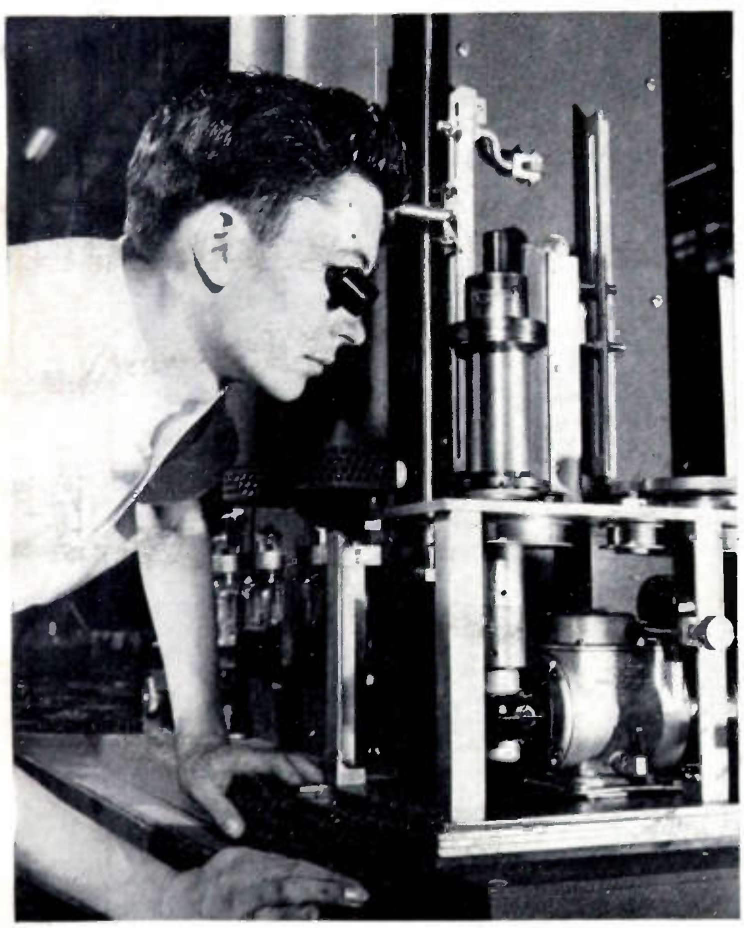
Proceedings of the I·R·E

A Journal of Communications and Electronic Engineering

(Including the WAVES AND ELECTRONS Section)



Western Electric Company

The winding of the voice coil for the 757A loudspeaker is a delicate operation which must be controlled carefully. The operator is shown inspecting the winding with the use of a jeweler's glass.

March, 1949

Volume 37 Number 3

PROCEEDINGS OF THE I.R.E.

Table of Contents Follows Page 32A

The Institute of Radio Engineers

the LITTLE differences

We know that our brazing techniques are as good as can be . . . but we also know that you can't always be sure of perfect heat conduction through the brazed metals.

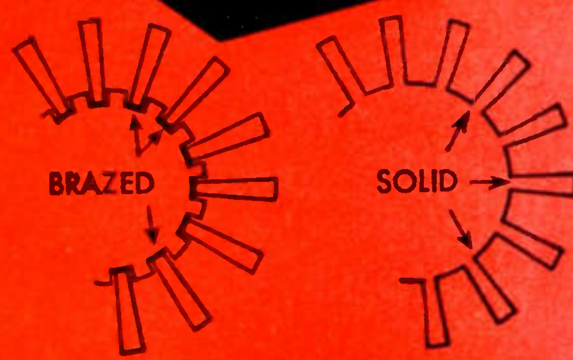
For that reason, we've developed a method of cutting our radiators for the 8002-R out of a solid chunk of metal; giving us a perfect heat conducting path between the core and its fins. This prevents "spot heating" of the tube's copper anode.

It's quite a trick to slice those cooling fins so that they radiate equally from the center and do not vary in thickness. But we mastered it!

And we have hundreds of other "little differences" in the design and construction of the many, many types of transmitting, rectifying and special purpose tubes that comprise the extensive Amperex line.

It's these little differences that combine to make the BIG difference when you

re-tube with Amperex



make the BIG difference

AMPEREX ELECTRONIC CORPORATION

25 WASHINGTON STREET, BROOKLYN 1, N. Y.
In Canada and Newfoundland: Rogers Majestic Limited
11-19 Brentcliffe Road, Leaside, Toronto, Ontario, Canada

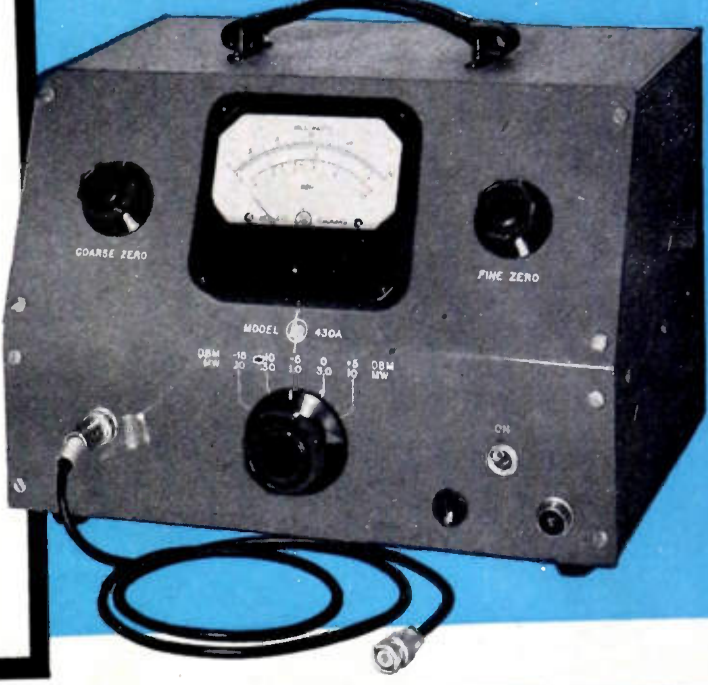
PROCEEDINGS OF THE I.R.E. March, 1949, Vol. 37, No. 3. Published monthly in two sections by The Institute of Radio Engineers, Inc., at 1 East 79 Street, New York 21, N.Y. Price $2.25 per copy. Subscriptions: United States and Canada, $18.00 a year; foreign countries $19.00 a year. Entered as second class 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.

Table of contents will be found following page 32A

NEW -hp- 430A MICROWAVE POWER METER

$250.00

F.O.B. PALO ALTO



Automatic operation! Instantaneous power readings! No tedious calculations or adjustments! Read direct in mw. or dbm! Use at any microwave frequency!

To measure an unknown microwave rf, just connect the new *-hp-* 430A Microwave Power Meter to the 200-ohm barreter in your system. This one compact power meter does all the rest! No tedious calculating or knob-twisting. Except for initial range selection and zero set, operation is *entirely automatic!* You can make direct power readings *instantly* in milliwatts from 0.02 to 10 mw, or dbm from −20 to +10 dbm. Higher powers may be measured by adding attenuators or directional couplers to the microwave system. Any of 5 ranges are quickly selected by a front-panel switch. Power is read on an open-scale, 4" square-face meter mounted on a sloping panel.

The new *-hp-* 430A Power Meter is an ac bridge, one arm of which is a 200-ohm barreter. This bridge is in precise balance with zero rf power across the barreter. When rf power is applied, an equivalent in audio power is *automatically removed.* The bridge remains balanced, but the change in audio power level indicates on the vacuum tube voltmeter. This meter thus measures the unknown rf directly and instantaneously.

The *-hp-* 430A is designed for use with any 200-ohm barreter and mount, and may be used over any microwave frequency for which the mount is designed. The meter incorporates the famous *-hp-* resistance-tuned oscillator principle, and is ruggedly built for long, trouble-free service. There are no delicate components to get out of adjustment.

For Complete Specifications, Write to

HEWLETT-PACKARD CO.

1830D Page Mill Road • Palo Alto, California

BRIEF SPECIFICATIONS

Power Range: 0.02 mw to 10 mw, 5 ranges, 5 db intervals. Scale also reads dbm continuously from −20 dbm to +10 dbm. (0 dbm = .001 Watt).

External Barreter: Frequency range depends on barreter and mount. (Must be 200 ohms at power level of approximately 15.3 mw.) (Barreter and mount not supplied.)

Accuracy: ±5% of full scale reading.

Size: 12" wide, 9" deep, 9" high. 4" Square-Face meter.

Power: 115 v., 50/60 cps, 60 watts.

hp laboratory instruments

FOR SPEED AND ACCURACY

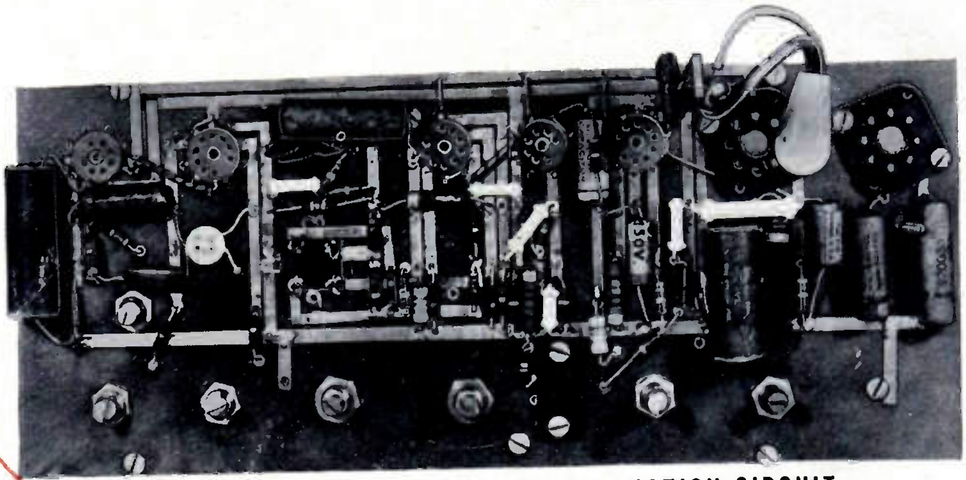
Power Supplies · Audio Signal Generators · Amplifiers · Electronic Tachometers · Frequency Meters · UHF Signal Generators · Square Wave Generators · Audio Frequency Oscillators · Attenuators · Frequency Standards · Noise and Distortion Analyzers · Wave Analyzers · Vacuum Tube Voltmeters

PROGRESS REPORT ON P.E.C.

More and more Hearing Aid Manufacturers are turning to Centralab's *Printed Electronic Circuits* to Simplify Production . . . to Build Smaller, Finer Units!

HI-Q COMPONENTS

Specified by FRANKLIN *Airloop* CORPORATION



FRANKLIN AIRLOOP'S COMPLETE DEFLECTION CIRCUIT

● The great demand for lower cost television receivers is one of the big problems confronting engineers today.

Die stamped inductances as developed by the Franklin Airloop Corporation are a partial answer to reduced manufacturing costs. Truly a precision operation, its successful performance is dependent upon precision components.

Hi-Q components — noted for their *precision — dependability — uniformity* and *miniaturization* contribute their part, not alone to Franklin, but to all manufacturers whose standards demand these 4 **Hi-Q** features.

Our engineering department is available for consultation with your engineering staff in the design of new circuits and the application of **Hi-Q** components to them. Why not write us today?

The **Hi-Q** Disc Capacitor used in the above deflection circuit is a high dielectric capacitor designed for application where physical shape is more adaptable than tubular units. Close connections are easily made, reducing inductance to a minimum.

HI-Q COMPONENTS BETTER 4 WAYS

PRECISION Tested step by step from raw material to finished product. Accuracy guaranteed to your specified tolerance.

UNIFORMITY Constancy of quality is maintained over entire production through continuous manufacturing controls.

DEPENDABILITY Interpret this factor in terms of your customers' satisfaction . . . Year after year of trouble-free performance. Our Hi-Q makes your product better.

MINIATURIZATION The smallest BIG VALUE components in the business make possible space saving factors which reduce your production costs . . . increase your profits.

HI-Q *Electrical Reactance Corp.*

FRANKLINVILLE, N. Y.

Plants: FRANKLINVILLE, N. Y.—JESSUP, PA.—MYRTLE BEACH, S. C.
Sales Offices: NEW YORK, PHILADELPHIA, DETROIT, CHICAGO, LOS ANGELES

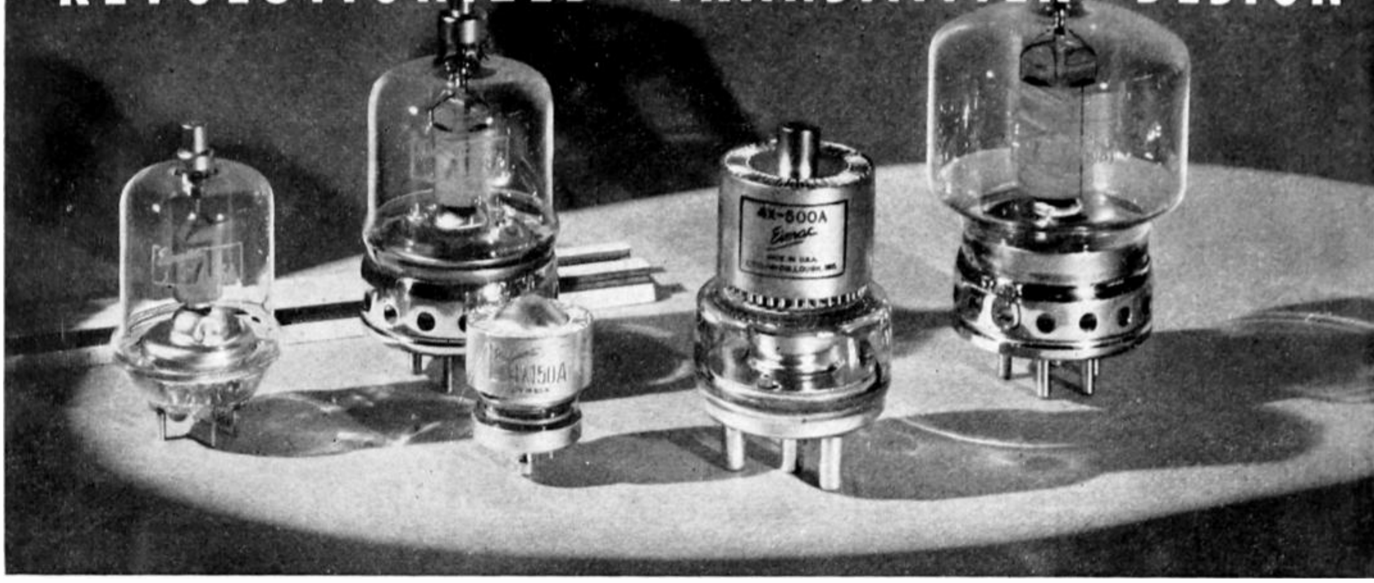
Follow the Leaders to

Eimac TUBES

The Power for R-F

THESE TUBES . . .

REVOLUTIONIZED TRANSMITTER DESIGN



THE 4-65A . . . is the smallest of the radiation cooled Eimac tetrodes. Its ability to produce relatively high-power at all frequencies up to 200-Mc. and over a wide voltage range offers considerable advantage to the end user. For instance the same tubes may be used in the final stage of an operator's mobile and fixed station. Two tubes, in the mobile unit operating on 600 plate volts will handle 150 watts input, while two other 4-65A's in the fixed station will provide a half kilowatt output on 3000 volts .

THE 4-125A . . . is the mainstay of present day communication. These highly dependable tetrodes have been proven in years of service and thousands of applications. Two tubes are capable of handling 1000 watts input (in class-C telegraphy or FM telephony) with less than 5 watts of grid driving power. In AM service two tubes high-level modulated will provide 600 watts output. For AM broadcast they carry an FCC rating of 125 watts per tube.

THE 4X150A . . . is highly versatile and extremely small (2½ inches high). It is an external anode tetrode capable of operating above 950-Mc. As much as 140 watts of useful output can be obtained at 500-Mc. Below 165-Mc. the output can be increased to 195 watts. It is ideally suited as a wide-band amplifier for television and for harmonic or conventional RF amplification.

THE 4X500A . . . is a top tube for high power at high frequencies and is especially suited to TV and FM. It is a small external anode tetrode, rated at 500 watts of plate dissipation. The low driving power requirement presents obvious advantages to the equipment designer Two tubes in a push-pull or parallel circuit provide over 1½ kw of useful output power with less than 25 watts of driving power at 108-Mc.

THE 4-250A . . . is a power tetrode with a plate dissipation rating of 250 watts and stability characteristics familiar to the 4-125A. Rugged compact construction together with low plate-grid capacitance, allows simplification of the associated circuits and the driver stage. As audio amplifiers, 2 tubes will provide 500 watts power output with zero drive.

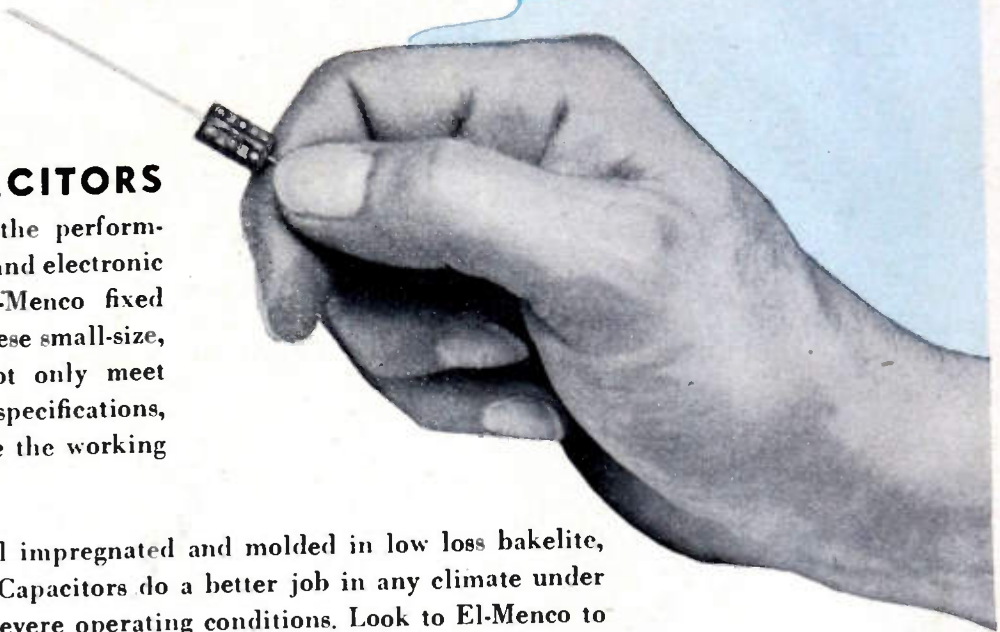
EITEL-McCULLOUGH, INC.

210 San Mateo Ave., San Bruno, California

Export Agents: Frazar & Hansen, 301 Clay St., San Francisco, California

Smaller than your fingernail

BUT SKY HIGH IN PERFORMANCE...

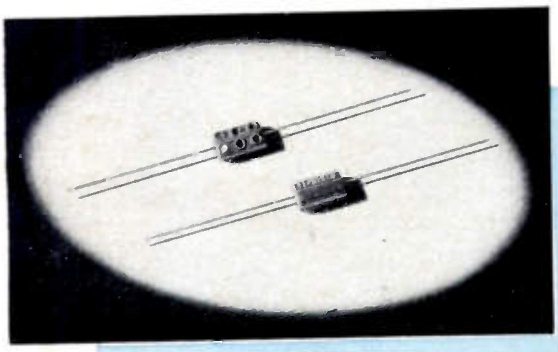


EL-MENCO CAPACITORS

One sure way to protect the performance of your radio, electrical and electronic equipment is to specify El-Menco fixed mica dielectric capacitors. These small-size, high capacity condensers not only meet Army and Navy JAN-C-5 specifications, but they are tested at *double* the working voltage.

All impregnated and molded in low loss bakelite, El-Menco Capacitors do a better job in any climate under the most severe operating conditions. Look to El-Menco to help you build and keep your reputation for using the superior components that make your electrical equipment superior.

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



NEW CM 15 MINIATURE CAPACITOR

Actual Size 1/32" x 1/2" x 3/16".
For Television, Radio and other Electronic Applications.
2 - 420 mmf. cap. at 500v DCA.
2 - 535 mmf. cap. at 300v DCA.
Temp. Co-efficient ±50 parts per million per degree C for most capacity values.
6-dot color coded.

Write on your firm letterhead for Catalog and Samples.

MOLDED MICA **El-Menco** MICA TRIMMER
CAPACITORS

Foreign Radio and Electronic Manufacturers communicate direct with our Export Dept. at Willimantic, Conn. for information.

ARCO ELECTRONICS, INC., 135 Liberty St., New York, N. Y. Sole agent for jobbers and distributors in U. S. and Canada.

. . for Oscillography .

Wide-band Amplifiers?

High Sensitivity?

Intensity Modulation?

Amplitude Calibration?

Low Price?

20 CPS—2 MC
Type 241
$458

Voltage Calibrator
Type 264-A
$39.50

Portable-22 lbs.
Type 164-E
$127.20

JUST CHOOSE FROM THESE DU MONT *Oscillographs*

Here's an adequate selection of Du Mont instruments to meet any of the foregoing requirements:

If you require a **wide-band amplifier**, there's a choice of either Type 241 (5-inch) or Type 224-A (3-inch). An intensity-modulation amplifier is also featured by the Type 241. The deflection factor of Type 241 is 0.07 rms v/in.; that of Type 224-A, 0.1 rms v/in.

If you require **quantitative measurements**, the Type 264-A Voltage Calibrator is available. It works with any oscillograph. Once attached, it need not be disconnected for operation of the oscillograph.

If **portability** is your main requirement, there is the Type 164-E weighing only 22 lbs. Its frequency response is uniform within 20% from 5 cps to 100 kc.

For a **high-sensitivity** (0.01 rms v/in.) general-purpose instrument, the Type 208-B is recommended. Its frequency response is within 10% from 2 cps to 100 kc.

And as a very-low-priced **general purpose** 5-inch oscillograph, the Type 274-A is unsurpassed in its class. Its frequency response is within 10% from 20 cps to 50 kc; deflection factor is 0.2 rms v/in.

Regarding **price**, all these Du Mont oscillographs meet the demand for low price and high quality.

Write for detailed specifications describing all of these important Du Mont instruments.

General Purpose
Type 274-A
$136.50

Sensitive
0.01 RMS v/in.
Type 208-B
$285

Wide Range
20 CPS—2 MC
Type 224-A
$290

ALLEN B. DU MONT LABORATORIES, Inc., INSTRUMENT DIVISION

. . *it must be* **DUMONT**

For wider frequency range . . . top writing rates . . . increased brightness . . . it's

DU MONT

High-voltage Oscillography

The basis is the Type 5RP-A Cathode-ray Tube operating at an accelerating potential up to 29,000 volts maximum. This achieves: (1) Greatly increased brightness; (2) Observation or recording of traces hitherto invisible; (3) Vastly increased writing rates even better than 400 inches per microsecond; (4) Optical magnification by projection lenses such as Du Mont Type 2542. Although deflection sensitivities are slightly less than those of low-voltage cathode-ray tubes, high-voltage oscillographs produce smaller spot size and higher brightness, thereby presenting a finer, better resolved trace.

And here's the Du Mont selection of high voltage oscillographs:

CAT. NO. 1275-E $5,550

10 CPS to 10 MC

Type 280: A precision time-measuring oscillograph with range of 10 cps to 10 mc. Sweep speeds as high as 0.25 microsecond/in. are available. Duration of any portion of signal measured on 0.25 microsecond/in. sweep to an accuracy of ±0.01 microsecond. Intervals greater than 5 microseconds read on calibrated dial to accuracy of ±0.1 microsecond. Ready application to precise measurement of duration of waveform of various components in the composite television signal. Accelerating potential adjustable from 7,000 to 12,000 volts. Recordable writing rates up to 63 inches per microsecond, with commercially available equipment.

WRITING RATES TO ABOVE 400 IN./MSEC.

CAT. NO. 1397-E $1,125

Type 281-A: Devoid of internal deflection amplifiers, there are no frequency response limitations within the ratings of its Type 5RP-A tube. Phenomena have been recorded photographically at writing speeds of 85 inches per microsecond. With external power supply (such as Du Mont Type 286-A), photographic writing speeds of over 400 inches per microsecond may be examined. Recommended when oscillographic needs are extremely specialized or too advanced for standard commercial equipment. An accelerating potential as high as 29,000 volts is available with the Types 281-A and 286-A in combination.

Type 250-H: Covers range from d-c to 200 kc. Potentials containing both d-c and a-c components may be examined. Many special features for general usage include: linear time-base of unusual flexibility; automatic beam control on driven sweeps; internal calibrator of signal amplitude. This is a high-voltage oscillograph with maximum accelerating potential of 13,000 volts. Recordable writing rate of approximately 40 inches per microsecond.

D-C to 200 KC

CAT. NO. 1314-E $850

20 CPS-5 MC

Type 248-A: Frequency range of 20 cps to 5 mc. Specifically intended for investigation of pulses containing high-frequency components of recurrent or transient nature. For this purpose it provides these necessary characteristics: High-frequency recurrent sweeps; short-duration driven sweeps; timing markers; signal delay network. Accelerating potentials up to 14,000 volts at recordable writing rate of approximately 69 inches per microsecond.

CAT. NO. 1244-E $1,870

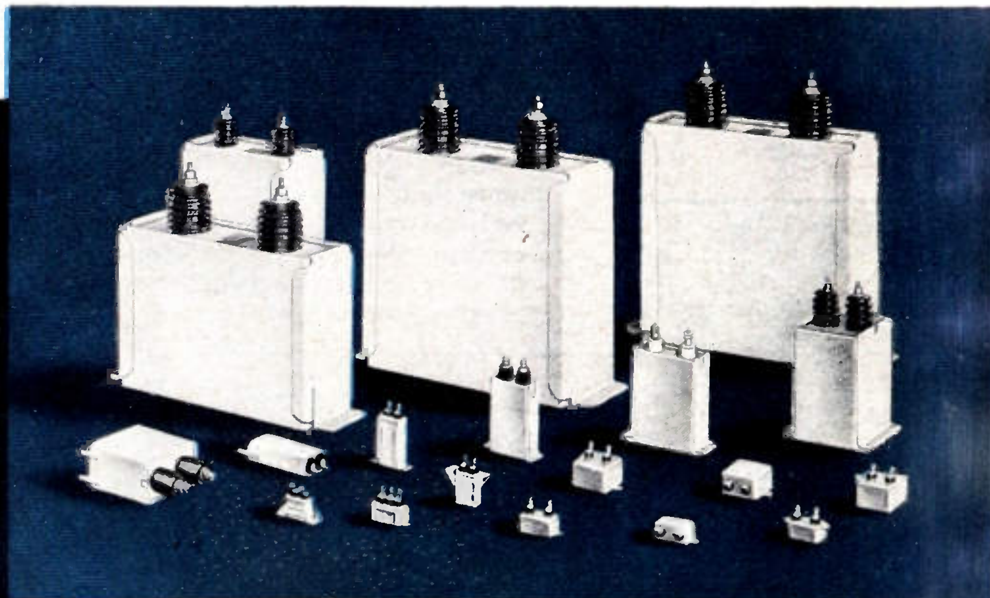
LITERATURE ON REQUEST

1000 MAIN AVENUE, **CLIFTON, N. J.** CABLE ADDRESS, ALBEEDU, NEW YORK, N. Y.

ELECTRONICS

Designers

take your choice...
FIXED PAPER-DIELECTRIC CAPACITORS

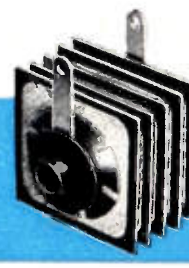


Readily available for DC electronic applications, these capacitors are manufactured in accordance with joint Army-Navy specifications JAN-C-25. Case styles include types CP 53, CP 54, CP 55, CP 61, CP 63, CP 65, CP 67, CP 69 and CP 70. Capacitance ratings are from .01 Muf to 15 Muf, and voltage ratings are listed from 100 to 12,500 volts.

These capacitors are constructed with thin Kraft paper, oil or Pyranol* impregnated, which provides stable characteristics and high dielectric strength. Plates are aluminum foil, manufactured according to detailed specifications. Special bushing construction provides for short internal leads, preventing possible grounds and short circuits. The cases have a permanent hermetic seal to provide longer life. A variety of mounting arrangements are available for various installation requirements. Write for detailed description and operating data: Bulletin GEA-4357A.

*Pyranol is General Electric's non-inflammable liquid dielectric for capacitors.

SAVE SPACE CUT COSTS



Less than one inch long, and only one inch square, this postage-stamp-size selenium rectifier offers radio builders substantial savings in production costs. Only two soldering operations and a minimum of hardware are necessary for installation in places where a rectifier tube and socket won't fit. They're built to safely withstand the inverse peak voltages obtained when rectifying (half-wave) 110-125 volts, rms, and feeding a capacitor as required in various radio circuits. Tests prove that selenium rectifiers will outlast the conventional type of rectifier tubes, at the same time costing less. Send for bulletin GEA-5238.

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS

HOLDS OUTPUT VOLTAGE CONSTANT

This 500-va voltage stabilizer is suitable for a wide variety of electronic applications where constant voltage is demanded. Voltage variations from 95 to 130 volts are absorbed almost instantaneously and output voltage maintained at 115 volts (plus or minus 1 percent). There are no moving parts, no adjustments to make. This unit will operate continuously at no load or short circuit without damage to itself. It will limit the short circuit current to approximately twice stabilizer's normal full load current rating. Other sizes available range from 15 to 5000 va. For details, check bulletin GEA-3634B.

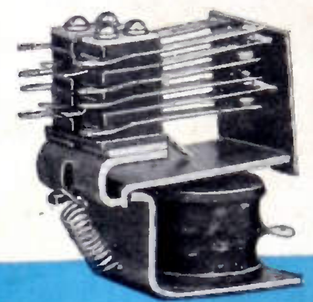
WANT TO TIME TUBE LIFE?

Suitable for installation in radio transmitters, these G-E time meters provide accurate record of tube operating time. They record in hours, tenths of hours, or minutes. Ratings range from 11 to 460 volts. Installation on a panel or switchboard is simplified by quick-wiring leads. Timer harmonizes with other panel instruments in appearance and size. Dependability is assured by Telechron* motor drive. Also available for portable use or conduit and junction box mounting. Check bulletin GEC-472.

FOR YOUR TELEVISION SETS

General Electric's television cord set comes in 6-foot lengths, made of 2/18 Pot-64 brown Flamenol* rip-cord. Set has brown plastic plug and new brown Flamenol connector molded on opposite end. Rip-cord has smooth finish, resists oil, water, acids, alkalies, or sunlight deterioration. Rating is 7 amps., no. 18 wire. Set is designed for assembly on television receiver rear panel, automatically disconnects when panel is removed. Write for further information.

*Trademark Reg. U. S. Pat. Off.



DEPENDABLE CONTROL FOR AUTOMATIC DEVICES

G.E.'s multi-contact relays are inexpensive units built specifically for appliances and vending machines. Construction features assure quiet, reliable operation, and compactness makes them adaptable to a variety of devices such as coin changers, phonographs, and television receivers. Single-circuit contacts or combinations of contacts for multi-circuit application are attached to the same sturdy frame and coil assembly, affording a multiplicity of relay forms. Ratings are 5 amperes at 115 volts or 24 volts, a-c or d-c. Get details from Bulletin GEC-306.

General Electric Company, Section B667-1
Apparatus Department, Schenectady, N. Y.

Please send me the following bulletins:

- ☐ GEA-3634B Voltage Stabilizers
- ☐ GEA-4357A D-C Capacitors
- ☐ GEA-5238 Selenium Rectifiers
- ☐ GEC-306 Multi-contact Relays
- ☐ GEC-472 Tube Timers

NAME ....
COMPANY ....
ADDRESS ....
CITY .... STATE ....

FP

FOR

TV

TELEVISION DEMANDS *PERFECTION*

There can be no compromise with quality — in television. New standards are essential for long life, dependability and trouble-free operation.

Mallory FP Capacitors are accustomed to severe service — have been operating at 85° C. for years. Even though this extreme temperature may not be apparent in your particular model, it's good to know that Mallory gives you an extra margin of safety.

The fact that no human hand* touches any vital part during processing and assembly shows the extreme care taken to insure the long life so characteristic of this remarkable Mallory product.

**The chlorides present in perspiration cause destructive corrosion and shorten the capacitor's life in the field.*

FP is the type designation of the Mallory developed electrolytic capacitor having the characteristic design pictured. Adopted as standard by RMA, it is famous for dependable performance.

P. R. MALLORY & CO., Inc.

MALLORY

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

SERVING INDUSTRY WITH

Capacitors Rectifiers
Contacts Switches
Controls Vibrators
Power Supplies
Resistance Welding Materials

Resistors Illustrated Are Grade 1, Class I, Characteristic "F"

OHMITE JAN TYPE WIRE-WOUND RESISTORS

MEET REQUIREMENTS OF JOINT ARMY-NAVY SPECIFICATION JAN-R-26

TYPES AND SIZES

TAB-TERMINAL TYPE

	Overall length	Diameter	*Watts
RW-30	1"	19/32"	8
RW-31	1½"	19/32"	10
RW-32	2"	19/32"	12
RW-33	3"	19/32"	18
RW-34	3"	29/32"	30
RW-35	4"	29/32"	38
RW-36	4"	1-5/16"	60
RW-37	6"	1-5/16"	78
RW-38	8"	1-5/16"	110
RW-39	12"	1-5/16"	166

TAB-TERMINAL TYPE with terminal hole to clear No. 8 screw

	Overall length	Diameter	*Watts
RW-40	3"	29/32"	24
RW-41	4"	29/32"	32
RW-42	4"	1-5/16"	49
RW-43	6"	1-5/16"	74
RW-44	8"	1-5/16"	108
RW-45	12"	1-5/16"	160

FERRULE-TERMINAL TYPE

	Overall length	Diameter	*Watts
RW-10	11-7/16"	1-5/16"	140
RW-11	9-5/8"	1-5/16"	116
RW-12	7-7/16"	1-5/16"	86
RW-13	5-1/8"	1-1/16"	50
RW-14	4-7/16"	1-1/16"	48
RW-15	2-15/16"	3/4"	20
RW-16	2-3/8"	3/4"	14

*Watts free air, JAN Characteristic "F"

To qualify for approval under Joint Army-Navy characteristics, resistors are required to withstand in excess of nine cycles of immersion in saltwater baths of 100°C and 0°C; to withstand a severe vibration test for five hours; and, in addition, are subjected to all other tests as specified in JAN-R-26. Ohmite Resistors designed for JAN-R-26 are specially vitreous enameled and have a textured gray finish. Available in the types and sizes listed.

Write on Letterhead for Bulletin No. 139

OHMITE MFG. COMPANY
4863 Flournoy St., Chicago 44, Ill.

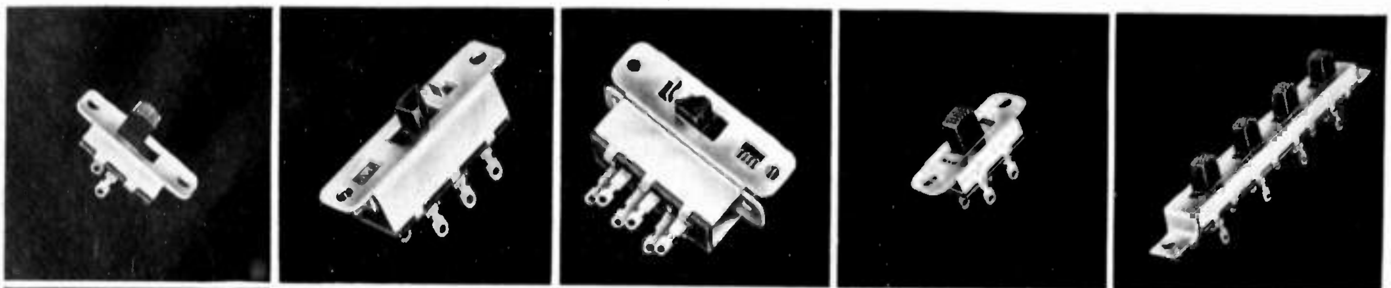
Be Right with...

OHMITE

RHEOSTATS • RESISTORS • TAP SWITCHES

The Right Switches... at the Right Price...

to modernize your product and to enhance its "saleability"



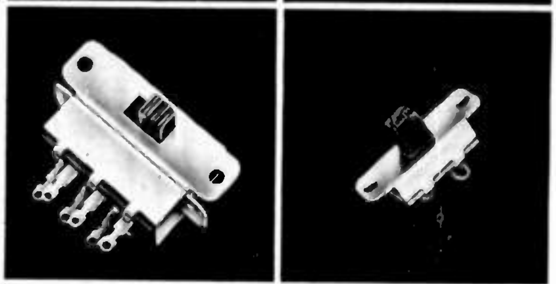
NEW!

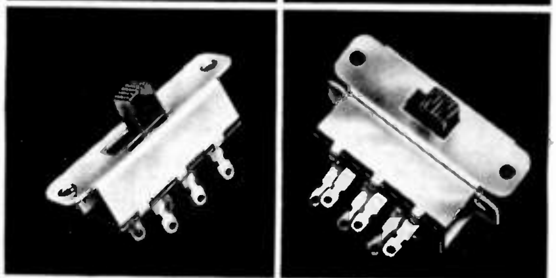
Two slide switches rated 1 ampere at 125 volts DC 3 amperes at 125 volts AC

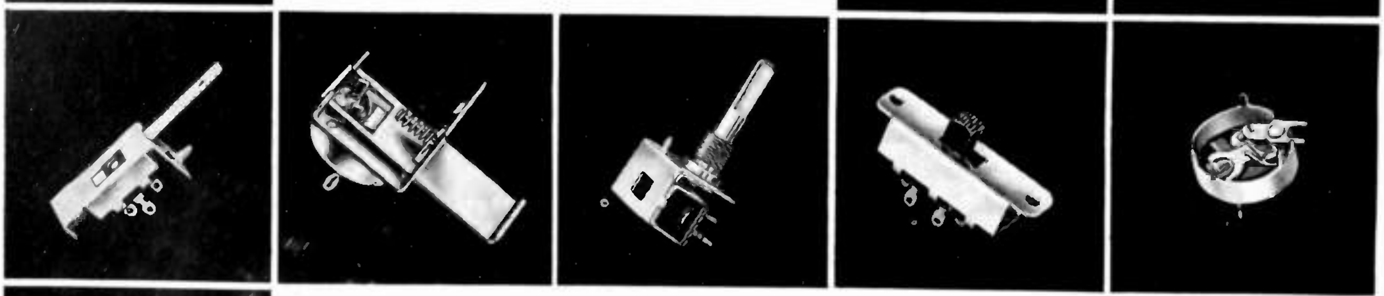
SS-26 Single-pole, single-throw

SS-26-1 Single-pole, double-throw

These sturdy little switches are ideal for appliances, toys and electrical equipment requiring 3-ampere switch contact carrying capacity. Both are Underwriters approved. Write for SS-26 Switch Bulletin.



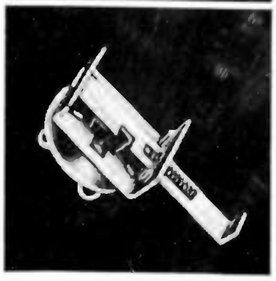


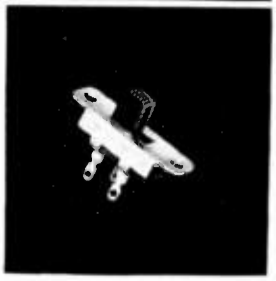


LINE-SLIDE-ROTARY ACTION

Dozens of Contact Arrangements

Inexpensive types are available for practically any switching requirement and at prices that will please you. Samples to specifications on request to quantity users. Write for Stackpole Switch Bulletin RC7C.





Fixed and Variable Resistors Iron Cores • Alnico II Permanent Magnets ...

ELECTRONIC COMPONENTS DIVISION,
STACKPOLE CARBON CO. St. Marys, Pa.

... and hundreds of molded iron powder, metal, carbon and graphite products.

STACKPOLE

PRD PRECISION MICROWAVE MEASUREMENT COMPONENTS

TYPE 211—PRECISION WAVEGUIDE SLOTTED SECTION
($\frac{1}{2}$" x $\frac{1}{4}$" Waveguide)

Breadband Operation; Crystal and Bolometer Detection; Ball Bearing Carriage Support

• Similar slotted sections and probes in standard rectangular waveguide and coaxial line sizes make possible precise impedance measurements over the microwave spectrum from 1000 to 40,000 megacycles per second.

TYPE 612—TUNABLE CRYSTAL AND BOLOMETER MOUNT
(Type N—$\frac{3}{8}$" Coaxial Line)

Broadband Operation; Accurate Square-Law Detection

• The instrument illustrated serves both as a general purpose crystal or bolometer detector and as an harmonic generator for the multiplication of crystal-controlled u-h-f signals into the microwave region.

TYPE 575—REACTION TYPE FREQUENCY METER
($1\frac{1}{2}$" x $\frac{3}{4}$" Waveguide)

Micrometer Precision; Full Waveguide Frequency Coverage; Ease of Operation

• Currently available in three waveguide sizes to provide coverage from 3950 to 10,000 megacycles per second, these frequency meters combine simplicity of operation, precision, and reliability.

TYPE 559-A—PRECISION FREQUENCY METER
(1" x $\frac{1}{2}$" Waveguide)

Direct Reading Dial; Linear Drive; Hermetic Sealing; Temperature Compensation

• This unit is representative of a complete new line of precision frequency meters available with reaction or transmission coupling, and providing maximum accuracy even when exposed to extremes of temperature and humidity.

TYPE 170—PRECISION CALIBRATED VARIABLE ATTENUATOR
(2" x 1" Waveguide)

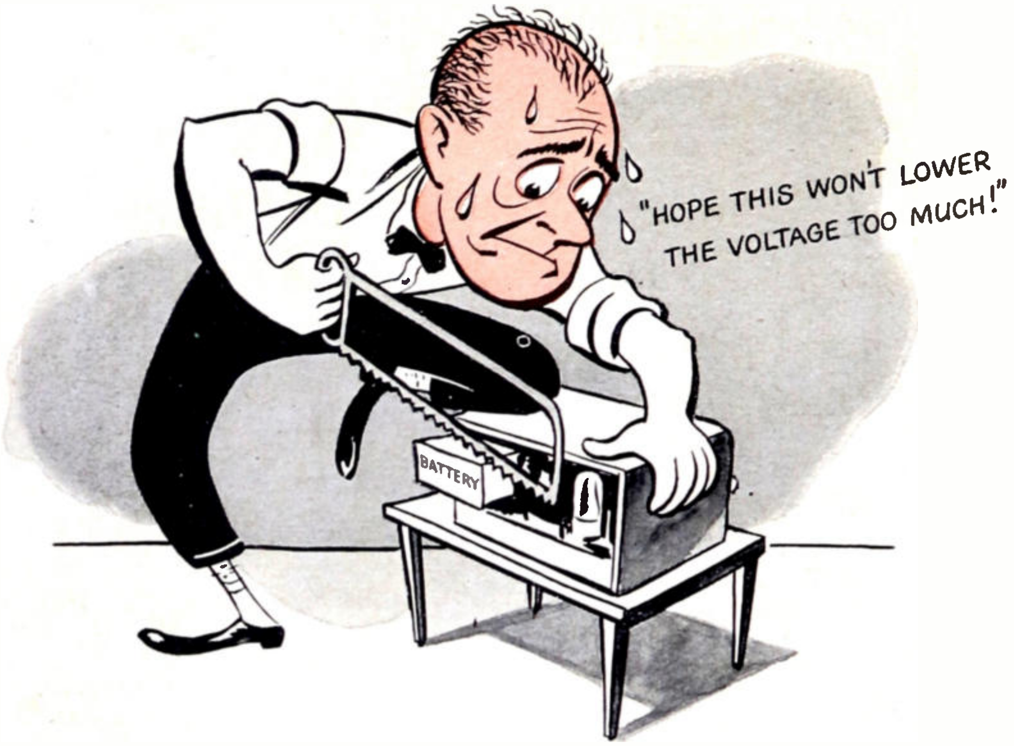
Metallized-glass Attenuating Element; Precise and Permanent Calibration; Negligible Insertion Loss

• A full complement of fixed and variable attenuators and broadband terminations in standard waveguide sizes provides coverage from 2600 to 40,000 megacycles per second.

The instruments illustrated above are the result of the continuing efforts of PRD's skilled staff to provide the microwave research engineer with test equipment of ultimate accuracy and reliability over broader and broader frequency bands. Techniques of novel character are used to give the many outstanding features available in the complete PRD line of precision microwave measurement and test equipment. An illustrated catalog may be obtained by writing on company letterhead to Dept. E-1.

Polytechnic RESEARCH and DEVELOPMENT COMPANY • Inc
202 TILLARY ST., BROOKLYN 1, NEW YORK

You can use a hack saw to make it fit...



...But it's simpler to design the radio around the battery!

"Eveready" No. 950 "A" batteries and the No. 467 "B" battery make an ideal combination for small portable radios.

Portable radios designed around "Eveready" radio batteries please everybody! The radio dealer is happy because he needn't clutter his shelves with slow-selling, special batteries. The user is pleased because "Eveready" battery replacements are available everywhere. And the radio designer is pleased because the dealer and the user are pleased.

There's an "Eveready" radio battery to fit any size portable. Call on our Battery Engineering Department for complete data.

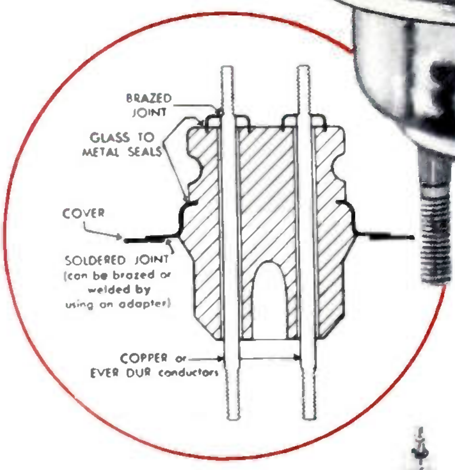
EVEREADY
TRADE-MARK
RADIO BATTERIES

The registered trade-marks "Eveready" and "Mini-Max" distinguish products of
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.

Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Glass bushings Now Available

to manufacturers of electronic equipment



The best way to evaluate these glass bushings for capacitors, modulator transformers, and other electronic equipment, is to see them. If you will send us a sketch and ratings of bushings you are now using, we will furnish you with samples of one or more of our standard glass bushings. Bulletin GEA-5093 contains complete listings of our standard designs, allowing you to select the particular bushing you require. ***Power Transformer Sales Division, General Electric Company, 16-215 Pittsfield, Mass.***

Can be welded, brazed, or soldered to case, forming a strong, permanent, hermetic seal that eliminates moisture problems and often permits more compact, light-weight design.

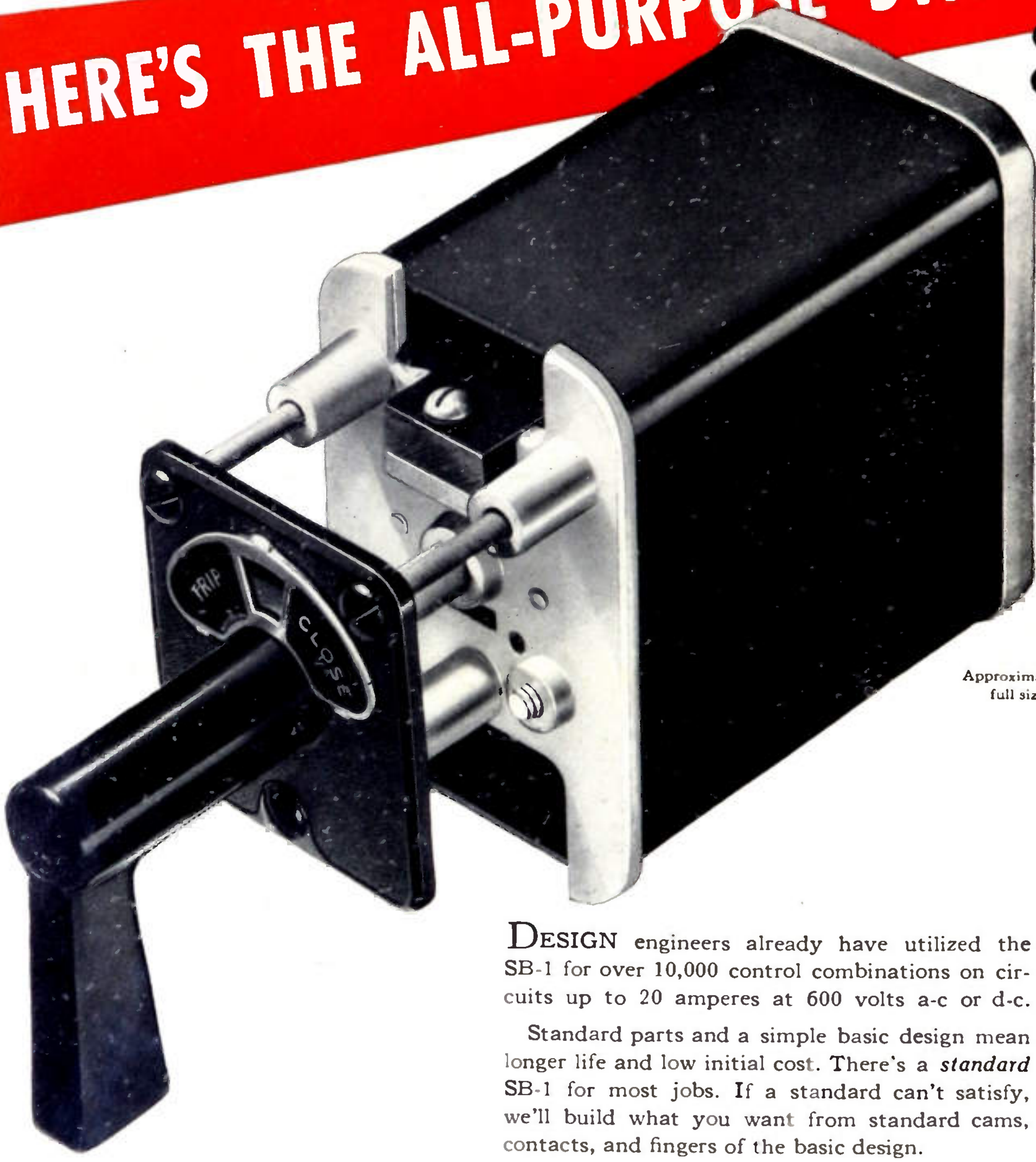
General Electric now offers to other manufacturers the glass bushings that it has used so successfully on capacitors, rectifiers, modulator and instrument transformers, and other electrical equipment. These bushings are cast of an exceptionally stable, low-expansion glass. Metal hardware is a special nickel-alloy steel, fused to the glass in casting. Bushings are attached directly to the apparatus without gaskets—by soldering, welding or brazing the metal bushing flange to the metal case.

The resulting joint between bushing and equipment is permanent, vacuum-tight, and of high mechanical strength. It is especially desirable for equipment subject to vibration, shock, fungus growth or severe changes in temperature. These glass bushings are available to meet dry, 60-cycle, flashover values of from 10 to 50 kv, and in current ratings of 25 and 50 amperes (large sizes up to 800 amperes). They may be single or multi-conductor and can be provided with a top flange to permit mounting tube sockets directly on the bushings. Diameters range from $1\frac{5}{8}$ to $3\frac{3}{8}$ inches and weights from $2\frac{1}{2}$ oz. to 4 lb.

WRITE TODAY FOR BULLETIN GEA-5093

GENERAL ELECTRIC

HERE'S THE ALL-PURPOSE SWITCH *



Approximately full size

DESIGN engineers already have utilized the SB-1 for over 10,000 control combinations on circuits up to 20 amperes at 600 volts a-c or d-c.

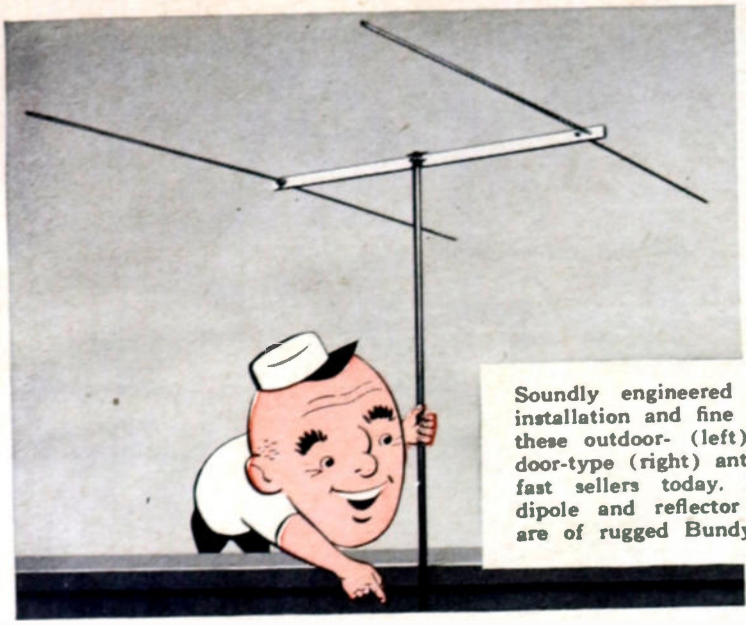
Standard parts and a simple basic design mean longer life and low initial cost. There's a ***standard*** SB-1 for most jobs. If a standard can't satisfy, we'll build what you want from standard cams, contacts, and fingers of the basic design.

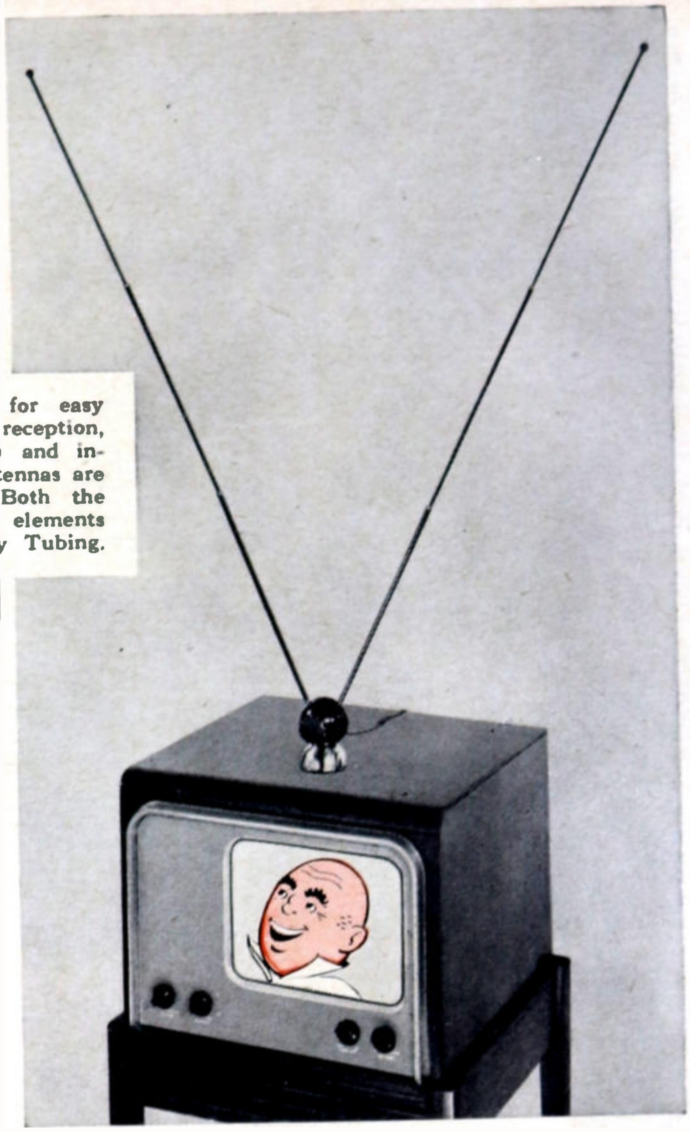
A variety of attractive switch handles, and water-tight, dust-tight, oil-immersed, fabricated-metal, or explosion-proof housings are available to fit your particular installation problems.

Your nearest G-E sales representative will be glad to assist you in the selection of an SB-1. Also, ask him for a copy of GEA-4746 which gives additional information about the SB-1, or write to *Apparatus Department, Section 856-6, General Electric Company, Schenectady 5, New York.*

* it's the.... SB-1 CONTROL AND TRANSFER SWITCH

GENERAL ELECTRIC





Soundly engineered for easy installation and fine reception, these outdoor- (left) and indoor-type (right) antennas are fast sellers today. Both the dipole and reflector elements are of rugged Bundy Tubing.

Look at Bundyweld* for better TV antennas

Do you make television antennas, either the indoor or outdoor type?

If so, you most certainly should consider Bundyweld* Tubing. Many other manufacturers have and they are turning out better antennas at lower costs because of Bundyweld's special advantages.

Double-walled Bundyweld is strong yet ductile. Simply stated, this means greater ease of fabrication for you.

It can also be supplied in the hard-drawn condition. This makes it doubly well suited for dipole and reflector elements, which must take all kinds of wind and weather without swaying or sagging.

Bundyweld is inexpensive. It lowers production costs, saves production time, gives better television antennas at bigger profits to you.

Call on us

If you didn't get an opportunity to talk to Bundy engineers first hand at the I.R.E. National Convention in New York, contact your near-by Bundy representative among those listed below, and he'll be glad to give you the full story on this miracle tubing of industry. Or, if you wish, write directly to: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

*REG. U. S. PAT. OFF.

WHY BUNDYWELD IS BETTER TUBING

1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.

4 Bundyweld comes in standard sizes, up to ⅝" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

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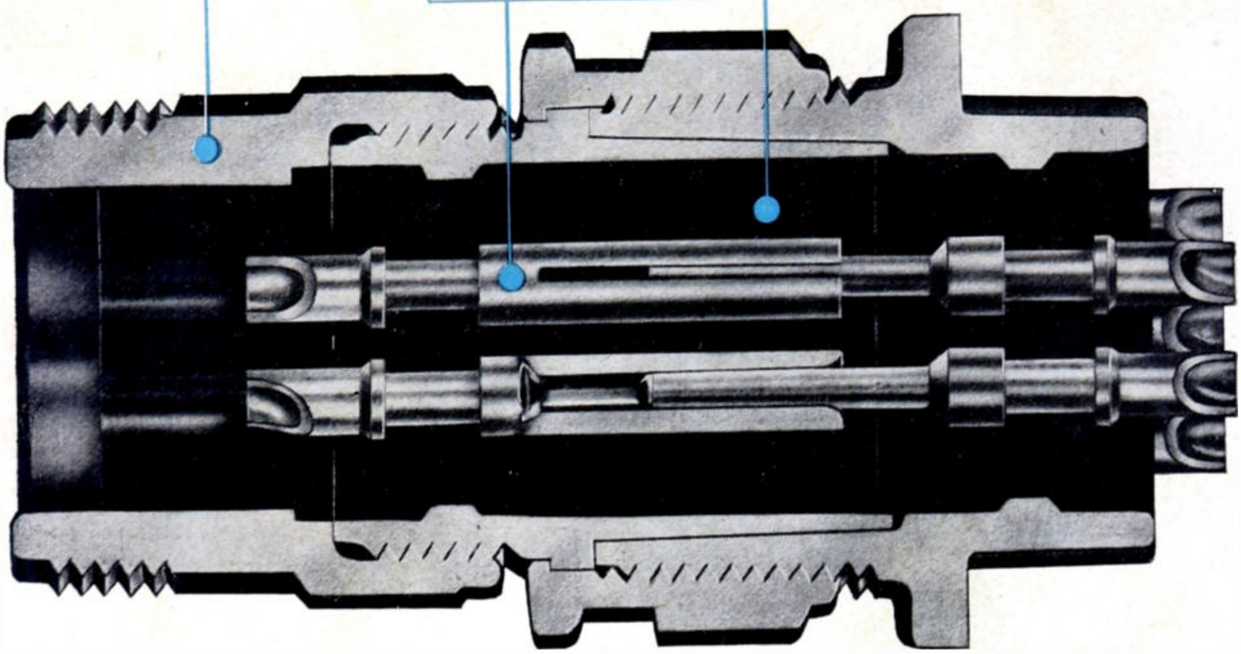
BUNDYWELD NICKEL AND MONEL TUBING IS SOLD BY INTERNATIONAL NICKEL COMPANY DISTRIBUTORS IN PRINCIPAL CITIES.

JUST LOOK AT THESE FEATURES . . .

SHELL
High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.

CONTACTS
High current capacity . . . Practically no voltage drop. No additional solder required.

SCINFLEX ONE-PIECE INSERT
High dielectric strength . . . High insulation resistance.



BENDIX-SCINTILLA

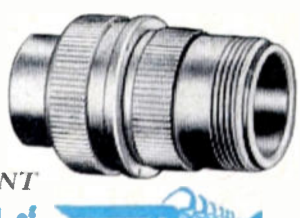
ELECTRICAL CONNECTORS

the Finest money can buy! Contacts that carry maximum currents with a minimum voltage drop are only part of the many new advantages you get with Bendix-Scintilla* Electrical Connectors. The use of "Scinflex" dielectric material, an exclusive new Bendix-Scintilla development of outstanding stability, increases resistance to flashover and creepage. In temperature extremes, from −67° F. to +300° F., performance is remarkable. Dielectric strength is never less than 300 volts per mil. Bendix-Scintilla Connectors have fewer parts than any other connector on the market—and that means lower maintenance costs and better performance.

*TRADEMARK

CHECK THESE OTHER ADVANTAGES

• Moisture-proof, Pressure-tight • Radio Quiet • Single-piece Inserts • Vibration-proof • Light Weight • High Insulation Resistance • Easy Assembly and Disassembly • Fewer Parts than any other Connector • No additional solder required



WRITE DIRECT TO THE SALES DEPARTMENT

BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION of Bendix AVIATION CORPORATION

SIDNEY, NEW YORK

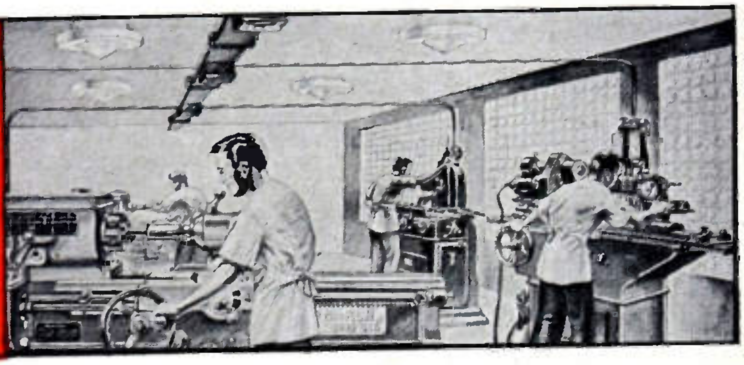
Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, New York

For the answers to your

ELECTRONIC-MECHANICAL PROBLEMS...

CONSULT SHERRON'S ANALYTICAL ENGINEERING-MANUFACTURING SERVICE

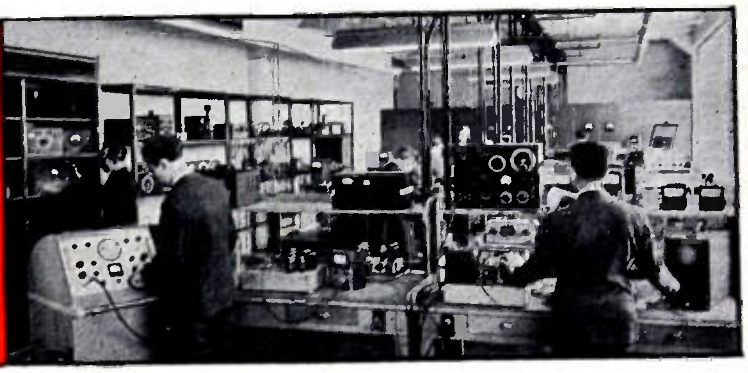
VIEW OF SHERRON ELECTRO-MECHANICAL LABORATORY



In the completeness of its departments, manpower and the skills and experience of its personnel, the Sherron Electronics Co. is organized to meet any challenge in the design, development and manufacture of:

Communications equipment . . . Electronic Control equipment . . . Vacuum Tube Circuit development . . . Control of Measuring Devices . . . Instrumentation . . . Television Transmitters . . . Television Test equipment . . . Test Equipment for Components.

VIEW OF SHERRON ELECTRONICS LABORATORY



In broad terms, Sherron's Analytical Engineering-Manufacturing Service means . . . complete design, development, engineering and manufacturing of "precision electronics" equipment. Comprehensive, confidential — this service is exclusively for manufacturers. It is defined by these facilities, personnel and operations:

DEVELOPMENT-DESIGN: Initiated in our electronics laboratory by experienced physicists, engineers and technicians.

ELECTRO-MECHANICAL LABORATORY: Staffed by graduate mechanical engineers fully conversant with the requirements for "precision electronics."

COMPLETE SHEET METAL FACILITIES

WIRING DEPARTMENT: Headed by production electrical engineers.

SHERRON ELECTRONICS COMPANY

DIVISION OF SHERRON METALLIC CORPORATION

1201 FLUSHING AVENUE • BROOKLYN 6, NEW YORK

RECENT SHERRON PROJECTS RELATING TO ELECTRONICS AND OTHER INDUSTRIES

COMMUNICATIONS

- *Trans-Receivers for various uses*
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- *Micro-wave techniques and Radio Relay Links*
- *Ample Test Equipment to assure successful operation of above*

ELECTRONIC CONTROL EQUIPMENT FOR

- *Drone Aircraft Guided Missiles*
- *High Gain Amplifiers*
- *Computers and Calculators*
- *Servo Equipment*
- *Velocity Propagation measurement*
- *Test Equipment including Instrumentation for above*

VACUUM TUBE CIRCUIT DEVELOPMENT

- *New applications for existing vacuum tubes*
- *Precision test equipment for vacuum tubes*

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- *Flow indicators*
- *Sorting, Counting*
- *Measurement of chemical titrations*
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- *Bridge measurements*
- *Null detectors*
- *Vacuum tube voltmeter-ammeters*
- *Multi-wave shape generators*

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- *Television Signal Synthesizer Sync Generators*
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Where's the manufacturer these days who doesn't need all the competitive and cost advantages he can get? Maybe you have new electrical or mechanical equipment in mind—designs or re-designs that should employ permanent magnets for best results. Maybe you have existing applications that permanent magnets will do *better*—save you time and money in production, and step up the efficiency of your product.

In either case, let Arnold's engineering service help you to find the answers to your magnet problems. Arnold offers you a fully complete line of permanent magnet materials, produced under 100% quality-control in any size or shape you require, and supplied in any stage from rough shapes to finish-ground and tested units, ready for final assembly. Write direct, or to any Allegheny Ludlum branch office.

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Specialists and Leaders in the Design, Engineering and Manufacture of ***PERMANENT MAGNETS***

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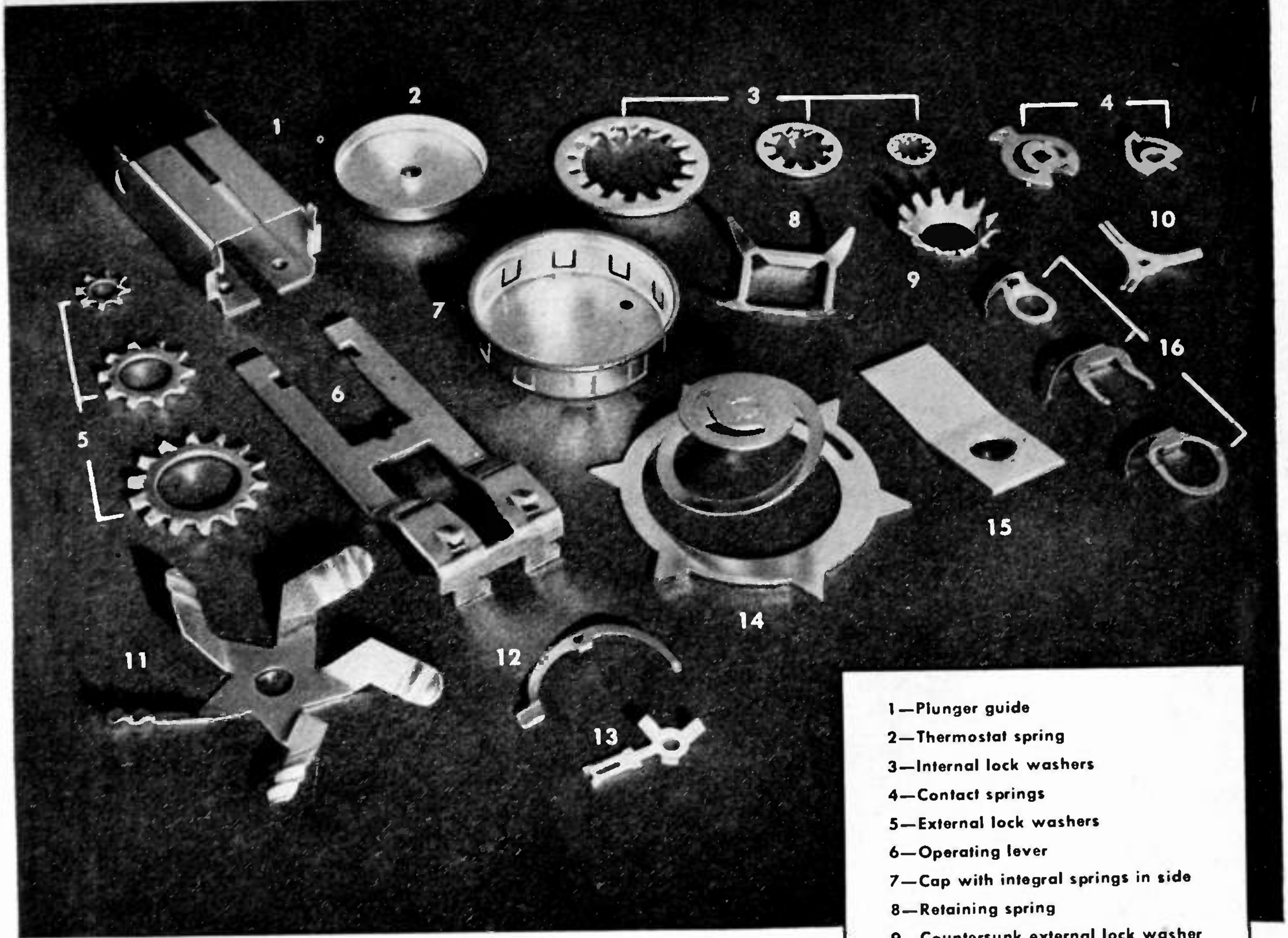
OFFER MANY ADVANTAGES



1—Plunger guide
2—Thermostat spring
3—Internal lock washers
4—Contact springs
5—External lock washers
6—Operating lever
7—Cap with integral springs in side
8—Retaining spring
9—Countersunk external lock washer
10—Pressure spring for capacitor
11—Five-contact spring
12—Contact spring for radio part
13—Pressure spring and terminal
14—Involute spring
15—Contact point for solenoid
16—Contact springs
—made of Phosphor Bronze strip supplied by Revere

STRENGTH — Resilience — Fatigue Resistance — Corrosion Resistance—Low Coefficient of Friction—Easy Workability—are outstanding advantages of Revere Phosphor Bronzes, now available in several different alloys.

In many cases it is the ability of Phosphor Bronze to resist repeated reversals of stress that is its most valuable property. Hence its wide employment for springs, diaphragms, bellows and similar parts. In addition, its corrosion resistance in combination with high tensile properties render it invaluable in chemical, sewage disposal, refrigeration, mining, electrical and similar applications. In the form of welding rod, Phosphor Bronze has many advantages in the welding of copper, brass, steel, iron and the repair of worn or broken machine parts. Revere suggests you investigate the advantages of Revere Phosphor Bronzes in your plant or product.

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Mills: Baltimore, Md., Chicago, Ill., Detroit, Mich.; New Bedford, Mass., Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

TALL IN TENNESSEE

Stands WBIR at Knoxville

Important member of the American Broadcasting Company's South Central Group is 250-watt WBIR. Knoxville and eastern Tennessee listeners now are dialing programs broadcast from its new 450-foot-tall Truscon Guyed Steel Radio Tower.

This recent addition to the nation-wide . . . and world-wide . . . string of Truscon Steel Towers climbs tall to serve mountainous Tennessee—and is another example of Truscon engineering to fit specific local conditions.

Another
TRUSCON
TOWER OF STRENGTH
450 FT.
HIGH

Whether your plans call for tall or small towers, it will pay you to consult experienced Truscon engineers. They offer you the most skillful engineering and construction in the industry . . . can help you make the correct choice of guyed or self-supporting towers, of tapered or uniform cross-section, for AM, FM or TV. Call or write our home office in Youngstown, Ohio, or any convenient district office for assistance—without obligation.

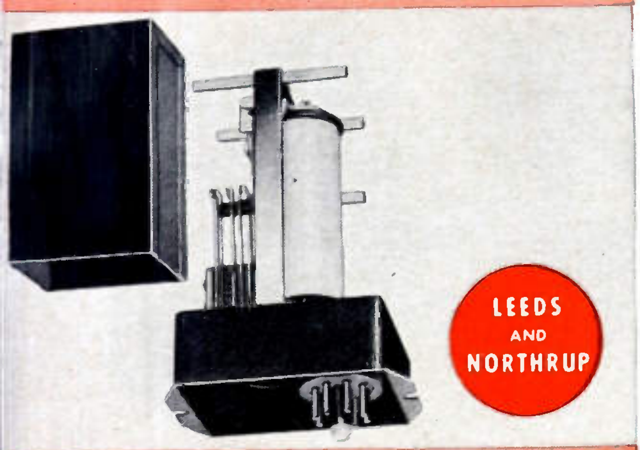
TRUSCON STEEL COMPANY
YOUNGSTOWN 1, OHIO
Subsidiary of Republic Steel Corporation

TRUSCON
SELF-SUPPORTING
AND UNIFORM
CROSS SECTION GUYED
TOWERS

"Can you give us a relay that..."

RCA turns to CLARE for a "relay we can install and forget" for Electron Microscope.

CLARE provides a precise operating relay, capable of long and reliable operating life, to meet the needs of this RCA precision instrument.



"Give Us a Dust-Tight Relay for Dusty Locations" — said LEEDS & NORTHRUP.

Radio plug mounted, with terminals brought through dust-tight Neoprene gasket and with dust-tight steel cover, this CLARE relay solved a LEEDS & NORTHRUP problem.

CLARE Relays in WESTERN UNION "Push-Button" High-Speed Switching System.

CLARE provides thousands of small relays of maximum reliability to meet exacting requirements of Western Union's high-speed communications program.

Tough relay problems are everyday routine with CLARE engineers

CLARE customers include some of the biggest names in the American industry . . . and many smaller concerns . . . whose engineers have sought and found in CLARE experiment and research the answer to unusual and difficult relay problems.

The decision to "put it up to CLARE" often saves untold hours of experiment, trial and error and sometimes costly delays. Many who get in touch with CLARE find our engineers have already solved their problem for somebody else.

CLARE leadership in the industrial relay field has been achieved by the ability of CLARE engineers to approach any and all relay problems with a completely open mind. No problem of relay size, shape or operating characteristics but finds them ready and anxious to cooperate in its solution.

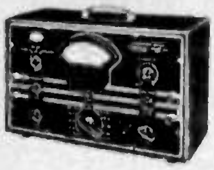
There is a CLARE sales engineer located near you . . . as close as your telephone. If your problem involves relays, why not take advantage of CLARE experience with every type of relay requirement. To do so may easily save you time and expense. Look for CLARE in your classified telephone directory, or write: C. P. CLARE & Co., 4719 West Sunnyside Ave., Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable address: CLARELAY.

CLARE RELAYS

First in the Industrial Field

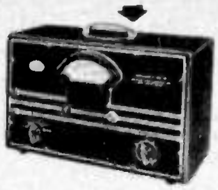
FREQUENCY SHIFT EXCITER —Provides RF drive and frequency shift keying to transmitter

B&W DISTORTION METER MODEL 400



B&W AUDIO OSCILLATOR MODEL 200

B&W AUDIO FREQUENCY METER MODEL 300



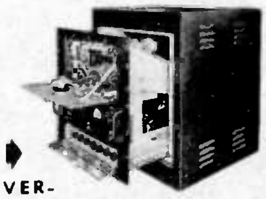
2 KW AMPLIFIER—Class C RF Amplifier. Range: 1-25 Mc's.

B&W

THE *TRADEMARK* THAT *GREW* through service to you!

Today, the Barker and Williamson trademark is backed by three plants, excellent manufacturing facilities, and a competent technical staff—all because you have shown a definite preference for quality products and a willingness to try practical ideas that give promise of improved performance. Today, too, this famous trademark appears on many new items of complete equipment—all produced by an organization that grew because it designed and built the kind of products you wanted. With its improved facilities, B&W pledges to continue to build better and better parts and equipment, and to develop and offer only those products which you can use with confidence and pride.

CONTROL UNIT — Operates as an electronic repeater in teletype lines.



DUAL DIVERSITY CONVERTER—Provides diversity mixing on frequency shift circuits.

NOW IN PRODUCTION AT B&W

Complete Radio Transmitters • Dual Diversity Converters, Control Units and Frequency Shift Exciters for Radio Teletype Transmission • Special Test Equipment • Redesign, Modernization and Modification of Existing Equipment • Machine Work • Metal Stamping • Coils • Condensers • Other Electronic Devices in a Wide Range of Types.

RECEIVER ASSEMBLY — Standard Army BC-342 modified for dual diversity reception.

B&W ALL BAND FREQUENCY MULTIPLIER MODEL 504

BARKER & WILLIAMSON, INC.

237 FAIRFIELD AVE. UPPER DARBY, PA.

B&W SINE WAVE CLIPPER MODEL 250

NEW

WESTON

MODEL 901 SERIES

A-C AND D-C PORTABLES

the modern concept

in **READABILITY . . .**

in **SHIELDING!**

Designed . . . and styled . . . to bring you Weston's concept of the finest general purpose portables ever produced! These instruments are offered with full assurance that their dependability will reflect credit upon the name they bear. Write for Circular A-22-A. Weston Electrical Instrument Corp., 589 Frelinghuysen Ave., Newark 5, N. J.

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New Orleans • New York • Orlando • Philadelphia • Phoenix • Pittsburgh • Rochester • San Francisco • Seattle • St. Louis • Syracuse • Tulsa • In Canada, Northern Electric Co., Ltd., Powerlite Devices, Ltd.

For dependable television...hour after hour...day in and day out...month after month...

OPERATING CONDITIONS	Group I	Group I-A	Group II	Group III
	AEROVOX TYPES AP; BT; E; G; S; SC	AEROVOX TYPES BTN; SCN	AEROVOX TYPES AF; APG; MM; MSF; MSQ; MSR; MST; PRS	AEROVOX TYPES GL; PBS; PRSA; PRSB; PRSV; PRV; PT; SCL
*Temperature Range	−60° C. to +85° C. (−76° F. to +185° F.)	−60° C. to +85° C. (−76° F. to +185° F.)	−60° C. to +85° C. (−76° F. to +185° F.)	−40° C. to +60° C. (−40° F. to +140° F.)
Humidity	any, including immersion	any, including immersion	high	average
Altitude	any	any	any	——

*The temperatures given are the minimum and maximum ambient operating temperatures. It is imperative, however, that the minimum and maximum ambient temperatures be stated for each application, as circuit design will affect the allowable temperature range.

AEROVOX *extra-severe-service* ELECTROLYTIC CAPACITORS

● The above chart was compiled in 1946. It is based on Aerovox wartime experience in meeting the extra-severe-service requirements of military equipment. Likewise the needs of workaday electronic assemblies for industrial purposes.

Found in the Aerovox engineering literature, this chart classifies Aerovox electrolytic types into four groups based on severity of service and cost considerations. Groups I and I-A comprise hermetically-sealed electrolytics meeting the most rugged conditions of temperature, humidity, pressure and vibration. Group II types compromise between severe-service requirements and cost. Group III types meet cost considerations primarily.

Thus today's television requirements, as regards electrolytics quite as well as other capacitors, have been fully anticipated by Aerovox engineering and production developments of long standing.

1949 IS TV YEAR

● Whether your electrolytic requirements be for extra-severe, severe or just normal service, let Aerovox engineers collaborate in working out the best answer.

AEROVOX capacitors

FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

AEROVOX CORPORATION, NEW BEDFORD, MASS., U.S.A.

SALES OFFICES IN ALL PRINCIPAL CITIES • Export: 13 E. 40th ST., NEW YORK 16, N. Y.

Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

FOR HIPERM ALLOY TRANSFORMERS

The UTC Hiperm alloy audio transformers are specifically designed for portable and compact service. While light in weight and small in dimensions, neither dependability nor fidelity has been sacrificed. The frequency characteristic of the Hiperm alloy audio units is uniform from 30 to 20,000 cycles. These units are similar in general design and characteristics to the famous Linear Standard audio Series.

Hiperm Alloy Transformers Feature

e Hum Balancing Coil Structure . . . maximum tralization of stray fields.

anced Variable Impedance Line . . . permits est fidelity on every tap of a universal unit . . . line reflections or transverse couplings.

versible Mounting . . . permits above chassis sub-chassis wiring.

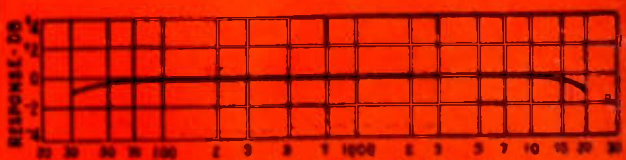
oy Shields . . . maximum shielding from induc- pick-up.

ltiple Coil, Semi-Toroidal Coil Structure imum distributed capacity and leakage reactance.

h Fidelity . . . UTC Hiperm Alloy Transformers a guaranteed uniform response of ±1.5DB 20-20,000 cycles.

FOR IMMEDIATE DELIVERY

From Your Distributor



Typical Curve for HA Series

Type No.	Application	Primary Impedance	Secondary Impedance	± 1 db from	Max. Level	Max Unbal. DC in primary	List Price
HA-100	Low impedance mike, pickup, or multiple line to grid.	50, 125, 200, 250, 333, 500 ohms	60,000 ohms in two sections	30–20,000	+22 DB	5 MA	$19.00
HA-100X	Same as above but with tri-alloy internal shield to effect very low hum pickup.						24.00
HA-101	Low impedance mike, pickup, or multiple line to push-pull grids.	50, 125, 200, 250, 333, 500 ohms	120,000 ohms overall, in two sections	30–20,000	+22 DB	5 MA	22.00
HA-101X	Same as above but with tri-alloy internal shield to effect very low hum pickup.						27.00
HA-108	Mixing, low impedance mike, pickup or multiple line.	50, 125, 200, 250, 333, 500 ohms	50, 125, 200, 250, 333, 500 ohms	30–20,000	+22 DB	5 MA	19.00
HA-106	Single plate to push-pull grids	8,000 to 15,000 ohms	135,000 ohms 1.5:1 ratio, each side	30–20,000	+22 DB	0	16.00
HA-113	Single plate to multiple line.	8,000 to 15,000 ohms	50, 125, 200, 250, 333, 500 ohms	30–20,000	+22 DB	1 MA	18.00
HA-134	Push-pull 89's or 2A3's to line.	5,000 to 10,000 ohms	50, 125, 200, 250, 300, 500 ohms	30–20,000	+32 DB	5 MA	20.00
HA-135	Push-pull 2A3's to voice coil.	3,000 to 5,000 ohms	30, 20, 15, 10, 7.5, 5, 2.5, 1.2	30–20,000	+32 DB	5 MA	19.00

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PROCEEDINGS OF THE I.R.E.

(Including the WAVES AND ELECTRONS Section)

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PROCEEDINGS OF THE I.R.E.

INSTITUTE NEWS AND RADIO NOTES SECTION

WAVES AND ELECTRONS SECTION

Regional Directors of the

HERBERT J. REICH

Director, 1948–1949

Region 1: North Atlantic

Herbert J. Reich (A'26–M'41–SM'43–F'49), well-known authority on electron tubes, was born on Staten Island, N. Y., on October 25, 1900.

Upon receiving the Ph.D. degree in 1928 from Cornell University, where he had won the M.E. four years previously, he joined the faculty of the University of Illinois as assistant professor of electrical engineering. He was advanced to the rank of associate professor in 1929 and to professor three years later.

In 1944 Dr. Reich was granted leave of absence to join the staff of the Radio Research Laboratory, at Harvard University. At the end of the war, in 1946, he accepted an appointment as professor of electrical engineering at Yale University.

Dr. Reich has served on many IRE Committees. A member of the AIEE, the American Association for the Advancement of Science, the American Society for Engineering Education, and a fellow of the American Physical Society, Dr. Reich has written numerous papers and books on electron tubes, and is the author of "Theory and Application of Electron Tubes," as well as co-author of "Ultra-High-Frequency Techniques."

JOHN V. L. HOGAN

Director, 1949–1950

Region 2: North Central Atlantic

John V. L. Hogan (M'12–F'15), president of the Interstate Broadcasting Co., was born in Philadelphia, Pa., on February 14, 1890. After working for a year as laboratory assistant to Lee de Forest, Mr. Hogan entered the Sheffield Scientific School in 1908. Two years later he became an electrical engineer on the staff of the National Electric Signaling Co., and in 1914 became chief research engineer.

In 1918 the company's name was changed to the International Radio Telegraph Co., and he was promoted to manager. Three years later he opened his own office as a consulting radio engineer in New York City.

President of Radio Inventions, Inc., Mr. Hogan has patented many inventions in the television and facsimile fields. In 1934 he founded radio station WQXR (then W2XR), which the New York *Times* acquired ten years later. As president of the Interstate Broadcasting Co., Mr. Hogan still directs operation of WQXR and its sister station WQXR-FM.

Mr. Hogan is a prolific contributor to radio literature. He also is one of the founders of the IRE, and a past President.

JOHN B. COLEMAN

Director, 1948–1949

Region 3: Central Atlantic

John B. Coleman (A'25–M'38–SM'45–F'48) was born in Indiana County, Pa., on August 29, 1899. Starting as an amateur in 1914, he became a radio operator for the Marconi Co. in 1917. The following year he taught at the Carnegie Institute's Signal Corps Air Service School for Radio Mechanics.

After World War I, Mr. Coleman graduated from the Carnegie Institute of Technology in 1923 with the B.S.E.E. degree. From 1923 to 1925 he served as engineer in charge of the Westinghouse Co.'s Radio Station WBZ; later becoming section engineer in charge of high-power transmitter design.

In 1930 Mr. Coleman left Westinghouse to join the engineering department of the RCA Manufacturing Co. at Camden, N. J. Appointed chief engineer of the special apparatus engineering department in 1939, he was advanced to the post of assistant director of engineering for RCA Victor in 1945.

Mr. Coleman was Chairman of the Philadelphia Section of the IRE in 1942. He is a member of the AIEE, the American Society of Naval Engineers, the Army Ordnance Association, Tau Beta Pi, and Eta Kappa Nu.

GEORGE R. TOWN

Director, 1949–1950

Region 4: East Central

George R. Town (A'37–SM'44) was born on May 26, 1905, in Poultney, Vt. He received the degrees of E.E. and D.Eng from the Rensselaer Polytechnic Institute in 1926 and 1929.

In 1929 he was appointed an engineer in the research laboratory of the Leeds and Northrup Co., remaining until 1933, when he left to work briefly as a development engineer for the Arma Engineering Co.; then was appointed to the faculty of Rensselaer as an instructor in mathematics and electrical engineering. Three years later Dr. Town joined the Stromberg-Carlson Co. as an engineer in the research department, and, after becoming engineer-in-charge of the television laboratory and assistant director of research, he attained his present position as manager of engineering and research. In 1945 he was elected assistant secretary.

Dr. Town was chairman of the Rochester Section of the IRE from 1942 to 1944, and has served on several IRE committees. Vice-president of the Rochester Engineering Society, he is a member of the AIEE and an officer on various RMA committees. He has also served on the RTPB and NTSC.

Institute for the Year 1949

THEODORE A. HUNTER

Director, 1948–1949

Region 5: Central

Theodore A. Hunter (A'45–M'45–SM'46) was born on December 5, 1900, in Dike, Iowa. In 1922 and 1924 he received the B.S. and M.S. degrees from the University of Iowa, and the E.E. degree in 1931.

After completing school, Mr. Hunter became a transmission line inspector for the Northwestern Bell Telephone Co., and later joined the Crosley Radio Corp. Subsequently he taught at the University of Pittsburgh and the Rose Polytechnic Institute.

Following a period of semiretirement, during which he engaged in consulting work on police radio systems, Mr. Hunter joined the Collins Radio Co. at Cedar Rapids, Iowa, in 1940. In 1947 Mr. Hunter left Collins to form his own firm, the Hunter Manufacturing Co., where he specializes in electronic equipment for amateurs and the medical profession. He also acts as consultant for the University of Iowa.

Mr. Hunter was one of the founders of the Cedar Rapids Section of the IRE in 1944. He is a member of Sigma Xi, a director of the Iowa Engineering Society, and president of the Cedar Rapids Engineer's Club.

