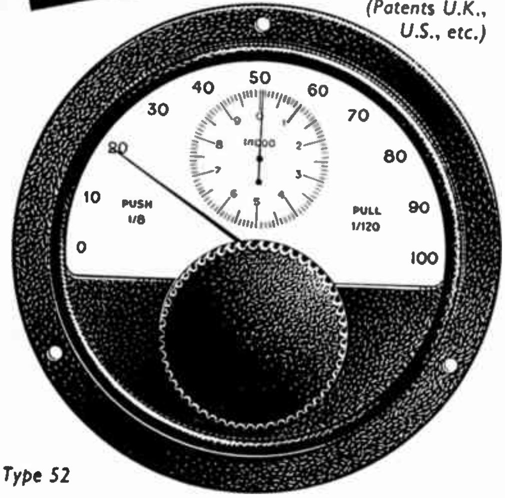
Miniature Coax Connector

A "bee" size connector, completely assembled with single conductor cable which has been treated with conductive materials reducing the self-generated noise by a factor of 90 per cent is available from **Microdot Div., Felts Corp.,** 1826 Fremont Ave., South Pasadena, Calif. This treatment is important whenever high impedance terminations such as crystals, photocells and capacitive types are considered.

The Microdot Connector and associated cable is useable at frequencies up to

(Continued on page 144A)





News—New Products

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(Continued from page 142A)

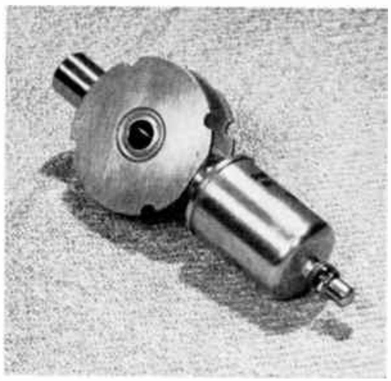
1,000 mc in short lengths with minimum insertion loss. The manufacturer states an insertion loss for 3 feet of cable and 2 complete male and female connectors of 0.9 db at 400 mc. The rated voltage of 600 volts RMS and the characteristic impedance of 50 ohms or higher indicates the applications to the audio, video, radio and radar applications.

The use of Teflon insulation for both cable and connectors insures broad temperature performance from 65° to +300°F. The small size of 0.220 inch diameter and length 0.85 inch (male and female) with 10.32 inch mounting thread provides easeful use for panel, chassis or blind hole mounting in microminiature assemblies. Vibration and moisture lock are provided through the use of "O" rings.

Associated couplings are available for use as chassis feed-throughs and for extending cable lengths.

Airborne Radar Tube

General Electric Co., Tube Dept., 1 River Rd., Schnectady 5, N. Y., announced that it has added to its TR tube line a new gas-switching tube for airborne radar.



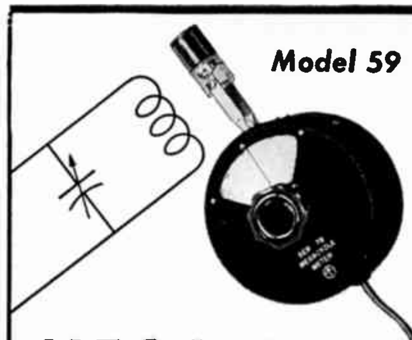
The tube, type GL-1B24-A, is an integral-cavity tunable type designed for use in simple duplexers in pulsed microwave circuits which do not require that the short circuit in the tube have a fixed electrical position.

The tube differs from others of this type in that its reservoir is made of steel instead of glass. Use of a steel reservoir not only increases the tube's strength, but also decreases the weight appreciably. The tube weighs ½ pound. Designed for use in an operation band from 8,490 to 9,600 mc, it operates to decouple the receiver effectively from a common transmitting and receiving antenna during a transmission period.

The GL-1B24-A has a recovery time of 4 μs at 10 kw peak, 3 db down. It has a leakage power of 30 mw. The transmitter peak power is 100 kw.

Further details on the GL-1B 24-A may be secured from the General Electric Co.

(Continued on page 145A)



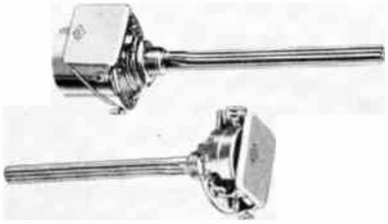
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 144A)

Compensated Volume Control

Compentrol is the new compensated volume control being manufactured by the **Centralab Div. of Globe Union, Inc.,** 900 E. Keefe Ave., Milwaukee 1, Wis.



The unit is a combination dual-tapped control and printed electronic-circuit plate combining the compensating network. The use of the PEC plate makes possible a size practically no larger than an ordinary volume control together with close control over the output of the entire network. Since all components in the "Compentrol" network are in shunt, there is no insertion loss, and no additional amplification is required.

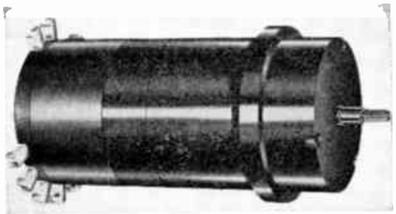
Compentrol has been designed as a direct replacement for standard controls in all audio equipment. It effectively compensates for the Fletcher-Munson hearing characteristic curves, boosting the very high and very low audio frequencies of sound at low volume level.

Two styles of Compentrol are now available, ½ and 1 megohm values, in both switch and nonswitch types.

Prices for Compentrol are $2.50 plain type audio net, $3.00 switch type audio net. A booklet describing "compensation" and the Compentrol unit is available free of charge at Centralab distributors, or by writing the company.

Electrical Resolvers

An electrical resolver system, capable of operating with accuracy over a wide environmental range, has been developed by the **Ford Instrument Co.,** 31-10 Thomson Ave., Long Island City 1, N. Y., for use in computers and computing systems.



The resolver system is composed of a resolver, a hi-gain amplifier, and a summing network box. The network box suitably combines its inputs for introduction into the hi-gain amplifier; the amplifier feeds the resolver, either the basic resolver

(Continued on page 146A)

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

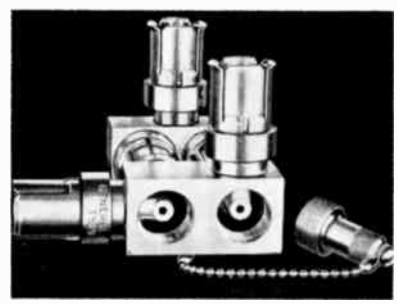
(Continued from page 145A)

or the vector solver type; the outputs of the resolver are the desired functions.

The following ratings and technical data are typical for the Ford resolver systems size 31 and size 23: frequency, 400 ±5 cps maximum; input voltage, 0.25–12.0 maximum; input impedance, 1.0 megohm; transformation ratio (at 8.0 volts input), 1±0°0′; variation of transformation ratio with input voltage from 0.25 v to 12.0 v, +0.06 per cent for size for size 31 system, +0.1 per cent for size 23 system; variation of transformation ratio with change in temperature (−60° to +160°F), +0.05 per cent for size 31 system, +0.1 per cent for size 23 system; maximum error of sine value during 360° rotor rotation (any one input voltage), +0.00060 for size 31 system, +0.00070 for size 23 system; maximum error of cosine value during 360° rotor rotation (any one input voltage), +0.00100; total null voltage (primarily 3rd harmonic), 1 mv/v input; error in null spacing, ±1½ minutes; inter axis error (rotor), ±3 minutes.

Balanced-Impedance Measurement

Accurate measurements of balanced impedances in a frequency range from 50 to 1,000 mc can be made with the help of a new transformer-type balanced impedance measurement device manufactured by **General Radio Co.**, 275 Massachusetts Ave., Cambridge 39, Mass.



Called the Balun, this tunable semi-artificial halfwave line makes it possible to connect a balanced impedance to an unbalanced coaxial system such as that used on high-frequency measuring instruments. The Balun has two important advantages over a conventional transformer. It can be tuned over a wide frequency range and has very low losses.

Since the use of balanced systems in television and communications has been growing rapidly, there has been a considerable need for a device to perform the functions of the Balun. The unbalanced end of the Balun is a type 874 coaxial connector, and thus can be used directly with any General Radio measuring equipment. New adaptors are available to connect to any of the other commonly used connector systems.

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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 146A)

Inductance Decades

Torocoil Co., 1374 Mobile Court, St. Louis 10, Mo., announces a complete line of decade-type inductance units. These units include four ranges from 1 mh to 10 henries and are available as single units which can be connected together to give an inductance change of as little as 1 mh in 10,000. These inductors are wound on the highest quality toroidally shaped powdered molybdenum permalloy cores. Quality Factors (Q) as high as 250 are obtainable with these units. Switching is performed by the use of high-current capacity, low-resistance, instrument type switches. Prices on these units are low enough so that every laboratory even with limited instrument budgets can afford the convenience of a precision set of high (Q) decade inductances. For further information write direct to the company.

Coaxial Cable System

A new coaxial cable system, with triple the telephone capacity of those now in use, has been developed by **Bell Telephone Laboratories,** 463 West St., New York 14, N. Y., and is undergoing exhaustive field trials prior to use in the Bell System. It is expected to go into actual service on circuits between New York and Philadelphia early in 1953.

The new system, known as "L-3" carrier, will enable one pair of coaxial pipes to handle simultaneously more than 1,800 telephone conversations, or 600 telephone

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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 147A)

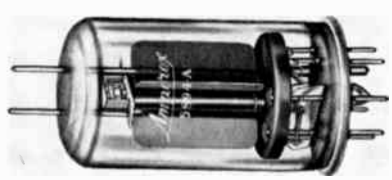
conversations plus one television program in each direction. It will be the first carrier system on which both television signals and regular telephone conversations can be sent over the same pair of coaxial pipes at the same time.

It was necessary to design new amplifiers or "repeaters" with characteristics exceeding any earlier type. In "L-3," as in earlier coaxial systems, power is fed to the repeaters over the coaxial cable from widely separated power points. The higher power requirements of the new repeaters, and the fact that twice as many are used in the new system, presented a number of technical problems.

New terminal equipment also was necessary to pile up 1,800 circuits and permit both addition and subtraction of smaller groups of circuits at intermediate points. Means for putting television signals on the line and distributing them at intermediate points without introducing distortion had to be developed. Sending both television and telephone signals over the same circuits created the problem of preventing interference between the two types of signals.

UHF-VHF Twin Tetrode

A new uhf and vhf tetrode is announced by the **Amperex Electronic Corp.,** 230 Duffy Ave., Hicksville, L. I., N. Y. Known as Model 5894-A, this new tube is a smaller, mechanically and electrically improved version of the Amperex AX-9903/5844 tube designed for wide band operation as an rf amplifier, modulator, frequency doubler, or a tripler.



Improved hf performance is made possible because the cathode and grid structure is supported at the top as well as the bottom of the tube. Being thus held in exact vertical alignment with the plates, the two sections of the tube are in closer electrical balance.

The Amperex 5894-A employs a new type of construction which enables the tube to withstand greater shock and vibration. The anode seal strength has been increased by replacing the top section of the tube with a powdered glass seal. With this new construction, the maximum force on the ends of the anode pins perpendicular to the pin axle is about 14½ pounds. With greater force, the pins bend without forming cracks in the glass.

Characteristics in brief: 250 mc, 85 watts output. 500 mc, 45 watts output. Filament voltage, Series 12.6 v; Parallel, 6.3v. Filament current, Series 0.9a; Parallel, 1.8a.

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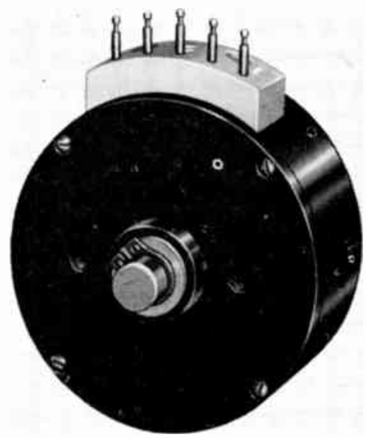
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 148A)

Potentiometer

A new $1\frac{3}{4}$ inch diameter, versatile potentiometer has been announced by **G. M. Giannini & Co., Inc.,** 117 E. Colorado St., Box N, Pasadena 1, Calif., and East Orange, N. J.



This new precision potentiometer is available in single-section units with either a syncro-type or screw-type mounting. Both sleeve bearing and ball bearing models are manufactured with torque requirements of 0.5 ounce/inch for the ball bearing unit. Standard linearity tolerance is ± 0.3 per cent with better linearity units available on special order. Mechanical rotation can be 360° continuous, or stops can be provided for any rotation up to 330°. Electrical contact angles up to 360° can be ordered, but the standard contact angle is 356°. Resistances from 2,000 to 200,000 ohms are available with a power dissipation of 3 watts at an ambient temperature of $+25$°C. Operating temperature range is from -54 to $+71$°C and the unit will function during 50 G acceleration applied along any axis. The case is black anodized aluminum, and close tolerances are held on all mounting surfaces. With their toroid coils, these units are ideal for applications requiring nonlinear functional outputs without external taps. Weight is $2\frac{1}{2}$ ounces for the sleeve bearing and $3\frac{1}{2}$ ounces for the ball-bearing units.

C-R Tube Increases Oscillograph Light Output

Incorporation of a Type 5XP-AM Metallized cathode-ray tube in the new Type 303-AH cathode-ray oscillograph was announced recently by the **Instrument Div. Allen B. Dumont Laboratories, Inc.,** 1500 Main Ave., Clifton, N. J.

The type 5XP-AM increases the light output from the screen by more than 50 per cent. Since the Type 303-AH is a high-voltage oscillograph often employed for the study of high-frequency signals of low repetition rates, or single transients, this is an advantage.

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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 150A)

Metallization also prevents the building up of spurious charges on the screen by successive transients. These spurious charges, under some circumstances, may distort succeeding transients.

Film fogging, a problem encountered when photo-recording with high-speed cameras, is also minimized by metallization. This fogging, partly caused by cathode glow passing through an unmetallized screen, may occur when the shutter is help open for a time, awaiting a single transient. In the Type 5XP-AM cathode glow cannot be transmitted through the metallized layer, thereby eliminating film fogging from this cause.

The price of the Type 303-AH with the Type 5XP-AM metallized cathode-ray tube remains unchanged, although the latter is more expensive than its unmetallized counter part.

Repeat Cycle Timer

An electronic repeat cycle timer suitable for regulation of automatic machinery, sampling, valve pacing and heat sealing as well as laboratory testing such as heat cycling and refluxing, is available from **G. C. Wilson & Co.**, 2 Passaic Ave., Chatham, N. J.

The timer uses a single electron tube to charge a resistance-capacitance network so that "on" cycles are adjustable from 0.2 to 200 and "off" cycles range from 0.1 second to 1 minute.

The unit is supplied in a sloping steel front cabinet, 6×6×6 inches for operation on 105–120 volt, 60 cps ac. Output is supplied to a double pole double throw relay for non-inductive loads up to 10 amperes at 115 volts or 2 amperes at 460 volts. Relay contacts are wired to a plug or a terminal strip to facilitate installation.