BEN AKERMAN

Director, 1949–1950

Region 6: Southern

Ben Akerman (A'38–SM-'44), assistant manager of Radio Station WGST in Atlanta, Ga., was born in Wilmington, N. C., on July 8, 1908. He entered the Richmond Academy in 1922, and, graduating, in 1926, matriculated at the Junior College of Augusta, Ga., completing the course in 1928.

For the next 3 years he studied at the Georgia Institute of Technology, leaving in 1930 to join the engineering staff of Radio Station WGST. He was made Chief engineer in 1937 and assistant manager in 1947.

At the same time Mr. Akerman acted as consultant to the Georgia Department of Public Safety: he was chief engineer of the Georgia State Police Patrol from 1939 to 1941, setting up the Department's first radio system in 1940. A registered professional engineer, he is a member of the National Association of Professional Engineers.

Mr. Akerman was Chairman of the Atlanta Section of the IRE in 1939, Chairman of the Program Committee of the IRE-Georgia Institute of Technology's Broadcast Engineering Conference in 1947, and General Chairman in 1949.

FREDERICK E. TERMAN

Director, 1948–1949

Region 7: Pacific

Frederick Emmons Terman (A'25–F'47) was born in English, Ind., on June 7, 1900. Educated at Stanford University, he received the B.A. in chemical engineering in 1920, and the E.E. in 1922. In 1924 he was given the D.Sc. in electrical engineering by the Massachusetts Institute of Technology.

The following year Professor Terman joined the electrical engineering faculty of Stanford as an instructor, and was advanced to assistant professor, associate professor, and full professor and executive head of the electrical engineering department. From 1942 to 1945, he directed the Harvard University Radio Research Laboratory. Returning to Stanford in 1945, he was appointed dean of the school of engineering.

Professor Terman received the honorary D.Sc. from Harvard in 1945, a decoration from the British Government in 1946, and the U. S. Medal for Merit in 1948. A past President of the IRE, he is also a member of the AIEE, the American Physical Society, the American Society for Engineering Education, and the National Academy of Sciences. He is the author of a number of books and technical papers on radio.

FRANK H. R. POUNSETT

Director, 1949–1950

Region 8: Canadian

Frank H. R. Pounsett (A'26–SM'44–F'47) was born on September 12, 1904, in London, England. Emigrating to Canada in 1910, he obtained the bachelor's degree in electrical engineering from the University of Canada in 1928.

In that year he joined the DeForest Radio Corp. in Toronto and rose to be senior radio engineer. He left in 1934 to become chief engineer of the Stewart-Warner-Alemite Corp. in Belleville, Ont. Six years later he moved over to the newly formed Research Enterprises, Ltd., in Toronto, where he was chief engineer, responsible for production design of all radar apparatus manufactured in Canada during World War II. In 1946 he was appointed chief engineer of Stromberg-Carlson Co., Ltd., in Toronto. He is responsible for design and engineering of the company's communications equipment in Canada.

Mr. Pounsett is a member of the Association of Professional Engineers of Ontario, the Acoustical Society of America, the Rochester Engineering Society, and the Royal Canadian Institute. He was Chairman of the Toronto Section of the IRE from 1945 to 1946.

Invention, or creative work, appears not to fall readily into conventional or purely logical sequences of mental processes. The element of intuition, born of need or knowledge, apparently plays a major role in bridging gaps in our information, processes, and devices.

The interesting questions which thus arise are of outstanding importance to many scientists and engineers. They are treated in stimulating fashion in the following guest editorial by the chairman of the department of electrical engineering at Northwestern University, who is, as well, a Senior Member of the IRE and a fellow of the AIEE.—*The Editor*.

Developing Design Abilities

J. F. CALVERT

Engineering progress is built upon invention and design, and we, in both college and industry, should seek new ways to find and develop the latent abilities for creative work which are possessed by many of the younger engineers. Formal engineering education is based largely on the techniques of analysis, because these provide for the accurate statements of fundamentals and for rigorous thinking in quantitative terms. But not often are new designs analyzed into being; usually they are synthesized by bold qualitative thinking.

Observation, memory, and logical thinking are the mental abilities required for analysis; and these are carefully developed along engineering lines through laboratory, lecture, and problem assignments. How to develop imagination and judgment, those additional qualities required for the synthesis of invention and creative design, is an intriguing challenge. Some have felt that, to achieve in design, one must become attuned to nature in order to project forward in time somewhat as does the painter who envisions the form and color of the finished work in oil. Sikorski speaks of intuition in invention as the "forerunner of knowledge" which tells of the correctness of things which later may be proven by observation and analysis. Yet all of this stems from imagination as a series of forms, colors, sounds, or images which occur in the mind, and intuition is that sense of rightness based upon subliminal cues which say, "Stop, this is it, the meaningful whole." If this is creative design, what may be done about so spritely a thing?

Actually, its progress can be described in almost sequential steps. A human need or want must be discovered which should be translated into engineering through a statement of desired physical results. Next, various physical combinations are devised in the hope that one or more eventually will yield these results; and, starting almost concurrently, the combinations must be evaluated in terms of the human need, and in terms of cost and time. These are the steps in the initial stages of design.

The designer should seek always to replenish his knowledge of human wants, real or potential, which he believes should be satisfied. He may classify them in terms of existing products, or perhaps in terms of certain perennial needs. Among the latter are: the preservation of life and health, individual freedoms of action (such as those concerned with shipment, travel, and the communication of intelligence), sheer amusements, escapes from the daily requirements of life, release from drudgery, and release from worry, anxiety, and fear. Sometimes at the start the designer does not even have a problem clearly defined, but he is well on his way when he can clearly specify what he wishes to produce or to determine, and what obstacles must be overcome.

Next comes the arduous "soaking-in" process where he strives to encompass within his ken all which may bear upon a solution, and where he strives to create images of physical entities which may yield a satisfactory combination. Block diagrams, curves, charts, vectors, home-made symbols, free-hand sketches, rough models, and analogies are employed to aid the free flow of images and their initial evaluations. Often from hours and days of seemingly useless efforts, frustration and great discouragement envelop the mind of the designer, and may be thrown off only by rest, diversion, and the perspective to be gained by returning, as from a distance.

What may be done to develop the techniques of creative engineering? At the undergraduate level, laboratory studies which call not only for answers but for the development of procedures permit a start to be made; system studies involving pneumatic, hydraulic, mechanical, and electrical controls permit advance; and senior seminars may give the more original students practice in the initial stages of design. At the graduate level, research may offer the student not only the chance for original work, but the opportunity to see how ideas are found and how decisions are made within a project team. In industry, a young engineer of presumed potential ability may be apprenticed to designers to give him much the same opportunities as those afforded through graduate research. Often in each of the last two training periods the student should be required to summarize and then to generalize upon his findings. This gives him practice in reducing experience to its simplest and most concise terms, and makes it possible for his progress to be guided. In his development, the young engineer must be brought to realize the difference between the "crackpot inventor" and the successful creative designer. While each has developed that knack for visualizing the new and novel, the difference is measured not by the degree of newness of ideas but by the judgment with which they are weighed.

The engineer learns that questions must be asked and answered: Why is this job worth doing; is the magnitude of the possible gain likely to make the result unquestionably accepted, or is the gain to be at best only marginal; what will be required in time, money, and materials; and is there other work which should take precedence? Yet the introduction of the young designer to these necessary appraisals must be accomplished without permanently damping his ardor for creative achievement.

Detection of Radio Signals Reflected from the Moon*

JOHN H. DEWITT, JR.†, SENIOR MEMBER, IRE, AND E. K. STODOLA‡, SENIOR MEMBER, IRE

Summary—**This paper describes the experiments at Evans Signal Laboratory which resulted in the obtaining of radio reflections from the moon, and reviews the considerations involved in such transmissions. The character of the moon as a radar target is considered in some detail, followed by development of formulas and curves which show the attenuation between transmitting and receiving antennas in a moon radar system. An experimental radar equipment capable of producing reflections from the moon is briefly described, and results obtained with it are given. Some of the considerations with respect to communication circuits involving the moon are presented. The effects of reflection at the moon on pulse shape and pulse intensity for various transmitted pulse widths are dealt with quantitatively in the Appendix.**

I. Introduction

THE POSSIBILITY of radio signals being reflected from the moon to the earth has been frequently speculated upon by workers in the radio field. Various uses for such reflections exist, particularly in respect to measurement of the refracting and attenuating properties of the earth's atmosphere. Other conceivable uses include communication between points on the earth using the moon as a relaying reflector, and the performance of astronomical measurements.

Late in 1945, a program to determine whether such reflections could be obtained and the uses which might be made of them was undertaken by the U. S. Army Signal Corps at Evans Signal Laboratory, Belmar, N. J. The work has been continued since then, and, although for various reasons progress on it has been slow, this paper has been prepared to indicate the nature of the work and results so far obtained.

II. The Moon as a Radar Target

The moon is approximately spherical in shape, is some 2,160 miles in diameter, and moves in an orbit around the earth at a distance which varies from 221,463 miles to 252,710 miles over a period of about one month.

In considering the type of signals to be used for reflections, the manner in which the reflection occurs must be considered. If it were assumed that the moon were a perfectly smooth sphere, the reflection would be expected to occur from a single small area at the nearest surface, as would be the case with light and a mirror-surfaced sphere. However, astronomical examination of the moon reveals that, in its grosser aspects at least, its terrain consists of plains and mountains of the same magnitude as those on the earth. Further, because of the lack of water and air on the moon to produce weathering, it is probable that the details of the surface are even rougher than the earth. Thus, it is assumed that the type of reflection to be obtained from the moon will resemble the reflections obtained on earth from large land masses, or, to use radar terminology, ground clutter. An example of such a reflection obtained experimentally on earth is shown in Fig. 1. The echoes shown

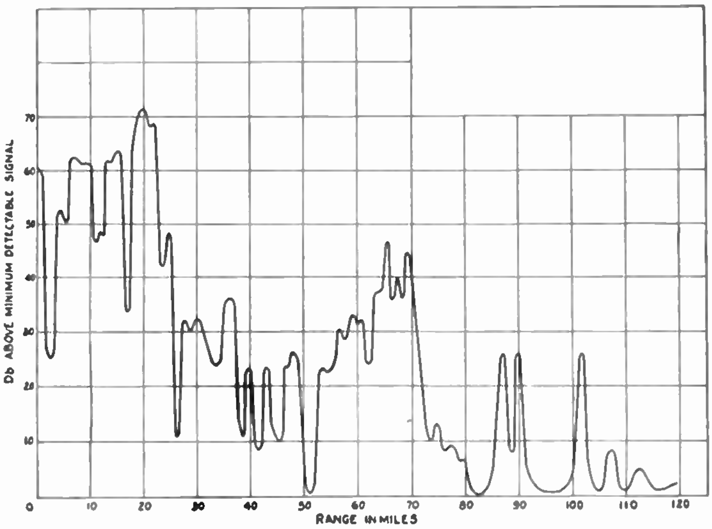

Fig. 1—Reflection obtained from a mountainous region on earth with a 25-microsecond, 106-Mc pulse.

were plotted from observations made with a 25-microsecond 106-Mc pulse transmitted into a mountainous region near Ellenville, N. Y. It will be seen that the intensity of reflection at various ranges varies in a quite random fashion, subject to a general dropping as the range increases. In this case, at 30 miles range and taking the antenna beam width as 12° and for the pulse width of 25 microseconds, or 2.7 miles, the echo at 30 miles range is the averaging of all echoes over an area of about 17 square miles. A pulse of the same width directed at the moon, using equation (35) in the Appendix, may act upon as much as 5,800 square miles. Thus, in the case of the moon, the return echo for a major portion of the time is an averaging of echoes over a very large area and could be expected to exhibit a high degree of constancy per unit projected area.

Thus the most reasonable assumption seems to be that, on the whole, the moon behaves for radio waves much as it behaves for light; that is, when illuminated from the direction of the earth, it presents a disk equal in area to the projected area of the sphere, the disk being illuminated in a generally uniform manner with any bright or dark spots distributed over the disk in a random manner. On the basis of this, it is evident that appreciable power contributions to the returning signal are received from areas on the moon which are at various ranges from the earth. Therefore, if a pulse system is used, to obtain maximum reflection the pulses should be long in time compared to the time required for a radio wave to travel in space the distance from the nearest

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† Radio Station WSM, Inc., Nashville, Tenn.
‡ Reeves Instrument Corporation, New York, N. Y.

The results of these equations are shown in Fig. 2. The solid curves give the attenuation for various sizes of antenna apertures, as indicated. The dashed line indicates the transition between a beam wider than the moon and one narrower. As indicated previously, this transition does not occur abruptly as in these idealized curves, but the curves do give a basis for close estimation of the system requirement.

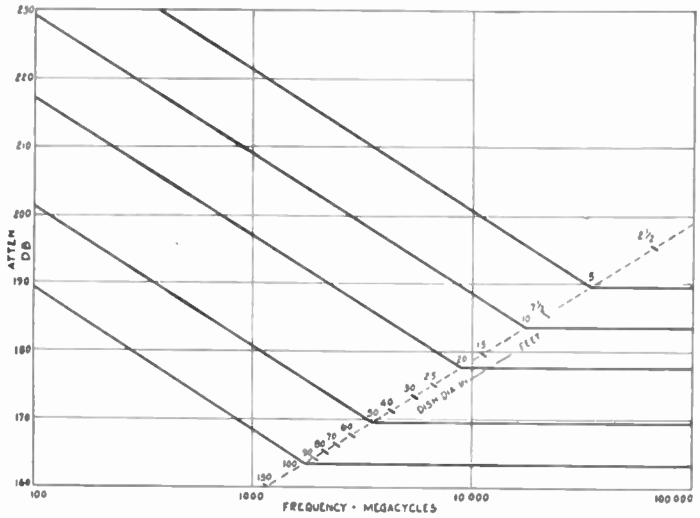

Fig. 2—Attenuation of the earth-moon-earth radar path for various frequencies and antenna apertures.

In all of the above, no effects of attenuation due to losses in the atmosphere or space, nor to the effect of refraction in the atmosphere, have been considered. However, at frequencies in the range from 100 to perhaps a few thousand megacycles, it is probable that for a considerable portion of the time these effects will not materially affect the attenuation figures given in the curve, since shorter-range radar operation in this frequency range gives results which are consistent with the assumption of negligible losses in the atmosphere and, with some exceptions, no refraction effects.

At frequencies much below 100 Mc, ionospheric refraction or reflection effects become much more pronounced, and it is probable that signals could not be sent to the moon and back at these lower frequencies.

It should also be noted that, in the above discussion, no attention has been given to ground reflections. If the antenna beam width is wide enough and the angle at which the antenna is aimed is low enough so that the ground is heavily illuminated by the beam, the ground-reflected wave will, at certain elevation angles, reinforce the direct wave, so that, under ideal conditions, the antenna gain will be increased by 6 db, and the over-all attenuation of Fig. 2 may be reduced under these conditions by as much as 12 db.

Equipment Requirements

The attenuations shown in Fig. 2 for ordinarily used antenna sizes are considerably in excess of the spread between transmitter power and minimum detectable signal for the receiver in a usual radar system. Further, as shown in the Appendix, to obtain attenuation even as small as shown in Fig. 2, a pulse width in excess of 12,000 microseconds is necessary, so that consideration of ordinary radar systems is ruled out on this ground, in addition to the long travel time to the moon and back which makes desirable the use of a low pulse-repetition rate.

Fig. 3 gives a basis on which the performance of a radar system may be approximately estimated. The input noise power with which a signal must compete is given by $P_{noise} = KTB$ where K = Boltzmann's constant $= 1.37 \times 10^{-23}$ joules/degree, T is the effective input (antenna) resistance temperature in °K, and B is the bandwidth in cps. This figure must in increased by the noise factor of the receiver.[2,5–7]

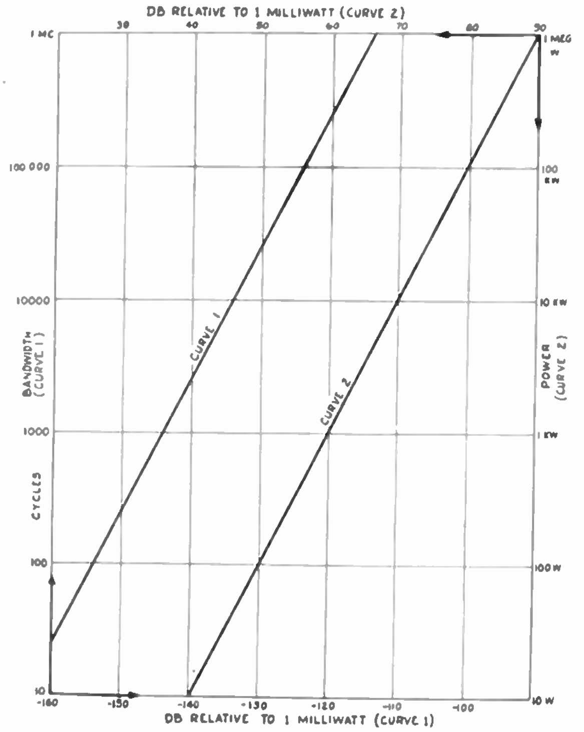

Fig. 3—Johnson noise and transmitter power levels in decibels with respect to 1 milliwatt.

If the pulse width of a radar transmitter is approximately (by a factor of from 1/2 to 2) equal in seconds to the reciprocal of receiver intermediate-frequency-amplifier bandwidth in cps, the minimum detectable signal will be of the order of the effective input noise (that is, KTB increased by the noise factor). It can be assumed that the effective antenna resistance is at a temperature of 300°K and, even if this assumption is not precise, when the noise factor referred to this temperature is not too close to 1, the error introduced by a lower effective antenna temperature will not be serious. The minimum detectable signal is also affected by pulse-repetition rate and other factors, but the above consideration gives a useful initial approximation.

[5] The references given are relevant to this and later discussion.
[6] A. V. Haeff, "Minimum detectable radar signal and its dependence upon the parameters of radar systems," Proc. I.R.E., vol. 34, pp. 857–861; November, 1946.
[7] H. T. Friis, "Noise figures of radio receivers," Proc. I.R.E., vol. 32, pp. 419–422; July, 1944.

In Fig. 3, curve 1 gives decibels relative to 1 milliwatt corresponding to Johnson noise (KTB) for various bandwidths at a temperature of 300°K, while curve 2 gives decibels relative to 1 milliwatt for various transmitter powers. As an example of the use of these curves, a typical 3,000-Mc radar set might have a receiver noise figure of 12 db, a receiver bandwidth of 1 Mc, a pulse width which is the reciprocal of this, 1 microsecond, and a transmitter peak power of 100 kw. The spread between transmitter and receiver would in this case be determined by:

(1) Receiver minimum signal is −114 db from the point on curve 1 for 1 Mc, increased by the noise factor of 12 db, or −102 db.

(2) Transmitter power from the point on curve 2 corresponding to 100 kw is +80 db.

The spread in this case is 182 db. In Fig. 2 it will be seen that, even with a 20-foot dish and assuming that full reflection could be obtained with the 1-microsecond pulse, the attenuation in the earth-moon-earth path would be 185 db. Actually, the use of the short (1-microsecond) pulse would make the attenuation 37.7 db greater, as discussed in the Appendix. Thus, on the basis of the assumptions used here, such a system falls about 40 db short of being capable of producing reflections from the moon.

All of this suggests that the type of radar system needed is one with a very wide pulse and correspondingly narrow receiver bandwidth. As previously pointed out, a pulse width substantially greater than 0.012 second is desirable, and, if a pulse width of 0.05 second be considered, using the criterion that the bandwidth should be the reciprocal of the pulse width, a bandwidth of about 20 cps is indicated.

To use such a narrow bandwidth requires a degree of frequency stability far beyond usual radar requirements, and so, in undertaking the moon-reflection experiment, the use of a rather elaborate crystal control was contemplated. The narrow bandwidth in the receiver makes it necessary to consider doppler shift between the frequencies of received and transmitted signal due to the relative velocity between the moon and the equipment on the earth. The relative velocity between a point on earth and the moon depends upon two components, one due to the rotation of the earth about its axis, and the second due to the motion of the moon in its orbit about the center of the earth. At the latitude of Evans Signal Laboratory, 40° 10′ North, the velocity component due to earth's rotation depends upon the angle at which the moon is viewed, and may be as much as 795 miles per hour at moonrise or moonset. Added algebraically to this is the velocity relative to the center of the earth of the moon in its orbit. This varies between plus 185 miles per hour and minus 185 miles per hour, so that the relative velocity may reach 795 plus 185 equals 980 miles per hour or 0.273 mile per second at this latitude. Since the velocity of light is 186,000 miles per second, and since the velocity with which the path length changes is twice the figure given above because of the two-way path, the frequency may be shifted by as much as a maximum amount ΔF which is related to the operating frequency by

$$\Delta F = F \times \frac{0.273 \times 2}{186,000} = 2.96F \times 10^{-6}. \qquad (17)$$

It was found that the Signal Corps was in possession of some experimental transmitting and receiving equipment, obtained from E. H. Armstrong, which was designed for 111.5-Mc operation, and which could be modified to approximate the requirements above. The system finally used overcame the frequency-stability problem by using a single crystal for obtaining the frequency control of the transmitter and all of the local-oscillator injections in the receiver except the final one. A multiplicity of mixers based on this single crystal is used to heterodyne the signal down to 1.55 Mc, where an independent adjustable-frequency crystal provides the final local-oscillator injection to heterodyne the signal down to the final intermediate frequency of 180 cps with a bandwidth of about 50 cps. Thus, the problem of frequency stability becomes one of maintaining a stability of about ±20 cps at 1,500 kc, which does not require unusual techniques. Variation of the frequency of this crystal allows tuning of the receiver to the precise frequency required. The frequency to which the receiver is tuned, or, more precisely, the frequency by which its tuning must differ from the transmitter, depends upon the magnitude of the doppler effect, which must be calculated for the particular circumstances under which the operation is conducted. At the 40° 10′ North latitude, considered here, the maximum shift for a 111.5-Mc signal, using (17), will be $\Delta F = 111.5 \times 10^6 \times 2.96 \times 10^{-6} = 327$ cps, which, although small, is an appreciable shift when bandwidths of 50 cps are being considered. A simplified block diagram of the equipment is shown in Fig. 4. The apparatus has been described in detail elsewhere.[8]

The transmitter used initially had a peak power of about 3 kw. The noise factor of the receiver was 5 db and its bandwidth about 50 cps. However, because the amplifiers preceding the 180-cps narrow-bandwidth amplifier had a bandwidth wide compared to the 180-cps intermediate frequency, the receiver had an image response equal to the main response and separated from it by 360 cps. This image in effect doubles the bandwidth of the receiver, so that the incoming signal must compete with the noise in 100 cps of bandwidth rather than 50. Referring to Fig. 3, the equivalent receiver noise level is −154 db for 100 cps plus 5 db for noise factor, or −149 db. The transmitter level is plus 65 db for 3 kw, so that the total spread is 149 plus 65, or 214 db.

Reference to Fig. 2 shows, at 111.5 Mc and with an

[8] Jack Mofenson, "Radar echoes from the moon," *Electronics*, vol. 19, pp. 92–98; April, 1946.

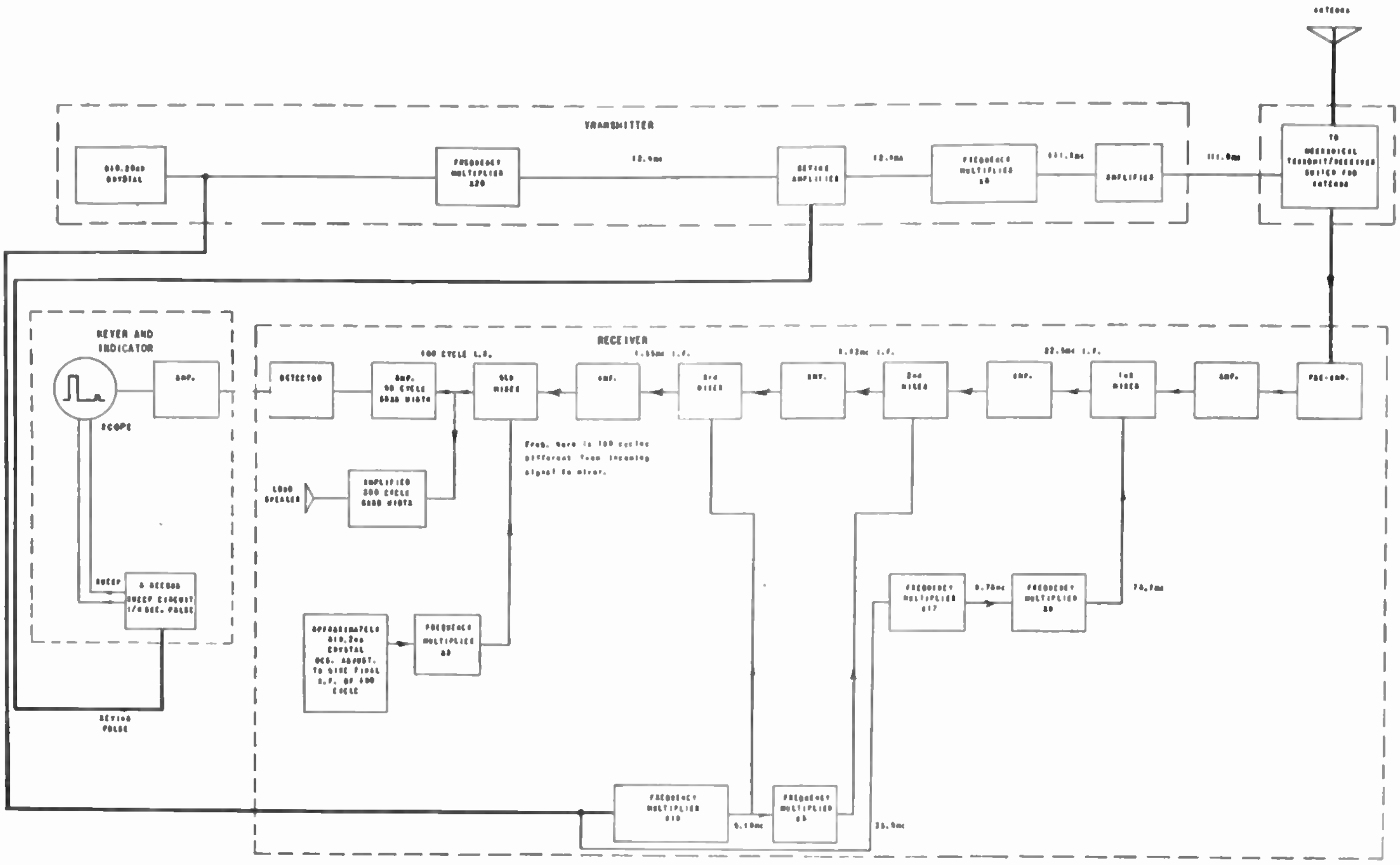

Fig. 4—Simplified block diagram of the 111.5-Mc moon radar system.

antenna diameter of 50 feet, an attenuation of slightly under 200 db. For 111.5-Mc operation, an antenna having gain equivalent to that of a 50-foot circular antenna is not too difficult to construct. (Large antennas for higher frequencies become difficult because of the accuracy of construction required.) It was decided that two antennas of the type used on the Army SCR-270-271 radar series could be assembled together to provide an array of dipoles about 40 feet square to give a gain (with the current distribution used) of about 250 over that of an isotropic radiator. Substituting this value in (5b) for $F=111.5$ Mc and the other values as used in deriving (12), it is found that $P_r/P_t = 1.34\times 10^{-21}$, corresponding to 198.7 db attenuation. Thus the equipment previously described, with its 214-db capability, should be capable of showing a reflection from the moon, even with allowance for moderate transmission-line losses not considered previously, some atmospheric attenuation, and a loss due to depolarization by the reflection at the moon.

The antenna described above was mounted on a reinforced standard mount for the SCR-271 radar system, which is capable of rotating the antenna in azimuth only. Because of this search limitation, observations were restricted to a relatively short time near moonset and moonrise. (The antenna beam width is about 12 degrees.) The fact that the beam necessarily is directed horizontally implies that substantial ground reflections occur which break the antenna beam into a lobed structure, with the round-trip attenuation in the center of these lobes being, under ideal conditions, as much as 12 db less than if no ground reflections were present. The extent to which this 12 db is realized depends upon ground conditions at the "bounce point," and in this case an arbitrary estimate is made of an 8-db gain from this source. Using the previous figures, which show an approximate 15-db margin, and adding the above 8 db gives a 23-db excess performance, neglecting transmission line, polarization, and propagation losses.

The power output of the transmitter was later increased to about 15 kw by use of an SCR-270-271 trans-

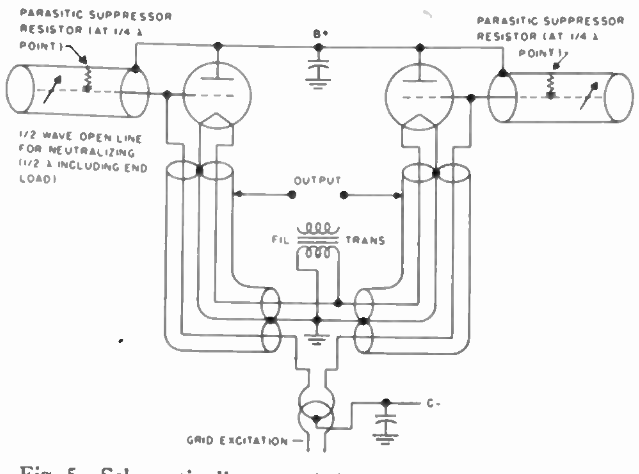

Fig. 5—Schematic diagram of the triode radar transmitter converted to a neutralized 15-kw amplifier.

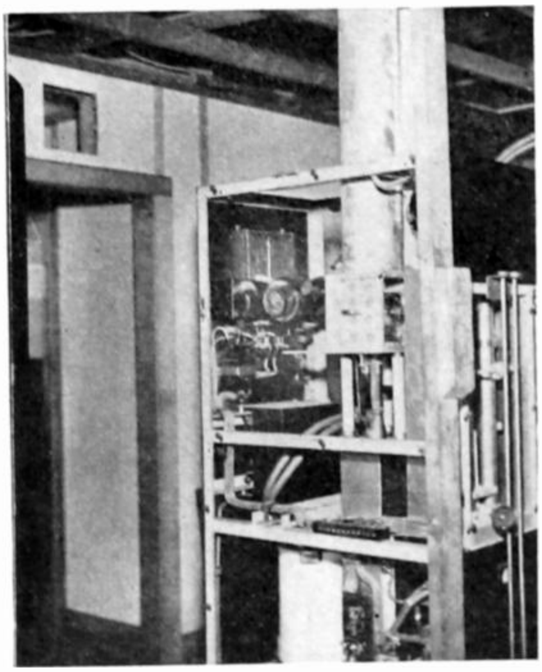

Fig. 6—Photograph of the radar transmitter converted to an amplifier. The ½-wavelength open lines for neutralizing are visible projecting out the top.

mitter modified to operate as a neutralized triode amplifier. The neutralizing was accomplished by open 1/2-wavelength lines connected between the plate and grid of the WL 530 tubes originally used as oscillators, and the grid excitation is supplied "bazooka" fashion by lengths of coaxial line attached to the cathode output lines. A schematic diagram of the rather unusual arrangement is shown in Fig. 5. Fig. 6 is a photograph of this amplifier, and Figs. 7 and 8 show other apparatus used in the experiments, and an aerial view of the station.

Measurement of System Performance

Measurements of the performance of such a system are necessary in order to evaluate the results obtained.

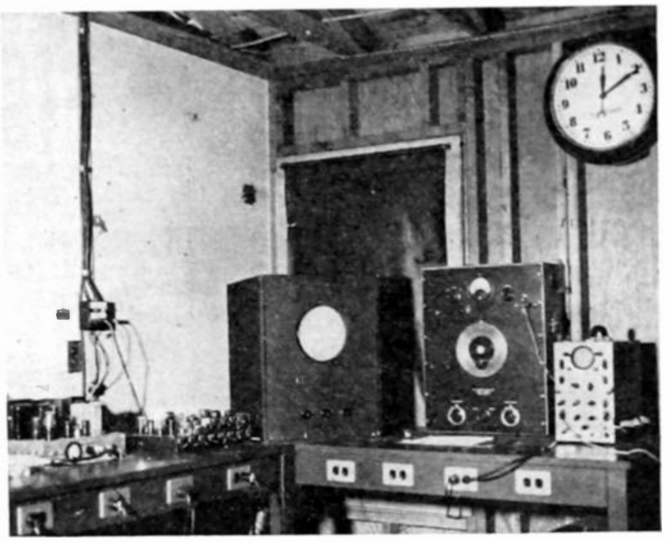

Fig. 7—Keying oscillator and sweep circuits, viewing oscilloscope, audio oscillator and oscilloscope for tuning the receiver to proper doppler shift, and miscellaneous controls.

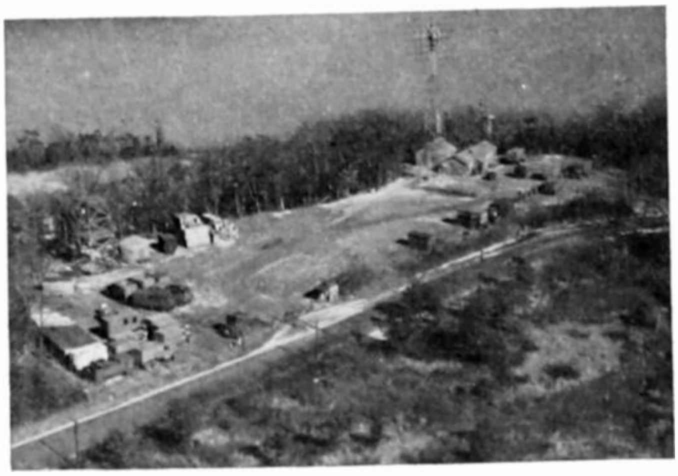

Fig. 8—Aerial view of the moon-radar installation looking in the general direction of moonrise.

Some of the measurements and adjustments are performed in a somewhat unusual way and will be described here.

The receiver has a pass band of about 50 cps at 111.5 Mc. It was found that ordinary signal generators are not capable of maintaining such stability even for a fraction of a second. A signal generator was converted to crystal-control operation with a vernier frequency control in the form of a variable capacitor across the crystal. With this it was found possible to maintain the frequency for very short intervals, but the problem of leakage due to inadequate shielding and filtering remained. This problem can be appreciated by considering the fact that, as indicated previously, the equivalent receiver input noise level is -149 db with respect to 1 milliwatt, or 1.25×10^{-18} watt, which in terms of voltage across a 50-ohm transmission line is 0.008 microvolts. In view of these difficulties, use of the signal generator was abandoned in favor of noise-factor measurement by a diode noise generator. The use of such a diode will be briefly described, since its use for this purpose has not been widely publicized.

In a diode operated so that the plate current is adjusted by the filament temperature with plate voltage fixed and high enough so that increasing plate voltage causes no increase in plate current (that is to say, a temperature-limited diode), a noise current is present in the plate circuit whose value is given by

$$I_{\text{noise}}^2 = 2eI_dB \qquad (18)$$

where

e = the charge on an electron, 1.59×10^{-19} coulombs
I_d = the diode plate current in amperes
B = the bandwidth in cps
I_{noise} = the rms noise current.

If this current is made to flow in a resistor of R ohms, the voltage developed across the resistor is

$$E_{\text{noise}} = R\sqrt{2eI_dB}. \qquad (19)$$

Thus the resistor may now be considered as a constant-voltage noise source E in series with a resistor R, from which the available power[4] is

$$P_{\text{noise}} = \frac{E_{\text{noise}}^2}{4R} = \frac{eI_dBR}{2}. \tag{20}$$

The noise available at the receiver output in the absence of any added diode noise is

$$P_{0_1} = NKTBG \tag{21}$$

where

G = the available power gain of the receiver

N = the noise factor of the receiver (N here is a power ratio. It may be converted to decibels if desired)

P_{0_1} = the receiver noise power with the diode noise source connected but no diode plate current; that is, no noise contribution from the diode.

If the diode noise is now added to the receiver input and increased until the receiver noise output is doubled, that is, increased to $2P_{0_1}$, then the contribution due to the added diode noise P_{noise} is P_{0_1}. For this condition, the added noise-output contribution of the diode is

$$P_{0_2} = P_{0_1} = \frac{eI_dBR}{2} G \tag{22}$$

where P_{0_2} is the added output noise power due to the diode plate current. Equating (21) and (22),

$$N = \frac{e}{2KT} I_dR \tag{23}$$

and substituting the previously given value of $e = 1.59 \times 10^{-19}$, $K = 1.37 \times 10^{-23}$, and $T = 300$, gives

$$N = 19.4 I_dR. \tag{24}$$

Fig. 9 shows a schematic diagram of the diode noise source for use on the 250-ohm line feeding the antenna system. The one-fourth-wave tubing supports for the diode assembly serve as isolating elements to feed filament and plate voltages to a special tungsten-filament diode. The whole assembly is placed on the transmission

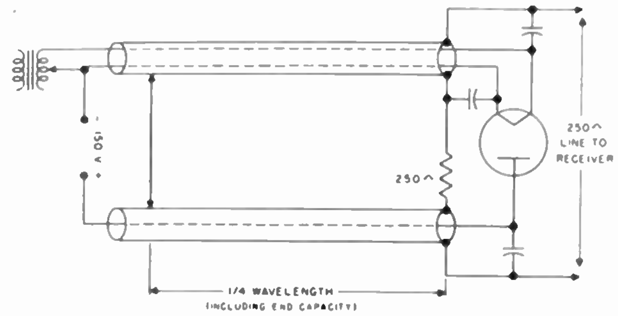

Fig. 9—Schematic diagram of diode noise generator for noise-factor tests.

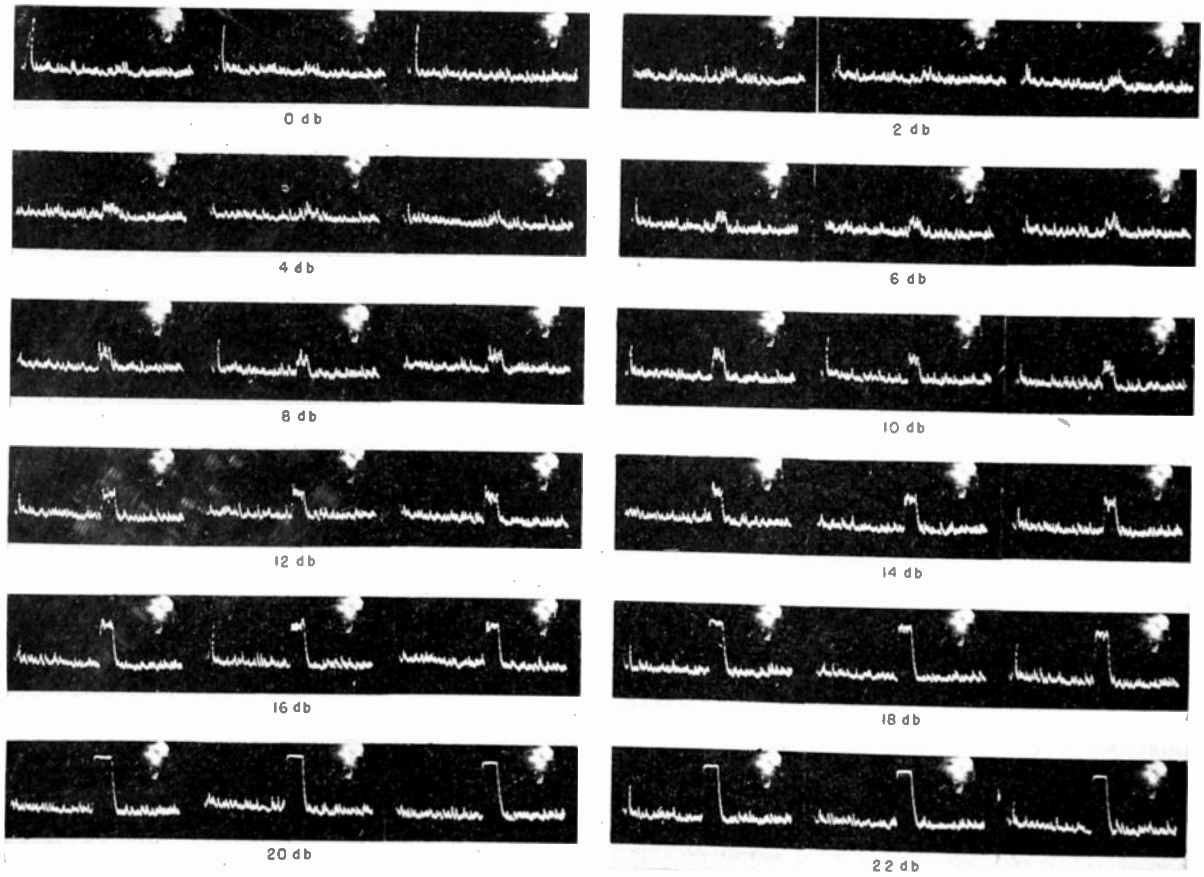

Fig. 10—Test calibrating signals in the moon-radar receiver. Levels given are db with respect to receiver equivalent-input-noise level.

line, and a short circuit placed on the line to the antenna at a distance of one-fourth-wavelength from the diode, so that the 250-ohm diode load replaces the antenna impedance. The diode current is then raised until the receiver noise power output, as indicated by a thermocouple connected *before* the final detector, is twice the output for no diode current. Substituting $R=250$ in (24), the noise factor is

$$N = 4.85 I_{ma} \tag{25}$$

where I_{ma} is the diode plate current in milliamperes.

The effect of a pulsed signal of any given intensity may be simulated by injecting a signal at one of the intermediate frequencies, and by means of a thermocouple at the receiver output, referring the level to the receiver input. This injection can be most conveniently done at the 180-cps intermediate frequency. A series of test signals of this kind is shown in the oscilloscope photographs of Fig. 10. These photographs show the test pulses on the 4-second sweep of the oscillosope, and the decibel levels shown are with respect to the noise output of the receiver. Referred to the receiver input, if the noise factor is 3.2, that is, 5 db, then the 0-db signal in the photo corresponds to an input signal of -149 db with respect to 1 milliwatt, the 2-db signal to -147 db, etc. These photographs facilitate estimation of the intensity of returns from the moon.

The receiver frequency can be easily adjusted by connecting the vertical deflection plates of an oscilloscope to the receiver output and a standard audio oscillator to the horizontal deflection plates. (See Fig. 7.) The small leakage from the transmitter produces a frequency in the output circuit which is the difference between the transmitter and receiver frequencies, $\pm$ the 180-cps final intermediate frequency. Thus, for example, if it is desired to receive on a frequency 200 cps higher than the transmitter frequency, the audio oscillator is set to 180 plus 200 or 380 cps, and the final receiver crystal oscillator is adjusted until a stationary circular pattern is obtained on the oscilloscope (care must, of course, be taken that the upper or lower heterodyne as required be chosen).

The transmitter output power is measured by a crystal detector used with a directional coupler.[9] This detector operates in conjunction with a calibrated amplifier and oscilloscope arrangement to give an oscilloscope deflection which is a measure of the transmitter power on each pulse. The directional coupler used is also capable of measuring power reflected back down the transmission line from the antenna, and so may also be used to determine the SWR of the transmission line.

Directional couplers for open lines and at this relatively low frequency are rather unusual, and the one used here will be briefly described. A photograph of the coupler is shown in Fig. 11. It consists of two one-fourth-wave shorted sections A and B which are tapped onto the main open 250-ohm transmission line at two points C and D which are separated by one-fourth wavelength.

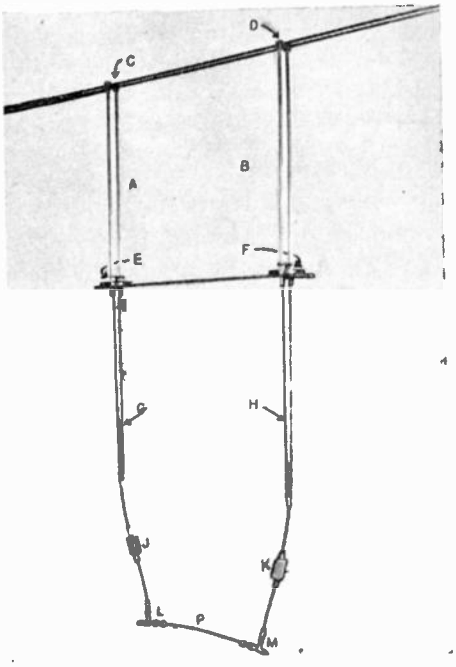

Fig. 11—Photograph of the directional coupler used for power measurement on the moon-radar system open transmission line.

On each of these a 50-ohm unbalanced line is tapped at a point (E and F) near the shorted end, so that approximately 1/30 of the voltages on the 250-ohm line at points C and D are applied to the respective 50-ohm lines. The 50-ohm lines are provided with "bazooka" one-fourth-wave skirts (G and H) to provide a balanced to unbalanced connection. The 20-db 50-ohm pads (J and K) are provided to furnish additional attenuation and assure proper termination of the 50-ohm lines. L and M are the two output points which are connected by the auxiliary one-fourth-wave line P (which is shorter physically than the open line one-fourth-wave section CD because of the dielectric material used in the 50-ohm line). It will be seen that energy extracted from the line at C travels to point L through a path of the same length as the energy extracted at point D which travels to point M.

Now, considering the functioning of the coupler, it will be seen that, of the energy traveling along the main transmission line, say in the direction C to D, small and (very nearly) equal fractions are extracted by lines A and B. These two fractions of the energy reach point M by equal path lengths and so are in phase at this point, and reach point L by path lengths which differ by one-half wavelength and so cancel (except for a small residue which exists because the energy available at D is less than that at C by the amount which has been extracted at C). Similar reasoning for the energy traveling along the main line in the direction from D to C will reveal that the extracted fractions add at L and cancel

[9] W. W. Mumford, "Directional couplers," Proc. I.R.E., vol. 35, pp. 160–165; February, 1948.

at M. Thus, very closely, a measurement at M is a measure of the power being transmitted along the main line in the direction CD, and a measurement at L is a measure of the power being transmitted along the main line in the opposite direction. From these measurements the net power and the SWR may be determined.

Reflections Obtained from the Moon

With the apparatus in somewhat cruder state than described above, echoes from the moon were first obtained at moonrise on January 10, 1946. Oscilloscope deflections and an audible tone pulse in the loudspeaker connected across the 180-cps if amplifier were easily perceptible. One of the earliest photographs, that of an echo at moonrise on January 22, 1946, is shown in Fig. 12. In this photograph the sweep is that of a conventional type-A radar oscilloscope; that is, the sweep starts at the left of the screen with the transmitter pulse (not visible except for a disturbance due to the mechanical transmit/receive switch) and progresses uniformly across the screen. At about $2\frac{1}{2}$ seconds a vertical deflection occurs due to the reception of the pulse returned from the moon. The total sweep in this case is slightly in excess of 3 seconds.

Unfortunately, the project has been beset by numerous apparatus difficulties and the fact that, because of other work, it has been difficult to concentrate effort on it. As a result, the data which can now be reported are still fragmentary, but some useful qualitative conclusions can be drawn.

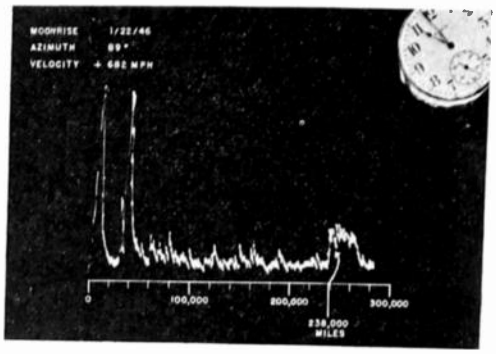

Fig. 12—Oscilloscope traces of moon radar echo observed during rising of the moon, January 22, 1946.

As previously indicated, observations have so far been limited to moonset and moonrise because of the limitations of the antenna structure. In general, results have been poorer at moonset than at moonrise, presumably

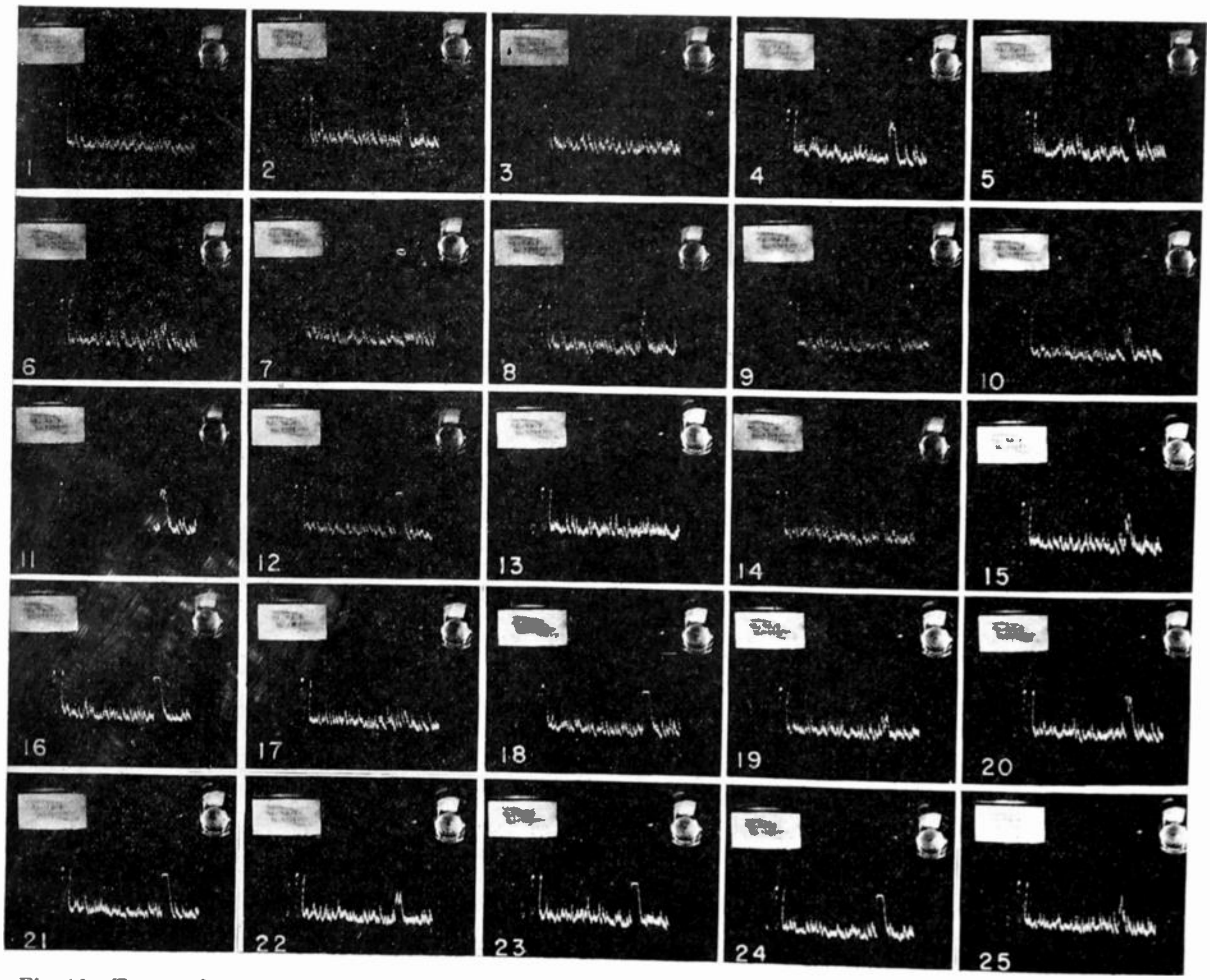

Fig. 13—Twenty-five successive moon echoes. The time interval between photographs is approximately 4 seconds.

because the antenna looks over land at moonset, under which condition the effect of ground reflection is probably less effective than when, as at moonrise, the antenna looks over the sea. So far, no significant correlation has been observed between echo effects and the time of day at which observations must be made, weather conditions, and the azimuth position of the moon. Undoubtedly, however, there are relations involving at least some of these factors, and it is hoped that eventually some precise information of this kind may be obtained. For example, it has been noted that the relation between the time on a particular day at which the first echoes were received differs from the time of optical moonrise by an amount which varies by several minutes from day to day. Frequently echoes are received before optical moonrise. This is undoubtedly due in part to changes in atmospheric refraction and attenuation from day to day, and in part to changes in the radiation pattern in different directions. Frequently, even with the equipment to all appearances in satisfactory working order, no echoes are observed.

One of the most striking effects noted has been a large, rapid variation in the signal strength observed. These changes occur much too rapidly to be accounted for by the coarse lobe structure of the antenna. In Fig. 13 is a sequence of 25 successive sweeps with the echoes in successive pictures separated by about 4 seconds. It will be seen by comparison between the test signals of Fig. 10 and the actual echo signals of Fig. 13 that, in the fourth line of echo signals, pictures 16 to 20, the decibel levels are about as follows:

Picture No. (Fig. 13)	*Decibel Level*
16	20
17	2
18	20
19	6
20	14

These are separated in time by only about 4 seconds, which corresponds to a change in elevation of the moon of about 0.016 degree, which is a very small amount in terms of the beam width, or even the width of the lobes into which the beam is broken by the ground reflections. This rapid variation in signal level conceivably could be due to rapid bending or absorption of the path through the atmosphere, and this seems reasonable and probable in view of the fact that on numerous occasions, when the equipment appeared to be working in a completely satisfactory manner, no echoes were obtained. Another possibility is that libration of the moon (rotation of the moon with respect to the point on earth from which it is viewed), might account for such variations. At moonrise or moonset this rotation reaches a maximum rate of 3 degrees per day. This corresponds to a (differential) velocity at the outer edge of the moon of about 1 meter per second. That is, in 4 seconds, one edge of the moon moves 4 meters closer to and the other edge 4 meters away from the observer. If large contributions to the particular reflection happen to come from large areas near the edge of the moon, this movement might easily cause large variations in signal strength. This view, however, is not consistent with the concept of random roughness of the moon, and is one of the questions which it is hoped future work will answer. An effort was made particularly to observe variations in signal strength on a day when it was calculated that the rate of libration in both latitude and longitude would be at a minimum, but no conclusive result was obtained.

It should be noted that the photographs of Fig. 13 were obtained with a transmitter peak power output of about 15 kw. According to the calculations given previously, this corresponds to a calculated excess system performance of about 30 db. Neglecting transmission-line losses, depolarization, and atmospheric attenuation, the signals received should have a peak power of 30 db above rms receiver noise. From comparison of Figs. 10 and 13 it is seen that moon echoes in excess of 20 db above receiver noise were obtained.

The effects of extraneous noise, both local and cosmic, have been very bothersome, and the effects are difficult to separate. Interference from ignition systems of passing automobiles, neon signs, harmonics, or other interference from other radio operations, and interference from other laboratory operations are among the local sources which have been identified, together with many unidentified disturbances. A 111.5-Mc narrow-band amplifier (about 100 kc wide using cavity resonant circuits) is included in the rf amplifier system to reject strong near-by signals which might cause cross-modulation difficulties in later stages, but does not aid in eliminating the interference from disturbances within the finally used pass band.

Noise from the sun has been observed in the form of a considerable increase in output noise level, superimposed on which are large bursts of noise of shorter duration. A comparison device in which the antenna connection of the receiver is periodically switched between the antenna and a resistor, with the output of the receiver being synchronously switched from one side to the other of a balance device, has been used as an extremely sensitive means to measure such noise. The resistor is so arranged that the known noise current from a temperature-limited diode may be passed through it to permit calibration of the system.

The noise from the sun has been observed as the sun rises and sets, and the maxima and minima of the antenna lobe structure are discernible as the sun passes through the beam. Observation of the echoes from the moon is usually impossible when the sun is in the same direction as the moon at the time observations must be made. It is outside the scope of this paper to discuss this noise question in more detail, but it is mentioned as one of the difficulties encountered.

From the time when the first moon-radar experiments were performed there appears to have been a progressive increase in the external noise level to an extent that it is frequently difficult or impossible to discern radar echoes from the moon because of the high noise level. Whether the increase has been local or cosmic is difficult to determine, because of the wide antenna beam width and the fact that the present antenna cannot be raised in elevation.

USE OF THE MOON IN COMMUNICATION CIRCUITS

One of the reasons for initiating the moon-radar study was the possibility that the moon might be used to reflect communication signals from one point on earth to another. It is outside the scope of this paper to consider this matter in extended detail, but it will be briefly discussed in the light of the moon radar experiments.

Analytical consideration of the question indicates that communication in this manner is subject to limitations and difficulties which rather discourage its consideration except in extreme situations. Some of these considerations are:

(a) Unless a very narrow-beam-width transmitting antenna is used, the probable multiplicity of reflections from the moon would make necessary complicated apparatus to obtain a wide-bandwidth communication channel.

(b) Unless narrow-beam-width antennas are used, the power requirements are very large.

(c) If narrow-beam antennas are used, the construction of them is difficult, and a tracking problem arises.

(d) A moon-communication circuit is only usable at such times as the moon is simultaneously visible from both receiving and transmitting points.

(e) The long transmission travel time would be objectionable in some cases.

The experiments reported above indicate that some of these considerations are very important, and that there are additional considerations that should also be mentioned.

(f) Examination of Fig. 13 indicates that the attenuation of the earth-moon-earth path is subject to rapid and large variations.

(g) If the attenuation variation mentioned in (f) is due to rapid bending of the path, the problem of using narrow-beam antennas becomes even more difficult.

(h) During periods when the sun and moon both fall in the beam width of the receiving antenna, the noise contribution of the sun will be very high. At other times there may be some contribution of noise from the sun by reflection from the moon, but this will probably be negligible. (It was not identifiable in the moon-radar experiments.)

Thus, while the moon-radar experiments are in themselves a demonstration of the fact that a communication link using the moon as a passive reflector is definitely possible, such a system is subject to difficulties and limitations which make its extensive and general use unlikely, as viewed at present.

In connection with the subject of communication circuits involving the moon, it is interesting to consider the possibility of a one-way radio circuit to the moon. Equation (1) gives the power flow per unit area at the moon at a range R. If a receiving antenna of area A_R' were placed on the moon, it would intercept a power P_R' given by

$$P_R' = S_0 A_R'. \qquad (26)$$

If G_R' is the gain of this receiving antenna, the relation of G_R' and A_R' is given in (4b). Combining (1), (4b), and (26) gives the gain from the transmitter antenna terminals on earth to the receiver antenna terminals on the moon as

$$\frac{P_R'}{P_t} = \frac{571 G_t G_R'}{R^2 F^2}. \qquad (27)$$

It should be remembered that the antenna gains are with respect to an isotropic antenna, R is in meters, and F is in megacycles.

To evaluate the above figures, consider a nondirectional transmitting antenna (gain of 1) and a simple receiving antenna with a gain of 10, at a frequency of 100 Mc. For this case and the range of 4.07×10^8 meters, $P_R/P_T = 3.45 \times 10^{-17}$, or an attenuation of 164.6 db.

Now consider a standard FM broadcast station of 50 kw operating on 100 Mc and an FM receiver operating with a bandwidth of 200 kc. From curve 1 of Fig. 3 the thermal input noise to such a receiver is -121 db with reference to 1 milliwatt and, allowing a receiver noise factor of 5 db, the equivalent input noise is $-121+5 = -116$ db. If it be assumed that a signal 10 db greater than this might give usable FM reception, a -106-db signal would be sufficient for operation of the receiver. The 50-kw transmitter output corresponds, from curve 2 of Fig. 3, to $+77$ db with respect to 1 milliwatt, so the spread between transmitter and receiver is 183 db against the path attenuation of 164.6 db. Thus it is evident that, even without an extraordinary antenna system, an FM broadcast station on earth could be readily received on the moon. In fact, this calculation shows that even a 1-kw FM station could probably be detected. If antennas similar to those used in the moon-radar experiment were used at each end of the circuit, the 164.6-db path attenuation would be reduced to about 127 db. If the path length were then increased to 50,000,000 miles, the attenuation would only be increased by 46 to 173 db, a figure still within the 183-db spread of the 50-kw 200-kc bandwidth FM system. Thus, using only presently developed radio equipment, Mars and Venus also are at times within reach of a 50-kw FM station on the earth, and vice versa.

These speculations, of course, omit consideration of the fading and attenuation observed in the radar experiments and which might make reception difficult. However, in the one-way path considered here, this should be less serious than in the two-way radar path, and if it ever becomes practical to place a nonpassive relay station on the moon, possibly with means for re-generating the signal shapes, earth-point to earth-point-communication via the moon might look much less discouraging.

General Conclusions

The work so far has indicated that, under some conditions, a radio signal can be transmitted from the earth to the moon, be reflected, and again be detected on the earth, and that the character of this path changes materially from time to time, both rapidly and on a long-time basis. The most important observations concern the interesting questions which are raised and which it is hoped future research and experiment will answer.

More detailed information concerning the precise nature of the reflection at the moon should be obtained by use of a pulse narrower than the 0.0116 second required for travel across the moon and back. Fig. 18 shows that with a pulse of 1,000 microseconds the peak return would only be down about 8 db, and the increased bandwidth required for a 0.001-second pulse over the 50-cps bandwidth used in the experiments reported here would increase the receiver noise contribution by 13 db, representing a degradation in system performance of 21 db. Fig. 13 shows just about this excess in system performance for the present equipment arrangement. Thus, with some increase in transmitter power and a compromise pulse width of perhaps 2,000 microseconds, under the best conditions it should be possible to get some indication of return pulse shape with equipment generally similar to that described in this paper, except with wider intermediate-frequency and video bandwidth in the receiver.

It would be desirable to obtain observations of moon echoes over extended periods, not only with a horizontally directed antenna as described, but also with an antenna capable of movement in all directions. The work should also be extended to other frequencies.

Fig. 13 shows the need for an arrangement for transmitting pulses in more rapid sequence so that the effects which occur during the 4-second intervals between the pulses in Fig. 13 can be observed. The effects of noise from the sun and other cosmic sources, and its effect on these operations, should be further investigated.

It is hoped that the plans which have been made for investigating these and other questions can be carried to completion and the results published in a later paper.

Acknowledgments

The authors particularly acknowledge the help of H. D. Webb and J. Mofenson for their extended work in the conduct of this experiment and in the review of this paper, and the contribution of Walter McAfee in discussions of echoing-area problems and review of this paper. Some of the other individuals who made substantial contributions to the work were J. Ruze, O. C. Woodyard, A. Kampinsky, J. Corwin, C. G. McMullen, W. S. Pike, F. Blackwell, H. Kaufman, R. Guthrie, H. Lisman, J. Snyder, G. Cantor, and A. Davis.

APPENDIX

Effect of Reflection from Moon on Shapes and Amplitude of Radio-Frequency Pulses

The shapes and intensity of echo pulses from the moon can be derived on the basis of the assumption that the moon looks, for radio waves in the frequency range considered, like a uniformly illuminated disk. Consider first the situation for a pulse of duration ΔT, which is small conpared to the time required for a wave to travel twice the distance equal to the radius of the moon (that is, the time for a round trip over a path length equal to the radius of the moon). If ΔT is the pulse length, the range interval in miles over which the reflection is obtained is $\Delta X = \Delta T/2 \times 186{,}000$.

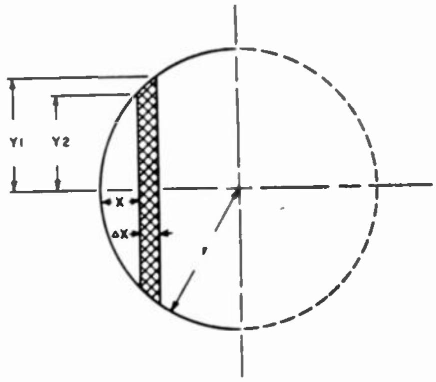

Fig. 14—Short radar pulse passing across the moon.

Referring to Fig. 14, the projected area active in producing a reflection for a pulse of width ΔX is the difference in the circles having radius of y_1 and y_2. That is,

$$\Delta A = \pi Y_1^2 - \pi Y_2^2. \tag{28}$$

By the geometry of Fig. 14,

$$Y_1^2 = r^2 - (r - X - \Delta X)^2 \tag{29}$$

and

$$Y_2^2 = r^2 - (r - X)^2. \tag{30}$$

Combining (28), (29), and (30)

$$\Delta A = 2\pi\Delta X\left(r - X - \frac{\Delta X}{2}\right) \tag{31}$$

and, for the condition stated, that ΔX is small compared to $r - X$ except for the very end of travel, where $r \approx X$, the $\Delta X/2$ may be ignored, leaving

$$\Delta A \approx 2\pi\Delta X(r - X). \tag{32a}$$

In Fig. 15 this is plotted and shows the shape (in terms of *power*) of the returned pulse (observed from a great distance) as the radiated pulse (measured from its trailing edge) passes over the moon. The manner of rise to the peak value $2\pi r\Delta X$ has not yet been considered, but obviously it rises to this value in the time ΔT in some such fashion as shown in the dotted portion of Fig. 15.

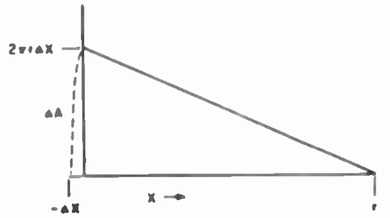

Fig. 15—Shape of return pulse from the moon for very short transmitted pulse. (Curve is on a power basis.)

The manner of rise will be considered in more detail in the analysis of the effect on a pulse wide compared to the moon.

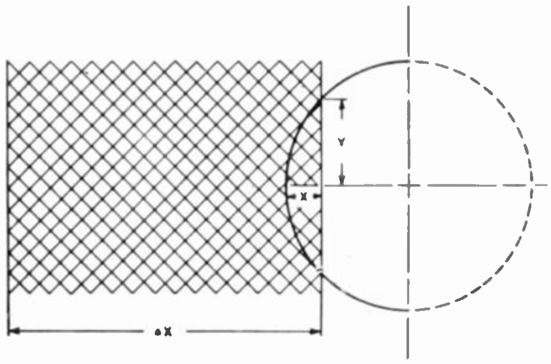

Fig. 16—Long radar pulse passing across the moon.

Consider a pulse such that ΔX is larger than r (see Fig. 16). Now, as the leading edge of pulse starts across the moon, the power returned varies in proportion to the area illuminated—that is, the area illuminated when the leading edge is at point X is

$$A_X = \pi(2rX - X^2). \tag{33}$$

This will continue until X reaches the value r when the pulse levels off to its peak value, corresponding to $A = \pi r^2$, at which level it continues until the trailing edge of the pulse reaches the edge of the moon at which time the power level starts to decrease. The power returned at the time the trailing edge is at position X' measured in the same co-ordinate as X is proportional to the total disk area less the portion left unilluminated, or, now using (33) for the unilluminated area

$$A_{X'} = \pi(r^2 - 2rX + X^2). \tag{34}$$

A plot of the effective area in terms of time which is the power shape of the returned pulse is given in Fig. 17, based on (33) and (34) and the above considerations. In this figure, distances have been converted to a time basis to show the extent of pulse broadening.

For values of pulse width $\Delta T'$ intermediate between ΔT very short and ΔT larger than 0.0116 second, the pulse will rise along the initial rise curve of Fig. 17 to a value given by analogy to (33) as

$$A_{\max}' = \pi(2r\Delta X - \Delta X^2) \tag{35}$$

and then drop linearly for a period of (0.0116 second $-\Delta T$) as shown in Fig. 15. At this point the leading edge of the pulse has reached the center of the moon, and the trailing edge is at $r - \Delta X$ so that the power contributing area has reached an intermediate value given by substituting $r - \Delta X$ for X in (34) or,

$$A_{\text{int}}' = \pi(\Delta X)^2 \tag{36}$$

after which the value then drops to zero as along the main decay curve of Fig. 17. This action has been dotted in on Fig. 17.

Fig. 18 facilitates estimation of the maximum value of area effective for a particular value of pulse width in terms of the area which would be effective if the pulse were wide enough to utilize the full moon. The rising portion of the curve of Fig. 4 has been replotted in Fig. 18 to show area (or echo power) in terms of db relative to power from full area and microseconds transmitted pulse length.

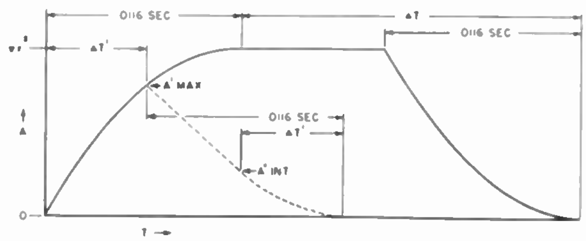

Fig. 17—Shape of return pulse from the moon for very long or fairly long (dotted curve) transmitted pulse. (Curves are on a power basis.)

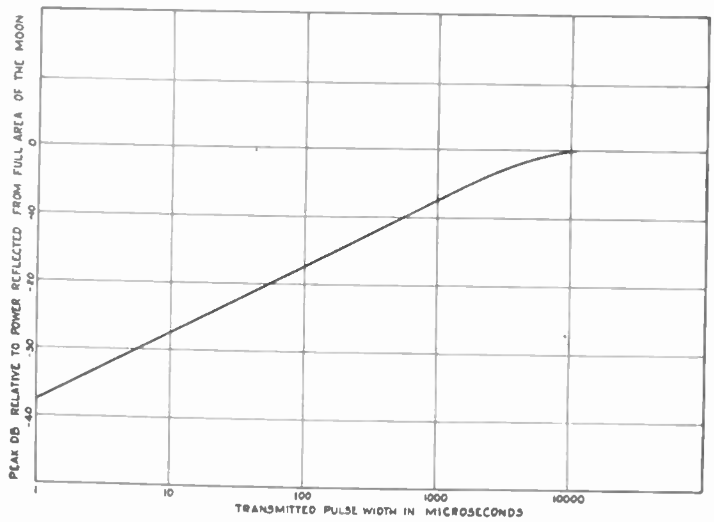

Fig. 18—Peak power reflected from moon as a function of pulse width, in terms of peak power reflected for a very long pulse.

Thus, for example, the peak power level of echo from a 1-microsecond transmitted pulse of a given peak power would be expected to be about 38 db below that of the echo from a 0.05-second transmitted pulse of the same peak power.

In all of the above, the effect of the back side of the moon is ignored, since, at the "line-of-sight" frequencies considered here, it is in a "shadow" region.

Oversea Propagation on Wavelengths of 3 and 9 Centimeters*

J. S. McPETRIE† SENIOR MEMBER, IRE, B. STARNECKI†, H. JARKOWSKI‡, AND L. SICINSKI†

Summary—This paper summarizes the results obtained from tests extending from 1943 to 1946 which were made to determine the meteorological factors controlling the propagation of centimeter waves. Oversea paths of 60 and 200 miles off the West Coast of Great Britain were used for the experiments. Continuous records of radio field strengths and frequent measurements of the meteorological conditions along the paths were made. The correlation between the radio results and the various meteorological parameters is studied in the light of current theories of microwave propagation.

I. Introduction

During the last war, when the importance of centimeter waves was rapidly increasing, it was very soon discovered that our knowledge concerning the propagation of these waves was quite inadequate. According to the then-existing theory of propagation of radio waves along the earth's surface, the useful range of centimeter waves should be limited to receiving positions within optical view of the transmitting antenna. On operational radar, however, it was soon observed that ranges far in excess of the optical horizon were frequently obtained. A new theory of propagation[1] was evolved in which the waves were assumed to be guided round the earth's curvature by superrefraction of the waves in the lower regions of the atmosphere due to particular distributions of water vapor and temperature. It was necessary to check how far this theory agreed with the experimental results, and whether there were any other factors influencing propagation which had not been taken into account. Another important requirement was to determine whether there was any possibility of forecasting the signal level purely from our knowledge of the general meteorological conditions, such as are given by synoptic charts, since the paramount influence of meteorological conditions upon the propagation of centimeter waves was already appreciated.

Following upon a recommendation by the Ultra-Short Wave Panel of the British Ministry of Supply, in 1941 an extensive series of experiments on centimeter-wave propagation over sea was started by the Signals Research and Development Establishment of the Ministry of Supply, in collaboration with the British Admiralty.

It was originally planned to build a number of fixed radio stations on the South Coast of England and to use paths in the English Channel between Beachy Head and the Lizard, but this plan was discarded as it was considered that these paths would be too close to enemy territory. Paths across Cardigan Bay and the Irish Sea were finally chosen, and G. W. N. Cobbold of the Signals Research and Development Establishment found the most suitable sites. These were located in the neighborhoods of Fishguard, in South Wales, Aberdaron, in North Wales, and Portpatrick, in Scotland. At each center the Signals Research and Development Establishment built two stations at different heights, as described more fully below.

These stations were in continuous operation for about three years, closing down in June, 1946, and an enormous amount of data in the form of recordings of field strengths, calibration charts, recordings of meteorological conditions, etc., have been collected. The aim of this paper is to present a short description of the experimental work, and also to analyze as completely as possible the results obtained.

II. Description of the Stations and Equipment

All these stations were referred to by letters A, B, C, etc., by the personnel and establishments concerned, and for convenience this nomenclature will be used throughout the paper.

Transmitter Locations

Station A—540 feet above sea level at Garn Fawr, near Fishguard, Pembrokeshire, South Wales.

Station B—93 feet above sea level at Strumble Head, near Fishguard, Pembrokeshire, South Wales.

Receiver Locations

Station C—826 feet above sea level at Rhiw, Caernarvonshire, North Wales.

Station D—97 feet above sea level at Aberdaron, Caernarvonshire, North Wales.

Station E—375 feet above sea level at Knockharnahan, Wigtownshire, South West Scotland.

Station F—93 feet above sea level at Portpatrick, Wigtownshire, South West Scotland.

It was thus possible, using these six stations, to work eight different radio links, the distances and "inverse opticalities"[2] of which are given in Table I.

All the sites were chosen so as to have a clear view to the sea. A map (Fig. 1) shows the position of the Welsh stations.

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† Signals Research and Development Establishment, Ministry of Supply, Christchurch, Hampshire, England.

‡ Formerly, Signals Research and Development Establishment; now, somewhere in Poland.

[1] H. G. Booker and W. Walkinshaw, "The mode theory of tropospheric refraction and its relation to wave guides and diffraction," from, "Meteorological factors in radio-wave propagation," pp. 80-127. (Report of a Conference held April 8, 1946, at the Royal Institution, London, by the Physical Society and the Royal Meteorological Society.)

[2] The "inverse opticality" is defined as the ratio d/d_1+d_2 where d_1 and d_2 are the horizon distances of the two stations, and d is the distance between them. In this paper the horizon distances are calculated using the true-earth radius, not the effective radius.

TABLE I

Link	Great Circle Distance (miles)	Inverse Opticality
A–C	59.2	0.9
A–D	57.0	1.4
A–E	195.5	3.7
A–F	196.3	4.9
B–C	57.9	1.3
B–D	55.7	2.3
B–E	194.0	5.5
B–F	194.6	8.2

Each station was provided with four "windows" through which transmitting or receiving paraboloids could be directed, thus permitting the simultaneous operation of four sets. Observations have been made on two centimeter wavelengths—9.2 and 3 cm, and also on a wavelength of 3.45 meters (using external Yagi antennas). Meteorological measurements (pressure, temperature, humidity, wind-speed, etc.) have been taken along the paths and also at each station. During a period of a few months of the project a large number of meteorological observations were made by ships of the Royal Naval Meteorological Service in Cardigan Bay, including observations up to 200 feet by means of balloons. These were replaced later by aircraft making the necessary observations in a manner shortly to be described.

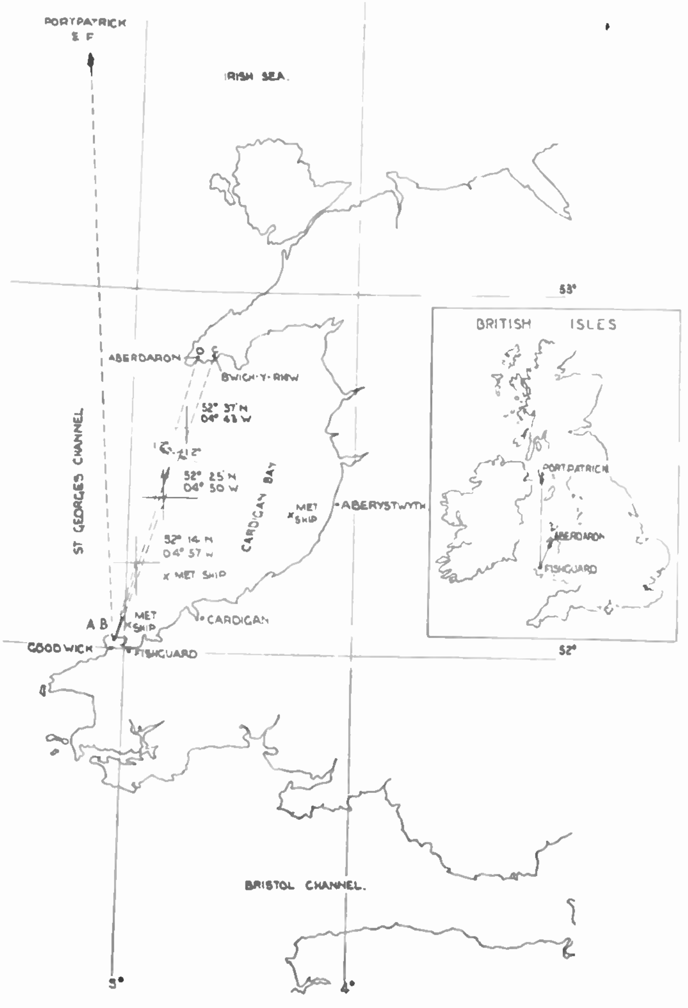


Fig. 1—Geographical disposition of the West Coast stations.

The radio stations were manned by SRDE personnel, the centimeter-wave measuring equipment having been developed and supplied by the Research Laboratories of the General Electric Company under contract to the Admiralty. A preliminary analysis of the results during the first two years of operation has been carried out by the National Physical Laboratory, which has also developed and provided some monitoring equipment for the centimeter-wave sets. The 3.45-meter equipment has been installed by the Admiralty.[3–5]

The Research Laboratories of the General Electric Company have also produced, under contract to SRDE, a 3-cm duplex radiotelephone set[6] which was used for communication between Stations A and C (i.e., along the optical path).

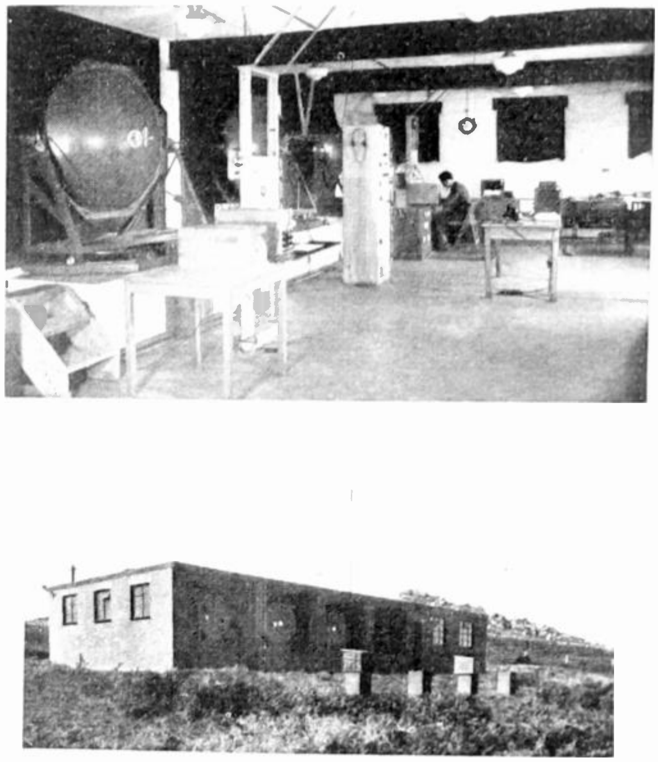


Fig. 2—Operations room and front view of Station A.

Fig. 2(a) shows an inside view of the operations room at Transmitting Station A. In the background is a 9-cm-band transmitter, in the middle is the 3-cm-band duplex radiotelephone set, and in the foreground is a 3-cm-band transmitting set. Some monitoring equipment can also be seen on the table in the foreground.

[3] R. L. Smith-Rose and A. C. Stickland, "An experimental study of the effect of meteorological conditions upon the propagation of centimetre radio waves," from, "Meteorological factors in radio-wave propagation," pp. 18–37. (Report of a Conference held April 8, 1946, at the Royal Institution, London, by the Physical Society and the Royal Meteorological Society.)

[4] H. Archer-Thomson and E. M. Hickin, "Radio technique and apparatus for the study of centimetre-wave propagation," *Jour. IEE*, Part IIIA, vol. 93, pp. 1367–1373; March, 1946.

[5] E. C. S. Megaw. "Experimental studies of the propagation of very short radio waves," *Jour. IEE*, Part IIIA. vol. 93, pp. 79–97; March, 1946.

[6] H. R. L. Lamont, R. G. Robertshaw, and T. G. Hammerton, "Microwave communication link," *Wireless Eng.*, vol. 24, pp. 323–332; November, 1947.

TABLE II

Link	Inverse Opticality	Wavelength
A–C	0.9	3 cm
B–C	1.3	9.2 cm
B–D	2.3	3.45 m
B–D	2.3	9.2 cm
B–D	2.3	3 cm
B–D'*	3.1–3.6	9.2 cm
B–D'*	3.1–3.6	3 cm
A–E	3.7	9.2 cm
A–E	3.7	3.45 m

* During October, 1945, some short-term trials were carried out on 3 and 9 cm between Station B and receivers situated on the beach near Station D. The height of the receivers above sea level varied between 10 and 20 feet, depending upon the tide, giving "inverse" opticalities from 3.1 to 3.6. D' refers to these temporary receivers.

Fig. 2(b) is a front view of Station A. The two boxes mounted on pillars in front of the building contain monitors for checking the output of the senders.

This paper is concerned mainly with the presentation and detailed analysis of the radio and meteorological results which were obtained during the five-month period from July to November, 1945. The greatest number of links were in operation during this period. Details of the various links are given in Table II.

It should be noted, however, that a similar analysis has been carried out for the period between July, 1944, and July, 1946. The results obtained during the whole period were quite consistent and similar during the corresponding periods of the year. Thus the conclusions reached seem to have quite a general validity—limited, of course, to the particular climatic and geographical conditions under which the experiment has been carried out.

III. Measurements

A. Radio

Signals transmitted from Stations A and B were continuously recorded at the receiving stations by means of recording milliammeters of the Evershed and Vignoles pattern. These recorders are of the pen-and-paper type. The chart speed normally used was one inch per hour.

The centimeter-wave receivers were calibrated at intervals by means of signal generators, and calibration

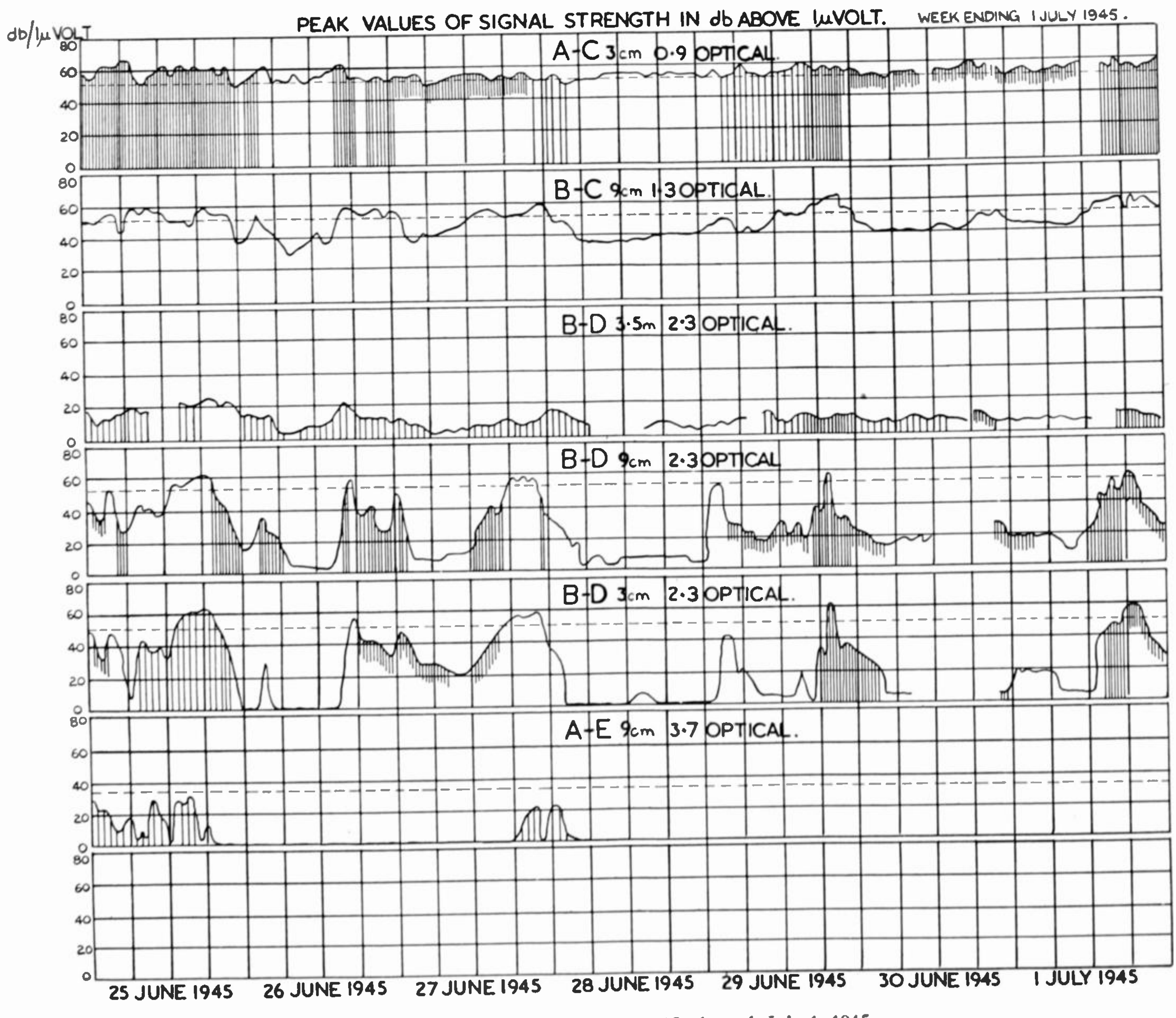


Fig. 3—Peak-value curves, June 25, 1945, through July 1, 1945.

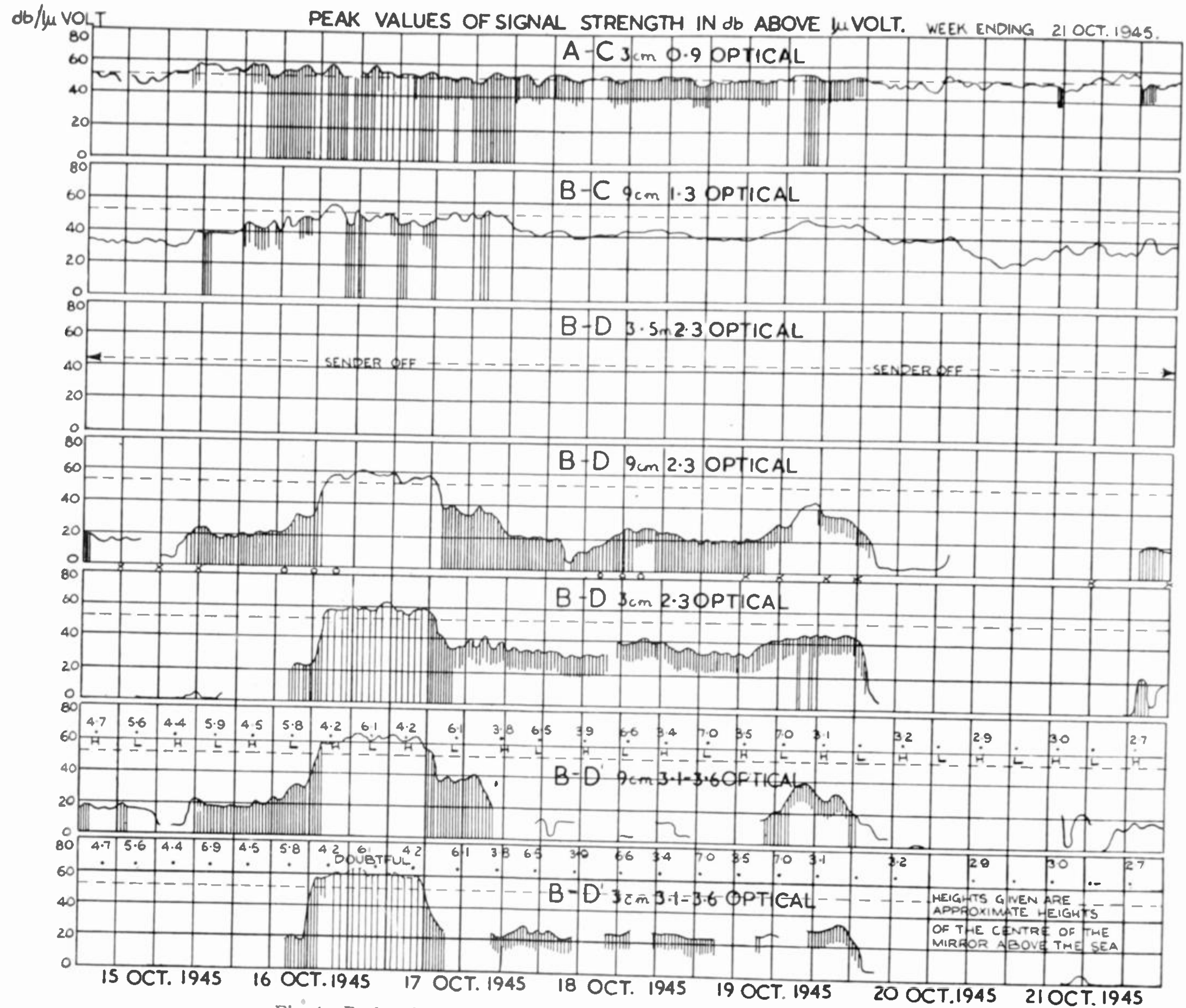


Fig. 4—Peak-value curves, October 15, 1945, through October 21, 1945.

curves were prepared showing the relationship between the recorder reading (ma) and the input to the receiver (db above 1 μv). The calibration of the receivers (including mirror gain) was checked from time to time by monitors of National Physical Laboratory design.[7]

The power radiated by the centimeter-wave senders (of the order of 0.3 watt for the 9-cm band and 0.075 watt for the 3-cm band) was checked from time to time by bolometer bridges (also of National Physical Laboratory design).