Applications include: refluxing, sign flashing, filter cleaning, heat cycling, life testing, food processing, sampling, electro plating, plastic molding, mixing machines, bag filling, bottle filling, valve metering and flight testing.

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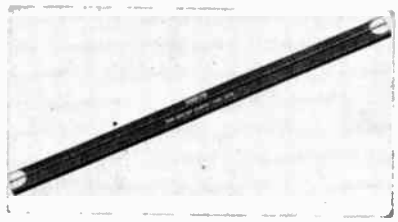
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 151A)

Potentiometer Element

The Markite Corp., 155 Waverly Pl., New York 14, N. Y., has announced the availability of its type 2028 potentiometer element. This is a rectilinear model of 20,000 ohms resistance having an active length of 10 inches and a linearity of ±1 per cent. These elements are of particular interest in applications where the advantages of extreme wear resistance and substantially infinite resolution are important.



Markite has also developed a variety of rotational as well as rectilinear type elements and potentiometers to customer specifications.

Functional and linear designs are available offering combinations of wear resistance, precision, high resolution and adaptability to miniaturization over a wide impedance range.

(Continued on page 153A)

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

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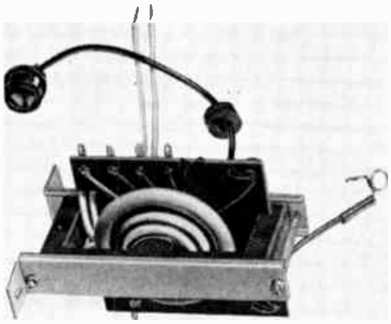
Flyback Transformers

Two flyback transformers, exact replacements for Admiral Parts, numbers 79C30-1, 79C30-3 and 79C30-4, are the latest in a complete line of horizontal output transformers just released by **Ram Electronic Sales Co.,** South Buckhout St., Irvington-on-Hudson, N. Y.



These two transformers are designed and constructed to the exact specifications of the set manufacturer and are guaranteed to equal or better the characteristics set up for them.

Both models are engineered for 66–70 degree horizontal deflection angle, utilize the new high-efficiency Ferrite "E" core, and deliver up to 15 kv with excellent stability for optimum performance of the circuit.

Ram builds a complete line of original equipment and replacement flybacks, yokes, linearity and width coils for television. For the latest catalog, write directly to Ram or see your local distributor.

Half-Wave Rectifier

A half-wave rectifier designed for use in high-voltage rectifier circuits has been added to the industrial tube line of the **General Electric Co., Tube Dept.,** 1 River Rd., Schnectady 5, N. Y.

The tube, type GL-4B32, is designed particularly for use as a rectifier in radio and television transmitters, industrial heating oscillators, and other applications where high-voltage direct current is required.

The GL-4B32 is an inert-gas-filled tube which will operate over a wide temperature range, from −55° to +70°C. Use of

(Continued on page 154A)

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 153A)

an inert gas instead of mercury permits mounting the tube in any position.

Maximum ratings for the GL-4B32 include a peak maximum cathode current of five amperes, an average maximum cathode current of 1.25 amperes, and a maximum peak inverse anode voltage of 10,000 volts.

The tube is recommended for use with a filament voltage of five volts and a filament current of 7.5 amperes.

Further information on the GL-4B32 may be secured by writing the company.

Electric Auto-Camera

J. A. Maurer, Inc., Photographic Instrumentation Div., 37-01 Thirty-first St., Long Island City 1, N. Y., has just announced the availability to the American market of the Mark 3 model Auto-Camera as manufactured in England by D. Shackman & Sons.

It may be used for all forms of data recording, such as study of repetitive processes, meter readings for future reference, motion study displacement study. Electrically operated with either 12 or 24 volt dc supply, the 21 foot film capacity cassettes with which this camera is loaded in daylight, will take either 200 exposures 1 inch×1 inch, (Model Mark 3-A) or 300 exposures ¾ inch×1 inch, (Model 3-B). Pulsing rate of exposure can be controlled from four per second to as long as necessary for the process being photographed. The camera is powered with a self-contained clock spring, the electrical impulse triggering the exposure and film transit and also closing an auxiliary contact for counter or signal light operation. When film has been fully exposed the camera locks out until reloaded, preventing spoilage of last picture.

As shipped, the lens is an f/3.5 of 35° inclusive angle of view, with five shutter speeds of 1/10th to 1/200th second and "time" exposure. A wide range of accessories from power supplies for line operation, to stands and adaptors for stereo, photo-micrography and similar applications are available. Weighing under 6 pounds the camera measures 9×3½×4 inches and adapts itself to close quarter operations. Full data can be had from J. A. Maurer, Inc.

(Continued on page 156A)

New 800-2600 MCS Frequency Meters

Lightweight-Portable Units.. For Field and Laboratory Use!

Models
FS-C-171-A 800-1200 MCS.
FS-C-172-A 1200-1600 MCS.
FS-C-173-A 1600-2250 MCS.
FS-C-174-A 1700-2600 MCS.

The input circuit is a type N connector (UG-58/U) . . . The output is monitored by a 1N21B crystal and microammeter circuit with adjustable sensitivity control for varying input power levels. The output of the crystal may be obtained from pin jacks provided on the panel of the instrument. A switch is provided to change the output from the microammeter to the pin jacks.

SPECIFICATIONS

1. **ACCURACY** Better than .05% from 20°F to 120°F
2. **SENSITIVITY** Usable indication with 1 milliwatt input Adjustable for higher levels
3. **INDICATOR** 50 Microammeter
4. **INPUT** 50 Ohm Type N Connector
5. **EXTERNAL DC OUTPUT** Pin Jacks
6. **EXCURSION OF MICROMETER** One-half inch
7. **MICROMETER SCALE**
   at 1000 Mc — 1 Division equals 290 KC
   at 1400 Mc — 1 Division equals 350 KC
   at 2000 Mc — 1 Division equals 450 KC
   at 2600 Mc — 1 Division equals 555 KC
8. **EXTERNAL SIZE** 6½ x 9¾ x 7"
9. **WEIGHT** Four pounds

CAVITY UNITS AVAILABLE

Units consist of cavity body, micrometer control, crystal, suitable connectors and calibration chart. Write for specifications and prices.

frequency standards

P. O. Box 504,
Asbury Park, New Jersey

new HEPPNER "GUARANTEED COUNT" ELECTRO-DYNAMIC speakers

With EXCLUSIVE "No-Rub" Voice Coil

ABSOLUTE UNIFORMITY TO YOUR SPECIFICATIONS BECAUSE:

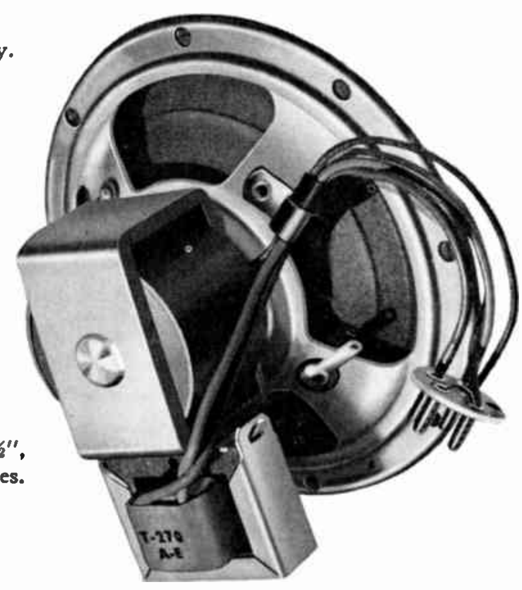
- EACH FIELD COIL GUARANTEED TO CONTAIN GIVEN NUMBER OF TURNS within standard tolerance. Quality fully controlled because all coils are wound by Heppner. No wire-stretching or other quality-reducing shortcuts. Resistance and wire size to your exact specifications.

- THE *EXCLUSIVE* HEPPNER PERFECTLY ROUND "NO-RUB" VOICE COIL is now available in Electro-Dynamic Speakers. This coil is installed perfectly round by means of a Heppner developed process which eliminates all egg-shaped coils which cause rubs.

Electro-Dynamic Speakers are available with or without bucking coils, transformers, plugs and/or brackets to your specifications.

Engineered for efficiency and fine acoustical performance. Exceptionally thorough final inspection.

Write for further information today.



Available in 3", 4", 5", 6½", 10", 12" sizes.

HEPPNER MANUFACTURING COMPANY
Round Lake, Illinois (50 Miles Northwest of Chicago)
Phone: 6-2161
SPECIALISTS IN ELECTRO-MAGNETIC DEVICES

Representatives:
James C. Muggleworth
506 Richey Ave., W., Collingswood, N. J.
Ralph Haffey
2417 Kenwood Ave., Ft. Wayne 3, Indiana
Irv. M. Cochrane Co.
408 So. Alvarado St., Los Angeles, California

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 154A)

Bulletin on Timing Relays

The Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee, Wis., is offering a 16-page bulletin featuring its complete line of timing relays.

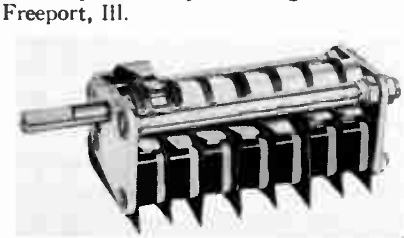
Fluid dashpot, pneumatic, and electronic timers are fully described. It also contains complete operation and engineering data. Applications are clearly stated. Timers are shown in a wide variety of standard enclosures.

A selector chart is provided along with suggestions on the various factors to consider in choosing a timing relay for a particular application.

A request to the company will be filled promptly.

Switch Assembly

A new series of extremely small size multiple rotary switch assemblies, designed for aircraft use but adaptable to a wide variety of either ac or dc switching applications, is announced by **Micro Div., Minneapolis-Honeywell Regulator Co.,** Freeport, Ill.



One of the series is a ganged assembly of seven "V3" type basic switches with single-pole, double-throw contact arrangement. Each "V3" basic switch measures $\frac{13}{32}\times\frac{5}{8}\times1\frac{3}{32}$ inches, and the entire assembly measures $1\frac{1}{2}\times1\frac{5}{8}\times4\frac{3}{4}$ inches. The dc rating of the 7AS71 (Catalog Listing) assembly for inductive and heater load is: 30 volts, 10 amperes at sea level; 30 volts, 6 amperes at 50,000 feet altitude. The ac

(Continued on page 158A)

COMMUNICATIONS EQUIPMENT CO.

PULSE TRANSFORMERS

D-166173: Video, Ratio = 50:900 Ohms 10KC—2MC $12.50
G.E.K.-2745 ....$39.50
G.E.K.-2744-A, 11.5 KV High voltage, 3.2 KV Low voltage @ 200 KW oper. (270 KW max.) 1 microsec. or 1/microsec. @ 600 PPS $39.50
W.E. D169271 Hi Volt input pulse Transformer $27.50
G.E. K2450A. Will receive 13KV, 4 micro-second pulse on pri. secondary delivers 14KV. Peak power out 100 KW G. E. $34.50
G. E. K2748A. Pulse Input line to magnetron $36.00
Ray UX 7896—Pulse Output Pri. 5v. sec. 41v $7.50
Ray UX 8442—Pulse inversion —40v + 40v $7.50
Ray UX 7361 ....$5.00
PHILCO 352-7250, 352-7251, 352-7287
UTAH 9332, 9278, 9341.
RAYTHEON: UX8693, UX5986 ....$5 ea.
W.E.: D-166310, D-16638, KS 9800, KS9948

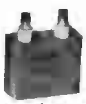
PULSE EQUIPMENT

APQ-13 PULSE MODULATOR. Pulse Width .5 to 1.1 Micro Sec. Rep. rate 624 to 1348 Pps. Pk. Pwr. out 35 KW Energy 0.018 Joules $49.00
TPS-3 PULSE MODULATOR. Pk. power 50 amp. 24 KW (1200 KW pk); pulse rate 200 PPS, 1.5 microsec. pulse line impedance 50 ohms. Circuit series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New with all tubes $49.50

DELAY LINES

D-168184: 0.5 microsec. up to 2000 PPS 1800 ohm term $4.00
D-170499: 25/.50/.75 microsec. 8 KV 50 ohms imp. $16.50
D-165997: 1¼ microsec. $7.50
RCA 255686-502, 2.2μ sec. 1400 ohms $2.00

PULSE NETWORKS



G.E. 26E3-5-2000-50P2T, 6KV "E" circuit, 3 sections .5 microsecond, 2000 PPS 50 ohms impedance $6.50
15A—1-400-50: 15 KV, "A" CKT, 1 microsec. 400 PPS, 50 ohms imp. $37.50
G.E. 23E (3-84-810) 8-2.24-405) 50P4T; 3KV "E" CKT Dual Unit; Unit 1, 3 sections, 0.84 Microsec. 810 PPS, 50 ohms imp.; Unit 2, 8 Sections, 2.24 microsec. 405 PPS. 50 ohms imp. $6.50
7.5E3-1-200-67P. 7.5 KV "E" Circuit, 1 microsec 200 PPS, 67 ohms impedance 3 sections $7.50
7.5E4-16-60, 67P. 7.5 KV. "E" Circuit, 4 sections 16 microsec. 60 PPS, 67 ohms impedance $15.00
7.5E3-3-200-6FT, 7.5 KV, "E" Circuit, 3 microsec. 200 PPS, 6 ohms imp. 3 sections $12.50
2755: 10KV, 2.2usec., 375 PPS, 50 ohms imp. $27.50
2754: 10KV, 0.85usec., 750 PPS, 50 ohms imp. $27.50
KS8865 CHARGING CHOKE: 115-150H @ .02A, 32-40H @ .08A, 30,700V Corona Test, 21KV Test $37.50
G.E. 25E5-1-350-50 P2T, "E" CKT, 1 Microsec. Pulse @ 350 PPS, 50 OHMS Impedance $69.50

400 CYCLE TRANSFORMERS

(All Primaries 115V, 400 Cycles)