The received-signal levels for the 9- and 3-cm-band links cannot be compared directly, as the power and mirror gains are different for the two wavelengths. Correcting terms have been worked out so that, when these are applied to the received-signal levels, the resulting values for both 9- and 3-cm band are those which would have been obtained if the powers and mirror gains had been such as to give the same free-space field strength. A standard free-space field strength of 52 db above 1 μv input to the receiver has been fixed for the short links (South Wales to North Wales), and the appropriate "normalizing" corrections are applied to both the 9- and 3-cm signal levels. On the same basis, the standard free-space field strength for the long links (South Wales to Scotland) works out to be 34 db above 1 μv.

The free-space field strengths for the meter-wave links have not been worked out very accurately, and so the numerical results for the meter wavelengths should be treated with caution.

A direct analysis from an examination of the recorder charts is difficult, chiefly due to the great lengths of chart involved (60 feet per month), and so condensed plots were prepared showing the peak values of signal strength ("normalized" to 52 or 34 db above 1 μv). On the same curves the depth and periodicity of fading is indicated by vertical shading. Figs. 3 and 4 show examples of these condensed plots. Each group is described by a letter and numbers denoting the link, frequency, and opticality. The peak value, rather than the

[7] J. A. Saxton and A. C. Grace, "A field strength meter and standard radiator for centimetre wavelengths," *Jour. IEE*, Part IIIA, vol. 93, pp. 1426–1430; 1946.

more usual mean value, of signal strength was used, as it was considered that the physical phenomena determining the received field strength could be more readily interpreted in this way, whereas they could be completely masked using mean values. For example, if the factors involved were due to the arrival at the receiving antenna of two interfering rays of equal amplitude and varying phase relation, the peak value of the received field strength would be double that due to either component ray alone. The depth of fading also would bring the received field strength to zero. These two results give some indication of the nature of the phenomena involved. The mean value of field strength, on the other hand, need have no correlation with the physical conditions determining the received field. The use of peak values also saves labor in computation.

The accuracy of the measurements is considered to be better than ± 2 db on the 9-cm band for signal levels greater than 4 db above 1 μv and on the 3-cm band for signal levels greater than 8 db above 1 μv, but is rather worse than this for the meter wavelength.

B. Meteorological

The results of an extensive series of meteorological soundings made along the Fishguard to Aberdaron path are available for the period from September, 1945, to June, 1946.

Aircraft were used, and both horizontal and vertical flights were made. On about two days per week the following procedure was carried out:

Four planes flew in formation from Fishguard to Aberdaron at heights of 50, 250, 500, and 1,000 feet, and returned at heights of 100, 250, 750, and 1,500 feet, the 250-foot flight being used as a reference level. Usually, the lowest plane would interrupt its horizontal flight in order to make a vertical sounding at each of the three positions indicated in Fig. 1 by means of latitude and longitude figures.

Usually three of these schemes were carried out in one day during the hours of daylight.

On about three days per week the following procedure was carried out:

Vertical soundings of the atmosphere in the neighborhood of the center of the path were carried out by a single plane. Four observations per day were made, including one during the hours of darkness.

Readings of wet- and dry-bulb thermometers were taken on the plane, thus giving the temperature and the humidity. From these wet- and dry-bulb readings and the pressure (obtained from synoptic charts), the excess of modified refractive index M of the atmosphere can be calculated* and graphs showing the variations of M along the path may be drawn. Fig. 5 shows two examples of the results obtained for two extreme cases, Fig. 5(a) being an example of a very turbulent atmosphere, and Fig. 5(b) an example of a fairly well-stratified atmosphere. The majority of cases are more like Fig. 5(a) than Fig. 5(b).

It can be seen that the analysis of such irregular results is difficult, and that any method based on calculating mean values of modified-index excess for the whole path would be useless. After some trials it was found that fairly regular and interesting results might be obtained by dividing the whole path into three approximately equal portions, calculating the mean values of modified-index excess for different levels of each portion, and then taking these as representative of the given portion.

Examples of such modified-index-excess curves are shown in Figs. 6(a), (b), and (c), and 7(a), (b), and (c), for three portions of the Fishguard-Aberdaron link labeled "first 18 miles," "second 18 miles" and "last 20 miles," the distance being measured from Fishguard. (The horizontal lines on the curves show the spread of the values measured for each portion.) It can be seen how these curves vary along the path. The curves in Fig. 6 are of particular interest, showing the gradual disappear-

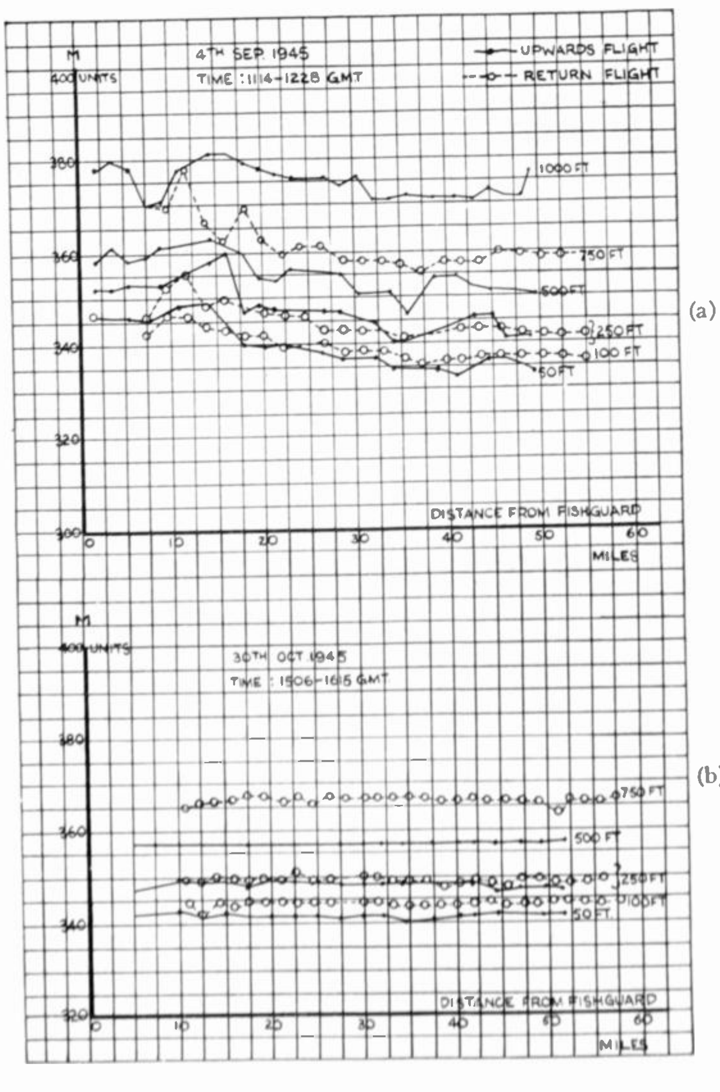


Fig. 5—Variations of modified refractive index along the path between Fishguard and Aberdaron.

* $M = \left(n + \frac{h}{a} - 1\right) 10^6$

where n = optical refractive index
h = height
a = radius of earth in same units as h
and the units of M are called "M-units."

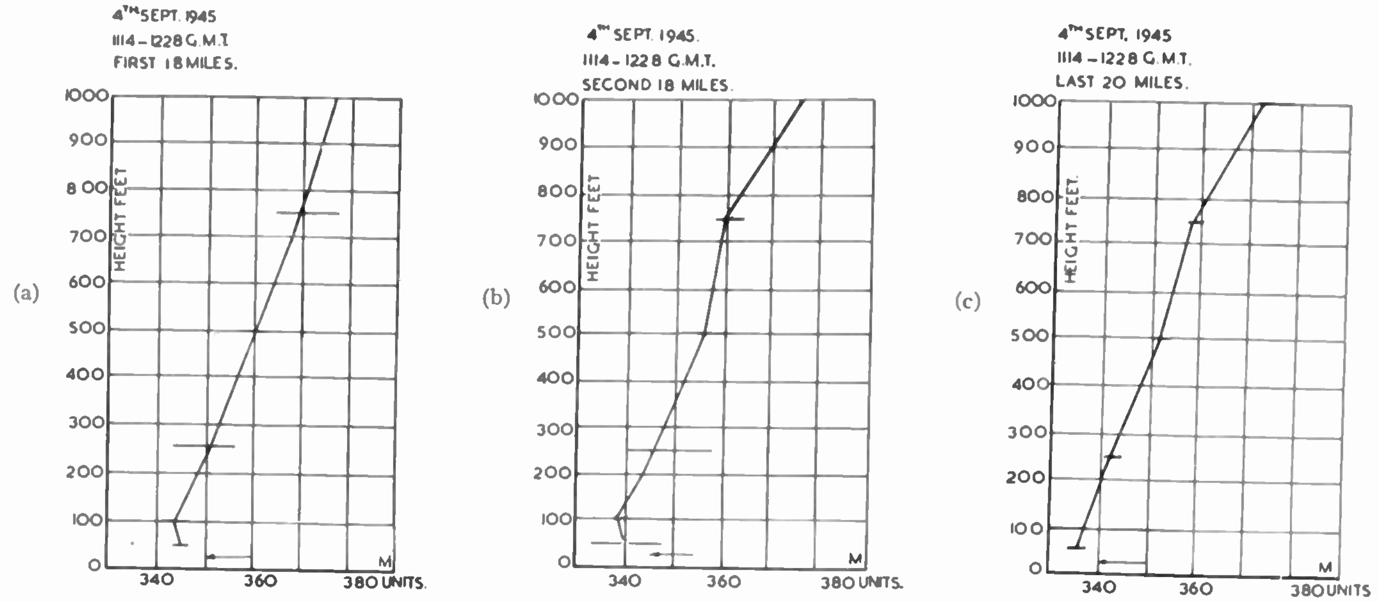


Fig. 6—M curves for the Fishguard—Aberdaron path.

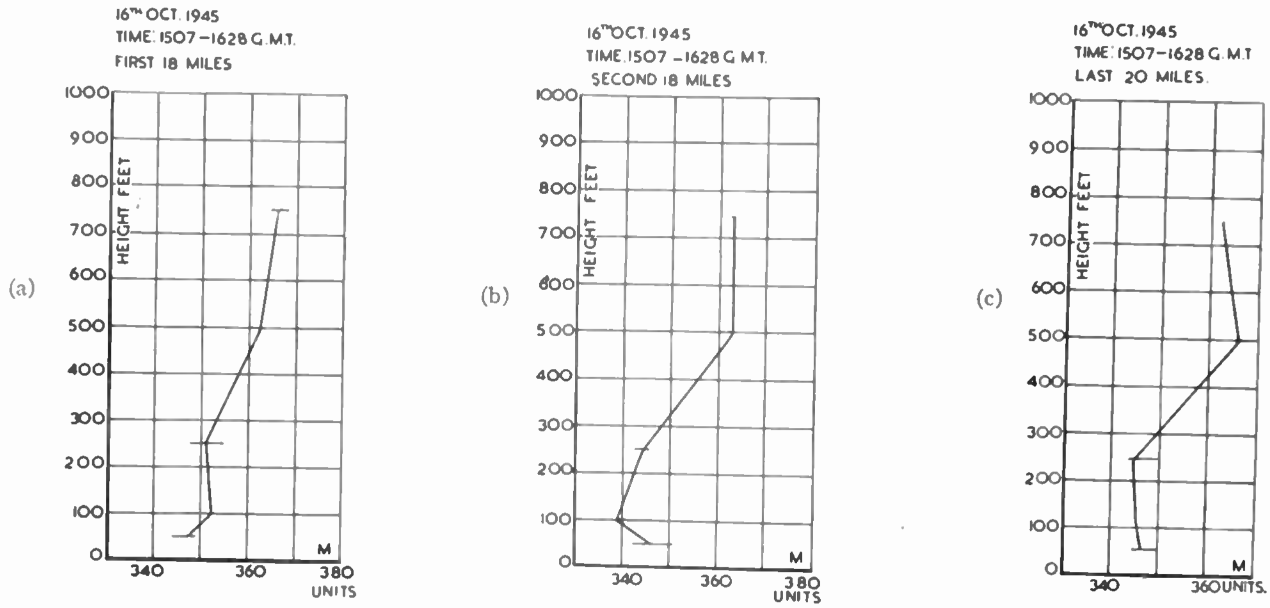


Fig. 7—Divided in three portions.

ance of an atmospheric duct (see Section IV(2)) when approaching Aberdaron.

IV. Theoretical Data

In order to analyze the experimental data and to compare them with existing theories on propagation, theoretical curves have been prepared in the following way:

(1) The most comprehensive set of formulas and curves for calculating the field strength in the interference and diffraction zones for normal propagation[9] has given given by Domb and Pryce.[10] Using their data, curves have been prepared giving the signal level in db above 1 μv input to the receiver as a function of the gradient of modified-index excess. These curves are valid for normal propagation within the optical range (interference zone) and in the nonoptical range (diffraction zone). Perfect stratification and a constant positive modified-index gradient have been assumed. Figs. 8(a), 8(b), and 8(c) represent such curves calculated for all links and frequencies investigated in the paper. The dot-circle points on the curves indicate the "cutoff" or the limit of radio visibility, and the arrows marked "standard" indicate the gradient of the standard atmosphere (3.6 M-units per 100 feet).

(2) According to modern ideas about microwave propagation, particularly beyond the optical horizon, the ranges obtained are very sensitive to the distribution of water vapor and temperature in the lower regions of the atmosphere. Superrefraction occurs when the distribution with height is such that the gradient of modi-

[9] In this paper the term "normal propagation" refers to propagation through an atmosphere with any constant positive refractive-index gradient. The "standard" value of this gradient is 3.6 M-units per hundred feet.

[10] C. Domb, and M. H. L. Pryce, "The calculation of field strengths over a spherical earth," *Jour. IEE*, Part III, vol. 94, pp. 325–336; September, 1947.

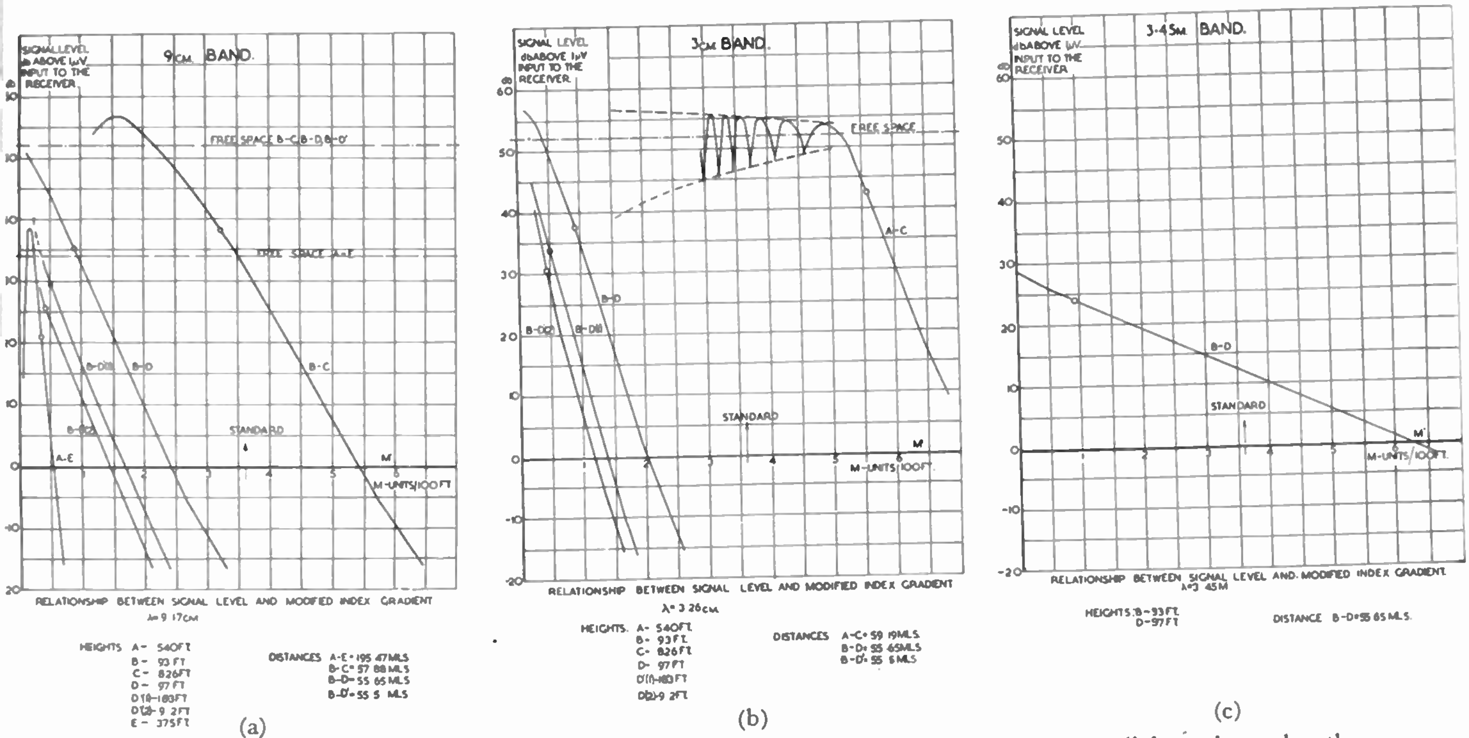


Fig. 8—Relationship between signal level and modified refractive-index gradient for different links and wavelengths. The dot-circle points indicate the "cutoff."

fied refractive index is negative over a range in values of height. For such conditions, a part of the energy in the radio waves is trapped, and so guided along the layer having this negative gradient. Such layers are called atmospheric ducts; they act very much like waveguides and show the same characteristic, in that the maximum wavelength which is trapped increases with increase in width (i.e., height) of the duct.

Several types of atmospheric profiles connected with radio refraction in the troposphere can be encountered in practice. It was found that most of these profiles can be described analytically by means of a formula containing Gamma functions but, unfortunately, this formula contains too many variable parameters to be of practical use. Several attempts were made to use simpler forms for describing the distribution of the refractive index in the troposphere (such as bilinear, power, or exponential distribution), but the use of most of them for numerical computation is difficult.

A comprehensive set of curves for calculating the field strength has been computed by Hartree and others[11] using the power distribution of refractive index of the form

$$\mu^2 = 1 - 2K_\infty\left(h - \frac{d^{1-m}h^m}{m}\right) \qquad (1)$$

where

$\mu = N/N_0$
$N = n + h/a$
$N_0 = (N)_{h=0}$

[11] D. R. Hartree, J. G. L. Michel, and Phyllis Nicolson, "Practical methods for the solution of the equations of tropospheric refraction," from, "Meteorological factors in radio-wave propagation," pp. 127–168. (Report of a Conference held April 8, 1946, at the Royal Institution, London, by the Physical Society and the Royal Meteorological Society.)

K_∞ = the curvature, at a great height, of a "modified" ray (assuming a flat earth) in radians per feet
N = the modified refractive index
h = the height in feet
d = the duct height in feet
a = the radius of the earth in feet
n = the optical refractive index.

As regards m, it is a common meteorological assumption[12] that the variation of wind speed with height may be represented over a certain range by the following formula:

$$v = Ah^m \quad \text{for} \quad 0 < m < 1$$

where

v = the wind speed
A = a constant
m = the parameter in this formula, sometimes known as the profile index.

Equation (1) corresponds to a so-called ground-based duct, of which typical examples for various duct heights and values of m are shown in Fig. 9. (Fig. 7 shows an experimental M curve with a rather infrequently occurring "elevated" duct.)

It will be seen later that, although this type of distribution corresponds to only one particular type of atmospheric duct, the numerical results obtained agree fairly well with the experimental data.

The curves (Figs. 10(a), (b), etc.) have been plotted for all the nonoptical links, in some cases for various different values of K_∞ and m. Usually, only the first mode (labeled $j=1$) could be calculated with appreciable accuracy. The second mode has been calculated completely in some cases, but only the positions of the

[12] D. Brunt, "Physical and Dynamical Meteorology," Cambridge University Press, Second Edition, p. 251, 1939.

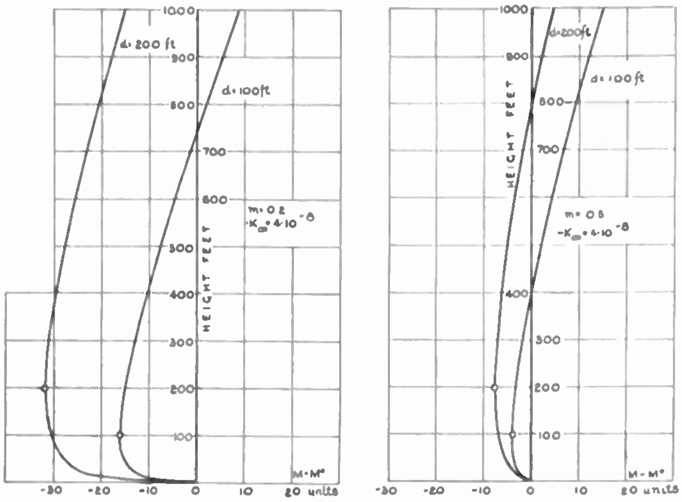


Fig. 9—Typical M curves for ground-based ducts. Variation of refractive index:

$$\mu^2 = 1 - 2K_\infty\left(h - \frac{d^{1-m}h^m}{m}\right)$$

$$M - M_0 = \tfrac{1}{2}(1-\mu^2)10^6.$$

maxima for the others. From Fig 10 it can be seen that, for the highly nonoptical links (B–D or A–E), the graphs of field strength against duct height for the first and second modes do not overlap appreciably, and thus the field strength for a given duct height can be obtained fairly accurately by using only the graphs of the first mode. For some links, however, the graphs for the two modes do overlap, and the field strength at certain duct heights can be obtained only by adding the separate field strengths for the first two modes, taking into account the phase relationship between them. Unfortunately, it is not possible to calculate the phase from the existing curves and tables and, therefore, in such cases only approximate results can be obtained.

It can also be seen from the curves that, for the B–D links, the results obtained for different values of m differ only slightly, and that for other links the influence of m is considerable. As it is not possible to take into account all possible values of m, usually only one set of curves for a particular value of m is taken as representative of the theory. This again results in a certain loss of accuracy.

Equation (1) can be modified in the following way: As

$$M = \left(n + \frac{h}{a} - 1\right)\cdot 10^6$$

and

$$N = n + \frac{h}{a},$$

we get

$$N = M\cdot 10^{-6} + 1;$$

and if

$$(N)_{h=0} = N_0$$

and

$$(M)_{h=0} = M_0,$$

then

$$\mu = \frac{N}{N_0} = \frac{M\cdot 10^{-6}+1}{M_0 10^{-6}+1}$$

$$\therefore\quad M = (M_0 + 10^6)\mu - 10^6.$$

Since

$$\mu \simeq 1,$$

we get

$$M \sim M_0 + (\mu - 1)\cdot 10^6. \tag{2}$$

From (1),

$$\mu^2 - 1 = -2K_\infty\left[h - \frac{d^{1-m}h^m}{m}\right]$$

$$= (\mu-1)(\mu+1)\,.$$

But, since $\mu + 1 \simeq 2$,

$$\therefore\quad (\mu - 1) = -K_\infty\left[h - \frac{d^{1-m}h^m}{m}\right]. \tag{3}$$

From (2) and (3), we get

$$M = M_0 - K_\infty\left[h - \frac{d^{1-m}h^m}{m}\right]\cdot 10^6. \tag{4}$$

The more convenient form of (4) is

$$\frac{M - M_0}{h} + K_\infty 10^6 = \frac{d^{1-m}}{m}K_\infty 10^6 h^{m-1}. \tag{5a}$$

Equation (5a) can be written in the form

$$\log y = \log A + b\log h \tag{5b}$$

where

$$y = -\left[\frac{M - M_0}{h} + K_\infty 10^6\right]$$

$$b = m - 1$$

$$A = -\frac{d^{1-m}}{m}K_\infty 10^6.$$

Assuming that the value of K_∞ is known, it is possible from the meteorological soundings to compute y. When the values of y are plotted on logarithmic paper against h, it is possible to draw the straight line which agrees best with the experimental data. (See Fig. 11.) From this line it is relatively easy to find the theoretical curve corresponding to (4) which best fits the results of meteorological soundings, or, in other words, to determine both the duct height d and the parameter m much more accurately than by using the original curves, such as those given in Fig. 9.

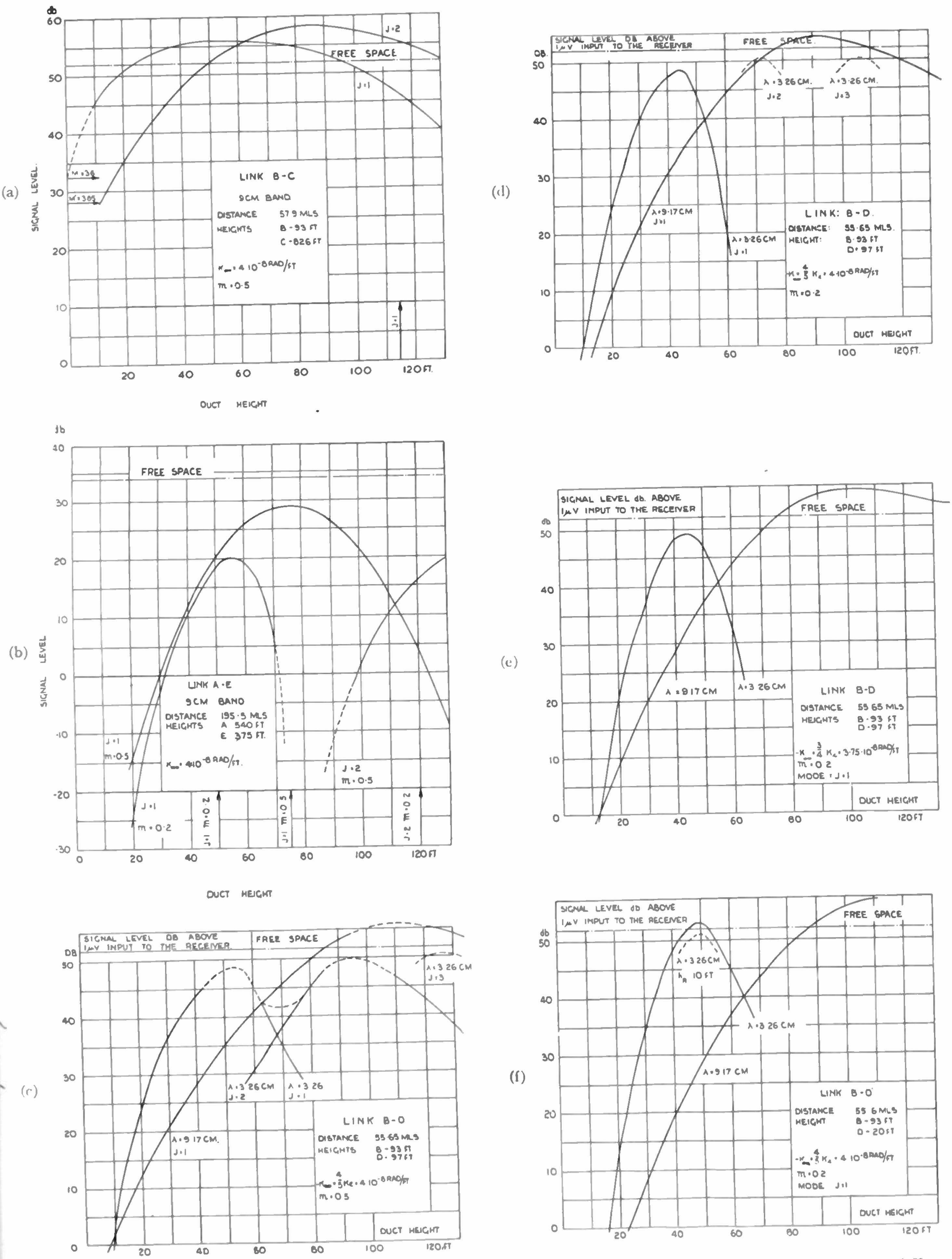


Fig. 10—Relationship between signal level and duct height for different links and wavelengths and for different values of m and K_∞.

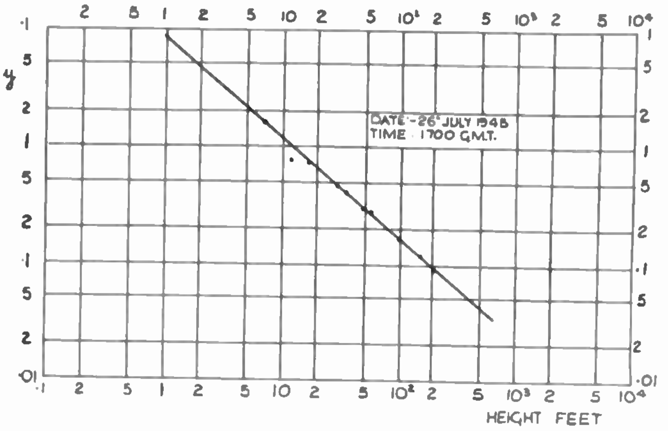


Fig. 11—Relationship between modified refractive index and height in the form $\log y = \log A + b \log h$.

(3) As mentioned in Section III (2), the meteorological conditions are seldom uniform along the path of propagation, and it may be assumed that in several cases of unorthodox propagation the existing atmospheric ducts would not cover the complete length of the path, but only a part of it. (An example of such a partial duct is shown in Fig. 6.)

G. H. Tait, formerly of SRDE, has solved the problem of partial ducts theoretically, although assuming bilinear distribution of the modified refractive index M instead of the distribution given by (1).

Fig. 12 shows an example of the results obtained by using that theory for a particular case corresponding roughly to the conditions for the B–D link (height of the transmitter, 100 feet; height of the receiver, 65 feet) for a wavelength of 10 cm. The curve in Fig. 12 shows the loss in signal strength due to the absence of a part of the duct, in comparison with the signal strength for a duct covering the whole length of the transmission path.

V. Analysis of Experimental Results

A. General

From a superficial analysis of the peak-value graphs (e.g., Figs. 3 and 4) for the whole investigated period, the following general observations can be made.

The variations in the 3-cm-band signal strength for the optical (A–C) link are in the main small—only a few decibels above and below the free-space value. A striking point is the occurrence of pronounced fades when the signal on the nonoptical path (B–D) is strong. When

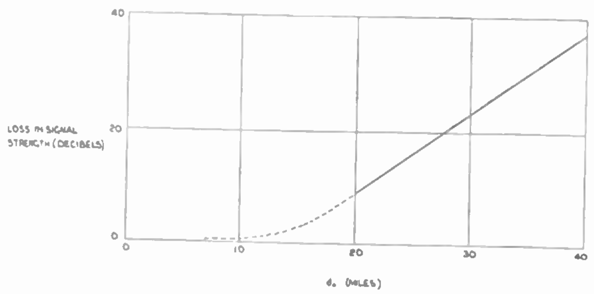


Fig. 12—Loss in signal strength due to gap of length d_0 in duct between transmitter and receiver. Transmitter height = 100 feet. Receiver height = 65 feet. $\lambda = 10$ cm.

there is no reception or poor reception on B–D, the A–C signals are usually very stable. It might be noted here that communication on the 3-cm-band radiotelephone link (operated on the A–C link) was fairly good, even during the periods of deep fading.

The slightly nonoptical link, B–C, shows larger long-term variations (of several hours' duration) on the 9-cm-band wavelength than does the optical link, but it is exceedingly stable as far as the short-period fades are concerned. It is apparent that such a slightly nonoptical link is well-suited for communication purposes because of the absence of short-period deep fades, which are usually those which affect reception most seriously.

In general, the nonoptical links B–D and B–D′ working on the 9-cm band and the 3-cm band show great similarity (e.g., Figs. 3 and 4). Usually the 9-cm-band links show less fading than the 3-cm band, but there are periods when the 3-cm-band links are better from this point of view.

The general shape of the meter-wave field-strength curves on the B–D link is usually similar to the 9-cm band curves on the B–C link, but considerably more fading appears on the meter-wave records.

The 9-cm-band long link A–E (3.7×optical) very rarely gives readable results; what results there are usually occur during periods of strong signals on the B–D links.

B. Comparison Between Experimental and Theoretical Data

A comparison between the radio and meteorological results would be fairly simple if only the atmospheric conditions were sufficiently uniform; i.e., if the gradients of modified refractive index were constant throughout the whole path and at different heights, or if the ducts, when present, covered the whole path. As a matter of fact, however, the meteorological results show very considerable irregularities. The gradients are very variable and change with height in an irregular manner, and when measurable ducts are present they usually cover only a part of the path between the transmitter and receiver. The analysis is even more difficult, because of the following limitations:

(a) The meteorological soundings were taken at fairly large height intervals (not less than about 50 feet).

(b) Only a limited number of observations were available for heights less than 50 feet. Such soundings as can be obtained for these low levels were based on ship measurements made at some distance from the path of propagation. (See Fig. 1.)

(c) The instrumental errors involved in the meteorological soundings may be considerable. In particular, a pressure altimeter was used to indicate the height in the aircraft measurements.

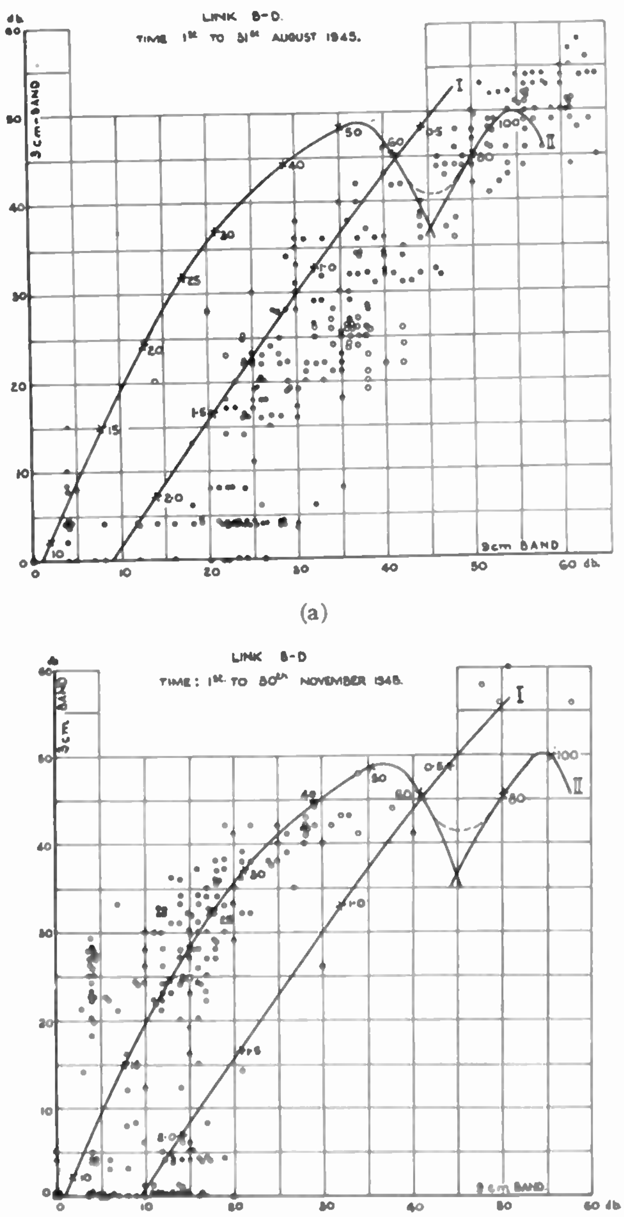
(d) The meteorological results which are combined to form a single graph have not been measured simultaneously, since it takes about half an hour to fly from Fishguard to Aberdaron.

As a result of all these difficulties, it is not possible to make a direct comparison between the radio results and such theoretical curves as are shown in Figs. 8 and 10, but some rather roundabout methods are necessary to find any correlation at all.

(a) *Analysis of the 9-cm-band B–C link* (*1.3×optical*). At first glance the B–C link might be expected to behave according to the theory of normal propagation, since the link is only slightly nonoptical and the probable paths of the rays lie, for the greater part of their length, above any probable meteorological ducts. Assuming that the modified-refractive-index gradient is uniform and that the propagation is normal, we can use the results of Domb and Pryce (Fig. 8(a)) to calculate what gradients of modified-index excess correspond to the field strengths obtained from the "peak values" graphs (Fig. 3). We can now use the previously mentioned partition of the path into three portions. Tracing the probable path of the rays between the transmitter (about 100 feet) and receiver (about 800 feet), it can be seen that in the first portion the path will lie below 100 feet, in the central portion between sea level and 300 feet, and in the last portion between 300 feet and 800 feet. An attempt was made to find out whether the gradients for modified refractive index calculated from the observed field strengths corresponded to actual values of gradients as obtained from meteorological soundings at the appropriate heights in the different portions of the link. It was found that in about 80 per cent of all the cases (the total number of cases analyzed being fifty-one), the calculated gradients did correspond to the measured ones in all the three portions of the path. Without this artifice of path division, little correlation between theoretical and experimental results could be obtained. This result suggests that the Domb and Pryce curves, with some modifications, can be applied for the analysis of normal propagation in an atmosphere where the gradient is not uniform along the transmission path. It may be shown by different methods that the theoretical curves can be used with good results for such an atmosphere, if a mean value of gradient is assumed at appropriate heights for the whole path, but this problem will be dealt with in a separate paper.

(b) *Analysis of B–D link* (*2.3×optical*) *on 9- and 3-cm bands.* As the B–D link is a greatly nonoptical low-level link (both receiver and transmitter at about 100 feet above sea level), we might expect that the propagation will be sometimes normal and will sometimes depend upon superrefraction. An attempt was made to find the percentage of cases due to these two modes of propagation and to analyze in some detail the applicability of the existing duct theories to such complicated meteorological conditions as have been found in the present experiment.

(1) First of all, a comparison was made between the field strengths measured simultaneously on the 9- and 3-cm bands. Corresponding values of field strength for 9- and 3-cm bands at two-hour intervals have been plotted for one month on the same figure (see, for example, Figs. 13(a) and 13(b)). Also, on the same figures are shown curves representing the theoretical dependence between the 9- and 3-cm band levels (as obtained from theoretical curves of Figs. 8 and 10). Curve I corresponds to normal propagation, and the figures marked on it represent the appropriate values of the gradient of modified index excess. Curve II corresponds to guided propagation, with the assumptions specified on Fig. 10(d), and the figures in this curve represent the appropriate duct heights (in feet). The results of Figs. 13(a) and 13(b) are typical for the whole investigated period. From Fig. 13(a) it can be seen that, in the lower part, the points are concentrated rather according to the Domb and Pryce normal propagation curve (gradients between 0.8 and 2 M-units per 100 feet), but the high-intensity points correspond better to the duct theory (ducts of 80 feet or more). In Fig. 13(b) the points are



(a)

(b)

Fig. 13—Relationship between signal levels of 3- and 9-cm bands, $B-D$ link.
(a) Theoretical curve for normal propagation.
(b) Theoretical curves for guided propagation.

concentrated along the theoretical curve for superrefraction with duct heights between some 20 and 40 feet, but again weaker signals correspond better to the normal propagation curve with gradients above 2 M-units per 100 feet.

For the whole investigated period (between July, 1945, and June, 1946), four months, September, October, November, and December, 1945, gave results similar to Fig. 13(b); July and August, 1945, and June, 1946, gave results similar to Fig. 13(a). Three winter months (January, February, and March, 1946) gave results similar to Fig. 13(b), but the corresponding duct heights were lower (15 to 30 feet). Two months (April and May, 1946) gave intermediate results. (The points were scattered along both theoretical curves I and II). If the atmosphere were uniform along the path, these results would mean fairly good agreement between theory and experiment, showing that the propagation is sometimes normal and sometimes due to ducts.

Analyzing the curves, we can risk the following deductions:

(i) The propagation during autumn and winter (September–March) suggests the presence of low atmospheric ducts (between 15 and 50 feet) for the greater part of the period.

(ii) During the summer months (June, July, and August), we can expect at times some fairly high atmospheric ducts (above 80 or 100 feet), but low ducts are not as frequent as during winter. Propagation seems to be normal for the weaker signals.

(iii) The most irregular conditions can be expected during March and April, when all sorts of radio meteorological conditions seem to occur.

Similar analysis of the results from BD and AD links lead to similar conclusions. Since we have seen, however, that the atmosphere is far from uniform along the path, all these results should be treated with caution.

(2) More information can be obtained from the fact that simultaneous radio results are available on different wavelengths over the same link (e.g., BD on 3 and 9 cm) and on the same wavelength for slightly different links (e.g., BC and BD on 9 cm). Assuming that the meteorological conditions everywhere along the paths at any time are the same, the propagation may either be normal or due to atmospheric ducts. If the propagation is normal, then the necessary values for M' derived from the curves in Fig. 8 for the observed field strengths should agree with one another within experimental error. Similarly, if superrefraction is taking place the required values of duct height obtained from the curves in Fig. 10 should agree. In general, when the values of M' agree, the values of duct height will not, and vice versa. In this way, the radio results were divided into three groups:

(i) Where M' values differ by less than 20 per cent, but duct-height values differ by more than 20 per cent.

(ii) Where duct-height values differ by less than 20 per cent, but M' values differ by more than 20 per cent.

(iii) Where both M' and duct-height values either agree between themselves to better than 20 per cent, or differ by more than 20 per cent.

Then we can reasonably assume that all the cases belonging to group (i) correspond to cases of normal propagation, while all cases belonging to group (ii) mean guided propagation. Group (iii) might cover cases to which none of the theoretical curves used can be applied, most probably due to the nonuniformity of atmospheric conditions along the path.

After applying this method to about 150 samples of field strengths, it was found that about 50 per cent of all cases belong to group (ii) (guided propagation), about 25 per cent to group (i) (normal propagation), and about 25 per cent to group (iii) (unknown or mixed conditions).

It is interesting to note that we have reached certain conclusions concerning the possible meteorological conditions prevailing along the path between Fishguard and Aberdaron, by the use of radio results alone. As will be seen below, these predictions were confirmed later by meteorological measurements, and are also in agreement with the results obtained elsewhere.[13]

When analyzing the M curves obtained from meteorological measurements and corresponding to the samples "radio-analyzed" above, it was found that visible ducts (i.e., ducts higher than 50 feet) covering the whole path (i.e., belonging to group (ii)) were present in 10 per cent of the cases only, which suggests—in view of the results shown above—that complete atmospheric ducts lower than 50 feet were present for about 40 per cent of all the time.

All these results demonstrate the importance of meteorological soundings at heights of less than 50 feet. As has been mentioned before, however, only a limited number of such low-level observations was available from the ships; besides, the position of the ships was outside the path of propagation. Nevertheless, quite interesting results were obtained from the analysis of the ships' measurements during the period from July 5, 1945, to August 8, 1945. The period taken into consideration comprised 193 soundings made up to a height of 200 feet. The modified-refractive-index excess was computed with an accuracy of ± 0.2 per cent. The method of calculating the duct height as described in Section IV (equations (5a) and (5b) was used. Fig. 14(a) shows the distribution curve (histogram) of duct height, as obtained from these measurements. It can be seen that the most frequent duct height is of the order of 20 feet and that the majority of duct heights which occur are lower than about 40 feet, thus confirming our previous deductions obtained from radio observations alone.

"No-duct" conditions were observed in about 30 per cent of all cases, a figure agreeing well with the previously predicted value of 25 per cent of cases of normal propagation.

[13] M. Katzin, R. Bauchman, and W. Binnian. "3- and 9-cm propagation in low ocean ducts," Proc. I.R.E., vol. 35, pp. 891–906; September, 1947.

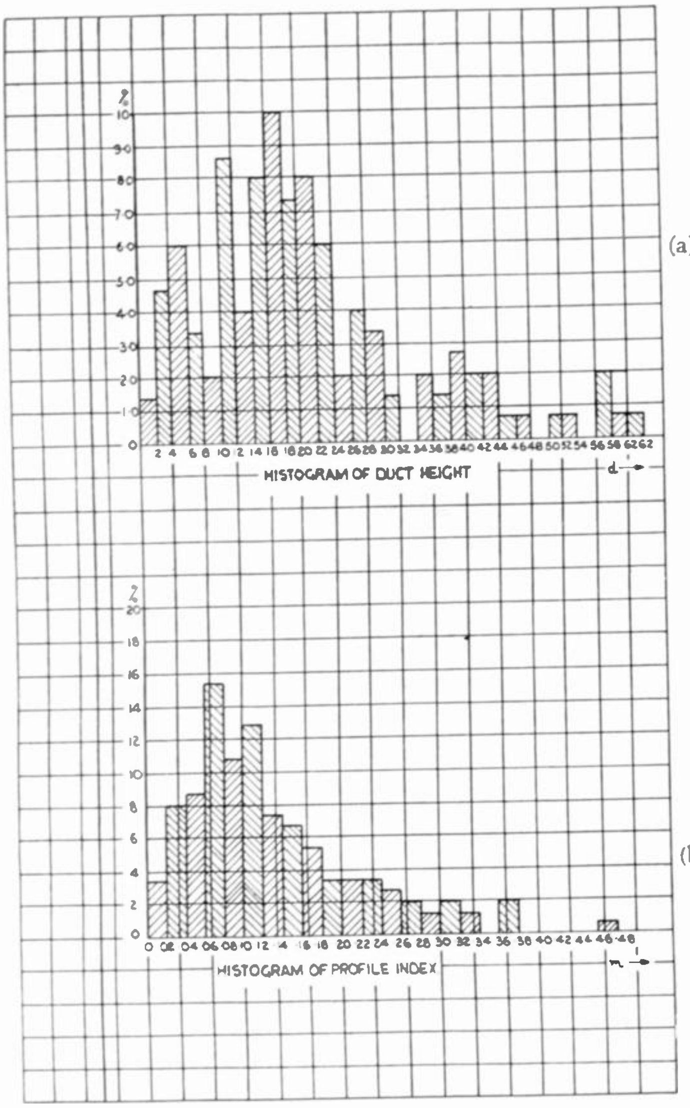


Fig. 14—Distribution curves of duct height *d* and profile index *m* obtained from low-level meteorological soundings in July, 1945.

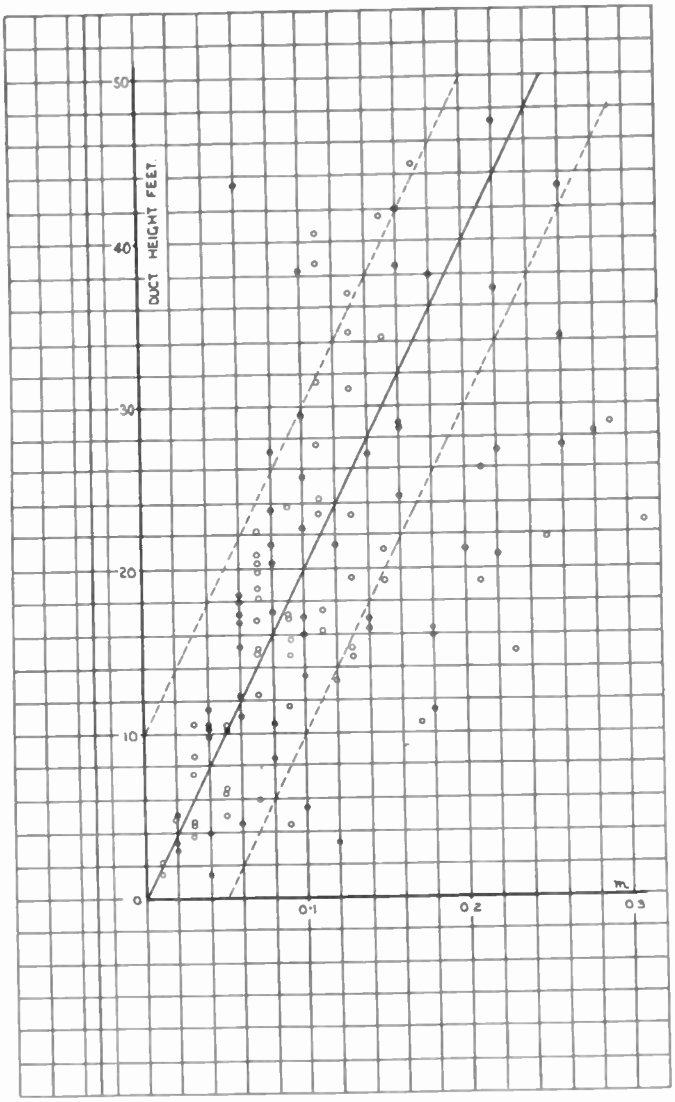


Fig. 15—Relationship between the duct height *d* and the profile index *m*.

It would be interesting, perhaps, to mention here the corresponding values of the parameter *m* obtained from these measurements. The distribution curve of *m* is shown in Fig. 14(b). The values of *m* were confined within limits of 0.01 and 0.46; in more than 50 per cent of the cases they lay between 0.07 and 0.17, with a maximum around the value of 0.1. It seems, then, that the value of 0.2 assumed for the theoretical calculations of field strength as a function of duct height is too big; in any case, for the small duct heights encountered. This results, of course, in a certain loss of accuracy, as already stated in Section IV, when comparing radio and meterorological measurements.

Fig. 15 shows the relationship between duct height and the parameter *m* obtained from the measurements described above. It seems that some correlation exists between duct height and the parameter *m*; higher values of duct height usually correspond to the higher values of *m*.

It should be stressed here that, even when we have ducts visible on the curves obtained from airplane soundings, the heights of these ducts as calculated from the field strengths are usually smaller than the measured duct heights. This might be due to the fact that the calculated duct heights are based on the assumption of complete ducts covering the whole path when, in fact, the ducts cover only a portion of the path. The total number of observed ducts was twenty-six. Of these, thirteen were present in only one-third of the path, eight in two-thirds of the path, and there were five present in all three portions. It can be deduced from Fig. 12 that, if the duct is covering only two-thirds of the path (about 40 miles), the signal will be smaller by about 10 db, as compared with a complete duct. In the case of a duct extending for one-third of the path, the corresponding loss of signal is of the order of 40 db. This loss in signal strength due to shortening of the length of duct between transmitter and receiver could explain the apparent discrepancy between the measured and calculated duct heights.

VI. Correlation between the Field Strengths and Sea and Air Temperature Differences

Several attempts have been made to find a correlation between the signal strengths (especially over nonoptical links) and individual meteorological parameters such as

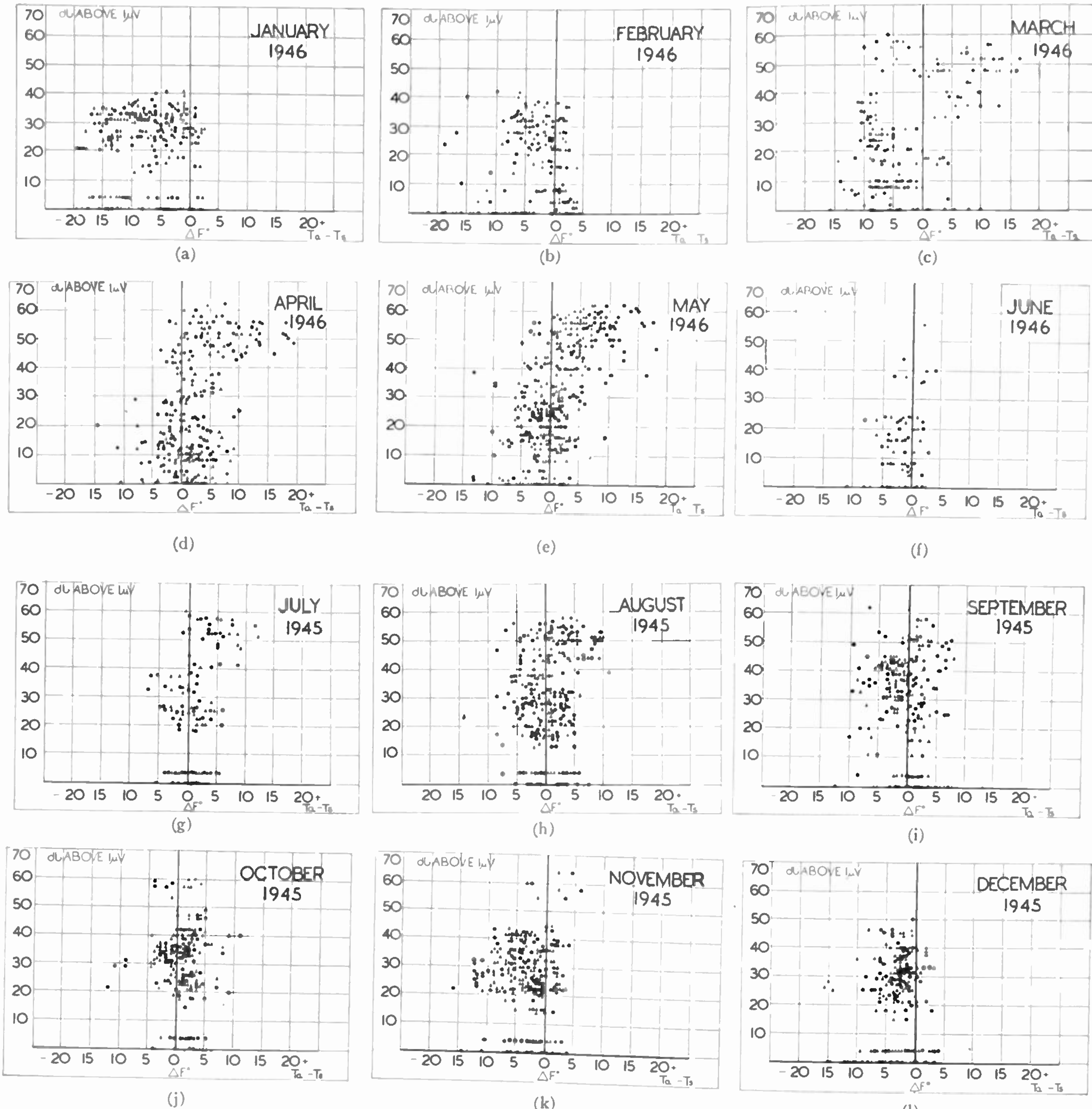


Fig. 16—Relationship between signal level and the difference of the temperature of sea (T_s) and air (T_a).

humidity, pressure, temperature, direction of the wind, etc., but all these attempts usually failed. It was found, however, that some correlation seemed to exist between the field strengths and the differences of the temperatures of sea water and air (the latter measured at the transmitting or receiving end).

Fig. 16 shows this relationship for a twelve-month period over the 9-cm B-D link. The points are plotted for intervals of three hours, and it can be seen that, when the temperature difference remains within ±5°F, any value of field strength can be expected. When, however, the air temperature is higher than the sea temperature by at least 5°F, usually only very high values of field strength (40–60 db) were obtained, as may be seen during March, April, May, July, and August.

When the air temperature was lower by at least 5° than the sea temperature, the received field strengths were concentrated between some 20 and 40 db, as can be clearly observed during November, December, and January. This phenomenon could also serve as a confirmation of the existence of low evaporation ducts in the winter, and high ducts caused probably both by temperature inversion and negative water-vapor gradient in summer.

It is worth while to note that the medium level of reception (10 to 20 db below free-space value) was quite often very stable, particularly during the periods of cold weather and very strong wind.

VII. Conclusions

It was impossible to include in this paper all the results obtained during the trials lasting for several years, but it would not be justifiable to draw any final conclusions from data described in this paper alone. The conclusions enumerated below have been based, therefore, on all the information available, neglecting in some cases any reference to the preceding text.

A. The Optical Links

The variations in 3- and 9-cm-band signal strengths for the optical (A–C link) are in the main small, only a few db above and below the free-space value (the largest differences noted were of the order of ± 12 db). A striking point is the occurrence of deep fades on the 3-cm signal when the 3-cm signal on the 2.3×optical path (B–D) is strong. When there is no reception or poor reception on B–D, the A–C signals are usually very stable.

The deep fades on the 9-cm band are much less frequent, but also in this case the deep fades correspond with strong signals on the B–D link.

It might be noted here that communication on the 3-cm radiotelephone link (operating on the A-C link) was fairly good, even during the periods of deep fading.

B. Slightly Nonoptical Links

(1) The slightly nonoptical link, B–C, shows larger long-term variations (of several hours' duration) on the 9-cm-band wavelength than does the optical link, but it is exceedingly stable so far as the short period fades are concerned. It is apparent that such a slightly nonoptical link might be better suited for communication purposes than an optical link, because of this lack of short deep fades.

(2) The propagation on the B–C 9-cm (1.3×optical) appears to be normal, and the Domb and Pryce curves can be applied for the calculation of signal levels from an "effective" refractive index gradient measured between two points some 50 and 500 feet high.

C. Highly Nonoptical Links

The propagation on the B–D (2.3×optical) 3- and 9-cm-band links is partly normal (some 25 per cent of all cases), partly due to ducts higher than 50 feet (10 per cent), and in the remaining cases, appears to be due to the presence of low ducts extending to some 20 to 40 feet above sea level.

D. Meter Band

The general shape of the meter-wave field-strength curves on the B–D link (2.3×optical) is usually similar to the 9-cm-band curves on the B–C link (1.3× optical), but considerably more fading appears on the meter-wave records.

The propagation appears to be normal, and again the Domb and Pryce curves can be applied for the calculation of signal levels from "effective" refractive-index gradients measured between points at a height of some 50 and 250 feet, respectively.

It seems that the presence of low ducts, while not affecting appreciably the amplitude of the signals, is the main cause of the occurring deep fades.

E. Diurnal Variation of Signal Levels

The mean curves of diurnal variations of signal level show fairly distinct minima and maxima, although the times and magnitudes of these are different for different links. On the B–D link the most pronounced minima usually occur between 0800 and 1000 hours, Greenwich Mean Time.

F. The Meteorological Ducts

Low meteorological ducts (extending to some 20 to 40 feet above sea level) were present for at least half of the time. These ducts result in fairly stable reception along the 2.3×optical link, giving signals some 10 to 30 db. below the free-space value. It is interesting to note that sometimes very stable signals of these magnitudes were obtained in the presence of particularly strong wind.

The theoretical curves for guided propagation calculated in the case of ground-based meteorological ducts are in fairly good agreement with the experimental results, especially for highly nonoptical links.

G. General

It was found that it is difficult to expect a better agreement between theoretical and experimental data than ± 10 db.

A correlation seems to exist between the field strengths and temperature difference between sea water and air.

It seems that observations on the performance of centimetric-wave equipment may be useful for determining the mean meteorological conditions along a given path. As a matter of fact, these observations could perhaps be more informative for a meterologist than the meteorological measurements are for the radio man in his attempts to forecast ultra-high-frequency propagation.

VIII. Acknowledgments

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Ratio of Frequency Swing to Phase Swing in Phase- and Frequency-Modulation Systems Transmitting Speech*

D. K. GANNETT†, SENIOR MEMBER, IRE, AND W. R. YOUNG†, ASSOCIATE, IRE

Summary—**Computed and measured data are presented bearing on the relation between the phase and the frequency swing in phase- and frequency-modulation systems when transmitting speech. The results were found to vary with different voices, with the microphone and circuit characteristics, and with the kind of volume regulation used. With a particular carbon microphone, it was found that a phase deviation of 10 radians corresponds to a frequency deviation of between 11 and 15 kc in a phase-modulation system, and between 6 and 12 kc in a frequency-modulation system, depending on conditions.**

Introduction

A USUAL REQUIREMENT for a phase- or frequency-modulation system is that the frequency swing of the modulated signal must not exceed the width of some frequency band which has been assigned to the system. However, in either type of system it is often desired to perform the modulation process with a phase modulator. This requires that the phase swing of the signal from the modulator must not exceed some limited range that can be handled by the modulator. Evidently, in designing such a system, it is important to know what frequency swing will correspond to a given phase swing.

The ratio between the frequency swing and the phase swing is, of course, very simple when the modulating signal is a sine wave. It is more complicated to determine, however, when the modulating signal is the heterogeneous mixture of frequencies constituting a speech wave. This paper presents both computed and experimental data on this ratio for speech-modulated phase- and frequency-modulation systems. The methods employed, as well as the data, are believed to be of interest.

For convenience, in this paper, the term "swing ratio" has been coined to describe the derived data, where swing ratio is rigorously defined as the numerical ratio of the frequency swing measured in *kilocycles* to the phase swing measured in *radians*. In practice, various approximations to the swing ratios may be made by taking ratios of other quantities than the frequency and phase swings which are related to the swings.

Frequency and phase swings are defined as the peak differences between the maximum and minimum values of the instantaneous frequency of the modulated wave, or of its instantaneous phase departure from the carrier phase, respectively. The maximum and minimum values may, however, be interpreted as applying not to a particular modulating voice, but to the extremes encountered with all the voices that may use the system. The wave forms of various voices differ considerably, so that the frequency or phase deviations of a large number of voices may be represented as distributions. If it is assumed that the voice waves are equally likely to be applied to the system in either poling, these distributions are symmetrical despite the asymmetry of the individual voice waves. In this case, the frequency or phase swings are evidently the spreads of these distribution curves of frequency or phase deviations, and the ratio of the swings is equal to the ratio of the peak deviations.

In the following paper the swing ratios are actually derived, sometimes from ratios of the peak frequency and phase deviations, sometimes from the ratio of the frequency and phase deviations which have the same small probability of being exceeded among many voices, and sometimes from the ratio of the rms frequency and phase deviations. The data, therefore, represent various approximations to the rigorous definition of swing ratio.

It may be noted that a swing ratio is identical, numerically, with the equivalent single frequency in kilocycles which, when substituted for the speech at the proper amplitude, results in the same frequency and phase swings as the speech.

I. Principles

The computations and the experimental work described below depend on the elementary fact that in an FM (frequency-modulation) or a PM (phase-modulation) system the instantaneous frequency of the modulated wave is proportional to the derivative of its instantaneous phase angle, and, conversely, that the instantaneous phase angle is proportional to the integral of the instantaneous frequency. Therefore, only voice frequencies need be considered in order to determine the swing ratios, since, if one of the two quantities, frequency or phase, differs from the carrier by an amount proportional to the instantaneous amplitude of the speech wave, the other one differs from the carrier by an amount proportional to the time integral or the time derivative of the original speech wave, respectively.

This will be more apparent from Figs. 1(a) and 1(b), which show the basic elements of a possible FM and a

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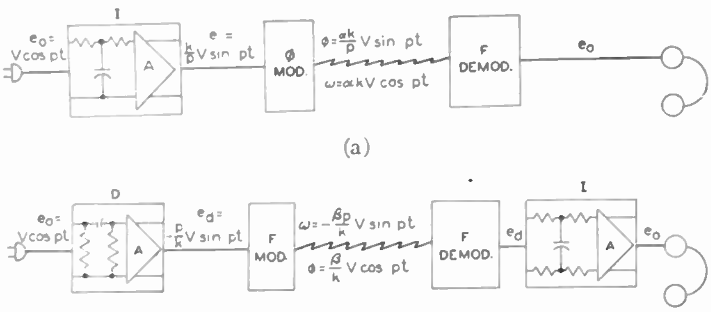
† Bell Telephone Laboratories, Inc., New York, N. Y.

possible PM system, respectively. In Fig. 1(a), the wave from the microphone, e_0, is sent through an integrating network I, which includes an amplifier A. The output wave from I is

$$e_i = k \int e_0 dt \tag{1}$$

where k is a constant depending upon the loss or gain through I. The inscriptions on the drawing show the values when e_0 is the single-frequency wave, $V \cos pt$. The wave e_i is impressed on a phase modulator.



(a)

(b)

Fig. 1—(a) Diagram of FM system. (b) Diagram of PM system.

The phase of the output wave from the modulator differs from that of the unmodulated carrier by Φ radians where

$$\Phi = \alpha e_i = \alpha k \int e_0 dt, \tag{2}$$

in which α is a constant of the modulator. The vector velocity of the modulated wave differs from that of the carrier by ω where

$$\omega = \frac{d\Phi}{dt} = \alpha k e_0. \tag{3}$$

Evidently this is an FM system, since ω, which is 2π times the instantaneous difference between the frequencies of the modulated wave and of the carrier in cycles per second, is proportional to the original speech wave e_0.

Now, let E_0 and E_i be the peak value of e_0 and e_i, respectively. The phase deviation of the modulated wave, which is by definition the peak value of Φ, is, from (2),

$$\Phi_m = \alpha E_i \text{ (radians)}. \tag{4}$$

The frequency deviation is, from (3),

$$f_m = \frac{\omega_m}{2\pi(1{,}000)} = \frac{\alpha k E_0}{2\pi(1{,}000)} \text{ (kilocycles)}. \tag{5}$$

From the earlier discussion, the swing ratio is equal to the ratio of these deviations, or

$$S = \frac{f_m}{\Phi_m} = \frac{k}{2\pi(1{,}000)} \cdot \frac{E_0}{E_i}. \tag{6}$$

If, now, the gain of the amplifier in I is adjusted so that $k = 2\pi(1{,}000)$, the swing ratio becomes

$$S = \frac{E_0}{E_i} \text{ (for FM)}. \tag{7}$$

It is evident that the swing ratio can be determined from the peak voice-frequency voltages E_0 and E_i, and that the modulating system is not required. A little thought will show that the gain adjustment which makes $k = 2\pi(1{,}000)$ corresponds to making the loss through the integrating circuit I, at a frequency of 1,000 cps, equal to 0 db.

In Fig. 1(b), the speech wave e_0 is applied to a differentiating network D which includes an amplifier A. The output wave from D is

$$e_d = \frac{1}{k} \cdot \frac{de_0}{dt} \tag{8}$$

where $1/k$ is a constant depending upon the loss or gain through D. The wave e_d is impressed on a frequency modulator, which produces a wave having a frequency variation and therefore a phase-velocity variation from the carrier which is proportional to e_d. That is,

$$\omega = \beta e_d = \frac{\beta}{k} \cdot \frac{de_0}{dt} \tag{9}$$

where β is a constant of the modulator. The phase of the modulated wave departs from the phase of the carrier by

$$\Phi = \int \omega dt = \frac{\beta}{k} e_0. \tag{10}$$

Evidently this is a PM system.

Now let E_0 and E_d be the maximum values of e_0 and e_d, respectively. It follows from (9) and (10) that

$$f_m = \frac{\omega_m}{2\pi(1{,}000)} = \frac{\beta E_d}{2\pi(1{,}000)} \text{ (kilocycles)} \tag{11}$$

and

$$\Phi_m = \frac{\beta}{k} E_0 \text{ (radians)}, \tag{12}$$

from which

$$S = \frac{f_m}{\Phi_m} = \frac{k}{2\pi(1{,}000)} \cdot \frac{E_d}{E_0}. \tag{13}$$

Once again, adjusting the gain of A so that $k = 2\pi(1{,}000)$ which as before makes the loss through D equal to 0 db at 1,000 cps, the swing ratio becomes simply

$$S = \frac{E_d}{E_0} \text{ (for PM)}. \tag{14}$$

In this case, also, the swing ratio is equal to the ratio of two peak voice-frequency voltages.

It will be noted from Figs. 1(a) and 1(b) that, for the single-frequency cases shown by the inscriptions, the ratio of the peak value of ω to the peak value of Φ is equal to p for either an FM or a PM system. This means that the swing ratio for a single-frequency wave is numerically equal to its frequency in kilocycles. If the swing ratio is measured for an actual speech wave, it is evident that the speech wave may be replaced by a sine wave whose frequency in kilocycles is equal to this swing ratio, with the same peak-modulation results. Therefore, an alternative definition of swing ratio is that it is numerically equal to the equivalent single frequency, in kilocycles, which, when substituted for the speech, gives the same ratio of frequency swing to phase swing.

II. Computation of Swing Ratio

To compute the swing ratios, it is necessary to find numerical values for E_0, E_i, and E_d in (7) and (14) of the previous section. The starting point is the average acoustic spectrum of speech taken from previously published data,[1] and shown as curve A on Fig. 2. The curve shows the speech power per cycle of bandwidth, plotted in terms of decibels versus frequency. The electrical spectrum of speech is derived from this by correcting for the characteristic of the microphone (curve B) and the characteristic of the microphone transformer (curve C), resulting in curve D. The microphone and its circuit were assumed to be the same as are used in the Bell System mobile radio equipment.

The spectra of the integrated and the differentiated speech waves may readily be derived from curve D by adding the loss characteristics of the integrating network I or the differentiating network D (Figs. 1(a) and 1(b)). These networks, with the included gains adjusted as described earlier, have losses which pass through 0 db at 1,000 cps and which have a negative slope of 6 db per frequency octave in the case of I, and a positive slope of 6 db per octave in the case of D. Curves E and F of Fig. 3 are thus obtained from curve D, which is also reproduced on Fig. 3. Curves D, E and F represent the spectra of waves e_0, e_i, and e_d (Figs. 1(a) and 1(b)), respectively.

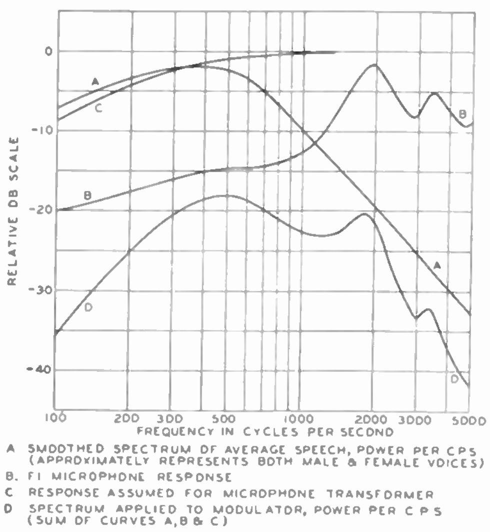


Fig. 2—Derivation of the speech spectrum applied to the modulator.

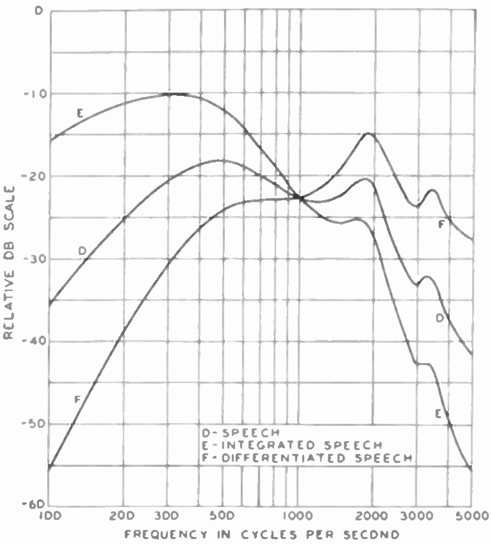


Fig. 3—Electrical spectra of speech, integrated speech, and differentiated speech.

The next step is to determine, from these spectra, values to use for E_0, E_i, and E_d in (7) and (14). These were defined earlier as peak values of the waves, but a spectrum of a wave supplies insufficient information to determine its peak value, since this is a function of the relative phases, as well as the relative magnitudes, of the frequency components. However, the rms amplitude of the wave is independent of the phase relations, and may be computed knowing only the relative amplitudes given by the spectrum. The rms amplitude of a wave is simply the square root of the total power of the wave obtained by integrating the area under its spectrum curve when the ordinates are plotted in terms of power per cycle of bandwidth instead of in decibels, and the abscissae are plotted on a linear instead of a logarithmic scale.

Determining thus the rms amplitudes of the waves corresponding to the spectrum curves D, E, and F, and using these figures in the equations as E_0, E_i, and E_d, respectively, a swing ratio of 0.6 was obtained for the FM case, and 1.5 for the PM case.

Evidently the swing ratios thus derived, since they represent ratios of rms rather than peak values, are only approximations. They would accurately represent the swing ratios as defined earlier only if the peak factors of the original speech wave, its integral, and its derivative were all the same. This is probably not quite true. In spite of this, the results agree roughly with those from

[1] N. R. French and J. C. Steinberg, "Factors governing the intelligibility of speech sounds," *Jour. Acous. Soc. Amer.*, vol. 19, pp. 90–119; January, 1947.

the experiments cited in the next section. Therefore, the figures derived by computation furnish a guide to the approximate true swing ratios, and the method may be useful in cases for which measurements are not available.

III. Experimental Determination of Swing Ratios

A. General Method

The experimental determination of the swing ratios was accomplished by laboratory tests with equipment that simulated the parts of Figs. 1(a) and 1(b) which precede the modulators. The essential parts of the experimental setup used for the tests are shown in schematic form in Fig. 4. At the left is a talking set which was either the F1 telephone transmitter circuit used in the Bell System mobile radio equipment or a special high-quality moving-coil microphone mounted in

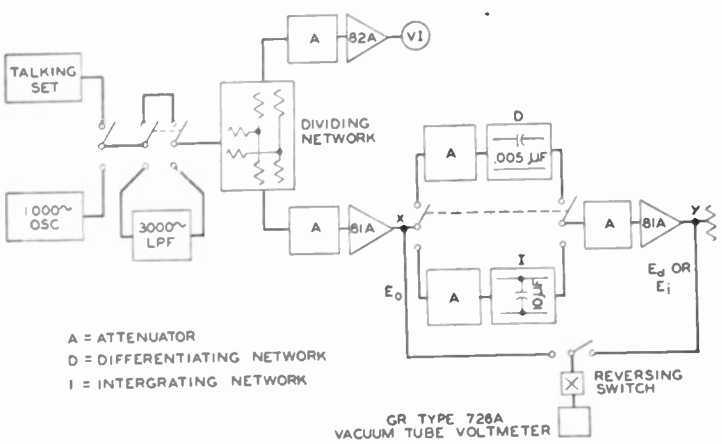


Fig. 4—Diagram of the testing circuit.

a handset. A 1,000-cps oscillator could be substituted for the talking set when desired for purposes of calibration. Next is a 3,000-cps low-pass filter which could be switched in or out of the circuit. Following the filter the circuit was divided into two branches by a dividing network, the upper branch going through an attenuator and amplifier to a volume indicator, and the lower branch through another attenuator and amplifier to the main testing circuit. This was done so that the readings of the volume indicator were independent of impedance changes due to operation of the succeeding switches. The gains in the two branches were the same to these points, so that the volume indicator read the same level as existed at the output of the lower amplifier. All amplifiers were Western Electric high-quality program amplifiers operated at levels below their nominal full-load capacities so as to introduce negligible distortion.

In the main circuit, switches permitted inserting either an integrating network I or a differentiating network D. These networks were capacitors inserted in resistance circuits as shown, and had time constants such as to give critical frequencies of about 50 and 25,000 cps, respectively, so that over the frequency range of interest their loss characteristics had substantially the desired 6-db per octave slope. Finally, the circuit ends with an attenuator and amplifier operating into a terminating resistance.

It will be observed that the portion of the circuit between the points marked x and y corresponds to the first part of Fig. 1(a) when the switches are thrown down, and to the first part of Fig. 1(b) when the switches are thrown up. The attenuators were adjusted so that the loss was 0 db between x and y for either position of the switch when a 1,000-cps tone was sent through the circuit. The voltage at x therefore corresponds to e_0, and the voltage at y to e_i or e_d, depending on the position of the switches.

The peak values of these voltages were read by a peak-reading vacuum-tube voltmeter (General Radio type 726A), which was arranged to be switched to either point x or y. The speech waves are very unsymmetrical, and, since the voltmeter reads peaks on only one side of the wave, a reversing switch was necessary to permit checking the peaks on both sides. Only the higher of the two readings was used for most of the analysis.

The technique of conducting the tests was for the speakers to say set phrases while watching the volume indicator, attempting to produce peak readings on it of −3 vu. The vacuum-tube voltmeter was read only when the talkers succeeded in hitting the desired volume within about ±0.5 vu. The tests were made with ten different voices, seven male and three female. (Incidentally, the data did not show any substantial difference between the male and female voices.) Each voice was tested saying three different set phrases, namely, "Joe took father's," "Bell Telephone Laboratories," and "Fair weather or foul." Originally, complete sentences including these phrases were used, but it was found that omission of the remainder did not affect the results, since these phrases produced much higher peaks in the speech waves than the omitted material.

B. Analysis of Data

The above tests resulted in thirty sets of observations on each condition tested, three for each of ten voices. Swing ratios computed from the peak voltages of the individual voices were found to vary by large ratios. It was, therefore, necessary to decide upon a method of analyzing the data which would express the results in the most useful form.

It was apparent on inspection of the data that the peak voltages produced by the different voices showed considerable variation, both in absolute amplitude and in the degree of the asymmetry or difference between the peaks on the two sides of the wave. From the practical standpoint, interest lies in the extreme values that are likely to be reached when the many voices of the general public use a system. It was, therefore, decided to assume that the variations shown by the thirty observations made on each condition are representative of the variations that would be found in the voices of the public generally, and to apply statistical methods to the analysis.

It was found that the distribution of the thirty observed values for any particular condition can be well represented by normal-law distribution curves. Therefore, the data for each set of thirty values can be described by two figures which can be computed from them; namely, the mean value and the standard deviation. (The standard deviation is the rms difference between the individual values and their mean.) Thus the voltages E_0, E_i, and E_d are no longer single fixed values, but are represented by distributions of peak voltages having the computed mean values and standard deviations. Table I tabulates the constants for the distributions, for four assumptions regarding the kind of volume regulation that is assumed to be employed in the radio transmitter.

TABLE I

Summary of Mean Values and Standard Deviations of Various Distributions

	E_0 Original Speech		E_d Differentiated Speech		E_i Integrated Speech	
	e_m	δ	e_m	δ	e_m	δ
F1 transmitter, no filter						
A	2.03	0.43	2.38	0.33	2.11	0.37
B	2.03	0	2.44	0.41	2.15	0.41
C	2.05	0.35			2.11	0
D	2.93	0.52	4.15	0.57	3.23	0.61
F1 transmitter, 3,000-cps filter						
A	1.82	0.39	2.00	0.33	2.08	0.46
B	1.82	0	2.04	0.41	2.09	0.41
C	1.85	0.30			2.08	0
D	2.70	0.48	3.61	0.58	3.12	0.66
Moving-coil microphone, no filter						
A	1.15	0.25	1.21	0.36	2.46	0.48
B	1.15	0	1.25	0.52	2.51	0.41
C	1.17	0.21			2.46	0
D	1.94	0.36	2.28	0.71	3.80	0.68
Moving-coil microphone, 3,000-cps filter						
A	1.17	0.26	0.88	0.21	2.37	0.44
B	1.17	0	0.90	0.21	2.41	0.58
C	1.19	0.24			2.37	0
D	1.96	0.38	1.63	0.36	3.70	0.675

e_m = mean of voltage peaks δ = standard deviation.
A = distribution of maximum voice peaks; original speech regulated to constant volume of −3 vu.
B = distribution of maximum voice peaks; original speech regulated to constant peak voltage.
C = distribution of maximum voice peaks; integrated speech regulated to constant peak voltage.
D = distribution of spreads between positive and negative peaks; original speech regulated to constant volume of −3 vu.

For example, the distributions labeled A in Table I are derived directly from the original data, using as the peaks for each voice the readings of the vacuum-tube voltmeter for whichever poling of the reversing switch gave the higher reading in each case. Because of the conditions of the tests, these distributions correspond to the assumption that the original speech was regulated to a constant volume of −3 vu.

By way of illustration, a cumulative normal-law distribution curve corresponding to the figures in Table I is shown in Fig. 5, for the F1 transmitter without a filter, case A, original speech. Superposed is a curve plotted directly from the original data to show how well the calculated normal-law distribution represents the data. It is assumed that, if the volume of data were increased, the actual curve would approach closer and closer to the calculated curve.

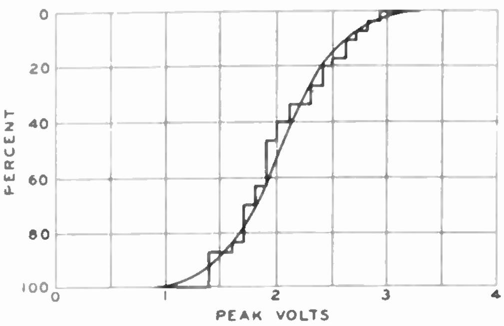


Fig. 5—Probability of exceeding various peak voltages in speech at −3 vu volume. F1 transmitter, no filter.

In order to compute swing ratios, it is necessary to pick values of E_0, E_i, and E_d from these curves. For practical reasons we are interested in the more extreme values which may be reached when many people use a system. The procedure that has been adopted, therefore, is to compare values chosen from the curves for which there is the same small probability—say, 10 per cent—that each will be exceeded. Thus E_0 is taken to be the peak speech voltage that is exceeded 10 per cent of the time in the original speech; E_i is the peak voltage exceeded 10 per cent of the time in the integrated speech; and E_d is the peak voltage exceeded 10 per cent of the time in the differentiated speech. These three values obviously do not necessarily occur with the same voice. The swing ratios given later in the summary are obtained by inserting these values in (7) and (14).

The values of E_0, E_i, and E_d may, of course, be computed directly from the data in Table I without drawing the curves. These are equal to the mean value, plus the standard deviation times a factor obtained from the standard normal-law tables. For a probability of 10 per cent, this factor is 1.28.

The figures labeled B on Table I represent the assumption that automatic regulators are used at the microphone output which adjust the speech level so that the speech voltage peaks, rather than the volume in vu, are constant. The figures labeled C assume that the peak-voltage regulator of B is placed immediately ahead of the phase modulator, instead of right after the microphone. This is identical with B for PM, but for FM places the regulator after the integrating network.

The figures labeled D represent the somewhat hypothetical possibility of introducing biases to compensate for the speech asymmetry, so that both the phase modulator and the frequency band after modulation are fully loaded by the positive and negative voice peaks at the same time. That is, the wave striking the phase modulator is assumed to be biased so as to be centered with respect to the positive and negative peaks. If the speech were derived from a local microphone, a fixed bias might suffice for this. If a distant microphone were employed, however, the bias would have to be derived automatically, since the polarity of the speech wave would be uncertain. Then, also, the frequencies on the line are assumed to be biased by shifting the carrier frequencies, so as to center the peaks of the instantaneous frequencies in the band. Physical means for obtaining these biases could doubtless be devised, if desired.

IV. Summary of Results

Table II gives the swing ratios for the several kinds of automatic level adjustment described above, derived as described from ratios of speech peaks which will be exceeded by 10 per cent of the voices. The computed swing ratio is included in the table for comparison.

TABLE II
Swing Ratios for Speech

Transmitter	Type of Regulation	No Filter PM	No Filter FM	3,000-cps Filter PM	3,000-cps Filter FM
F1	Computed in Section 2	1.5	0.6		
F1	A—Constant input volume	1.1	1.0	1.0	0.9
F1	B—Constant peak level of speech	1.5	0.8	1.4	0.7
F1	C—Constant phase peaks	1.5	1.2	1.4	1.1
F1	D—Spread centered	1.4	0.9	1.3	0.8
Moving-coil	A—Constant input volume	1.1	0.5	0.8	0.5
Moving-coil	B—Constant peak level of speech	1.7	0.4	1.0	0.4
Moving coil	C—Constant phase peaks	1.7	0.6	1.0	0.6
Moving-coil	D—Spreads centered	1.3	0.5	0.8	0.5

Note: PM = phase modulation. FM = frequency modulation.

Conclusions

In closing, the following comments may be made on the data which have been presented:

(1) The computed swing ratios tend to be equal to or higher than the experimentally determined values for phase modulation, and lower than the experimental values for frequency modulation. This is probably largely because the computation was based on rms speech voltages, while the experimental method was based on measured peak speech voltages.

(2) Of the four methods of volume regulation assumed in analyzing the experimental data, the method of regulating to constant voltage peaks applied to the phase modulator results in the greatest swing ratios, and therefore appears the most efficient in regard to use of the modulator. This is of practical importance, since the greater the efficiency, the higher the carrier frequency at which the modulator may operate, and the fewer the required number of stages of subsequent frequency multiplication.

(3) The 3,000-cps low-pass filter had little effect on the swing ratios, except in the case of the moving-coil microphone and phase modulation.

(4) The moving-coil microphone without any filter gave swing ratios substantially the same as the F1 carbon microphone for phase modulation, but only about half as great for frequency modulation.

A general conclusion is that the swing ratios are quite dependent on the microphone and its circuits, on the kind of volume regulation employed, and probably on other features of the circuit. For accurate results, the swing ratios should therefore be determined for the particular circuits which are to be used. The figures derived here will, however, serve to indicate roughly the values to be expected.

The Helical Antenna*

JOHN D. KRAUS†, SENIOR MEMBER, IRE

Summary—**The helix is a fundamental form of antenna of which loops and straight wires are limiting cases. When the helix is small compared to the wavelength, radiation is maximum normal to the helix axis. Depending on the helix geometry, the radiation may, in theory, be elliptically, plane, or circularly polarized.**

When the helix circumference is about 1 wavelength, radiation may be maximum in the direction of the helix axis and circularly polarized or nearly so. This mode of radiation, called the axial or beam mode, is generated in practice with great ease, and may be dominant over a wide frequency range with desirable pattern, impedance, and polarization characteristics. The radiation pattern is maintained in the axial mode over wide frequency ranges because of a natural adjustment of the phase velocity of wave propagation on the helix. The terminal impedance is relatively constant over the same frequency range because of the large initial attenuation of waves on the helix. The conditions for circular polarization are analyzed, and the importance of the array factor in determining the radiation pattern of a long helix is discussed.

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† Department of Electrical Engineering, Ohio State University, Columbus, Ohio.

Introduction

A HELIX is a fundamental geometric form. It has applications in many branches of physics and engineering. For example, in mechanical systems the helix or coil spring is a familiar structure; in electrical systems, a helical conductor or inductor is a common type of circuit element; and in many dynamic phenomena, particles follow helical paths. Recently the helix has been applied as a beam antenna.[1–6]

In considering the helix as an antenna, it is important that it be regarded, not as a unique or special form of antenna, but rather as a basic type of which the more familiar loop and straight-wire antennas are merely special cases.[2] Thus, a helix of fixed diameter collapses to a loop as the spacing between turns approaches zero, and, on the other hand, a helix of fixed spacing straightens into a linear conductor as the diameter approaches zero. It is the purpose of this paper to discuss the helical antenna from this general point of view including the axial or beam mode of radiation as a particular case. The possibility of a normal mode of radiation, as suggested by Wheeler,[7] is also included as a special case.

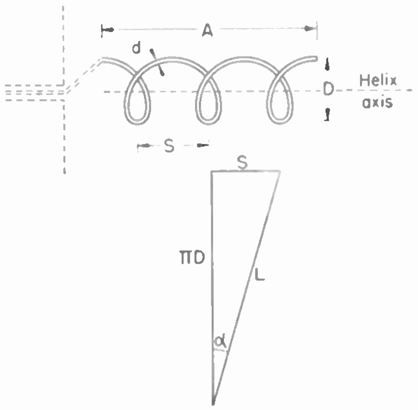

Fig. 1—Relation of helix dimensions.

Referring to Fig. 1, the following symbols will be used to describe a helix:

D = diameter of helix (center-to-center)
S = spacing between turns (center-to-center)
α = pitch angle = arctan $S/\pi D$
L = length of one turn
n = number of turns
A = axial length = nS
d = diameter of helix conductor.

A coaxial transmission line and ground plane as used for exciting the helix in the beam mode of radiation are shown by the dashed lines. A subscript λ signifies that the dimension is measured in free-space wavelengths. For example, D_λ is the helix diameter in free-space wavelengths.

[1] J. D. Kraus, "Helical beam antenna," *Electronics*, vol. 20, pp. 109–111; April, 1947.
[2] J. D. Kraus and J. C. Williamson, "Characteristics of helical antennas radiating in the axial mode," *Jour. Appl. Phys.*, vol. 19, pp. 87–96; January, 1948.
[3] O. J. Glasser and J. D. Kraus, "Measured impedances of helical beam antennas," *Jour. Appl. Phys.*, vol. 19, pp. 193–197; February, 1948.
[4] J. D. Kraus, "Helical beam antennas for wide-band applications," Proc. I.R.E., vol. 36, pp. 1236–1242; October, 1948.
[5] J. D. Kraus, "Design data for helical beam antennas," to be published.
[6] J. D. Kraus, "Measured phase velocities on helical conductors," to be published.
[7] H. A. Wheeler, "A helical antenna for circular polarization," Proc. I.R.E., vol. 35, pp. 1484–1488; December, 1947.