Stock	Ratings	Price
M-7467886	2X140V/.014A, 120V/.012A, 1200 VRMS TEST, P/O MX-8/APG-2	$ 4.95
352-7102	5.3V/2.5A	1.45
M-7472426	1450V/ MA, 2.5V/.75A, 6.4V/3.9A, 5V/2A, 6.5V/.3A, P/O ID-39/APG-13	4.95
352-7039	640VCT @ 250MA, 6.3V/.9A, 6.3V/6A, 5V 6A	$5.49
702724	9800 8600 @ 32MA	8.95
K59584	5000V/290MA, 5V/10A	22.50
52J652	13,500V 3.5MA	14.65
KS9607	734VCT/.177A, 1710VCT/.177A	6.79
352-7273	700VCT/350MA, 6.3V 0.9A, 6.3V 2.5A 6.3V/.06A, 5V CA	6.95
352-7070	2X2.5V 2.5A (2KV TEST) 6.3V/2.25A, 1200 1000/75 OV @ .005A	7.45
352-7196	1140V 1.25MA, 2.5V/1.75A, 2.5V/ 1.75A —5KV Test	3.95
352-7176	320VCT 50MA, 4.5V/3A, 6.3VCT/20A, 2X6.3VCT/6A	4.75
RA6400-1	2.5V/1.75A, 6.3V/2A—5KV Test	2.39
901692	13V 9A	2.49
901699-501	2.77V @ 4.25A	3.45
901698-501	900V/75MA, 100V/.01A	4.29
UX8855C	900VCT .067A, 5V 3A	3.79
RA6405-1	800VCT 65MA, 5VCT/3A	3.69
T-48852	700VCT 80MA, 5V 3A, 6V/1.75A	4.25
352-7098	2500V/6MA, 300 VCT, 135MA	5.95
KS 9336	1100V 50MA TAPPED 625V 2.5V/5A	3.95
M-7474319	6.3V/2.7A, 6.3V/.66A, 6.3VCT/21A	4.25
KS 8984	27V 4.3A, 6.3 2.9A, 1.25V/.02A	2.95
52C080	526VCT/50MA, 6.3VCT/2A, 5VCT/2A	3.75
32332	400VCT 35MA, 6.4V/2.5A, 6.4V/.15A	3.85
68G631	1150-0-1150V	2.75
80G198	6VCT .00006 KVA	1.75
302433A	6.3V/9.1A, 6.3VCT/6.5A, 2.5V/3.5A, 2.5V 3.5A	4.85
KS 9445	592VCT/118MA, 6.3V/8.1A, 5V/2A	5.39
KS 9685	6.4/7.5A, 6.4V 3.8A, 6.4V 2.5A ALL CT	4.79
70G30G1	600VCT 36MA	2.65
M-7474318	2100V/.027A	4.95

MICROWAVE COMPONENTS

S BAND—3" x 1½" WAVEGUIDE

DIRECTIONAL COUPLER, Broadband type "N" Coupling, 20 db. with std. flanges. Navy 2CABV 47AAN-2. As shown $37.50
WAVEMETER, 2700-3400 MC. Reaction type with counter Dial Mfg., W.E. $92.50
REACTION WAVEMETER, Mfg. G.E. 3000-3700 MC, Mic Head $125.00
LHTR. LIGHTHOUSE ASSEMBLY, Part of RT39 APG 5 & APG 15, Receiver and Trans. Cavities w/assoc. Tr. Cavity and Type N CPLG. To Recvr. Uses 2C40, 2C43, 1B27. Tunable APX 2400-2700 MCS. Silver Plated $49.50
BEACON LIGHTHOUSE cavity 10 cm. Mfg. Bernard Rice, each $47.50
MAGNETRON TO WAVEGUIDE Coupler with 721A Duplexer Cavity, gold plated $45.00
RT-39 APG-5 10 cm. lighthouse RF head c/o Xmtr.-Recvr-TR, cavity compl. recvr. & 30 MC IF strip using 6AK5 (2C40, 2C43, 1B27 lineup) w/Tubes.
721A TR BOX complete with tube and tuning plungers $12.50
McNALLY KLYSTRON CAVITIES for 707B or 2K28 ....$4.00
F 29 SPR-2 FILTERS, type "N" input and output $12.50
WAVEGUIDE TO ⅞" RIGID COAX "DOOR-KNOB" ADAPTER CHOKE FLANGE, SILVER PLATED BROAD BAND $32.50
AS14A AP-10 CM Pick up Dipole with "N" Cables $4.50
OAJ ECHO BOX, 10 CM TUNABLE $22.50
HOMERELL-TO-TYPE "N" Male Adapters. W.E. 2D167284 ....$2.75
I. F. AMP. STRIP: 30 MC, 120 d.b. gain, 2 MC Bandwidth, uses 6AC7's—with video detector. Less tubes $24.50
POLYROD ANTENNA, AS31/APN-7 in Lucite Ball, Type "N" feed $22.50
ANTENNA, AT49A/APR: Broadband Conical, 300-3300 MC Type "N" Feed $12.50
"E" or "H" PLANE BENDS, 90 Deg. less flanges $7.50

⅞" RIGID COAX—⅜" I.C.

RIGHT ANGLE BEND, with flexible coax output pickup loop $8.00
SHORT RIGHT ANGLE BEND, with pressurizing nipple $3.00
RIGID COAX to flex coax connector $3.50
RT. ANGLES for above $2.50
RT. ANGLE BEND 15" L. OA $3.50
FLEXIBLE SECTION, 15" L. Male to female $4.25
⅞" RIGID COAX, BULKHEAD FEED-THRU $14.00

⅞" RIGID COAX—⅜" I. C.

ROTARY JOINT, Stub-supported, UG 46/UG 45 fittings $27.50
10 CM STABILIZER Cavity, tunable, standard UG46/UP 45 fittings $45.00
RG 44/U RIGID COAX, stub support, 5 ft. sections, with UG46/UG45 connectors $12.50
RIGHT ANGLE BEND, with flexible coax output pickup loop $8.00
SHORT RIGHT ANGLE BEND, with pressurizing nipple $3.00
RIGID COAX to flex coax connector $3.50
RT ANGLES for above $2.50
RT. ANGLE BEND 15" L. OA $3.50
FLEXIBLE SECTION, 15 L. Male to female ..$4.25
⅞" RIGID COAX, BULKHEAD FEED-THRU $14.00

X BAND—1" x ½" WAVEGUIDE

1" x ½" waveguide in 5' lengths, UG 39 flange to UG40 cover ....per length $7.50
Rotating joints supplied either with or without deck mounting. With UG40 flanges ....each, $17.50
Bulkhead Feed-thru Assembly $15.00
Pressure Gauge Section 15 lb. gauge and press nipple $10.00
Pressure Gauge, 15 lbs. $2.50
Directional Coupler, UG-40/U Take off 20 db. $17.50
TR-ATR Duplexer section for above $8.50
Waveguide Section 12" long choke to cover 45 deg. twist & 2½" radius, 90 deg. bend $4.50
Twist 90 deg. 5" choke to cover w/pres nipple $6.50
Waveguide Section 2½ ft. long silver plated with choke flange $5.75
Rotary joint choke to choke with deck mounting $17.50
3 cm. mitered elbow "E" plane $12.00
UG 39 Flanges ....$ .85
90 degree elbows, "E" or "H" plane 2½" radius $12.50
90 degree twist 6" long $8.00
45 degree twist $8.00
Microwave Receiver, 3 CM. Sensitivity: 10-13 Watts. Complete with L.O. and AFC Mixer and Waveguide Input Circuits, 6 I.F. Stages give approximately 120 DB gain at a bandwidth of 1.7 MC. Video Bandwidth: 2 MC. Uses latest type AFC circuit. Complete with all tubes, including 723A/B Local Oscilator $175.00

POWER TRANSFORMERS

Comb. Transformers—115V/50-60 cps Input

CTJ5-2-600VCT/.2A, 5V/CA				$5.95
CT-15A	550VCT	.085A	6.3V/.6A, 6.3V/1.8A	2.85
CT-164	4200V,002A/12KV Test, 5VCT 3A/12KV Test, 6.3V/0.6A/5400 V Test			12.95
CT-341	1050V, 10MA,—625V @ 5 MA, 26V @ 4.5A 2x2.5V 3A, 6.3V @ 3A			16.95
CT-825	360VCT	.340A	6.3VCT/3.6, 6.3VCT/3A	3.95
CT-626	1500V	.160A	2.5 12, 30/.100	9.95
CT-071	110V	.200A	33/.200, 5V/10, 2.5 10	4.95
CT-367	580VCT	.050A	5VCT 3A	2.25
CT-99A	2x110VCT	.010A	6.3 1A, 2.5VCT/7A.	3.25
CT-403	350VCT	.026A	5V 3A	2.75
CT-931	585VCT	.086A	5V 3A, 6.3V/6A	4.25
CT-610	1250	.002A	2.5V/2.1A, 2.5V/1.75A	4.95
CT-456	390VCT	80MA	6.3V/1.3A, 5V/3A	3.45
CT-160	800VCT	100MA	6.3V 1.2A, 5V 3A	4.95
CT-931	585VCT	86MA	5V/3A, 6.3V 6A	4.95
CT-442	525VCT	75MA	5V 2A, 10VCT/2A, 50V/200MA	3.85
CT-720	550-0-550V/250MA, 6.3V 1.8A			8.95
CT-43A	600-0-600V/.08A, 2.5VCT/6A, 6.3VCT/1A			6.49
CT7-501	650VCT 200MA, 6.3V 5A			6.49
CT-444	230-0-230V/.085A, 5V/3A, 6V/2.5A			3.49

Filament Transformers—115V/50-60 cps Input

Item	Rating	Each
FT-674	8.1V 1.5A	$ 1.10
FT-157	4V/16A,2.5V/1.75A	2.95
FT-101	6V/.25A	.79
FT-924	5.25V 21A, 2x7.75V/6.5A	14.95
FT-824	2x26V 2.5A, 16V 1A, 7.2V/7A, 6.4V/10A, 6.4V 2A	8.95
FT-463	6.3VCT 1A, 5VCT 3A, 5VCT 3A	5.49
FT-55-2	7.2V/21.5A, 6.5V/6.85A, 5V/6A, 5V/3A	8.95
FT-986	16V @ 4.5A or 12V @ 4.5A	3.75
FT-38A	6.3/2.5A, 2x2.5V 7A	4.19
FT-A27	2.5V 2.5A, 7V/7A, TAP 2.5V/2.5A, 16KV TEST	18.95
FT-608	6.3V 3A 750V Test	1.79
FT-873	4.5V/.5A, 7V/7A	2.19
FT-899	2x5V @ 5A, 29KV Test	24.50

Plate Trans.—115V, 60 cps

Item	Rating	Price
PT-446	18.5V3.5A	$4.59
PT-699	300/150V/.05A, 300/150V/.05A	2.79
PT.302	120-0-120V 350MA	4.69
PT-671	62V 3.5A	7.95

Special Fil. Transformers—60 cps

Item	Pri. Volts	Secondaries	Price
STF-370	220 440	3x2.5V/5A, 3KV Test 2.5V 15A	$ 6.95
STF-11A	220V	2x40V .05A, 2x5V/6A 12.6V 1A	4.49
STF-608	220V	24V 0.6A, 5V/3A, 6.3V/1A, 6.3V 1A	3.45
STF-968	230V	2.5V/6.5A	3.50
STF-631	230V	2x5V, 27A, 2x5V/9A	17.59

THERMISTORS VARISTORS

D167018	$1.50	D171812	$1.50
D167332	1.50	D172155	1.50
D167613	1.50	D167176	1.50
D166228	1.50	D168687	1.50
D164699	2.50	D167208E, D171858	1.50
D163903	1.95	308A, 27-B	1.50
D166792	2.15	D168403	2.15

FILTER CHOKES

Stock	Description	Price
CH-366	20H/.3A	$ 6.95
CH-322	.35H/350 MA—10 Ohms DCR	2.75
CH-141	Dual 7H/75MA, 11H/60 MA 5KV DC Test	4.69
CH-119	8.5H/125 MA	2.79
CH-69-1	Dual: 120H/17 MA	2.35
CH-8-28	2 x .5H/380 MA/25 Ohms DCR. 1 KV TEST	1.79
		2.95
CH-776	1.28H/130 MA 75 ohms	2.25
CH-344	1.5H/145MA/1200V Test	2.35
CH-43A	10HY/15MA—850 ohms DCR	1.75
CH-917	10H, 450MA, 10KV TEST	12.95
CH-366	20H/300MA	6.95
CH-999	15HY/15MA—400 ohms DCR	1.95
CH-511	6H/80MA—310 ohms DCH	2.45
CH3-501	2 x .5HY/400MA	2.79
CH-188M	5HY 200MA	1.79
CH-488	10HY .030A	1.19
CH-791	Dual 1.75-.125 HY 100 MA	1.27
CH-981	15 HY .110A	1.59
CH-22-1	1 HY .100A	1.17
CH-779	.6HY .490A	1.25
CH-25A	SW .09/.018 HY 3/.3A	8.95
CH-922	10000 HY 0 MA	2.75
CH-043	2.2 HY 80 MA	.98
CH-89A	2 x 1.52H @ .167A	1.39
CH-303	300H/.02A, 2500V Test	1.69
CH-932	SWING 9-60H/.4-.05A, 10KV	7.95
CH-445	0.5 HY/200 MA, 32.2 OHMS, 3000V.T.	1.39
CH-170	2XO.5H/380 MA, 25 OHMS	2.79
CH-533	13.5H, 1.0 AMP DC, 13.5KV INS.	39.95

MAGNETRONS

Tube	Tube	Tube
2J27	2J49	718DY
2J31	2J56	720BY
2J21	2J61	725-A
2J22	700	730-A
2J26	706	QK 62
2J32	2J62	OK 61
2J38	3J31	QK 60
2J39	5J30	

MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND M.O. OR CHECK. ONLY SHIPPING SENT C.O.D. RATED CONCERNS SEND P.O. ALL MDSE. SUBJECT TO PRIOR SALE, AND PRICES SUBJECT TO CHANGE WITHOUT NOTICE.
PARCELS IN EXCESS OF 20 POUNDS WILL BE SHIPPED VIA CHEAPEST TRUCK OR RAILEX.

131 Liberty St., New York 7, N. Y. Dept I-4 Chas. Rosen Phone: Digby 9-4124

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 156A)

rating for inductive and heater load is: 125 or 250 volts, 10 amperes. Current ratings are based on a maximum permissible temperature rise of 65°C. Inductive load ratings were determined by using AN3179 inductors.

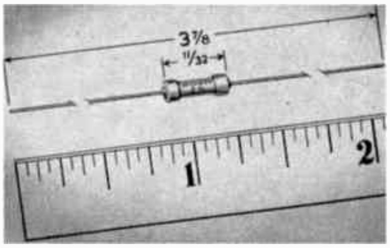
Other variations of the 7AS71 assembly are available in from three to eight gang assemblies of "V3" type single-pole double-throw basic switches and from two to eight switching positions at 45° angular rotation between positions.

Applications of the new series, in addition to lighting control, include aircraft landing gear indicators, X-ray and electronic equipment and aircraft electric windshield wipers.

Deposit Carbon Resistors

Rockbar Corp., 209 E. 37 St., New York 17, N. Y., manufacturers' representative, announces a completely new line of Welwyn high stability deposit carbon resistors.

The resistors include a subminiature series available in a range from 10 ohms to 1 megohm, with dimensions measuring ⅛-inch diameter by 15/32-inch long. Supplied in tolerances of 1, 2, and 5 per cent, these resistors lend themselves to precision applications where current flow is small. These miniature resistors are rated at ⅛-watt, under which conditions the temperature rise does not exceed 40° over ambient. They also may be safely used at ¼-watt ratings where a temperature increase of 100° is permissible.



These and all other Welwyn high stability resistors are constructed to insure permanent contact between pigtail terminals and resistor element. They are made of crystalline carbon deposit on porcelain rods to which machined end-caps are firmly attached, and into which the tinned-copper terminal wires are staked and then soldered for double protection.

Ceramic Microphone

The Century microphone produced by **Electro-Voice, Inc.**, Buchanan, Mich., is now available in the "Ceramic" Model 715.