Transmission and Radiation Modes of Helices

The dimensions of a helix are very conveniently illustrated by a diameter versus spacing chart or, as in Fig. 2, by a circumference versus spacing chart. On this chart, the dimensions of a helix may be expressed either in rectangular co-ordinates by the spacing S_λ and circumference πD_λ or in polar co-ordinates by the length of one turn L_λ and the pitch angle α.

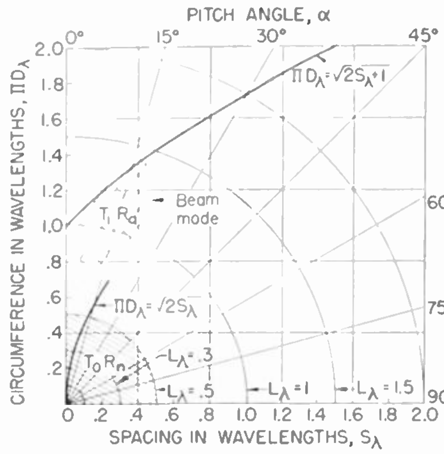

Fig. 2—Circumference versus spacing chart for helices showing regions for normal radiation mode (shaded) and axial or beam mode (cross hatched).

The electromagnetic field around a helix may be regarded from two points of view, as (1) a field which is guided along the helix, and (2) a field which radiates. In the present discussion, it will be convenient to treat these as independent. As regards the first point of view, it is assumed that an electromagnetic wave may be propagated without attenuation along an infinite helix in much the same manner as along an infinite transmission line or waveguide. This propagation may be described by the *transmission mode*, a variety of different modes being possible. On the other hand, a field which radiates may be described by the radiation pattern of the antenna. It will be convenient to classify the general form of the pattern in terms of the direction in which the radiation is a maximum. Although an infinite variety of patterns is possible, two kinds are of particular interest. In one, the direction of the maximum radiation is normal to the helix axis. This is referred to as the *normal radiation mode*[8] or, in shorthand notation, as the R_n mode. In the other, the direction of maximum radiation is in the direction of the helix axis. This is referred to as the *axial* or *beam radiation mode*, or, in shorthand notation, as the R_a mode.

The lowest transmission mode for a helical conductor has adjacent regions of positive and negative charge

[8] The word "mode" is used here in its general sense to indicate merely the general form or type of radiation pattern. In the case of "transmission mode," the word "mode" is employed in a more restricted sense to indicate a particular field configuration. In discussing transmission modes, it is assumed that the helix is infinitely long. However, a radiation pattern implies a helix of finite length, it being assumed that the wave propagates along the finite helix in a particular transmission mode or modes in the same manner as along a portion of an infinite helix, end effects being neglected.

separated by many turns. This mode will be designated as the T_0 mode and the instantaneous charge distribution is suggested by Fig. 3(a). The T_0 mode is important when the length of one turn is small compared to the wavelength $L \ll \lambda$, and is the mode commonly occurring

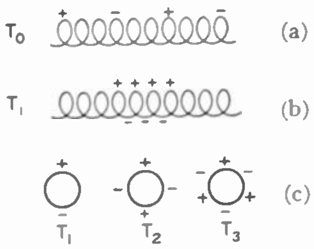

Fig. 3—Approximate charge distribution on helices for different transmission modes.

on low-frequency inductors. It is also the dominant mode in the traveling-wave tube.[9–13] Since the adjacent regions of positive and negative charge are separated by an appreciable axial distance, a substantial axial component of the electric field is present, and in the traveling-wave tube this field interacts with the electron stream. If the criterion $L_\lambda < \frac{1}{2}$ is arbitrarily selected as a boundary for the T_0 transmission mode, the region of helix dimensions for which this mode is important is shown by the shaded area in Fig. 2.

Theoretically, it is of interest to examine some of the possible radiation patterns associated with the T_0 transmission mode. Only the simplest radiation case will be considered. This occurs when the helix is very short so that $nL \ll \lambda$ and the assumption is made that the current on the helix is uniform in magnitude and in-phase along its length.[14] Referring to Fig. 3(a), the length is much less than that between adjacent regions of maximum positive and negative charge. Theoretically, it is possible to approximate this condition with a standing wave on a small end-loaded helix. The terminal impedance of such a small helix would be sensitive to frequency and the radiation efficiency would be low. However, let us assume that appreciable radiation can be obtained. The maximum radiation is then normal to the helix axis for all helix dimensions, provided only that $nL \ll \lambda$. Hence, this condition is referred to as a normal radiation mode R_n. Referring to Fig. 4, any component E of the distant electric field perpendicular to the radius vector is given approximately by $E = k \sin \theta$, where k is a constant. The radiation is, in general, elliptically polarized, but for particular helix dimensions may be linearly or circularly polarized.[7] These cases are discussed further in a later section (Normal Radiation Mode). We can describe both the transmission mode and radiation pattern for very short, small helices by combining the T_0 transmission mode and the R_n radiation mode designations as T_0R_n. This designation is applied to the region of helix dimensions near the origin in Fig. 2.

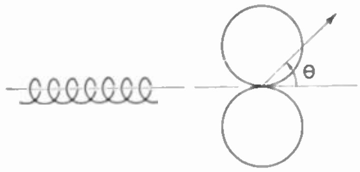

Fig. 4—Sinusoidal field variation for small helices.

A first-order transmission mode, designated T_1, has adjacent regions of maximum positive and negative electric charge approximately one-half turn apart or near the opposite ends of a diameter, as suggested in Fig. 3(b) for the case of a small pitch angle. This mode is important when the length of one turn is of the order of the wavelength ($L \sim \lambda$). It is found that the radiation from helices of this turn length and of a number of turns ($n > 1$) is usually a maximum in the direction of the helix axis and is circularly polarized, or nearly so.[1,2] This type of radiation pattern is referred to as the axial or beam mode of radiation R_a. This radiation mode occurs for a wide range of helix dimensions and, being associated with the T_1 transmission mode, the combined designation appropriate to this region of helix dimensions is T_1R_a. The axial type of radiation is discussed further in a later section (Axial Radiation Mode).

Still higher-order transmission modes, designated T_2, T_3, etc., will have the approximate charge distributions suggested in the one-turn views of Fig. 3(c) for the case of a small pitch angle. For these modes to exist, the length of one turn must generally be at least one wavelength.[15]

The normal R_n and axial R_a radiation modes are, in reality, special cases for the radiation patterns of helical antennas. In the general case, the maximum radiation is neither at $\theta = 0$ nor at $\theta = 90°$ but at some intermediate value, the pattern being conical or multilobed in form.[2,4]

The Normal Radiation Mode

The direction of maximum radiation is always normal to the helix axis when the helix is small ($nL \ll \lambda$). Referring to Fig. 5(a), the helix is coincident with the polar or y axis. At a large distance r from the helix, the electric field may have, in general, two components E_ϕ and E_θ, as shown.

Two limiting cases of the small helix are: (1) the short electric dipole of Fig. 5(b), $\alpha = 90°$, and (2) the small loop of Fig. 5(c), $\alpha = 0°$. In the case of the short electric dipole, $E_\phi = 0$ everywhere and the distant electric field

[9] R. Kompfner, "The traveling-wave tube as amplifier at microwaves," Proc. I.R.E., vol. 35, pp. 124–127; February, 1947.

[10] J. R. Pierce and L. M. Field, "Traveling-wave tubes," Proc. I.R.E., vol. 35, pp. 108–111; February, 1947.

[11] J. R. Pierce, "Theory of the beam-type traveling-wave tube," Proc. I.R.E., vol. 35, pp. 111–123; February, 1947.

[12] L. J. Chu and D. Jackson, "Field theory of traveling-wave tubes," Proc. I.R.E., vol. 36, pp. 853–863; July, 1948.

[13] C. C. Cutler, "Experimental determination of helical-wave properties," Proc. I.R.E., vol. 35, pp. 230–233; February, 1948.

[14] It is assumed here that the phase velocity on the helical conductor is approximately that of light. The in-phase condition requires an infinite phase velocity, but this can be approximated by considering only short helices $nL \ll \lambda$.

[15] The phase velocity along the helical conductor for T_1 and higher modes may differ considerably from that of light. It is often less, and, as shown later, it may be a function of the helix pitch angle and diameter.

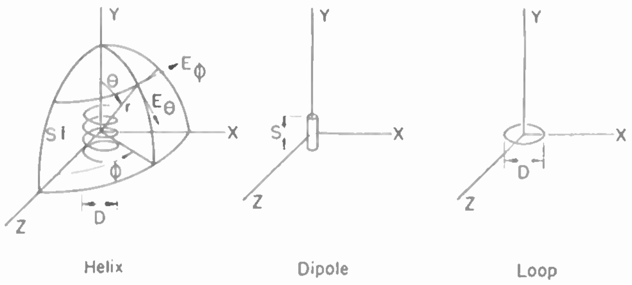

Fig. 5—Relation of field components to helix, dipole, and loop.

has only an E_θ component. On the other hand, with the small loop, $E_\theta=0$ everywhere and the distant electric field has only an E_ϕ component. By the retarded potential method, it may be shown that E_θ at a large distance from a short electric dipole ($r\gg\lambda\gg s$) is given by[16,17]

$$E_\theta = \frac{j\omega[I]s\sin\theta}{4\pi\epsilon c^2 r^2} = \frac{j60\pi[I]\sin\theta}{r}\frac{s}{\lambda} \tag{1}$$

where

s = length of short dipole
$\omega = 2\pi f$
r = distance from origin
c = velocity of light (in free space)
ϵ = dielectric constant of medium (free space)

and $[I]$ = retarded value of the current $= I_0 \exp[j\omega(t-r/c)]$.

In an analogous way, E_ϕ at a large distance, from a short magnetic dipole or from the equivalent small loop ($r\gg\lambda\gg D$) is

$$E_\phi = -\frac{120\pi^2[I]\sin\theta}{r}\frac{A}{\lambda^2} \tag{2}$$

where

A = area of loop $=\pi D^2/4$
$[I]$ = retarded value of the current on the loop.

If $nL\ll\lambda$, a helix may be considered, as has been done by Wheeler,[7] to be a combination of a series of loops and linear conductors as illustrated in Fig. 6. Each turn is assumed to consist of a short dipole of length S connected in series with a small loop of diameter D. Further, the current on the helix of Fig. 6 is assumed to be uniform and in phase over the entire length. The required end loading is not shown. Provided $nL\ll\lambda$ where

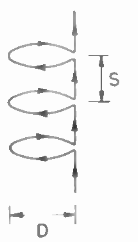

Fig. 6—Equivalent form of small helix.

[16] See, for example, S. Ramo and J. R. Whinnery, "Fields and Waves in Modern Radio," John Wiley and Sons, New York, N. Y., 1944; p. 430.
[17] Rationalized mks units are used.

the length of one "turn" is now given by $L=S+\pi D$, the far field pattern will be independent of the number of turns. Hence, to simplify the analysis, only a single turn will be considered. The electric field components at a large distance are then given by (1) and (2). The operator j in (1) and its absence in (2) indicates that E_ϕ and E_θ are in time phase quadrature. Taking the ratio of the magnitudes of E_θ and E_ϕ, we have

$$\frac{E_\theta}{E_\phi} = \frac{S\lambda}{2\pi A}. \tag{3}$$

Introducing the relation between the area and diameter of the loop, $A=\pi D^2/4$, (3) becomes

$$\frac{E_\theta}{E_\phi} = \frac{2S\lambda}{\pi^2 D^2}. \tag{4}$$

In the general case, both E_θ and E_ϕ have values and the electric field is elliptically polarized. Since E_θ and E_ϕ are in time phase quadrature, either the major or the minor axis of the polarization ellipse will lie in a plane through the polar or y axis (see Fig. 5(a)). Let us assume that the y axis is vertical and that observations of the field are confined to the equatorial or x-z plane. The ratio of the major to minor axes of the polarization ellipse is conveniently designated as the ***axial ratio*** (A.R.). Let us define the axial ratio in this case as

$$\text{A.R.} = \frac{E_\theta}{E_\phi} = \frac{2S\lambda}{\pi^2 D^2}. \tag{5}$$

Thus, in the extreme case when $E_\phi=0$, the axial ratio is infinite and the polarization ellipse becomes a straight vertical line indicating linear vertical polarization. At the other extreme, when $E_\theta=0$, the axial ratio is zero and the polarization ellipse becomes a straight horizontal line indicating linear horizontal polarization.

An interesting special case occurs for an axial ratio of unity ($E_\theta=E_\phi$). This is the case for circular polarization. Setting the axial ratio in (4) equal to 1, we have

$$\pi D = \sqrt{2S\lambda} \quad \text{or} \quad \pi D_\lambda = \sqrt{2S_\lambda}. \tag{6}$$

This relation was first shown by Wheeler in an equivalent form.[7] For this case, the polarization ellipse becomes a circle. The radiation is circularly polarized not only in all directions in the x-z plane but in all directions in space except the direction of the $\pm y$ axis, where the field is zero.

The relation of helix dimensions for circularly polarized radiation normal to the axis as given by (6) is indicated in Fig. 2, and also in Fig. 7 by the curve marked C.P. (Circular Polarization). This curve is accurate only in the region for which $\pi D\ll\lambda$ and $S\ll\lambda$. This region is shown to an enlarged scale in Fig. 7. In general, the radiation is elliptically polarized. If $\pi D>\sqrt{2S\lambda}$, the major axis of the polarization ellipse is horizontal, while if $\pi D<\sqrt{2S\lambda}$ the major axis is vertical. By varying the pitch angle α of a helix of constant turn length L, ori-

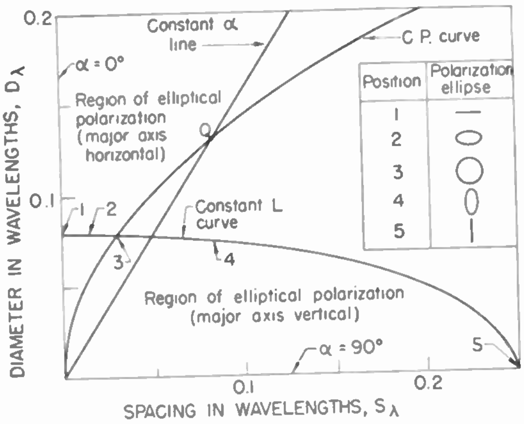

Fig. 7—Diameter versus spacing chart for small helices, showing polarization for different dimensions.

ented as in Fig. 5(a), from the loop case $\alpha=0°$ as in Fig. 5(c) to the straight conductor case $\alpha=90°$ as in Fig. 5(b), the radiation changes progressively through the forms listed in Table I.

TABLE I

Normal Radiation Mode

Position in Fig. 7	Condition	Radiation
(1)	$S=0$ $\alpha=0°$	Linear (horizontal) polarization
(2)	$S>0$ and $\pi D>\sqrt{2S\lambda}$	Elliptical polarization with major axis of polarization ellipse horizontal
(3)	$\pi D=\sqrt{2S\lambda}$	Circular polarization
(4)	$0<\pi D<\sqrt{2S\lambda}$	Elliptical polarization with major axis of polarization ellipse vertical
(5)	$\pi D=0$ $\alpha=90°$	Linear (vertical) polarization

The five conditions of Table I are suggested by the polarization ellipses at the five positions along the constant-L (turn-length) curve in Fig. 7. The fact that the linear polarization is horizontal for the loop and vertical for linear conductors assumes, of course, that the axis of the helix is vertical as in Fig. 5.

For a helix of fixed physical dimensions, the dimensions in wavelengths change along a constant-pitch-angle line as a function of frequency. Thus, as shown in Fig. 7, circularly polarized normal-mode radiation is obtained at only one frequency; that is, where the constant-pitch-angle line for the helix intersects the C.P. curve (point Q in Fig. 7).

In the above discussion of the normal mode of radiation, the assumption is made of a uniform in-phase current along the helical conductor. As already mentioned, this assumption would be approximated if the helix is small ($nL\ll\lambda$). To approximate such a distribution on longer helices would require a phase shifter of some type at intervals along the conductor. This may be inconvenient or impractical.

However, if the assumption of uniform, in-phase current is made without regard as to how it might be produced, it is interesting to consider some of the above relations further. Although the circularly polarized condition of (6) is true only when $nL\ll\lambda$, the relation is nevertheless approximately correct for larger values, say for S_λ and D_λ up to $\lambda/4$. The inaccuracy of (6) for large dimensions is due to the deterioration of (1) and (2) when the dipole or the loop are not small. Even if field formulas not restricted to small dipoles or loops are used, another limitation in extending the small-helix equations to helices of larger dimensions is that the simplification of Fig. 6 is no longer adequate. This is because the field of the vertical component of one turn of the helix cannot be properly approximated by a single vertical dipole but must be represented by a series of short dipoles at the circumference of the helix cyclinder.

Although there are practical limitations to the application of the normal circularly polarized condition of radiation from a pure helix, an antenna having four slanting dipoles which is suggestive of a modified helix radiating in the normal mode has been built by Brown and Woodward.[18] Their arrangement is based on design principles derived by Lindenblad.[19]

Axial Radiation Mode

The preceding section deals mainly with small helices ($nL\ll\lambda$). For this condition, the lowest T_0 transmission mode is dominant and any radiation is in the normal R_n mode. When the circumference of the helix is increased to about one wavelength ($\pi D\sim\lambda$), the first-order T_1 transmission mode becomes important, and over a considerable range of helix dimensions the radiation may be in the axial R_a or beam mode.

An outstanding characteristic of the axial or beam mode of radiation is the ease with which it is produced. In fact, owing to the extremely noncritical nature of the helix dimensions in this mode, a helical beam antenna is one of the simplest types of antennas which it is possible to build.

In speaking of transmission modes, it is assumed that the helix is infinite in extent. In discussing radiation modes, the helix must be finite. For convenience, the finite helix is assumed to be in the first approximation a section of an infinite helix. The observed current-dis-

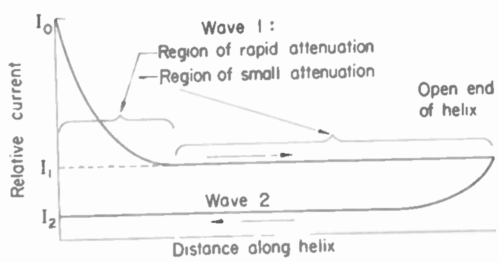

Fig. 8—Resolution of current distribution on the helical beam antenna into current distributions for outgoing and reflected waves. Curves are idealized.

[18] G. H. Brown and O. M. Woodward, "Circularly polarized omnidirectional antenna," *RCA Rev.*, vol. 8, pp. 259–269; June, 1947.

[19] N. E. Lindenblad, "Antennas and transmission lines at the Empire State television station," *Communications*, vol. 21, pp. 13–14; April, 1941.

tribution and terminal-impedance characteristics presented in footnote references 2 and 3 form the basis for making this assumption. Thus the observed current distribution on a helix may be resolved into the current distribution for an outward traveling wave and a current distribution for an inward traveling wave of considerably smaller magnitude, as in Fig. 8. Here each wave is characterized by an initial region of relatively rapid attenuation which is followed by a region in which the current is relatively constant in value. Hallén[20] has pointed out that a similar type of current distribution is characteristic for a traveling wave on a straight cylindrical conductor. Current-distribution measurements on long-straight cylindrical conductors by Bhargava,[21] when resolved into distributions for two traveling waves, indicate that the initial attenuation is greater for conductors of large diameter. In comparing the current distributions on straight cylindrical conductors and on helical conductors, it appears that a relatively thin conductor of diameter d, wound as a helix, has a current distribution with an initial attenuation for the component traveling waves as large as that on a straight cylindrical conductor of much greater diameter. The helix must, of course, be radiating in the beam mode for this to be the case. This large attenuation of the reflected wave on the helical conductor results in the relatively uniform current distribution over the central region of long helices. The marked attenuation of both the outgoing and reflected waves also accounts for the relatively stable terminal impedance of a helical antenna radiating in the axial mode, since relatively little energy reflected from the open end of the helix reaches the input. Thus the SWR of current at the input terminals is

$$SWR = \frac{I_0 + I_2}{I_0 - I_2}.$$

Since I_2 is small compared to I_0 (see Fig. 8), the SWR at the input terminals is nearly unity, the same as for a transmission line terminated in approximately its characteristic impedance.

When the helix is radiating in the axial mode, the phase velocity of wave propagation on the helix is such as to make the component electric fields from each turn of the helix add nearly in phase in the direction of the helix axis. The tendency for this to occur is sufficiently strong that the phase velocity adjusts itself to produce this result. This natural adjustment of the phase velocity is one of the important characteristics of wave transmission in the T_1 mode on a helix. It is this fact which accounts for the persistence of axial-mode R_a radiation patterns over such a wide frequency range. The phase velocity of wave propagation along a helical conductor is approximately equal to the velocity of light in free space c when the frequency is too low for the axial R_a mode of radiation. As the frequency is increased, it is found that there is a frequency range in which the phase velocity is decreased. In this same frequency range, the radiation is observed to be in the axial R_a mode and the current distribution changes from that due to two nearly equal but oppositely directed traveling waves, to essentially a single outgoing traveling wave and a small reflected wave, as in Fig. 8.

[20] Erik Hallén, private communication to the author, March 25, 1948.

[21] B. N. Bhargava, "A study of current distribution on long radiators," master's thesis, Department of Electrical Engineering, Ohio State University, Columbus, Ohio; 1947.

Array Factor

As an approximation, a helical antenna radiating in the axial mode can be assumed to have a single uniform traveling wave on its conductor. Based on this assumption, an approximate expression for the field pattern of a single-turn helix is developed in footnote reference 2. The pattern of a helix of a number of turns is then calculated as an array of such turns by taking the product of the pattern for the single turn and for the array. When the helix is sufficiently long (nS large), the array factor is dominant and largely determines the shape of the helix pattern. Calculated and measured patterns for a helix of 7 turns and 12° pitch angle ($n=7$, $\alpha=12°$) are compared in Fig. 21 of footnote reference 2. As an example which illustrates the dominant effect of the array factor, the component electric field patterns for this case are presented in Fig. 9. In this figure,

$E_{\phi T}$ = pattern of horizontally polarized component for one turn

$E_{\theta T}$ = pattern of vertically polarized component for one turn

Y_n = pattern of array of seven ($n=7$) isotropic point sources spaced 0.225 wavelength ($S_\lambda=0.225$) and for phase-velocity factor $p=0.83$.

$E_\phi = E_{\phi T} Y_n$ = pattern of horizontally polarized component of electric field from entire helix

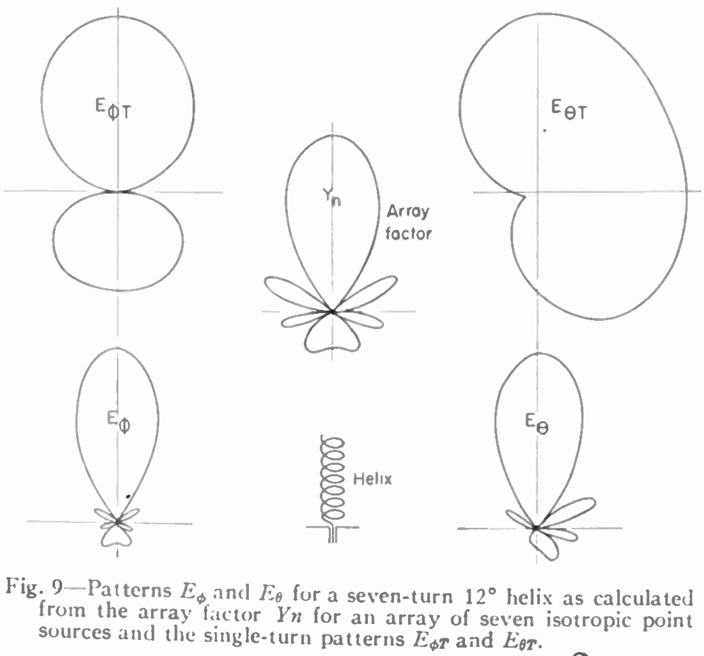

Fig. 9—Patterns E_ϕ and E_θ for a seven-turn 12° helix as calculated from the array factor Yn for an array of seven isotropic point sources and the single-turn patterns $E_{\phi T}$ and $E_{\theta T}$.

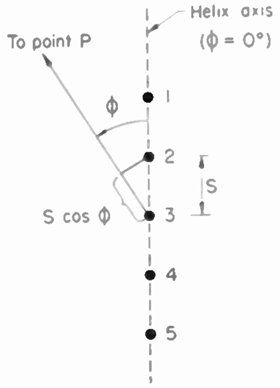

Fig. 10—Linear array of isotropic point sources.

$E_\theta = E_{\theta T} Y_n$ = pattern of vertically polarized component of electric field from entire helix.

It is interesting to note that, although the patterns of the horizontally and vertically polarized components for a single turn are very different in form, the patterns of the horizontally and vertically polarized components for the entire helix are nearly the same.[22] Furthermore, the main lobes of the E_θ and E_ϕ patterns are very similar to the array-factor pattern. Thus it is apparent that, for long helices, a calculation of the array factor alone suffices for the approximate helix pattern in any polarization.

To calculate the array factor, a helix of n turns is replaced by n isotropic point sources separated by the spacing S between turns of the helix. An array of n point sources is illustrated by Fig. 10. The normalized array factor (maximum value unity) is then given by equations (18) and (19) of footnote reference 2, or more simply by[23]

$$Y_n = \frac{1}{n} \frac{\sin \frac{n\psi}{2}}{\sin \frac{\psi}{2}} \tag{7}$$

where n = any integer (1, 2, 3, $\cdots$), and ψ is an auxiliary function giving the phase difference between successive sources in a particular direction ϕ. For $\psi = 0$, (7) is indeterminate, so that in this case it is necessary to take Y_n in the limit as ψ approaches zero. The phase of the wave arriving at a distant point P due to source 1 is advanced over the phase of the wave from source 2 by $2\pi S_\lambda \cos \phi$, but is retarded by $2\pi L_\lambda / p$. This retardation is proportional to the length of time required for a wave to travel around one turn or from source 2 to 1.

The value of ψ is then the difference of these. Thus,

$$\psi = 2\pi\left(S_\lambda \cos \phi - \frac{L_\lambda}{p}\right) \tag{8}$$

where

S_λ = spacing between helix turns in free-space wavelengths

ϕ = direction angle with respect to helix axis

L_λ = length of one helix turn in free-space wavelengths

p = phase velocity factor $= v/c$, or

$$p = \frac{\text{phase velocity along helix conductor}}{\text{velocity of light in free space}}.$$

It is interesting to examine the case for which the fields from the sources arrive at a remote point on the axis in the same phase; that is, when $\psi = -2\pi m$ and $\phi = 0$, where m is any integer (0, 1, 2, $\cdots$). Then,

$$\frac{L_\lambda}{p} = m + S_\lambda. \tag{9}$$

When $m = 1$, we have the approximate relation for the T_1 transmission mode:[24]

$$\frac{L_\lambda}{p} = 1 + S_\lambda \quad \text{or} \quad \frac{L}{p} = \lambda + S, \tag{10}$$

and, if $p = 1$, $L - S = \lambda$. Equation (10) is a fair approximation for helical antennas radiating in the axial mode. The phase difference is actually observed to be slightly greater, as given by the somewhat better approximation[25]

$$\frac{L_\lambda}{p} = 1 + \frac{1}{2n} + S_\lambda \tag{11}$$

where n = number of turns. The additional phase shift represented by $1/2n$ results in sharper helix patterns, as it does also for all end-fire arrays.[26] The additional phase shift is a natural phenomenon in the helical beam antenna and is maintained over a considerable frequency range. The condition of (11) will be referred to as the condition for "maximum directivity."

When $m = 2$ we have the approximate relation for the T_2 transmission mode:

$$\frac{L_\lambda}{p} = 2 + S_\lambda. \tag{12}$$

The approximate relation for the general T_m transmission mode of higher order ($m \geqq 1$) is as given by (9). If $p = 1$, and introducing also the relation $L^2 = S^2 + \pi^2 D^2$ for a helix, we obtain $D_\lambda = \sqrt{2mS_\lambda + m^2}/\pi$ and, when $m = 1$, $D_\lambda = \sqrt{2S_\lambda + 1}/\pi$.

The diameter versus spacing chart of Fig. 11 has curves of the helix relations for the T_1 transmission

[22] The calculated E_ϕ pattern of Fig. 21, footnote reference 2, is a mirror image along the helix axis of the E_θ pattern in Fig. 9. The image was taken in footnote reference 2 to allow a direct comparison between the left-handed helix used in the calculations and the right-handed helix which was measured.

[23] S. A. Schelkunoff, "Electromagnetic Waves," D. Van Nostrand Co., Inc., New York, N. Y., 1943; p. 342.

[24] The ratio L_λ/p in (9) and (10) is the length of one turn measured in terms of the wavelength on the helical conductor. This ratio times 2π is the phase length of one turn in radians and will be designated L_p. Thus, from (10) we have $L_p = 2\pi(1 + S_\lambda)$, which indicates that, for the T_1 transmission mode, one turn has a phase length of 2π radians plus $2\pi S_\lambda$.

[25] To convert (9) and (11) to radian measure, multiply both sides by 2π, while to convert to degrees multiply both sides by 360.

[26] W. W. Hansen and J. R. Woodyard, "A new principle in directional antenna design," Proc. I.R.E., vol. 26, pp. 333–345; March 1938.

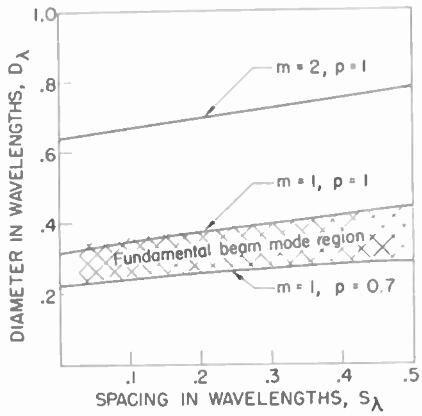

Fig. 11—Diameter versus spacing chart showing region for fundamental axial or beam mode of radiation.

mode for two cases of the phase-velocity factor $p=1$ and $p=0.7$. The cross-hatched area indicates the observed region of the fundamental axial or beam mode of radiation R_a. The two curves define quite well the upper and lower limits of the region. A curve for a higher-order transmission mode T_2 is also shown in Fig. 11 for the case of $p=1$.

Returning to a further consideration of the axial radiation mode, we have from (10), substituting also $L_\lambda=\pi D_\lambda/\cos\alpha$ and $S_\lambda=\pi D_\lambda \tan\alpha$,

$$p=\frac{L_\lambda}{1+S_\lambda}=\frac{1}{\left(\tan\alpha+\frac{1}{\pi D_\lambda}\right)\cos\alpha},$$

or

$$p=\frac{1}{\sin\alpha+\frac{\cos\alpha}{\pi D_\lambda}}. \qquad (13)$$

Equation (13) gives the required variation in p for the fields of each turn of a helix of pitch angle α to add in phase in the axial direction.

In a similar way, we can obtain from (11) the required variation of p for "maximum directivity" as

$$p=\frac{L_\lambda}{1+\frac{1}{2n}+S_\lambda}=\frac{1}{\sin\alpha+\left(\frac{2n+1}{2n\pi D_\lambda}\right)\cos\alpha}. \qquad (14)$$

Conditions for Circular Polarization[27]

In this section, the conditions necessary for circularly polarized radiation in the direction of the helix axis will be analyzed. The discussion is concerned entirely with helices radiating in the axial mode.

Referring to Fig. 12(a), let us consider a helix of diameter $D=2r$ having its axis coincident with the z axis. Expressions will be derived for the electric field at a point P a large distance z_1 in the direction of the axis of a helical antenna, as shown. The antenna is assumed

[27] In connection with the analysis in this section, it is a pleasure to acknowledge the interest and criticisms of Victor H. Rumsey.

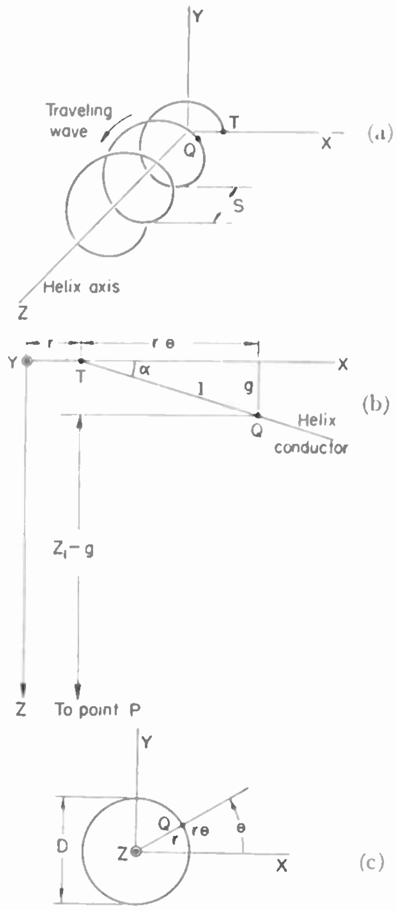

Fig. 12—Relations for analysis of circular-polarization conditions.

to have a single uniform traveling wave. If the helix is unrolled in the x-z plane, the relations are as indicated in Fig. 12(b). Let point Q on the helix be a distance l along the helix from the terminal (point T). It is also convenient to specify a cylindrical co-ordinate system as in Fig. 12(c), the angular position of Q with respect to the x-z plane being given by θ. From the geometry in Fig. 12, we have

$$\left.\begin{aligned} g &= l\sin\alpha\\ z_1-g &= z_1-l\sin\alpha\\ \alpha &= \arctan(S/\pi D)=\arccos(r\theta/l)\\ r\theta &= l\cos\alpha. \end{aligned}\right\} \qquad (15)$$

At a large distance z_1, the component of the relative electric field intensity in the x direction E_x for a helix of an integral number of turns n is given by

$$E_x=E_0\int_0^{2\pi n}\sin\theta\, e^{j\omega(t-z_1/c+(l\sin\alpha)/c-l/pc)}d\theta \qquad (16)$$

where

E_0 = a constant involving the current magnitude on the helix

c = velocity of light in free space (3×10^8 meters/second)

t = time in seconds

$\omega=2\pi$ (frequency)

p = phase-velocity factor $= v/c$, where
v = phase velocity of wave propagating along helical conductor.

Using the relations of (15), the last two terms of the exponent may be re-expressed:

$$\frac{l \sin \alpha}{c} - \frac{l}{pc} = \frac{r\theta}{c}\left(\tan \alpha - \frac{1}{p \cos \alpha}\right) = \frac{r\theta b}{c} \qquad (17)$$

where

$$b = \tan \alpha - \frac{1}{p \cos \alpha}.$$

For $\alpha = 0$, we have a loop, and $b = -1/p$. Hence, the relation being derived may be applied not only to the general helix case but also the special case of a loop. Since t and z_1 are independent of θ, the first two terms of the exponent may be taken outside the integral. Hence (16) becomes

$$E_z = E_0 e^{j(\omega t - \beta z_1)} \int_0^{2\pi n} \sin \theta e^{jk\theta} d\theta \qquad (18)$$

where

$$\beta = 2\pi/\lambda$$

$$k = \beta r b = L_\lambda\left(\sin \alpha - \frac{1}{p}\right). \qquad (19)$$

Integrating and introducing limits, we obtain

$$E_z = \frac{E_1}{k^2 - 1}(e^{j2\pi nk} - 1) \qquad (20)$$

where

$$E_1 = E_0 e^{j(\omega t - \beta z_1)}.$$

The expression for the relative electric field intensity in the y direction E_y is identical to (20) except that it has $\cos \theta$ instead of $\sin \theta$. From this we obtain

$$E_y = \frac{E_1 k}{j(k^2 - 1)}(e^{j2\pi nk} - 1). \qquad (21)$$

For circular polarization on the axis, the required condition is

$$\frac{E_z}{E_y} = \pm j. \qquad (22)$$

Taking the ratio of E_z to E_y as given by (20) and (21), we get

$$\frac{E_z}{E_y} = \frac{j}{k}. \qquad (23)$$

Hence, for circular polarization on the axis of a helix of an integral number of turns ($n = 1, 2, 3, \cdots$), k must equal ± 1.

However, as will be shown, nearly circular polarization may be obtained provided only that the helix is long and k is nearly unity. For this case, the number of turns may assume nonintegral values. Hence, the length of the helical conductor will be specified as θ_1 instead of $2\pi n$. Thus, rewriting (18), we have

$$E_z = \frac{E_1}{2j}\int_0^{\theta_1}\left[e^{j(k+1)\theta} - e^{j(k-1)\theta}\right] d\theta \qquad (24)$$

which becomes, after integrating, introducing the condition $k \sim -1$, and the approximation for $k+1 \sim 0$ that $e^{j(k+1)\theta_1} \cong 1 + j^{(k+1)\theta_1}$,

$$E_z = -\frac{E_1}{2}\left[j\theta_1 - \frac{e^{j(k-1)\theta_1} - 1}{k - 1}\right]. \qquad (25)$$

In a similar fashion, we obtain for the relative electric field intensity component in the y direction, E_y:

$$E_y = \frac{E_1}{2j}\left[j\theta_1 + \frac{e^{j(k-1)\theta_1} - 1}{k - 1}\right]. \qquad (26)$$

If the helix is very long ($\theta_1 \gg 1$), (25) and (26) become very nearly

$$E_z = -j\frac{E_1\theta_1}{2} \quad \text{and} \quad E_y = \frac{E_1\theta_1}{2}. \qquad (27)$$

The ratio of these then gives $E_z/E_y = -j$, which satisfies the condition for circular polarization. Although these give the important conditions for circular polarization, another condition resulting in circular polarization is obtained when $(k \pm 1)\theta_1 = 2\pi m$ where m = integer. This condition is fulfilled when either the positive or negative sign in $(k \pm 1)$ is chosen, but not for both. To summarize the important conditions:[28]

(1) The radiation in the axial direction from a helical antenna of any pitch angle ($0 < \alpha < 90°$) and of an integral number of one or more turns will be circularly polarized if $k = \pm 1$.

(2) The radiation in the axial direction from a helical antenna of any pitch angle ($0 < \alpha < 90°$) and a large number of turns, which are not necessarily an integral number, is nearly circularly polarized if k is nearly ± 1.

Let us now investigate the significance of the requirement that $k = \pm 1$. Referring to (19), k is negative in the case of interest, since $\sin \alpha \leqq 1$ and $1/p \geqq 1$. Thus, for $k = -1$ we have

$$L_\lambda\left(\sin \alpha - \frac{1}{p}\right) = -1$$

or

$$p = \frac{L_\lambda}{L_\lambda \sin \alpha + 1} = \frac{L_\lambda}{S_\lambda + 1}. \qquad (28)$$

If $p = 1$, the circular, polarization condition is $L_\lambda - S_\lambda = 1$ or $L - S = \lambda$. This was first pointed out in footnote reference 1. The relation for p in (28) is identical with the

[28] A single, traveling wave (1 in Fig. 8) is assumed on the helix and the effect of the reflected wave (2 in Fig. 8) is neglected. The effect of the reflected wave on the axial ratio is discussed in footnote reference 2, p. 91.

value of p required for the fields of each turn of a helix to add in phase in the axial direction as given by (13).[29]

Phase-Velocity Comparison

Several expressions for the required phase-velocity factor p have been derived corresponding to different conditions. These are summarized for the T_1 transmission mode in Table II. Two of the expressions are identical, namely, for circular polarization (C.P.), and in-phase fields from each turn. In Table II, ϕ_0 is the value of ϕ at the first null in the radiation pattern, and ψ_0 is the value of ψ at the first null in the array factor.

TABLE II

Condition	Required Phase-Velocity Factor p
(1) and (2) C.P. and in-phase fields	$p=\dfrac{L_\lambda}{S_\lambda+1}=\dfrac{1}{\sin\alpha+\dfrac{\cos\alpha}{\pi D_\lambda}}$
(3) Maximum directivity	$p=\dfrac{L_\lambda}{S_\lambda+1+\dfrac{1}{2n}}=\dfrac{1}{\sin\alpha+\left(\dfrac{2n+1}{2n}\right)\dfrac{\cos\alpha}{\pi D_\lambda}}$
(4) From first null of measured pattern[30]	$p=\dfrac{L_\lambda}{S_\lambda\cos\phi_0+1+\dfrac{\psi_0}{2\pi}}$

Curves calculated by the three different methods of Table II are compared in Fig. 13 with the measured variation of the phase velocity as a function of frequency on a seven-turn 12° helix.[31] All curves are in general agreement in the region in which p increases with frequency.[32] In Fig. 13, 300 Mc corresponds to a helix circumference of 0.72 free-space wavelengths and 500 Mc to a helix circumference of 1.2 free-space wavelengths. It can be effectively demonstrated that p for "maximum directivity" is most probably the one actually occurring on the helix by noting the close agreement of measured field patterns with array-factor patterns calculated with this value of p and the poor agreement when other values of p are used.

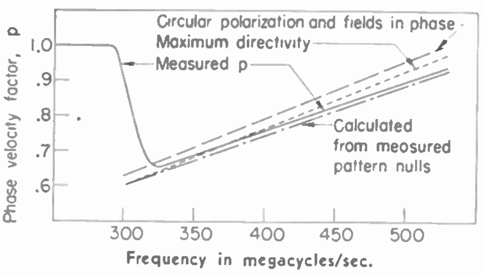

Fig. 13—Comparison of variation of measured phase-velocity factor ($p=v/c$) with frequency on a seven-turn 12° helix with the calculated variation for several conditions.

[29] The condition was expressed in equation (1) of footnote reference 1 as $L-S=n\lambda$ where n corresponds to m in the present paper. Two corrections to footnote reference 1 are that n may be any integer, not merely an odd integer, and the same condition is not for maximum directivity but for the fields from each turn to add in phase.

[30] See p. 96 of footnote reference 2.

[31] This is the same helix as shown in Fig. 5 of footnote reference 2, $D=23$ cm.

[32] The agreement of the measured velocity factor with p for maximum directivity is better than with p for in-phase fields.

Single-Turn Pattern

The pattern of a single turn is an important factor in determining the pattern of short helices. In the case of long helices, the array factor is relatively more important, and is usually sufficient to give the approximate main-lobe pattern of the helix. However, it is nevertheless necessary that the direction of maximum radiation from a single turn be approximately in the axial direction. Accordingly, it is of interest to investigate briefly the form of the single-turn pattern of helical antennas radiating in the axial mode. Referring to the preceding sections, the condition $k=-1$ also results in the single-turn pattern maximum being nearly in the axial direction. This follows from the fact that when α is small the length of a turn is nearly one wavelength, so that the instantaneous current directions on a single turn are as shown in Fig. 14(a). If α is small, this is approximately equivalent at one instant of time to a broadside array of two short dipoles spaced by about the diameter of the helix, as in Fig. 14(b). Since the dipoles are in phase, the maximum radiation is normal to their plane or in the axial direction. The pattern is also very broad in the axial direction, as indicated. With passage of time, these equivalent dipoles rotate around the axis, yielding circular polarization. If α is not small, then it becomes necessary to approximate the single turn of the helix by a square turn with four short linear segments, as was done in the pattern calculations of footnote reference 2. A square turn is suggested by the perspective sketch in Fig 14(c). Since the wave on the helix is, to a good approximation a single, traveling wave, the radiation maximum is tilted forward from the normal to the conductor. As shown in footnote reference 2, it turns out that the tilt angle τ of the radiation maximum for a short segment ($D\sim0.3\lambda$) is of the order of 10°. When $\alpha=\tau$, the radiation maximum for each segment is in the axial direction (Fig. 14(d)). Adding the fields of the segments gives the single-turn pattern.

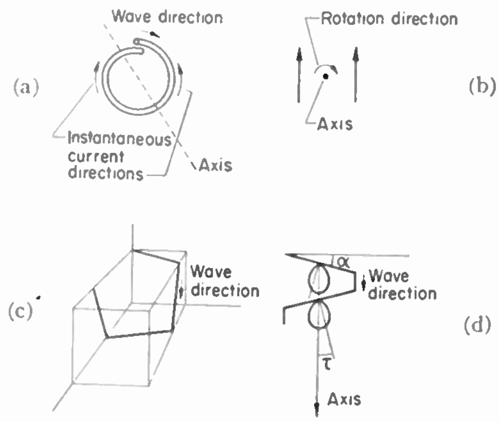

Fig. 14—Relations for discussion on pattern of single turn.

Electronics of Ultra-High-Frequency Triodes*

R. R. LAW†, SENIOR MEMBER, IRE

Summary—The electronic behavior of ultra-high-frequency triodes is well understood, but there is need for an easily interpreted relationship correlating the various factors in terms of performance. An empirical relation for anode efficiency as a function of frequency, interelectrode spacing, and operating voltage which largely fulfills this need is deduced from the aforementioned theory and existing experimental data.

Analysis

THE ELECTRONIC behavior of ultra-high-frequency triodes is well understood,[1-5] but there is need for an easily interpreted relationship correlating the various factors in terms of performance. Prince[1] has given a detailed account of triode operation at low frequencies. For a grounded-grid triode, the time variation of voltage and current on anode and cathode may be represented as shown in Fig. 1. Ordinarily, the tube is operated under class-C conditions to give good efficiency. That is, the instantaneous cathode potential swings below the grid so that the grid is effectively positive with respect to the cathode for only a fraction of the cycle of operation, the interval $2t_0$, and a momentary pulse of current i_k is drawn from the cathode and injected in the grid-anode space. If the instantaneous anode potential is below the dc value when the current arrives at the anode, a portion of the dc power is converted into ac energy.

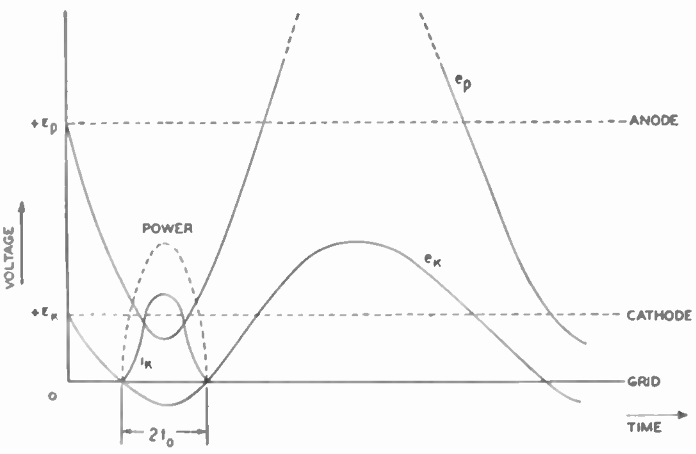

Fig. 1—Grounded-grid triode operation.

At higher frequencies, where transit-time effects become appreciable, the current pulse is no longer related to the voltage pulse in this simple manner. Wagener[2] and Haeff[3] have discussed the effects of electron-transit time and have presented specific efficiency versus frequency data and generalized curves of transit-time-efficiency factors for triode oscillators and amplifiers. Their data show efficiency to be an almost linear function of frequency in accordance with an empirical relation which can be adjusted to fit both the amplifier and oscillator. Thus,

$$\eta = \eta_0(1 - K_1 f) \tag{1}$$

where

η_0 = efficiency at low frequency where transit-time effects are negligible

K_1 = a constant determined by operating and design parameters

f = frequency.

In an oscillator, the driving power is derived from the plate output; inasmuch as the electron input loading increases with frequency, the efficiency of an oscillator falls off more rapidly than does that of an amplifier.

Wang[4] has developed electronics equations which permit analysis of class-C operation. He has indicated methods for calculating the performance of conventional power tubes at high frequencies, and shows that the mode of operation for a specified waveform depends upon a single normalization constant

$$C = 2(e/m)t_0^2 E_{gm}/d^2 \tag{2}$$

where

e/m = ratio of charge to mass of an electron

E_{gm} = peak value of voltage pulse

t_0 = half period of voltage pulse

d = equivalent diode spacing.

Lehmann and Vallarino[5] have extended this result by describing the voltage pulse in terms of the anode voltage. Thus, under practical operating conditions, the voltage pulse in the cathode-grid region will be proportional to the dc anode voltage; furthermore, the relative duration of the voltage pulse is circumscribed by the compromise between power output and efficiency. On this basis, the properties of class-C uhf amplifiers and oscillators may be expressed in terms of the dimensionless parameter

$$\phi = fd/\sqrt{E_p} \tag{3}$$

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† RCA Laboratories Division, Radio Corporation of America, Princeton, N. J.

[1] D. C. Prince, "Vacuum tubes as power oscillators," Proc. I.R.E., vol. 11, p. 275, June; p. 405, August, 1943; and p. 527, October, 1923.

[2] W. G. Wagener, "The developmental problems of two new uhf triodes," Proc. I.R.E., vol. 26, pp. 401–414; April, 1938.

[3] A. V. Haeff, "Effect of electron transit time on efficiency of a power amplifier," *RCA Rev.*, vol. 4, pp. 114–122; July, 1939.

[4] C. C. Wang, "Large-signal high-frequency electronics of thermionic vacuum tubes," Proc. I.R.E., vol. 29, pp. 200–214; April, 1941.

[5] G. J. Lehmann and A. R. Vallarino, "Study of ultra-high frequency tubes by dimensional analysis," Proc. I.R.E., vol. 33, pp. 663–666; October, 1945.

where

f = frequency

d = effective cathode-grid spacing

E_p = anode voltage.

This dimensionless parameter is evidently contained in (1). To satisfy the observed frequency dependence, $K_1 f$ must be equal to $Kfd/\sqrt{E_p}$, whereupon the empirical relation for anode efficiency as a function of frequency, spacing, and voltage may be written

$$\eta = \eta_0(1 - Kfd/\sqrt{E_p}), \tag{4}$$

where

η = anode efficiency

η_0 = anode efficiency at low frequency where transit-time effects are negligible, characteristic value 70 per cent

f = frequency in megacycles

d = effective cathode-to-grid spacing in inches

E_p = anode voltage in volts

K = a constant; characteristic value for oxide-coated-cathode tubes, 1.75 for oscillator service, 1.2 for amplifier service.

The term "effective cathode-to-grid spacing" is employed to account partially for the effects of initial velocity. Although the kinetic energy of emission is ordinarily small in comparison to the kinetic energy imparted to the electrons by the voltage pulse, the effect of initial velocity upon the position of the virtual cathode may not be neglected. For closely spaced triodes the grid-to-virtual-cathode spacing may be appreciably less than the geometric spacing. The values of the constant K, 1.75 for oscillator service and 1.2 for amplifier service, are empirically determined from experimental data on oxide-coated-cathode tubes.

By way of illustrating the practical application of this relationship, it is of interest to plot oscillator efficiency as a function of frequency for a typical anode voltage and representative cathode-grid spacings. Such a plot

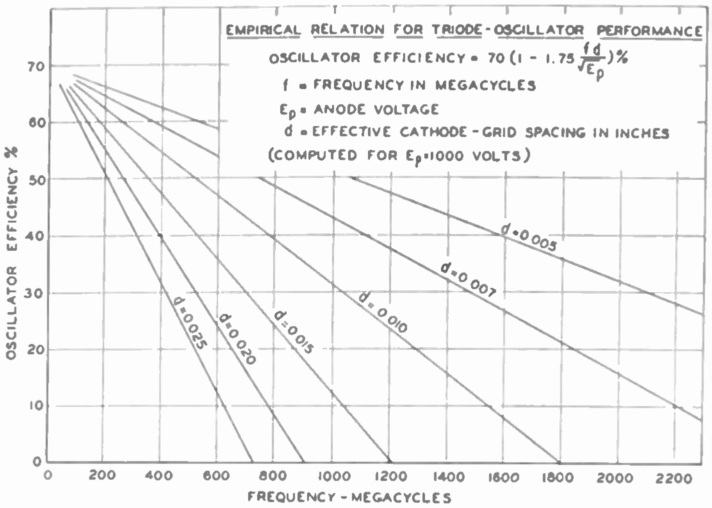

Fig. 2—Empirical relation for triode-oscillator performance.

is shown in Fig. 2 for the case of an anode voltage of 1,000 volts. This plot emphasizes the importance of keeping cathode-to-grid spacing small, inasmuch as the practical upper limit for cw operation of oxide-coated-cathode tubes appears to be near 1,000 volts.

In the more fundamental sense, this simple relationship has proved useful in predicting the performance of oxide-coated-cathode triode amplifiers and oscillators throughout the range from a few hundred to several thousand megacycles. In view of its empirical nature and the necessity of correcting for the position of the virtual cathode, no claim can be made for accuracy. Furthermore, the characteristic value of the constant K undoubtedly depends upon emission density, which in turn depends upon the type of cathode. Experimental verification of this point awaits tests in structures similar to the indirectly heated oxide-coated cathode where the grid-to-cathode spacing can be accurately determined. The author would like to hear of instances where other cathodes give performances materially different from that indicated.

Contributors to the Proceedings of the I.R.E.

J. H. DeWitt, Jr.

John H. DeWitt, Jr. (A'31–M'38–SM'43) was born in Nashville, Tenn., on February 20, 1906. He attended Vanderbilt University, and became a member of the technical staff of Bell Telephone Laboratories following graduation, remaining until 1932. From 1932 to 1942 he was engaged as chief engineer of radio station WSM, in Nashville, Tenn; and from 1942 to 1943, he was once more associated with the Bell Telephone Laboratories, this time at Whippany, N. J.

Mr. DeWitt, a former lieutenant colonel in the Signal Corps, was director of the Evans Signal Laboratory from 1943 to 1946. He is now president of radio station WSM, Inc., Nashville, Tenn.

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D. K. Gannett

D. K. Gannett (A'42) was born on November 22, 1894, at Minneapolis, Minn. He received the B.S. degree in engineering in 1916, and the E.E. degree in 1917, both from the University of Minnesota. From 1917 to 1919 he was a member of the engineering department, and from 1919 to 1934, of the department of development and research of the American Telephone and Telegraph Company.

Since 1934, Mr. Gannett has been a member of the technical staff of the Bell Telephone Laboratories. He has specialized

Contributors to the Proceedings of the I.R.E.

n transmission engineering of long-distance communication facilities, including telephone, program, and video systems. During both world wars, he was engaged in secret war projects for the government.

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H. S. Jarkowski was born on December 21, 1908, at Warsaw, Poland, and studied electrical engineering at Warsaw Technical University. In 1935 he joined the Telecommunication Institute in Warsaw, working on problems connected with infrared radiation and ultrasonics. During the war he was on active service in the Polish Army in France and Great Britain. In 1943 he was attached to the Signals Research and Development Establishment, Ministry of Supply, in Great Britain, where he worked on mine detection and the propagation of centimeter waves.

H. S. Jarkowski

In 1945 Mr. Jarkowski obtained a Diploma of Electrical Engineering from Polish University College in London, and in 1947 he returned to Poland.

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For a biography and photograph of John D. Kraus, see page 1260 of the October, 1948, issue of the Proceedings of the I.R.E.

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R. R. Law (A'34–M'40–SM'43) was born on January 11, 1907, at Hampton, Iowa. He received the B.S. degree in electrical engineering in 1929, and the M.S. degree in 1931, both from Iowa State College. In 1933 he received the D.S. degree from the Harvard Engineering School. From 1933 to 1934 he was a research associate in geophysics at Harvard University. He entered the research and engineering department of the RCA Manufacturing Company in Harrison, N. J., in 1934, and is now with RCA Laboratories at Princeton, N. J.

R. R. Law

J. S. McPetrie (SM'46) was born in 1902 at Aberdeen, Scotland. He holds the degrees of Ph.D. and D.Sc., conferred by Aberdeen University. In 1925 he joined the National Physical Laboratory where, until 1943, he carried out work on various aspects of radio research, particularly the production and propagation of short radio waves. He has published a number of papers describing the results of this work. For a period of six months, during 1943–1944, he acted as radiophysicist to the British Supply Mission in Washington, D.C.

J. S. McPetrie

Since 1944, Dr. McPetrie has been in charge of research at the Signals Research and Development Establishment, Ministry of Supply, Christchurch, England. He is a member of the Institution of Electrical Engineers, and a Fellow of the Physical Society, in London.

❖

Leszek W. Sicinski was born on November 28, 1907, at Lwow, Poland. He attended the Technical University at Lwow, and received the degree of Dipl. Ing. in electrical engineering in 1936. During 1936–1937 he acted as assistant professor in the Radio Laboratory of that University. He was employed as the chief of the vhf group of the State Telecommunication Works (P.Z.T.) in Warsaw, from 1937 until 1939.

L. W. Sicinski

From 1944 until 1947 Mr. Sicinski was on active service in the Polish Army, attached to the Signals Research and Development Establishment in England, where he acted as an Experimental Officer.

Since July, 1947, Mr. Sicinski has been with British Telecommunications Research Ltd., at Taplow, England, engaged in the development of carrier telephony on power lines.

❖

B. J. Starnecki was born on January 28, 1905, in Warsaw, Poland. He received the Diploma of Electrical Engineering from Warsaw Technical University in 1929. From 1928–1932 he was associated with various lines of activities of the Polish branch of Philips, in Eindhoven, Holland. Between 1933 and 1939, he conducted research on atmospheric noise and the ionosphere for the Polish Meteorological Office, and, at the same time, worked in the Radio Receivers Research and Development Group of the State Telecommunications Works in Warsaw.

B. J. Starnecki

From 1939 until 1943 Mr. Starnecki was on active service in France and Great Britain. Since 1943 he has been attached to the Signals Research and Development Establishment in England, carrying out research work on mine detection, radio wave propagation, and antennas. Mr. Starnecki is an associate member of the Institution of Electrical Engineers, in London.

❖

E. King Stodola (A'37–SM'45) was born in Brooklyn, N. Y., on October 31, 1914. He received the degree of B.S. in electrical engineering in 1936, and the E.E. degree in 1947, both from Cooper Union Institute of Technology in New York, N. Y. From 1936 to 1939 he worked as an engineer with Radio Engineering Laboratories in New York, N. Y. During the period 1939–1947 he served as a radio engineer with the U. S. War Department, Signal Corps, in Washington, D. C., and from 1941 to 1947 he was stationed at Evans Signal Laboratory in Belmar, N. J.

E. King Stodola

Mr. Stodola is now an engineer with Reeves Instrument Corporation in New York, N. Y. He is a member of the American Institute of Electrical Engineers.

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For a photograph and biography of W. R. Young, see page 931, of the July, 1948, issue of the Proceedings of the I.R.E.

Institute News and Radio Notes

IRE-RMA Announce Spring Meeting

The Fourth Annual Spring Meeting, sponsored jointly by The Institute of Radio Engineers and the Radio Manufacturers Association in the interest of radio transmitter and radio transmitting tube engineers, will be held at the Benjamin Franklin Hotel in Philadelphia, Pa., from April 25 to 27.

The tentative program will include the delivery of technical papers by outstanding radio transmitter authorities, and visits to the Philadelphia Navy Yard, Philco television station WPTV, and the RCA plant at Camden, N. J. The annual banquet will be held the evening of April 26. Engineers engaged in television, FM, navigational aids, and aircraft and broadcast radio will find the meeting of especial interest.

AIEE Conference on Electron Tubes

The American Institute of Electrical Engineers' Conference on the Industrial Application of Electron Tubes will be held in the Statler Hotel, Buffalo, N. Y., on April 11, and 12, 1949. The conference will provide a means for electron-tube users to discuss their mutual problems with control equipment designers and tube manufacturers.

The first day's program will include a technical session on the application of electron tubes in control and other industrial equipment, an inspection trip to the new Westinghouse plant in Buffalo, and the presentation of several papers by the users of electron tubes describing their operating experience and maintenance. The second day will be devoted to a discussion of items which equipment manufacturers consider in designing control and other equipment using tubes, followed by a technical session on the methods used by the electron tube manufacturers in building and rating tubes for industrial applications.

IRE-URSI-AIEE Hold Joint Technical Meeting

A joint technical meeting of The Institute of Radio Engineers and the International Scientific Union (URSI), U. S. A. National Committee, was held in Washington, D. C., on October 7, 8, and 9, 1948. The morning session on Thursday, October 7, which dealt with radio relay, television, radar, and electronic heating, was held jointly with District 2 of the AIEE. Forty-seven papers were presented at the five sessions of the meeting: Ionospheric Propagation, Ionospheric and Tropospheric Propagation, Antennas and Broadcast Coverage, Electron Tubes and Microwave Instruments, and Circuit Analysis and Measurements. An evening session was held on Thursday, October 7, consisting of a number of informal talks on the international radio meetings and conferences held in the summer of 1948.

Abstracts of the papers presented at the meeting have been prepared in booklet form. A few copies are still available, and may be obtained from Newbern Smith, Secretary of the U. S. A. National Committee, Central Radio Propagation Laboratory, National Bureau of Standards, Washington 25, D. C.

The name of the Executive Committee of URSI's American Section was changed to the U. S. A. National Committee, which established seven national commissions, corresponding to the international commissions of the same names which were established by the eighth general assembly of URSI, held in Stockholm, Sweden, in 1948.

The next meeting of the IRE and URSI will be held in the East Building Lecture Room, National Bureau of Standards, in Washington, D. C., on May 2, 3, and 4. The first two days will be devoted to a program of fundamental scientific and research papers on the following topics: radio standards, methods of measurement, terrestrial radio noise (natural and manmade), communication theory, antennas, circuits, electron tubes, semiconductors, and properties of matter. Wednesday, May 4, will be reserved for meetings of the National Commission on Radio Standards and Methods of Measurement, Terrestrial Radio Noise, Radio Waves and Circuits, and Electronics. A booklet listing the program of titles and abstracts will be available for distribution before the meeting, and may be obtained from Dr. Smith.

Calendar of COMING EVENTS

1949 IRE National Convention, New York City, March 7–10

Winter Meeting, Optical Society of America, New York City, March 10–12

1949 Chicago Production Show, Chicago, Ill., March 14–17

Annual Meeting, Armed Forces Communications Association, Washington, D. C., March 28–29

Annual Symposium, Engineers Council of Houston, Houston, Tex., April 2, 1949

Semiannual Convention, Society of Motion Picture Engineers, New York City, April 4–8

AIEE Conference on Electron Tubes, Buffalo, N. Y., April 11–12

AIEE Southwest District Meeting, Dallas, Tex., April 19–21

Third Annual Spring Conference, Cincinnati Section, IRE, Cincinnati, Ohio, April 23

IRE-RMA Spring Meeting, Philadelphia, Pa., April 25–27

IRE-URSI Meeting, Washington, D. C., May 2–4

National Electronics Conference Held in Chicago

Recent advances in electronics, with emphasis on industrial and commercial applications, highlighted the recent National Electronics Conference which held its annual meeting on November 4, 5, and 6 at the Edgewater Beach Hotel in Chicago. More than 2,000 scientists and engineers attended the three-day conference, at which 64 papers were presented during 15 technical sessions. Electronic systems, components, and recent developments were displayed in the East and West Lounges of the hotel by 52 exhibitors.

E. O. Neubauer, of the Illinois Bell Telephone Co., president of the 1948 conference, took charge at the opening day noon luncheon, which was attended by over 500 engineers. The principal speech was given by Anton J. Carlson, Professor Emeritus, Department of Physiology, University of Chicago, on "Science, Industry, and the Future of Man." The Friday noon luncheon, with an attendance of 525, was presided over by W. C. White of the General Electric Co., chairman of the board of directors, National Electronics Conference. At this luncheon, Donald J. Fink, editor-in-chief of *Electronics* magazine, presented an address on "The Decline and Fall of the Free Electron."

The majority of the papers given at the conference will be published as the "Proceedings of the 1948 National Electronics Conference," and copies may be ordered from R. R. Buss, Secretary NEC, Northwestern University, Evanston, Ill.

The National Electronics Conference, Inc., is sponsored jointly by The Institute of Radio Engineers, the Illinois Institute of Technology, Northwestern University, the University of Illinois, and the AIEE. The 1949 Conference will be held September 26, 27, and 28 at the Edgewater Beach Hotel in Chicago, Ill., it was announced by G. H. Fett, professor of electrical engineering at the University of Illinois, and newly elected president of the conference.

Abstracts and References Will Stay

Replies received to the boxed notice in the October and November, 1948, issues of the Proceedings concerning the possible discontinuance of the Abstracts and References totalled 101. Of these, 11 definitely approved of Abstracts and References' being omitted and more technical papers substituted in their place. Two suggested that Abstracts and References be printed separately. The remaining 88 favored the continuance of the material in its present form and suggested that one or more of the following types of material be eliminated instead: (1) review articles on nuclear physics; (2) technical papers not of the very highest caliber; (3) guest editorials, IRE people, section chairmen biographies, and Institute News and Notes. It was decided by the Executive Committee that the Abstracts and References be continued through 1949.

Technical Committee Notes

The **Standards Committee,** which met on January 13, approved a proposed standard on methods of testing and accompanying definitions which had been prepared by the Railroad and Vehicular Communications Committee. Proposed frequency-band designations prepared by a subcommittee under the chairmanship of Richard F. Shea will be printed in a forthcoming issue of the PROCEEDINGS. Three months after publication, the proposed frequency-band designations will be considered for standardization. . . . The name of the Antennas Committee was changed to **Technical Committee on Antennas and Wave Guides.** It met on January 7 to review comments received on the Standards reports on "Methods of Testing Antennas 1948" and "Antennas, Modulation Systems, and Transmitters: Definitions of Terms, 1948." Work is continuing on the formulation of definitions for transmission-line and waveguide terms. . . . The Audio and Video Techniques Committee has been divided into three new technical committees, **Audio Techniques, Video Techniques,** and **Sound Recording and Reproducing,** thus bringing the number of standing technical committees to 23. The scope of the Audio Techniques Committee will be the definitions of fundamental terms, standard symbols, and standard methods of measurement and test in the audio field. The Video Techniques Committee will cover the same aspects of the video field, and the Sound Recording and Reproduction Committee will establish definitions of basic terms, standard symbols, and standard methods of measurement and test in that field. . . . **Technical Committee on Electron Tubes and Solid-State Devices** is the new name of the Electron Tubes Committee. . . . **The Industrial Electronics Committee** met on January 14, and D. E. Watts, chairman of the Definitions Subcommittee, and H. O. Peterson, chairman of the Subcommittee on Good Engineering Practices, reported on the activities of their groups. C. W. Frick, chairman of the Subcommittee on High Frequency Measuring Methods, reported on the results obtained on dielectric measurements. . . . The **Navigation Aids Committee** met on January 12 to revise the Committee's definitions in the light of comments received, so that they may be ready for final review by the Standards Committee in February. . . . The **Nuclear Studies Committee** met the last week in January. It was proposed that a joint IRE-AIEE group be set up to plan future conferences in the field of nucleonics. James K. Pickard and H. H. Goldsmith have prepared lists of references to the literature of interest to the nucleonics engineer, and these have in part been reviewed by the Committee. It is planned to expand these references into a list for publication in the PROCEEDINGS. . . . The name of the Radio Receivers Committee has been changed to **Technical Committee on Receivers.** The standard on "Radio Receivers: Methods of Testing Amplitude Modulation Broadcast Receivers" is now being printed, and will be available shortly. The Committee plans to begin revision of the 1938 standard on definitions of terms. . . . **The Railroad and Communications Committee's** proposed standards on methods of measurement with accompanying definitions of terms have been approved, but the Committee plans to work toward a expansion of this standard. . . . The **Television Systems Committee** and the **Wave Propagation Committee** are assisting the Joint Technical Advisory Committee in preparing reports for hearings before the FCC. . . . Meetings of the following technical committees will be held during the 1949 **National Convention of the IRE:** Audio Techniques, Circuits, Navigation Aids, Nuclear Studies, Research, Sound Recording and Reproducing, Symbols, Video Techniques, and Wave Propagation.

Industrial Engineering Notes[1]

Tin Shortage Threatens Television

The current tin shortage could develop into a television set production bottleneck in 1949, parts manufacturers and government officials have told the RMA, and the pinch is already being felt by both set and component manufacturers. Since television receivers use about ten times as much tin as radio sets, the metal is of vital importance to the industry. Although the Commerce Department, which is now allocating the tin under M-43, has allowed for television's greater tin requirements, as compared to radio, the over-all tin situation has forced these officials to cut allocations, for, while world tin production is increasing, world developments, especially in Asia, might suddenly reduce tin imports by the United States to a considerable extent.

Some readjustments in tin requirements within the industry and the substitution of other metals wherever possible might alleviate the situation, Commerce Department officials pointed out, and might make more tin available for the components in which tin is essential. Other industries have worked out tin conservation programs.

The RMA has, consequently, appointed a conservation and allocations committee to deal at once with the threatened tin shortage and other material shortages as they arise. The committee will consider methods by which manufacturers can conserve tin in its less essential uses, and thus make more tin available for television components.

Bureau of Standards Publicizes New Developments

The U. S. Bureau of Standards has offered to the public details of two of its new developments: a technique for visually observing the external field patterns surrounding magnetic media such as wire or tape used for recording purposes; and the spiral contractometer, a new direct-reading instrument which measures stress in electrodeposits.

[1] The data on which these NOTES are based was selected from "Industry Reports," published by the Radio Manufacturers Association, issues of November 19 and 26 and December 3, 10, 17, and 24, 1948, and January 7, 14, and 28, and February 4, 1949; and the Canadian RMA "News" of December 20, 1948, and February 2, 1949. We hereby acknowledge the kindness of both the U. S. and Canadian RMA in permitting the use of this material.

The new measurement technique was developed by Irvan L. Cooter in order to study the magnetizing current, pulse width, and frequency of coded pulses as related to blending in magnetic media, and details have been published in the January issue of the *Technical News Bulletin,* obtainable from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 10 cents per copy.

A description of the spiral contractometer, which is rugged and self-contained, requires no auxiliary apparatus, and is well adapted to both industrial process control and laboratory research, appeared in the February issue of the same publication, which is also available.

A third development is an atomic clock, which, when used as a frequency control, will permit more radio and television stations in the now overcrowded radio and television spectrum. Based on a constant natural vibration frequency of atoms in the ammonia molecule, the atomic clock is a scientific achievement which offers an entirely new primary standard of frequency and time.

New Government Publications

A detailed study of radar developments, prepared by the Office of Scientific Research and Development, and including a considerable amount of information previously classified as secret, was released to the public by the Office of Technical Services, U. S. Department of Commerce. Copies of the 1300-page document, entitled *History of Radar,* which is in four parts, may be inspected at the Library of Congress's Government Publication Room. Photostatic and microfilm copies may be obtained from the Library at prices ranging from $4.50 to $9.00 for the microfilms and $13.75 to $53.75 for the photostats. The OTS is willing to prepare and sell mimeographed reproductions when the demand warrants.

Production tolerances in the design of electronic systems are discussed in a report released by the OTS. The report presents a theoretical framework through which operational requirements of electronic systems can be reconciled with economic production tolerances. Copies of the document (PB 94625) may be obtained from the Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C., at $7.50 in photostat form, $2.75 in microfilm.

A **series of twelve reports on quality control,** including one on radio (PB 27165), is also available from the OTS, at $2 per set.

The OTS has compiled a special list of **recent scientific and technical publications of British government agencies.** Standards for hearing aids and audiometers are included among the numerous items listed. The publication may be obtained free of charge from the OTS's Reference Service, Washington 25, D. C.

Still another report released by the OTS is a **comprehensive study of the present state of knowledge on infrared.** Based on German documents, the report (PB 95308) may be obtained from the Office of Technical Services, Department of Commerce, Washington 25, D. C., for $3.

A report on microwave filter theory and design, prepared by the Coles Signal Laboratory of the Army Signal Corps, was released by the Office of Technical Services. The report (PB-94664) is available at $6.25 per copy in photostatic form and $2.50 on microfilm from the Library of Congress, Photoduplication Board Project, Washington 25, D. C.

The Office of Technical Services released **a series of Army Department documents** in the electrical and electronic fields, which may be purchased from the Library of Congress, Photoduplication Service, Washington 25, D. C. The reports are: "Improvement in Resonance Characteristics of Power Supply Leads for UHF Vacuum Tubes (PB 95444)," "Extension of Dry Battery Cell Life through Improvement in Electrolyte-Absorbent Element (PB 95446)," "Improvement in Method of Obtaining Circular Polarization in Wave Guides of Circular Cross Section (PB 95447)," "Improved Electrical Connectors (PB 95449)," "Moisture-Proofed Compounds for Crystal Holders (PB 95453)," "Improvement in Transfer of Radio Frequency Energy between Coaxial Lines and Wave Guides (PB 95454)," "Coaxial Transmission Line Having Low Attenuation and Low Standing Wave Ratio (PB 95459)," "An Improved Multivibrator (PB 95461)," "An Improved Tow-Line Coupler (PB 95462)," "A Shock and Vibration Resistant Connector (PB 95463)," "Improvement in Low Pass RF Filters (PB 95464)," "An Improved Stub Antenna Mounting Plate (PB 95465)," "Improved High Speed Automatic Keyer for Radio Transmitters (PB 95466)," "Imprcved Remote Controlled (Radio) Device (PB 95467)," "Improved Shielding for Cathode Ray Tubes (PB 95468)," "Improved Modulation Control of Reflex Klystron Tubes (PB 95469)," "Improvement in Resnatron Tubes (PB 95471)," "Improved Electric Voltage Regulator (PB 95472)," "Improved Means for Measuring Gain of Amplifiers (PB 95473)," "Improved Electronic Voltage Regulator (PB 95474)," and "An Improved Wide-Band UHF Amplifier (PB 95475)." The price of this material is $1.25 for the photostat or for the microfilm, except for PB 95466 and PB 95468, which cost $2.50 each for the photostats and $1.75 each for the microfilms.

Basic information sources of the radio and television industry have been brought together in a booklet which was released by the U. S. Department of Commerce's Inquiry Reference Service. Prepared by J. B. Forman, of the General Products Division, the book deals primarily with trade and other general aspects of radio and television, and does not include technical information. It lists government and nongovernment publications of interest to the trade, radio and television trade directories, trade papers and magazines, and trade associations. The booklet may be obtained free of charge from the Department of Commerce's Inquiry Reference Service, Washington 25, D. C.

The Bureau of Standards has published a 12-page pamphlet containing detailed directions for use of **radioactive standards and calibrated samples of radioisotopes.** The booklet (NBS Circular 473), "Measurement of Radioactive Isotopes," may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at five cents per copy.

Military Amateur Radio System Activated

The U. S. Army and Air Force have activated a military amateur radio system (MARS) to provide a backlog of trained radio communication personnel in case of local or national emergency. The Army Signal Corps and the Air Force Director of Communications are authorized to use military equipment wherever practical in the training of MARS members. Membership will be open to persons in the Military Service, Organized Reserve Corps, National Guard, or the Reserve Officers Training Corps who possess a valid amateur radio operator's license.

FCC Actions

The FCC's fourteenth **annual report to Congress** stated that "the fiscal year 1948 emphasized the acuteness of the 'housing shortage' which exists in the radio spectrum." The FCC told Congress further that it was co-operating with industry in reviewing and revamping existing radio services, and conducting engineering and other studies looking to future adjustments with a view to increased radio service. The number of radio receivers in the country, the FCC noted, now is nearing 75,000,000, and 94 per cent of the families of the United States own sets. Copies of the FCC report may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 30 cents each.

All AM stations were ordered by the FCC to use **approved monitoring equipment,** because of the present availability of frequency and modulation monitors. Commission rules had required all standard broadcast stations to maintain a constant check on modulation percentage and on frequency deviation by means of monitors which have received formal FCC approval, but due to the lack of this type of equipment, the Commission waived this provision since the war.

The FCC announced that it would not issue any more **authorizations for high-powered state police transmitters** on an experimental basis. The Commission pointed out that it has issued grants for nine 5,000-watt transmitters of this type to the states of Iowa, Kansas, and Missouri, and that these should be adequate to obtain the needed interference and coverage data.

FM News

Officials of the FCC Bureau of Engineering stated that both broadcaster and set owners have complained that some FM receivers do not tune in stations assigned the top frequency-modulation channel near 108 Mc.

The FCC granted DePauw University at Greencastle, Ind., a construction permit for a noncommercial educational FM station with 10-watt power. At present 736 FM stations, including 30 noncommercial outlets, are in operation. New stations went on the air in the following states:

Ala., Birmingham (WBRC-FM); *Ark.*, Conway (KOWN); *Calif.*, Los Angeles (KFAC-FM), Santa Ana (KVOE); *Fla.*, Miami (WTHS); *Ill.*, Champaign (WDWS-FM); *Ind.*, Anderson (WCBC-FM), Marion (WMRI), Wabash (WWNI); *Iowa*, Muscatine (KWPC-FM); *Kan.*, McPherson (KNEX-FM); *La.*, New Orleans (WDSU-FM); *Mass.*, Brockton (WBKA-FM); *Mich.*, Detroit (WLDM and WDET-FM); *Mo.*, Cape Girardeau (KFVS), St. Louis (KWGD); *Neb.*, Omaha (WBON-FM); *N. J.*, Newark (WVNJ), Paterson (WNNJ); *N. Y.*, Buffalo (WWOL-FM); New York City (WMCA-FM); *N. C.*, Forest City (WBBO-FM), Rocky Mount (WEED-FM); *Ohio*, Cleveland (WTAM-FM); *Pa.*, Philadelphia (WHAT-FM), Pittsburgh (WPIT-FM), Pottsville (WPPA-FM), Scranton (WQAN-FM and WGBI-FM), York (WNOW-FM), Wilkes-Barre (WILK-FM); *Tex.*, Amarillo, (KFDA-FM); *Wash.*, Seattle (KOMO-FM); *W. Va.*, Martinsburg (WEPM-FM); and *Wisc.*, Madison (WHKW), Sheboygan (WHBL-FM).

Television News

The Joint Technical Advisory Committee, appointed by the IRE and RMA, submitted its second report on television to the FCC at an informal technical engineering conference called by the FCC to consider propagation and allied subjects in the vhf radio-frequency spectrum, particularly as it affects standards and allocation problems of television and FM services. Agreement was reached during the meeting that tropospheric effects on television and FM broadcasting should be recognized in the engineering standards of these two services. It was indicated, however, that, before this can be done, the FCC must publish a revision of its proposed rules and then hold another engineering conference.

There are now 57 television broadcasting stations on the air in the United States, 67 construction permits outstanding, and a total of 314 applications on hand but still "frozen" by previous FCC action. New television stations are: KTTV, Los Angeles, Calif.; KPIX, San Francisco, Calif.; WTVS, Miami, Fla.; WDSU-TV, New Orleans, La.; WMCT, Memphis, Tenn.; and KRSC-TV, Seattle, Wash.

In France, technical characteristics for a nation-wide television broadcasting service using a picture definition of 819 lines were established by the government. The main characteristics of the proposed television service are 4 channels in the 162- to 216-Mc band, with 3 in the 174- to 216-Mc band; definition: 819 lines; positive modulation; sound transmission with amplitude modulation. In France 50-cps electric current is used, while in the United States it is 60 cps.

The British film industry has agreed to co-operate with the British Broadcasting Corp. in arranging, for an experimental period, the televising of selected films and the showing of selected television programs in motion-picture houses for further experimentation with large-screen television.

Brazil may be the first South American country to institute a television broadcasting service, as it has announced plans for the installation of three television stations, two in Rio de Janeiro and one in Sao Paulo. The equipment for two of the outlets has already been purchased from American manufacturers. A French firm is also carrying on experimental work at Rio de Janeiro with 525-line-image television equipment installed in vehicles and airplanes. As yet there are only ten or twelve television receivers in Brazil, and these are for advertising purposes only.

Production Rises in 1948

Television receiver production, continuing its consistent trend upwards, established another record in 1948, with a total of 975,000 sets, thus bringing the total output since the war by RMA set manufacturers to 1,160,000.

Television receiver shipments by RMA member-companies in the third quarter of 1948 totalled 188,120, and brought postwar shipments for that period to 609,892.

FM-AM radio production in 1948 was high in spite of the general decline in the production of radio receivers because of set manufacturers' applying an increasingly large share of their manufacturing facilities to television. Over 100,000 FM only sets were reported, and 1,590,056 FM-AM sets. More than 16,000,000 radio sets were produced, dropping by about 20 per cent from the all-time peak of over 20,000,000 sets reached by the industry in 1947. Nevertheless, last year's radio output was the second highest in the industry's history.

Sales of radio and television transmitting and communications equipment by RMA member-companies in the third quarter of 1948 totalled $34,021,278. Sales for the three quarters of 1948 amounted to $111,228,411.

Reflecting the record-breaking television receiver production of the latter part of 1948, sales of cathode-ray tubes to set manufacturers rose sharply in the third quarter of 1948 over the second quarter. During the first 9 months of 1948, cathode-ray-tube sales to receiver manufacturers totaled 732,971 units valued at $17,779,749, as compared with sales during the entire year of 1947 of 255,035 units with a value of $7,218, 358.

November collections of the 10 per cent excise tax on radios, phonographs, and certain of their components increased by more than $800,000 over October, but fell considerably below collections in November, 1947.

Canadian Radio Notes

A new transmitter division has been approved by the Board of Directors of the Canadian RMA, and all Canadian companies interested in the manufacture of video, sound, facsimile, or other radio transmitters, commercial radio equipment, radio direction finders, and other apparatus used in connection with transmitters and broadcasting systems will be invited to become members. The new Division is already dealing with proposed CSA specifications on transmitters and many other problems involving standardization, interference, and so forth.

Canadian National Radio Week has been tentatively set for October 10 to 15, 1949. The Canadian RMA expects to work closely with the Association of Radio and Appliance Dealers in developing the plan.

P. M. Brophy, chairman of the Canadian RMA Industrial Mobilization Committee, has been elected chairman of the new Industrial Defence Preparedness Committee on Communications and Electronics. S. D. Brownlee was appointed secretary of the committee, which comprises representatives of industry and the armed services.

At the fourth annual meeting of the Canadian Radio Technical Planning Board held in Ottawa, R. A. Hackbusch was elected president for the year 1948–1949, G. W. Olive of the Canadian Broadcasting Corp. was elected vice-president, and S. D. Brownlee was re-appointed secretary-treasurer.

Radio receiving sets manufactured in Canada during 1948 totalled 603,000, down 38 per cent from the 1947 all-time high of 904,349 receivers, and 4 per cent below 1946 production of 580,525. Total list price value of Canadian RMA 1948 sales was $47,058,470, compared with $58,204,218 in 1947, and $28,855,142 in 1946. Burdened by the 25 per cent excise tax, sales in the first seven months of 1948 totaled only 244,018 receivers. With the reduction of the tax at the end of July, sales in the last five months of the year totaled 337,802 units compared with 390,398 in the same period of 1947, and 282,438 in the same period of 1946.

Radio Abroad

A chain of radio transmitting stations operating under the British-constructed Decca Navigator System was opened for public use in Denmark on October 15, 1948, and was investigated by a Norwegian delegation with a view to its possible use in Norway. The present marine users of the Decca system total some 600 ships trading in the waters round the United Kingdom and to and from continental ports.

The broadcasting industry in Mexico has risen to the rank of a "big business," according to a report received by the U. S. Department of Commerce. There are now 180 long-wave stations operating and 18 using short-wave facilities.

Guatemala has 17 radio broadcasting stations in operation. Six of them are run by the government and 11 by private owners.

The Government of South Africa has re-imposed a comprehensive system of import controls on "nonessential" items, including radios and phonographs, because of the steady drain of the country's gold reserves Among the prohibited imports were radio phonographs exceeding £25 ($100), radio receiving sets exceeding £15 ($60), and coin-operated gramophones and phonographs. In 1947 South Africa was the fourth largest U. S. radio market, with imports from this country of radio equipment totaling more than $4,000,000.

The Transportation and Communications Branch of the Office of International Trade, U. S. Department of Commerce, has prepared a 30-page booklet called "World Electrical Current Characteristics," which lists the principal voltages of the various countries of the world. Copies of the booklet may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Radio Industry Mobilizes

The newly appointed Electronics Advisory Committee elected Fred R. Lack (F'37) as assistant chairman at its first meeting. Captain William C. Wade, Chief of the Facilities Division of the Munitions Board, was named to the chairmanship. The chief topic under discussion was radio and electronics procurement planning.

Selected from industry by the Munitions Board and the National Security Resources Board, members of the Committee will assist the two boards and the armed services in the solution of problems encountered in the preparation of a mobilization plan for use in the event of an emergency. At the second meeting, Mr. Lack, using the authority given him at the first, named an eight-man task committee of industry representatives to draw up a master procurement plan to be utilized by the government and the radio industry in the event of an emergency.

RMA Prepares for Silver Anniversary

The Radio Manufacturer's Association will celebrate the "Silver Anniversary" of its founding from May 16 to 20 at the Stevens Hotel in Chicago, Ill., at the same time as the Annual Parts Trade Show. Joining in this tribute to the radio industry's quarter century of progress will be the Electronic Parts and Equipment Manufacturers Association of Chicago, the Eastern Sales Managers Club, the West Coast Electronic Manufacturers Association, and the National Electronic Distributors Association.

Books

Circular 460: Publications of the National Bureau of Standards

Published (1948) by the National Bureau of Standards. Available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 221 pages, 153 pages of indexes, ii pages. 6×9¼. $0.75.

This is a complete catalogue of all the material published by the National Bureau of Standards from 1901 through June 30, 1947. Since the Bureau's activities include research in electricity, electronics, atomic physics, applied mathematics, mechanics and sound, radio and radio propagation, optics, heat and power, metallurgy, metrology, ordnance, physical chemistry, mineral products, organic and fibrous materials, and building technology, this volume is very valuable to all scientists in those fields.

The catalogue is divided into five parts. The first contains general information as to purchase procedures, announcements, catalogues, mailing lists, depository libraries, and bound volumes. The second describes the Bureau's three periodicals: *The Journal of Research*, *Technical News Bulletin*, and *Basic Radio Propagation Predictions*. The third gives titles of publications, grouped under the following headings: scientific papers, technologic papers, research papers, circulars, handbooks, miscellaneous publications, simplified practice recommendations, commercial standards, building materials and structure reports, building and housing publications, and mathematical tables. Brief abstracts are given for publications issued from 1942 until the middle of 1947; and circulars containing abstracts of earlier material are described. Parts four and five consist of author and subject indexes, respectively.

Physics for Arts and Sciences, by L. G. Hector, H. S. Lein, and C. E. Scouten

Published (1948) by the Blakiston Co., Philadelphia, Pa. 715 pages, 13-page index, vii pages. 295 figures. 5¾×8¾.

It is a difficult task to write a well-rounded general book on physics at the elementary level, since many of the concepts of physics are best presented in mathematical terms, and the mathematical background of the beginner in physics is usually limited. Likewise, the development of one principle from another is best accomplished mathematically. In this text, the authors achieve singular success in discussing the broad field of physics from the modern point of view, yet in a manner that is comprehensible to the beginner.

Owing to its mathematical limitations, the text is largely descriptive, although analysis and logical development introduce the physical concepts in a manner just short of mathematical. The use of diagrams frequently aids in the clarity of the presentation.

The text is divided into two parts: Part I deals with mechanics, heat, and sound, and is composed of new material. Part II covers electricity, optics, and nuclear physics, and is substantially the same material that was originally published as a separate work under the title "Electron Physics."

The 24 chapters in Part I are divided into the following groups: Chapters 1 and 2 are largely historical; Chapters 3 through 8 contain background material in mechanics; Chapters 9 through 15 cover various topics in the fields of fluids and gases; Chapters 16 through 20 cover heat; and Chapters 21 through 24 consider the properties of sound.

Part II is also divided into 24 chapters. Chapters 1 through 11 contain material on electricity and magnetism; Chapters 12 and 13 discuss wireless and electron tubes; Chapters 14 through 20 are concerned with light and radiation; Chapter 21 discusses photoelectricity; Chapters 23 and 24 cover miscellaneous aspects of radioactivity, both natural and artificial, and include an introduction to the symbolism of nuclear reactions.

The text is generously illustrated, an interesting feature being the use of color in the line drawings. The authors maintain that the material parts of the drawings are indicated in black; whereas the pertinent features are drawn in red. However, they do not adhere to this practice uniformly. For example, the anode and envelope of vacuum tubes are shown in black, but the filament and grids are indicated in red. Many other inconsistencies, as regards this particular question, may be found. The two-color sketches make for striking illustrations, but it is questionable whether the use of two colors contributes particularly to the clarity of the drawings.

The book should serve well as a text for beginners, and it seems suitable for an introductory first-year college course in physics. Moreover, the general tenor of its presentation should do much toward instilling in the student an interest for further study in physics.

Samuel Seely
Syracuse University
Syracuse 10, N. Y.

Battlefronts of Industry: Westinghouse in World War II, by David O. Woodbury

Published (1948) by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 334 pages, 8-page index. 6¼×9¼. $3.50.

This book tells the interesting story of the Westinghouse Corporation's research, engineering, and manufacturing contributions to the winning, for the Allies, of World War II. There have been other excellent books of this order, sponsored by other large manufacturing companies, and, doubtless, there will be more. When a particular company's writers tell the story of particular new inventions or developments, applied during the war years, readers (particularly the historically inclined) feel that they are adequately informed only when all of the large corporations engaged in manufacturing for war have placed their stories between the covers of books. The use of radar during the late war is a case in point. When a score of inventors and manufacturers have told their separate stories about radar there is a full sieve for the winnower to sift.

Mr. Woodbury's book in its scope covers a wide field of manufacture; it describes and illustrates systems, devices, and instruments about which something became generally known while the war was in progress, and numerous technical developments which for long were top secrets. This wide coverage makes the book informative and educational. The book is of particular value to engineers and technicians in the employ of companies likely to be called upon for war effort in manufacture, should there be another war.