The Model 715, with all the features of the Century, has a moisture-proof ceramic generating element and unusually high output (−55 db.). Assures dependable and

(Continued on page 159A)

News—New Products

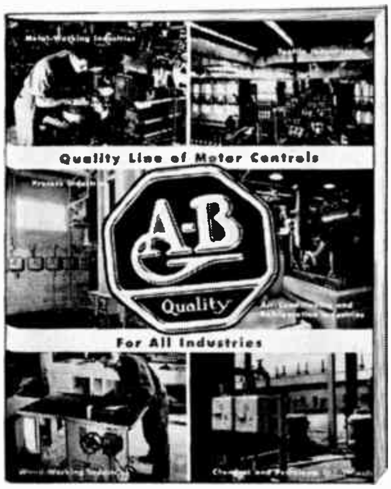
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 158A)

long-lasting service in extremely hot, humid climates. Essentially non-directional, becoming directive at higher frequencies. Can be used in any position in hand, on table, on stand or overhead. It is ac-dc insulated, and has high impedance. Pressure cast case is finished Satin Chromium. Has 5 foot cable. Size 3 inches×2$\frac{3}{16}$ inches×1 inch. Weighs only 6 ounces. List price is $11.25.

Motor Controls Bulletin

The Allen-Bradley Co., 114 W. Greenfield Ave., Milwaukee 11, Wis., has released a new 28-page bulletin, "Quality Line of Motor Controls for All Industries."



In this Bulletin the most important items in Allen-Bradley's line of standard motor control apparatus have been outlined. Controls, starters, and accessories are described and their applications listed.

A special feature of the Bulletin is the section illustrating glimpses behind the scenes of the Allen-Bradley Company.

Requests for this Bulletin, submitted on company letterhead, will receive prompt attention.

Carbon Mobile Microphone

A new Model 208 hand-held differential type noise cancelling, high output, single-button carbon microphone is now being produced by **Electro-Voice, Inc.,** Buchanan, Mich.

Unusually small in size, the Model 208 is designed for convenient close-talking and maximum intelligibility in mobile communications and similar applications. Articulation is at least 97 per cent under quiet conditions, 88 per cent under 115 db of ambient noise.

Frequency response: to sounds of close origin, substantially flat 100 to 4,000 cps. Output: −50 db. Temperature Range: from −40° to 185°F. Blast proof, water

(Continued on page 160A)

News—New Products

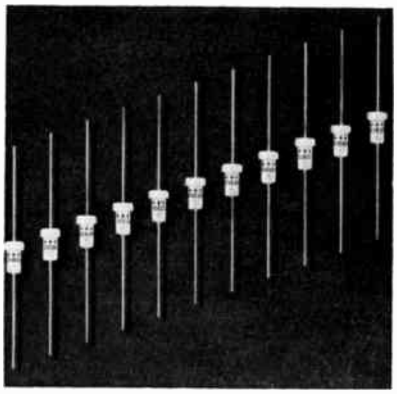
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 159A)

proof, shock resistant. Press-to-talk switch actuates button and relay simultaneously. Input, standard single button. Supplied with 5 foot three-conductor cable. Size 2¼ inches×1½ inches×1¼ inches. Net weight 3 ounces. List price, $16.50.

Tantalum Capacitors

Bulletin 6.100, just released, **Fansteel Metallurgical Corp.**, North Chicago, Ill., lists and describes a line of tantalum electrolytic capacitors ranging from 1.5 to 30 μf, with working voltages up to 125 volts dc.



These capacitors, intended for applications where unusually stable characteristics are required and space is at a premium, employ porous tantalum anodes. The normal temperature range at rated working voltage is from 55°C and +85°C. Excluding connection leads, the capacitor occupies less than 1/10 of a cubic inch.

The bulletin lists 22 standard capacitors, all of which are in commercial production. The bulletin also contains a page of curves showing capacity and equivalent series resistance in relation to temperature and frequency.

Although tantalum capacitors of this type have been in production since October, 1949, it is only recently that plant facilities have been expanded so that they are now generally available.

Copies of Bulletin 6.100 may be obtained from the manufacturer.

X-Band ATR

Microwave Associates, Inc., 22 Cummington St., Boston 15, Mass., has a new type 6976 ATR, designed for operation in the X-Band at a frequency of 9280 mc. It is electrically but not mechanically interchangeable with such types as the 1B35 and 1B35A. It features a braid gasket flange type of mounting located near the window instead of a resonant choke mounted seat. Because of this, lower values of normalized equivalent conductance and freedom from arcing at high power operation are achieved. The tube is

(Continued on page 161A)

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 160A)

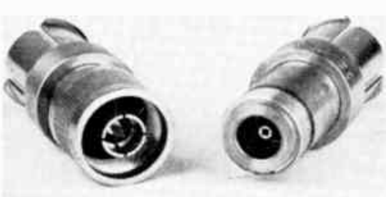
completely silver brazed resulting in extreme electrical and mechanical uniformity. It is small and compact in design, having an overall length of one inch. The tubulation is located on the narrow side of the waveguide body, thus providing greater clearance for associated equipment.

The mount for the 6276 is of the flange contacting type and may be procured from Airtron, Inc. under part number 47855.

The electrical equivalent of the type 1B37 is also available. This tube, the 6284, is mechanically interchangeable with the type 6276 and may be used in the same mount. It is designed for operation at frequency of 8750 mc.

Coaxial Adaptors and Accessories

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass., now has adaptors to connect from Type 874 coaxial connectors to either male or female of Types N, C, BNC, or uhf high-frequency connectors. The adaptors have excellent electrical characteristics with a low vswr even at several thousand mc. These adaptors not only make it possible to utilize the advantages of the Type 874 line when measurements are made on equipment fitted with military-type connectors, but also make it simple to interconnect systems using any of the various connectors.



A new adjustable line is also announced for use in measurement work requiring a section of coaxial line of adjustable length but with uniform impedance. The Type 874-LK is a 50-ohm line adjustable from 58 to 80 centimeters. It has a vswr of less than 1.10 at 2,000 mc.

A shielded component mount has also been added to the GR Type 874 line of coaxial elements to facilitate the accurate measurement of resistors, capacitors, and inductors.

(Continued on page 163A)

Thank You!

I R E

is grateful to the tens of thousands of engineers who have attended the 1953 Radio Engineering Show.

The 407 exhibitors who have co-operated with the Institute of Radio Engineers have truly provided a "Preview of Progress" of the radio-electronic industry. Their exhibits follow the path of the electron into every industry. Exhibitors are presenting radio and television of tomorrow both in the component and the apparatus, which will make the new electronic age.

Certainly the engineers in our industry have provided in these exhibits an informative report on their progress. The hours spent visiting the show should yield a rich reward in information.

For March 22-25, 1954 KINGSBRIDGE IS A SOLUTION

While the Grand Central Palace has been three things to us, grand, central, and definitely a palace, nevertheless its limits have been reached and this year 106 manufacturers in our industry were unable to show their products. Obviously, New York's largest exhibition hall has become too small for the enormous electronic industry! The Kingsbridge Armory provides a solution to those static elements of Grand Central Palace which hampered growing firms from having larger exhibits. The fact that so many firms have been unable to exhibit this year means that many new firms anxious to show new products and some excellent established companies who have built big electronic departments have been frozen out of exhibiting due to lack of space. The Kingsbridge Armory will relieve this situation, at least until the Coliseum is built.

Kingsbridge offers us 86,000 square feet of actual exhibit space in 796 booth units. This represents a gain of 35% in exhibit space over the usable total in Grand Central Palace. At Kingsbridge everything is on one floor, which gives us the most democratic type of exhibition.

Because this building is the largest in America under a single suspension roof and the area is completely free of pillars, the standard 10′ x 10′ exhibit unit offers exhibitors maximum economy. Moreover, there are no high walls which require draping. We confidentially believe that we can run a more satisfactory show than ever before.