The running narrative style of presentation makes the book interesting, and easy to read. Since the book tells a story of American heavy industry in its stride, the reader gains new insight into the basic might of a great and modern nation functioning continuously under the free enterprise system, where labor is efficient and men are free. The illuminating account of the multifactory requirements to produce hitherto-unheard-of large quantities of ordnance, munitions, and all of the endless accessories which make the war machines effective in battle is an extensive treatise on manufacturing organization well worth reading by executives, scientists, engineers, and mechanics employed by producing companies, large and small.

The topics presented cover a wide range, and include: electric torpedoes, tank-gun stabilizers, bomb fuzes, radar, aviation gas turbines, uranium, fissionable material, mobile powerhouses, jet propulsion units, X-rays, plastics, lighting for war, and the battle of the isotopes.

Donald McNicol
Consultant
New York, N.Y.

Mathematics, Our Great Heritage, edited by William L. Schaaf

Published (1948) by Harper and Bros., 49 E. 33 St., New York, N. Y. 288 pages, 3-page index, xi pages. 5¾×8¾. $3.50.

This book is a compilation of 16 essays written by 15 American mathematicians and one British mathematician. It is the avowed purpose of the book to answer the following questions: With what is mathematics really concerned? Where do mathematical concepts originate? Are mathematical ideas discovered or invented? How did mathematics develop? Is mathematics affected by culture? What motivation directs the activities of mathematicians and how do they think? How is mathematics related to reality? How is it related to creative arts? What are some of the contrary signs and humanistic implications of mathematics? What is the basic need that urges man on in his mathematical activities?

These essays have been grouped according to the various aspects of mathematics, namely, its lowest creative arts, its origins and developments, its internal structure and inclusive nature, its relation to science and technology, and its cultural and humanistic bearings.

Written for the average nonmathematically trained reader, this book is designed primarily as an outline of material suitable for the promotion of mathematics appreciation. The author is to be complimented on the selection of both authors and subject matter.

Although the book is so readable that it may be read through at a single sitting, it is quite thought-provoking. Perhaps the only serious criticism that might be leveled is a tendency on the part of the individual authors of these essays to over-sell their subject. Their pride in mathematical achievement may be justifiable; nevertheless, it is not generally conceded that mathematics is the highest intellectual achievement. Scientists trained in fields other than mathematics are inclined to feel that the only reason that mathematicians are infallible is that they are playing a game in which it is impossible to be wrong as long as they follow the rules precisely. In other sciences, the rules are devised by nature, and it is the job of the scientist to uncover these rules rather than to invent them. As a result, in many respects practically any other science is more difficult than mathematics.

The real problem for scientists in fields other than mathematics is to try to establish mathematical systems isomorphic to the systems involved in their own particular sciences. This requires a higher stage of development than that required of the pure mathematician, for the scientist in a field other than mathematics must fully understand the rules of mathematics as well as the laws of nature, before he may elaborate his own particular science.

It has been pointed out that mathematics pushes its conquests out in many directions, frequently annexing new domains, never yielding up what it has once attained, and remaining youthful in its period of conquest. Mathematics, as the authors say, is "destined to become, if indeed it is not already, the most extensive scientific doctrine in the whole range of knowledge."

Lloyd T. DeVore
University of Illinois
Urbana, Ill.

Radio Receiver Design, Volume II, by J. R. Sturley

Published (1948) by John Wiley and Sons, 440 Fourth Ave., New York 16, N. Y. 468 pages, 12-page index, xv pages, 181 figures. 5¾×8¾. $5.50.

This volume, originally published in England, discusses the details of good engineering design practice for FM and television receivers, and gives in even greater detail the problems encountered in designing of amplifiers, power output stages, low-voltage dc power supplies, automatic-gain-control circuits, and push-button, remote, and automatic-tuning controls. In addition, a chapter is devoted to the measurement of receiver over-all performance.

The information on design is clearly presented and the examples given are completely worked out. Sufficient background is given to support the general problems, and material is repeated often enough to obviate the annoyance of constant reference to other portions of the same book. Moreover, since there are very few references to Volume I, Volume II can stand alone as a complete book in itself. One especially good feature of the book is its usually complete references, which cover the whole field and are not confined to British publications. The lack of a chapter on loudspeakers and over-all acoustic problems is a drawback, and is reflected in the author's treatment of tone-control circuits, which neglects to include compensated volume control and hence leaves the chapter incomplete.

Although Volume II was written in 1944 and published in England in 1945, the American edition has not been revised; and, therefore, it incorporates no material since 1944. This is most noticeable in the chapters on FM and television, for the more recent developments, such as the ratio detector, kick-back high-voltage supplies, and intercarrier sound are not included. However, the wealth of basic information which the book gives and the clarity with which it is presented compensates for its being slightly out of date, and the book is recommended for the practicing radio and television design engineer, particularly to those who have entered the field in the postwar period. Moreover, it should also prove to be a convenient reference for the radio patent engineer.

J. D. Reid
Crosley Division, Avco Mfg. Corp.
Cincinnati, Ohio

Atomic Energy, by Karl K. Darrow

Published (1948) by John Wiley and Sons, Ltd., 440 Fourth Ave., New York 16, N. Y. 78 pages, 2-page index, 13 figures. 5½×8¼. $2.00.

This book contains the four Norman Wait Harris lectures delivered at Northwestern University in 1947 by Dr. Darrow. These lectures present in popular style the background to the subject of nuclear energy addressed to an audience of laymen—the term "laymen" being used in the sense of "people whose special fields of interest were other than physics." As such, the volume may well serve as a "kindergarten" introduction to the nuclear science series currently appearing in the Proceedings.

Ionospheric Radio Propagation

Published (1948) by the National Bureau of Standards, U. S. Department of Commerce, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 206 pages, 3-page index, iv pages. 205 figures. 7¾×10¼. $1.00.

This volume, in part a revision and expansion of the IRPL Radio Propagation Handbook prepared during the war at the request of the Armed Services, presents the physical and mathematical theory underlying electromagnetic-wave propagation, with particular reference to radio-wave propagation by reflection; and the fundamental principles involved are brought into understandable relationship with the practical problems of radio communication. Current knowledge and techniques of making radio-propagation calculations are summarized, and much of the material included has appeared heretofore only in the form of reports that have had a limited circulation.

Since the book is intended to explain the basic facts and principles of electromagnetic-wave propagation and the ionosphere for persons who have not had advanced courses in electrodynamics, the mathematical treatment is necessarily of a fairly elementary type.

The nine chapters of this text are planned to yield a basic understanding of the complex geophysical phenomenon which the variations of the ionosphere with locality, season, time of day or night, and solar activity constitute. A number of problems are worked out in detail to assist the reader in applying the methods to specific cases.

National Electrical Safety Code

Published (1948) by the U. S. Government Printing Office, Washington, D. C. 379 pages, 28-page index, vii pages. 5×7½. $1.25.

This handbook contains the first five parts of the fifth edition of the National Electrical Safety Code, which is now used by over half of the states in their power-transmission requirements, as well as by municipal governments, electrical power companies, telephone and telegraph systems, and railroads. Each of these parts has been approved by the ASA an American Standard. Part 6 of the code has not been included, as it is still under revision.

The Bureau of Standards points out that it has given up its prerogative of determining details in return for the implied understanding that the many parties concerned will accept a code that they can agree upon among themselves. Since decisions made by virtually unanimous agreement among the interests affected would, in general, be wiser than those at which the Bureau might arrive after weighing the arguments of advocates for different views, it has accepted the inevitable compromise between conflicting aims of which this code is the outgrowth, recognizing the fact that this also involves the acceptance of some details of which it might not itself approve.

New Advances in Printed Circuits, edited by Cledo Brunetti

Published (1948) by the National Bureau of Standards, U S Department of Commerce; available (Miscellaneous Publication 192) from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 73 pages, vi pages. 45 figures. 7¾×10¼. $0.40.

This booklet is a report of the proceedings of the First Technical Symposium on Printed Circuits, which was held on October 15, 1947, in Washington, D. C., under the sponsorship of the Aeronautical Board and the technical direction of the National Bureau of Standards. An unusual feature is the summary of data obtained from the questionnaires filled out by the persons attending the symposium. This information, which follows the formal papers, suggests potential possibilities and applications.

Since it was beyond the scope of the symposium to attempt complete coverage of all the various processes, applications, and other matters related to printed circuits, the reader is referred to National Bureau of Standards Circular 468, "Printed Circuit Techniques," for a complete treatment of the subject.

Television Interference: Its Causes and Cures, edited by Lawrence LeKashman

Published (1948) by Radio Magazines, Inc., 342 Madison Ave., New York 17, N. Y. 62 pages. 50 figures. 6¼×9¼. $0.50.

The first general publication on this topic, this booklet considers the problem from the point of view of the transmitting radio amateur, and the bulk of the treatment concerns the alleviation of interference to television receivers from amateur stations. However, a sufficiently complete analysis of the effects produced by all principal sources of interference—ghosts, diathermy, electric shavers, ignition, local-oscillator radiation, as well as receiver maladjustment—is given in the form of typical patterns to make it of value to radio servicemen, manufacturers, and television sales people generally. The treatment proceeds from diagnosis and analysis to corrective measures at the receiver and in the amateur transmitter, including detailed design suggestions.

Sources of Engineering Information, by Blanche H. Dalton

Published (1948) by the University of California Press, Berkeley 4, Calif. 109 pages, v pages. 6¼×9¼. $4.00.

This compilation, prepared by the University of California's engineering librarian, is the revised edition of a syllabus originally written to be used with lectures on the use of the library. It is divided into seven sections: indexes to periodical and serial literature, abstracts, location of articles, bibliography, reference, the trade catalogue collection, and standards and specifications.

Although it is true, as the preface states, that "a very real need has existed for a compilation listing source material for American engineers and librarians," this volume, good as far as it goes, does not fill that need. Prepared by a librarian rather than an engineer, it is limited in scope and does not display a thorough knowledge of the entire field. Nevertheless, it does contain a good deal of valuable material, and may perhaps prove a useful tool for engineers.

Notes on Soldering, by W. R. Lewis

Published (1948) by the Tin Research Institute, Fraser Road, Greenford, Middlesex, England. 88 pages. 47 figures. 6¼×9¼. Free.

Advances in soldering technique are discussed in this book, with particular reference to mass-production methods of assembly, and the various forms of solder and methods of applying heat to the joints are described. The behavior of solders at various temperatures, under tensile and sheer stresses, and under creep conditions, together with notes on the metallurgical constitution of the tin-lead solders, is included, and special methods are suggested for soldering aluminum, stainless steel, cast iron, and other "difficult-to-solder" alloys.

This booklet is available free of charge from Bruce Gonser, the Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio. British readers may obtain it, also without cost, directly from the Tin Research Institute.

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J. F. Myers 249 Linwood Ave. Buffalo 9, N. Y.	BUFFALO-NIAGARA March 16	R. F. Blinzler 558 Crescent Ave. Buffalo 14, N. Y.
M. S. Smith 1701 10th St. Marion, Iowa	CEDAR RAPIDS	V. R. Hudek Collins Radio Co. Cedar Rapids, Iowa
K. W. Jarvis 6058 W. Fullerton Ave. Chicago 39, Ill.	CHICAGO March 18	Kipling Adams General Radio Co. 920 S. Michigan Ave. Chicago 5, Ill.
C. K. Gieringer 3016 Lischer Ave. Cincinnati, Ohio	CINCINNATI March 15	F. W. King RR 9 Box 263 College Hill Cincinnati 24, Ohio
F. B. Schramm 2403 Channing Way Cleveland 18, Ohio	CLEVELAND March 24	J. B. Epperson Box 228 Berea, Ohio
Warren Bauer 376 Crestview Rd. Columbus 2, Ohio	COLUMBUS April 8	George Mueller Electrical Eng. Dept. Ohio State University Columbus, Ohio
S. E. Warner Aircraft Electronics Assoc. 1031 New Britain Ave. Hartford 10, Conn.	CONNECTICUT VALLEY March 17	H. L. Krauss Dunham Laboratory Yale University New Haven, Conn.
A. S. Levelle 801 Telephone Bldg. Dallas 2, Texas	DALLAS-FT. WORTH	E. A. Hegar 802 Telephone Bldg. Dallas 2, Texas
George Rappaport 132 East Court Harshman Homes Dayton 3, Ohio	DAYTON April 14	C. J. Marshall 1 Twain Place Dayton 10, Ohio
C. F. Quentin Radio Station KRNT Des Moines 4, Iowa	DES MOINES-AMES	F. E. Bartlett Radio Station KSO Old Colony Bldg. Des Moines 9, Iowa
C. F. Kocher 17186 Sioux Rd. Detroit 24, Mich.	DETROIT March 18	P. L. Gundy 519 N. Wilson Royal Oak, Mich.
R. W. Slinkman Sylvania Electric Products Emporium, Pa.	EMPORIUM	T. M. Woodward 203 E. Fifth St. Emporium, Pa.
W. H. Carter 1309 Marshall Ave. Houston 6, Texas	HOUSTON	J. C. Robinson 1422 San Jacinto St. Houston 2, Texas
R. E. McCormick 3466 Carrollton Ave. Indianapolis, Ind.	INDIANAPOLIS	Eugene Pulliam 931 N. Parker Ave. Indianapolis, Ind.
Karl Troeglen KCMO Broadcasting Co. Commerce Bldg. Kansas City 6, Mo.	KANSAS CITY	Mrs. G. L. Curtis 6005 El Monte Mission, Kan.
R. W. Wilton 71 Carling St. London, Ont., Canada	LONDON, ONTARIO	G. H. Hadden 35 Becher St. London, Ont., Canada
Berhard Walley Radio Corp. of America 420 So. San Pedro St. Los Angeles 13, Calif.	LOS ANGELES March 15	J. J. Fiske Westinghouse Electric Corp. 600 St. Paul Ave. Los Angeles 14, Calif.
O. W. Towner Radio Station WHAS Third & Liberty Louisville, Ky.	LOUISVILLE	D. C. Summerford Radio Station WKLO Henry Clay Hotel Louisville, Ky.
F. J. Van Zeeland Milwaukee School of Eng. 1020 N. Broadway Milwaukee, Wis.	MILWAUKEE	H. F. Loeffler Wisconsin Telephone Co. 722 N. Broadway Milwaukee 1, Wis.
K. R. Patrick RCA Victor Div. 1001 Lenoir St. Montreal, Canada	MONTREAL, QUEBEC April 13	S. F. Knights Canadian Marconi Co. P.O. Box 1690 Montreal, P. Q., Canada
L. A. Hopkins, Jr. 1711 17th Loop Sandia Base Branch Albuquerque, N. M.	NEW MEXICO	T. S. Church 3079-Q-34th Street Sandia Base Branch Albuquerque, N. M.
J. W. McRae Bell Telephone Labs. Murray Hill, N. J.	NEW YORK April 6	R. D. Chipp DuMont Telev. Lab. 515 Madison Ave. New York, N. Y.
J. T. Orth 4101 Fort Ave. Lynchburg, Va.	NORTH CAROLINA-VIRGINIA	C. E. Hastings 117 Hampton Rds. Hampton, Va.
W. L. Haney 117 Bourque St. Hull, P. Q.	OTTAWA, ONTARIO March 17	G. A. Davis 78 Holland Ave. Ottawa, Canada
M. W. Bullock Capital Broadcasting Co. 501 Federal Securities Bldg. Lincoln 8, Nebraska	OMAHA-LINCOLN	B. L. Dunbar Radio Station WOW Omaha, Nebraska
A. N. Curtiss Radio Corp. of America Camden, N. J.	PHILADELPHIA April 7	C. A. Gunther Radio Corp. of America Front & Cooper Sts. Camden, N. J.
M. A. Schultz 635 Cascade Rd. Forest Hills Borough Pittsburgh, Pa.	PITTSBURGH April 11	E. W. Marlowe Union Switch & Sig. Co. Swissvale P.O. Pittsburgh 18, Pa.
A. E. Richmond Box 441 Portland 7, Ore.	PORTLAND	Henry Sturtevant Rt. 6, Box 1160 Portland 1, Oregon
A. V. Bedford RCA Laboratories Princeton, N. J.	PRINCETON	L. J. Giacoletto 9 Villa Pl. Eatontown, N. J.
K. J. Gardner 111 East Ave. Rochester 4, N. Y.	ROCHESTER March 17	Gerrard Mountjoy Stromberg-Carlson Co. 100 Carlton Rd. Rochester, N. Y.
E. S. Naschke 1073-57 St. Sacramento 16, Calif.	SACRAMENTO	W. F. Koch 1340 33rd St. Sacramento 14, Calif.
G. M. Cummings 7200 Delta Ave. Richmond Height 17, Mo.	ST. LOUIS	C. E. Harrison 818 S. Kings Highway Blvd. St. Louis 10, Mo.
O. C. Haycock Dept. of Elec. Eng. University of Utah Salt Lake City, Utah	SALT LAKE	M. E. Van Valkenburg Dept. of Elec. Eng. University of Utah Salt Lake City, Utah
C. L. Jeffers Radio Station WOAI 1031 Navarro St. San Antonio, Texas	SAN ANTONIO	L. K. Jonas 267 E. Mayfield Blvd. San Antonio, Texas
L. G. Trolese U. S. Navy Elect. Lab. San Diego 52, Calif.	SAN DIEGO April 5	Jack Jacoby U. S. Navy Elect. Lab. Point Loma, Calif.
F. R. Brace 955 Jones St. San Francisco 9, Calif.	SAN FRANCISCO	R. A. Isberg Radio Station KRON 901 Mission St. San Francisco 19, Calif.
J. M. Patterson 2009 Nipsic Bremerton Wash.	SEATTLE March 10	J. E. Hogg General Electric Co. 710 Second Ave. Seattle 1, Wash.
F. M. Deerhake 600 Oakwood St. Fayetteville, N. Y.	SYRACUSE	S. E. Clements Dept. of Electrical Eng. Syracuse University Syracuse 10, N. Y.
A. R. Bitter 4292 Monroe St. Toledo 6, Ohio	TOLEDO	J. K. Beins 435 Kenilworth Ave. Toledo 10, Ohio

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T. J. Carroll National Bureau of Stand. Washington, D. C.	WASHINGTON March 14	P. DeF. Mekeel Civil Aeronautics Adm. Commerce Bldg. Washington, D. C.
J. C. Starks Box 307 Sunbury, Pa.	WILLIAMSPORT	R. G. Petts Sylvania Electric Products, Inc. 1004 Cherry St. Montoursville, Pa.

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J. B. Minter Box 1 Boonton, N. J.	NORTHERN N. J. (New York Subsection)	A. W. Parkes, Jr. 47 Cobb Rd. Mountain Lakes, N. J.
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R. M. Wainwright Elec. Eng. Department University of Illinois Urbana, Illinois	URBANA (Chicago Subsection)	M. H. Crothers Elec. Eng. Department University of Illinois Urbana, Illinois
S. S. Stevens Trans Canada Airlines Box 2973 Winnipeg, Manit., Canada	WINNIPEG (Toronto Subsection)	S. G. L. Horner Hudson's Bay Co. Brandon Ave. Winnipeg, Manit., Canada

IRE People

Henry George Booker (SM'45) of Cambridge University, one of the world's foremost authorities on the propagation of electric waves, has been appointed a professor of electrical engineering at Cornell University.

Dr. Booker was born on December 14, 1910, at Barking, Essex, England. After receiving the B.A. degree with honors from the University of London, Dr. Booker continued his studies at Christ College, Cambridge, from 1930 to 1934, reaching the distinction of Wrangler in the year 1933. From 1934 to 1935, Mr. Booker was an Allen Scholar at the University of Cambridge, and Smith's Prizeman in 1935. The following year he attained the Ph.D. degree and became a Fellow of Christ College and Faculty Assistant Lecturer in Mathematics.

During his sabbatical year in 1937 and 1938, Dr. Booker engaged in ionospheric research in the United States at the Carnegie Institution of Washington's Department of Terrestrial Magnetism and returned to England to become Cavendish Lecturer at the University of Cambridge. There he became internationally known for his theoretical research in electromagnetism, and particularly for his work on radio propagation in the substratosphere and the Heaviside layer. He evolved the theory of propagation through the ionosphere, taking into account the effect of stratification and the earth's magnetic field in shaping the wave path. During World War II Dr. Booker was decorated by the U. S. Government for his contributions to wartime radar development.

Several special projects in Dr. Booker's field are under way at Cornell, and he will be associated with Charles R. Burrows and others in the development of the research program and in the academic activities of the School of Electrical Engineering. Dr. Booker is a Fellow of the Cambridge Philosophical Society.

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Cledo Brunetti (A'37-SM'46), former chief of the Engineering Electronics Section in the U. S. Bureau of Standards and a well-known inventor, has joined the staff of the Stanford Research Institute as associate director.

Dr. Brunetti was born in Virginia, Minn., on April 1, 1910, and, after receiving the bachelor of engineering degree with honors from the University of Minnesota in 1932, he continued with his graduate work as a teaching fellow and instructor. In 1937 he received the first Ph. D. degree in electrical engineering granted by the University and was subsequently appointed director of electronic research at Lehigh University.

Cited "America's Outstanding Young Electrical Engineer" in 1941, Dr. Brunetti lectured on radio at the evening session of George Washington University. Meanwhile, he had been working during the summers of 1939 and 1940 as research associate in the radio section of the National Bureau of Standards. In 1941 he left Lehigh to work at the Bureau on the development of the radio-proximity fuze and joined the Bureau of Standards on a full-time basis the following year. Becoming alternate chief of the Electronics Development Section, he organized and headed the Production Engineering Section of the Ordnance Development Division in 1943.

In 1945 Dr. Brunetti received the U. S. Naval Ordnance Development Award and the War Department Certificate for Outstanding Services. Two years later he was awarded the "Industrial Oscar"—the National Materials and Methods Achievement Grand Award—for the contribution printed electric circuits have made to industry.

During World War II, Dr. Brunetti played a leading part in the development of the radar-guided bomb and of the radio proximity fuze, one of the major secret weapons of the war. He also was one of the developers of the two-way wrist radio and a radio transmitter so small it can be slipped into a lipstick cylinder. As a result of these developments in the field of miniatures, it is now possible to abolish the wire which dangles from the earpiece of hearing aids.

The author of more than 30 technical publications, as well as of many textbooks, nontechnical publications, and classified reports, Dr. Brunetti is a member of Sigma Zi, Tau Beta Pi, Eta Kappa Nu, and Pi Tau Pi Sigma.

Vladimir K. Zworykin (M'30-F'38), vice-president and technical consultant of the RCA Laboratories Division of RCA, was awarded the Chevalier Cross of the French Legion of Honor for his outstanding contributions in the field of television and especially for his assistance in developing French television. The award, made in 1948, coincided with the twenty-fifth anniversary of Dr. Zworykin's invention of the iconoscope, television's first electronic "eye." As a pioneer in the development of all-electronic television, Dr. Zworykin is also the inventor of the kinescope, electronic picture tube of the television receiver.

Dr. Zworykin was born in 1889 in Mourom, Russia. After receiving the E. E. degree from the St. Petersburg Institute of Technology, in 1912, he studied physics under Boris Rosing and started his first experiments in television. Later he entered the laboratory of the College de France in Paris in order to do X-ray research under P. Langevin, and he spent two years there.

During the first World War, Dr. Zworykin served as an officer in the Signal Corps of the Russian Army. From 1920 to 1929 he was employed in the Westinghouse Co.'s research laboratory. He became a citizen of the United States in 1924, and won the Ph. D. degree from the University of Pittsburgh two years later.

In 1930 he joined RCA as director of their Electronics Research Laboratory, where he worked on television, electron optics photoelectric cells, and allied problems. He was elected to his present position in 1947.

Dr. Zworykin has been the recipient of numerous honors and awards. In 1934 he was given the IRE's Morris Liebmann Memorial Prize. Four years later he was awarded the Overseas Premium by the British Institution of Electrical Engineers. In 1940 he won the Modern Pioneers Award of the American Manufacturers Association; in 1941, the Rumford award of the American Academy of Arts and Sciences; in 1947, the Howard N. Potts medal of the Franklin Institute in Philadelphia; and in 1948, the Poor Richard award.

Dr. Zworykin is a member of the American Association for the Advancement of Science, the American Physical Society, the AIEE, the American Academy of Arts and Sciences, the National Academy of Sciences, the Franklin Institute, the French Academy of Sciences, and Sigma Xi.

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Five IRE members have been advanced to high executive positions in the Philco Corp.: **Palmer M. Craig** (A'36-SM'43), who has been named director of engineering; and **Sterling C. Spielman** (S'33-A'35-SM'35), **Luke E. Closson** (SM'46), **James F. Koehler** (SM'46), and **Bertram P. Haines** (A'43), all of whom have been named chief engineers.

Mr. Craig, who now heads the electronics division of the engineering department, has been with Philco for more than 15 years. He was graduated from the University of Delaware in the class of 1927 with the degree of B.S. in electrical engineering, and, before coming to Philco in 1933, was associated with the Westinghouse Electric and Manufacturing Co. At Philco he assisted in the development of high-fidelity-reception automobile and remote-control radio receiving sets. In 1938 he was appointed engineer in charge of console radios and was active in the development of military radio equipment even before the war. During the war he served as chief engineer in charge of radar and military development, and he was named chief engineer of the company's radio division in 1943.

Mr. Spielman was appointed chief television engineer, so that he can take care of the expanding work in television receiver development. He too has had more than 15 years of radio, radar, and television experience with Philco. Reporting to him will be three basic groups, including a television receiver design section, an advanced development section, and a field engineering group.

Mr. Closson has been named chief engineer in the home radio department. Also credited with over 15 years of engineering experience with the company, he has made important contributions to audio radio and radar design as well as in home set development.

Dr. Koehler will head a relatively new phase of the company's development activities, the design of specialized government and industrial electronics equipment, where he holds the post of chief engineer. After outstanding service in the Navy's airborne radar development program during the war, he joined Philco to co-ordinate military research and engineering projects.

Mr. Haines will be chief mechanical engineer and new mechanical engineering development for the electronics division, including Philco phonograph mechanisms and other mechanical devices, will be under his direction. His term of service with Philco numbers nearly 15 years, and he has had experience there in factory engineering and in auto radio design, as chief engineer of the wartime crystal division, and most recently as section engineer responsible for phonograph development.

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John N. Fricker (A'41-M'44) and **Robert B. Beetham** (S'34-A'36) have been appointed director of engineering services and executive assistant to the vice-president, respectively, at the Airborne Instruments Laboratory in Mineola, Long Island, N. Y.

Mr. Fricker was graduated from the Massachusetts Institute of Technology in 1931 with the degree of B. S. in electrical engineering. After serving on the National Broadcasting Co.'s engineering staff, Mr. Fricker joined the Airborne Instruments Laboratory during the war. He has also been vice-president in charge of engineering at Radio Station KSTP, St. Paul, Minn.

Mr. Beetham is a graduate of Ohio State University, having received the B.E.E. degree in 1934 and the M.S. degree the following year. In 1935 he joined the Collins Radio Co., where until 1944 he was active in the development and design of radio transmitters of many types. In 1944 he was appointed assistant to the president of that organization, with the duties of co-ordinating engineering and manufacturing processes and procedures and developing management control processes over organization and costs.

Mr. Beetham has been a member of the Public Relations Committee of the IRE, and was also a member of the Radio Technical Planning Board and the Technical Committee of the Telecommunications Companies conducted by the State Department. He is a member of the AIEE.

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Chester H. Page (A'41-SM'48), formerly chief of the National Bureau of Standards' Electronic Computer Section, has been named electronics consultant for the entire organization. Available as a consultant for all Bureau divisions concerned with electronic research, Dr. Page will also participate in over-all research projects of the Electronics Division, including research into and the development of new types of electronic ordnance devices: electronic tubes, circuits, and controls, and high-speed digital computing machines.

Dr. Page was born in Providence, R. I., and attended Brown University from 1930 to 1934, receiving the B.A. and M.A. degrees. The following year he was awarded a fellowship at Yale University, where he received the Ph. D. degree in 1937. The following year he was appointed to the faculty of Lafayette College, where he taught physics until 1941, when he joined the staff of the National Bureau of Standards.

Three years later he was designated chief of the Ordnance Electronics Engineering Section, where he worked on the design and development of the proximity fuze. In 1946 he was made chief of the Ordnance Research Section, and from 1947 to 1948 was chief of the Electronic Computers Section.

Dr. Page is a member of the IRE's Committee on Electronic Computers. A member of the American Physical Society, Phi Beta Kappa, and Sigma Xi, Dr. Page is the author of a number of technical papers, and has several classified wartime patents pending.

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George E. Ziegler (SM'46) has been appointed director of the Midwest Research Institute in Kansas City, Mo., where he had previously acted as chief administrator.

Dr. Ziegler received the Ph.D. degree from the University of Chicago, and took additional post-doctorate studies at the Massachusetts Institute of Technology. He came to the Midwest Research Institute at the time of its inception in 1945 in the capacity of executive scientist. Previously, he had been associated with the Armour Research Foundation in Chicago.

Although Dr. Ziegler has devoted the past ten years to solving the problems of industry through the practical application of the fundamental sciences to industrial questions, he is better known in scientific circles for his experimental X-ray diffraction studies, and he has numerous publications and patents to his credit.

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Robert E. Leo (S'44-A'47) has taken a position in radio work with the Arabian-American Oil Co. in Dharan, Saudi Arabia.

Mr. Leo left his position with the Civil Aeronautics Commission in the fall of 1947 in order to join the Gatti-Hallicrafter Expedition to Africa. In July, 1948, he went to Saudi Arabia, where he accepted his present employment.

J. W. McRae

CHAIRMAN, NEW YORK SECTION

J. W. McRae was born on October 25, 1910, in Vancouver, British Columbia, Canada. In 1933 he received the B.S. degree in electrical engineering from the University of British Columbia, and the following year he was given the M.S. degree by the California Institute of Technology, from which he also received the Ph.D. degree in 1937.

In the latter year he became an Associate of the IRE and joined the Bell Telephone Laboratories, where he engaged successively in research on transoceanic radio transmitters, microwave research, and military projects, including microwave oscillators and microwave radar research.

Early in 1942, Dr. McRae accepted a commission as major in the U. S. Army Signal Corps, and attained the rank of colonel before returning to civilian life and the Bell Telephone Laboratories in 1945. He received the Legion of Merit for his work in co-ordinating development programs for airborne radar equipment and for radar countermeasure devices.

At Bell Dr. McRae was appointed director of radio projects and television research in 1946, and in 1947 became director of electronic and television research. He was elected an IRE Fellow in that year. In 1949 he was promoted to assistant director of apparatus development.

A member of the IRE Board of Editors since 1946, Dr. McRae received Honorable Mention for 1933 in the Eta Kappa Nu awards for outstanding young electrical engineers. He is also a member of the AIEE and Sigma Xi.

Sydney E. Warner

CHAIRMAN, CONNECTICUT VALLEY SECTION

Sydney E. Warner was born in Spring Lake, N. J., on September 12, 1907. He became an instructor of electrical engineering and physics at the Rensselaer Polytechnic Institute after having received the electrical engineering degree from that school in 1929. At the same time, he worked as a radio operator at the Institute's Radio Station WHAZ, one of the pioneer broadcasting stations, and worked summers at WTIC during the early days of synchronization with WEAF. He became a Member of the IRE in 1930.

Having obtained the Master's degree in communications from Rensselaer in 1934, Mr. Warner became chief engineer of W1XBS-WBRY in Waterbury, Conn., one of the first experimental broadcast stations. In 1939 he was appointed radio supervisor of the Connecticut State Police, where he helped to develop the first mobile FM communication system, which has since served as a design model for FM military and police communications.

At the start of World War II, Mr. Warner joined the staff of Columbia University's Airborne Instrument Laboratories as a development engineer. Later, he became chief radio engineer of the Crystal Research Laboratories in Hartford, Conn.

Early in 1946 Mr. Warner became part owner and chief engineer of the Aircraft Electronics Associates in Hartford, Conn., and he was advanced to the rank of Senior Member of the IRE. He is a registered professional engineer in the State of Connecticut and a member of Sigma Xi.

Radio Progress During 1948*

Introduction

DURING 1948 the electronics art continued its advances into new frontiers. Considerable progress was reported in the theoretical field dealing with the philosophy of communicating intelligence. Mathematical analyses of the bandwidth required for the transmission of information-bearing signals in the presence of noise, and of methods of modulation which utilize the redundancy or statistical structure of the intelligence, led to the realization that important savings in spectrum space or increases in efficiency may be available. The published studies, however, did not describe communication systems to make these theoretical improvements practical. The antenna art was advanced considerably by theoretical work on super-gain antennas, as well as by developments in the design of helical and lens types of antennas.

The expansion of the television industry continued at an accelerated pace. The number of television receivers produced during the year increased the total number of receivers in service in the United States to about 1 million, and the number of operating television stations increased from 16 to 51. The development of the metal cathode-ray tube aided the trend toward larger pictures for home reception. Several commercial television transmitters commenced operation in the "high" band (174–216 Mc). With the installation of a microwave relay circuit from New York to Boston, facilities for networking television stations on the East Coast were completed from Boston to Richmond. In the Middle West, television network facilities employing coaxial cable were completed from St. Louis to Chicago, Toledo, and Buffalo, with branch facilities (microwave) to Milwaukee and Detroit. It was announced that a link connecting these two networks would be completed in January, 1949, thereby providing television network facilities for the area of the United States north and east of St. Louis.

In addition to "live" networking, four television networks and several other organizations installed equipment capable of making television recordings (from a picture tube) for the distribution of television program material to stations throughout the nation.

Experience with the interference range of television broadcasting stations led the Federal Communications Commission to suspend temporarily the granting of new construction permits and to hold an industry-government conference at the end of November for the review of available propagation data, particularly in the band 475 to 890 Mc.

An important joint committee in which representatives of The Institute of Radio Engineers have been active was the Joint Technical Advisory Committee, which was established on June 20, 1948, by action of the Boards of Directors of The Institute of Radio Engineers and of the Radio Manufacturers Association, to advise government bodies and industry groups on the wise use and regulation of radio facilities. The JTAC has assumed many of the tasks of the Radio Technical Planning Board, which was dissolved July 1, 1948. The JTAC was formed as a result of an informal request by the chairman of the Federal Communications Commission for assistance from the IRE and RMA in collecting information on the utilization of ultra-high frequencies for television. The first important act of JTAC was the preparation and filing of the report on "Utilization of Ultra-High Frequencies for Television" with the Federal Communications Commission, Docket 8976, September 20, 1948. This committee made a further presentation of material on radio propagation at the engineering conference held by the FCC, November 30–December 2, 1948.

"J.T.A.C., its purpose and program," *Electronics*, vol. 21, pp. 72–75; September, 1948.

Geophysical studies of the atmosphere were continued by upper-air research groups, and a better understanding of radio-frequency propagation is indicated.

A new semiconductor, three-electrode amplifying device, known as the "transistor," was announced. Subject to certain limitations, it will perform many of the functions of an electron tube, such as amplification, oscillation, and modulation. The transistor consists of two thin wires touching a pinhead of a solid semiconductive material soldered to a metal base. One of these is part of the input circuit; the other is in the output circuit. While the device is still in the experimental stage, tests have shown that the transistor will amplify at least 100 times (20 db). Test models have also been operated as amplifiers at frequencies up to 10 Mc.

In the field of home sound reproduction, a new "long-playing" (LP) record was introduced. This record, which plays at $33\frac{1}{3}$ rpm and which has a finer groove than previous home records, provides up to 45 minutes of recorded material on a double-faced, 12-inch vinylite record.

The continued growth of the broadcasting industry in the United States during 1948 is shown in Table I.

Following the action taken at the International Radio Conference held in Atlantic City in 1947, the Provisional Frequency Board convened in Geneva, Switzerland, during 1948 and began the formidable task of assigning specific frequencies to the various international communication circuits of the world, on an engineering basis. The specific problems of the aeronautical service were dealt with at a separate conference, also held at Geneva. In addition, an international engineering com-

* Decimal classification: R090.1. Original manuscript received by the Institute, January 13, 1949. This report is based on material from the 1948 Annual Review Committee of The Institute of Radio Engineers, as co-ordinated by the Chairman.

TABLE I

Comparison of Radio Broadcast Stations for which Licenses and Construction Permits Were Issued by the FCC Outstanding on December 31, 1947, and December 31, 1948

Class of Broadcast Station	Licenses and Construction Permits 12/31/47	Licenses 12/31/48	Construction Permits 12/31/48	Total 12/31/48
Standard	1962	1865	262	2127
Commercial high-frequency (FM)	787	222	699	966*
Commercial television	73	7	117	124

* Including 45 conditional grants.

mittee met at Geneva to consider the specific requirements of high-frequency broadcasting. This Broadcast Planning Committee arrived at a proposed allocation plan for high-frequency broadcasting which formed the framework for consideration at the High-Frequency Broadcast Conference, which convened at Mexico City on October 22, 1948. A meeting of the International Radio Consultative Committee (CCIR) was held at Stockholm in July.

Radio Transmitters

The year 1948 was a very active one in radio transmitter progress, as evidenced by published literature on associated circuit and component developments. Many improvements in detail were reported, but, from an overall viewpoint, 1948 was not spectacular.

In the 1948 literature, the subject of radio relaying was prominent, showing the intense interest and activity in this field where radio may perform many duties of wire lines for overland telephony and telegraphy. Methods of modulation, considered from the system standpoint, were under continued study and development. Multiplexing methods were subjects of extensive research both theoretically and practically. Relay systems reported in trade news and technical papers ranged from simple one-channel to large multichannel systems, and included those intended for television relaying.

(1) "Microwave radio communication: 8-channel multiplex point-to-point equipment," *Electrician*, vol. 140, p. 963; March 26, 1948.
(2) Rivére, P., "La liaison radiotélépbonique multiplex continent-corse," *Ann. Radioélectricité*, vol. 3, pp. 221–239; July, 1948.
(3) H. T. Friis, "Microwave repeater research," *Bell Sys. Tech. Jour.*, vol. 27, pp. 183–246; April, 1948.
(4) A. A. Roetken, "Repeaters for the New York to Boston radio relay system," *Bell Lab. Rec.*, vol. 26, pp. 193–198; May, 1948.
(5) J. G. Chaffee, "Terminals for the New York to Boston radio relay system," *Bell Lab. Rec.*, vol. 26, pp. 97–100; March, 1948.
(6) L. A. Meacham and E. Peterson, "An experimental multichannel pulse-code modulation system of toll quality," *Bell Sys. Tech. Jour.*, vol. 27, pp. 1–43; January, 1948.

Television relaying was greatly extended in the United States with the experimental opening of the Boston–New York system. Other systems were extended and improved. Successful relaying was achieved for temporary services by cascading several microwave links of the type used for studio-to-station transmission.

(7) W. H. Forster, "Two-way TV relay," *Tele-Tech*, vol. 7, pp. 46–48; April, 1948.
(8) A. L. Durkee, "A microwave relay system between New York and Boston," *Bell Lab. Rec.*, vol. 25, pp. 437–441; December, 1947.

The number of television stations in service greatly increased, and scheduled network operations were greatly expanded. Public acceptance of television became a major incentive to engineers and business men. New television transmitters were announced commercially for both 500 and 5,000 watts output. Some significant developments in television transmitters were made for the purpose of making field tests of the higher frequencies, though these were in the nature of advanced developments.

(9) G. E. Hamilton, "TV transmitter design," *Communications*, vol. 28, pp. 12–15, 30, May; pp. 20–22, 29, June; pp. 10–13, July; pp. 8–9, 32–33; August, 1948.
(10) C. D. Kentner, "TT-5A television transmitter," *Broadcast News*, no. 48, pp. 4–15; March, 1948.
(11) M. Matricon, "Allouis OC III center for broadcasting on decimeter waves," *Onde Elec.*, vol. 28, pp. 121–128; April, 1948.

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(16) D. A. Miller, "International broadcast h.f. transmitter with continuously tunable plate system," *Communications*, vol. 28, pp. 10–13, 28; January, 1947.
(17) T. C. Macnamara, A. B. Howe, and P. A. T. Bevan, "The design and operation of high-power broadcast transmitter units with their outputs combined in parallel," *Jour. IEE*, vol. 95, part III, pp. 183–198; May, 1948.
(18) V. O. Stokes, "Transmitters in parallel," *Marconi Rev.*, vol. 1, pp. 39–44; April–June, 1948.

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Radio Progress During 1948*

Introduction

DURING 1948 the electronics art continued its advances into new frontiers. Considerable progress was reported in the theoretical field dealing with the philosophy of communicating intelligence. Mathematical analyses of the bandwidth required for the transmission of information-bearing signals in the presence of noise, and of methods of modulation which utilize the redundancy or statistical structure of the intelligence, led to the realization that important savings in spectrum space or increases in efficiency may be available. The published studies, however, did not describe communication systems to make these theoretical improvements practical. The antenna art was advanced considerably by theoretical work on super-gain antennas, as well as by developments in the design of helical and lens types of antennas.

The expansion of the television industry continued at an accelerated pace. The number of television receivers produced during the year increased the total number of receivers in service in the United States to about 1 million, and the number of operating television stations increased from 16 to 51. The development of the metal cathode-ray tube aided the trend toward larger pictures for home reception. Several commercial television transmitters commenced operation in the "high" band (174–216 Mc). With the installation of a microwave relay circuit from New York to Boston, facilities for networking television stations on the East Coast were completed from Boston to Richmond. In the Middle West, television network facilities employing coaxial cable were completed from St. Louis to Chicago, Toledo, and Buffalo, with branch facilities (microwave) to Milwaukee and Detroit. It was announced that a link connecting these two networks would be completed in January, 1949, thereby providing television network facilities for the area of the United States north and east of St. Louis.

In addition to "live" networking, four television networks and several other organizations installed equipment capable of making television recordings (from a picture tube) for the distribution of television program material to stations throughout the nation.

Experience with the interference range of television broadcasting stations led the Federal Communications Commission to suspend temporarily the granting of new construction permits and to hold an industry-government conference at the end of November for the review of available propagation data, particularly in the band 475 to 890 Mc.

An important joint committee in which representatives of The Institute of Radio Engineers have been active was the Joint Technical Advisory Committee, which was established on June 20, 1948, by action of the Boards of Directors of The Institute of Radio Engineers and of the Radio Manufacturers Association, to advise government bodies and industry groups on the wise use and regulation of radio facilities. The JTAC has assumed many of the tasks of the Radio Technical Planning Board, which was dissolved July 1, 1948. The JTAC was formed as a result of an informal request by the chairman of the Federal Communications Commission for assistance from the IRE and RMA in collecting information on the utilization of ultra-high frequencies for television. The first important act of JTAC was the preparation and filing of the report on "Utilization of Ultra-High Frequencies for Television" with the Federal Communications Commission, Docket 8976, September 20, 1948. This committee made a further presentation of material on radio propagation at the engineering conference held by the FCC, November 30–December 2, 1948.

"J.T.A.C., its purpose and program," *Electronics*, vol. 21, pp 72–75; September, 1948.

Geophysical studies of the atmosphere were continued by upper-air research groups, and a better understanding of radio-frequency propagation is indicated.

A new semiconductor, three-electrode amplifying device, known as the "transistor," was announced. Subject to certain limitations, it will perform many of the functions of an electron tube, such as amplification, oscillation, and modulation. The transistor consists of two thin wires touching a pinhead of a solid semiconductive material soldered to a metal base. One of these is part of the input circuit; the other is in the output circuit. While the device is still in the experimental stage, tests have shown that the transistor will amplify at least 100 times (20 db). Test models have also been operated as amplifiers at frequencies up to 10 Mc.

In the field of home sound reproduction, a new "long-playing" (LP) record was introduced. This record, which plays at $33\frac{1}{3}$ rpm and which has a finer groove than previous home records, provides up to 45 minutes of recorded material on a double-faced, 12-inch vinylite record.

The continued growth of the broadcasting industry in the United States during 1948 is shown in Table I.

Following the action taken at the International Radio Conference held in Atlantic City in 1947, the Provisional Frequency Board convened in Geneva, Switzerland, during 1948 and began the formidable task of assigning specific frequencies to the various international communication circuits of the world, on an engineering basis. The specific problems of the aeronautical service were dealt with at a separate conference, also held at Geneva. In addition, an international engineering com-

* Decimal classification: R090.1. Original manuscript received by the Institute, January 13, 1949. This report is based on material from the 1948 Annual Review Committee of The Institute of Radio Engineers, as co-ordinated by the Chairman.

TABLE I

Comparison of Radio Broadcast Stations for which Licenses and Construction Permits Were Issued by the FCC Outstanding on December 31, 1947, and December 31, 1948

Class of Broadcast Station	Licenses and Construction Permits 12/31/47	Licenses 12/31/48	Construction Permits 12/31/48	Total 12/31/48
Standard	1962	1865	262	2127
Commercial high-frequency (FM)	787	222	699	966*
Commercial television	73	7	117	124

* Including 45 conditional grants.

mittee met at Geneva to consider the specific requirements of high-frequency broadcasting. This Broadcast Planning Committee arrived at a proposed allocation plan for high-frequency broadcasting which formed the framework for consideration at the High-Frequency Broadcast Conference, which convened at Mexico City on October 22, 1948. A meeting of the International Radio Consultative Committee (CCIR) was held at Stockholm in July.

Radio Transmitters

The year 1948 was a very active one in radio transmitter progress, as evidenced by published literature on associated circuit and component developments. Many improvements in detail were reported, but, from an overall viewpoint, 1948 was not spectacular.

In the 1948 literature, the subject of radio relaying was prominent, showing the intense interest and activity in this field where radio may perform many duties of wire lines for overland telephony and telegraphy. Methods of modulation, considered from the system standpoint, were under continued study and development. Multiplexing methods were subjects of extensive research both theoretically and practically. Relay systems reported in trade news and technical papers ranged from simple one-channel to large multichannel systems, and included those intended for television relaying.

(1) "Microwave radio communication: 8-channel multiplex point-to-point equipment," *Electrician*, vol. 140, p. 963; March 26, 1948.
(2) Rivére, P., "La liaison radiotéléphonique multiplex continent-corse," *Ann. Radioélectricité*, vol. 3, pp. 221–239; July, 1948.
(3) H. T. Friis, "Microwave repeater research," *Bell Sys. Tech. Jour.*, vol. 27, pp. 183–246; April, 1948.
(4) A. A. Roetken, "Repeaters for the New York to Boston radio relay system," *Bell Lab. Rec.*, vol. 26, pp. 193–198; May, 1948.
(5) J. G. Chaffee, "Terminals for the New York to Boston radio relay system," *Bell Lab. Rec.*, vol. 26, pp. 97–100; March, 1948.
(6) L. A. Meacham and E. Peterson, "An experimental multichannel pulse-code modulation system of toll quality," *Bell Sys. Tech. Jour.*, vol. 27, pp. 1–43; January, 1948.

Television relaying was greatly extended in the United States with the experimental opening of the Boston–New York system. Other systems were extended and improved. Successful relaying was achieved for temporary services by cascading several microwave links of the type used for studio-to-station transmission.

(7) W. H. Forster, "Two-way TV relay," *Tele-Tech*, vol. 7, pp. 46–48; April, 1948.
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(18) V. O. Stokes, "Transmitters in parallel," *Marconi Rev.*, vol. 1, pp. 39–44; April–June, 1948.

FM vhf communication for mobile, vehicular, and rural telephone services was greatly extended throughout the United States, and also certain other countries. The possibilities of this kind of communication were recognized as more applications were being made to police, taxi, delivery, bus, truck, train, emergency, forestry, tugboat, and other mobile operations, and to certain short-distance point-to-point circuits. The public telephone services to vehicles expanded notably during the year in the United States.

(19) N. Monk and S. B. Wright, "Technical aspects of experimental public telephone service on railroad trains," PROC. I.R.E., vol. 36, pp. 1146–1152; September, 1948.
(20) H. W. Nylund, "Rural party-line service by radio," *Bell Lab. Rec.*, vol. 26, pp. 49–54; February, 1948.
(21) H. I. Romnes, "Radio for telephone service in America," presented in connection with 50th Anniversary of Marconi's demonstration of radio, Rome, September 28–October 5, 1947. Tipografia del Senato, Del Dott, Giovanni Bardi, Roma, 1948. *Elec. Eng.*, vol. 67, p. 941; October, 1948.

The use of vhf for airport traffic control and for short-range communication increased.

Maritime radiotelephone service made increasing use of vhf operation. Otherwise, marine radio transmitters for shipboard use showed no significant change during the year. The number of ships using navigational radar increased notably during the year. A new radio transmitter for coastal stations was described.

(22) J. F. McDonald, "Recent developments in radiotelegraph transmitters for shore stations," *RCA Rev.*, vol. 8, pp. 751–764; December, 1947.
(23) F. M. Ryan, "A new look at marine radiotelephony," *Marine News*, vol. 35, pp. 25–30; August, 1948.

Radar generally underwent further development, as evidenced by some papers on details of the subject. Reference is made elsewhere in the present Review to papers on FM radar systems.

The evolution of point-to-point radiotelegraph services continued in the direction of frequency-shift keying and teleprinter operation. Morse signaling was gradually decreasing on heavy-traffic circuits. Progress in the point-to-point radiotelegraph field was largely a continuation of trends from previous years.

(24) J. R. Davey and A. L. Matte, "Frequency-shift telegraphy—radio and wire line," *Bell Sys. Tech. Jour.*, vol. 27, pp. 265–304; April, 1948.
(25) B. T. Ellis, "Medium-power multichannel communication transmitters," *Elec. Commun.* (London), vol. 24, pp. 433–435; December, 1947.

In the same sense, the international radiotelephone services expanded, using single-sideband reduced-carrier methods. Some new equipment for this purpose was described. A new method for obtaining asymmetric-sideband transmission was also published.

(26) C. T. F. van der Wyck, "Modern single-sideband equipment of the Netherlands postal telephone and telegraph," PROC. I.R.E., vol. 36, pp. 970–980; August, 1948.
(27) O. G. Villard, Jr., "A high-level single-sideband transmitter," PROC. I.R.E., vol. 36, pp. 1419–1425; November, 1948.

Further discussion of developments in radio transmitters appears in the section of this Review relating to Railroad and Vehicular Communications.

Modulation Systems

During the past year many experimental and practical applications were reported which utilized pulse techniques and pulse-modulation systems. Special electron-beam-coding tubes were developed in order to simplify the instrumentation of pulse-code-modulation systems. On the theoretical side, analytical studies were made of various systems of multiplex transmission in order to compare the capabilities, properties, advantages, and disadvantages of each system.

(28) L. A. Meacham and E. Peterson, "An experimental multichannel pulse code modulation system of toll quality," *Bell Sys. Tech. Jour.*, vol. 27, pp. 1–43; January, 1948.
(29) C. B. Feldman, "A 96 channel pulse code modulation system," *Bell Lab. Rec.*, vol. 26, pp. 364–370; September, 1948.
(30) R. W. Sears, "Electron beam deflection tube for pulse code modulation," *Bell Sys. Tech. Jour.*, vol. 27, pp. 44–57; January, 1948.
(31) V. D. Landon, "Theoretical analysis of various systems of multiplex transmission," *RCA Rev.*, vol. 9, pp. 287–351; June, 1948; also vol. 9, pp. 433–482; September, 1948.
(32) B. Chance, "Time modulation," PROC. I.R.E., vol. 35, pp. 1039–1044; October, 1947.
(33) B. Chance, "Time demodulation," PROC. I.R.E., vol. 35, pp. 1045–1048; October, 1947.
(34) S. Moskowitz and D. D. Grieg, "Noise-suppression characteristics of pulse-time modulation," PROC. I.R.E., vol. 36, pp. 446–450; April, 1948.
(35) B. Haard, "Signal-to-noise ratios in pulse modulation systems," *Ericsson Technics*, (Stockholm, Sweden), no. 47, pp. 3–31; 1948.

Video Techniques and Television

Television

Perhaps the most significant aspect of television work during 1948 was the whole-hearted and unanimous acceptance of the existing RMA standards as a framework within which to develop. Clearly realizing the generous room for improvement of present pictures within the framework of existing standards, the industry settled down to develop apparatus and equipment without suggesting additional variations.

(36) D. G. Fink, "Avenues of improvement in present-day television," PROC. I.R.E., vol. 36, pp. 896–905; July, 1948.

It has become apparent that the range of television stations (and especially the interference range) is substantially greater than had been predicted. It was the general opinion of the industry that by the time all channels provided for in the allocations had been put into service, intercity interference would be extremely objectionable, at least in certain areas of high population density. For this reason, the Federal Communications Commission held a series of engineering conferences to investigate the situation, and during this investigation suspended the granting of new construction permits. At these conferences it was brought out that tropospheric interference effects are virtually independent of transmitting antenna height, so that maximum useful service area can be achieved by encouraging broadcasters to erect antennas as high as possible without limiting the transmitting power because of such antenna height. Data were presented on a means of synchronizing radio-frequency carriers of television stations operating on the same channel in different cities, as a means of reducing interference. It was also suggested that immediate allocation of 6-Mc channels conforming to present RMA standards in the frequency range between 480 and 920 Mc could alleviate this problem. Several possible allocation plans were presented for Commission consideration, but no action had been taken at the end of the year.

Video Transmission

During 1948, the service area of network television was extended southward to Richmond, Va., and a midwest network was placed in operation connecting Buffalo, Cleveland, Toledo, Chicago, and St. Louis by coaxial cable. Connections to Detroit and Milwaukee by means of radio relay were included. Tests were completed on the Philadelphia-to-Cleveland coaxial cable with combined Eastern and Midwestern network operation scheduled for service early in January, 1949. In addition, a reversible television radio relay system was installed and tested during 1948 connecting Philadelphia and New York.

(37) F. M. Deerhake, "2,000-Mc television program chain," *Electronics*, vol. 21, pp. 94–97; February, 1948.
(38) W. H. Forster, "Two-way TV relay," *Tele-Tech*, vol. 7, pp. 46–48; April, 1948.
(39) "NBC installing alternate video route, microwave relay to link Baltimore & Philadelphia," *Broadcasting*, vol. 34, pp. 17, 93; January 12, 1948.
(40) "Bell System opens mid-west television network," *Bell Lab. Rec.*, vol. 26, pp. 423–424; October, 1948.

Possible alternatives to permanent intercity links for wide-range television coverage were explored. One possibility, that of broadcasting directly to a large area by stratovision, was the subject of continuing experimentation. This system, as demonstrated in 1948, utilized an airborne television transmitter to which programs were relayed by microwave transmission from a ground station. The service area was estimated to have a radius of about 200–250 miles. As another alternative, the signals from a New York broadcasting station were received regularly at a suitable location outside New Haven and transmitted over a radio link to a New Haven station for rebroadcasting.

(41) J. F. Beatty, "Stratovision clicks," *Broadcasting*, vol. 34, pp. 21, 68–69; June 7, 1948.
(42) R. P. Wakeman, "Indirect microwave relay system," *Tele-Tech*, vol. 7, pp. 42–43, 106; September, 1948.

Technical activities during the year included the development of a motion-picture camera for recording television images directly from the screen of the cathode-ray tube. In some cases, these images were developed by a rapid process requiring less than a minute and projected immediately on theater screens. Several successful demonstrations of this form of theater television were made. In other cases, the films themselves, with suitably recorded sound tracks, were processed and supplied to other television stations for rebroadcast at a later date.

(43) J. L. Boon, W. Feldman, and J. Stoeber, "Television recording camera," *Jour. Soc. Mot. Pic. Eng.*, vol. 51, pp. 117–126; August, 1948.
(44) T. T. Goldsmith, Jr., and H. Milholland, "Television transcription by motion picture film," *Jour. Soc. Mot. Pic. Eng.*, vol. 51, pp. 107–113; August, 1948.
(45) T. T. Goldsmith, Jr., and H. Milholland, "Television transcriptions," *Electronics*, vol. 21, pp. 63–71; October, 1948.
(46) R. M. Fraser, "Motion picture photography of television images," *RCA Rev.*, vol. 9, pp. 202–217; June, 1948.
(47) A. N. Goldsmith, "Theatre television: A general analysis," *Jour. Soc. Mot. Pic. Eng.*, vol. 50, pp. 95–117; February, 1948.

In the receiver field, relatively little new development appeared. Vigorous activity appeared to have eased somewhat the serious bottleneck in the supply of cathode-ray tubes, and estimates of receiver production for 1949 were made reaching figures as high as two million units. A 16-inch cathode-ray tube having conical metal side walls, much lighter than existing types of similar size, was developed and put into experimental production. Intercarrier sound was used successfully in several smaller receivers, but still occupied a minor position. A neatly packaged optical system for projection television appeared, augmenting but not supplanting other systems previously designed. Further information regarding television-tube development appears in the section of this Review relating to Electron Tubes.

(48) S. W. Seely, "Design factors for inter-carrier television sound," *Electronics*, vol. 21, pp. 72–75; July, 1948.
(49) H. Rinia, J. deGier, and P. M. van Alphen, "Home projection television," Proc. I.R.E., vol. 36, pp. 395–411; March, 1948.

Video Techniques

Notable progress was made in the comparatively new field of television recording on film. This rapidly growing art combines the techniques of motion-picture photography, television, and film processing. One of the important uses of television transcriptions was to provide delayed-broadcast network service beyond the limits of coaxial-cable or radio-relay service areas. Transcriptions also served other purposes, such as promotional advertising, as aids to criticism of program techniques and content, and as historical or legal records.

Considerable impetus was given the new art during the coverage of the 1948 national political conventions. Television broadcasters filmed the proceedings and flew the transcriptions to stations in the Midwest and West Coast areas where no cable or microwave-relay facilities were available for direct transmission.

(50) R. M. Fraser, "Motion picture photography of television images," *RCA Rev.*, vol. 9, p. 202; June, 1948.

Postwar commercial television emphasized the desirability of larger pictures for home receivers. Two approaches to the problem have developed—large direct-viewing tubes, and optical projection of the picture formed on small high-intensity tubes. Heretofore, projection systems have not greatly reduced the space required below that necessary for the larger direct-viewing tubes. New systems were developed during the year which are both compact and efficient. Pictures 12×16 inches are produced with satisfactory brightness, contrast, and resolution. In some cases, the circuit requirements may be satisfied by a basic 10-inch receiver chassis.

Advances were made in large-screen television, and several demonstrations were given during the year utilizing both film-recorded and direct systems.

(51) G. J. Siezen and F. Kerkhof, "Home projection television, Part II: Pulse-type high-voltage supply," Proc. I.R.E., vol. 36, pp. 401–407; March, 1948.

(52) J. Haantjes and F. Kerkhof, "Home projection television, Part III: Deflection circuits," Proc. I.R.E., vol. 36, pp. 407–411; March, 1948.
(53) H. G. Boyle and E. B. Doll, "Compact projection television system," *Electronics*, vol. 21, pp. 72–77, April 1948. Also, "Big picture practices," *Tele-Tech*, vol. 7, pp. 30–35, 67; March, 1948.

Television for military uses was noted at various times during the year. The applications generally took the form of remote viewing of events. One such interesting application involved deep-sea exploration by the Navy at Bikini at depths as great as 180 feet. Problems of remote adjustment of the television-camera controls and transmission of video and sync pulses over long cables were successfully solved.

(54) C. L. Engleman, "Underwater television," *Electronics*, vol. 21, pp. 78–80; February, 1948.

The possibility that television may play a significant role in education was augured by a project begun under Navy sponsorship toward the end of 1948. Mass training of military personnel with a minimum number of instructors got under way at the Navy's Special Devices Center at Port Washington, N. Y. Weekly television lectures on naval science were telecast to the Merchant Marine Academy located near by at Kings Point, N. Y. The system made very efficient use of a small group of specially trained instructors and assured each student, in effect, a front seat. Whether this method of training will prove to be equal to or superior to conventional methods was being carefully studied. A similar application of television was employed by the Northwestern University Medical School in bringing surgical procedures and clinical demonstrations to physicians and surgeons attending the American Medical Association meeting in Chicago in June, 1948.

Some work in the field of color television was reported, and demonstrations of television in color were noted during the year.

(55) A. Bronwell, "New viewing tube for color TV," *Tele-Tech*, vol. 7, pp. 40–41, 65; March, 1948.
(56) Frank J. Bingley, "The application of projective geometry to the theory of color mixture," Proc. I.R.E., vol. 36, pp. 709–723; June, 1948.

Facsimile

The year 1948 brought several important events in the field of facsimile broadcasting. Delivery to broadcasters of the first postwar facsimile transmitting and receiving equipment marked the entrance of facsimile into general broadcasting. The initial equipment was used extensively for technical and operational familiarization programs. Promotional experiments were conducted to show the public types of program services to be offered over broadcast facsimile in the future.

(57) R. G. Peter, "Facsimile transmitter at the Miami Herald, Florida," *Communications*, vol. 28, pp. 12–15, 33; February, 1948.
(58) "Atlanta facsimile show given by WSB, 'Journal,'" *Broadcasting*, vol. 34, p. 66; May 31, 1948.
(59) F. K. Lauden, "Radio facsimile may print 'Newspapers of Tomorrow,'" *Radio News*, vol. 40, pp. 39, 148, 149; August, 1948.

In March, 1948, the Federal Communications Commission devoted a period to a hearing on standardization for facsimile broadcasting. This hearing led to the promulgation by the Commission of equipment and operating standards under which the first broadcasting of commercial facsimile programs commenced on July 15, 1948. The standards called for either simplex or multiplex transmission with an index of co-operation of 984 (8.2-inch scanned line) on the FM broadcasting channels.

(60) A. A. McKenzie, "Facsimile goes commercial," *Electronics*, vol. 21, p. 97; August, 1948.
(61) "Fax goes commercial," *Communications*, vol. 28, p. 9; June, 1948.
(62) "FCC's facsimile rules & standards," *Broadcasting*, vol. 34, pp. 24, 64; June 14, 1948.

The facsimile ruling of the Federal Communications Commission favored the development and use of multiplex sound and facsimile broadcasting. While several organizations in the United States had been experimenting with the multiplex problem, it was not until September, 1948, that a multiplex system was revealed which members of the Commission said was outstanding because the multiplexed facsimile signals did not degrade a sound program in any portion of the audible range. This multiplex system required no filters to exclude the facsimile signals from the sound portion of a normal FM receiver not equipped to receive facsimile, thus meeting present requirements as stated by the Federal Communications Commission.

(63) H. Brandschain, "Multiplexing," *Broadcasting*, vol. 35, p. 24; September 27, 1948.

"Ultrafax," first disclosed in 1947, was demonstrated to government officials in October, 1948. Using high-speed photographic equipment in conjunction with modified television broadcast equipment, Ultrafax showed that it could transmit specially prepared copy at the rate of a million words per minute to a receiving location where high-speed film processing delivered a single frame of film ready for printing or projecting in forty-five seconds.

(64) "Ultrafax defined," *Broadcasting*, vol. 32, p. 19; June 30, 1947.

Facsimile continued to hold the interest of groups with needs for special service communications. A nation-wide military air-weather network was formed to relay weather maps and information. Police communication officers declared that facsimile used on high-frequency links would be of great value in the distribution of fingerprints and associated data. The U. S. Weather Bureau announced a high-speed radio facsimile service in Chicago between the central weather station in the city and the municipal-airport weather station. The Weather Bureau claimed this facsimile installation was necessary to avoid using either a messenger service or multiple plotting offices.

(65) "Fingerprints by electronics," *Gen. Elec. Rev.*, vol. 51, p. 47; September, 1948.
(66) "Weather Facsimile Service," Proc. I.R.E., vol. 36, p. 752; June, 1948.

Railroad and Vehicular Communications

Service Expansion

Developments in the mobile communication field during 1948 were marked chiefly by rapid expansion of established mobile communication services and by the introduction of new services. Taxicab and common-carrier systems experienced particularly rapid growth.

Work on systems designed to permit continuous communication over railroad main lines was carried forward, with at least one such system permitting continuous communication between the train dispatcher and moving trains over a 315-mile stretch of railroad. Application of highway mobile common-carrier communication to moving trains to provide for public correspondence was also extended, with the attendant problems in antenna design and noise reduction successfully solved.

(67) M. B. Sleeper, "2-way radio has become a business need," *FM and Telev.*, vol. 8, p. 17; January, 1948.
(68) B. Cutting, "How FM fought forest fires," *FM and Telev.* vol. 8, pp. 26, 34; January, 1948.
(69) N. Monk and S. B. Wright, "Technical aspects of experimental telephone service on railroad trains," Proc. I.R.E., vol. 36, pp. 1146–1152; September, 1948.
(70) "Train communication saves railroad time," *Railway Age*, vol. 124, pp. 52–55; April 10, 1948.
(71) "Radio expedites switcher service," *Railway Age*, vol. 124, pp. 48–50; May 1, 1948.
(72) "Radio and carrier equipment tests on the Southern Pacific," *Railway Signaling*, vol. 41, pp. 94–98; February, 1948.
(73) C. J. Anderson, "Railway radio in the steel industry," *Railway Signaling*, vol. 41, pp. 230–233; April, 1948.
(74) A. A. Curry, "Development and application of railway vhf communication equipment," *Telegr. and Teleph. Age*, p. 7; June, 1948.
(75) C. C. Donley, "The Lincoln, Nebraska mobile radio telephone system," *Telephony*, vol. 134, pp. 9–11, 32; January 31, 1948.
(76) B. L. Fisher, "Consider mobile telephone service now," *Telephone Eng.*, vol. 52, pp. 28–29, 63, 65; January, 1948.
(77) "Two-way radio simplifies sagging-in procedure on transmission lines," *Electric World*, vol. 129, pp. 60–61; January 31, 1948.
(78) S. Freedman, "Two-way taxicab radio systems," *Communications*, vol. 28, pp. 8–11; February, 1948.
(79) R. B. Holt, " Arms of the law'—police communications," *Bell Tel. Mag.*, vol. 26, pp. 208–220; Winter, 1947–1948.
(80) P. R. Kendall, "Brookhaven, Long Island, police 72–76/152–162 MC 2-way fm system," *Communications*, vol. 28, pp. 6–7; February, 1948.
(81) "Train communication on the Missouri-Pacific," *Railway Signaling*, vol. 41, pp. 153–159; March, 1948.
(82) B. P. Cattrell, "Land line mobile service," *FM and Telev.*, vol. 8, pp. 33–35, 42, 44; April, 1948.
(83) J. P. Coty, "FM for Indianapolis," *FM and Telev.*, vol. 8, pp. 28–29; May, 1948.
(84) R. G. Peters, "Philadelphia police duplex two-way f-m system," *Communications*, vol. 28, pp. 22, 30; May, 1948.
(85) "Longest train telephone service to open in fall," *Telephony*, vol. 135, p. 27; July 17, 1948.
(86) J. N. Sitton, "How New York tugs use fm," *FM and Telev.*, vol. 8, pp. 32–33, 40; August, 1948.
(87) "Erie radio increases operating efficiency," *Railway Age*, vol. 125, pp. 56–59; September 11, 1948.
(88) F. H. B. Bartelink, "Mobile selective calling," *Electronics*, vol. 21, pp. 103–105; November, 1948.
(89) F. D. Norris, "Mobile telephone service," *Telephony*, vol. 135, pp. 42–43, 102; October 23, 1948.
(90) "Erie main line radio," *Modern Railroads*, p. 3; October, 1948.

Frequency Allocations

The most pressing problem throughout the year has continued to be that of providing adequate frequency assignments. During the year the Federal Communications Commission issued proposed rules, including frequency allocations to mobile services, among others, in several frequency bands between 25 and 460 Mc. These rules have not yet been made effective.

The proposed rules recognized that the sharing of channels between television and the mobile services on a noninterfering basis was not practical. As partial compensation for loss of their sharing possibilities, the mobile services were allocated the band from 44 to 50 Mc, formerly television channel No. 1.

(91) "Radio frequencies for railroads," *Telegr. and Teleph. Age*, vol. 66, pp. 24–25; June, 1948.
(92) J. Courtney, "More space for mobile radio," *FM and Telev.*, vol. 8, pp. 19–20, 23; July, 1948.
(93) J. Courtney, "What's wrong with U.S. frequency allocations?" *Electronics*, vol. 21, pp. 73–75; August, 1948.

Equipment Developments

Equipment developments during the year were largely directed toward the reduction of interference, both intersystem and intrasystem, the utilization of closer frequency spacing, and the reduction of physical size.

It became apparent that the demands for many communication systems could not be met unless the fullest utilization were made of the portion of the frequency spectrum assigned to mobile communication. A large part of the effort during 1948 was toward the improvement of equipment for operation in the frequency range between 152 and 162 Mc, where, although channels are assigned on a 60-kc separation basis, it has been generally considered that adjacent-channel operation in the same or adjacent area was not practical except under very special conditions. Most of the new developments announced during 1948 bore on this particular problem. These include improved receiver adjacent-channel selectivity, reduction in receiver spurious response, and reduction in transmitter spurious radiation. Further to alleviate interference problems, selective calling and selective squelch circuits were described which, while not contributing directly to selectivity, achieve somewhat the same effect by reducing interference between systems operating on the same or adjacent frequencies.

Automatic-level-control or peak-limiting circuits were added to transmitters to reduce splatter into adjacent channels. Some of these circuits operate on the slope of the modulating wave rather than the amplitude, in order effectively to limit the frequency of phase-modulated transmitters.

The trend towards miniature tubes and miniature components continued, with the result that transmitters and receivers of smaller over-all physical dimensions were becoming available.

(94) B. P. Cattrell, "Selective calling for mobile telephone service," *FM and Telev.*, vol. 8, pp. 32–34; January, 1948.
(95) L. P. Morris, "Compact universal mobile units," (Part I), *FM and Telev.*, vol. 8, pp. 34–38; July, 1948. (Part II), *FM and Telev.*, vol. 8, pp. 19–22; August, 1948.
(96) W. R. Young, Jr., "Interference between very-high-frequency radio communication circuits," Proc. I.R.E., vol. 36, pp. 923–930; July, 1948.
(97) C. M. Backer and P. J. Brewster, "Circuits for selective calling," *FM and Telev.*, vol. 8, pp. 20–21, October, 1948.
(98) H. B. Carlson, "Mobile system monitor," *FM and Telev.*, vol. 8, pp. 19, 44, 46.

General

Additional papers were published during the year having to do with the general application of radio communication to mobile units. Some of these are referred to in the section of the present Review relating to Radio Transmitters.

(99) A. Bailey, "Mobile radio communication," *Elec. Eng.*, vol 67, p. 655; July, 1948.
(100) "Power for radio equipped railroad vehicles," *Telegr. and Teleph. Age*, vol. 66, pp. 7–8; February, 1948.
(101) J. R. Brinkley, "Multi-carrier vhf police radio scheme," *Jour. Inst. Radio Eng.*, (London), vol. 8, pp. 128–142; disc. pp. 143–147; May–June, 1948.

Radio Receivers

The year 1948 saw a continuation of the trend, begun in 1947, toward the use of miniature tubes and components. There was also a further swing toward printed-circuit subassemblies and the use of selenium rectifiers.

Several new designs of table-model AM-FM receivers were developed. Improved AM-FM and FM tuners were also introduced. A few of the new designs utilized a double-superheterodyne circuit. Although further theoretical work was done on superregenerative receivers, practical applications in this field were limited chiefly to further tests and comparisons involving previously announced commercial designs.

(102) W. W. Hensler, "New trends in receiver design," *Radio News*, pp. 46, 47, 170–172; June, 1948.
(103) W. F. Frankhart, "Low-cost FM-AM receiver design," *Tele-Tech*, vol. 7, pp. 40–41; April, 1948.
(104) W. C. Black, "Pattern for FM profits receiver and antenna," *FM and Telev.*, vol. 8, pp. 36–39, 43, 58; September, 1948.
(105) G. E. Gustafson and J. L. Rennick, "Low-cost FM-AM receiver circuit," *Tele-Tech*, vol. 7, pp. 36–38; October, 1948.
(106) R. S. Hawkins and C. H. Shelton, "A universal FM receiver," *FM and Telev.*, vol. 8, pp. 20–22, and 53; February, 1948.
(107) W. J. Harrison, "FM double superhet," *FM and Telev.*, vol. 8, pp. 17–19; April, 1948.
(108) G. G. Macfarlane and J. R. Whitehead, "The theory of the superregenerative receiver operated in the linear mode," *Jour. IEE*, vol. 95, Part III, pp. 143–157; May, 1948.
(109) A. Hazeltine, D. Richman, and B. D. Loughlin, "Superregenerator design," *Electronics*, vol. 21, pp. 99–102; September, 1948.
(110) W. E. Bradley, "Superregenerative detection theory," *Electronics*, vol. 21, pp. 96–98; September, 1948.
(111) A. A. McKenzie, "Fremodyne FM receivers," *Electronics*, vol. 21, pp. 83–87; January, 1948.

FM receiver circuit elements, such as detector circuits, squelch arrangements, and tuning-eye schemes, received further study and were the subject of minor refinements and innovations. Means for and methods of measuring noise in radio receivers received attention.

(112) B. D. Loughlin, "Performance characteristics of FM detector systems," *Tele-Tech*, vol. 7, pp. 30–34; January, 1948.
(113) C. W. Carnahan, "Squelch circuits for FM receivers," *Electronics*, vol. 21, pp. 98–99; April, 1948.
(114) M. L. Greenough, "Polarity response from tuning-eye tubes," *Electronics*, vol. 21, pp. 162, 164, 166, 168; April, 1948.
(115) F. L. H. M. Stumpers, "On the calculation of impulse noise transients in frequency-modulation receivers," *Philips Res. Rep.*, vol. 2, pp. 468–474; December, 1947.
(116) D. Weighton, "Impulsive interference in amplitude-modulation receivers," *Jour. IEE*, vol. 95, Part III, pp. 69–79; March, 1948.
(117) P. G. Sulzer, "Noise generator for receiver measurements," *Electronics*, vol. 21, pp. 96–98; July, 1948.
(118) M. Allen, "Method for determining receiver noise figure," *Tele-Tech*, pp. 38–39, 77–78; January, 1948.

New types of phonograph pickups and circuit arrangements were described. New amplifier designs, especially adapted for use in radio-phonographs, were evolved. There was a definite tendency to include noise suppression circuits in such amplifiers, and a slight trend toward a return to triode output tubes for high-fidelity units of relatively low power.

(119) D. G. Fink, "Transcription recordings for the home," *Electronics*, vol. 21, pp. 86–87; September, 1948.
(120) B. P. Haines, "Lightweight pick-up design for microgroove record playing," presented, Rochester Fall Meeting, Rochester, N. Y., November 10, 1948.
(121) H. F. Olson and J. Preston, "Electron tube phonograph pick-up," *Audio Eng.*, vol. 32, pp. 17–20; August, 1948.
(122) J. F. Gordon, "A vacuum-tube-type transducer for use in the reproduction of lateral phonograph recordings," Proc. I.R.E., vol. 35, pp. 1571–1575; December, 1947.
(123) R. S. Burwen, "Feedback preamplifier for magnetic pick-ups," *Audio Eng.*, vol. 32, pp. 18–20; February, 1948.
(124) H. H. Scott and E. G. Dyett, Jr., "An amplifier and noise suppressor unit," *FM and Telev.*, vol. 8, pp. 28–30, 40–44; March, 1948.
(125) C. G. McProud, "High quality amplifier with the 6AS7G," *Audio Eng.*, vol. 32, pp. 21–24; March, 1948.
(126) C. G. McProud, "General purpose 6AS7G amplifier," *Audio Eng.*, vol. 32, pp. 24–29; June, 1948.

Circuits

Introduction

An excellent review of network theory was given by Dietzold at the AIEE Mid-Winter Convention in Pittsburgh, Pa., in January, 1948. This paper is a good introduction to modern work in network theory. The general field of circuits (including in this term network theory) appears to be undergoing concentrated study and expansion of a kind one senses when new and major stimuli have been injected in a well-recognized realm of study. The year 1948 was notable in this respect.

(127) R. L. Dietzold, "Network theory comes of age," *Elec. Eng.*, vol. 67, pp. 895–899; September, 1948.

Efficacy; Noise Studies

(a) *Communication Theory.* With the publication of Shannon's paper on communication theory and the extensive discussion of the work of Shannon, Wiener, Tuller, and others in the United States and abroad, the general subject of communication theory has become a field of renewed activity. Exchange of bandwidths for signal-to-noise ratios and the taking advantage of redundancy in communication indicate potential savings in spectrum or increases in efficiency which have heretofore not been realized. Further reference to this matter appears in the section of the present Review relating to Radio Wave Propagation—Noise.

Wiener, in his book, "Cybernetics," generalizes the field and speaks of the "essential unity of the set of problems centering about communication, control and statistical mechanics." This is a large area of knowledge to attempt to bring together with unifying principles. The Wiener approach is essentially statistical, and interestingly enough at least part of the impetus to the development came from a study of the problem of data smoothing or "smoothing of time series," a field which involves the application of networks for operation at frequencies of the order of 1 cps.

(128) N. Wiener, "Cybernetics," John Wiley & Sons, Inc., New York, N. Y., 1948.
(129) C. E. Shannon, "A mathematical theory of communication," *Bell. Sys. Tech. Jour.*, vol. 27, pp. 379–423; July, pp. 623–656; October, 1948.
(130) B. M. Oliver, J. R. Pierce, and C. E. Shannon, "The philosophy of PCM," Proc. I.R.E., vol. 36, pp. 1324–1331; November, 1948.
(131) "How rigid is the Hartley law?" *Tele-Tech*, vol. 7, pp. 52–53; January, 1948.

(b) *Noise and Distortion.* The general subject of noise and distortion, as dealt with in connection with over-all circuits, has already been touched on above in connection with communication theory. This is a subject which is of growing importance as indicated by the number and the quality of papers being presented in the field. It is a subject which, broadly, is joined with the theory of communication, although in its details it applies to particular elements of circuits.

(132) A. S. Gladwin, "The distortion of frequency-modulated waves by transmission networks," Proc. I.R.E., vol. 35, pp. 1436–1445; December, 1947.
(133) S. Goldman, "Frequency Analysis, Modulation and Noise," McGraw-Hill Book Co., New York, N. Y., 1948.
(134) W. Rae Young, Jr., "Interference between very-high-frequency radio communication circuits," Proc. I.R.E., vol. 36, pp. 923–930; July, 1948.
(135) F. L. H. M. Stumpers, "Distortion of FM signal on passage through an electrical network," *Tijdschr. Ned. Radiogenoot.*, vol. 13, pp. 1–21; January, 1948.
(136) H. Wallman, A. B. Macnee, and C. P. Gadsden, "A low-noise amplifier," Proc. I.R.E., vol. 36, pp. 700–708; June, 1948.
(137) I. Pollack, "Effects of high pass and low pass filtering on the intelligibility of speech in noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 259–266; May, 1948.
(138) J. C. R. Licklider and I. Pollack, "Effects of differentiation, integration, and infinite peak clipping upon the intelligibility of speech," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 42–41; January, 1948.
(139) F. L. H. M. Stumpers, "Theory of frequency-modulation noise," Proc. I.R.E., vol. 36, pp. 1081–1092; September, 1948.
(140) S. O. Rice, "Statistical properties of a sine wave plus random noise," *Bell Sys. Tech. Jour.*, vol. 27, pp. 109–157; January, 1948.
(141) J. R. Pierce, "Noise in resistances and electron streams," *Bell Sys. Tech. Jour.*, vol. 27, pp. 158–174; January, 1948.

General Linear Circuits with Constant Parameters

(a) *Passive, Lumped-Constant Parameters.* The synthesis of passive networks of prescribed phase and amplitude characteristics has been advanced by a number of studies.

(142) E. A. Guillemin, "Network synthesis and servomechanism design," presented, AIEE Midwinter 1948 Technical Meeting Pittsburgh, Pa., January, 1948.
(143) R. F. Baum, "A contribution to the approximation problem," Proc. I.R.E., vol. 36, pp. 863–869; July, 1948.
(144) R. M. Fano, "A note on the solution of certain approximation problems in network synthesis," MIT, Research Laboratory of Electronics, Technical Report No. 62; April, 1948.
(145) R. M. Redheffer, "Design of a circuit to approximate a prescribed amplitude and phase," MIT, Research Laboratory of Electronics, Technical Report No. 54; November, 1947.
(146) D. E. Thomas, "Tables of phase associated with a semi-infinite unit slope of attenuation," *Bell Sys. Tech. Jour.*, vol. 26, pp. 870–899; October, 1947.
(147) F. M. Fano, "Theoretical limitations on the broadband matching of arbitrary impedances," MIT, Research Laboratory of Electronics, Technical Report No. 41; January, 1948.
(148) W. H. Huggins, "A note on frequency transformations for use with the electrolytic tank," Proc. I.R.E., vol. 36, pp. 421–424; March, 1948.
(149) F. C. Isely, "A new approach to tunable resonant circuits for the 300- to 3000-Mc frequency range," Proc. I.R.E., vol. 36, pp. 1017–1022; August, 1948.
(150) S. Chang, "Parabolic loci for two tuned coupled circuits," Proc. I.R.E., vol. 36, pp. 1384–1388; November, 1948.
(151) J. Rybner, "Circle diagrams of impedance or admittance for four-terminal networks," *Jour. IEE* (London), vol. 95, pt. III, pp. 243–252; July, 1948.
(152) M. P. Givens, "Note on the parallel-T network," *Rev. Sci. Instr.*, vol. 18, p. 802; October, 1947.
(153) H. S. McGaughan, "Variation of an RC parallel-T null network," *Tele-Tech*, vol. 6, pp. 48–51, 95; August, 1947.
(154) C. Kafian, "On a remarkable property of the bridged-T line and its application to the calculation of the powers distributed in the branches of this line," *Radio Franc.*, pp. 18–20 and 11–14; March and April, 1948.
(155) D. G. C. Luck, "Properties of some wide-band phase-splitting networks," presented, 1948 IRE National Convention, March 22, 1948, New York, N. Y.
(156) M. S. Wong, "Impedance measurement through an arbitrary network," presented, URSI-IRE Fall Meeting, Washington, D. C., October, 1948.
(157) B. Salzberg and G. S. Kan, "Rapid measurement of admittance at radio frequencies," presented, URSI-IRE Fall Meeting, Washington, D. C., 1948.
(158) L. Tasny-Tschiassny, "Network analysis by the chain-relaxation method," *Jour. IEE* (London), vol. 95, pt. III, pp. 177–182; May, 1948.
(159) R. V. Southwell, "Relaxation Methods in Theoretical Physics," Oxford, Clarendon Press, 1946.
(160) R. E. Vowels, "Matrix methods in the solution of ladder networks," *Jour. IEE* (London), vol. 95, pt. III, pp. 40–49; January, 1948.
(161) A. W. Glazier, "Transient response of symmetrical 4-terminal networks," *Wireless Eng.*, vol. 25, pp. 11–20, January, 1948.
(162) W. J. Frantz, "The transmission of a frequency-modulated wave through a network," Proc. I.R.E., vol. 34, pp. 114P–125P; March, 1946.
(163) A. S. Gladwin, "The distortion of frequency-modulated waves by transmission networks," Proc. I.R.E., vol. 35, pp. 1436–1445; December, 1947.
(164) M. S. Corrington, "Variation of bandwidth with modulation index in frequency modulation," Proc. I.R.E., vol. 35, pp. 1013–1020; October, 1947.
(165) A. G. Clavier, "Application of Fourier transforms to variable frequency circuit analysis," presented, URSI-IRE Fall Meeting, Washington, D. C., October, 1948.

(b) *Active.* An active network as considered here is one in which operation is linear and in which tubes and devices other than the usual resistors, inductors, and capacitors appear. In this field the general problem of broad-band amplification has been so advanced that an editorial in one of the trade magazines refers to progress as having produced results ahead of demand. In general, the idea, introduced by Percival and since used as a basis by others, of "distributed amplification" has led to the development of broad-band amplifiers which may have bandwidths of the order of 200 Mc. When one considers that during World War II contracts were made for the development of amplifiers to go up to approximately 10 Mc, the extent of the further advances in this aspect of network theory can be appreciated.

In connection with active circuits, a fact which is gradually being appreciated is that, so long as linear operation is followed, an electron tube represents a circuit element in much the same sense as a resistor or inductor or capacitor. The theory of linear active networks has been well started and, while it would be incorrect to say that it has been developed to the extent of passive-network theory, nevertheless the theory of active networks constitutes a well-defined and well-started section of network theory.

(166) E. L. Ginzton, W. R. Hewlett, J. H. Jasberg, and J. D. Noe, "Distributed amplification," Proc. I.R.E., vol. 36, pp. 956–969; August, 1948.
(167) M. J. Di Toro, "Phase and amplitude distortion in linear networks," Proc. I.R.E., vol. 36, pp. 24–36; January, 1948.
(168) E. F. Grant, "Time response of an amplifier of *N* identical stages," Proc. I.R.E., vol. 36, pp. 870–871; July, 1948.

(169) J. H. Mulligan, Jr., and L. Mautner, "The steady-state and transient analysis of a feedback video amplifier," Proc. I.R.E., vol. 36, pp. 595–610; May, 1948.
(170) W. C. Elmore, "The transient response of damped linear networks with particular regard to wideband amplifiers," *Jour. Appl. Phys.*, vol. 19, pp. 55–63; January, 1948.
(171) L. C. Peterson, "Equivalent circuits of linear active four-terminal networks," *Bell. Sys. Tech. Jour.*, vol. 27, pp. 593–622; October, 1948.
(172) J. S. Brown and F. D. Bennett, "The application of matrices to vacuum-tube circuits," Proc. I.R.E., vol. 36, pp. 844–852; July, 1948.
(173) G. E. Valley, Jr., and H. Wallman, "Vacuum Tube Amplifiers," MIT Radiation Laboratory Series, no. 18, McGraw-Hill Book Co., New York, N. Y., 1948.
(174) L. B. Arguimbau, "Vacuum-Tube Circuits," John Wiley & Sons, New York, N. Y., 1948.
(175) H. E. Harris, "A simplified negative-resistance-type Q multiplier," presented, 1948 IRE National Convention, March 2, 1948, New York, N. Y.
(176) P. G. Sulzer, "Cathode-coupled negative-resistance circuit," Proc. I.R.E., vol. 36, pp. 1034–1039; August, 1948.
(177) H. M. Zeidler and J. D. Noe, "Pentriode amplifiers," Proc. I.R.E., vol. 36, pp. 1332–1338; November, 1948.

(c) *Passive, Distributed Parameters.* A few of the papers published in this field during the year are listed below:

(178) G. L. Ragan, "Microwave Transmission Circuits," McGraw-Hill Book Co., New York, N. Y., 1948.
(179) C. T. Tai, "High-frequency polyphase transmission line," Proc. I.R.E., vol. 36, pp. 1370–1375; November, 1948.
(180) D. M. Kerns, "The basis of the application of network equations to waveguide problems," National Bureau of Standards Report CRPL 9-5, June 30, 1948.
(181) P. I. Richards, "Resistor-transmission-line circuits." Proc. I.R.E., vol. 36, pp. 217–220; February, 1948.
(182) M. Cerrillo, "Transient phenomena in waveguides," MIT Research Laboratory of Electronics, Technical Report No. 33, January, 1948.
(183) S. O. Rice, "Reflections from circular bends in rectangular wave guides-matrix theory," *Bell Sys. Tech. Jour.*, vol. 27, pp. 305–349; April, 1948.
(184) R. M. Whitmar, "Fields in nonmetallic waveguides," Proc. I.R.E., vol. 36, pp. 1105–1109; September, 1948.
(185) N. Marcuvitz, "On the representation and measurement of waveguide discontinuities," Proc. I.R.E., vol. 36, pp. 728–735; June, 1948.
(186) A. F. Pomeroy, "Precision measurement of impedance mismatches in waveguide," *Bell Sys. Tech. Jour.*, vol. 26, pp. 446–459; July, 1947.
(187) A. F. Stevenson, "Theory of slots in rectangular waveguides," *Jour. Appl. Phys.*, vol. 19, pp. 24–38; January, 1948.

Parameters Not Constant

(a) *Linear, Varying Parameters.* Varying-parameter circuits have received more than usual study. One specific application is in superregenerators, in which the basic circuit is often considered as a simple parallel circuit of L, C, and G, with the G varying as a function of the time. Four papers on superregenerators were presented at the 1948 IRE National Convention.

Other linear varying-parameter circuits which have been studied include those containing varying capacitance and varying inductance or the equivalent. Many of the circuits are associated with FM.

(188) E. Cambi, "Trigonometric components of a frequency-modulated wave," Proc. I.R.E., vol. 36, pp. 42–49; January, 1948.
(189) E. M. Williams and L. Vallese, "Wide-deviation frequency-modulated oscillators," Proc. I.R.E., vol. 36, pp. 1282–1284; October, 1948.
(190) S. Chang, "External and internal characteristics of a separately quenched superregenerative circuit," presented, 1948 IRE National Convention, New York, N. Y., March 23, 1948.
(191) H. Stockman, "Superregenerative circuit applications," *Electronics*, vol. 21, pp. 81–83; February, 1948.

(b) *Nonlinear Circuits.* The many aspects of nonlinear circuits which appear in modulation, detection, and distortion studies, etc., have received the usual attention during the year. Aside from a few generalities, such as the small-signal series, and the approximation by straight lines of nonlinear characteristics, the field appears to be one in which general laws are missing and sundry problems are treated on an individual basis.

(192) N. Minorsky, "Introduction to Nonlinear Mechanics," J. W. Edwards, Ann Arbor, Mich., 1947.