A system of high-speed, private, express buses from the Waldorf-Astoria Hotel area to Kingsbridge, and the two excellent lecture halls right in the building, seating 720 and 960 people respectively, will make Kingsbridge a genuine solution to our problems.

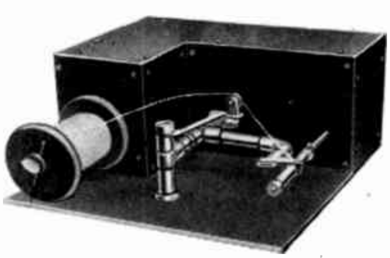
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 161A)

Coil Winder

Alcar, Inc., 2 Godwin Avenue, Fair Lawn, N. J., has a new coil winder Model 101, an efficient, compact instrument for winding precision universal coils. Setting coils of as much as four inches diameter may be wound. The instrument comes complete with motor, wire foot, spool rack and tension control. It is a self-contained unit in its own storage case with no extras to buy or loose parts to change.



Directions are included to wind experimental cross-over coils.

Our engineering department is available for consultation. Price F.O.B. Fair Lawn $200.00.

(Continued on page 165A)

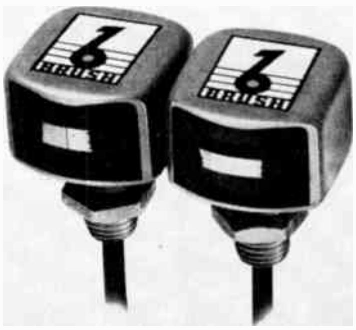
PROFESSIONAL CARDS

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 163A)

Magnetic Heads

The first two units of the new line of magnetic heads are now in production at the **Brush Development Co.,** 3405 Perkins Ave., Cleveland 14, Ohio. One is a record /reproduce head, BK-1090; the other, its erase head companion, is a BK-1110. The BK-1090 is intended for dual track recording, and distinguishes itself by very high resolution and uniformity. The most outstanding feature of the BK-1110 is its low power consumption of less than ½ volt amperes.



These units are cast into a block of specially selected synthetic resin which makes them extremely uniform, moisture proof, nonmicrophonic, and allows operation throughout a wide temperature range. The low loss core structure is made from thin molybdenum permalloy laminations carefully annealed and cemented together to permit the use of high bias and erase frequencies. These components are enclosed in a mu metal shield to provide optimum shielding from extraneous magnetic fields. Shape of the head permits close mounting of adjacent heads and provides correct approach angle of the tape.

Four Watt Resistor

A new power resistor, type PW4 rated at four watts, has been developed by **International Resistance Co.,** 401 N Broad St., Philadelphia 8, Pa.

Completely insulated with an inorganic core material molded in a high temperature plastic, this unit will not support combustion. Wire element is uniformly and tightly wound on glass fibre core with axial leads 1½ inches long; 0.036 inch diameter. Body dimensions: 1¾ inches long by 21/64 inch diameter. Type PW4 available from 1 ohm to 8200 ohms in ±5 per cent and ±10 per cent tolerance. This four watt resistor is suited for television circuits requiring 2 to 3 watts actual dissipation at high ambient temperature, resistance element of resistance capacitance filter in automobile receiving sets where operation is at high ambient temperature, and all other circuits where a stable resistor is required, with wattage dissipation of 4 watts and less.

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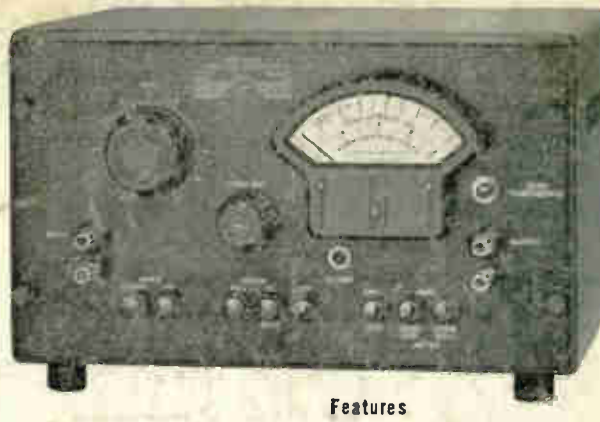
All in One

Bridge Detector
UHF Standing-Wave Indicator
General Purpose Amplifier



Type 1231-B Amplifier and Null Detector is a battery-operated, resistance-coupled amplifier which may be used as a sensitive bridge detector, a general purpose laboratory amplifier, or as a standing-wave indicator at ultra-high frequencies.

This instrument can be operated either with the usual linear amplifier characteristic or with a semi-logarithmic characteristic which makes it useful as a sensitive visual null detector in bridge measurements. For linear operation, the voltmeter scale has two ranges of two volts and twenty volts, respectively. At the semi-logarithmic position, and at maximum gain, less than 15 microvolts will produce a perceptable meter deflection, while more than 4,500 microvolts are required to drive the meter off scale. A built-in vacuum-tube voltmeter measures output voltage; head telephones can be used for aural indication where preferable.

High sensitivity combined with wide voltage range permits bridge balance with precision and without bothersome gain adjustments.

Features

★ *Gain is greater than 70 db at 10 cycles and greater than 45 db at 100 kc — at midband (1 kc), maximum open-circuit voltage gain is greater than 83 db.*
★ *At "null detector" position, less than 100 microvolts input gives 10% indication on meter at 1 kc.*
★ *At "amplifier" position, less than 25 μv input at 1 kc gives 10% indication on sensitive range of meter.*
★ *Maximum output voltage is 5 volts into 20,000 ohms; 20 volts into 1 megohm.*
★ *Low noise level of 15 microvolts (referred to input) can be further reduced along with hum and harmonics, by connecting external filter to panel jack.*
★ *Input impedance is 1 megohm in parallel with 20 μμf. Output impedance is 50,000 ohms resistive.*
★ *Push buttons provide convenient operation of input attenuator, set the condition of operation, select the meter-scale range and check battery voltages.*
★ *Tubes are mounted on shock-absorbing suspension for minimum microphonic effects.*
★ *Type 1261-A Power Supply Unit can be used to operate the Type 1231-B from 40 to 60 cycle a-c lines; power supply fits into cabinet in place of battery.*

1231-BM Amplifier and Null Detector, Battery operated	$250.00
1231-BMA Amplifier and Null Detector, a-c operated	370.00
1231-P2 400 and 1000 cycle Filter	25.00
1231-P3 60 cycle Filter	20.00
1231-P5 Adjustable Filter (11 frequencies from 50 c. to 100 kc.)	215.00

At ultra-high frequencies, a slotted coaxial transmission line, such as the G-R Type 874-LB, is often used with a traveling crystal detector to measure standing-wave ratios. If the UHF power source is pulsed, or amplitude modulated at an audio-frequency rate, the rectified output may be amplified and detected by the Type 1231-B.

The most sensitive input range enables detection of 5 microvolts in the mid-frequency range. This sensitive range was incorporated into the instrument's vacuum-tube voltmeter specifically for this application.

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Massachusetts, U. S. A.
90 West St. NEW YORK 6   920 S. Michigan Ave. CHICAGO 5   1000 N. Seward St. LOS ANGELES 38

Admittance Meters ☆ Coaxial Elements ☆ Decade Capacitors
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Noise Meters ☆ Null Detectors ☆ Precision Capacitors
Pulse Generators ☆ Signal Generators ☆ Vibration Meters ☆ Stroboscopes ☆ Wave Filters
U-H-F Measuring Equipment ☆ V-T Voltmeters ☆ Wave Analyzers ☆ Polariscopes