Certain Conventional Units

(a) *Oscillators.* Each year oscillators receive extensive study. The past year was no exception, and the references indicate in a general way the extent and character of these studies. Particularly noteworthy was the work which was done with *RC* feedback networks for oscillator frequency control or servosystem stabilization.

(193) O. A. Tkhorzhevski and B. K. Shembel, "The synchronization (pulling in) of a valve oscillator by a harmonic of the fundamental frequency," *Zh. Teck. Fiz.*, vol. 17, no. 2, pp. 215–230; 1947.
(194) R. D. Huntoon and A. Weiss, "Synchronization of oscillators," Proc. I.R.E., vol. 35, pp. 1415–1423; December, 1947.
(195) P. Aigrain and E. M. Williams, "Theory of amplitude-stabilized oscillators," *Onde Elec.*, vol. 27, pp. 385–391; October, 1947.
(196) J. Dieutegard, "Autostabilized oscillator," *Toute la Radio*, vol. 14, pp. 16–21; December, 1947.
(197) K. F. Teodorchik, "On the theory of the blocking oscillator," *Zh. Teck. Fiz.*, vol. 17, no. 4, pp. 435–438; 1947.
(198) R. Benjamin, "Blocking oscillators," *Jour. IEE* (London), vol. 93, pt. III A, no. 7, pp. 1159–1175; 1946.
(199) P. G. M. Dawe, "The resistance-capacitance oscillator," *Engineering* (London) vol. 164, pp. 429–432; October 31, 1947.
(200) A. Sobczyk, "Stabilization of carrier-frequency servomechanisms: I. Gain phase margin diagrams of controller characteristics, II. Design formulae for proportional derivative networks, III. Methods of obtaining required carrier phase-shift," *Jour. Frank. Inst.*, vol. 246, pp. 21–43; July, pp. 95–121; August, pp. 187–213; September, 1948.
(201) K. F. Teodorchik, "The theory of ladder-type *RC* oscillators," *Zh. Teck. Fiz.*, vol. 17, no. 4, pp. 439–442; 1947.
(202) G. E. White and M. Relson, "Alternating current rate circuits," U. S. Patent No. 2,446,567, August 10, 1948.
(203) G. Willoner and F. Tihelka, "A phase-shift oscillator with wide-range tuning," Proc. I.R.E., vol. 36, pp. 1096–1100, September, 1948.

(b) *Filters.* The most extensive work on filters was in the projection of filters into the microwave range. This was done primarily by the use of coaxial lines and waveguides as circuit elements.

(204) W. D. Lewis and L. C. Tillotson, "A non-reflecting branching filter for microwaves," *Bell Sys. Tech. Jour.*, vol. 27, pp. 83–95; January, 1948.
(205) W. W. Mumford, "Maximally-flat filters in waveguide," *Bell Sys. Tech. Jour.*, vol. 27, pp. 684–713; October, 1948.
(206) C. W. Oatley and C. M. Burrell, "Ultra-high frequency filters," *Jour. IEE* (London), vol. 93, pt. III A, no. 8, pp. 1338–1342; 1946.
(207) D. E. Mode, "Low-pass filters using coaxial transmission lines as elements," Proc. I.R.E., vol. 36, pp. 1376–1383; November, 1948.
(208) C. L. Cuccia and H. R. Hegbar, "An ultra-high-frequency low-pass filter of coaxial construction," *RCA Rev.*, vol. 8, pp. 743–750; December, 1947.
(209) A. M. Stone and J. L. Lawson, "Infinite-rejection filters," *Jour. Appl. Phys.*, vol. 18, pp. 691–703; August, 1947.
(210) P. E. Krasnushkin, "Normal waves in multipolar ladder filters," *Zh. Tech. Fiz.*, vol. 17, no. 6, pp. 705–722; 1947.
(211) V. Belevitch, "Extension of Norton's method of impedance transformation to band-pass filters," *Elec. Commun.*, vol. 24, pp. 59–65; March, 1947.
(212) M. Levy, "Study of the properties of quadripoles by impulse response. General method for the realization of electric filters. Filters with linear or 90° phase shift," *L'Onde Elec.*, vol. 27, pp. 261–275; July, 1947.
(213) J. F. Klinkhamer, "Empirical determination of wave filter

transfer functions with specified properties," *Philips Res. Rep.* 3, pp. 60–80; February, 1948.

(c) *Magnetic Amplifiers.* This topic is included here ecause of the amount of work which was done in this eld, and because it is now at a state where the devices re in rather extensive practical use.

214) A. S. Fitzgerald, "Magnetic amplifier circuits; neutral type," *Jour. Frank. Inst.*, vol. 244, pp. 249–265; October, 1947.
215) A. S. Fitzgerald, "Some notes on the design of magnetic amplifiers," *Jour. Frank. Inst.*, vol. 244, pp. 323–362; November, 1947.
216) H. B. Rex, "The transductor (or magnetic amplifier)," *Instruments*, vol. 20, pp. 1102–1109; December, 1947.

New Elements

(a) *Delay Lines.* Electric delay lines have been well :nown for some time; acoustic delay lines for electric mpressed signals have been in use for and received exensive development during World War II.

217) J. P. Blewett and J. H. Rubel, "Video delay lines," Proc. I.R.E., vol. 35, pp. 1580–1584; December, 1947.
218) H. B. Huntington, A. G. Emslie, and V. W. Hughes, "Ultrasonic delay lines, Part I," *Jour. Frank. Inst.*, vol. 245, pp. 1–24; January, 1948.
219) A. G. Emslie, H. B. Huntington, H. Shapiro, and A. E. Benfield, "Ultrasonic delay lines, Part II," *Jour. Frank. Inst.*, vol. 245, pp. 101–115; February, 1948.
220) D. L. Arenberg, "Ultrasonic solid delay lines," *Jour. Acous. Amer. Soc.*, vol. 20, pp. 1–26; January, 1948.

(b) *Traveling-Wave Tubes.* A traveling-wave tube :omprises a new circuit element which has been under study for several years. The references given in the sec:ion of this Review on Electron Tubes report the con:inuation of these studies.

(c) *Lens and Other New Types of Antennas.* Lens an:ennas and certain other types of antennas constitute new circuit elements to which further reference is made in the section of this Review on Antennas.

(d) *Semiconductors.* A new amplifying device termed a transistor is described in the section of this Review on Solid-State Devices.

Components and Construction

Both in an extensive article in the Proceedings of the I.R.E. and in a separate publication of the National Bureau of Standards, printed circuits have been extensively discussed. The manufacture of components, as well as the joining of units and printing of metallic parts, is a development which has occurred over recent years and which has promise of much wider application in the future.

(221) C. Brunetti and R. C. Curtis, "Printed-circuit techniques," Proc. I.R.E., vol. 36, pp. 121–161; January, 1948.
(222) National Bureau of Standards, "New advances in printed circuits," Miscellaneous Publication 192.
(223) A. F. Murray, "Present status of printed circuit technics," *Tele-Tech*, vol. 6, pp. 29–33, December, 1947.
(224) C. I. Bradford, B. L. Weller, and S. A. McNeight, "Printed vitreous enamel components," *Electronics*, vol. 20, pp. 106–108; December, 1947.

Aids to Circuit Analysis

An interesting development is that of equivalent circuits for the representation of rather unusual operations by equivalent electric networks. For example, in the design of a particular control mechanism, one company has been using an electric circuit which represents the equivalent of the action of a door in a furnace. It appears that there is a broad field in application of this type of work which is just beginning to develop.

(225) G. A. Philbrick, "Designing industrial controllers by analog," *Electronics*, vol. 21, pp. 108–111; June, 1948.

Quality Control

During the year 1948 there was considerable activity in the field of general quality control and in the application of associated statistical techniques to industrial problems, including those associated with the radio and electronic arts.

Although it first might appear that quality control is more of a production problem than it is of an engineering problem, some reflection would indicate, perhaps, that just the opposite is true. Quality of product is dependent upon several factors, not the least being the ease with which control may be administered during production.

Quality control during production, in turn, is also dependent upon several factors, one of the more important of which might be termed "quality of design." An important phase of the broader picture, therefore, is the use of statistical methods in the design and development of electronic subassemblies, products, and systems. Here a knowledge of statistical techniques can be used to definite advantage. Many of these are similar to the techniques employed in industrial quality control, and all have a common origin in the mathematical theory of probability. Assume, for example, that an engineer attempts to design a small product, such as a radio tube, or a large electronic system, such as a complete operating network. In both instances, many individual parts or components are required. Each has its tolerances which vary in accordance with some statistical distribution.

It seems opportune for the Institute to take a broad and active interest in the general subject of quality control, with the realization, perhaps, that an understanding by the members of its possibilities, and an official acknowledgment by the Institute of its sponsorship, will assist materially in making our future electronics world a better place in which to live.

(226) L. S. Schwartz, "Statistical methods in the design and development of electronic systems," Proc. I.R.E., vol. 36, pp. 664–670; May, 1948.
(227) F. R. Del Priore and B. B. Day, "An application of a simple technique in curve fitting of certain types of data," *The Instrument Maker*; September–October, 1948.
(228) B. A. Griffith, A. E. R. Westman, and B. H. Lloyd, "Analysis of variance," *Industrial Quality Control*, vol. IV, pp. 20–25; March, 1948; vol. IV, pp. 13–22; May, 1948.
(229) E. G. Olds and F. S. Acton, "Mathematics for engineers—I," *Elec. Eng.*, vol. 67, pp. 988–993; October, 1948.
(230) "New statistical method of predicting sunspots aids radio propagation forecasts," *Jour. Frank. Inst.*, vol. 244 (6), pp. 481–487; December, 1948.
(231) "Electron tubes for instrumentation and industrial use," AIEE Proceedings of the Conference on Electron Tubes, Philadelphia, Pa.; March 29–30, 1948.
(232) S. S. Wilks, "Statistical training for industry," *Analytical Chem.*, vol. 19, pp. 953–955; December, 1947.

Audio Techniques

The year 1948 was a significant one for audio and video engineers. For the first time in the history of IRE, a technical committee on Audio and Video Techniques was established, thus recognizing these allied fields in their own right instead of as adjuncts to other branches of the art. Under the new IRE Professional Group System, the first to be organized and approved was the Audio Group. Officially established on June 2, 1948, it has for its scope of interest the "technology of communication at audio frequencies and the audio-frequency portion of radio systems." At a meeting held in New York, N.Y., on February 17, 1948, the Audio Engineering Society was organized, and on April 13, the Society formally adopted its constitution and by-laws. Later in the year a section was formed in San Francisco, Calif.

(233) "The IRE Professional Group System—A Status Report," Proc. I.R.E., vol. 36, p. 1507; December, 1948.

Audio Techniques

In the field of audio systems no developments of major significance were reported. Work was concentrated on improving existing equipment and designing new facilities along lines well established within the industry. Several papers reported on modern facilities for broadcast and sound-reinforcement services. The systems described reflected the ultimate refinement in modern design, combining excellence of performance, ease of operation, and maintenance with pleasing functional appearance.

(234) R. B. Monroe and C. A. Palmquist, "Modern design features of CBS studio audio facilities," Proc. I.R.E., vol. 36, pp. 778–786; June, 1948.
(235) M. Rettinger and S. M. Stevens, "Sound reinforcement in the Hollywood Bowl," *Audio Eng.*, vol. 32, pp. 15–17, 42; February, 1948.
(236) C. E. Talley and R. W. Kautsky, "A modern sound reinforcement system for theatres," *Jour. Soc. Mot. Pic. Eng.*, vol. 50, pp. 149–161; February, 1948.
(237) E. Julsrud and G. Weider, "Speech-input equipment for new Oslo broadcasting house," *Elec. Commun.*, vol. 25, pp. 21–29; March, 1948.

Further studies were made during the year to determine the tonal-range preferences of radio-broadcast listeners. A report was made on an extensive series of experiments aimed at ascertaining the listener's preferences when the reproducing system is compensated for the change in the response of the ear with loudness level. The results of the study were consistent with those of previous similar tests. Based on single-channel listening using present-day program pickup techniques, the principal conclusions were that most listeners do not prefer a wide range, whether or not the system is compensated. Most listeners dislike an excess of high frequencies in music, dislike sibilance in speech, but like to have bass frequencies included. The reasons for the preferences exhibited in this and other tests are not yet entirely clear, since it is not certain that they can safely be ascribed to residual distortions in the reproducing system.

(238) H. A. Chinn and P. Eisenberg, "Influence of reproducing system on tonal range preferences," Proc. I.R.E., vol. 36, pp. 572–580; May, 1948.

Continued progress was noted in the field of audio-frequency measurements. Indicative of a growing trend was the attention given to audio-frequency transient phenomena and to phase distortion in audio systems. Methods of analysis and test gear were described for measuring and evaluating the transient responses of audio facilities and components. An analysis was made of the effects upon the ear of phase distortion in audio systems and its relation to the apparent deterioration of the reproduced sound. The intermodulation method of distortion measurement continued to receive attention during the year. New and somewhat more versatile intermodulation-measuring instruments appeared on the market. The relationships between the results obtained by the intermodulation method and those of harmonic measurement were analyzed.

(239) S. Saboroff, "Technique for distortion analysis," *Electronics*, vol. 21, pp. 114–117; June, 1948.
(240) W. J. Warren and W. R. Hewlett, "An analysis of the intermodulation method of distortion measurement," Proc. I.R.E., vol. 36, pp. 457–466; April, 1948.
(241) G. W. Read and R. R. Scoville, "An improved inter-modulation measuring system," *Jour. Soc. Mot. Pic. Eng.*, vol. 50, pp. 162–173; February, 1948.
(242) D. E. Maxwell, "CBS transmission measuring set," *Audio Eng.*, vol. 32, pp. 16–19, 43; April, 1948.

Disk Recording and Reproduction

An outstanding event in the field of disk recording and reproduction was the presentation of a long-playing (LP) phonograph record for the home market. A six-fold increase in recording time per disk was obtained by reducing the turntable speed to $33\frac{1}{3}$ rpm, and by cutting grooves of extremely fine pitch with a stylus of small tip radius. The increased time, which is as much as 22 minutes per disk side, makes it possible to accommodate the average symphony or concerto on a single disk, with attendant savings in weight and storage space.

Playback requires a small stylus tip and, in addition, a pickup of low mechanical impedance, in order to obtain proper tracking with a vertical force low enough to insure good record life. The use of vinylite for the pressings, together with the lightweight pickup, permit a highly acceptable noise level to be achieved while maintaining a dynamic range in the order of 45 db. Special precautions in the design of the turntable driving mechanism are required to guard against excessive wow.

The LP record is of particular interest because it represents a wide departure from the practice which has so long been associated with the home-phonograph field. The development has been based on the assumption that the art has progressed to the point where a new approach to recording is justified, and where it is no longer necessary to use a record designed to produce sound directly. The rapidity with which suitable pickups and turntable equipment have been developed commercially during the year appears to verify the assumption.

(243) C. G. McProud, "Columbia LP microgroove records," *Audio Eng.*, vol. 32, pp. 24, 32; August, 1948.

Progress was reported in the development and refinement of methods of calibrating frequency records. A light-pattern meter was developed which obviates the need of a dark room for measurement of the useful "Christmas-tree pattern." The meter provides an accurate, portable, and time-saving device for the otherwise tedious job of light-pattern measurement.

(244) R. E. Santo, "The light-pattern meter," Proc. I.R.E., vol. 36, pp. 1431–1433; November, 1948.

The problem of the measurement of variation in the instantaneous speed of turntables, commonly called wow, received attention, and commercial meters for this measurement were developed. In addition, new mechanical vibrators were devised for the direct testing of phonograph pickups.

(245) E. W. Pappenfus and G. L. Sansbury, "Wow meter for turntable testing," *Electronics*, vol. 21, pp. 108–111; March, 1948.
(246) U. R. Furst, "Measuring wow," *FM and Telev.*, vol. 8, pp. 30, 50; May, 1948.
(247) H. A. Pearson, R. W. Carlisle, and H. Cravis, "Vibrators for measurement of response and compliance of phonograph pickups," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 830–833; November, 1948.

Continued interest was shown in noise suppressors for record reproduction.

(248) H. F. Olson, "Audio noise reduction system," *Jour. Acous. Soc. Amer.*, vol. 20, p. 222; March, 1948 (Summary only).
(249) C. D. Cole. "Experimental noise suppressor," *Audio Eng.*, vol. 32, pp. 9–12; January, 1948.
(250) S. L. Price, "Balanced clipper noise suppressor," *Audio Eng.*, vol. 32, pp. 13–16, 37; March, 1948.

Magnetic Recording and Reproduction

Magnetic-wire recorders for home use were produced in considerable numbers during 1948. These instruments employed essentially the same design features as were used in models of the previous year. The ever-increasing application of magnetic-tape recorders has brought about many constructional improvements which greatly simplify the operation of these units. During the latter part of 1948, tape recorders were commercially introduced, using two sound tracks, side by side on ¼-inch-wide tape. One-half hour can be recorded while the tape moves in one direction, and another half hour while the tape returns to the beginning of the first recording.

Particular emphasis was laid, in 1948, by various manufacturers, on the development of tape recorders for transcription use. Instruments were made available which cover a frequency range from 30 to 15,000 cps with a signal-to-noise ratio in the order of 60 db and with less than 2 per cent harmonic distortion.

Magnetic recording gained considerable ground in the motion-picture industry. Many optical recorders were provided with attachments for magnetic sound recording. Perforated magnetically coated tape was manufactured in limited quantities.

Because of the increasing importance of magnetic-tape recording, considerable efforts were made by the industry to produce tapes which would provide, for any given set of operating conditions, a better frequency response, with less noise and distortion. Research activities along these lines are continuing.

(251) S. J. Begun, "Magnetic field distribution of a ring recording head," *Audio Eng.*, vol. 32, pp. 11–13, 39; December, 1948.
(252) W. W. Wetzel, "Review of the present status of magnetic recording theory, Part I," *Audio Eng.*, vol. 31, pp. 14–17, 39; November, 1947.
(253) W. W. Wetzel, "Review of the present status of magnetic recording theory, Part II," *Audio Eng.*, vol. 31, pp. 12–16, 37; December, 1947.
(254) W. W. Wetzel, "Review of the present status of magnetic recording theory, Part III," *Audio Eng.*, vol. 32, pp. 26–30, 46–47; January, 1948.
(255) R. E. Zenner and R. B. Vaile, Jr., "Two channel two-way-drive magnetic recorder," *Audio Eng.*, vol. 32, pp. 11–15; April 1948.
(256) "Electron optical schlieren effect," *Tech. News Bull., Nat. Bur. Stand.*, vol. 32, pp. 82–84; July, 1948.

Electroacoustics

The amount of material published in the field of acoustics probably reached an all-time high in 1948.

A considerable number of papers were published concerning radiation, directivity and diffraction from various diaphragms, resonators, sound concentrators, circular cones, etc. These solutions are useful in determining the acoustic behavior of devices having similar shapes. For instance, the "directivity index," which is defined as the ratio of the total acoustic power output of the radiator to the acoustic power output of a point source producing the same pressure at the same point on the axis, permits calculations to be made for all radiations in the same manner as for point sources. Only a limited number of these theoretical papers are listed here.

(257) H. Levine and J. Schwinger, "On the radiation of sound from an unflanged circular pipe," *Phys. Rev.*, vol. 73, pp. 383–406; February 15, 1948.
(258) J. B. Keller and H. B. Keller, "Reflection and transmission of sound by a spherical shell," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 310–313; May, 1948.
(259) F. M. Wiener, "Notes on sound diffraction by rigid circular cones," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 367–369; July, 1948.
(260) C. T. Molloy, "Calculation of the directivity index for various types of radiators," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 387–405; July, 1948.
(261) E. N. Fox, "Diffraction of sound pulses by an infinitely long strip," *Roy. Soc. Lond., Phil. Trans.*, vol. 241, series A, pp. 71–103; June 22, 1948.

The calibration and measurement of sound was discussed in two papers.

(262) F. V. Hunt and A. E. Benfield, "Method for a precise measurement of the velocity of sound," *Amer. Jour. Phys.*, vol. 15, pp. 465–467; November-December, 1947.
(263) J. Hartmann and T. Mortensen, "Comparison of the Rayleigh disk and the acoustic radiometer methods for the measurement of sound-wave energy," *Phil. Mag.*, vol. 39, pp. 377–394; May, 1948.

The field of ultrasonics was studied in its various phases, and measuring equipment covering this frequency range was described. In the design of such equipment, the elimination of diffraction errors was found to be an important consideration. This led to the use of extremely small probes. In addition, the reciprocity method of calibration was extended to this frequency range, and also to the measurement of vibrations. An electromechanical reciprocity calibration theory, analogous to that of MacLean for extended media, was developed and supplied in the mechanical design of vibration pickups.

The propagation of ultrasonic sound in various media, especially in liquid helium II, and in mercury, has been studied. Mercury has found an important application for delay lines, which have to cover a wide frequency range, such as is required for the transmission of a pulse; for a liquid having a high mechanical impedance permits a wider frequency band to be generated by a quartz crystal.

In regard to the biological and psychological effects of ultrasonics, it was shown that ultrasonic and also sonic waves of high intensity may produce discomfort and even injury, but that these effects were associated more with the high intensity than with any particular frequency range. It is, of course, in general easier to concentrate ultrasonic frequencies in narrow beams having very high intensity than audio frequencies.

(264) J. R. Pellam and C. F. Squire, "Ultrasonic velocity and absorption in liquid helium," *Phys. Rev.*, vol. 72, pp. 1245–1252; December 15, 1947.
(265) C. H. Allen, H. Frings and L. Rudnick, "Some biological effects of intense high frequency airborne sound," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 62–65; January, 1948.
(266) H. B. Huntington, A. C. Emslie, and V. W. Hughes, "Ultrasonic delay lines," *Jour. Frank. Inst.*, vol. 245, pp. 1–23; January, 1948.
(267) H. J. McSkimin, "Theoretical analysis of the mercury delay line," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 418–424; July, 1948.
(268) J. K. Galt, "Sound absorption and velocity in liquefied argon, oxygen, nitrogen, and hydrogen," *Jour. Chem. Phys.*, vol. 16, pp. 505–507; May, 1948.
(269) F. Massa, "Sound pressure measurement equipment for the range 50 cycles to 250 kc," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 451–454; July, 1948.
(270) S. P. Thompson, "Reciprocity calibration of primary vibration standards," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 637–640; September, 1948.

Measurements were made of the distribution of the average power in various speech sounds. The effect on intelligibility of eliminating either the high-frequency speech sounds or the low-frequency speech sounds was explored, and the relative contributions of the various speech frequencies were determined. Further information was obtained on the effect of noise, especially of repeated short bursts of noise which had application in some war work.

(271) G. A. Miller and W. G. Taylor, "Preception of repeated bursts of noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 171–182; March, 1948.
(272) I. Pollack, "Effects of high pass and low pass filtering on the intelligibility of speech in noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 259–266; May, 1948.
(273) H. W. Rudmose, K. C. Clara, F. D. Carlson, J. C. Eisenstein, and R. W. Walker, "Voice measurements with an audio spectrometer," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 503–512; July, 1948.

Further work was done on the visual presentation of speech. It was shown, for instance, that the movement of the major resonances in speech sounds may be represented by traces in a three-dimensional graph, and that a great deal can be learned about speech through investigation of such traces.

(274) G. A. Kopp and H. Green, "Visible speech," *Volta Rev.*, vol. 50, pp. 60–62; February, 1948.
(275) R. K. Potter and G. E. Peterson, "Representation of vowels and their movements," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 528–535; July, 1948.

A large amount of the acoustical literature was concerned with the subject of sound absorption, studio and auditorium acoustics, and related subjects. Further work was done in the fields of measuring technique, reverberation time, impact, sound transmission, and sound absorption. Acoustic materials were studied and data compiled as to their absorption characteristics. Studies of the acoustic requirements and the design of studios, auditoriums, and dead rooms for acoustic testing were published.

(276) P. J. Mills, "Construction and design of Parmly Sound Laboratory and anechoic chamber," *Jour. Acous. Soc. Amer.*, vol. 19, pp. 988–995; November, 1947.
(277) V. O. Knudsen, "Recent progress in architectural acoustics: Geometric and wave acoustics in the design of rooms," *Amer. Jour. Phys.*, vol. 15, pp. 437–446; November–December, 1947.
(278) W. Tak, "Measuring reverberation time by the method of exponentially increasing amplification," *Philips Tech. Rev.*, vol. 9, no. 12, pp. 371–378; 1947/1948.
(279) N. N. Wolpert, "Trapping sound in ventilating ducts," *Heating and Ventilating*, vol. 45, pp. 65–67; January, 1948.
(280) G. M. Nixon, "Acoustic problems in studio design," *Electronics*, vol. 21, pp. 86–89; May, 1948.
(281) P. E. Sabine and L. G. Ramer, "Absorption-frequency characteristics of plywood panels," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 267–270; May, 1948.
(282) C. M. Harris, "Acoustic impedance measurement of very porous screen," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 440–447; July, 1948.
(283) J. P. Maxfield, "Auditorium acoustics," *Jour. Soc. Mot. Pic. Eng.*, vol. 51, pp. 169–176; disc., pp. 176–183; August, 1948.
(284) R. K. Cook, "Behavior of acoustic materials," *Jour. Soc. Mot. Pic. Eng.*, vol. 51, pp. 192–202; August, 1948.

Effort in the design of hearing aids was in the direction of making them smaller and less conspicuous. Advantage was taken in this connection of recent development in subminiature tubes, small-size batteries, and printed circuits.

The measuring technique of hearing aids was further developed. The design objectives of hearing aids were experimentally explored by means of systematic articulation tests on a representative group of hard-of-hearing listeners.

(285) C. V. Hudgins and others, "Comparative performance of an experimental hearing aid and two commercial instruments," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 241–258; May, 1948.
(286) I. J. Hirsch, "Modern electronic hearing aid," *Hearing News*, vol. 16, pp. 1–2, 14, 16, 18, 20; January, 1948.
(287) "Hearing aid circuit printed on plastics base," *Plastics World*, vol. 6, p. 1; July, 1948.
(288) "Sub-miniature valves for hearing aids," *Engineer*, vol. 185, p. 145; February 6, 1948.

Further declassification of scientific war work made available to scientists many of the technical developments in the field of underwater sound. A large number of papers appeared on this subject in the technical literature covering theory, design, and application of underwater sound.

(289) E. L. Carstensen, "Self-reciprocity calibration of electracoustic transducer," *Jour. Acous. Soc. Amer.*, vol. 19, pp. 961–965; November, 1947.
(290) H. F. Olson, R. A. Hackley, A. R. Morgan, and J. Preston, "Underwater sound transducers," *RCA Rev.*, vol. 8, pp. 698–718; December, 1947.
(291) C. Eckart, "Vortices and streams caused by sound waves," *Phys. Rev.*, vol. 73, pp. 68–76; January 1, 1948.
(292) O. H. Shuck, "Standard lag line for phase measurement," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 26–39; January, 1948.

(293) C. F. Eyring, R. J. Christensen, and R. W. Raitt, "Reverberation in the sea," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 462–475; July, 1948.
(294) D. P. Loye, and W. F. Arndt, "A sheet of air bubbles as an acoustic screen for underwater noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 143–145; March, 1948.
(295) F. P. Bundy, "Characteristics of stepped-frequency transducer elements," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 297–304; May, 1948.
(296) E. Gerjuoy, "Refraction of waves from a point source into a medium of high velocity," *Phys. Rev.*, vol. 73, pp. 1442–1449; June 15, 1948.
(297) W. P. Mason and F. H. Hibbard, "Absorbing media for underwater sound measuring tanks and baffles," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 476–482; July, 1948.

Relatively little attention was paid to microphones and loudspeakers in the year 1948, in comparison with the large amount of material published on other phases of acoustics. It may well be that fundamental improvements in this field come slowly, and that work undertaken since the war has not yet reached the publication stage.

Electron Tubes

Small-Signal High-Vacuum Tubes

Receiving Tubes. The increasing use of electron tubes in relay systems, industrial applications, and electronic computers, where reliability requirements are as stringent as in commercial communications systems, was reflected in the literature of 1948. Much attention was given to the increase of the useful life of tubes, to the maintenance of their characteristics within close tolerances throughout their lives, and to the increase in resistance to mechanical shock and vibration. This work resulted in the registration with the Radio Manufacturers Association of a number of receiving tubes with high shock and vibration resistance, and with long life.

(298) I. Cherrick, "Rugged electron tubes," *Electronics*, vol. 21, pp. 111–113; April, 1948.
(299) G. Freedman, "Miniature resistance welding and its application in the radio tube industry," *The Welding Jour.*, vol. 27, pp. 838, 844; October, 1948.

The increasing importance of electron tubes in fields other than the communication field was indicated by the American Institute of Electrical Engineers, which sponsored a conference on electron tubes for instrumentation and industrial use in Philadelphia, Pa., on March 29 and 30, 1948. The conference was based on a report entitled "Report on Electron-Tube Survey of Instrument Manufacturers and Laboratories," prepared by the AIEE joint subcommittee on electronic instruments.

(300) "Digests of papers presented at Conference on Electron Tubes," *Elec. Eng.*, vol. 67, pp. 589–600; June, 1948.

Space-charge-grid tubes have long been known, but they have seen little practical use because the relatively large amount of current required by the space-charge grid has offset the possible advantages of the tube.

Comparisons of a new form of space-charge-grid output pentode with triodes and beam-power pentodes indicate that in some applications the sensitivity and low distortion of the new tube may make its use advantageous.

(301) N. Pickering, "Space-charge tetrode amplifiers," *Electronics*, vol. 21, pp. 96–99; March, 1948.

The performance of several types of receiving tubes in the radio-frequency circuits of television receivers was discussed, and data on the performance characteristics were presented.

(302) R. M. Cohan, "Radio-frequency performance of some receiving tubes in television circuits," *RCA Rev.*, vol. 9, pp. 136–148; March, 1948.
(303) G. Bartlett, "Electrical and allied developments," *Gen. Elec. Rev.*, vol. 51, p. 11; January, 1948.

Mechano-Electronic Transducers. The work on mechano-electronic transducers reported in the Annual Review for 1947 has resulted in the announcement of a transducer tube, RMA type 5734. Another tube for transforming mechanical movement into electrical signals, employing a movable grid, was described. An experimental model of this tube and its performance in an appropriate circuit were described in detail.

(304) J. F. Gordon, "A vacuum-tube-type transducer for use in the reproduction of lateral phonograph recordings," PROC. I.R.E., vol. 35, pp. 1571–1575; December, 1947.

Microwave Tubes. The volume of published material on the traveling-wave tube was considerably less than in 1947. The material which did appear was of a theoretical nature and dealt with the small-signal analysis of traveling-wave tubes in terms of practical design parameters, and the gain of tubes in which the rf field at the mean position of the beam is entirely transverse. It was shown that the addition of a longitudinal magnetic focusing field reduces the gain due to transverse fields, and increases the electron velocity required for maximum gain.

(305) C. Shulman and M. S. Heagy, "Small-signal analysis of the traveling-wave tube," *RCA Rev.*, vol. 8, pp. 585–611; December, 1947.
(306) J. R. Pierce, "Transverse fields in traveling-wave tubes," *Bell Sys. Tech. Jour.*, vol. 27, pp. 732–746; October, 1948.

A simple theory of the electronic frequency control of a reflex klystron was developed by which it is possible to calculate the frequency deviation over which the power output does not fall below a certain fraction of the power output at zero frequency deviation.

(307) B. Bleaney, "Electronic tuning of reflection klystrons," *Wireless Eng.*, vol. 25, pp. 6–11; January, 1948.
(308) J. O. McNally and W. G. Shepherd, "Reflex oscillators for reflex systems," PROC. I.R.E., vol. 35, pp. 1424–1435; December, 1947.

Electron-Tube Theory. A new approach to the theory of space-charge flow appeared. The salient feature of this theory is that it takes account of the effect of the random motions of the electrons on the mass flow by including the hydrostatic pressure of the electrons in the force equation. As a result, the theory yields the usual temperature-limited-emission formula for maximum current, the space-charge-limited characteristic, and the transition region from one to the other, in a unified form.

(309) W. C. Hahn, "Effects of hydrostatic pressure on electron flow in diodes," PROC. I.R.E., vol. 36, pp. 1115–1121; September, 1948.

The theory of the effects of space charge in the grid-anode regions of electron tubes of plane geometry received further experimental confirmation. The theory was also extended to the case of cylindrical geometry, and quantitative solutions were obtained for several ratios of electrode diameters.

(310) G. W. Wood, "Positive-grid characteristics of a triode," Proc. I.R.E., vol. 36, pp. 804–808; June, 1948.
(311) A. van der Ziel, "The virtual cathode problem for cylindrical electrodes," *Appl. Sci. Res.*, vol. B1, pp. 105–118; 1948.

The theory of the current distribution in positive-grid triodes, neglecting space charge and the initial velocities of both primary and secondary electrons, was compared with experimental results, and fair agreement was found.

(312) H. C. Hamaker, "Current distribution in triodes, neglecting space charge and initial velocities," *Appl. Sci. Res.*, vol. B1, pp. 77–104; 1948.

A theory of the resistance of a rectifier as a function of applied voltage was developed, and it was shown that the resistance may be represented by a constant plus an exponential function of the applied voltage. By an adjustment of the three available parameters, this formula can be made to fit the behavior of diode, cuprous-oxide, selenium, silicon, and germanium rectifiers.

(313) D. G. Tucker, "Rectifier resistance laws," *Wireless Eng.*, vol. 25, pp. 117–128; April, 1948.

Thermionic and Secondary Emission. An empirical equation was found to apply to the thermionic emission of oxide-coated chemically dissimilar wires. Experimental data on the sparking potentials of barium, magnesium, and aluminum cathodes in inert gases show that the nature of the cathode material is important in determining the magnitude of the sparking potential.

(314) H. Jacobs, G. Hees, and W. P. Crossley, "The relationship between the emission constant and the apparent work function for various oxide-coated cathodes," Proc. I.R.E., vol. 36, pp. 1109–1114; September, 1948.
(315) H. Jacobs and A. P. LaRoque, "The role of the cathode surface in sparking phenomena," *Phys. Rev.*, vol. 74, pp. 163–165; July 15, 1948.

The secondary-electron yield of barium-strontium oxide as induced by microsecond pulses of primary electrons was studied. The secondary-to-primary ratio versus primary energy curves have the usual form and show a maximum near 1,200 electron volts. At room temperature, the maximum ratio is of the order of 12, but it may be reduced to 6 by less than 0.1 atomic layer of barium obtained by evaporation from an adjacent thermionic cathode.

(316) J. B. Johnson, "Secondary electron emission from targets of barium-strontium oxide," *Phys. Rev.*, vol. 73, pp. 1058–1073; May 1, 1948.

Secondary emission was the subject of a survey paper which discussed the factors influencing yield and distribution, methods of measurement, and the application of secondary emission in electronic devices.

(317) L. R. Koller, "Secondary emission," *Gen. Elec. Rev.*, Part I, vol. 51, pp. 33–34, April, 1948; Part II, vol. 51, pp. 50–52; June, 1948.

Noise and Microphonism. A brief discussion of the theoretical foundations of the various noise formulas was published, and included noise in resistances, shot noise, partition noise, space-charge reduction of noise, noise in electron multipliers, triodes, and tetrodes. Another general treatment of noise summarized the work of other authors and considered the noise in tubes with large transit times. A third paper extended the Campbell mean-square theorem to show that the variations in pulse shape due to irregularity in the potential near the grid will give rise to an ultra-high-frequency noise analogous to partition noise in screen-grid tubes. Signal and noise in microwave tetrodes were discussed with particular emphasis on their behavior as space-charge conditions in the grid-screen or drift region were varied. A new figure of merit for the noise performance of an electron tube was proposed. This figure of merit was defined as the frequency at which the product of the equivalent noise resistance and the input conductance is unity.

(318) J. R. Pierce, "Noise in resistances and in electron streams," *Bell Sys. Tech. Jour.*, vol. 27, pp. 158–174; January, 1948.
(319) N. R. Campbell, V. J. Francis, and E. G. James, "Valve noise and transit time," *Wireless Eng.*, vol. 25, pp. 148–157; May, 1948.
(320) R. L. Bell, "Negative-grid partition noise," *Wireless Eng.*, vol. 25, pp. 294–297; September, 1948.
(321) W. A. Harris, "Some notes on noise theory and its application to input circuit design," *RCA Rev.*, vol. 9, pp. 406–418; September, 1948.

Measurements of the noise of pentodes at very-high frequencies showed an asymmetry of the noise-resonance curve due to the phase relation between the induced grid noise and the normal shot effect, and showed the effects of cathode-lead inductance and internal feedback on the noise factor. A study was made of the theory of the noise factor in grounded-grid amplifiers.

(322) A. van der Ziel and A. Versnel, "Induced grid noise and total-emission noise," *Philips Res. Rep.*, vol. 3, pp. 13–23; February, 1948.
(323) A. van der Ziel and A. Versnel, "Measurements of noise-factors of pentodes at 7.25 wavelength," *Philips Res. Rep.*, vol. 3, pp. 121–129; April, 1948.
(324) A. van der Ziel and A. Versnel, "The noise-factor of grounded-grid valves," *Philips Res. Rep.*, vol. 5, pp. 255–270; August, 1948.

A study of the effect of vibratory motion of the grid and cathode of a tube upon the output signal was made. Tests of microphonism and methods of tube design to avoid microphonism were considered.

(325) V. W. Cohen and A. Bloom, "Microphonism in a subminiature triode," Proc. I.R.E., vol. 36, pp. 1039–1048; August, 1948.

Miscellaneous. A novel device of interest is a tube which is capable of detecting the presence in the air of extremely small amounts of certain gases.

(326) W. C. White and J. S. Hickey, "Electronics stimulates the senses of smell," *Electronics*, vol. 21, pp. 100–102; March, 1948.

Power-Output High-Vacuum Tubes

A number of the articles published in the domestic and foreign literature during this period presented elaborations of the developments announced during preceding years. The greater part of these papers were concerned with electron tubes suitable for operation at frequencies of 100 to 10,000 Mc. Much attention was given to additional theoretical interpretations of the electron mechanism in all types of tubes.

Among the new developments were X-ray tubes with a magnification of 500, the "smeller" tube, and the "memory" tube.

Klystrons. In the field of velocity-modulation tubes, disk-seal klystrons designed for microwave repeaters and television relay service at 4,000 Mc and 2,000 Mc, with outputs of about 1 watt, were described.

(327) H. T. Friss, "Microwave repeater research," *Bell Sys. Tech. Jour.*, vol. 27, pp. 183–246; April, 1948.
(328) J. Markus, "New York-Boston television relay," *Electronics*, vol. 21, pp. 114–116; January, 1948.
(329) F. M. Deerhake, "2000 Mc Television program chain," *Electronics*, vol. 21, pp. 94–97; February, 1948.

Secondary-emission klystrons, previously described in the Annual Review for 1946 as a new research product, were announced as practical tubes with 5 watts output, 3 to 5 per cent efficiency, and mechanically tunable to frequencies from 2,900 to 4,000 Mc.

(330) Editorial, "Secondary emission klystrons," *Electr. Ind. and Electr. Instr.*, vol. 2, p. 34; November, 1947.

Theoretical investigation and practical development of several types of high-output klystrons were reported, including a 10-cm klystron with more than 1 kw output.

(331) R. Warnecke, "Sur quelques modèles typiques de tubes a modulation de vitesse," *L'Onde Élec.*, vol. 28, pp. 175–186; May, 1948; pp. 243–256; June, 1948.

Several papers dealt with mathematical analyses of klystron operation, with regard to more effective electron bunching, and improved efficiency and frequency range.

(332) W. H. Huggins, "Multifrequency bunching in reflex klystrons," Proc. I.R.E., vol. 36, pp. 624–630; May, 1948.
(333) G. Vincent, "Consideration sur la bande d'accord Électronique et sur le rendement utile des klystrons reflex," *Ann. de Radioélec.*, vol. 3, pp. 21–29; January, 1948.
(334) G. J. Miakishev, "To the theory of electron-beam high-frequency tube generators," *Jour. Tech. Phys.* (USSR), pp. 1063–1069; August, 1948.

Magnetrons. In the field of magnetrons, contributions were made by both theoretical and experimental studies of multicavity tubes in regard to space-charge distribution, efficiency, frequency stability, and wide-band tunability. Wide-band tuning—greater than 1.4 to 1—is achieved by simultaneous variation of both the inductance and the capacitance of the resonant cavities by means of a single mechanical motion. Magnetrons with such tuning arrangements were constructed for 2 kw useful power output in continuous-wave operation for the 1,000-Mc region. Another design giving a tuning band up to 2 to 1 was the "interdigital" structure having two sets of intermeshed fingers. Tubes of this latter design were made for the 10-cm region having a continuous-wave output of 500 watts at 70 per cent efficiency.

(335) R. B. Nelson, "Methods of tuning multicavity magnetrons," Proc. I.R.E., vol. 36, pp. 53–56; January, 1948.
(336) J. F. Hull and A. W. Randals, "High-power interdigital magnetrons," Proc. I.R.E., vol. 36, pp. 1357–1363; November, 1948.
(337) O. Doehler, "Sur les propriétés des tubes a champ magnetique constant," *Ann. de Radioélec.*, vol. 3, pp. 29–40; May, 1948.

Work was also done in the region of wavelengths approaching a few millimeters with the "rising-sun" magnetron. Although rising-sun magnetrons have been known for several years, closer study of structures having large numbers of cavities suggested the feasibility of using this type of magnetron for production of waves shorter than 1 cm. The same construction also appears to be suitable for high-power magnetrons in the centimeter-wave region. The advantages derived from the use of a large number of cavities are, principally, an increase in cathode size and some reduction in the required magnetic field.

(338) S. Millman and A. T. Nordsieck, "The rising-sun magnetron," *Jour. Appl. Phys.*, vol. 19, pp. 156–165; February, 1948.
(339) S. Millman, A. V. Hollenberg, and N. Kroll, "Rising-sun magnetrons with large numbers of cavities," *Jour. Appl. Phys.*, vol. 19, pp. 624–635; July, 1948.

A 50-kw water-cooled magnetron for continuous operation at 100 Mc, having a cathode heated by secondary-emission electrons, was announced.

(340) Editorial, "New Tubes," *Radio-Electr. Eng.* (section of *Radio News*), vol. 11, p. 25; October, 1948.

Traveling-Wave Tubes. The traveling-wave tube continued to be the subject of many theoretical studies and experiments. A more or less successful kinematic theory was developed for the purpose of predetermining the limits for power and efficiency of such tubes.

(341) C. C. Cutler, "Experimental determination of helical-wave properties," Proc. I.R.E., vol. 36, pp. 230–234; February, 1948.
(342) O. Doehler and W. Kleen, "Phénomènes non-lineaires dans les tubes à propagation d'onde à faisceaux lineaire," *Ann. de Radioélec.*, vol. 3, pp. 124–143; April, 1948; pp. 184–189; July, 1948.
(343) J. R. Pierce, "Effect of passive modes in traveling-wave tubes," Proc. I.R.E., vol. 36, pp. 993–997; August, 1948.
(344) L. J. Chu and J. D. Jackson, "Field theory of traveling wave tubes," Proc. I.R.E., vol. 36, pp. 853–863; July, 1948.

Tetrodes. The requirements of television and FM for tubes operating at frequencies of 100 Mc and above prompted the design of new types of tetrodes suitable for operation at these very high frequencies. One of them, an internally neutralized duplex tetrode, is capable of delivering 5 kw at frequencies up to 300 Mc. Its design is very compact and every tube electrode, as well as each glass-to-kovar seal, is water-cooled. Air-cooled tetrodes were designed for frequencies up to 500 Mc with 400 watts output, and for 150 Mc with more than 1 kw output. A tetrode was used as a frequency multiplier to 950 Mc.

(345) Editorial, "The RCA 8D21, high-power at very-high frequency," *Broadcast News*, No. 48, pp. 16–17; March, 1948.
(346) P. Smith and H. R. Hegbar, "Duplex tetrode uhf power tube," Proc. I.R.E., vol. 36, pp. 1348–1353; November, 1948.
(347) W. G. Wagener, "500-Mc transmitting tetrode design considerations," Proc. I.R.E., vol. 36, pp. 611–619; May, 1948.
(348) B. O. Ballou, "STL circuit design," *FM and Telev.*, vol. 8, pp. 49–50, September, 1948.

Triodes. In the field of triodes, several new tubes were announced for various applications. As remnants of wartime developments, two pulse triodes were described in detail. One of them, a tunable twin triode with a concentric cavity resonator, all enclosed in a metal vacuum envelope, is capable of developing nearly 1,000 kw peak power at 400 Mc. The other was designed as a single cylindrical tube with close spacing between the electrodes. In an external cavity resonator it was capable of delivering 200 kw peak power at 600 Mc. A recent development of a 100-watt grounded-grid triode for continuous-wave operation at full rating to 1,200 Mc was also described. Its unusual mechanical design features permit its manufacture by production-line methods. The development of another uhf triode tunable oscillator for frequencies from 370 to 3,700 Mc was announced under the name of the "diotron oscillator." This is a triode with the grid by-passed to the cathode, and a cavity resonator connected between grid and anode.

(349) C. E. Fay and J. E. Wolfe, "A tunable vacuum-contained triode oscillator for pulse service," PROC. I.R.E., vol. 36, pp. 234–239; February, 1948.
(350) L. S. Nergaard, D. G. Burnside, and R. P. Stone, "A developmental pulse triode for 200 kw output at 600 Mc," PROC. I.R.E., vol. 36, pp. 412–416; March, 1948.
(351) W. P. Bennett, E. A. Eshbach, C. E. Haller, and W. R. Keyes, "A new 100-watt triode for 1000 megacycles," PROC. I.R.E., vol. 36, pp. 1296–1302; October, 1948.
(352) Editorial, "The diotron oscillator," *Communications*, vol. 28, pp. 24–25; May, 1948.

For FM transmitter applications, several new triodes were announced with ratings from 3 to 50 kw for frequencies as high as 150 Mc. Some of these have thoriated-tungsten filamentary cathodes. New triodes designed expressly for industrial rf heating were also reported.

(353) A. Arigoni, "50 kw output on 88 to 108 Mc," *FM and Telev.*, vol. 8, pp. 37–39; February, 1948.
(354) Editorial, "New tubes," *Radio Electr. Eng.* (section of *Radio News*), vol. 10, p. 21; February, 1948; vol. 11, p. 25; August, 1948.
(355) E. G. Shower, "New vacuum tubes for very high frequencies," *Bell Lab. Rec.*, vol. 26, pp. 361–363; September, 1948.

Cathodes. In connection with the increased popularity of more efficient cathodes for power-output tubes, thoriated-tungsten and oxide-coated cathodes were subject to more studies.

(356) H. J. Dailey, "Designing thoriated tungsten filaments," *Electronics*, vol. 21, pp. 107–109; January, 1948.
(357) H. Jacobs, G. Hees, and W. P. Crossley, "The relationship between the emission constant and the apparent work function for various oxide-coated cathodes," PROC. I.R.E., vol. 36, pp. 1109–1114; September, 1948.

General Theory and Design. In addition to specific considerations in designing electron tubes for various applications, more general theoretical studies were the subject of several papers during the last year. A very interesting application of the differential analyzer to the study of electron trajectories in tubes was suggested and demonstrated. Theoretical studies of the wavelength law in split-anode magnetrons, a mathematical study of space-charge effects in electron tubes, measurement methods in the domain of centimeter waves, and the behavior of negative-grid triodes were reflected in the literature. The work of the tube designer was greatly assisted by pertinent developments in the line of metallurgy and ceramics.

(358) J. P. Blewett, G. Kron, F. J. Maginiss, H. A. Peterson, J. R. Whinnery, and H. W. Jamison, "Tracing of electron trajectories using the differential analyzer," PROC. I.R.E., vol. 36, pp. 69–83; January, 1948.
(359) G. H. Metson, "Wavelength laws of split-anode magnetrons," *Wireless Eng.*, vol. 24, pp. 352–356; December, 1947.
(360) M. Denis and R. Liot, "Contribution à l'étudé des procédés et appareils de mesure dans le domaine des ondes centimetrique," *Ann. de Radioélec.*, vol. 2, pp. 409–438; October, 1947.
(361) C. D. Gvozdover and B. A. Zore, "Self excitation of the triode generator with feedback in the decimeter range," *Jour. Tech. Phys.* (USSR), pp. 1194–1207; September, 1948.
(362) M. R. Gavin, "V.h.f. valves and circuits," *Wireless Eng.*, vol. 25, pp. 315–321; October, 1948.
(363) G. Wood, "Positive-grid characteristics of a triode," PROC. I.R.E., vol. 36, pp. 804–808; June, 1948.
(364) J. S. Brown and F. D. Bennett, "The application of matrices to vacuum-tube circuits," PROC. I.R.E., vol. 36, pp. 844–852; July, 1948.
(365) J. A. Pask, "New techniques in glass-to-metal sealing," PROC. I.R.E., vol. 36, pp. 286, 289; February, 1948.
(366) A. Danzin and P. Meunier, "Appareil pour l'étude des échauffments et la mesure de puissances dissipées dans les corps vitreaux soumis à des champs électriques de haute fréquance," *Ann de Radioélec.*, vol. 3, pp. 40–49; January, 1948.
(367) J. Peyssou, "Contribution à l'étude des phénomènes électrolytiques dans le vérre," *Ann. de Radioélec.*, vol. 3, pp. 107–115; April, 1948.

New Developments. An X-ray tube was announced which is capable of intensifying the X-ray picture many times by the consecutive conversion of X-ray quanta into light and light into photoelectrons which are then focussed on a fluorescent screen.

(368) Editorial, "New x-ray tube magnifies 500 times," *Electronics*, vol. 21, p. 11; June, 1948.

Cathode-Ray Tubes and Television Tubes

During the year 1948, television expansion was extremely rapid and the demand for tubes continued far ahead of supply. Improvements in and extended field experience with the image orthicon have firmly established this tube as a television camera tube for outside and studio pickup. The 10-inch picture tube continued to be the popular directly viewed cathode-ray tube for television receivers, although more interest was being shown in the larger directly viewed picture tubes, as television-tube manufacturers develop more economical methods of making them. Projection-type picture tubes accounted for only a small percentage of the television receiver market, largely because of the relative high cost of projection television receivers; but development in this field continued.

Active development took place on a variety of special types of electron-beam tubes such as image tubes, camera tubes, storage tubes, signal-generating tubes, multiple-beam cathode-ray tubes, etc., while the electron microscope continued to solve problems in an ever-widening field of research.

In the camera-tube field, no important new developments were reported. Image orthicons were improved to provide better picture quality and the spectral response for better color rendition. The development of a small version of the image iconoscope, called an Eriscope, was reported.

(369) B. France, "The Eriscope camera tube," *Electronics*, vol. 21, p. 130; October, 1948.

The brightness intensifier, a multiple image tube, has been developed. This tube showed promise of being an important aid to viewing low-intensity images such as those produced on X-ray fluoroscopic screens or photographic film illuminated by infrared radiation.

(370) G. A. Morton, J. E. Ruedy, and G. L. Krieger, "The brightness intensifier," *RCA Rev.*, vol. 1, pp. 419–432; September, 1948.

A storage orthicon having a high-capacity target capable of storing an image for several seconds was developed for picking up radar PPI presentation for television reproduction.

(371) S. V. Forgue, "The storage orthicon and its application to teleran," *RCA Rev.*, vol. 8, pp. 633–650; December, 1947.

Another storage device called the barrier-grid storage tube, which is capable of storing electrical signals for many hours and of discriminating between repetitive and new signals, extended the applications of the storage principle.

(372) A. S. Jensen, J. P. Smith, M. A. Mesner, and L. F. Flory, "Barrier grid storage tube and its operation," *RCA Rev.*, vol. 9, pp. 112–135; March, 1948.

A third storage device called the repeller storage tube, which is also capable of discriminating between periodically recurring and new information, was described.

(373) H. Klemperer and J. T. de Bettencourt, "Repeller storage tube," *Electronics*, vol. 21, pp. 104–106; August, 1948.

An electron-beam deflection tube for pulse-code modulation was added to the signal-generating type of beam tubes. This tube has a fine grid mounted close to a signal plate which has a variety of different-sized rectangular openings to produce a special type of signal used with a pulse-code transmission system.

(374) R. W. Sears, "Electron beam deflection tube for pulse code modulation," *Bell Sys. Tech. Jour.*, vol. 27, pp. 44–57; January, 1948.

The performance characteristics of long-persistence cathode-ray-tube screens used in many radar indicators have been described. The methods of manufacture and measurement of these screens were described in detail.

The development of multiple-gun cathode-ray tubes was expanded to provide tubes with 1 to 10 electron guns in one envelope with nearly complete electrostatic shielding between the separate guns.

(375) R. E. Johnson and A. E. Hardy, "Performance characteristics of long persistence cathode-ray tube screens: their measurement and control," *RCA Rev.*, vol. 8, pp. 660–681; December, 1947.

(376) H. S. Bamford, "Multigun cathode ray oscillography," *Electronic Ind.*, vol. 2, pp. 10–13; May, 1948.

A radial-beam cathode-ray tube in which the beam continuously sweeps over 12 or more anodes during each revolution around the cathode was described. The tube may serve as an inertialess distributor for various high-speed switching functions.

(377) A. M. Skellett, "Electrostatically focused radial beam tube," Proc. I.R.E., vol. 36, pp. 1354–1357; November, 1948.

The study of electron optics continued to provide information of value in solving cathode-ray-tube design problems. A study of electron optics and space charge in simple systems with circular symmetry showed that, for any grid-anode spacing, there is a corresponding optimum grid-cathode spacing for which the focused-beam current density is a maximum. The spherical aberration and the beam divergence also have minimum values at the optimum grid-cathode spacing. The presence of ions of the residual gas not only modifies the optimum spacing values, but may modify the aberrations and beam divergence.

(378) O. Klemperer and B. J. Mayo, "Electron optics and space charge in simple emission systems with circular symmetry," *Jour. IEE* (London), vol. 95, pp. 135–141; May, 1948.

An optical bench for electron studies was described. This optical bench is mounted in a large evacuated chamber which has provisions for moving several components of an electron-optical system by means of outside controls. Details of construction and special features of the equipment were included in the description. This instrument made possible, not only the convenient demonstration of electron-optical principles, but also the study of aberrations of different types of electron lenses.

(379) J. H. Reisner and R. G. Picard, "An optical bench for electron optical studies," *Rev. Sci. Instr.*, vol. 19, pp. 556–560; September, 1948.

Equipment for the automatic plotting of electrostatic fields added another instrument to aid in the design of improved electron lenses. A servomechanism was added to the usual circuitry used with an electrolytic tank containing electrode models of electron lenses. A stepping relay which was operated by a limit switch provided automatic plotting of different equipotential lines and limited the plot to the desired area.

(380) P. E. Green, Jr., "Automatic plotting of electrostatic fields," *Rev. Sci. Instr.*, vol. 19, pp. 646–653; October, 1948.

The applications of the electron microscope have become so extended that it is not possible to do justice to the many papers published in a wide variety of fields. One paper reported a study of chromatic aberration and resolving power in electron microscopy which indicated that, if sufficiently small apertures were used, the effects of chromatic aberration and diffraction could be reduced sufficiently so that dark-field resolution was almost as good as bright-field resolution.

(381) E. G. Rambert and J. Hillier, "Chromatic aberration and resolving power in electron microscopy," *Jour. Appl. Phys.*, vol. 19, pp. 678–682; July, 1948.

An ion microscope of the emission type with a transverse magnetic field was described. When surfaces which emitted more than one type of ion were examined, the images produced by the different ions were separated by means of a magnetic field, and the atomic weights of the ions could be calculated from the image displacements.

(382) N. Sasaki, "An ion microscope with a transverse magnetic field," *Jour. Appl. Phys.*, vol. 19, pp. 1050–1053; November, 1948.

Phototubes

Following the development of the lead-sulfide photoconductive cell, research was extended to lead-selenide and lead-telluride cells which are sensitive farther in the infrared region of the spectrum. One group of workers reported a peak sensitivity for lead-telluride cells equal to the peak sensitivity of the best lead-sulfide cells, and equal to or better than the thermocouple as far as 4.3 microns.

(383) O. Simpson, G. B. B. M. Sutherland, and D. E. Blackwell, "Lead telluride cells for infra red spectroscopy," *Nature*, vol. 161, p. 281; February 21, 1948.
(384) T. S. Moss and R. P. Chasmar, "Spectral response of lead selenide," *Nature*, vol. 161, p. 244; February 14, 1948.
(385) O. Simpson, G. B. B. M. Sutherland and D. E. Blackwell, "Lead selenide cells for infra red spectroscopy," *Nature*, vol. 160, p. 792; December 6, 1947.

Considerable progress was made in the application of multiplier phototubes to radiation detection. The procedure involved exciting a fluorescent material with the radiation, and measuring the visible light produced with a multiplier phototube. The device was used to record, as pulses, light quanta excited by alpha rays, beta rays, gamma rays, neutrons, high-speed ions, and X rays of energy as low as 8 kilovolts. A resolution of 10^{-7} seconds was reported. In one paper, the author described the use of a naphthalene screen to obtain an intrinsic efficiency of 60 per cent in counting gamma rays of the order of 1 million electron volts. In another paper, the author described a similar screen excited by 0.87-Mev beta rays. By comparing the counting rate with measurements using a Geiger counter, the conclusion was reached that the multiplier was counting approximately 100 per cent of the electrons striking the naphthalene.

(386) J. W. Coltman and F. Marshall, "Photomultiplier radiation detector," *Nucleonics*, vol. 3, pp. 58–64; November, 1947.
(387) J. S. Allen, "Particle detection with multiplier tubes," *Nucleonics*, vol. 3, pp. 34–39; July, 1948.
(388) M. Deutsch, "Naphthalene counters for beta and gamma rays," *Nucleonics*, vol. 2, pp. 58–59; March, 1948.

In the field of astronomy, the photomultiplier, because of its extraordinary sensitivity to low light intensity, began to find wide application. A photoelectric guider was described for astronomical telescopes using the 1P21 photomultiplier. The same tube was reported in use for measuring the light intensity from three variable stars, while spectrographic observations were being made at another station.

The theoretical limit of astronomical photoelectric photometers was discussed in one paper and the limit of the most sensitive, a blue-sensitive photomultiplier of the 1P21 type, was reported to be a star of magnitude 20.9 using a 100-inch telescope. This can be compared with an actual measurement described in another paper of the light intensity and color of an 18.2-magnitude extragalactic nebula with a 100-inch telescope.

Also in the field of astronomy, the lead-sulfide cell received recognition as the most sensitive detector for infrared radiation. One paper was published describing the design and operation of an infrared stellar spectrometer using the lead-sulfide cell.

(389) H. W. Babcock, "A photoelectric guider for astronomical telescopes," *Astrophys. Jour.*, vol. 107, pp. 73–77; January, 1948.
(390) H. L. Johnson, "A theoretical discussion of the ultimate limits of astronomical photoelectric photometers," *Astrophys. Jour.*, vol. 107, pp. 35–47; January, 1947.
(391) K. C. Gordon and G. E. Kron, "Photoelectric light curves of R. R. Lyrae, T. U. Cassiopeiae, and T. Monocerotis," *Astrophys. Jour.*, vol. 106, pp. 318–325; November, 1947.
(392) G. P. Kuiper, W. Wilson, and R. J. Cashman, "An infra red stellar spectrometer," *Astrophys. Jour.*, vol. 106, pp. 243–250; September, 1947.
(393) G. E. Kron, "Electronics in astronomy," *Electronics*, vol. 21, pp. 98–103; August, 1948.

Solid-State Devices

A new semiconductor three-electrode amplifying device, known as the transistor, was announced. Subject to certain limitations, it will perform many of the functions of an electron tube, such as amplification, oscillation, and modulation. The transistor consists of three electrodes placed on a small block of germanium. Two of these electrodes, called the emitter and collector, are of the point-contact rectifier type and are placed closely together on the upper surface. The third electrode, called the base, is a large-area low-resistance contact.

Each point contact considered separately in conjunction with the base electrode has characteristics similar to those of the high-back-voltage rectifier. The emitter is biased slightly positive, with respect to the base in the direction of easy flow, causing a current of the order of 1 ma to flow into the surface.

A considerably larger negative bias is applied to the collector, causing a current of several milliamperes to flow out of the surface in the reverse direction to easy flow. If, now, the emitter current is varied by a signal voltage, there will be a corresponding variation in collector current. The current from the emitter is composed in large parts of holes; i.e., of carriers of opposite sign to those normally in excess in the body of the *N*-type germanium. The holes are attracted to the collector, and it has been found that they may alter the normal reverse current flow from the base to the collector in such a way that the change in collector current may be larger than the change in emitter current causing it. The emitter, being operated in the forward direction, has a relatively low impedance, whereas the collector, being operated in its reverse direction, has a high impedance which may be matched to a high-impedance load. Thus there may occur voltage amplification of the same order as the ratio of the reverse to forward impedances, current amplification, and corresponding power amplification. Power gains of over 20 db have been obtained, and such units have been operated at frequencies up to 10 Mc.

(394) J. Bardeen and W. H. Brattain, "The transistor, a semiconductor triode." J. Bardeen and W. H. Brattain, "Nature of forward current in germanium point contacts." W. Shockley and G. L. Pearson, "Modulation of conductance by surface charges." Letters to the Editor of *Phys. Rev.*, vol. 74, pp. 230–233; July 15, 1948.
(395) "The transistor," *Bell Lab. Rec.*, vol. 24, pp. 321–324; August, 1948.
(396) D. H. Fink and F. H. Rockett, "The transistor—a crystal triode," *Electronics*, vol. 21, pp. 68–71; September, 1948.

Piezoelectric Crystals

Much of the progress during the past year was in the nature of extension along already well-developed lines of crystal investigation, especially with respect to quartz crystals and their vibrations.

The most noteworthy advances were in the growth and study of certain artificial crystals. Outstanding among these was barium titanate, single crystals of which present interesting problems of a purely physical nature, while in the form of ceramics they offer significant possibilities for technical applications.

Books

The following French book on piezoelectricity and its applications has not been mentioned in previous Annual Reviews:

(397) E. Palmans, "Piézo-électricité. Théorie et Pratique," 162 pp. P. H. Brans, Antwerp, 1946.

Quartz Cuts, Vibrations, and Mountings

Progress is to be recorded in the study of vibrational modes. Flexural vibrations with minimum temperature coefficient of frequency, quartz plates with convex surfaces, and improvements in crystals for filters, have received attention. One paper was on the technique of manufacture of mounted high-frequency units.

(398) R. S. Bever, V. E. Bottom, and L. R. Weber, "Modes of vibration in contoured quartz plates," presented, Pasadena Meeting, American Phys. Soc., Pasadena, Calif.; June, 1948.
(399) I. Özdogan, "Measurement of vibrations of a quartz prism using Pierce's acoustic interferometer," *Rev. Fac. Sci. Univ. Istanbul* (Sér. A), vol. 12, no. 2, pp. 53–79; 1947; (see *Phys. Abstr.*, vol. 50, p. 230: 1947).
(400) V. Petrzilka and A. Kotler, "Flexural vibrations of quartz rods," *Věstnik Královske České Společnosti Nauk*, Ročnik 1947, Cislo IX, pp. 1–20; Praha, 1948.
(401) R. A. Sykes, "High-frequency plated quartz-crystal units," Proc., I.R.E., vol. 36, pp. 4–7; January, 1948.
(402) J. J. Vormer, "Quartz filter crystals with low inductance," Proc. I.R.E, vol. 36, pp. 802–804; June, 1948.

Vibration and Oscillator Theory

The perennial problem of the piezo-oscillator was again attacked, this time with emphasis on phase relations.

Another inexhaustible subject is the theory of vibrations in crystals, to which two papers were devoted.

(403) G. Hok, "Response of linear resonant systems to excitation of a frequency varying linearly with time," *Jour. Appl. Phys.*, vol. 19, pp. 242–250; March, 1948.
(404) G. Hok, "Thickness-shear vibrations of thin anisotropic plates," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 406–417; July, 1948.
(405) Illinois University, "Theory of Crystal Oscillator Circuit Design," Interim Engineering Report No. 6, October 15, 1947 to January 15, 1948, 15 pp.

Elastic and Piezoelectric Constants of Quartz

For β-quartz, all elastic constants from 580° to 800° C were measured by a dynamic method, using high-frequency thickness vibrations.

In terms of modern lattice theory, and by the use of earlier data, theoretical values of the piezoelectric constants e_{11} and e_{14} of quartz, and their dependence on temperature, were derived, in good agreement with experimental values.

(406) F. W. Kammer, T. E. Pardue, and H. F. Frissel, "A determination of the elastic constants for beta-quartz," *Jour. Appl. Phys.*, vol. 19, pp. 265–270; March, 1948.
(407) B. D. Saksena, "Calculation of the piezo-electric constants of α- and β-quartz," *Nature* (London), vol. 161, pp. 283–284; February 21, 1948.

Impurities in Quartz

The effects of radiation and temperature on the color of quartz and on its performance as a resonator, mentioned in the Annual Review for 1945, has received further attention. Amethyst plates oscillate poorly, but smoky quartz makes satisfactory resonators.

(408) Bh. Krishnamurty, "Ultrasonic studies in amethyst and smoky quartz," *Proc. Ind. Acad. Sci.*, vol. 27, Sec. A, pp. 132–137; 1948.
(409) D. A. A. S. Narayana Rao, "Dielectric constants of crystals. I. Different types of quartz," *Proc. Ind. Acad. Sci.*, vol. 25, no. 5, Sec. A, pp. 408–412; 1947.
(410) N. E. Vedeneyeva and L. G. Chentzova, "Thermal discoloration of smoky quartz," *Compt. Rend. Acad. Sci.* (URSS), vol. 55, pp. 437–440; 1947; (see *Phys. Abstr.*, vol. 50, p. 252; 1947).

X-Ray Investigations of Crystal Vibrations

The effect of crystal vibration upon the reflection of characteristic X rays, well-known with quartz, was found also with Rochelle salt and ADP crystals.

(411) D. C. Miller, "Effect of the piezoelectric properties of a crystal on diffuse X-ray reflections," *Phys. Rev.*, vol. 74, pp. 166–169; July 15, 1948.

Artificial Crystals

A study of the modes of vibration of ADP crystals was reported from Italy. Crystals of ethylene diamine tartrate, mentioned in the Annual Review for 1947, quickly found an important application in filters.

Another recent addition to the growing family of piezoelectric crystals is aluminum phosphate.

Methods for growing quartz crystals were under development in several laboratories. One paper on the subject has appeared in the current literature.

(412) R. H. Bolt and A. Giacomini, "Report on the National Electroacoustics Institute 'C. M. Corbino' (I.N.E.A.C.), Rome, Italy," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 328–343; May, 1948.
(413) J. P. Griffin and E. S. Pennell, "Design and performance of ethylene diamine tartrate crystal units," AIEE Technical Paper No. 48-87, presented, AIEE Meeting, Pittsburgh, Pa., January, 1948.
(414) D. R. Hale, "The laboratory growing of quartz," *Science*, vol. 107, pp. 393–394; April 16, 1948.

Barium Titanate

The physical properties of single crystals of barium titanate were investigated, and microphotographs showing the domain structure were made. Below the Curie point at 120°C the crystal is ferroelectric and tetragonal; above this temperature it is cubic and not piezoelectric. In the ferroelectric state values of the dielectric constant amounting to several thousand were reported, while the piezoelectric constant d_{14} is several times as great as that of Rochelle salt. Solid solutions of barium-strontium and barium-lead titanates also have ferroelectric properties.

A flat plate of barium-titanate ceramic, containing many minute crystal fragments in random orientation, placed in a biasing field, behaves like a plate of piezoelectric crystal. Several vibrational modes, including compressional and shear, can be excited.

(415) H. Blattner, B. Matthias, and W. Merz, "Single crystals of barium-titanium compounds," *Helv. Phys. Acta.*, vol. 20, pp. 225–228; 1947.

(416) W. L. Cherry, Jr., and R. Adler, "Piezoelectric effect in polycrystalline barium titanate," *Phys. Rev.*, vol. 73, p. 1230; May 15, 1948.
(417) G. C. Danielson, B. T. Matthias, and J. M. Richardson, "Dielectric behavior of single domain crystals of $BaTiO_3$," *Phys. Rev.*, vol. 74, pp. 986–987; October 15, 1948.
(418) M. G. Harwood, P. Popper, and D. F. Rushman, "Curie Point of barium titanate," *Nature* (London), vol. 160, pp. 58–59; July 12, 1947.
(419) H. Jaffe, "Volume electrostriction in barium titanate ceramics," *Phys. Rev.*, vol. 73, p. 1261; May 15, 1948.
(420) W. P. Mason, "Electrostrictive effect in barium titanate ceramics," *Phys. Rev.*, vol. 74, pp. 1134–1147; November 1, 1948.
(421) J. M. Richardson and B. T. Matthias, "Theory of the dielectric behavior of $BaTiO_3$," *Phys. Rev.*, vol. 74, pp. 987–988; October 15, 1948.
(422) B. Matthias and A. von Hippel, "Domain structure and dielectric response of barium titanate single crystals," *Phys. Rev.*, vol. 73, pp. 1378–1384; June 1, 1948.
(423) "Physical properties of substances of high permittivity," Symposium of Electronics Group of (Brit.) Institute of Physics, June 12, 1948. *Nature* (London), vol. 162, pp. 245–247; August 14, 1948.

Antennas

AM Broadcast Antennas

Progress in AM broadcast transmitting antennas during 1948 was largely of a developmental nature, such as extending and improving existing equipment and methods. The trend continued toward more complicated arrays consisting of four, five, and six elements, indicating a closer approach toward the saturation point of available facilities in the 550- to 1,600-kc band. Antenna coupling equipment in connection with these arrays tended to include more adjustments, some motor-driven and remotely controlled, for the precise maintenance of the more complicated radiation patterns.

The increasing use of more complicated arrays to avoid interference as a result of congestion (in both geographical and frequency separation) led to more effective control of the distribution of available energy between useful radiation and ohmic loss; it also led to measurements which permit more effectively taking into account the parasitic effects of currents in other broadcast antennas near the transmitting station.

(424) G. D. Gillett, "Analysis of effect of circulating currents on the radiation efficiency of broadcast directive antenna designs," PROC. I.R.E., vol. 36, p. 372; March, 1948, (abstract).
(425) A. Alford and H. Jasik, "A model study of reradiation from broadcast towers," PROC. I.R.E., vol. 36, p. 372; March, 1948 (abstract).

Antennas for AM broadcast receivers were more closely geared to mass-production techniques through the development of "printed-circuit" methods of stamping loop antennas from a single sheet of copper.

FM Broadcast Antennas

A number of commercial FM transmitting antenna designs were offered to the broadcaster, having such descriptive trade names as Cloverleaf, Donut, Pylon, Ring, Sky Rocket, Square Loop, and Tower. All of these antennas were designed to operate in the 88- to 108-Mc range, and all were characterized by horizontal polarization, small azimuth directivity, and power gains of the order of 2 to 10.

(426) P. H. Smith, " 'Cloverleaf' antenna for FM broadcasting," PROC. I.R.E., vol. 35, pp. 1556–1563; December, 1947.
(427) O. O. Fiet, "Antenna design for low angle FM propagation," *Tele-Tech*, vol. 7, pp. 30–33; February, 1948.
(428) O. O. Fiet, "8-bay pylon antenna," *FM and Telev.*, vol. 8, pp. 46–48, 60; September, 1948.

Television Antennas

The year 1948 was a year of manufacture and installation of television antennas, by and large, rather than one of research and development. The television broadcast antenna in most extensive use in the United States was the Super Turnstile. Except for a few short articles previously recorded, little was published on this antenna.

Considerable work was and is being done on receiving antennas. The receiving-antenna problem is a difficult one to solve ideally, because of the wide range of frequencies (four to one) over which the antenna must operate. A possible solution, adopted by at least one manufacturer, consisted of using a combination of a high- and a low-frequency dipole with reflectors. Economics remained a limiting factor in receiving antenna design. One paper listed six different receiving antenna types and discussed them at short length.

(429) L. L. Libby, "Wide-range dual-band TV antenna design," *Communications*, vol. 28, pp. 12–14, 30–31; June, 1948.
(430) F. A. Kolster, "Antenna design for television and FM reception," PROC. I.R.E., vol. 36, pp. 1242–1247; October, 1948. Correction to same, PROC. I.R.E., vol. 36, p. 1363; November, 1948.
(431) F. R. W. Strafford and J. N. Pateman, "Television aerials," *Wireless World*, vol. 53, p. 344; September, 1947.
(432) E. G. Hills, "Cathode-follower TV-antenna system," *Communications*, vol. 28, pp. 22–25, 30–32; January, 1948.
(433) "All-wave television FM antenna," *Radio News*, pp. 49, 197, 199; October, 1947.

Microwave Antennas

Two papers were published which dealt with the properties of antennas used to feed microwave energy into a waveguide. The first of these papers presented a simple method for obtaining the radiation resistance of the antenna by considering it as one element of an infinite array. The second paper was concerned with the power-handling capacities of antennas in waveguides. The approximate theory used gave answers which checked reasonably well with available experimental data.

(434) H. A. Wheeler, "The radiation resistance of an antenna in an infinite array or waveguide," PROC. I.R.E., vol. 36, pp. 478–487; April, 1948.
(435) J. S. Gooden, "The field surrounding an antenna in a waveguide," *Jour. IEE*, vol. 95, Part III, pp. 346–350; September, 1948.

Two interesting papers dealing with quantitative measurements on antennas at microwave frequencies were published. In one of these papers, techniques and methods used for the measurement of gain, beamwidth, mutual impedance, phase and polarization were discussed, and the components for a complete measuring system were described. The other paper gave a critical discussion of four methods commonly used to measure gain, with a clear statement of the advantages and limitations of each method.

(436) C. C. Cutler, A. P. King, and W. E. Kock, "Microwave antenna measurements," PROC. I.R.E., vol. 35, pp. 1462–1471; December, 1947.

(437) J. D. Lawson, "Some methods for determining the power gain of microwave aerials," *Jour. IEE*, vol. 95, pp. 205–209; July, 1948.

Slot Antennas

Because of their many desirable features, and also because they still represent relatively unexplored territory, slot antennas continued to receive the attention of investigators. Among the many problems posed by slot antennas, the following were studied. The electromagnetic field of a narrow circular slot in a large, flat conducting plane was calculated by classical diffraction theory, and an expression for the admittance across the slot was derived. The impedance of, as well as the field distributions near, a center-fed half-wave slot were obtained. Further consideration was given to a slot antenna array consisting of inclined slots in a circular waveguide.

(438) A. A. Pistolkors, "Theory of the circular diffraction antenna," Proc. I.R.E., vol. 36, pp. 56–60; January, 1948.
(439) J. L. Putnam, B. Russell, and W. Walkinshaw, "Field distributions near a centre-fed half-wave radiating slot," *Jour. IEE*, vol. 95, Part III, pp. 282–289; July, 1948.
(440) J. L. Putnam, "Input impedances of centre-fed slot aerials near half-wave resonance," *Jour. IEE*, vol. 95, Part III; pp. 290–294; July, 1948.
(441) Z. Szepesi, "Systems of slots in the wall of a circular waveguide giving a spindle-shaped radiation diagram," *Compt. Rend. Acad. Sci.*, (Paris), vol. 226, pp. 883–885; March 15, 1948.

Antenna Theory

A set of antenna impedance and admittance curves was published in report form, based on E. Hallén's integral-equation solution to the cylindrical antenna problem. The impedance values given by these curves were in quite good agreement with those shown by Schelkunoff, and also with available measured values collected from various sources. The information was given in terms of both admittance and impedance curves for a wide range of antenna thicknesses, and for dipole-antenna lengths up to two wavelengths.

(442) Erik Hallén, "Admittance diagrams for antennas and the relation between antenna theories," Technical Report no. 46, Cruft Laboratory, Harvard University; June, 1948.

The problem of obtaining very high gain from antennas of limited aperture again received considerable attention. Several investigators, notably, Chu, Ramo, and Taylor, showed that theoretically there is a limit to the gain which can be obtained from an antenna of given aperture. It was pointed out that the presence of severe ohmic losses is the limiting factor. It was concluded that antennas having gain much in excess of that obtainable from a uniform distribution are not practical.

(443) H. J. Riblet, "Note on the maximum directivity of an antenna," Proc. I.R.E., vol. 36, pp. 620–623; May, 1948.
(444) P. M. Woodward and J. D. Lawson, "The theoretical precision with which an arbitrary radiation-pattern may be obtained from a source of finite size," *Jour. IEE*, vol. 95, Part III, pp. 363–370; September, 1948.
(445) R. M. Wilmotte, "Note on the practical limitations in the directivity of antennas," Proc. I.R.E., vol. 36, p. 878; July, 1948.
(446) T. T. Taylor, "A discussion of the maximum directivity of an antenna," Proc. I.R.E., vol. 36, p. 1135; September, 1948.

The theory of arrays of dipoles was treated by several investigators. The properties of two identical and parallel coupled linear antennas were discussed, as well as those of a dipole with a tuned parasitic antenna. End-fire, collinear, and broadside arrays were studied. A method was presented for estimating the gain of a directive antenna from its polar pattern, by assuming the directive lobe to be ellipsoidal in shape.

(447) C. T. Tai, "Coupled antennas," Proc. I.R.E., vol. 36, pp. 487–500; April, 1948.
(448) R. King, "The field of a dipole with a tuned parasite at constant power," Proc. I.R.E., vol. 36, pp. 872–876; July, 1948.
(449) C. H. Pappas and R. King, "The radiation resistance of end-fire and collinear arrays," Proc. I.R.E., vol. 36, pp. 736–741; June, 1948.
(450) J. A. Saxton, "Determination of aerial gain from its polar diagram," *Wireless Eng.*, vol. 25, pp. 110–116; April, 1948.

A new integral equation for radiation problems was studied and applied to the calculation of the impedances of antennas of revolution. A new calculation of the impedance of a linear antenna was made, including the effect of the gap. The field of a dipole antenna of conical shape was solved as an exact boundary-value problem. The properties of small dipole and loop antennas received attention in a number of papers.

(451) G. E. Albert and J. L. Synge, "The general problem of antenna radiation and the fundamental integral equation, with application to an antenna of revolution—Part 1," *Quart. Appl. Math.*, vol. 6, pp. 117–131; July, 1948.
(452) J. L. Synge, "The general problem of antenna radiation and the fundamental integral equation, with application to an antenna of revolution—Part II," *Quart. Appl. Math.*, vol. 6, pp. 133–156; July, 1948.
(453) R. King and T. W. Winternitz, "The cylindrical antenna with gap," *Quart. Appl. Math.*, vol. 5, pp. 403–416; January, 1948.
(454) P. D. P. Smith, "The conical dipole of wide angle," *Jour. Appl. Phys.*, vol. 19, pp. 11–23; January, 1948.
(455) R. H. Barfield and R. E. Burgess, "Small aerials in dielectric media," *Wireless Eng.*, vol. 25, pp. 246–253; August, 1948.
(456) R. G. Medhurst, "Radiation from short aerials," *Wireless Eng.*, vol. 25, pp. 260–266; August, 1948.
(457) F. Horner, "Properties of loop areials," *Wireless Eng.*, vol. 25, pp. 254–259; August, 1948.
(458) R. B. Watson and C. W. Horton, "The radiation patterns of dielectric rods—experiment and theory," *Jour. Appl. Phys.*, vol. 19, pp. 661–670; July, 1948.

A number of papers published in the past year indicated advances in new types of antennas, notably helical antennas and the lens antennas.

(459) J. D. Kraus and J. C. Williamson, "Characteristics of helical antennas radiating in the axial mode," *Jour. Appl. Phys.*, vol. 19, pp. 87–96; January, 1948.
(460) J. D. Kraus, "Helical beam antennas for wide band applications," Proc. I.R.E., vol. 36, pp. 1236–1242; October, 1948.
(461) H. A. Wheeler, "A helical antenna for circular polarization," Proc. I.R.E., vol. 35, pp. 1484–1488; December, 1947.
(462) W. E. Koch, "Metallic delay lenses," *Bell Sys. Tech. Jour.*, vol. 27. pp. 58–82; January, 1948.
(463) G. Wilkes, "Wavelength lenses," Proc. I.R.E., vol. 36, pp. 206–212; February, 1948.

The Reciprocity Theorem was examined critically and a more rigorous formulation presented. The properties of a pair of semi-infinite parallel plates, considered as a transmitting antenna and as a receiving antenna, were studied.

(464) A. F. Stevenson, "Relations between the transmitting and receiving properties of antennas," *Quart. Appl. Math.*, vol. 5, pp. 369–384; January, 1948.
(465) A. E. Heins, "The radiation and transmission properties of a pair of semi-infinite parallel plates—I," *Quart. Appl. Math.*, vol. 6, pp. 157–166; July, 1948.

(466) A. E. Heins, "The radiation and transmission properties of a pair of semi-infinite parallel plates—II," *Quart. Appl. Math.*, vol. 6, pp. 215–220; October, 1948.

Radio Wave Propagation

Tropospheric Propagation

The term "tropospheric propagation" is now taken to include all radio propagation phenomena in which the ionosphere plays no part, and in which the propagation path lies entirely within the lower region of the troposphere. This region extends from the surface up to about 30,000 feet and comprises the region in which the index of refraction is affected by meteorological conditions. Under the stimulus provided by radar, aircraft communication and navigation, FM and television broadcasting, microwave radio links, and other developments, the study of the nature of tropospheric propagation has continued at an accelerated pace. Recent experiments have revealed more and more clearly the extremely complex character of the refractive-index distribution in the atmosphere which controls the path followed and the attenuation experienced by a radio wave in its course from the transmitting antenna to the receiving antenna. For most applications in the uhf and shf ranges, the concept of a standard atmosphere, with a uniform lapse rate of refractive index, is now found to have little value. Even in the vhf range, field-strength calculations made by classical methods can yield only rough approximations. The problem is further complicated by the increased shadowing effect of surface obstacles and terrain irregularities with increasing frequency.

Books

A volume published in England during 1947 reported a conference on radio meteorology held jointly by the Physical Society of Great Britain and the Royal Meteorological Society in April, 1946. A detailed review of this book appeared during the year.

(467) "Meteorological factors in radio-wave propagation," Proc. I.R.E., vol. 36, pp. 645–646; May, 1948. Review of book published by the Physical Society. London, 1947.

The printing of a three-volume Summary Technical Report of the Committee on Propagation of the National Defense Research Committee has been previously reported. The original release was restricted to 250 copies. Continuing demand for a second printing by those unable to secure the original edition and subsequent declassification of much of the original material have led to republication in the form of a single volume.

(468) "Radio wave propagation," Consolidated Summary of Technical Report of the Committee on Propagation, Charles R. Burrows, Chairman. Stephen S. Attwood, Editor. Academic Press, Inc., New York, N. Y.

A comprehensive bibliography of reports on tropospheric propagation was published by the Central Radio Propagation Laboratory. Hundreds of references which are not otherwise generally available are listed. The period covered extends generally from 1940 to the early part of 1948, with articles included which have been published since August, 1945.

(469) "Bibliography of Reports on Tropospheric Propagation," Report CWPL-2-3, National Bureau of Standards, Central Radio Propagation Laboratory, Washington, D. C.

A manual of radio propagation was prepared by Menzel. This report represented an elaboration of a training pamphlet for use by the U. S. Navy personnel. The methods presented were developed in part by the author, and in part by the Interservice Radio Propagation Laboratory. About one-third of the book is devoted to tropospheric propagation. It contains a great many valuable nomograms and other illustrations, as well as a comprehensive survey of practice and theory. Both standard and nonstandard atmospheric conditions are treated.

(470) D. H. Menzel, "Elementary Manual of Radio Propagation," Prentice-Hall, Inc., New York, N. Y., 1948. Review published in Proc. I.R.E., vol. 36, p. 1009; August, 1948.

A paper, "Radio Wave Propagation in the Frequency-Modulation Broadcast Band," by Kenneth A. Norton, presented before the IRE West Coast Convention, September 26, 1947, was available in a book in which it is one in a series. In this paper the author applied statistical methods to the analysis of field-strength measurements to determine the service and interference ranges of FM stations in the 100-Mc band.

(471) "Advances in Electronics," vol. 1, Academic Press, Inc., New York, N. Y.

General Review of Tropospheric Propagation

Several papers appeared which reviewed propagation characteristics over a wide range of frequencies and distances, and summarized the relation between field strength and meteorological factors. Kerr provided a highly condensed summary of the immense mass of theory and data existing at the end of the war. Schwartz discussed the factors which play a part in determining the optimum frequency for a particular line-of-sight system.

(472) D. E. Kerr, "Propagation of very short waves," *Electronics*, vol. 21, pp. 124–129 and 118–123; January and February, 1948.
(473) L. S. Schwartz, "Transmission frequencies for line-of-sight systems," *Proc. N.E.C.*, vol. 3, pp. 350–370; 1947.
(474) "USW propagation," *Funk. and Ton*, nos. 2 and 4, pp. 100–105 and 206–212; 1947.

Nomograms and Formulas

Even under idealized conditions of a smooth spherical earth and uniform lapse rate of refractive index, the calculation of field strength is often a laborious process. Under conditions where such simplifying assumptions are justified, as over sea water with a well-mixed atmosphere, or when only rough approximations are required, nomograms, curves, and empirical or semi-empirical formulas may be used to accelerate the calculations. The following papers provide such time-saving devices. Bullington also provides methods for estimating the effect of obstacles, such as hills and buildings.

(475) K. Bullington, "Radio propagation at frequencies above 30 Mc," Proc. I.R.E., vol. 35, pp. 1122–1136; October, 1947.
(476) A. L. Hammerschmidt, "Free space microwave propagation," *RCA Rev.*, vol. 9, pp. 159–166; March, 1948.
(477) R. E. Samuelson, "Field tests for citizens band," *Electronics*, vol. 21, pp. 92–96; January, 1948.
(478) H. J. Peake, "Radio attenuation," *Tele-Tech*, vol. 7, p. 45; August, 1948. (A brief account of a paper presented before URSI-IRE meeting, May, 1948.)
(479) J. H. Battison, "F-M service areas" and "Tele service areas," *Electronics*, vol. 21, p. 122; June and October, 1948.

Mathematical Treatment of Diffraction and Duct Propagation

The difficulty of computing the field strength over a curved earth beyond the horizon, and particularly in the vicinity of the horizon, has long been recognized. During the war, Booker, Hartree, and others exploited the mode theory of propagation in atmospheric ducts. Booker showed that the mechanism of diffraction at the horizon is essentially that of a leaky waveguide. The problem then became one of calculating the characteristic values of the normal modes for various assumed distributions of refractive index with height. Solutions were effected for the first mode for various distributions, including power-law, exponential, and linear-exponential, and the effects of finite earth constants were determined.

(480) J. Voge, "Guided propagation in metal tubes and in the atmosphere," *Onde Élec.*, vol. 28, pp. 29–38; January, 1948.
(481) C. L. Pekeris, "The field of a microwave dipole antenna in the vicinity of the horizon, II," *Jour. Appl. Phys.*, vol. 18, pp. 1025–1027, November, 1947.
(482) C. L. Pekeris and W. S. Ament, "Characteristic values of the first normal mode in the problem of propagation of microwaves through an atmosphere with a linear-exponential modified index of refraction," *Phil. Mag.*, vol. 38, pp. 801–823; November, 1947.
(483) C. L. Pekeris, "The effect of ground constants on the characteristics values of the normal modes in nonstandard propagation of microwaves," *Jour. Appl. Phys.*, vol. 19, pp. 102–105; January, 1948.
(484) G. G. Macfarlane, "The application of a variational method to the calculation of radio-wave-propagation curves for an arbitrary refractive index profile in the atmosphere," *Proc. Phys. Soc.* (London), vol. 61, part 1, pp. 48–58; July, 1948.
(485) H. Bremmer, "On the theory of spherically symmetric inhomogeneous waveguides, in connection with tropospheric radio propagation and under-water acoustic propagation," *Philips Res. Rep.*, vol. 3, pp. 102–120; April, 1948.
(486) H. Bremmer, "On the propagation of radio waves around the earth," *Physica*, vol. 14, pp. 301–318; June, 1948.

Radio Meteorology—General

Many studies over recent years have established the intimate relation between radio propagation at frequencies above 30 Mc and the weather. Of particular interest is the condition of horizontal stratification in the atmosphere in which a layer of relatively warm, dry air overlies a layer of moist, cool air. This produces a minimum of refractive index aloft and may lead to trapping, or the formation of a duct. Various meteorological factors, such as nocturnal radiation from the surface, trade winds, off-shore winds at a coast line, or subsidence may produce superrefraction. Other factors may lead to substandard refraction. Most nearly standard propagation has been found to occur in a turbulent, well-mixed atmosphere. Cloud and haze layers are often found to be associated with stratification which leads to anomalous propagation. Several reviews of recent and current activity in this field were published during 1948.

(487) R. L. Smith-Rose, "Meteorology and the propagation of radio waves," *Nature*, vol. 161, pp. 145–146; January 24, 1948.
(488) J. Voge, "Meteorological effects on the propagation of very short waves," *Onde Élec.*, vol. 28, pp. 99–107; March, 1948.
(489) A. Perlat, "Meteorology and radio," *Onde Élec.*, vol. 28, pp. 44–54; February, 1948.
(490) J. R. Gerhardt, "The symposium on micrometeorology at Austin, Texas, March 18–19, 1948," *Bull. Amer. Met. Soc.*, vol. 27, pp. 367–374; September, 1948.

Refractive Index Studies of Low Atmospheric Layers

Since most ultra-high-frequency and microwave propagation paths lie entirely within the region between the surface and an elevation of 1,000 feet, especially for moderate distances and ground-based terminals, and since experience has shown that the most marked anomalies of refractive index gradient occur below the 1,000-foot level, the bulk of the experimental investigation has been confined to this region. In more conventional measuring techniques, point measurements of air temperature and wet-bulb temperature are made over a given vertical range with relatively slow instruments, the entire ascent requiring as much as 15 to 30 minutes. Evidence indicates that rapid fluctuations in time and position occur which are entirely obscured in such measurements. This has led to the development of faster instruments and methods. The fine-detail investigation of refractive index is generally termed "micrometeorology." Extensive measurements of vertical gradients of temperature and humidity over the sea off the New England coast were recently reported.

(491) K. H. Jehn, "The experimental micrometeorological field station at Manor, Texas," *Bull. Amer. Met. Soc.*, vol. 29, pp. 367–374, September, 1948.
(492) J. R. Gerhardt and W. E. Gordon, "Microtemperature fluctuations," *Jour. Met.*, vol. 5, pp. 197–203; October, 1948.
(493) G. Emmons, "Vertical distributions of temperature and humidity over the ocean between Nantucket and New Jersey," *Physical Oceanography and Meteorology*, vol. 10, 89 p.; December, 1947. (Published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institute.)

Velocity of Propagation Studies

In order to establish the accuracy obtainable with British radio aids to navigation, such as gee, decca, and oboe, which utilize propagation times of a short pulse from several fixed stations for establishing systems of co-ordinates, careful measurements of the velocity of propagation were made. The results agreed well with the accepted figure for the velocity of light when allowance was made for the effect of earth currents at 100 kc.

(494) E. B. Mendoza, "A method of determining the velocity of radio waves over land on frequencies near 100 kc/s," *Jour. IEE* (London), vol. 94, part III, pp. 396–398; November, 1947.
(495) F. E. Jones, "The measurement of the velocity of propagation of centimetre radio waves as a function of height above the earth," *Jour. IEE* (London), vol. 94, part III, pp. 399–401; November, 1947.
(496) Discussion of the three above papers, *Jour. IEE* (London), vol 94, part III, pp. 402–406; November, 1947.

Propagation Experiments

Various investigations to determine the service and interference ranges of FM and television transmitters were covered in the literature. New information regarding the interference capabilities of vhf signals at long distances and public pressure for assignment of additional FM and TV channels led the Federal Communications Commission to re-examine its standards and to hold an industry-government conference to review the available propagation data with respect to frequencies in the band 475 to 890 Mc.

Investigations indicated that surface ducts may produce interfering signals far beyond the horizon, particularly during hours of darkness, and that tropospheric refraction and reflection give rise to unexpectedly strong, fluctuating signals at long ranges, even in the complete absence of surface ducts. Statistical analyses of such field-strength data to indicate the percentage of time during which, and the percentage of locations at which, various signal levels are exceeded were used for lack of a sufficiently complete understanding of the propagation phenomena to permit reliable theoretical predictions. Further studies of selective fading were reported.

(497) T. W. Bennington, "Radio propagation in the frequency range 40–100 mc/s," *BBC Quart.*, vol. 2, pp. 233–243; January, 1948.
(498) G. W. Pickard and H. T. Stetson, "A study of tropospheric reception at 42.8 Mc and meteorological conditions," Proc. I.R.E., vol. 35, pp. 1445–1450; December, 1947.
(499) G. H. Brown, J. Epstein, and D. W. Peterson, "Comparative propagation measurements; television transmitters at 67.25, 288, 510, and 910 Mc," *RCA Rev.*, vol. 9, pp. 177–201; June, 1948.
(500) W. L. Carlson, "Simultaneous field-strength recordings on 47.1, 106.5, and 700 Mc," *RCA Rev.*, vol. 9, pp. 76–84; March, 1948.
(501) G. V. Waldo, "East coast tropospheric and sporadic 'E' field-intensity measurements on 47.1, 106.5 and 700 Mc," TID Report 2.4.4, Federal Communications Commission, Washington, D. C.; September 24, 1948.
(502) W. C. Boese and H. Fine, "Summary of tropospheric propagation measurements and the development of empirical vhf propagation charts," TID Report 2.4.5, Federal Communications Commission, Washington, D. C.; October 20, 1948.
(503) L. E. Thompson, "Microwave propagation experiments," Proc. I.R.E., vol. 36, pp. 671–675; May, 1948.
(504) W. J. Bray, H. G. Lillicrap, and F. C. Owen, "The fading machine and its use for the investigation of the effects of frequency selective fading," *Jour. IEE* (London), vol. 94, Part IIIA, pp. 283–297; 1947.

Extensive tests have been made over a range of microwave frequencies to determine the most useful frequency, the maximum station spacing, and other required characteristics of microwave radio relay links. Thompson cited advantages gained with vertically spaced diversity antennas. Further reference to the application of such studies appears in the section of the present Review relating to Radio Transmitters.

Price showed that theoretical prediction of the existence of shadow zones above certain inversions, in which aircraft could not be detected at frequencies around 200 Mc, was verified by experiments.

(505) W. L. Price, "Radio shadow effects produced in the atmosphere by inversions," *Proc. Phys. Soc.* (London), vol. 61, part 1, pp. 59–77; July, 1948.

Klein and Dufour reported that, in certain tests made from an elevated transmitting station in the Alps, horizontal polarization yielded stronger fields in the optical zone and vertical polarization in the zone beyond optical range. Other investigators had reported no effect from a change in plane of polarization under conditions where the surface wave is negligible.

(506) W. Klein and J. Dufour, "Broadcasting research with FM ultra-short wave," *Tech. Mitt. Schweiz. Telegr.-Teleph. Verw.*, vol. 26, pp. 1–21 and 61–83; February 1 and April 1, 1948. (In German.)

Atmospheric Absorption

Much work has been done in determining the absorption of radio waves by water vapor at a 1.3-cm wavelength. Lamont reported the results of measurements of attenuation by oxygen molecules in a wavelength region around 5 mm.

(507) H. R. L. Lamont, "Atmospheric absorption of microwaves," *Phys. Rev.*, vol. 74, p. 353; August 1, 1948.

Detection of Storms

Numerous studies indicated the possibility of determining, with useful accuracy, the intensity of rainfall at a distant point (around 100 km) by a radar echo from that point. Semiempirical formulas were made available for relating reflected power with drop size and number, and with rainfall intensity.

(508) J. R. Marshall, R. C. Langville, and W. McK. Palmer, "Measurement of rainfall by radar," *Jour. Met.*, vol. 4, pp. 186–192; December, 1947.
(509) A. F. Spilhaus, "Drop size, intensity, and radar echo of rain," *Jour. Met.*, vol. 5, pp. 161–164; August, 1948.
(510) R. Wexler, "Rain intensities by radar," *Jour. Met.*, vol. 5, pp. 171–173; August, 1948.
(511) B. A. Shlyamin, "Radar and weather," *Priroda*, No. 3, pp. 50–52; 1947. (In Russian.)

Meteorological Echos

Spectacular results were reported from a number of sources, indicating that useful radar reflections were obtained from cloud and haze layers and even from the boundaries of air masses in clear weather when intense beams at centimeter wavelengths were directed vertically. Measurements of refractive-index gradients with very fast instruments were made which indicated the existence of sufficiently high gradients in turbulent air to account for observed reflections.

(512) M. W. Baldwin, Jr., "Radar reflections from the lower atmosphere," Proc. I.R.E., vol. 36, p. 363; March, 1948.
(513) W. E. Gordon, "A theory of radar reflections from the lower atmosphere," Proc. I.R.E., vol. 37, pp. 41–44; January, 1949.

Angle-of-Arrival Studies

The Electrical Engineering Research Laboratory of the University of Texas continued its work in the very accurate measurement of the phase front of 3.2-cm waves and the correlation of such measurements with observed refractive-index gradients. This work shed light on the mechanism of atmospheric refraction and ground reflection.

(514) A. W. Straiton, W. E. Gordon, and A. H. LaGrone, "A method of determining the angle of arrival," *Jour. Appl. Phys.*, vol. 19, pp. 524–533; June, 1948.
(515) A. W. Straiton and J. R. Gerhardt, "Results of horizontal mi-

crowave angle-of-arrival measurements by the phase-difference method," PROC. I.R.E., vol. 36, pp. 916–922; July, 1948.
(516) E. W. Hamlin and W. E. Gordon, "Comparison of calculated and measured phase difference at 3.2 cm wavelength," PROC. I.R.E., vol. 36, pp. 1218–1223; October, 1948.

Ionospheric Propagation

The long-term program for the collection and dissemination of ionospheric data continued to be centralized at the Central Radio Propagation Laboratory, National Bureau of Standards, Washington, D. C. Functions of this Laboratory were described in a paper.

(517) J. H. Dellinger and N. Smith, "Developments in radio sky-wave propagation research and applications during the war," PROC. I.R.E., vol. 36, pp. 258–266; February, 1948.

The handbook which was a wartime product of the Bureau of Standards group was superseded by a volume which is more complete and up to date.

(518) "Ionospheric Radio Propagation," National Bureau of Standards Circular No. 462, 1948.

Another volume was published which offered a somewhat different treatment of the numerous factors influencing ionospheric communications.

(519) D. H. Menzel, "Elementary Manual of Radio Propagation," Prentice-Hall, Inc., New York, N. Y., 1948.

A new volume by Mitra represented an especially important contribution to knowledge of the entire upper atmosphere. In it he assembled the available information from a wide variety of sources and combined it in a logical and instructive fashion.

(520) S. K. Mitra, "The Upper Atmosphere," Royal Asiatic Society of Bengal, 1 Park St., Calcutta, India.

The results of a long series of ionospheric observations in Peru, Western Australia, and Alaska were published in three volumes by the Carnegie Institution of Washington. Introductory chapters in each volume review some of the results of analyses and describe the apparatus used at each station. The basic data which comprise a major portion of the volumes are of especial value because of the long periods covered.

(521) H. W. Wells and L. V. Berkner, "Ionospheric research at Huancayo Observatory, Peru, January 1938–June, 1946," *Carnegie Inst. of Washington Pub.* 175, vol. XI, 1947.
(522) S. L. Seaton, H. W. Wells, and L. V. Berkner, "Ionospheric research at College, Alaska, July, 1941–June, 1946," *Carnegie Inst. of Washington Pub.* 175, vol. XII, 1947.
(523) L. V. Berkner and H. W. Wells, "Ionospheric research at Watheroo Observatory, Western Australia, June, 1938–June, 1946," *Carnegie Inst. of Washington Pub.* 175, vol. XIII, 1948.

Investigators, both here and abroad, continued to work on the interesting problem of interpretation of ionospheric observations in terms of oblique-incidence radio wave propagation, or vice versa. Some attempts were made to explain the small discrepancies which were occasionally observed. Good progress was made in the forecasting of ionospheric conditions and in the application of knowledge of the ionosphere to the solution of general, as well as specific communication problems.

(524) W. J. G. Beynon, "Some observations of the maximum frequency of radio communication over distances of 1000 km and 2400 km," *Proc. Phys. Soc.*, vol. 59, pp. 521–534; July 1, 1947.
(525) F. J. Hewitt, J. Hewitt, and T. L. Wadley, "A frequency prediction service for Southern Africa," *Trans. S. Afr. Inst. Elec. Eng.*, vol. 38, part 7, pp. 180–193; July, 1947.
(526) K. Rawer, "The forecasting of ionosphere critical frequencies," *Rev. Sci.* (Paris), vol. 85, pp. 234–235; February 15, 1947.
(527) C. Domb and M. H. L. Pryce, "The calculation of field strengths over a spherical earth," *Jour. IEE* (London), part III, vol. 94, pp. 325–336; September, 1947.
(528) J. E. Jacke, Jr., and A. H. Waynick, "Restricted-range sky-wave transmission," PROC. I.R.E., vol. 36, pp. 787–793; June, 1948.
(529) T. W. Bennington, "Ionosphere review: 1947," *Wireless World*, vol. 54, pp. 44–47; February, 1948.
(530) O. Zinke, "Propagation of long waves round the earth," *Frequenz*, vol. 1, pp. 16–22; October, 1947.
(531) E. V. Appleton, "The investigation and forecasting of ionospheric conditions," *Jour. IEE* (London), part IIIA, vol. 94, no. 11, pp. 186–199; 1947; and summary, *Jour. IEE*, part I, vol. 94, pp. 483–484; October, 1947.
(532) K. W. Tremellen and J. W. Cox, "The influence of wave-propagation no the planning of short-wave communication," *Jour. IEE* (London), part IIIA, vol. 94, no. 11, pp. 200–219; 1947; and summary, *Jour. IEE*, part I, vol. 94, pp. 485–486; October, 1947.
(533) T. W. Bennington, "Techniques for the application of ionosphere data to practical short wave transmission and reception," *Proc. RSGB*, no. 2, pp. 1–7; 1948.
(534) H. E. Hallborg and S. Goldman, "Radiation angle variations from ionosphere measurements," *RCA Rev.*, vol. 8, pp. 342–351; June, 1947.

The exhibit, "Characteristics of the upper atmosphere," prepared by the Air Matériel Command, Wright-Patterson Air Force Base, for the March, 1948, IRE National Convention was dynamically presented and capably described.

Exploratory research involving the propagation of radio waves in the ionosphere contributed to knowledge of the upper atmosphere. Analyses of results facilitated the establishment of parameters for temperature, pressure, and gaseous composition. A better understanding of the relationship between "virtual" and "true" ionospheric heights was established. Theoretical development established bases for tidal motions in the outer atmosphere and a differential-penetration effect influencing the development of magnetic storms.

(535) R. Penndorf, "The temperature of the upper atmosphere," *Bull. Amer. Met. Soc.*, vol. 27, pp. 331–342; June, 1946.
(536) B. K. Banerjea, "On the propagation of electromagnetic waves through the atmosphere," *Proc. Roy. Soc. A*, vol. 190, pp. 67–81; June 17, 1947.
(537) J. A. Pierce, "The true height of an ionospheric layer," *Phys. Rev.*, vol. 71, pp. 698–706; May 15, 1947.
(538) P. S. Epstein, "Radio-wave propagation and electromagnetic surface waves," *Proc. Nat. Acad. Sci.*, vol. 33, pp. 195–199; June, 1947.
(539) D. F. Martyn, "Atmospheric tides in the ionosphere: Part 2—Lunar tidal variations in the *F* region near the magnetic equator," *Proc. Roy. Soc. A*, vol. 190, pp. 273–288; July 8, 1947.
(540) H. Rakshit, "Distribution of molecular and atomic oxygen in the upper atmosphere," *Indian Jour. Phys.*, vol. 21, pp. 57–68; April, 1947.
(541) V. D. Gusev, "One of the reasons for a change of amplitude of a single pulse reflected from the ionosphere," *Bull. Acad. Sci.* (URSS), sér. phys., vol. 11, no. 2, pp. 195–201; 1947.
(542) A. Pande, "Critical surveys of recent theoretical work on the ionosphere," *Terr. Mag. Atmo. Elec.*, vol. 52, pp. 375–396; September, 1947.
(543) S. L. Seaton, "Rate of electron production in the ionosphere," *Phys. Rev.*, vol. 72, pp. 712–714; October 15, 1947.
(544) L. A. Manning, "The determination of ionospheric electron distribution," PROC. I.R.E., vol. 35, pp. 1203–1207; November, 1947.
(545) T. L. Eckersley, "Differential-penetration theory," *Terr. Mag. Atmo. Elec.*, vol. 52, pp. 305–314; September, 1947.
(546) H. W. Wells, "Polar radio disturbances during magnetic bays," *Terr. Mag. Atmo. Elec.*, vol. 52, pp. 315–320; September, 1947.
(547) D. F. Martyn and S. Chapman, "Location of the currents causing the solar and lunar diurnal magnetic variations," *Nature* (London), vol. 160, pp. 535–537; October 18, 1947.

(548) P. H. Liang and E. V. Appleton, "F_1 ionization and geomagnetic latitudes," *Nature* (London), vol. 160, pp. 642–643; November 8, 1947.
(549) J. L. Alpert, "On the anistropy effect of the ionosphere," *Compt. Rend. Acad. Sci.* (URSS), vol. 53, pp. 699–702; September 20, 1946.
(550) J. E. Hacke, Jr., "An approach to the approximate solution of the ionosphere absorption problem," Proc. I.R.E., vol. 36, pp. 724–728; June, 1948.
(551) M. N. Saha, B. K. Banerjea, and U. C. Guha, "On the propagation of E.M. waves through the upper atmosphere," *Indian Jour. Phys.*, vol. 21, pp. 181–198; August, 1947.
(552) C. F. Booth and G. Gregory, "The effect of Doppler's principle on the comparison of standard frequencies over a transatlantic radio path," *P.O. Elec. Eng. Jour.*, vol. 40, part 4, pp. 153–158; January, 1948.
(553) B. Decaux, "Modification of the frequency of radio waves during propagation," *Compt. Rend. Acad. Sci.* (Paris), vol. 226, pp. 328–329; January 26, 1948.
(554) R. Jouaust, "Influence of wind on the frequency of radio waves," *Compt. Rend. Acad. Sci.* (Paris), vol. 226, pp. 329–330; January 26, 1948.
(555) D. R. Bates and H. S. W. Massey, "The bsaic reactions in the upper atmosphere. Part 2—The theory of recombination in the ionized layers," *Proc. Roy. Soc. A*, vol. 192, pp. 1–16; December 23, 1947.
(556) R. A. Helliwell. "On the measurement of ionospheric virtual height at 100 kilocycles," *Phys. Rev.*, vol. 73, p. 77; January 1, 1948.
(557) R. Rivault, "The fine structure of atmospherics. Contribution to the study of the ionosphere," *Compt. Rend. Acad. Sci.* (Paris), vol. 221, pp. 540–542; November 5, 1945.
(558) A. Haubert, "Contribution to the study of the fine structure of atmospherics," *Compt. Rend. Acad. Sci.* (Paris), vol. 221, pp. 543–545; November 5, 1945.
(559) R. Rivault, "Origin of certain types of atmospherics," *Compt. Rend. Acad. Sci.* (Paris), vol. 226, pp. 1300–1302; April 19, 1948.
(560) D. F. Martyn, "Solar radiation in the radio spectrum: Part 1—Radiation from the quiet sun," *Proc. Roy. Soc. A*, vol. 193, pp. 44–59; April 22, 1948.

Several eclipse expeditions were made to Brazil for ionospheric recordings on May 20, 1947. Observations were conducted by a National Bureau of Standards group with panoramic equipment giving four records per minute. Preliminary analyses of the motion-picture record were discussed before the IRE Washington Section, in December, 1947. French observers reported E and F_1 layer effects in phase with the eclipse, but did not agree regarding the F_2 effect. Local fluctuations in F_2 ionization probably account for the apparent discrepancies. Approximate recombination coefficients calculated from the May 20, 1947, eclipse are in good agreement with those obtained by Pierce for October 1, 1940.

(561) J. A. Pierce, "The ionospheric eclipse of October 1, 1940," Proc. I.R.E., vol. 36, pp. 8–16; January, 1948.
(562) Y. Rocard, "Provisional results obtained by the French Mission to Brazil during the total solar eclipse, 20th May 1947," *Rev. Sci.* (Paris), vol. 85, p. 618; June 1 and 15, 1947.
(563) J. F. Denisse, P. Seligmann, and R. Gallet, "Results of ionosphere observations during the total eclipse of the Sun 20th May 1947," *Compt. Rend. Acad. Sci.* (Paris), vol. 225, pp. 1169–1171; December 10, 1947.
(564) S. Gejer and P. Åkerlind, "Some experimental results obtained by ionospheric investigations in Sweden during the total solar eclipse of July 9, 1945," *Terr. Mag. Atmo. Elec.*, vol. 52, pp. 479–491; December, 1947.

Observations of the aurora established conditions for excitation and ionization in the outer atmosphere. Several stages of ionization of the oxygen atom were identified. Some effects of auroral-zone absorption were discussed. It was also suggested that a sporadic layer (probably similar to sporadic E) is often formed in the auroral zone which is capable of supporting communications on unusually high frequencies. One group made an interesting observation of radio echoes at 460-km range apparently from a luminescent cloud near the zenith which appeared and disappeared with the echo.

(565) K. Rawer, "Ionospheric perturbations in the zone of polar auroras," *Rev. Sci.* (Paris), vol. 85, pp. 287–288; March 1–15, 1947.
(566) A. C. B. Lovell, J. A. Clegg, and C. D. Ellyett, "Radio echoes from the aurora borealis," *Nature* (London), vol. 160, p. 372; September 13, 1947.
(567) W. Petrie, "Excitation conditions in the upper atmosphere as determined from a study of atomic emission lines in the auroral spectrum," *Canad. Jour. Res.*, vol. 25, pp. 293–301; September, 1947.

The reflection of radio waves from ionized meteor trails provided a fruitful field of research. A number of simultaneous observations of meteors and radio reflections established a direct relationship whenever the geometry of the meteor trail is suitable. Diurnal and seasonal characteristics of transient bursts of atmospheric ionization showed close correlation with known characteristics of meteors. Estimates were made of ionization in a meteor trail and of particle size. An amateur observer, C. A. Little, reported an unexpected increase in average range shortly after sunrise.

(568) E. V. Appleton and R. Naismith, "The radio detection of meteor trails and allied phenomena," *Proc. Phys. Soc.* (London), vol. 59, pp. 461–472; May 1, 1947.
(569) D. W. Heightman and T. W. Bennington, "Whistling meteors," *Wireless World*, vol. 53, p. 219; June, 1947.
(570) E. W. Allen, Jr., "Reflections of very-high-frequency radio waves from meteoric ionization," Proc. I.R.E., vol. 36, pp. 346–353; March, 1948.
(571) A. C. B. Lovell, "Electron density in meteor trails" *Nature* (London), vol. 160, pp. 670–671; November 15, 1947.
(572) P. M. Millman, D. W. R. McKinley, and M. S. Burland; A. C. B. Lovell, "Combined radar, photographic and visual observations of the Perseid meteor shower of 1947," *Nature* (London), vol. 161, pp. 278–280; February 21, 1948.
(573) R. Jouaust, "Radio and meteorites," *Onde Élec.*, vol. 28, pp. 150–157; April, 1948.
(574) J. P. M. Prentice, A. C. B. Lovell, and C. J. Banwell, "Radio echo observations of meteors," *Mon. Not. R. Astr. Soc.*, vol. 107, no. 2, pp. 155–163; 1947.
(575) A. C. B. Lovell, C. J. Banwell, and J. A. Clegg, "Radio echo observations of the Giacobinid meteors 1946," *Mon. Not. R. Astr. Soc.*, vol. 107, no. 2, pp. 164–175; 1947.
(576) J. S. Hey, S. J. Parsons, and G. S. Stewart, "Radar observations of the Giacobinid meteor shower, 1946," *Mon. Not. R. Astr. Soc.*, vol. 107, no. 2, pp. 176–183; 1947.

Rockets were used for upper-atmospheric research, reaching altitudes of nearly 200 km. The opportunities for direct sampling of the upper atmosphere offer real promise of important advances in knowledge. The technical problems of instrumentation are great, but the goals justify a concentrated effort in exploitation of this new research tool.

(577) N. Best, R. Havens, and H. La Gow, "Pressure and temperature of the attmosphere to 120 km," *Phys. Rev.*, vol. 71, pp. 915–916; June 15, 1947.
(578) H. E. Newell, Jr., "Exploration of the upper atmosphere by means of rockets," *Sci. Mon.*, vol. 64, pp. 453–463; June, 1947.
(579) Upper Atmospheric Research Report No. I, NRL Report No. R-2955; October 1, 1946.
(580) Upper Atmospheric Research Report No. II, NRL Report No. R-3030; December 30, 1946.
(581) Upper Atmospheric Research Report No. III, NRL Report No. R-3120; April, 1947.
(582) Upper Atmospheric Research Report No. IV, NRL Report No. R-3171; October 1, 1947.

Apparatus for ionospheric research was improved and special equipment developed as required. The first "production-line" ionospheric recorders of commercial manufacture were submitted to the National Bureau of Standards for tests. A high-speed recorder developed at the Department of Terrestrial Magnetism, Carnegie Institute of Washington, for study of rapid ionospheric changes was successfully operated at a rate of 12 records per minute. Measurements on wide-band properties of various antennas have contributed to more efficient performance of ionospheric apparatus. High-power equipment was developed for observation of back scatter and other special projects.

(583) T. A. Wadley, "Single-band ionosphere recorder, 0.1–20 Mc," *South African Council for Sci. and Indus. Res.*, Johannesburg, South Africa.
(584) P. G. Sulzer, "High-power ionosphere-measuring equipment," PROC. I.R.E., vol. 36, pp. 389–395; March, 1948.
(585) "Ionosphere recorder," *Tele-Tech*, vol. 6, pp. 79–81; December, 1947.
(586) H. A. Thomas and R. G. Chalmers, "An improved ionospheric height recorder," *Jour. IEE* (London), part III, vol. 95, pp. 7–13; January, 1948.
(587) H. N. Cones, "Interim report on experimental broad-band antennas for vertical-incidence ionosphere sounding," CRPL no. 5-3; May 3, 1948.

Waveguides, Transmission Lines, and Cavity Resonators

Many papers in this field were published during the year; for the most part they were mainly concerned with refinements of established theory and of experimental techniques. Here there are mentioned only a few theoretical papers which appear to be of rather general interest, omitting many others which may be of equal significance but which deal with more limited aspects of the general field.

Three books, which were published since the last report, give between them a good idea of the present state of development of the theory and technique of waveguides and transmission lines.

(588) L. G. H. Huxley, "A Survey of the Principles and Practice of Wave Guides," Cambridge University Press, The Macmillan Co., New York, N. Y., 1947.
(589) A. B. Bronwell and R. E. Beam, "Theory and Application of Microwaves," McGraw-Hill Book Co., Inc., New York, N. Y., 1947.
(590) G. L. Ragan (editor), "Microwave Transmission Circuits," Radiation Laboratory, MIT, McGraw-Hill Book Co., Inc., New York, N. Y., 1948.

Waveguides. In waveguide theory one of the main objects of study throughout the year was the effect of various types of discontinuity on the propagation of electromagnetic waves. If diaphragms and circular apertures are inserted at regular intervals along a circular guide, the system may be designed to vary the resulting phase velocity, and also to act as a band-pass filter.

(591) E. L. Chu and W. W. Hansen, "The theory of disk-loaded wave guides," *Jour. Appl. Phys.*, vol. 18, pp. 996–1008; November, 1947.
(592) J. C. Slater, "Electromagnetic waves in iris-loaded waveguides," Research Laboratories of Electronics, MIT Technical Report no. 48, 18 pp.; September 19, 1947.

The theory of the transmission of an electromagnetic wave through a single iris was discussed in greater detail in a Russian paper.

(593) M. I. Kontorovich, "On the penetration of an electromagnetic field through a diaphragm in a wave guide," *Jour. Tech. Phys.* (USSR), vol. 17, no. 3, pp. 269–282; 1947.

The scattering of a $TE_{1,1}$ wave by suspending a circular metallic ring in a circular guide was also discussed.

(594) P. Feuer and A. S. Akeley, "Scattering of electromagnetic radiation by a thin circular ring in a circular wave guide," *Jour. Appl. Phys.*, vol. 19, pp. 39–47; January, 1948.

The mathematical theory of slots in a rectangular guide was developed in some detail, using transmission-line analogies.

(595) A. F. Stevenson, "Theory of slots in rectangular wave guides," *Jour. Appl. Phys.*, vol. 19, pp. 24–38; January, 1948.

There were several papers which discussed the effect of changing the shape of a waveguide. It was found that all waves in a circular guide, other than those of E_0 and H_0 type, became unstable if the walls of the guide were flattened.

(596) M. Jouguet, "Wave propagation in a guide of nearly circular section," *Compt. Rend.* (Paris), vol. 226, pp. 1436–1438; May 3, 1948.

It was reported that, if oval sections of a guide are introduced, the plane of polarization of a plane polarized wave may be rotated, or the wave may be transformed to an elliptically or circularly polarized wave.

(597) M. Jouget, "Properties and applications of wave guides of oval section," *Compt. Rend.* (Paris), vol. 226, pp. 1515–1517; May 10, 1948.
(598) E. Safa, "Nearly circular polarization by means of flattened cylindrical wave guides," *Ann. Télécommun.*, vol. 2, pp. 356–363; November, 1947.

Another very interesting method of changing the polarization of a wave, using circular guide sections, was announced. This used two plane-polarized waves, at right angles to each other, traveling with different phase velocities, to obtain any desired phase shift in the outgoing wave or any desired polarization.

(599) A. G. Fox, "An adjustable waveguide phase changer," PROC. I.R.E., vol. 35, p. 1489–1498; December, 1947.

A mathematical treatment of bends in rectangular guides was published, using matrix theory first developed for a straight guide.

(600) S. O. Rice, "Reflections from circular bends in rectangular waveguides-matrix theory," *Bell Sys. Tech. Jour.*, vol. 27, pp. 305–349; April, 1948.

Another paper discussed the effect of a complete circumferential slot in a cylindrical guide.

(601) H. Buchholz, "The influence of joints on the field in a wave guide," *Arch. Elek. Übertragung*, vol. 2, pp. 14–22; January, 1948.

The coupling of rectangular guides along a common flat face by means of pairs of slots was used to obtain a directional coupler.

(602) H. J. Riblet and T. S. Saad, "A new type of waveguide directional coupler," PROC. I.R.E., vol. 36; pp. 61–64; January, 1948.

One paper discussed the excitation of an electromagnetic field in a waveguide.

(603) J. S. Gooden, "Field surrounding an antenna in a wave guide," *Jour. IEE* (London), vol. 95, part III, pp. 346–350; September, 1948.

Another discussed the field in a dielectric guide due to a suitably oriented current filament.

(604) R. M. Whitmer, "Fields in nonmetallic waveguides," Proc. I.R.E., vol. 36, pp. 1105-1109; September, 1948.

Transmission Lines. In transmission-line theory there were many papers published in which lines were used as parts of complex transmission systems, but there were also a few papers discussing general theoretical aspects. One of these gave the theory of a coaxial line in which the outer conductor was of finite thickness.

(605) F. Pollaczek, "Theory of the coaxial cable," *Jour. de Phys. et Radium*, vol. 8, pp. 215-224 and 244-251; July and August, 1947.

Other papers discussed dielectric inserts between coaxial conductors. One of these considered continuous dielectric bridges by analyzing an equivalent system of two parallel planes separated by alternate layers of air and dielectric.

(606) H. Buchholz, "Wave propagation in concentric broad-band cable with continuous dielectric bridges," *Arch. Elek. Übertragung*, vol. 1, pp. 137-150; September-October, 1947.

Another presented the idea that concentric disks between the conductors could be replaced by shunt capacitances.

(607) J. W. Miles, "Plane discontinuities in coaxial lines," Proc. I.R.E., vol. 35, pp. 1498-1502; December, 1947.

The propagation of impulses along a coaxial line was studied, and used to locate and evaluate irregularities in the line structure.

(608) L. A. Zhekulin, "Propagation of signals along a coaxial cable," *Radiotekhnika*, vol. 3, no. 1, pp. 22-35; 1948.

(609) P. Herreng and J. Ville, "Study of impedance irregularities in coaxial cables by oscillographic observation of impulse echoes," *Cables and Trans.* (Paris), vol. 2, pp. 111-130 and 219-232; April and July, 1948.

Another paper of interest discussed the use of a tee-structure of coaxial lines to obtain a low-pass filter.

(610) D. E. Mode, "Low-pass filters using coaxial transmission lines as elements," Proc. I.R.E., vol. 36, pp. 1376-1383; November, 1958.

Cavity Resonators. A general mathematical discussion of coaxial cavity resonators was published in two papers.

(611) M. Kline, "Some Bessel equations and their application to guide and cavity theory," *Jour. Math. Phys.* (MIT), vol. 27, pp. 37-48; April, 1948.

(612) H. B. Dwight, "Tables of roots for natural frequencies in coaxial type cavities," *Jour. Math. Phys.* (MIT), vol. 27, pp. 84-89; April, 1948.

A special type of cavity resonator using a guide with a parallelogram cross section was described and shown to have very high Q values for the fundamental mode.

(613) K. F. Niessen, "On a cavity resonator of high quality for the fundamental frequency," *Appl. Sci. Res.*, vol. B1, no. 1, pp. 18-34; 1947.

The design of a cavity attenuator to eliminate unwanted modes by proper current distribution was described.

(614) J. J. Freeman, "Theory and design of a cavity attenuator," *Jour. Res. Nat. Bur. Stand.*, vol. 40, pp. 235-243; March, 1948.

Forced oscillations in spherical resonators were discussed.

(615) O. E. H. Rydberg, "On the forced electromagnetic oscillations in spherical resonators," *Phil. Mag.*, vol. 39, pp. 633-644; August, 1948.

Mention should be made of the use of a cavity resonator to measure the velocity of electromagnetic waves.

(616) L. Essen and A. C. Gordon Smith, "Velocity of propagation of electromagnetic waves derived from the resonant frequencies of a cylindrical cavity resonator," *Proc. Roy. Soc. London*, vol. 194, pp. 348-361; September 2, 1948.

Noise

During recent years, and especially during the war, there was a large increase made in the use of the higher-frequency end of the radio spectrum; that is, of frequencies from 50 Mc up to those in the microwave region. With this increased use of the higher frequencies came a realization of the importance of noise in limiting the usefulness of radio systems. Noise problems were attacked from both a theoretical and experimental standpoint.

At the higher frequencies, transit time plays an important part in the operation of electron tubes. It was found to have a very definite influence on the noise generated at these frequencies.

(617) L. C. Petersen, "Space-charge and transit-time effects on signal and noise in microwave tetrodes," Proc. I.R.E., vol. 35, pp. 1264-1272; November, 1947.

(618) N. R. Campbell, V. J. Francis, and E. G. James, "Valve noise and transit time," *Wireless Eng.*, vol. 25, pp. 148-157; May, 1948.

Advances were made in the study of the statistical properties of noise and in noise theory in general.

(619) S. O. Rice, "Statistical properties of a sine wave plus random noise," *Bell Sys. Tech. Jour.*, vol. 27, pp. 109-157; January, 1948.

(620) R. Furth, "On the theory of electrical fluctuations," *Proc. Roy. Soc. A*, vol. 192, pp. 593-615; March, 1948.

(621) J. R. Pierce, "Noise in resistances and electron streams," *Bell Sys. Tech. Jour.*, vol. 27, pp. 158-174; January, 1948.

(622) S. Rodda, "Thermal noise in resistors," *Wireless Eng.*, vol. 25, p. 131; April, 1948.

(623) A. van der Ziel and A. Versnel, "Induced grid noise and total emission noise," *Philips Res. Rep.*, vol. 3, pp. 13-23; February, 1948.

A resurvey of the bandwidth versus speed-of-signaling problem led to a realization that, under certain conditions, it is possible to exchange noise figure for bandwidth without reducing the speed of transmission. Further reference to this matter appears in the section of the present Review relating to Circuits—Noise Studies.

The influence of the type of modulation on the final signal-to-noise ratio of a communication system continued to receive attention, and the advantages of the various pulse-modulation systems were emphasized.

(624) S. Moskowitz and D. D. Greig, "Noise-suppression characteristics of pulse time modulation," Proc. I.R.E., vol. 36, pp. 446-450; April, 1948.

(625) F. L. H. M. Strumpers, "Theory of frequency-modulation noise," Proc. I.R.E., vol. 36, pp. 1081-1092; September, 1948.

(626) L. A. Meacham, "An experimental multichannel pulse code modulation system of toll quality," *Bell Sys. Tech. Jour.*, vol. 27, pp. 1-43; January, 1948.

(627) Z. Jelonek, "Noise problems in pulse communication," *Jour. IEE* (London), part IIIA, vol. 94, no. 13, pp. 533-545, 1947.

(628) G. G. Gouriet, "Random noise characteristics of a pulse-length modulated system of communication," *Jour. IEE* (London), part IIIA, vol. 94, no. 13, pp. 551-555; 1947.

(629) L. J. Libois, "Signal-to-noise ratio in different methods of radio transmission. Spectrum of pulse modulation," *Onde Élec.*, vol. 27, pp. 411–425; November, 1947.

Noise in radar equipment has a very definite bearing on the maximum operating range, and accordingly continued to receive a considerable amount of attention, both theoretical and practical.

(630) S. Walden, "Signal-to-noise ratio in radar," *Wireless Eng.*, vol. 25, pp. 97–98; March, 1948.

It was pointed out that the early circuits of a receiver or an amplifier were mainly responsible for the noise generated in the equipment, and several circuits were devised which would reduce this noise to a minimum. The triode was unanimously selected as the ideal choice for the first amplifier stage, although the manner of employment varied.

(631) H. Wallman, A. B. MacNee, and C. P. Gadsden, "A low-noise amplifier," Proc. I.R.E., vol. 36, pp. 700–708; June, 1948.
(632) H. Goldberg, "Some notes on noise figures," Proc. I.R.E., vol. 36, pp. 1205–1214; October, 1948.
(633) W. Q. Crichlow, "The effects of antenna circuit loss, receiver noise, and external noise on radio reception in the frequency band from 50 to 5,000 kc," *Nat. Bur. Stand. Rep.* CRPL-4-4.
(634) M. J. O. Strutt, "Gain and noise figure at vhf and uhf," *Wireless Eng.*, vol. 25, pp. 21–32; January, 1948.
(635) W. A. Harris, "Some notes on noise theory and its application to input circuit design," *RCA Rev.*, vol. 9, pp. 406–418; September, 1948.

The effect of the bandwidth of the measuring or receiving equipment was determined, thereby permitting the correlation of results from various types of noise measurements. Noise generators were devised to permit the easy testing of equipment.

(636) G. L. Hamburger, "Interference measurement. Effect of receiver band width," *Wireless Eng.*, vol. 25, pp. 55–60; February, 1948; and vol. 25, pp. 89–96; March, 1948.
(637) J. C. Tellier, "Impulse noise generator for testing FM receivers," *Tele-Tech*, vol. 6, pp. 28–30; November, 1947.

In the field of acoustics, studies were made of the effect of noise upon the ear and of the masking of speech by noise.

(638) G. A. Miller, "The perception of short bursts of noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 160–170; March, 1948.
(639) G. A. Miller and W. C. Taylor, "The perception of repeated bursts of noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 171–182; March, 1948.
(640) J. C. R. Licklider, "The influence of interaural phase relations upon the masking of speech by white noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 150–159; March, 1948.
(641) J. Pollack, "Monaural and binaural sensitivity for tones and for white noise," *Jour. Acous. Soc. Amer.*, vol. 20, pp. 52–57; January, 1948.

Radio Astronomy

Galactic Radiation. During the past year, two more papers appeared giving intensity contours for galactic radiation at 64 and 480 Mc. When these contours were compared with previously obtained data, the similarities made it appear that the same basic phenomenon was responsible for radiation at all of these radio frequencies. However, it was suggested that the differences between the several sets of contours were due to the possibility that the higher frequencies represented radiation coming from greater distances from the observer. In general, they showed a more or less slowly varying background luminosity in the direction of the Milky Way upon which was superimposed a number of positions of high intensity. These positions were located, using interferometer techniques, and the available evidence indicated that they approximated point sources. Some of these sources had an intensity which varied with time, and in a general way they were regarded as variable-type radio stars.

(642) J. S. Hey, S. J. Parsons, and J. W. Phillips, "An investigation of galactic radiation in the radio spectrum," *Proc. Roy. Soc.*, vol. 192, pp. 425–445; February 18, 1948.
(643) G. Reber, "Cosmic static," Proc. I.R.E., vol. 36, pp. 1215–1218; October, 1948.
(644) J. G. Bolton and G. J. Stanley, "Variable source of radio-frequency radiation in the constellation of Cygnus," *Nature*, vol. 161, pp. 312–313; February 28, 1948.
(645) J. G. Bolton, "Discrete sources of galactic radio-frequency noise," *Nature*, vol. 162, pp. 141–142; July 24, 1948.
(646) M. Ryle and F. G. Smith, "A new intense source of radio-frequency radiation in the constellation of Cassiopeia," *Nature*, vol. 162, pp. 462–463; September 18, 1948.
(647) J. G. Stanley and G. J. Bolton, "Variable radiation from Cygnus," *Jour. Sci. Res.* (Australia), vol. 1, pp. 58–69; March, 1948.

It has been demonstrated that the intensity of galactic radio waves is an inverse function of frequency.

(648) J. W. Herbstreit and J. R. Johler, "Frequency variation of the intensity of cosmic radio noise," *Nature*, vol. 161, pp. 515–516; April 3, 1948.

Solar Radiation. The study of the sun in the radio-frequency range continued, and a large number of papers appeared on the subject. It was demonstrated that the sun's luminosity is characterized by a normally steady level of radiation upon which are occasionally superimposed bursts of high-intensity radiation lasting for periods of from a few seconds to an hour or more. The normal luminosity increases with wavelength. At a wavelength of 1 cm it is equivalent to black-body radiation at a temperature of 10,000, while at a wavelength of a few meters it is equivalent to black-body radiation at a temperature of more than 1,000,000 degrees. The short-duration bursts may rise to an intensity of several thousand times the normal level. They are more pronounced at the lower frequencies, and are practically unknown above 10,000 Mc.

Measurements at 200 and 10,000 Mc were made on the eclipse of May 20, 1947, by two observers in Brazil. It was found that at 200 Mc the sun appeared much larger than in the visible region, while at 10,000 Mc the sun appeared very little larger than in the visible region. It was demonstrated that a part of the solar radiation comes from sunspots, and that certain types of short-period bursts are directly associated with solar flares. The time-intensity characteristics of short-period solar variations were the subject of study. Numerous theoretical papers appeared in this field.

(649) Khaykin and Chikhachev, "Solar radio waves during total eclipse," *Acad. Phys.* (URSS), vol. 12, pp. 38–43; January and February, 1948.
(650) J. P. Hagen, T. B. Jackson, R. J. McEwan, and C. B. Strang, "Microwave solar radiation during a total eclipse," Joint Meeting, URSI-IRE, Washington, D. C., October 20, 1947.
(651) M. Ryle and D. D. Vonberg, "An investigation of radio frequency radiation from the sun," *Proc. Roy. Soc.*, vol. 193, pp. 98–120; April 22, 1948.
(652) C. W. Allen, "Solar radio noise at 200 Mc," *Monthly Notices Roy. Astr. Soc.*, vol. 107, pp. 386–396; 1947.

(653) G. Reber, "Solar intensity at 480 Mc," PROC. I.R.E., vol. 36, p. 88; January, 1948.
(654) M. Schulkin, F. T. Haddock, K. M. Decker, C. H. Mayar, and J. P. Hagen, "Observation of a solar noise burst at 9,500 Mc and a coincident solar flare," *Phys. Rev.*, vol. 74, p. 840; October 1, 1948.
(655) A. E. Covington. "Solar noise observations at 10.7 cm." PROC. I.R.E.. vol. 36. pp. 454-457; April. 1948.
(656) F. J. Lehany and P. E. Yabsley. "Solar noise at 600 Mc and 1200 Mc," *Nature*, vol. 161, pp. 645-646; April 24, 1948.
(657) S. E. Williams, "Shape of pulses of radio-frequency radiation from the sun," *Nature*, vol. 162, p. 108; July 17, 1948.
(658) R. G. Giovanelli, "Emission of enhanced microwave solar radiation," *Nature*, vol. 161, pp. 133-134; January 24, 1948.
(659) I. L. Thompsen and M. Ryle, "Solar radio emissions and sunspots," *Nature*, vol. 161, pp. 134-136; January 24, 1948.
(660) M. Waldmeier, "Radio waves from solar corona," *Experimentia*, vol. 4, pp. 64-66; February, 1948.
(661) V. A. Bailey, "Spontaneous waves in discharge tubes and in the solar atmosphere," *Nature*, vol. 161, pp. 599-600; April 17, 1948.
(662) D. F. Martyn, "Solar radiation in the radio spectrum—radiation from the quiet sun," *Proc. Roy. Soc.*, vol. 193, pp. 44-59; April 22, 1948.
(663) R. G. Giovanelli, "Magnetic and electric phenomena in solar atmosphere," *Monthly Notices Roy. Astro. Soc.*, vol. 107, pp. 338-355; 1947.
(664) Newton, "Geomagnetic, solar and radio data," *Geo. Sup. Monthly Notices Roy. Astro. Soc.*. vol. 5, pp. 200-215; January, 1948.

The following paper indicates that certain types of enhanced solar radiation were observed as early as 1940 in Denmark.

(665) E. Schott, "175 Mc solar radiation," *Physikalische Blatter'* vol. 3, pp. 159-160; 1947.

Navigation Aids

During 1947 and 1948, a tremendous amount of literature appeared dealing with radar and pulse navigational systems whose elements or techniques were developed during World War II. Civilian agencies have derived from or based upon the military background plans for new systems to be developed and installed for operation up to the year 1963. It is interesting to note that this plan sets up a timetable for inventions, as well as for the production of equipment. The primary emphasis as shown by the literature has been upon systems, rather than on components or new basic principles.

While new navigational systems were proposed, material continued to be released on the great accumulation of information collected during World War II. The MIT Radiation Laboratory Series published by the McGraw-Hill Book Company added several volumes during the year.

Several excellent summaries of the present situation in the field have appeared during the year. This is indicative of the general stock-taking attendant upon the integration of wartime developments into internationally standardized systems.

(666) C. E. Strong, "Position finding by radio; first thoughts on the classification of systems," *Jour. IEE* (London), vol. 95, part 1, pp. 31-35; January, 1948. Also, *Jour. IEE*, vol. 95, part 3, pp. 2-6; January, 1948.
(667) R. Watson Watt, "Radio aids to navigation, *Jour. Inst. Nav.*, vol. 1, pp. 15-21; January, 1948.
(668) "International recommendations for marine electronic aids," *Electronics*, vol. 24; pp. 144, 146; August, 1947.
(669) H. J. Brown, "Developments in airline radio and radar communications and navigational facilities: Parts I and II," *Proc. I.R.E.* (Australia), vol. 8, pp. 4-9; August, 1947; pp. 4-15; September, 1947. Discussion pp. 19-21; October, 1947.
(670) W. J. O'Brien, "Radio navigational aids," *Jour. IEE* (London), vol. 7, pp. 215-246; October, 1947. Discussion, pp. 247-248, same issue.
(671) R. B. Michel, "The second international meeting on radio aids to marine navigation: New York and New London," *Jour. Inst. Nav.*, vol. 1, pp. 69-75; January, 1948.
(672) J. Fagot, "New radio aids to aerial navigation," *Onde Élec.*, vol. 28, pp. 3-12; January, 1948, pp. 70-76; February, 1948.
(673) M. F. Penin, "Radio and aerial navigation in civil aviation," *Onde Élec.*, vol. 28, pp. 87-98; March, 1948.

Government bodies in the United States concerned with both civilian and military aviation, including the Congress, issued reports on policy and procedures for navigation which indicate the wide interest in navigation and the tremendous role which radio aids to navigation play in modern transportation.

(674) Report of the Congressional Aviation Policy Board, Congress of the United States, "National Aviation Policy," March 1, 1948.
(675) "Navigation and national security," The National Military Establishment Research and Development Board, March 5, 1948.

The Radio Technical Commission for Aeronautics through its special committees has issued the results of studies of an ultimate standardized system of radio aids to air navigation. Reports by its special committees, many of which have concentrated in the past year on the problem of air traffic control, are available from the office of the RTCA in Washington. The extent to which these plans were in actual operation was demonstrated by the Civil Aeronautics Authority in November, 1948.

(676) Publication of the Radio Technical Commission for Aeronautics. Washington. D. C., "Special Committees": Paper 116-48/RE-103, October 26, 1948.
(677) "Résumé of United States planning in air navigation, traffic control, communication," Radio Technical Commission for Aeronautics, September 1, 1948.
(678) "Air traffic control," Paper 27-48/DO-12, Radio Technical Commission for Aeronautics May 12, 1948.
(679) "Air traffic control report aims at all-weather safety," *C.I.I Jour.* vol. 9, pp. 49, 54-55; May 15, 1948.
(680) RTCA Demonstration, "Transition Air Navigation Aids," CAA Experimental Station, Indianapolis, Indiana, November, 1948 (pamphlet published by the CAA)

Papers were published on over-all radar system performance which dealt with many of the complex correlated factors leading to the perception of the object being detected. The effect of noise brightness and contrast of the cathode-ray screen, obstacles in the path of the radiated beam, and certain system characteristics were analyzed.

(681) S. D. Robertson, "Targets for microwave radar navigation," *Bell Sys. Tech. Jour.*, vol. 26, pp. 852-869; October, 1947.
(682) W. R. Garner and F. Hamburger, Jr., "Detectability and discriminability of targets on a remote projection plan-position indicator," PROC. I.R.E., vol. 35, pp. 1220-1225; November, 1947.
(683) M. Katzin, "Quantitative radar measurements," PROC. I.R.E., vol. 35, pp. 1333-1334; November, 1947.
(684) E. C. S. Megaw, "Some effects of obstacles on the propagation of very short radio waves," *Jour. IEE*, vol. 95, part 3, pp. 97-105; March, 1948.
(685) R. F. Rinehart, "A solution of the problem of rapid scanning for radar antennae," *Jour. Appl. Phys.*, vol. 19, pp. 860-862; September, 1948.

(686) A. V. Haeff, "Minimum detectable radar signal and its dependence upon parameters of radar systems," Proc. I.R.E., vol. 34, pp. 857–861; November, 1946. Discussion, V. Tiberio, Proc. I.R.E., vol. 36, p. 1261; October, 1948.
(687) S. Goldman, "Some fundamental considerations concerning noise reduction and range in radar and communications," Proc. I.R.E., vol. 36, pp. 854–594; May, 1948.
(688) R. Payne-Scott, "Visibility of small echoes on radar PPI displays," Proc. I.R.E., vol. 36, pp. 180–196; February, 1948.
(689) M. Levy, "Signal-noise ratio in radar," *Wireless Eng.*, vol. 24, pp. 349–352; December, 1947.
(690) J. C. Tellier and J. F. Fisher, "Testing long-persistence screens," *Electronics*, vol. 21, pp. 126–130; February, 1948.
(691) J. W. Leas, "Surveillance radar deficiencies and how they can be overcome," Proc. I.R.E., vol. 36, pp. 1015–1017; August, 1948.

Descriptions of radar systems continued to appear. These included a listing of existing GCA installations, descriptions, and design principles for airborne radar, as well as new systems for ground, air, and marine use.

(692) "G.C.A. radar systems, list, CAA operated, Navy operated, Air Force operated," *Aviation Week*, vol. 48, p. 102; February 23, 1948.
(693) R. W. Ayer, "Airborne radar," *Elec. Eng.*, vol. 67, pp. 246–248; March, 1948.
(694) H. H. Lynn, "Airborne radar equipment design," *Tele-Tech*, vol. 6, pp. 50–54; November, 1947.

Certain of the new systems of air navigation which were described use radar principles or have a radar system as one of the principal components. Several such systems were proposed as parts of the RTCA coordinated program and some were being constructed for demonstration or test.

(695) K. McIlwain and C. J. Hirsch, "The Hazeltine Lanac system of air and marine navigation," *Navigation*, vol. I, pp. 210–216; June, 1947.
(696) I. C. Nye, "New York radar charts air traffic," *Aero Digest*, vol. 57, pp. 102, 104, 115, 116; September, 1948.
(697) "Two-color radar provides constant measurements from plane to fixed ground beacons," *Tele-Tech*, vol. 7, pp. 67, 96; July, 1948.
(698) N. F. Silsbee and R. W. Brown, "Air Force flies the weather," *Aero Digest*, vol. 56, pp. 37–38; 80–81; April, 1948.
(699) D. H. Ewing, H. J. Schraeder, and R. W. K. Smith, "Teleran," *RCA Rev.*, vol. 8, pp. 612–632; December, 1947.
(700) J. Fagot, "New radio aids to aerial navigation," *Onde Élec.* vol. 28, pp. 3–12; January, 1948, and pp. 70–76; February, 1948.
(701) P. A. Noxon, "Flight path control," *Aeronaut. Eng. Rev.*, vol. 7, pp. 38–45; August, 1948.
(702) "Electronics tracks for aircraft," *Gen. Elec. Rev.*, vol. 51, p. 51; April, 1948.

The year 1948 was marked by a pronounced interest in secondary radar. The shortcomings of primary radar have long been recognized, and the use of radar assistance in the form of airborne transponder beacons was recognized as one of the means for overcoming these shortcomings.

One of the principal components of the RTCA proposals is the distance-measuring equipment. This pulsed navigation aid was the subject of intensive development and was scheduled for early installation and operation. In addition to the RTCA publications, the following references report various phases of the study.

(703) H. Busignies, "High-stability radio distance-measuring equipment for aerial navigation," *Elec. Commun.*, vol. 25, pp. 237–243; September, 1948.
(704) J. G. Downes, "Operational trials of the Australian distance measuring equipment and multiple track radar range," *Proc. I.R.E.* (Australia), vol. 9, pp. 10–21; April, 1948. Discussion, pp. 21–23; same issue.
(705) H. C. Bostwick and R. B. Roe, "Stability chief approach problem," *Aviation Week*, vol. 49, pp. 27, 29–30; August 16, 1948.

Radar was used or studied in a number of new applications, including surveying, geophysical prospecting, weather forecasting and reporting, measurement of group velocity of radio waves, tropospheric sounding, detection of meteors, control of guided missiles, and communication.

(706) H. Stockman, "Communication by means of reflected power," Proc. I.R.E., vol. 36, pp. 1196–1204; October, 1948.
(707) W. W. Hansen, "Surveying with pulsed light radar." *Electronics*, vol. 21, pp. 76–79; July, 1948.
(708) A. W. Friend, "Continuous tropospheric soundings by radar," Proc. I.R.E, vol. 36, pp. 501–503; April, 1948.
(709) "Radar's magic eye surveys a continent. Australian mapping project," Civil Engineering, vol. 18, p. 117; February, 1948.
(710) R. A. Smith, E. Franklin, and F. B. Whiting, "Accurate measurement of the group velocity of radio waves in the atmosphere, using radar technique," *Jour. IEE*, vol. 94, part III, pp. 391–395; discussion, pp. 402–406; November, 1947.
(711) "Radar and raindrops," *Westinghouse Eng.*, vol. 8, pp. 44–45; March, 1948.
(712) R. Wexler and J. Weinstein, "Rainfall intensities and attenuation of centimeter electromagnetic waves," Proc. I.R.E., vol. 36, pp. 353–355; March, 1938.
(713) W. W. Burns, "Modern exploratory tools being used in five company Bahama oil search," *Oil and Gas Jour.*, vol. 46, pp. 38–40, 42, 129; November 8, 1947.
(714) E. B. Stern, "Shoran radar; War's contribution to oil exploration," *Oil and Gas Jour.*, vol. 46, pp. 70–72; January 15, 1948.
(715) W. F. Kroemmelbein, "Shoran for surveying," *Electronics*, vol. 21, pp. 112–117; March, 1948.
(716) L. A. Manning, "Theory of radio detection of meteors," *Jour. Appl. Phys.*, vol. 19, pp. 689–699; August, 1948.
(717) "Checking the 'test birds,'" *Aero Digest*, vol. 56, pp. 49, 103; February, 1948.

Noteworthy additions to the literature included descriptions of radar systems using other than pulsed or continuous-wave transmission.

(718) I. Wolff and D. G. C. Luck, "Principles of frequency-modulated radar," *RCA Rev.*, vol. 9, pp. 50–75, 352–362; March, June, 1948.
(719) "Superregenerative radar," *Electronics*, vol. 21, p. 176; February, 1948.

New installations of marine radar equipment continued to be made. Some applications involved interesting variations which increased the usefulness of this proved aid to river, harbor, and coastal navigation. It is interesting to note that many of the following references are to other than radio technical publications.

(720) "Marine radar on Southend pier," *Electrician* (London), vol. 141, p. 646; August 27, 1948.
(721) "Mersey harbour radar installation," *Engineer* (London), vol. 186, pp. 130–132; August 6, 1948. (Abstract) *Electrical Rev.* (London), vol. 143, p. 205; August 6, 1948.
(722) "Radar navigational aid for Liverpool," *Engineering* (London), vol. 165, p. 534; June 4, 1948.
(723) "Special radar designed for Great Lakes," *Marine Eng.*, vol. 53, pp. 94, 95; January, 1948.
(724) H. F. Harvey, Jr. and F. P. Coleman, "Electronics on shipboard," (Abstract); *Marine Eng.*, vol. 53, p. 65; January, 1948. Discussion, pp. 66–67; same issue.
(725) "Radar for river oil tows," *World Oil*, vol. 127, p. 175; January, 1948.
(726) "River radar promises faster tows for mills and fabricators," *Iron Age*, vol. 160, pp. 121–122; December 25, 1947.
(727) R. B. Mitchell, "Second International Meeting on Radio Aids to Marine Navigation," *Jour. Inst. Nav.*, vol. 1, pp. 69–75; January, 1948.

(728) "Douglas Harbour radar," *Wireless World*, vol. 54, p. 130; April, 1948.
(729) "Tug boat radar demonstrated by New Haven and PRR," *Railway Age*, vol. 123, pp. 918–919; November 22, 1947.

Hyperbolic systems of radio navigation, which have proved exceptionally useful at distances beyond the possibilities of microwave radar, continued to receive attention. Following the recommendations of the International Radio Conference, experimentation on low-frequency systems and propagation continued.

(730) E. Y. Shchegolev, "Radio technique in the service of long range navigation (Loran), *Nauki i Zhzin*, No. 2, pp. 2–7; 1947. (In Russian.)
(731) A. V. J. Martin, "The Decca Navigator," *Toute la Radio*, vol. 15, pp. 100–105; March and April, 1948.
(732) R. V. Whelpton and P. G. Redgment, "The development of CW radio navigation aids, with particular reference to long range operation," *Jour. IEE* (London), part IIIA, vol. 94, No. 11, pp. 244–254; 1947; and summary, part I, vol. 94, pp. 489–490; October, 1947. Discussion, part IIIA, vol. 94, No. 16, pp. 1022–1030; March and April, 1947.
(733) J. A. Pierce, A. A. McKenzie, and R. H. Woodward (Editors), "Loran Long Range Navigation," McGraw-Hill Book Co., New York, N. Y., 1948.

As an aid to aircraft identification, vhf direction finders were used in conjunction with airport surveillance radar. High-frequency Adcock direction finders continued to be used for air-sea rescue. New types of instantaneous-reading direction finders and a method for measuring errors in goniometers were described. A historical summary and a proposal for improved direction finders for marine use were published.

(734) B. G. Pressy, "Measurement of errors in radiogoniometers at high and very high frequencies," *Jour. IEE*, vol. 95, part III, pp. 221–228; July, 1948.
(735) P. C. Hansel, "Instant-reading direction finder," *Electronics*, vol. 21, pp. 86–91; April, 1948.
(736) H. Busignies, "New developments in marine radio direction finders," *Elec. Commun.*, vol. 25, pp. 196–203; June, 1948.
(737) W. Ross and R. E. Burgess, "H type Adcock direction finders, *Wireless Eng.*, vol. 25, pp. 168–179; June, 1948.
(738) L. Brady, "Low-cost ADF installation," *Aero Digest*, vol. 56, pp. 74, 75; June, 1948.

Vhf, which has gained universal acceptance in aircraft communication and instrument-landing systems, came into considerable use for on-route navigation overland as the CAA expanded its network of omnidirectional range stations.

(739) "Vhf to revolutionize radio aids to air navigation," *CAA Jour.*, vol. 9, p. 30; March 15, 1948.

A global navigation system was proposed which would set up radio lines of position coincident with the geographical lines of latitude and longitude.

(740) R. I. Colin, "Polatomic navigation for world air routes," *Air Transport*, vol. 6, pp. 28–32; March, 1948.

Electronic Computers

The year 1948 was marked by great activity in the electronic computer field. The armed services and industry have become increasingly aware of the tremendous advantages offered by electronic computing equipment. Both scientific and commercial problems can be solved by the various computers which were under construction. It was a year of many advancements. Many ideas were tested, while other ideas were going into the testing stage. The 1948 IRE Convention scheduled two full sessions for presentation of papers on the subject of electronic computing equipment.

(741) "Summaries of technical papers (electronic computers)," Proc. I.R.E., vol. 36, pp. 377–379; March, 1948.

Because of this tremendous amount of technical activity, the Institute formed a Technical Committee on Electronic Computers. Its aim was to follow these activities, to aid in the intercommunications of information, and to formulate standards and definitions. The committee divided the field of electronic computing into the following subfields: (1) analogue computers, (2) systems and applications, (3) storage and memory, (4) input-output equipment, (5) circuits and components.

The analogue-computer field saw the development of computers such as that installed at the Westinghouse Electric Corporation and at the California Institute of Technology. A smaller analogue computer, known as the REAC, was put into service, and proved to be of value in the solution of many types of engineering problems.

(742) W. A. Adcock, "Automatic simultaneous equation computer and its use in solving secular equations," *Rev. Sci. Instr.*, vol 19, pp. 181–187; March, 1948.
(743) M. Beard and T. Pearcey, "The logical basis of high-speed computer design," Council for Scientific and Industrial Research, Division of Radiophysics, Sydney, p. 157; April, 1948. (RPR83)
(744) G. W. Brown and Edwin A. Goldberg, "An electronic simultaneous equation solver," *Jour. Appl. Phys.*, vol. 19, pp. 339–345; April, 1948.
(745) G. S. Brown and D. P. Campbell, "Principles of Servomechanisms," John Wiley and Sons, Inc., New York, N. Y., p. 400; 1948.
(746) G. C. Curtis, "An electrical instrument for solving second degree algebraic equations," *Jour. Sci. Instr.*, vol. 25, pp. 341–343; October, 1948.
(747) E. C. Dench and A. C. Hardy, "An electronic method for solving simultaneous equations," *Jour. Opt. Soc. Amer.*, vol. 38, pp. 308–312; April, 1948.
(748) S. Frost, "Compact analog computer," *Electronics*, vol. 21, p. 116; July, 1948.
(749) J. S. Koehler, "An electronic differential analyzer," *Jour. Appl. Phys.*, vol. 19, pp. 148–155; 1948.
(750) G. A. Korn, "Elements of DC analog computer elements," *Electronics*, p. 122; April, 1948.
(751) G. A. Korn, "Design of DC electronic integrators," *Electronics*, p. 124; May, 1948.
(752) L. Malavard and J. Tissot, "Sur une methode utilisant le bassin electrique pour la determination des racines d'une equation algebrique," *Compt. Rend.*, vol. 227, pp. 620–622; September 27, 1948.
(753) R. C. Oldenbourg and H. Sartorius (Siemens and Halske), "The dynamics of automatic controls," p. 276; 1948. (Translated and edited by H. L. Mason, Iowa State College.) Published by the American Society of Mechanical Engineers, New York, N. Y.

Great strides in the digital-computer field have been made in the past few years. The ENIAC was completed in February, 1946, and marked the beginning of the all-electronic computer. Many newer machines were subsequently designed. The IBM selective-sequence electronic calculator and the Eckert-Mauchly Computer Corporation's BINAC have been completed. Interest reached beyond the United States, and projects for the design and construction of electronic computers were going forward with equal activity in England.

(754) H. H. Aiken and G. M. Hopper, "The automatic sequence controlled calculator—I," *Elec. Eng.*, vol. 65, pp. 384–391; August and September, 1946; vol. 46, pp. 449–454 and 522-528; October, 1946.
(755) F. L. Alt, "A Bell Telephone Laboratories' Computing Machine," I and II, *Math. Tables and other aids to computation*, vol. 3, Part I: pp. 1–13; January, 1948; Part II: pp. 69–84; April, 1948.
(756) "Electronic digital computers," *Mechanical Eng.*, vol. 69, pp. 413–414; May, 1947.
(757) "Mark II calculator," *Rev. Sci. Instr.*, vol. 18, p. 202; March, 1948.
(758) "Selective sequence digital computer," *Electronics*, p. 138; April, 1948.
(759) M. Beard and T. Pearcey, "The logical basis of high-speed computer design," Council for Scientific and Industrial Research Division of Radiophysics, Sydney, p. 157; April, 1948. (RPR83)
(760) "Theory and technique for design of electronic digital computers," Moore School, University of Pennsylvania, vol. 2; 1947. (Lectures)
(761) "Electronic computers known as Eniac," *Mechanical Eng.*, vol. 68, pp. 560–561; 1946.
(762) J. G. Brainerd and T. K. Sharpless, "The Eniac," *Elec. Eng.*, p. 163; February, 1948.
(763) A. W. Burks, "Super electronic computing machine," *Electronic Ind.*, vol. 5, pp. 62–67, 96; July, 1946.
(764) Burke, Goldstine, and von Neumann, "Preliminary discussion of the logical design of an electronic computing instrument," Ord. Dept., U.S.A., June, 1946.
(765) L. J. Comrie, "Calculations and electronics, automatic computer designed by the National Physical Laboratory," *Electrician*, vol. 137, pp. 1279–1280; November 8, 1946.
(766) E. U. Condon, "Electronics and the future," *Elec. Eng.*, vol. 66, pp. 355–356; 1947.
(767) Goldstine and Neumann, "Planning and coding problems for an Electronic Computing Instrument," Institute for Advanced Study, Princeton, N. J.; 1947.
(768) S. Lilley, "ENIAC, ASCC and ACE, Machines that solve complex mathematical problems," *Discovery*, vol. 8, pp. 23–27, 32; January, 1947.
(769) F. J. Murray, "Theory of Mathematical Machines," p. 114, Columbia University Press; New York, N. Y., 1947.
(770) F. Russo, "Les grandes machines mathematiques," *Rev. des Quest. Scien.*, S. 5, vol. 8, pp. 611–616; 1947.
(771) G. R. Stibitz, "A new class of computing aids," *Math. Tables and Other Aids to Computation*, vol III, No. 23, pp. 217–221; July, 1948.
(772) R. C. Tumbleson, "Calculating Machines," *Federal Science Progress*, vol. 1, pp. 3–7; June, 1947.
(773) R. C. Tumbleson, "Calculating machines," *Elec. Eng.*, p. 6; January, 1948.
(774) "Proceedings of a symposium on large-scale digital calculating machinery," jointly sponsored by the Navy Department, Bureau of Ordnance, and Harvard University at the Computation Laboratory January 7–10, 1947, p. 302, Harvard University Press (Annals of the Computation Laboratory, vol. 16); 1948.

In keeping with the strides made in the technical field, mathematicians continuously supplied information on the application of this new equipment. New fields of usefulness were being learned, and it is not evident yet how broad the application of electronic computing equipment may become.

(775) "Electronic computer assures solution of scientific problems," *Iron Age*, vol. 157, pp. 132–134; February 28, 1946.
(776) "Mathematics by robot," *Army Ordnance*, vol. 30, pp. 329–331; 1946.
(777) E. C. Berkeley, "Electronic machinery for handling information, and its uses in insurance," *Actuarial Soc. Amer., Transonics*, vol. 48, Part I, pp. 36–52; 1948.
(778) H. B. Curry and W. A. Wyatt, "A study of inverse interpolation on the Eniac," Ballistic Research Laboratories Report No. 615, p. 58; August, 1946.
(779) L. J. Comrie, "Calculators—past, present, and future," *Future*, vol. 1 (Overseas Issue), pp. 61–69; 1947.
(780) J. L. McPherson, "Applications of large-scale high-speed computing machines to statistical work," *Math. Tables and Other Aids to Computation*, vol. III, No. 23, pp. 149–161; July 1948.
(781) R. R. Seeber, "Value of super-calculators," *National Underwriter* (Life Edition), No. 4, p. 6; April 4, 1948.
(782) J. W. Ludwig, "Electronic computers for printing control," *Electronics*, p. 108; November, 1947.
(783) G. A. Philbrick, "Industrial controllers designed by analog computers," *Electronics*, p. 108; June, 1948.

The problems encountered in the design of an electronic computer may be roughly divided into three parts. The first is the problem of storing information in what is usually termed the memory. The second is the problem of transferring information in and out of the computer. The third is briefly summed up as the problem of circuits and components. At the present time the mercury-tank and storage-tube types of memory are being used. Several other types are anticipated, but are still in the research stage. Much work was being done on these phases of the computer problem, but few papers appeared in the literature.

(784) Z. Bay and G. Papp, "Coincidence device of 10^{-8}, 10^{-9} resolving power," *Nature*, vol. 161, No. 4080, pp. 59–60 (Letter); January 10, 1948.
(785) B. H. Briggs "The Miller integrator," *Elec. Eng.*, vol. 20, pp. 243–247; August, 1948.
(786) A. W. Burks, "Electronic computing circuits of the Eniac," Proc. I.R.E., vol. 35, pp. 75–76; August, 1947.
(787) H. W. Fuller, "Numerscope for cathode ray printing," *Electronics*, p. 98; February, 1948.
(788) I. E. Grosdoff, "Electronic counters," *RCA Rev.*, vol. 7, pp. 438–447; September, 1946.
(789) B. Howland, "Scale of *N* counting circuits," *Electronics*, p. 182; July, 1947.
(790) H. B. Huntington, A. G. Emslie, and V. W. Hughes, "Ultrasonic delay lines," *Jour. Frank. Inst.*, vol. 245, pp. 1–24; January, 1948.
(791) B. Howland, "Capacitor counting circuits," *Electronics*, vol. 21, p. 182; June, 1948.
(792) C. B. Leslie, "Megacycle stepping counter," Proc. I.R.E., vol. 36, p. 1030; August, 1948.
(793) H. Lifschutz, "A complete Geiger-Muller counting system," *Rev. Sci. Instr.*, vol. 10, pp. 21–26; January, 1939.
(794) C. H. Page, "Computer switching circuits," *Electronics*, vol. 21, p. 110; September, 1948.
(795) J. Rajchman, "Electrostatic storage," *Tele-Tech*, vol. 6, p. 61; May, 1947.
(796) J. Rabinow, "Magnetic fluid clutch," *Trans. AIEE (Elec. Eng.)* p. 1167; 1948.
(797) T. K. Sharpless, "High-speed *n*-scale counters," *Electronics*, vol. 21, p. 122; March, 1948.

Nuclear Studies

Electronic Circuitry (Nuclear)

This Review covers an interval a little longer than the calendar year 1948, since no summary was prepared for 1947. The advances fall into two categories: (1) previously invented, but disclosed or declassified for public use at this time; (2) current new developments. As it happens, the first group is the more important, representing the integral of five war years. Typical information is that from the Manhattan District atomic research, now available through the U. S. Atomic Energy Commission, Document Sales Agency, P. O. Box 62, Oak Ridge, Tenn.

MDDC-23 —"The Multi-Channel Pulse Analyzer"
MDDC-26 —"Higinbotham Scale of 64, Mark 5, Model 3"
MDDC-89 —"Model 100 Delay Line Shaper"
MDDC-101—"10 M.C. Wide Band Amplifier and Scope"
MDDC-102—"Model 500 Amplifier"
MDDC-103—"Pre-Amplifier—Model 500"
MDDC-112—"Scale of 64 Discriminator"
MDDC-128—"Counting Rate Meter Model 100"
MDDC-131—"Model 100 Amplifier"
MDDC-303—"Model 100 Pre-amp Circuit Schematic"
MDDC-740—"Electronic Circuits—111"
MDDC-791—"A Portable Pulse Generator"
MDDC-839—"A Fast Coincidence Circuit with Pulse Height Selection"

See also:

(798) W. C. Elmore, "Electronics for the nuclear physicst," *Nucleonics*, vol. 2, pp. 4–17; February, pp. 16–36; March, pp. 43–55; April, pp. 50–58; May, 1948.
(799) W. C. Elmore, "Lectures on Fast Electronic Circuits," Palmer Physical Laboratory, Princeton, N. J.
(800) W. A. Higinbotham, J. Gallagher, and M. Sands, "Model 200 pulse counter," *Rev. Sci. Instr.*, vol. 18, pp. 706–715; October, 1947.
(801) V. L. Fitch and E. W. Titterton, "A laboratory oscilloscope," *Rev. Sci. Instr.*, vol. 18, pp. 821–830; November, 1947.
(806) W. H. Jordan and P. R. Bell, "A general purpose linear amplifier," *Rev. Sci. Instr.*, vol. 18, pp. 703–705; October, 1947.
(803) T. K. Sharpless, "High-speed *N*-Scale counters," *Electronics*, vol. 21, pp. 122–125; March, 1948.
(804) W. L. Buys, "Analysis of scale units " *Nucleonics*, vol. 3, pp. 49–61; November, 1948.

Microwave techniques of instrumentation, generation, and detection have also contributed to nuclear instrumentation, particularly to the field of microwave spectroscopy.

Volumes of the MIT Radiation Laboratory Technical Series, published by the McGraw-Hill Book Company, dealt with the subjects of electronic instruments, cathode-ray-tube techniques, timing circuits, frequency stabilization, pulse techniques, and pulse transformers.

(805) W. Gordy, "Microwave spectroscopy," *Rev. Mod. Phys.*, vol. 20, pp. 668–717; October, 1948.
(806) A. Roberts, "Radio-frequency spectroscopy in nuclear studies," *Nucleonics*, vol. 1, pp. 10–17; October, 1947.
(807) H. M. Davis, "Radio waves and matter," *Sci. Amer.*, vol. 179, pp. 16–23; September, 1948.
(808) R. V. Pound, "On the nuclear moments of I^{127}, Ga^{69}, Ga^{71}, and P^{31}," *Phys. Rev.*, vol. 73, pp. 1112–1113; May 1, 1948.
(809) B. G. Farley, "A pulse transformer technique for application to coincidence counting," *Phys. Rev.*, vol. 73, p. 1240; May 15, 1948.
(810) C. W. Sherwin, "The neutrino," *Nucleonics*, vol. 2, pp. 16–24; May, 1948.
(811) C. W. Sherwin, "Momentum conservation in the beta-decay of P^{32} and the angular correlation of neutrinos with electrons," *Phys. Rev.*, vol. 73, pp. 216–225; February 1, 1948.

Of the second class (current new developments), the greatest emphasis was upon circuitry to provide improved time resolution, higher counting speed, and improved coincidence techniques. All this was brought about by advances during the year in input devices (detectors), crystal counters, scintillation counters, photomultipliers, and electron multipliers. These devices have very short resolving times compared with usual Geiger tubes with pulse rate of rise of the order of 10^{-8} to 10^{-9} second.

(812) E. L. Brady and M. Deutsch, "Angular correlation of gamma rays," *Phys. Rev.*, vol. 73, p. 1541; May 15, 1948. (Abstract).
(813) P. R. Bell, "The use of anthracene as a scintillation counter," *Phys. Rev.*, vol. 73, pp. 1405–1406; June 1, 1948.
(814) M. Deutsch, "High efficiency, high-speed scintillation counters for beta and gamma rays," *Phys. Rev.*, vol. 73, p. 1240; May 15, 1948. (Abstract.)

A report at a Brookhaven Symposium in 1947 foreshadowed the entire trend of 1948 as the improved resolving times and higher efficiencies of these counters permitted better coincidence experiments. A conference on high-speed counters was held at the University of Rochester under the chairmanship of G. B. Collins and J. R. Platt.

(815) Brookhaven Conference Report, "High speed counters and short pulse techniques," August, 1947.
(816) J. S. Allen, "Particle detection with multiplier tubes," *Nucleonics*, vol. 3, pp. 34–39; July, 1948.
(817) L. del Rosario, "Use of an electron multiplier tube as a new technique in disintegration experiments," *Phys. Rev.*, vol. 74, pp. 304–314; August, 1948.
(818) G. Papp, "Determination of the pulse period of electron multiplier tubes," *Rev. Sci. Instr.*, vol. 19, pp. 568–569; September, 1948.
(819) A. Linz, Jr., F. T. Rogers, Jr., and G. W. Crawford, "A cathode-follower type of dual-coincidence circuit," *Phys. Rev.*, vol. 74, p. 119; July 1, 1948. (Abstract.)
(820) C. E. Mandeville and M. V. Scherb, "Nuclear disintegration schemes and the coincidence method," *Nucleonics*, vol. 3, pp. 2–12; October, 1948.
(821) H. L. Schultz and R. Beringer, "Coincidence-counting system of high resolution," *Rev. Sci. Instr.*, vol. 19, pp. 424–427, July, 1948.
(822) E. Baldinger, P. Huber, and K. P. Meyer, "High-speed coincidence circuit used for multipliers," *Rev. Sci. Instr.*, vol. 19, pp. 473–474; July, 1948.
(823) S. H. Neddermeyer, E. J. Althaus, and W. Allison, "The measurement of ultra-short time intervals," *Rev. Sci. Instr.*, vol. 18, pp. 488–496; July, 1947.
(824) R. H. Dicke, "A high-speed coincidence circuit," *Rev. Sci. Instr.*, vol. 18, pp. 907–914; December, 1947.

All of the foregoing covered direct experimental circuitry. Electronic techniques are, of course, vastly important in all forms of auxiliary control during nuclear experiments; for example, precise voltage control or current control by electronic means, development of circuit elements, and improvement in standardization thereof. A few typical examples include the following:

(825) A. Thomas, "High-voltage supplies for G-M counters," *Electronics*, vol. 21, pp. 100–103; December, 1948.
(826) L. C. L. Yuan, "A precision high-voltage vacuum tube voltmeter," *Rev. Sci. Instr.*, vol. 19, pp. 450–452; July, 1948.
(827) J. E. Brolley, Jr., "Integrator for small currents," *Rev. Sci. Instr.*, vol. 19, pp. 405–406, June, 1948.
(828) H. P. Kalmus and G. O. Striker, "A new radiation meter," *Rev. Sci. Instr.*, vol. 19, pp. 79–82; February, 1948.

Radiation-Detector Components

Prime radiation-detector components are the standard Geiger-Mueller tubes, and the relatively new scintillation counters and crystal counters. The year has been one of intense activity in the latter two fields, although little has been published to date. Corson and Wilson published an excellent review article concerning the operating mechanism and special properties of commonly used counters.

(829) D. R. Corson and R. R. Wilson, "Particle and quantum counters," *Rev. Sci. Instr.*, vol. 19, pp. 207–233; April, 1948.

Perhaps the best improvement in Geiger-Mueller tubes is in the introduction of new gases which decrease the dead time of the tube. Morganstern and associates claimed that ethylene-filled counters were very stable with respect to counting rate, and had a rapid recovery. Characteristics of methane-filled counters were discussed by Friedlander, and by Farmer and Brown. Curran and Reid indicate new geometrical forms that have some advantages over the standard cylinder. Liebson and Friedman discussed halogen mixtures used in self-quenching counters, which they stated have apparently unlimited lifetimes in terms of total counts.

(830) K. H. Morganstern, C. L. Cowan, and A. L. Hughes, "Note on ethylene self-quenching G-M counter," *Phys. Rev.*, vol. 74, pp. 499–500; August 15, 1948.
(831) S. S. Friedland, "On the life of self-quenching counters," *Phys. Rev.*, vol. 74, pp. 898–901; October 15, 1948.
(832) E. C. Farmer and S. C. Brown, "A study of the deterioration of methane-filled C-M counters," *Phys. Rev.*, vol. 74, pp. 902–905; October 15, 1948.
(833) S. C. Curran and J. M. Reid, "Properties of some new types of counters," *Rev. Sci. Instr.*, vol. 19, pp. 67–75; February, 1948.
(834) S. H. Liebson and H. Friedman, "Self-quenching halogen-filled counters," *Rev. Sci. Instr.*, vol. 19, pp. 303–306; May, 1948.
(835) S. C. Curran and E. R. Rae, "Analysis of the impulses from Geiger-Mueller tubes," *Rev. Sci. Instr.*, vol. 18, pp. 871–876; December, 1947.
(836) C. W. Sherwin, "Short time delays in Geiger counters," *Rev. Sci. Instr.*, vol. 19, pp. 111–115; February, 1948.
(837) L. W. Labow, "An inside G-M counter for soft beta-emitters," *Rev. Sci. Instr.*, vol. 19, pp. 390–395; June, 1948.
(838) G. Salvini, "Some Geiger-Mueller and proportional counters of spherical shape," *Rev. Sci. Instr.*, vol. 19, pp. 490–496; August, 1948.
(839) G. E. Hagen and D. H. Loughridge, "Circuit for testing efficiency of Geiger counters" *Rev. Sci. Instr.*, vol. 19, pp. 526–528; August, 1948.
(840) H. C. Thomas and N. Underwood, "A counter for low energy ionizing particles," *Rev. Sci. Instr.*, vol. 19, pp. 637–639; October, 1948.
(841) C. E. Mandeville and M. V. Scherb, "On the resolving time and genuine coincidence loss for Geiger Mueller counters," *Phys. Rev.*, vol. 73, pp. 90–91; January 1, 1948.
(842) H. A. Glassford, R. L. Macklin, "Tetramethyl lead filled Geiger counters," AECD—2003.

In the field of scintillation counters, no improvements (other than manufacturer's) were reported in the photomultiplier tube (931A). It now appears that the choice of a crystal should be governed by the use to which it is to be put; e.g., calcium tungstate is very sensitive, easy to use, but has a long recovery time. Phosphors like $CaWO_4$ and ZnS are best for alpha particles, while naphthalene or antracene must be used for beta and gamma rays, since they are transparent to the fluorescent radiation, allowing it to escape from the crystal. These latter crystals have recovery times of the order of 0.01 microsecond, whereas the others require times of the order of a microsecond.

The silver, thallium, and sodium halides or mixtures were reported to act as crystal counters, as well as the known diamond counter. No agreement has been reached as to the property of diamonds which make them count. The halides still possess the disadvantage of requiring low temperatures for operation due to ionic conduction at room temperature.

Although, as stated above, much work was done on crystal and scintillation counters during the year, no extensive works were published. Some brief papers are noted below.

(843) R. J. Moon, "Inorganic crystals for the detection of high energy particles and quanta," *Phys. Rev.*, vol. 73, p. 1210; May 15, 1948.
(844) P. R. Bell, "Use of antracene as a scintillation counter," *Phys. Rev.*, vol. 73, pp. 1405–1406; June 1, 1948.
(845) M. Deutsch, "Naphthalene counters for Beta and Gamma rays," *Nucleonics*, vol. 2, pp. 58–59; March, 1948
(846) R. Hofstadter, "Alkali halide scintillation counters," *Phys. Rev.*, vol 74, pp. 100–101; July 1, 1948.
(847) R. Hofstadter, "Remarks on diamond crystal counters," *Phys. Rev.*, vol. 73, p. 631; March 15, 1948.
(848) W. L. Whittemore and J. C. Street, "Silver chloride used as an ionization detector for cosmic rays," *Phys. Rev.*, vol. 73, p. 543; March 1, 1948.
(849) K. Lonsdale, "Remarks on diamond crystal counters," *Phys. Rev.*, vol. 73, p. 1467, June 15, 1948.
(850) G. B. Collins and R. C. Hoyt, "Detection of beta-rays by scintillations," *Phys. Rev.*, vol. 73, pp. 1259–1260; May 15, 1948.
(851) S. K. Allison and L. del Rosario, "Performance of an electron multiplier tube counting alpha-particles," *Phys. Rev.*, vol. 73, p. 1224, May 15, 1948.
(852) J. H. Pannel, "Radioactivity measurement techniques," AECD-2270.
(853) E. P. DeBlizard and S. DeBenedetti, "Distant counting of scintillations," AECD-2284.
(854) R. F. Taschek, "Relative sensitivities of some organic compounds for scintillation counters," AECD-2353.
(855) A. H. Jaffey, T. P. Kohman, and J. A. Crawford, "A manual on the measurement of radioactivity," MDDC-388.

Standards

The year 1948 marked a continuing rapid growth of electronic and radio manufacturing for both civilian and government uses. The design, manufacture, and sale of television broadcast transmission and receiving apparatus grew phenomenally during the year.

There was increased activity of the technical committees of the Institute, especially some of the new committees, including Electronic Computers, Nuclear Studies, Audio and Video Techniques, and the newly named Television Systems Committees.

During the year 1948 the Institute issued the following standards:

"Standards on Television: Methods of Testing Television Receivers, 1948."
"Standards on Antennas, Modulation Systems, Transmitters: Definitions of Terms, 1948."
"Standards on Abbreviations, Graphical Symbols, Letter Symbols and Mathematical Signs, 1948."
"Standards on Antennas: Methods of Testing, 1948."
"Standards on Television: Definitions of Terms, 1948."

The following additional material has been approved by the Standards Committee:

"Standards on Radio Receivers: Methods of Testing AM Broadcast Radio Receivers."
"Standards on Electron Tubes: Methods of Testing and Definitions of Terms" (certain sections only).

The standards on "Abbreviations, Graphical Symbols, Letter Symbols, and Mathematical Signs" presented for the first time graphical symbols to represent coaxial and waveguide objects on schematic diagrams. It is of interest to note that the symbols were picked for use on single-line diagrams. The IRE Committee on Symbols recognizes its debt to Edward Bennett and his ASA committee, who spent many years obtaining general agreement to the abbreviations, letter symbols, and mathematical signs listed. The IRE differs from the ASA in not listing as many alternates.

Among the standards on symbols published by the American Standards Association during 1948 were:

ASA—Letter Symbols for Mechanics of Solid Bodies—Z10.3—1948.
ANA—Aeronautical Bulletin—Approved List of Abbreviations and Contractions—ASA Bulletin Number 261—1948.
Letter Symbols for Physics—Z10.6—1948.

The Institute, together with several other organizations, established several joint technical committees to expedite the preparation of standards working toward minimizing duplication of effort. Included in such joint activities were the American Standards Association, the Radio Manufacturers Association, the American Institute of Electrical Engineers, and the Society of Motion Picture Engineers.

In the interests of better correlation of definitions, the Standards Committee created a Definitions Co-ordination subcommittee. The objective of this subcommittee is to assist in the production of definitions with less duplication of effort. This subcommittee began work on a master index of all terms defined or to be defined by The Institute of Radio Engineers in co-operation with the chairmen of all technical committees of the Institute, and some groups outside of the Institute.

Acknowledgments

As in previous years, this summary of Radio Progress in 1948 covers generally, for the subjects dealt with, the principal developments described in publications issued up to about the first of November. The material in the several fields was compiled by members of the 1948 Annual Review Committee of the Institute. Editing and co-ordinating was done by the Chairman, with the assistance of Trevor H. Clark, who served as Vice-Chairman. The following persons comprised the 1948 Annual Review Committee:

H. S. Black	Modulation Systems
G. P. Bosomworth	Industrial Electronics
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L. E. Whittemore, *Chairman*

The members of the above Annual Review Committee wish to acknowledge the assistance given them in many cases by other members of the Technical Committees of the Institute. Special acknowledgment is due Norman H. Young for the preparation of material on Television; Albert R. Hodges for the preparation of material on Radio Receivers; Urner Liddell and Malcolm M. Hubbard for the preparation of material on Nuclear Studies; George Sinclair, P. H. Smith, and R. W. Masters, for co-operation in the preparation of material on Antennas; and to the following persons for the preparation of material relating to Electron Tubes: G. D. O'Neill, Small-Signal High-Vacuum Tubes; I. E. Mouromtseff and C. E. Fay, Power-Output High-Vacuum Tubes; L. B. Headrick, Cathode-Ray Tubes and Television Tubes; A. M. Glover, Phototubes; and J. A. Morton, Solid-State Devices.

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Abstracts and References

Prepared by the National Physical Laboratory, Teddington, England, Published by Arrangement with the Department of Scientific and Industrial Research, England, and *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 and not to the IRE.

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.

The Institute of Radio Engineers has made arrangements to have these Abstracts and References reprinted on suitable paper, on one side of the sheet only. This makes it possible for subscribers to this special service to cut and mount the individual Abstracts for cataloging or otherwise to file and refer to them. Subscriptions to this special edition will be accepted only from members of the IRE and subscribers to the PROC. I.R.E. at $15.00 per year. The Annual Index to these Abstracts and References, covering those published from February, 1948, through January, 1949, may be obtained for 2s. 8d. postage included from the *Wireless Engineer*, Dorset House, Stamford St., London S. E., England.

ACOUSTICS AND AUDIO FREQUENCIES

534.321.9:535.61-15 273
Supersonic Detection of Infra-Red Radiation—F. J. Fry and W. J. Fry. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 537–548; 1947.) A 932-kc standing-wave system is set up in a gas, which is then irradiated with a modulated infrared beam. The modulation is transferred to the standing-wave pattern and normally the effect decreases with increasing modulation frequency. In gases showing anomalous acoustic absorption, the effect does not fall off in this way; an explanation is suggested.

534.756+534.78 274
New Possibilities in Speech Transmission—D. Gabor. (*Jour. IEE* (London), part III, vol. 95, pp. 411–412; September, 1948.) Discussion on 1228 of 1948.

534.851:621.395.813 275
The Design of Dynamic Noise Suppressors—H. H. Scott. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 25–37; 1947.) For another account see 932 of 1948.

621.395.61 276
Parabolic Sound Concentrators—R. C. Coile. (*Jour. Soc. Mot. Pic. Eng.*, vol. 51, pp. 298–311; September, 1948.) An analytical history of the subject, with detailed references to original work, together with experimental studies on a reflector with aperture 130 cm in diameter. Theoretical work in Russia by L. J. Gutin is found to agree with experimental results for frequency response, amplification, and directivity. For the sound field between the focus and the vertex of a paraboloid, a construction based on geometrical optics is derived theoretically and confirmed experimentally.

621.395.625.2 277
Transcription Recordings for the Home—D.G.F. (*Electronics*, vol. 21, pp. 86–87; September, 1948.) A 33⅓ r.p.m. system using vinylite records in which as many as 300 grooves per inch are cut. Noise and distortion are low.

621.395.625.3 278
Magnetic Tape Recorder—H. Lindsay and M. Stolaroff. (*Audio Eng.*, vol. 32, pp. 13–16; October, 1948.) Design details of the Ampex Model 200A recorder. The frequency range is 30 to 15,000 cps, and response is flat to ± 1 db. Distortion and noise level are claimed to be very low. A low-force tape, Type RR, is used because erasure is easy; its uniform coating results in low-modulation noise and uniform output. Playback time can be reproduced within 0.5 second per half-hour of program time. High tape speeds, both forward and rewind, are possible. 5,400 feet of 0.002-inch tape can provide 36 minutes of continuous program time and can be stored on a single 14-inch reel with a 4-inch hub.

534 279
Vibration and Sound [Book Review]—P. M. Morse. McGraw-Hill, New York, N. Y., 2nd edition 1948, 468 pp., $5.50. (*Electronics*, vol. 21, pp. 226, 228; September, 1948.) "A valuable addition to the literature in acoustics, particularly to the serious student and investigator. . . . The subject matter is confined for the most part to types of vibrations that can be handled mathematically." The illustrative diagrams are an outstanding feature.

ANTENNAS AND TRANSMISSION LINES

621.315.2:621.317.333.4 280
Investigation of Cable Faults in the Case of Discontinuity and Poor Insulation—L. Dupuis. (*Bull. Soc. Franç. Élec.*, vol. 8, pp. 417–418; August and September, 1948.) Three methods are discussed briefly: (a) measurement of the impedance between a conductor and the Pb sheath; (b) measurement of the voltage induced by current in a parallel conductor; (c) measurement involving the distance between successive maxima, or minima, of the current when the modulation frequency of the applied voltage is swept through the range 0 to 100 kc.

621.315.2:621.317.333.4 281
Investigation of Faults on Low-Voltage Cables—C. Philippe. (*Bull Soc. Franç. Élec.*, vol. 8, pp. 439–450; August and September, 1948). A detailed account of various methods of fault location used by the Société Nationale des Chemins de Fer Français on their signal, telephony, and power networks.

621.315.2:621.317.333.4:621.3.015.33 282
Application of Pulse Methods to Fault Location on Cables—G. Le Parquier. (*Bull. Soc. Franç. Élec.*, vol. 8, pp. 434–438; August and September, 1948.) An outline of apparatus and methods using a 600-watt generator giving extremely short pulses. Echoes received from faults are displayed on the screen of a cro, together with the initial pulse. Marking pips are provided at 6.67-microsecond internals, corresponding to distances of 1 km in free space. The marking scale can be adjusted to make one the pips coincide with the echo in order to obtain greater reading accuracy. Typical oscillograms illustrate the results obtained with different kinds of fault.

621.315.2:621.317.333.4:621.317.733 283
Application of the de Sauty Bridge to Fault Finding on Very Long Cables—H. Josse and R. Tellier. (*Bull. Soc. Franç. Élec.*, vol. 8, pp. 427–429; August and September, 1948.) The de Sauty bridge gives results which differ from the true values, even for cable lengths <10 km. The discrepancies increase with increase of cable length, so that a correction is necessary. The correction factor is determined and plotted for cable lengths up to 20 km.

621.315.2:621.385 284
An Ionic Valve for Clearance of Faults in Cables—Schmidt. (*See* 559.)

621.315.212:621.3.09 285
Wave Propagation in Beaded Lines—R. E. Beam. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 90–96; 1947.) The lines are treated as cascade connections of T-sections, each of which represents a length of line with a bead at the center. Characteristic admittance and propagation constants are derived, and curves are included to illustrate the variation of these quantities with bead spacing for a number of RMA standard coaxial cables.

621.315.23:621.317.333.4 286
Investigation of Faults in Underground Cables—H. Aschere. (*Bull. Soc. Franç. Élec.*, vol. 8, pp. 397–412; August and September, 1948.) The various types of fault are discussed and classified. Methods for locating faults are reviewed and their advantages and disadvantages are compared.

621.315.23:621.317.333.4 287
Investigation of Faults in Underground Cables—R. Bourdon and E. Masson. (*Bull. Soc. Franç. Élec.*, vol. 8, pp. 413–416; August and September, 1948.) Comment on 286 above.

621.315.23:621.317.333.4 288
Investigation of Cable Faults in Underground Cables—M. Roger. (*Bull. Soc. Franç. Élec.*, vol. 8, pp. 419–426; August and Septem-

ber, 1948.) An account of test methods and apparatus used by the Centre de Distribution de Paris-Électricité, with a few results for cables already installed.

621.315.23:621.317.333.4 289

Detection of Faults in Underground Cables by Ground Vibration—E. Marchand. (*Bull. Soc. Franç. Élec.*, vol. 8, p. 433; August and September, 1948.) The vibrations are picked up by means of a granule microphone, the resulting voltage being amplified and finally applied to an indicator. If the curve shown on the indicator is oscillatory, there is a fault; if it is not periodic, there is none. The method has been used successfully on 60-kv supply cables.

621.392.029.64:621.392.26† 290

Waveguides—In future the recently proposed U.D.C. number 621.392.26† will be used for waveguides instead of 621.392.029.64, the least unsatisfactory number previously available.

621.392.26† 291

On Representing the Field in a Waveguide as a Sum of the TE and TM Fields—A. A. Samarski and A. N. Tikhonov. (*Zh. Tekh. Fiz.*, vol. 18, pp. 959–970; July, 1948. In Russian.) It has been stated by various authors without proof that any field in a waveguide can be represented as a sum of the transverse electric field *TE* and the transverse magnetic field *TM*. A rigorous mathematical proof is given that any electromagnetic field in a waveguide can be represented by two Hertzian vectors each having only one component differing from zero. The problem of determining the electromagnetic field in a waveguide is then reduced to the problem of finding two scalar functions Z_b and Z_m (transverse components of the electric and magnetic Hertzian vectors).

621.392.26† 292

Remarks on Slow Waves in Cylindrical Guides—A. A. Oliner. (*Elec. Commun.* (London), vol. 25, pp. 157–159; June, 1948.) An alternative method for deriving certain relations obtained in 22 of 1948 (Frankel) and 334 of 1948 (Bruck and Wicher), together with graphs of certain Bessel-function combinations which can be used to simplify the calculations.

621.392.26† 293

A Critical Study of Variational and Finite-Difference Methods for Calculating the Operating Characteristics of Wave Guides and Other Electromagnetic Devices—R. M. Soria and T. J. Higgins. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 670–679; 1947.) Discussion of the relative merits of various methods for obtaining approximately the characteristic values and the electromagnetic fields associated with waveguides and other bounded hollow devices, when exact analytical solution is impossible. Each of these methods is applied to the calculation of characteristic values and electromagnetic fields of both *TM* and *TE* modes in waveguides of various cross sections.

621.392.26† 294

A Waveguide Branching Filter—W. D. Lewis. (*Bell Lab. Rec.*, vol. 26, pp. 372–376; September, 1948.) Equipment for frequencies around 4,000 Mc. The system uses 4-arm waveguide hybrids in conjunction with band reflection filters made from a length of waveguide with three screw-probes $\lambda/4$ apart. A tandem arrangement for a 5-channel branching filter is described.

621.392.26†+621.396.611.4]:517.564.3 295

Some Bessel Equations and their Application to Guide and Cavity Theory—Kline. (*See* 416.)

621.392.26†+621.315]:621.3.09 296

Electromagnetic Waves in Wave Guides: Part 1—W. Opechowski. (*Philips Tech. Rev.*, vol. 10, pp. 13–25; July, 1948.) The commonly accepted theory of transmission lines and resonant circuits has only limited validity for waveguides. The theory of propagation is here developed from the fundamental Maxwell equations. Methods of solving these equations are summarized and the properties of rectangular waveguides are considered; cylindrical waveguides will be considered in part 2.

621.392.26†+621.315.212]:621.3.09 297

Electromagnetic Waves in Wave Guides: Part 2—Coaxial Cables and Circular Wave Guides—W. Opechowski. (*Philips Tech. Rev.*, vol. 10, pp. 46–54; August, 1948.) Possible modes of propagation in conductors of circular cross section and cylindrical symmetry are deduced by a direct solution of Maxwell's equations. Part 1: 296 above.

621.392.26†:517.564.3 298

Table of Roots for Natural Frequencies in Coaxial Type Cavities—Dwight. (*See* 417.)

621.392.26†:621.3.09 299

Higher Mode Techniques for Wave Guides—W. M. Goodhue. (*Proc. N.E.C.* (Chicago), vol. 3, p. 162; 1947.) Summary only. Mode filters permit the transmission of either a pure first mode or of a pure higher mode at will, in a waveguide whose dimensions greatly exceed the critical dimensions. Apparatus has been developed for excitation of pure modes, mode filtering, matching, loading, and measurement of field distribution and of standing waves, in large wave guides. Frequencies up to five times the cutoff frequency have been propagated without degeneration.

621.392.26†:621.3.09 300

Multiplex Transmission Through Wave Guides Using Higher Order Modes—G. R. Buss, W. A. Hughes, H. D. Ross, and A. B. Bronwell. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 163–179; 1947.) The possibility of transmitting two or more signals through a waveguide on the same carrier frequency, but using different modes to separate the signals, is investigated both experimentally and theoretically. Signals can be well separated by mode differences alone. Transmission through gradual bends and tapered sections does not introduce serious mode scrambling. Various antenna systems for setting up higher-order modes in rectangular and circular waveguides are analyzed.

621.396.67+621.396.621 301

Pattern for F.M. Profits: Part 5—Receiver and Antenna—Black. (*See* 495.)

621.396.67 302

The Theoretical Precision with which an Arbitrary Radiation-Pattern May Be Obtained from a Source of Finite Size—P. M. Woodward and J. D. Lawson. (*Jour. IEE* (London), part III, vol. 95, pp. 363–370; September, 1948. Summary, *ibid.*, part I, vol. 95, p. 405; September, 1948.) It is possible to approximate as closely as desired to a specified radiation pattern by a suitable distribution of field over an aperture of given size, though the necessary currents in the conducting elements of the source would, in general, be prohibitively large in comparison with the power radiated. The same is true for a linear array of given length if no limit is set to the number of elements. The treatment here presented differs essentially from that of Schelkunoff (1890 of 1943) and can be applied equally well to continuous source distributions of field or to arrays of discrete source elements.

621.396.67 303

High Gain with Discone Antennas—A. G. Kandoian, W. Sichak, and R. A. Felsenheld. (*Elec. Commun.* (London), vol. 25, pp. 139–147; June, 1948.) The discone antenna was discussed in 1180 of 1946 (Kandoian). Two systems of such antennas are here considered: (a) an omnidirectional system consisting of 9 antennas stacked vertically, operating at frequencies between 960 and 1,215 Mc, (b) a unidirectional pencil-beam system in which a single discone antenna is placed at the focus of a paraboloid reflector; the SWR is <2 over the frequency range 700 to 3,100 Mc. Reprinted from *Proc. N.E.C.* (Chicago), vol. 3, pp. 336–346; 1947.

621.396.67 304

8-Bay Pylon Antenna—O. O. Fiet. (*FM and Telev.*, vol. 8, pp. 46–48, 60; September, 1948.) Detailed description of the antenna, which has contours of field strength that are nearly circular for both 20 and 1,000 microvolts per meter with an input of 50 kw. A primary coverage up to 200 miles is obtained.

621.396.67 305

Antenna Design for Television and FM Reception—F. A. Kolster. (Proc. I.R.E., vol. 36, pp. 1242–1248; October, 1948.) Discussion of: (a) an approximate method for determining, at the preliminary design stage, the variation of the resistance and reactance of an antenna with change of frequency or physical dimensions, (b) the essential requirements for good performance over the wide band of frequencies necessary for efficient reception of all existing television channels and FM bands, (c) an antenna system designed for efficient response at all frequencies between 44 and 225 Mc.

621.396.67 306

Helical Beam Antennas for Wide-Band Applications—J. D. Kraus. (Proc. I.R.E., vol. 36, pp. 1236–1242; October, 1948.) Over a wide frequency band, the pattern shape, circularity of polarization, and terminal impedance are relatively stable. Measured performance data are included for a medium-gain antenna of optimum dimensions with a bandwidth of about 1.7 to 1. A high-gain broadside array of 4 such antennas is described and other applications are discussed.

621.396.671 307

Measurement of Aircraft Antenna Patterns in Flight—J. S. Prichard and A. H. Mankin. (*Proc. N.E.C.* (Chicago), vol. 3, p. 349; 1947.) Summary only. Description of an air versus ground system which can automatically plot the polar diagram of both horizontally and vertically polarized radiation from an aircraft flying straight and level.

621.396.671 308

Ring-Aerial Systems—H. Page. (*Wireless Eng.*, vol. 25, pp. 308–315; October, 1948.) Continuation of 1862 of 1948. An investigation of the minimum number of antennas required to give a tolerable approximation to the field of the idealized ring, in which the number of antennas is infinite. Measurement results for a 5-antenna system are given.

621.396.671 309

The Patterns of Slotted Cylinder Antennas—G. Sinclair. (*Proc. N.E.C.* (Chicago), vol. 3, p. 348; 1947.) Summary only. Patterns have been calculated for single slots in cylinders having diameters up to $\lambda/2$. The use of multiple slots is also considered.

621.396.674 310

Spaced Loop Aerials—F. Horner. (*Wireless Eng.*, vol. 25, pp. 281–285; September, 1948.) Two types of screened loop for use in a vhf coaxial system are compared; each loop is about 90 cm square. The "simple" loop has a screen gap in the center of one side and output terminals at the center of the opposite side. The "twin" loop has two screen gaps at the center points of opposite sides and output terminals at the center of an additional member parallel to, and mid-way between, the sides containing the screen gaps. The "twin" loop has three advantages: (a) it is easier to test for polarization error, (b) the geometrical tolerances in setting it up are less strict, and (c) it is mechanically more stable and can be designed with lower moment of inertia. These advantages are achieved with no apparent reduction in sensitivity or in directional accuracy.

621.396.677 311
Calculation of Doubly Curved Reflectors for Shaped Beams—A. S. Dunbar. (PROC. I.R.E., vol. 36, pp. 1289–1296; October, 1948.) A method based upon the conservation of energy and the simple laws of geometrical optics is described, for calculating the double-curvature surfaces required to produce from a point source, a beam of arbitrary shape in one plane and uniformly narrow in the perpendicular plane. The method is applied to the case of certain radar antennas for which the optimum elevation pattern is found empirically to be $G(\theta) = K \operatorname{cosec}^2 \theta \cos \theta$. Patterns are shown for antennas whose reflectors were computed by this method. Some control of the antenna pattern can be achieved by proper motion of the antenna feed. Errors are discussed.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.015.3 312
The Transient Behavior of Non-Linear Systems—C. S. Roys. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 663–669; 1947). Analysis of the steady-state performance of tube circuits is frequently based on the series expansion for the anode current. This method is extended to provide a general operational procedure for the transient response of nonlinear systems.

621.314.3† 313
Transductor Fundamentals—S. E. Hedstroem and L. F. Borg. (*Electronics*, vol. 21, pp. 88–93; September, 1948.) Discussion of: (a) types of cores and windings used for transductors or controlled reactors and methods of self-excitation, (b) the mode of operation and control characteristics for single- and multi-element transductors, (c) effects of departure of the magnetizing curve from the ideal and the behavior of a self-excited circuit in pulse operation, and (d) applications, and the relative merits of transductors and electronic amplifiers.

621.314.3† 314
Saturable Reactors and Magnetic Amplifiers—F. G. Logan. (*Electronics*, vol. 21, pp. 104–109; October, 1948.) A general account, in which the most desirable features of self-saturated reactors and magnetic amplifiers are discussed. Tests on reactor core material show a wide variation in permeability between samples of the same nominal value. Applications of magnetic amplifiers include line-voltage regulation, automatic battery charging, and theater lighting control.

621.314.3† 315
Simplified Magnetic Amplifier—D. A. Bell. (*Wireless Eng.*, vol. 25, pp. 303–304; September, 1948.) The conventional amplifier using a double-balanced system of four coil units is simplified to a bridged-tee form, for applications where proportionality between output and input is unimportant, such as the operation of electro-mechanical relays. Feedback can be applied from the rectified output to the control circuit or to separate feedback windings; the amplifier can then discriminate between inputs of different polarity.

621.316.313 316
Analyzing Electromagnetic Field Problems—K. Spangenberg, G. Walters, and F. W. Schott. (*Tele-Tech*, vol. 7, pp. 22–25, 58; August, 1948.) The particular network constructed gives solutions of the wave equation in two-dimensional cylindrical co-ordinates for cases of rotational symmetry, making it possible to determine all of the electrical characteristics of cavity resonators and transmission systems which lie within this category.

621.316.86 317
Precision Carbon Resistors—A. C. Pfister. (*Bell Lab. Rec.*, vol. 26, pp. 401–406; October, 1948.) Thin films of carbon are deposited on ceramic cores for resistances of the order 10 kΩ. High resistances are obtained by grinding a helical groove through the carbon film. The perfection and cleanliness of the ceramic surface are most important. See also 318 below.

621.316.86 318
High-Frequency Deposited Carbon Resistors—W. Van Roosbroeck. (*Bell. Lab. Rec.*, vol. 26, pp. 407–410; October, 1948.) Deposited carbon resistors are useful at high-frequency because they have low reactance and constant effective resistance, and there is no skin effect. The resistors should be made as small as is possible without allowing the carbon to reach oxidation temperature. Power dissipation for a given size can be increased by sealing the resistor in an envelope containing a neutral gas, or by liquid cooling. Applications to radar are discussed. See also 317 above.

621.318.4.011.3:518.4 319
Calculating Mutual Inductance—R. C. de Holzer. (*Wireless Eng.*, vol. 25, pp. 286–289; September, 1948.) Formulas and graphs are given for three types of multi-layer coils: (a) identical coaxial coils, (b) different coaxial coils, and (c) concentric coplanar coils. Both finite and very small cross-sectional areas are considered. The results are derived from known equations and are sufficiently accurate for most practical cases.

621.318.572 320
A New Quenching Circuit for Geiger Counters—H. Maier-Leibnitz. (*Rev. Sci. Instr.*, vol. 19, pp. 500–502; August, 1948.) The quenching circuit operates on the multivibrator principles, but uses two different grids of the input tube for the signal and for the regenerative feedback.

621.319.4 321
Oil-Filled Minitature Tuning Capacitors—S. Wald. (*Tele-Tech*, vol. 7, pp. 43–45, 57; October, 1948). Manufacturing techniques for capacitors designed for high-altitude operation at temperatures from −60° to +85°C. Petroleum naphtha was found to give the least variation of capacitance and of Q with temperature. Oil-filled capacitors can be made both smaller and lighter than corresponding air-dielectric capacitors.

621.319.4:621.315.612 322
Cyclic Variations of Capacitance—W. Reddish. (*Wireless Eng.*, vol. 25, pp. 331–337; October, 1948.) The capacitance of a capacitor with titanate ceramic as dielectric varies with temperature and also with the applied voltage. A superposed of alternating voltage is found to cause cyclic inphase capacitance variations. The ac characteristics of such capacitors can be predicted approximately from their dc characteristics. Application to FM is possible.

621.392 323
Analysis of Single-Phase Grid-Controlled Gas-Rectifier Circuits—C. M. Wallis. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 322–335; 1947.) Discussion, with numerical examples, of a method of analysis suitable for cases where the current and voltage waveforms are discontinuous functions of time.

621.392:621.396.813:621.396.619.13 324
The Distortion of Frequency-Modulated Waves by Transmission Networks—A. S. Gladwin. (PROC. I.R.E., vol. 36, pp. 1257–1259; October, 1948.) Discussion on 1294 of 1948.

621.392:621.396.822 325
Some Notes on Noise Theory and Its Application to Input Circuit Design—Harris. *See* 584.)

621.392.43 326
Theoretical Limitations on the Broadband Matching of Arbitrary Impedances—R. M. Fano. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 109–118; 1947.) The general problem of matching an arbitrary load impedance to a pure resistance by means of a reactive network is considered in terms of complex variable theory. Necessary and sufficient conditions are derived for a function of frequency to be realized which represents the input reflection coefficient of the matching network. These conditions lead to a set of integral relations which are used to determine the limitations on bandwidth and matching tolerance. Design curves are obtained for approaching optimum tolerance by means of a finite network, for a particular type of load impedance.

621.396.611 327
Mode Separation in Oscillators with Two Coaxial-Line Resonators—H. J. Reich. (PROC. I.R.E., vol. 36, pp. 1252–1255; October, 1948.) The natural frequencies of a coaxial-line resonator, of characteristic impedance Z_0 and terminated by a capacitance C, can easily be found graphically. The frequencies are not exact multiples of the fundamental. An oscillator using two such resonators can be designed so that oscillation must take place in a chosen mode. Mode separation is favored by the use of resonators that differ largely in their CZ_0 products. Theoretical and experimental tuning curves for a lighthouse-tube oscillator are in general agreement.

621.396.611 328
An Inductance-Capacitance Oscillator of Unusual Frequency Stability—W. A. Roberts. PROC. I.R.E., vol. 36, pp. 1261–1262; October, 1948.) Comment on 2193 of 1948 Clapp).

621.396.611:621.316.729 329
Pseudosynchronization in Amplitude-Stabilized Oscillators—D. G. Tucker. (PROC. I.R.E., vol. 36, p. 1262; October, 1948.) Comment on 3044 of 1948 (Aigrain and Williams).

621.396.611:621.396.619.13 330
Frequency Modulation of an Oscillator—M. R. Gavin. (*Wireless Eng.*, vol. 25, pp. 290–293; September, 1948.) A self-oscillatory tuned circuit has another tuned circuit of the same resonant frequency f_0 coupled to it. The frequency f_0 is then unstable for the coupled system, but the secondary series reactance can be adjusted so that the two stable frequencies of this system differ little from f_0. Small modulating variations of this reactance then cause a relatively large degree of FM. Some AM may also occur.

621.396.611:621.396.619.13:621.384.6 331
Wide-Deviation Frequency-Modulated Oscillators—E. M. Williams and L. Vallese. (PROC. I.R.E., vol. 36, pp. 1282–1284; October, 1948.) Discussion of instantaneous frequency and power relations in these oscillators, with special reference to types used in particle accelerators. There are no fundamental limitations on deviation and modulating frequency in the present range of interest, but a fluctuating load effect arises which may be of importance.

621.396.611.1:621.396.621 332
Formulas for Image Rejection Calculations—L. O. Vladimir. (*Tele-Tech.* vol. 7, pp. 26–27; October, 1948.) Image rejection is expressed in terms of Q and the ratio γ of the actual frequency to the resonant frequency for 5 types of tuned circuit commonly used in receivers. equivalent circuits are also shown.

621.396.611.21 333
Series-Mode Quartz Crystal Oscillator Circuit—H. Goldberg and E. L. Crosby, Jr. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 240–250; 1947.) Analysis, and discussion of modifications, of a circuit proposed by Butler (32 of 1945). See also 3048 of 1948.

621.396.615 334
Valve Oscillator Circuits—E. Williams. (*Wireless Eng.*, vol. 25, pp. 297–300; September, 1948.) Oscillators of the feedback type are considered as particular cases of a basic circuit and classified as (a) phase-restored circuits, (b) zero-phase-shift circuits, (c) tapped resonant circuits.

621.396.615 335
The Tapered Phase-Shift Oscillator—P. G. Sulzer. (Proc. I.R.E., vol. 37, pp. 1302–1305; October, 1948.) Feedback is obtained by means of T sections in cascade, the sections comprising series-C and shunt-R elements, or vice versa. The values of the series-C elements are progressively decreased by a factor a, while the shunt-R elements are increased by the same factor to obtain less attenuation for the same phase-shift. The performance of af oscillators of this type is shown for varied heater and plate voltages.

621.396.615:621.316.726 336
Semigraphical Analysis of Oscillator Frequency Instability—F. P. Fischer. (*Proc. N.E.C.* (Chicago), vol. 3, p. 662; 1947.) Summary only. A method is described for determining the equilibrium conditions for certain types of tube oscillator. It is possible to observe the effects of altering the controlling parameters and thus to solve problems of stabilization.

621.396.615.14+621.396.645 337
V.H.F. Valves and Circuits—M. R. Gavin. (*Wireless Eng.*, vol. 25, pp. 315–321; October, 1948.) The use of negative-grid tubes as oscillators and amplifiers is discussed. Improvement in performance can be obtained by adapting the tubes to the circuits in which they operate, and particularly by making the tubes integral parts of concentric-line circuits. Examples of this procedure are given and possible future developments are indicated. See also 683 of 1948 (Bell, Gavin, James, and Warren).

621.396.615.14:621.385.3 338
Triodes for Very Short Waves—Oscillators—J. Bell, M. R. Gavin, E. G. James, and G. W. Warren. (*Jour. IEE* (London), part III, vol. 95, p. 414; September, 1948.) Discussion on 683 of 1948.

621.396.615.142 339
A Velocity-Modulation Reflection Oscillator for Wavelengths of about 3.2 cm—A. F. Pearce. (*Jour. IEE* (London), part III, vol. 95, pp. 415–422; September, 1948. Summary, *ibid.*, part I, vol. 95, pp. 403–404; September, 1948.) A harmonic resonator is used in conjunction with disk-seal construction. Tuning is effected by flexure of one of the resonator diaphragms. The average power output is over 100 mw. Characteristics and dimensional details are given. Performance is discussed in relation to the theory of Barford and Manifold (894 of 1948).

621.396.615.17 340
Low-Power Frequency Multipliers—R. J. Schwarz. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 220–239; 1947.) A frequency f is fed into the grid of a class-C pentode amplifier whose anode circuit is tuned to a harmonic nf. Expressions are derived relating the input voltage to the harmonic output voltage for linear and square-law characteristics and for both fixed and grid-leak bias. Experiments confirm the analytical results.

621.396.619.14 341
Phase Modulation Circuit—S. M. Beleskas. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 654–661; 1947.) An arrangement for phase modulation up to +90°, with not more than 10 per cent distortion.

621.396.619.23 342
Serrasoid F.M. Modulator—J. R. Day. (*Electronics*, vol. 21, pp. 72–76; October, 1948.) A phase-shift type of frequency modulator which produces 100 per cent modulation, with noise 80 db down and 0.25 per cent harmonic distortion in broadcast service. A linear sawtooth generator is triggered by short rectangular pulses spaced 10 microseconds apart. These are derived from a crystal-controlled 100-kc oscillator. The sawtooth generator is directly coupled to the grid of the modulator tube, which is biased so that conduction begins when the sawtooth voltage has risen to half its maximum value. A pulse of anode current flows during the latter half of the sawtooth wave and if the modulator bias is varied, the leading edge of the pulse will vary in phase. Audio signals, fed through a conventional phase-corrector network, vary the bias, and so modulate the phase of the output pulse. This pulse, after frequency multiplication by 972, yields a carrier of 97.2 Mc, with a deviation of ±75 kc at 100 per cent modulation. The circuits are discussed in detail, and well illustrated by means of circuit diagrams and wave forms. For another account see *Tele-Tech*, vol. 7, p. 39; October, 1948.

621.396.619.23:621.396.931 343
The Miller F.M. Circuit and its Use in Railroad Radios—P. L. Bargellini. (*Electronics*, vol. 21, pp. 130, 190; October, 1948.) The tuned circuit of a Hartley oscillator is connected between the modulator grid and earth. Variation of input capacitance of the modulator is achieved by using for anode load a triode whose resistance depends on the af signal voltage. This type of modulator has given satisfactory results in equipment built for the Italian State railway.

621.396.645 344
Amplitude-Selective Amplifier—C. E. Lowe (*Electronics*, vol. 21, pp. 156, 184; October, 1948.) Circuit devised to improve a servo-system which operates a drag-cup motor in response to the output signal of a magnetic bridge. This signal is amplified and the fundamental frequency is separated from the envelope of the second harmonic. The motor-operating sine-wave output remains almost constant in frequency up to the point of complete bridge balance, when its frequency rapidly changes to the second harmonic of the bridge excitation frequency. Essential features of the circuit are cascaded discriminators, followed by a pulse reshaper.

621.396.645 345
Some Considerations Concerning Cathode-Tapped Cathode-Followers—B. B. Underhill. (*Proc. N.E.C.* (Chicago), vol. 3, p. 219; 1947.) If the grid of a cathode follower is returned to a tap on the cathode resistor instead of to ground, the output admittance of the cathode follower differs from the transconductance of the tube. The difference includes terms depending on the impedance of the source to which the cathode follower is connected, the tube parameters, and the fraction of the cathode resistance included in the grid return circuit. Graphs illustrate the effect of variations of the cathode tap on various circuit quantities. Simplifying assumptions are made which usually apply in practice.

621.396.645.371 346
Dynamic Impedance Circuit—Y. P. Yu. (*Tele-Tech*, vol. 7, pp. 28–29, 57; August, 1948.) Discussion of a negative-feedback amplifier whose effective input impedance may be made resistive or reactive and varied linearly by a factor of about 10 in response to an external control voltage. Applications suggested include filters with variable cutoff frequency and wide-band frequency modulators.

621.396.645.371 347
The Miller Integrator—B. H. Briggs. (*Electronic Eng.* (London), vol. 20, pp. 243–247, 279–284, and 325–330; August to October, 1948.) The basic principles of the integrator are discussed, with particular reference to the production of a potential variation which is linear with time. The extent of the departures from linearity which may be expected with this type of circuit is considered for different plate loads, consisting of (a) resistance and capacitance in parallel, (b) resistance and inductance in series, and (c) inductance and capacitance in parallel. The action of various special circuits, including the sanatron and the phantastron, is explained and applications to the generation of special wave forms and to electronic calculators are discussed briefly.

621.396.662.029.64 348
A Bead Supported Coaxial Attenuator for the Frequency Band 4,000–10,000 Mc—H. J. Carlin and J. W. E. Griemsmann. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 79–89; 1947.) A metallized resistance film on glass tubing is used for the inner conductor. Special couplings and grooved-bead supports allow the units to terminate in Type-N fittings without introducing much reflection.

621.396.662.3:537.228.1 349
Single-Sideband Crystal Filters—P. K. Taylor. (*Electronics*, vol. 21, pp. 116–120; October, 1948.) X-cut crystals are used in multi-section filters for the upper and lower sidebands and for the carrier frequency. The sideband filter response is flat within 0.6 db for nearly 6 kc, and the carrier filter has a bandwidth of 16 cps at the 3-db point. The temperature versus attenuation characteristic shows an average shift of 0.44 cps per degree. Circuit diagrams of the filters are given.

621.396.662.3.015.3 350
Network Transients—E. V. D. Glazier. (*Wireless Eng.*, vol. 25, pp. 338–339; October, 1948.) Application of the late A. W. Glazier's theory (1611 of 1948) to symmetrical constant-resistance types of network. Two examples are discussed, one being the low-pass filter described by Simmonds and Roberts (1430 of 1945).

621.396.665:621.397.62 351
Automatic Gain Controls for Television Receivers: Part 1—General Considerations—K. R. Wendt and A. C. Schroeder. (*RCA Rev.* vol. 9, pp. 373–385; September, 1948.) The use of agc is outlined and factors limiting the operation of various types of circuit are discussed. Several early types of agc circuits are described, with circuit diagrams illustrating the development of rapidly operating controls with improved noise immunity. Great improvement in noise immunity is obtained by using circuits which only operate within a keying pulse occurring during the signal synchronizing pulse. Part 2, 352 below.

621.396.665:621.397.62 352
Automatic Gain Controls for Television Receivers: part 2—A New Fast Noise-Immune Television A.G.C. Circuit—K. R. Wendt. (*RCA Rev.*, vol. 9, pp. 385–393; September, 1948.) Description and diagram of an "inverted keying" circuit, in which response to noise impulses is slow and recovery rapid. This circuit responds more rapidly to a decreased than to an increased signal. Part 1, 351 above.

621.396.69 353
Radio Components—(*Jour. IEE* (London), part IIIA, vol. 94, pp. 938–942; 1947.) Discus-

sion on 1895 of 1948 (Lee) and on 1900 of 1948 (Ross).

621.318.572.029.64 354
Microwave Duplexers [Book Review]—L. D. Smullin and C. G. Montgomery (Eds). McGraw-Hill, London, 437 pp., 39s. (*Wireless Eng.*, vol. 25, p. 302; September, 1948.) No. 14 of the MIT Radiation Laboratory series. The book combines a "mass of important empirical data, a valiant attempt at a theory of the gaseous discharge, and much detailed circuit analysis." It is mainly concerned with transmit-receive and anti-transmit-receive switches, discovered in their modern form at the Telecommunications Research Establishment.

621.392:621.385 355
Vacuum Tube Circuits [Book Review]—L. B. Arguimbau. John Wiley and Sons, New York, N. Y., 1948, 657 pp., $6.00. (Proc. I.R.E., vol. 36, p. 1272; October, 1948.) "On the whole, this is an excellent reference book on the design of vacuum-tube circuits. . . . It could be very useful in teaching a design course to those who have already had a basic course."

GENERAL PHYSICS

53.081+621.3.081 356
The Origin of the Giorgi System of Electrical Units—W. de Groot. (*Philips Tech. Rev.*, vol. 10, pp. 55–60; August, 1948.)

537.291 357
Plotting Electron Paths—P. J. Selgin. (*Electronics*, vol. 21, pp. 124, 166; September, 1948.) A method using a universal set of curves developed on the assumption that the electron trajectory between equipotentials is an arc of a parabola.

537.311.33:621.396.645:621.315.59 358
Design of Amplifying Crystal Units—White. (*See* 581.)

537.311.33:621.396.645:621.315.59 359
Experimental Data on Germanium Crystal Amplifiers—White. (*See* 582.)

537.311.62 360
The High-Frequency Skin Effect at Low Temperatures—A. B. Pippard. (*Jour. IEE* (London), part III, vol. 95, p. 343; September, 1948. Discussion, pp. 343–345.) Summary of IEE Scientific Radio Convention paper. At low temperatures (→2°K), the surface resistivity of a metal tends to a constant value instead of a value inversely proportional to the square root of the bulk conductivity. This is due to the long free paths of the conduction electrons.

537.523 361
High-Frequency Electrical Breakdown Phenomenon in Gases—R. Cooper and W. A. Prowse. (*Jour. IEE* (London), part III, vol. 95, p. 342; September, 1948. Discussion, pp. 343–345.) Summary of IEE Scientific Radio Convention paper. For frequencies below a critical value, the breakdown stress of air agrees with the 50-cps value. At higher frequencies, it falls quickly to a value of about 28 kv/cm. A true minimum stress for breakdown exists at frequencies in the range 2,800 to 9,800 Mc. Methods of measurement and the form of the discharge are discussed.

537.525 362
Studies in High Frequency Discharges—J. I. Lodge and R. W. Stewart. (*Canad. Jour. Res.*, vol. 26, sec. A, pp. 205–229; July, 1948.) Theoretical discussion, assuming that the discharge is largely determined by its dc wall and space charges, and that the chief function of the high-frequency field is to maintain the electron temperature.

537.525.3(23.084):621.396.933 363
Corona Discharge at High Altitude and Its Control to Reduce Radio Interference—H. J. Dana. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 40–46; 1947.) The causes of interference with radio navigational aids and the basic laws of corona discharge are discussed. Measurement apparatus and methods are considered and results of tests are examined in detail.

538.22 364
Investigations of Magnetic Phenomena at Centimetre Wavelengths—J. H. E. Griffiths. (*Jour. IEE* (London), part III, vol. 95, pp. 342–343; September, 1948. Discussion, pp. 343–345.) Summary of IEE Scientific Radio Convention paper. Discussion of: (a) complex permeability of γ Fe_2O_3 for λ 3 to 60 cm, (b) ferromagnetic resonance, and (c) resonance absorption by paramagnetic salts.

538.31 365
On the Mutual Magnetic Energy of a Current and a Magnet—É. Brylinski. (*Rev. Gén. Élec.*, vol. 57, pp. 340–345; August, 1948.) Discussion of the two cases where the elements are free to move and where they are relatively at rest. It is concluded that this magnetic energy should not enter into the expression for the total magnetic energy of the system.

538.569.3/.4].029.64 366
High-Frequency Absorption Phenomena in Liquids and Solids—W. Jackson and J. A. Saxton. (*Jour. IEE* (London), part III, vol. 95, pp. 341–342; September, 1948. Discussion, pp. 343–345.) Summary of IEE Scientific Radio Convention paper. A review of recent work by various authors.

538.569.4.029.64 367
Microwave Spectroscopy of Gases—B. Bleaney. (*Jour. IEE* (London), part III, vol. 95, pp. 340–341; September, 1948. Discussion, pp. 343–345.) Summary of IEE Scientific Radio Convention paper. Discussion of: (a) methods of measuring cm-λ absorption, (b) theoretical and experimental absorption spectra for NH_3 and for atmospheric gases. See also 3100 and 3397 of 1948 and back references.

53 368
Reports on Progress in Physics. Vol. 11, 1946–47 [Book Review]—The Physical Society, London, 461 pp., 42s. (*Wireless Eng.*, vol. 25, p. 321; October, 1948.) Titles of selected papers are quoted. For abstracts of individual papers, see 3300, 3395, 3401, 3402, 3473, and 3483 of 1948.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.53:551.510.535:621.396.11.029.62 369
Reflection of Very-High-Frequency Radio Waves from Meteoric Ionization—E. W. Allen, Jr. (Proc. I.R.E., vol. 36, pp. 1255–1257; October, 1948.) Discussion on 2328 of 1948.

523.53:621.396.9 370
Meteors and Their Effect on Radio—A.C.B. Lovell. (*Jour. IEE* (London), part III, vol. 95, pp. 324–325; September, 1948. Discussion, pp. 327–330.) Summary of IEE Scientific Radio Convention paper. Discussion of: (a) scattering as a function of wavelength, (b) number and duration of echoes, (c) fluctuations in intensity, (d) diffraction effects, and (e) sporadic-E ionization.

523.7+550.385]"1947.10/.12" 371
Solar and Magnetic Data October to December, 1947, Mount Wilson Observatory—S. B. Nicholson. (*Terr. Mag. Atmo. Elec.*, vol. 53, p. 26; March, 1948.)

523.72+523.854]:621.396.822 372
Galactic and Solar Radio Noise—J. S. Hey. (*Jour. IEE* (London), part III, vol. 95, p. 333; September, 1948. Discussion, pp. 334–340.) Summary of IEE Scientific Radio Convention paper. The high-intensity rf emission from sunspots, which is particularly strong for $\lambda \simeq 5$ meters, suggests that stars may have similar spots which cause galactic noise. Movements of electrons in inter-stellar ionized gas may be an additional contributory cause.

523.72.029.62 373
Some Observations of Solar Radiation on Wavelengths of 1.7 and 3.8 Metres—M. Ryle. (*Jour. IEE* (London), part III, vol. 95, pp. 333–334; September, 1948. Discussion, pp. 334–340.) Summary of IEE Scientific Radio Convention paper. In the absence of sunspots, the sun radiates with an intensity corresponding to a surface temperature of about 10^{6}°K. Sunspot areas radiate as if they were at a temperature of 10^{9} to 10^{10}°K. Bursts of intense radiation do not occur simultaneously on the above wavelengths. Radiation from the undisturbed sun is randomly polarized. Radiation from sunspots is usually circularly polarized in a sense determined by the direction of the magnetic field of the sunspot.

523.72.029.63:621.396.822 374
Solar Radio Noise—(*Observatory*, vol. 68, pp. 178–183; October, 1948.) Summary of Royal Astronomical Society discussion. The unexpectedly high intensity of 1 to 5-meter radiation from the quescent sun can be explained on thermodynamical grounds. Attempts were made to explain similarly the much more intense radiation from sunspots. The possibility that plasma oscillations might be the effective cause was also considered, and suggestions for further research were made.

523.746"1947.10/.12" 375
Provisional Sunspot-Numbers for October to December, 1947—M. Waldmeier. (*Terr. Mag. Atmo. Elec.*, vol. 53, p. 34; March, 1948.

523.752 376
Chromospheric Flares—R. G. Giovanelli. (*Mon. Not. R. Astr. Soc.*, vol. 108, pp. 163–176; 1948.) A brief account of the observed properties. The flares may be caused by variations in the magnetic flux through a nearby sunspot. If the electric field exceeds a certain value, electrons acquire sufficient energy to excite H atoms by collision and flares may result. The flares should occur in definite places depending largely on the shape of the magnetic field in the neighborhood of sunspot groups. Most of the well-known features of flares are explained by this theory.

523.854:621.396.822 377
Cosmic Static—G. Reber. (Proc. I.R.E., vol. 36, pp. 1215–1218; October, 1948.) The results of a survey of the galaxy made at a frequency of 480 Mc are compared with previous results for 160 Mc given in 1028 of 1945. The apparatus used is described briefly. The principal new findings are: (a) a projection from Sagittarius in the direction of the north galactic pole; (b) a supplementary small rise in Aquilla; and (c) a splitting of the maxima in Cygnus and Orion each into two parts.

550.38"1947.10/.12" 378
K-Indices and Sudden Commencements, October to December, 1947, at Abinger—H. Spencer Jones. (*Terr. Mag. Atmo. Elec.*, vol. 53, p. 78; March, 1948.)

550.38"1947.10/.12" 379
Cheltenham [Maryland] K-Indices for October to December, 1947—R. G. Gebhardt. (*Terr. Mag. Atmo. Elec.*, vol. 53, p. 81; March, 1948.)

550.383 380
The Radial Variation of the Earth's Magnetic Field—S. K. Runcorn and S. Chapman. (*Proc. Phys. Soc.*, vol. 61, pp. 373–382; October

1, 1948.) Core and distributed theories of geomagnetism predict different variations of field intensity with depth *d*. Core theories give an increase on both H and V inversely proportional to d^3, but on a distributed theory such as that of Blackett (3112 of 1947), V should increase for small depths inversely as d^3, while H should decrease. If experiments on the variations with depth favor the distributed theories, experiments on the magnetic effect of gorges in the earth's surface might further elucidate the problem.

550.384.3 381
The Secular Change in the Earth's Magnetic Field—E. C. Bullard. (*Mon. Not. R. Astr. Soc., Geophys. Supplement*, vol. 5, pp. 248–257; July, 1948.) A theoretical discussion attempting to explain the known facts. Causes situated in the solid outer skin of the earth are ruled out. A possible explanation is the existence of shallow eddies in the liquid core, which is assumed to be composed of Fe and Ni in the proportions commonly found in meteorites, but the required speed of movement in the eddy seems unduly high. Further investigation, both theoretical and experimental, is required.

550.385"1947.10/.12" 382
Principal Magnetic Storms [Oct.–Dec. 1947]—(*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 84–95; March, 1948.)

550.385"1947.01/.06" 383
Five International Quiet and Disturbed Days for January to June, 1947—W. E. Scott. (*Terr. Mag. Atmo. Elec.*, vol. 53, p. 66; March, 1948.)

550.387 384
The Magnetic Field Produced by Earth Currents Flowing in an Estuary or Sea Channel—N F. Barber. (*Mon. Not. R. Astr. Soc. Geophys. Supplement*, vol. 5, pp. 258–269; July, 1948.) Measurements in the Clyde estuary of fluctuations of the earth's vertical magnetic field, and of simultaneous fluctuations in the horizontal potential gradients in the water, show definite correlation. Similar results were obtained by Hoare and Rowe in Iceland. A large proportion of the short-period fluctuations of vertical intensity recorded at the magnetic observatory at Abinger can be ascribed to variations in the earth current in the English Channel.

551.509:621.396.9 385
Radar and the Forecaster—P. F. Duncan. (*Weather* (London), vol. 3, pp. 34–36; February, 1948.) Discussion of the use of radar for obtaining information about clouds, rain, thunderstorms, etc., for weather forecasting.

551.510.535 386
A Model of the Ionosphere—R. H. Woodward. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 1–25; March, 1948.) A brief survey is made of the main geophysical phenomena. Qualitative explanation of these phenomena is provided by a model which assumes an upward flow of electrons in low and in medium latitudes and a corresponding downward flow in polar regions, the circuit being completed by the earth and the ionosphere. The combined action of electric and magnetic fields results in negative-ion concentration at the poles and a positive-ion ring around the geomagnetic equator. Solar radiation pressure produces marked distortion of this ring. Electric discharges between the ring and the negative polar caps produce magnetic disturbances and the associated auroral displays.

551.510.535 387
On a New Method for Exploring the Upper Ionosphere—D. K. Bailey. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 41–50; March, 1948.) The intensity of ionization in the region above the height of maximum F_2-layer ionization is not known, but some information can be obtained by measuring the refraction of radio waves arriving at the earth after passage through the entire ionosphere. An experimental technique for such measurement is discussed. A theoretical expression is derived for the refraction of radio waves which pass through a parabolic-layer model; the range of frequencies within which refraction measurements should be made is deduced. Extraterrestrial radio waves can be obtained either from the sun or by reflection from the moon.

551.510.535 388
The Production of the E-Layer—F. Hoyle and D. R. Bates. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 51–62; March, 1948.) Difficulties in the current theory of *E*-layer formation are summarized. An alternative suggestion is that the layer is produced by high-energy photons from the solar corona. An incident energy flux with maximum around either 325 eV or 1,300 eV could give the observed ionization, but only the former value would be fully satisfactory.

551.510.535 389
The Geomagnetic Nature of the F_2-Layer Longitude-Effect—D. K. Bailey. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 35–39; March, 1948.)

551.510.535 390
A Sporadic F-Layer—O. Burkard. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 63–65; March, 1948.) Results of observations at Tromso, Norway, on a night-time sporadic-*F* layer, during the winter of 1944 and 1945.

551.510.535:523.746 391
Comparative Correlations of f°F2 with "Ionospheric Sunspot-Number" and Ordinary Sunspot-Number—M. L. Phillips. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 79–80; March, 1948.) See also 727 of 1948.

551.515.4:621.396.9 392
A Summary of some Radar Thunderstorm Observations—H. B. Brooks. (*Bull. Amer. Met. Soc.*, vol. 27, pp. 557–563; December, 1946.) Statistics of 300 showers observed at Spring Lake, N. J., during June to August, 1945.

551.577:621.396.9 393
Radar Detection of Precipitation—A. E. Bent. (*Weather* (London), vol. 3, pp. 37–41; February, 1948.) Reprint of major portion of article in *Jour. Met.*, vol. 3, September, 1946. An account of results obtained with 10-cm equipment, using a PPI display.

551.594.2 394
Atmospheric Electricity during Disturbed Weather—G. C. Simpson. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 27–33; March, 1948.) Long summary of a paper to be published by the London Meteorological Office as Geophysical Memoir No. 84, dealing with a special investigation at Kew Observatory from October, 1942, to May, 1946, which included observations of the potential gradient and of the charge carried by rain and snow.

551.594.6 395
Atmospherics—T. W. Wormell and E. T. Pierce. (*Jour. IEE* (London), part III, vol. 95, pp. 331–332; September, 1948. Discussion, pp. 334–340.) Summary of IEE Scientific Radio Convention paper. An account of investigations of (a) the effects of lightning flashes at distances up to about 100 km, (b) the detailed wave form of the field disturbance due to flashes at much greater distances.

551.594.6:621.396.822 396
The World Distribution of Radio Noise—H. A. Thomas. (*Jour. IEE* (London), part III, vol. 95, pp. 332–333; September, 1948. Discussion, pp. 334–340.) Summary of IEE Scientific Radio Convention paper. Measurements have been made hourly for nearly 3 years at each of 14 stations, at frequencies of 2.5, 5, 10, 15, and 20 Mc. The median noise characteristic for a particular location has a very real significance but does not appear to apply to a large area. The incomplete results suggest that the sources of atmospherics may be local.

551.510.535 397
Ionospheric Research at Watheroo Observatory, Western Australia, June 1938–June 1946 [Book Review]—L. V. Berkner and H. W. Wells. Carnegie Institution of Washington, Publication 175, vol 13, 1948, 421 pp. (PROC. I.R.E., vol. 36, p. 1272; October, 1948.) A repository of data, with an introductory text giving a concise account of methods of ionospheric research. See also 2795 of 1948 (Seaton, Wells, and Berkner).

LOCATION AND AIDS TO NAVIGATION

621.396.9 398
Minimum Detectable Radar Signal—U. Tiberio. (PROC. I.R.E., vol. 36, p. 1261; October, 1948.) Comment on 1095 of 1947 (Haeff).

621.396.9 399
Some Applications of Frequency-Modulated Radar—I. Wolff and D. G. C. Luck. (*RCA Rev.*, vol. 9, pp. 531–555; September, 1948.) Continuation of 2798 and 3124 of 1948. The principles there discussed are applied to the production of light, compact FM radar for aircraft. A FM radar system is particularly suitable for operating a low-altitude automatic bomb release. Other applications include altimetry, automatic flight control, control of aircraft landing approach, and radar search.

621.396.9:621.385.832 400
Three-Dimensional Cathode-Ray Tube Displays—Parker and Wallis. (*See* 577.)

621.396.933 401
Functional Requirements for Radio Aids to Civil Aviation—V. A. M. Hunt (*Jour. Brit. I.R.E.*, vol. 8, pp. 41–56; March and April, 1948.) Discussion, pp. 56–60.) Discussion with special reference to the conclusions reached by the special Radio Technical, or "Cot" Division of P.I.C.A.O. at the Montreal conference, November, 1946. Reprinted in PROC. I.R.E. (Australia) vol. 8, pp. 16–25; September, 1947.

621.396.933 402
C.W. Navigation Aids—(*Jour. IEE* (London), part IIIA, vol. 94, no. 16, pp. 1022–1030; 1947.) Discussion on 1958 of 1948 (Whelpton and Redgment) and on 1960 of 1948 (Williams).

621.396.933 403
The Application of Existing Techniques to the Problem of Air Traffic Control—W. D. White. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 468–479; 1947.)

621.396.933 404
Teleran—A Technical Progress Report—R. W. K. Smith, D. H. Ewing, and H. J. Schrader. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 429–448; 1947.)

621.396.933:518.5 405
Computer for Aeronautical Navigation—Schuck. (*See* 422.)

621.396.933:537.525.3(23.084) 406
Corona Discharge at High Altitude and its Control to Reduce Radio Interference—Dana. (*See* 363.)

621.396.9 407
Radar; What Radar Is and How It Works [Book Review]—O. E. Dunlap, Jr. Harper Bros, New York, N. Y., 2nd edition 1948, 246 pp., $3.00. (PROC. I.R.E., vol. 36, p. 1272; October, 1948.) The second edition of a book

noted in 2201 of 1946 under the title "Radar." A sensational account of what radar has done, containing thought-provoking suggestion of what radar might do. See also 2134 of 1947 (Rider and Rowe).

MATERIALS AND SUBSIDIARY TECHNIQUES

533.15 408
A Mass Spectrometer Type Leak Detector Utilizing a Cold Cathode Ion Source—H. A. Thomas, H. Sommer, and R. Wall. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 371–376; 1947.) This is simpler and cheaper than the hot-cathode type. 1 part of He in 400,000 parts of air can be detected with laboratory-type instruments.

533.5 409
Vacuum Systems, Seals, and Valves—F. N. D. Kurie. (*Rev. Sci. Instr.*, vol. 19, pp 485–493; August, 1948.) Discussion of all-metal, kinetic vacuum systems designed to operate at pressures down to 10^{-5} mm Hg, and of precautions necessary in assembling and maintaining such systems. Reliable, high-speed tubes are needed. Rubber gaskets are considered in detail, and the usefulness of O-rings is also noted, with specific examples.

535.371.07:621.317.755 410
Luminescent Screens for Cathode-Ray Oscillography—Feldt. (*See* 445.)

549.514.51 411
Synthetic Crystals of Quartz—(*Bell Lab. Rec.*, vol. 26, pp. 384–385; September, 1948.) Summary of paper by E. Buehler and A. C. Walker read at a meeting of the International Union of Crystallography. Finely powdered silica is placed in a steel bomb with an aqueous alkaline solution. Under pressures above 15,000 lb/inch² and at a temperature of about 750° F the silica dissolves, rises to the cooler part of the bomb, and crystallizes on a thin seedplate of quartz. The standard growth rate is stated to be four times as fast as any previously reported.

549.514.51 412
The Effect of Spurious Resonances and Parallel Losses on the Equivalent Parameters of Quartz Crystals—B. A. Mamyrin and L. N. Sosnovkin. (*Zh. Tekh. Fiz.*, vol. 18, pp. 955–958; July, 1948. In Russian.) A report of an experimental investigation of quartz crystals manufactured in Russia, Germany, and the United States of America. Results are tabulated.

621.315.59 413
Electrical Semi-Conductors—K. Lark-Horovitz. (*Proc. N.E.C.* (Chicago), vol. 3, p. 524; 1947.) Summary only. Discussion of the electrical behavior of metals, insulators, and semiconductors, with experimental verification of theory for Ge with various types of impurity. Applications are also considered.

621.315.612 414
Properties of Barium-Magnesium Titanate Dielectrics—G. R. Shelton, A. S. Creamer, and E. N. Bunting. (*Jour. Res. Nat. Bur. Stand.*, vol. 41, pp. 17–26; July, 1948.) Results are given of measurements on samples of various compositions (a) for dielectric constant K at 1 Mc and temperatures from −60° to +85°C, (b) for Q, the reciprocal of power factor, at 25°C and frequencies of 50 kc and 1, 20, and 3,000 Mc. K values ranged from 12 to 1,550 and those of Q from 9 to 10,000.

621.315.612:621.319.4 415
Cyclic Variations of Capacitance—Reddish. (*See* 322.)

MATHEMATICS

517.564.3:[621.392.26†+621.396.611.4 416
Some Bessel Equations and their Application to Guide and Cavity Theory—M. Kline. (*Jour. Math. Phys.*, vol. 27, pp. 37–48; April, 1948.) Discussion of the real positive values of x which satisfy either,

$$J_n(x)\,N_n(\rho/x) - J_n(\rho/x)\,N_n(x) = 0, \text{ or}$$
$$J'_n(x)\,N'_n(\rho/x) - J'_n(\rho/x)\,N'_n(x) = 0,$$

where $0<\rho<1, n=0, 1, 2, 3, \cdots$, and $J_n(x)$, $N_n(x)$ are Bessel functions of the first and second kinds. The existence of electromagnetic modes in coaxial, circularly cylindrical waveguides and cavities depends upon the existence of such values of x. See also 417 below.

517.564.3:621.392.26† 417
Table of Roots for Natural Frequencies in Coaxial Type Cavities—H. B. Dwight. (*Jour. Math. Phys.*, vol. 27, pp. 84–89; April, 1948.) Numerical values of the smaller roots of the equations discussed in 416 above, for various values of ρ from 1 upwards.

518.5 418
Digital Computer Switching Circuits—C. H. Page. (*Electronics*, vol. 21, pp. 110–118; September, 1948.) An account of the fundamental principles of digital computers and the basic operational requirements. Methods of representing, transmitting, and storing numbers and orders as trains of pulses at a repetition rate of 2×10^6 per second are described. The operation of an elementary adder and the functions of gates and buffers are discussed, and also serial adding circuits using diodes for coding and decoding orders.

518.5 419
Electronic Computers—J. W. Mauchly and J. P. Eckert, Jr. (*Proc. N.E.C.* (Chicago), vol. 3, p. 200; 1947.) 2-line summary only. Discusses Edvac and other types.

518.5:512.25 420
Details of the Simultaneous Equation Solver—E. A. Goldberg. (*RCA Rev.*, vol. 9, pp. 394–405; September, 1948.) The electrical design and operation of a practical model for solving systems of up to 10 linear simultaneous equations are considered in detail. Stability is considered by E. A. Goldberg and G. W. Brown in *Jour. Appl. Phys.*, vol. 19, pp. 339–345; April, 1948.

518.5:621.395.625.3 421
Storage of Numbers on Magnetic Tape—J. M. Coombs. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 201–209; 1947.) The tapes are bonded to the surface of an Al drum. Associated with each tape are 3 heads for reading, writing, and erasing magnetized spots on the tapes. 200,000 magnetized spots can be stored on a drum 34 inches in diameter and 10 inches wide.

518.5:621.396.933 422
Computer for Aeronautical Navigation—O. H. Schuck. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 210–218; 1947.) By electrical means, bearing and distance from a radio beacon are converted to distance from destination and distance off track. Aircraft are thus enabled to fly on parallel paths.

51:621.396 423
Basic Mathematics for Radio [Book Review]—G. F. Maedel. Prentice-Hall, New York, N. Y., 1948, 334 pp., $4.75. (PROC. I.R.E., vol. 36, p. 1269; October, 1948.) An earlier edition (with a different title) was noted in 3383 of 1939.

518.5+621.317.7+621.526+621.316.72 424
Electronic Instruments [Book Review]—Greenwood, Jr., Holdam, Jr., and MacRae, Jr. (*See* 454.)

MEASUREMENTS AND TEST GEAR

621.317.083.7:623.746.48 425
Telementary for Guided Missiles—L. J. Neelands and W. Hausz. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 404–416; 1947.) A mechanical commutator samples each of 28 channels 35 times per second; the information is transmitted to a ground station, where it is displayed on a crt and photographed.

621.317.3.029.5/.62 426
An Appraisal of Laboratory Radio Measuring Techniques: Part 1—Frequencies below 300 Mc/s—T. I. Jones. (*Jour. IEE* (London), part III, vol. 95, pp. 315–316; September, 1948. Discussion, pp. 318–324.) Summary of IEE Scientific Radio Convention paper. Methods of calibration and accuracies obtainable for voltmeters, ammeters, attenuators, and impedance meters are discussed.

621.317.3.029.63/.64 427
An Appraisal of Laboratory Radio Measuring Techniques: Part 2—Frequencies above 300 Mc/s—F. M. Colebrook. (*Jour. IEE* (London), part III, vol. 95, p. 316; September, 1948. Discussion, pp. 318–324.) Summary of IEE Scientific Radio Convention paper. Power measurement technique is now substantially as described by Oatley (1988 of 1948). Both resonance and standing-wave methods of impedance measurement are considered.

621.317.32 428
Radio Field-Strength Measurement—R. L. Smith-Rose. (*Jour. IEE* (London), part III, vol. 95, pp. 317–318; September, 1948. Discussion, pp. 318–324.) Summary of IEE Scientific Radio Convention paper. A survey of present techniques and attainable accuracies. Above 30 Mc the main recent improvements have been due to (a) the separation of the calibrating unit from the field-strength measuring set, and its replacement by a method of producing a known field by radiation, and (b) replacement of current or voltage measurement by power measurement.

621.317.32 429
A Method of Measuring the Field Strength of High-Frequency Electromagnetic Fields—R. Truell. (PROC. I.R.E., vol. 36, pp. 1249–1251; October, 1948.) Discussion of the case of an electron beam directed parallel to a uniform steady magnetic field and perpendicular to a high-frequency electromagnetic field. The equations of motion simplify if $e\,Hz/mc+\omega$ where ω is the frequency of the electromagnetic field. This relation can be used to measure the strength of the high-frequency field.

621.317.333.4:621.315.2 430
Various Papers on Investigation of Faults in Cables—(*See* 280, 282, 283, and 286 to 289.)

621.317.333.4:621.315.212 431
Test Sets for Dielectric Faults in Coaxial Cable—J. W. Kittner, Jr. (*Bell Lab. Rec.*, vol. 26, pp. 416–420; October, 1948.) The "Sliver Burner" 94A test set burns out low-resistance dielectric faults eelctrically. The 90A test set locates, by a bridge method, those faults which cannot be burnt out.

621.317.336 432
A Null-Method for the Determination of Impedance in the 100-400 Mc Range—J. F. Byrne. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 603–614; 1947.) The unknown impedance is connected to a branched transmission line and the phase and amplitude of the current through it are determined independently in a bridge type of equipment including a double section of slotted line. The method is quick and its accuracy is within 3° and 5 per cent over the frequency band tested, 130 to 220 Mc.

621.317.361 433
Frequency Measurement by Sliding Harmonics—J. K. Clapp. (PROC. I.R.E., vol. 36, pp. 1285–1288; October, 1948.) The output of a 950-kc crystal oscillator is mixed with that

of a 50 to 60-kc accurately calibrated bridge oscillator to produce a standard frequency variable between 1,000 and 1,010 kc, which drives a harmonic generator. Methods of extending the range of a given standard are discussed. Accuracy is within 1 part in 10^6.

621.317.373 434
The Accurate Measurement of Relative Phase—R. A. Glaser. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 593–602; 1947.) Direct phase-difference measurement is frequently carried out by observing the characteristics of the Lissajous figure (ellipse) traced on a cro when the two signals are applied to the two sets of deflecting plates. The accuracy is poor but can be greatly improved, at the expense of added ambiguities, by use of frequency multiplication.

621.317.44 435
An Electronic Fluxmeter—R. H. Dicke. (*Rev. Sci. Instr.*, vol. 19, pp. 533–534; August, 1948.) Similar in performance to the Grassot meter, but superior to it. Edgar's fluxmeter (3886 of 1937) used the same principles of operation. Operation, circuit, and performance details are given.

621.317.44:621.314.3† 436
Applications of the Saturable-Core Magnetometer—W. E. Tolles. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 504–513; 1947.)

621.317.7 437
Coaxial Elements and Connectors—W. R. Thurston. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 97–108; 1947.) A general review of the principal uhf methods of measuring impedance, power, and voltage, and of matching impedances, a system of coaxialline units with connectors is described, which may be used to build up apparatus for these measurements. The connectors on all units are identical, and rapid assembly of apparatus is possible.

621.317.725/.726 438
Stable Voltmeter Amplifier—R. G. Woodville. (*Wireless Eng.*, vol. 25, p. 304; September, 1948.) Comment on 2847 of 1948 (Clare). A latter form of the amplifier there described was suggested by Silver (3333 and 3600 of 1945).

621.317.725:621.396.611.1 439
Electronic Circuit Has Logarithmic Response—A. W. Nolle. (*Electronics*, vol. 21, pp. 166, 178; September, 1948). The circuit uses the exponential decay characteristics of a *RC* circuit. The instrument is designed to measure the time interval required for the voltage under test to decay to a standard value. A specific circuit is described having a 20-db or 30-db scale with accuracy within 0.1 db.

621.317.726 440
Peak-to-Peak Voltmeter—F. H. Shepard, Jr., and E. Osterland. (*Electronics*, vol. 21, pp. 101–103; October, 1948.) A discussion of design requirements with circuit details of a meter for measuring pulses and transients of short duration covering a range of 0.001 to 1,000 volts peak-to-peak or 0.00035 to 355 volts rms. A near-zero impedance output is achieved by means of pulse-stretching circuits and feedback in the pre-amplifier. Circuit diagrams and voltage versus frequency characteristics are given.

621.317.733:621.316.86:621.317.784 441
Self-Balancing Thermistor Bridge—C. C. Bath and H. Goldberg. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 47–57; 1947.) The instrument uses two matched thermistors, one of which is exposed to rf power while the other is not. The former is part of a bridge which is in the feedback loop of a 6-kc sine-wave oscillator. The latter thermistor, which is exposed to the same ambient temperature, is part of an identical bridge in shunt with the power-measuring bridge. Exposure of the power-measuring thermistor to rf power unbalances the second bridge and the unbalance voltage is measured with a tube voltmeter. Temperature compensation is thus automatic. The output is a linear function of the rf input power.

621.317.733:621.396.677 442
Transmission Line Bridge—A. L. Cullen. (*Wireless Eng.*, vol. 25, pp. 304–305; September, 1948.) Comment on 2854 of 1948 (Westcott).

621.317.755 443
New Cathode-Ray Oscillographs and Applications—C. Berkley. (*Proc. N.E.C.* (Chicago), vol. 3, p. 294; 1947.) Summary only. Discussion of design features and accessories.

621.317.755:531.761 444
Short-Time Oscillography—J. V. Lebacqz. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 68–77; 1947.) A mathematical analysis of the deflection of a cro spot when a transient voltage with linear rise is applied. A method is described for obtaining transient Lissajous figures by the use of a T-junction and phase-delay cables. The patterns obtained can be used to deduce times of rise as small as 10^{-9} seconds.

621.317.755:535.371.07 445
Luminescent Screens for Cathode-Ray Oscillography—R. Feldt. (*Proc. N.E.C.* (Chicago), vol. 3, p. 78; 1947.) Summary only. Criteria governing the choice of such screens are discussed. The effects of accelerating potential, beam current, spot size, screen efficiency, writing rate, repetition rate, decay time, and other factors are evaluated. The requirements for general visual oscillography and for the study of single transient phenomena are compared. A standard method is described for calculating maximum writing rates under given conditions.

621.317.77 446
The Phase Meter—E. O. Vandeven. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 587–592; 1947.) A circular trace is produced on a cro in the usual manner and is modulated in intensity by a pulse derived from the signal whose phase is to be measured. A bright (or dark) spot appears at a particular point on the circle. The phase meter described applies these principles to the case of a 3-phase supply. The relative positions of the 3 spots on the circle indicate the relative phases directly.

621.317.784:621.317.733 447
A Balanced Water-Flow Wattmeter for Centimetre Wavelengths—W. A. Penton and I. R. A. Overton. (*N.Z. Jour. Sci. Tech.*, vol. 29, pp. 215–222; January, 1948.) The rf power is balanced against 50-cps mains power by means of a resistance bridge whose arms are contained in chambers of polystyrene through which a steady stream of water flows.

621.317.79:621.396.615:621.397.335 448
Television Synchronizing Signal Generator—A. J. Baracket. (*Electronics*, vol. 21, pp. 110–115; October, 1948.) Horizontal and vertical driving pulses, the composite blanking signal and the composite synchronizing signal are produced within FCC and RMA specifications.

621.317.79:621.396.97 449
A Pulse Counter Type FM Station Monitor—N. B. Schrock and D. Packard. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 630–643; 1947.) The intermodulation and harmonic-measurement methods for determining af distortion are compared. Curves are given which show the ratio of intermodulation distortion to harmonic distortion as a function of the latter.

621.317.79:621.397.7 450
Monitor for Television Broadcasting Stations—M. Silver. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 569–578; 1947.) Equipment for monitoring, with the required FCC accuracy, the carrier frequency of the picture transmission and the center frequency and depth of modulation of the sound transmission.

621.317.794 451
Broad Band Bolometer Type UHF Power Meters—M. J. DiToro. (*Proc. N.E.C.* (Chicago), vol. 3, p. 119; 1947.) Summary only. Broad-band performance is achieved by the introduction of complementary reactive elements which annul the inherent inductive component of a resistive bolometer element. Design procedures are discussed for a number of sensitive meters for frequencies from 20 to 10,000 Mc and powers from 20 microwatts to 2 watts.

621.396(083.74) 452
Radio Standards—L. Hartshorn and L. Essen. (*Jour. IEE* (London), part III vol. 95, p. 315; September, 1948. Discussion, pp. 318–324.) Summary of IEE Scientific Radio Convention paper. Discussion of the meaning and terminology of "standards", of recent improvements in technique, and of the effect of the change from international to absolute units.

621.396.69.001.4 453
Tests for the Selection of Components for Broadcast Receivers—G. D. Reynolds. (*Jour. IEE* (London), part III, vol. 95, pp. 412–413; September, 1948.) Discussion on 2864 of 1948.

621.317.7+621.526+621.316.72+518.5 454
Electronic Instruments [Book Review]—I. A. Greenwood, Jr., J. V. Holdam, Jr., and D. MacRae, Jr. (Eds) McGraw-Hill, New York, N. Y., 1948, 708 pp., $9.00 (PROC. I.R.E., vol. 36, p. 1273; October, 1948.) Vol. 21 of the MIT Radiation Laboratory series. Not only measuring instruments, but also electronic analogue computers, servomechanisms, and voltage and current regulators, are discussed in relation to the war-time work of the Radiation Laboratory.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.746 455
The Position "Convectron," a New Type of Dynamic Vertical Sensitive Element—M. A. Babb. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 192–196; 1947.) The resistance of a very thin straight hot wire in a gas depends on its inclination to the vertical. Two wires inclined to form a 90° *V* are inserted in a bridge whose balance is upset when the *V* is tilted. Tests show that a tilt of 1 minute of arc gives an amplified output of 2 volts. The time lag is about 0.1 second.

535.33:538.569.4 456
Microwave Spectroscopy—D. K. Coles. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 180–190; 1947.) General discussion of apparatus and methods and of the physical significance of the results obtained.

535.61-15 457
German Applications of Infrared in World War II—E. A. Underhill. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 284–293; 1947.)

535.61-15:534.321.9 458
Supersonic Detection of Infrared Radiation—Fry and Fry. (*See* 273.)

535.61-15:535.33.072 459
High Resolving Power Infrared Recording Spectrometer—R. C. Nelson and W. R. Wilson. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 579–586; 1947.) The PbS photoconductive cell developed by Cashman (3330 of 1947) has simplified accurate measurements of radiation of wavelengths up to 3μ. The design, construction, operation, and application of a grating spectrograph for the near infrared are discussed.

539.16.08 460
The Photomultiplier Radiation Detector—

J. W. Coltman and F-H. Marshall. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 377–384; 1947.) α, β, γ, or X rays, fast ions or neutrons, produce scintillations on a phosphor screen, the light from which is focused on the cathode of a photomultiplier followed by an amplifier. The output pulses may be counted normally or integrated for very high rates. The device has a higher efficiency and counting speed than a G-M counter. Discrimination between wanted and dark-current pulses in discussed.

539.16.08 461
Circuit for Testing Efficiency of Geiger Counters—G. E. Hagen and D. H. Loughridge. (*Rev. Sci. Instr.*, vol. 19, pp. 526–528; August, 1948.) The circuit is of the coincidence type, requiring no standardized Geiger tubes or standard sources, and is designed to minimize random errors due to pulse irregularities.

539.16.08 462
Some Geiger-Müller and Proportional Counters of Spherical Shape—G. Salvini. (*Rev. Sci. Instr.*, vol. 19, pp. 494–496; August, 1948.) The pulse shape for spherical counters is similar to that for cylindrical counters, but the higher degree of symmetry is an advantage. Slight modifications to avoid spurious discharge are discussed.

621.317.381:538.652 463
A Magnetostriction Torquemeter—C. M. Rifenbergh, D. S. Schover, and E. H. Schulz. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 493–503; 1947.)

621.319.3:539 464
Precision Studies of Nuclear Physics using the Electrostatic Generator—W. E. Shoupp. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 385–394; 1947.) Methods are given for obtaining mass values from values from threshold determinations of nuclear reactions, the production of variable-energy neutron beams, the determination of the maximum of β-ray spectra, etc.

621.365.5 465
High-Frequency Induction Heating. Application to the Theory of [metal-] Melting Furnaces—M. Renouard. (*Rev. Gén. Élec.*, vol. 57, pp. 322–337; August, 1948.) The theory of the electromagnetic effects in conductors subjected to high-frequency fields is reviewed and applied to a study of the operation of high-frequency induction furnaces with no magnetic circuit. Such furnaces have a relatively high efficiency for the melting of metals or alloys of high resistivity, but for low-resistivity materials, the efficiency is only moderate. Furnaces operated at a fixed frequency have applications limited to alloys of a particular class, or articles of similar dimensions, if good efficiency is to be maintained.

621.38 466
General Trends in Foreign Electronic Developments—A. H. Sullivan, Jr. (*Proc. N.E.C.* (Chicago), vol. 3, p. 417; 1947.) Summary only. Special reference to war-time German work.

621.38.001.8 467
Industrial Applications of Electronic Techniques—H. A. Thomas. (*Jour. IEE* (London), part I, vol. 95, pp. 381–396; September, 1948.) Discussion on 3992 of 1947.

621.38.001.8:531.771 468
High-Speed Revolution Counter—A. B. Kaufman. (*Electronics*, vol. 21, pp. 80–82; September, 1948.) The movement of rotating fan, propeller, or impeller blades past fixed vanes causes changes in capacitance which are used to vary the oscillation amplitude in a rf oscillator. Rectification produces an af output whose frequency is measured on an electronic tachometer. Speeds up to 30,000 rpm can be measured.

621.38.001.8:535.241.44 469
The Brightness Intensifier—G. A. Morton, J. E. Ruedy, and G. L. Krieger. (*RCA Rev.*, vol. 9, pp. 419–432; September, 1948.) By certain combinations of optical and electronic apparatus, an image of a scene can be produced with greater brightness than that of the original. The use of such apparatus to improve seeing under low light conditions is discussed; the fundamental limit to such improvement is shown to be the statistical fluctuation in the number of photons entering the eye. Applications are discussed.

621.38.001.8:786.6 470
Design of Electronic Organs: Part 4—W. Wells. (*Audio Eng.*, vol. 32, pp. 28–31, 47; September, 1948.) Further details of the Hammond organ, including the construction of the phonic wheels. Part 3: 3203 of 1948.

621.384.6 471
A Fifteen-Inch Glass Betatron Toroid—L. Rushforth, S. J. Morrison, and J. G. Brett. (*Electronic Eng.* (London), vol. 20, pp. 249–251; August, 1948.) A description of the method of construction from channel rings of low-expansion borosilicate glass, using ovens of special design permitting rotation of the rings for sealing and annealing.

621.384.6 472
Electromagnetic Deflector for the Beam of the 184-Inch Cyclotron—W. M. Powell, L. R. Henrich, Q. A. Kerns, D. C. Sewell, and R. L. Thornton. (*Rev. Sci. Instr.*, vol. 19, pp. 506–512; August, 1948.) A pulsed electric deflector can impart a radial oscillation to the ions of as much as 7 cm. The ions are forced outward toward a magnetic deflector which is outside the range of the circulating ions.

621.385.38.001.8:621.313.36 473
Thyratron Control of A.C. Commutator Motors—W. N. Tuttle. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 514–523; 1947.)

621.385.833:061.3 474
Summarized Proceedings of Conference on Electron Microscopy—London, April 1948—V. E. Cosslett. (*Jour. Sci. Instr.*, vol. 25, pp. 328–331; September, 1948.)

623.746.48:621.317.083.7 475
Telemetry for Guided Missiles—Neelands and Hausz. (*See* 425.)

623.746.48:621.398 476
The Role of Electronics in Guided Missile Research—W. N. Brown, Jr. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 395–403; 1947.)

623.978+550.838]:538.71 477
Airborne Magnetometer—(*Electronics*, vol. 21, pp. 124, 144; October, 1948.) Brief description of the basic circuit and of the auxiliary circuits necessary for adequate amplification, cancellation of part of the earth's field to avoid saturation, and correct orientation of the sensing element. See also 3336 of 1945 (Vacquier), 220 of 1948 (Felch et al.), and 798 of 1948 (Vacquier, Simons, and Hull).

664.8:621.319.44 478
Heatless Preservation with Penetrating Electrons from the Capacitron—W. Huber. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 252–271; 1947.) For a shorter account see 2325 of 1948.

PROPAGATION OF WAVES

538.566 479
Characteristic Values of the First Normal Mode in the Problem of Propagation of Micro-Waves through an Atmosphere with a Linear-Exponential Modified Index of Refraction—C. L. Pekeris and W. S. Ament. (*Phil. Mag.*, vol. 38, pp. 801–824; November, 1947.) Approximate methods used include a variational method, a perturbation method, the method of transitional modes, and the phase integral method. Both surface ducts (superrefraction) and subrefraction are considered: the results are shown graphically. The various methods yield results which agree for most practical applications, especially in the case of superrefraction. The horizontal decrement of the electromagnetic field beyond the horizon can be deduced in the important case when only the first mode is strongly excited. For subrefraction, two types of solution are found, one associated with the gradient of the refractive index near the surface and the other associated with the upper (standard) portion of the refractive index curve. See also 2892 of 1947 (Booker and Walkinshaw).

538.566 480
A Relation between the Sommerfeld Theory of Radio Propagation over a Flat Earth and the Theory of Edge-Diffraction—H. G. Booker. (*Jour. IEE* (London), part III, vol. 95, pp. 326–327; September, 1948. Discussion, pp. 327–330.) Summary of IEE Scientific Radio Convention paper. For a linear transmitter parallel to the surface of a flat perfectly conducting earth, the angular spectrum of the reflected waves can be regarded as due to a line source which is the optical image of the transmitter. The correction for imperfect conductivity involves, in addition, an aperture distribution extending indefinitely downward from the image line. This aperture distribution is essentially that produced by diffraction of the Zenneck wave under a screen extending from the image line upward. Ray theory involves calculating the Zenneck-wave diffraction by the edge-wave approximation. When this approximation is unsatisfactory, the full theory of edge diffraction based on the Cornu spiral must be used; this leads to the Sommerfeld theory.

621.396.11 481
Transmission Frequencies for Line-of-Sight Systems—L. S. Schwartz. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 350–370; 1947.) Discussion of the factors governing choice of frequency, with particular reference to the case of an interrogator beacon.

621.396.11:535.3 482
The Intensity-Distance Law in Radiation—D. A. Bell. (*Wireless Eng.*, vol. 25, p. 338; October, 1948.) Reply to comment by Lamont and Saxton (3492 of 1948) on Bell's earlier letter (2592 of 1948). Support for Bell's value of critical distance is claimed from a paper by Cutter, King, and Kock noted in 1281 of 1948, and from a report on German antenna design practice.

621.396.11:551.510.535 483
Propagation—(*Jour. IEE* (London), part IIIA, vol. 94, no. 16, pp. 874–878; 1947.) Discussion on 2048 of 1948 (Appleton) and on 2050 of 1948 (Tremellen and Cox).

621.396.11:551.510.535 484
Propagation of Radio Waves—W. J. G. Beynon. (*Wireless Eng.*, vol. 25, pp. 322–330; October, 1948.) A paper originally communicated to the Radio Research Board in 1944. The maximum usable frequency for the F_2-region was measured by a pulse technique over a transmission path of 715 km. The mean value showed excellent agreement with that calculated from simultaneous normal-incidence equivalent-height measurements made at the terminals of the transmission path. The upper frequency limit of the oblique reflections from the 100-km (abnormal-*E*) level generally showed no close relationship to the simultaneous normal-incidence observations. For a small number of observations, the separation between the oblique penetration frequencies of the two magneto-ionic components was not very different from that measured at normal incidence. The mean seasonal variation of maximum usable frequency was measured and compared with that calculated from normal-incidence observations.

621.396.11:551.510.535 485
The Reflection of Radio Waves from the Ionosphere at Oblique Incidence—W. J. G. Beynon. (*Jour. IEE* (London), part III, vol. 95, p. 325; September, 1948. Discussion, pp. 327–330.) Summary of IEE Scientific Radio Convention paper. Discussion of: (a) the variation of the equivalent path with frequency, and its relation to corresponding measurements at normal incidence, (b) calculation of maximum usable frequency from normal-incidence data, (c) ionospheric absorption of radio waves.

621.396.11:551.510.535 486
The Interaction of Radio Waves—J. A. Ratcliffe. (*Jour. IEE* (London), part III, vol. 95, p. 325; September, 1948. Discussion, pp. 327–330.) Summary of IEE Scientific Radio Convention paper. The usefulness of observations of this phenomenon has been extended by observing the phase of the transferred modulation and comparing it with the phase of the modulation received as a ground wave direct from the interacting station. In this way, the collision frequency at a known height can be measured. Experiments have given values around 5×10^6/second for heights around 85 km. The experimental results suggest that the electrons at a distance of 150 km from the Droitwich station (100 kw, 200 kc) are maintained at a temperature which is 2 per cent higher than that of the surrounding molecules.

621.396.11:551.510.535 487
A Frequency Prediction Service for Southern Africa with Special Reference to an Ionosphere Recorder Embodying Certain New Techniques—F. J. Hewitt, J. Hewitt, and T. L. Wadley. (*Trans. S. Afr. Inst. Elec. Eng.*, vol. 39, p. 144; April, 1948.) Authors' reply to discussion on 229 of 1948.

621.396.11.029.4/.52 488
The Propagation of Very Long Radio Waves—R. N. Bracewell. (*Jour. IEE* (London), part III, vol. 95, p. 326; September, 1948. Discussion, pp. 327–330.) Summary of IEE Scientific Radio Convention paper. Frequencies up to about 50 kc are considered. The interference pattern for ranges up to 800 km has been determined using an airplane. The height of reflection is about 80 km, with a diurnal variation of 12 to 18 km. For λ 16 kc, the reflection coefficient is about 0.5 for angles of incidence near 45° except during the day in summer, when it is about 0.15. Ionospheric disturbances cause a temporary fall of about 3 km in the height of reflection. The effect of reflection on polarization is considered.

621.396.11.029.62:551.510.535:523.5 489
Reflection of Very-High-Frequency Radio Waves from Meteoric Ionization—E. W. Allen, Jr. (Proc. I.R.E., vol. 36, pp. 1255–1257; October, 1948.) Discussion on 2328 of 1948.

621.396.812:621.396.9 490
Refraction of Radar Beams—A. E. Carver. (*Weather* (London), vol. 3, p. 316; October, 1948.) An example of the superrefraction of radar rays was noted in the ocean weather ship "Weather Observer" in the North Atlantic on May 18 and 19, 1948, when ship echoes were obtained on various bearings at ranges between 70 and 100 miles. Radiosonde measurements of temperature and humidity gradients on these dates indicate that a temperature inversion and a large lapse rate of humidity favor this phenomenon. See also 492 below (Booker).

621.396.812.029.58 491
Simultaneous Observations of Field-Intensity Measurements of WWV at Needham, Massachusetts, and at Intervale, New Hampshire, during the Summer of 1947—H. T. Stetson and G. W. Pickard. (*Terr. Mag. Atmo. Elec.*, vol. 53, pp. 67–77; March, 1948.) Continuous field-intensity recordings of WWV 5-Mc and 10-Mc signals at a distance of 373 miles show that the diurnal variation undergoes progressive seasonal and sunspot-cycle changes. Simultaneous measurements made at a distance of 463 miles in the same direction show the same general form of diurnal variations, and coincidence of sudden ionospheric disturbances. Similar results were also obtained at a distance of 270 miles in the same direction from the transmitter, so that the observations may be expected to apply over a region approximately 200 miles across.

621.396.812.029.64 492
Radio Refraction in the Atmosphere—H. G. Booker. (*Weather* (London), vol. 3, pp. 42–50; February, 1948.) Examples of extraordinary radar ranges observed in various parts of the world are described and discussed. For a more detailed account see 5515 of 1947.

621.396.812.029.64 493
Comparison of Calculated and Measured Phase Difference at 3.2 Centimeters Wavelength—E. W. Hamlin and W. E. Gordon. (Proc. I.R.E., vol. 36, pp. 1218–1223; October, 1948.) The variation, with height, of the magnitude and phase of the field for a 27-mile near-optical desert path could be calculated from the direct wave and one reflected from a surface tangential to the earth's profile at the point of reflection, provided that the variation of atmospheric refractive index with height was linear. Apparent reflection coefficients between 0.3 and 0.8 were found.

RECEPTION

621.396.621+621.396.619.13+621.396.97 494
FM Profits—M. B. Sleeper. (*FM and Telev.*, vol. 8, pp. 27, 50; September, 1948.) The organizers of Rural Radio Network find that a receiver operational threshold of 20 microvolts per meter is necessary for good FM reception at all points within the 50-microvolts per meter contours of their proposed stations. Most FM-AM receivers tested had threshold values between 250 and 500 microvolts per meter. Specifications for suitable FM receivers and antennas have now been determined; units meeting these requirements should bear a recognized mark. For further details of the network see 495, 523, 551, 594, 595, and 596 below.

621.396.621+621.396.67 495
Pattern for F.M. Profits: Part 5—Receiver and Antenna—W. C. Black. (*FM and Telev.*, vol. 8, pp. 36–39, 43; September, 1948.) Mobile reception tests with field-strength measuring equipment enabled a FM receiver specification to be drawn up. The G.L.F. Model F-770 receiver was designed to meet this specification. For nondirectional reception of horizontally polarized radiation, a single turnstile antenna composed of two folded dipoles, was adopted. A second turnstile, in a stacked array, can be added to increase the gain. See also 494 above.

621.396.621:621.396.611.1 496
Formulas for Image Rejection Calculations—Vladimir. (*See* 332.)

621.396.621.54:621.396.611.21 497
A Review of Crystal Saver Circuits for VHF Receivers—W. R. Hedeman, Jr. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 449–456; 1947.) Circuits for obtaining as many as 280 crystal-controlled channels with few crystals. See also 2342 of 1948.

621.396.622 498
Superregenerative Detection Theory—W. E. Bradley. (*Electronics*, vol. 21, pp. 96–98; September, 1948.) The operation of the superregenerative circuit is explained in terms of a time aperture function, depending on the quenching wave form. A theory is developed to identify the factors controlling selectivity, optimum quenching, and signal-to-noise ratio, and to account for the difficulty of reproducing a given response in different types of detector. See also 499 below.

621.396.622 499
Superregenerator Design—A. Hazeltine, D. Richman, and B. D. Loughlin. (*Electronics*, vol. 21, pp. 99–102; September, 1948.) Theoretical values for the gain in either the logarithmic or linear mode of superregenerative receivers are obtained by considering the build-up of oscillations in the transient condition resulting from the application of a short rf pulse. Sensitivity limitations are discussed and expressions derived for the selectivity with various specific quenching wave forms. See also 3501 of 1948 (Macfarlane and Whitehead) and 498 above.

621.396.622 500
An Analysis of the Behavior of a Limiter-Discriminator FM Detector in the Presence of Impulse Noise—J. C. Tellier. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 680–696; 1947.) Experimental results indicate how the limiter-discriminator differs from an ideal FM detector The response of the discriminator to noise is discussed.

621.396.8:621.396.619.11 501
Basic Considerations on the S/N Ratio in Amplitude Modulated Receivers—E. C. Fubini and D. C. Johnson. (*Proc. N.E.C.* (Chicago), vol. 3, p. 39; 1947.) Summary only. The signal-to-noise ratio S at the audio or video output of an AM receiver is the same as S^2, the signal-to-noise ratio at the input of the second detector, in receivers for broadcasting and similar applications. But S and S^2 are unequal when the if bandwidth is much greater than the video or audio bandwidth, as may be the case in vhf or uhf systems. Experimental data on the relations between these quantities and the input signal are included.

621.396.81:621.396.619 502
Signal-to-Noise Ratios in Pulse Modulation Systems—B. Håård. (*Ericsson Tech.*, no. 47, 31 pp.; 1948. In English.) Signal-to-noise ratios are calculated for amplitude, frequency, phase, pulse-amplitude, pulse-width, and pulse-time modulation systems. Comparisons are based on the ratio for AM systems. In a conventional AM system, the ratio of signal power to noise power per unit bandwidth is constant through the receiver. The same result is obtained by the use of bottom limiting with pulse-amplitude modulation, but, for the same mean mean rf signal power, with pulse-width modulation there is a gain proportional to the duty cycle and to the pulse spectrum bandwidth, while with pulse-time modulation there is a gain inversely proportional to the duty cycle and directly proportional to the pulse spectrum bandwidth.

621.396.82 503
Impulsive Interference in Amplitude-Modulation Receivers—D. Weighton. (*Jour. IEE* (London), part III, vol. 95, p. 370; September, 1948.) Discussion on 2901 of 1948.

621.396.82:621.396.932 504
External Cross-Modulation in the 100-Mc/s Band—K. W. Blake. (*Jour. IEE* (London), part IIIA, vol. 94, no. 13, pp. 659–662; 1947. Summary, *ibid.*, part IIIA, vol. 94, no. 11, p. 114; 1947.) Interference often occurs in naval high-frequency communication when the separation between two transmitted frequencies is the same as that between one of these frequencies and the receiving frequency. This effect was found to be due to parts of the ship's structure, particularly corroded joints, which acted as nonlinear conductors. Equipment for locating such sources of interference is described and its performance discussed.

621.396.822 505
Some Notes on Noise Figures—H. Goldberg. (Proc. I.R.E., vol. 36, pp. 1205–1214; October, 1948.) A clarification of the basic ideas and definitions for thermal noise and

noise factors proposed by H. T. Friis (3457 of 1944). Noise factors are determined for grounded-cathode, grounded-grid and grounded-anode amplifiers and for the Wallman low-noise circuit (grounded-cathode stage followed by grounded-grid stage). Transit-time effects and the use of noise diodes are discussed.

621.396.822 506
A Survey of Recent Progress in the Study of Fluctuation Noise—D. K. C. MacDonald. (*Jour. IEE* (London), part III, vol. 95, pp. 330–331; September, 1948. Discussion, pp. 334–340.) Summary of IEE Scientific Radio Convention paper. Discussion of recent work on such noise arising within the receiver unit itself. See also 534 of 1948 (Thomas and Burgess).

621.396.822:551.594.6 507
The World Distribution of Radio Noise—Thomas. (*See* 396.)

621.396.823 508
An Experimental Investigation of Motor-Vehicle Ignition Interference—H. Page and G. G. Gouriet. (*BBC Quart.*, vol. 3, pp. 182–192; October, 1948.) Results of tests to determine the effects of such interference on wide-band FM broadcasting at 45 and 90 Mc are discussed. The interference was found to be 6 to 10 db less with horizontal than with vertical polarization. For a given field strength, interference was less for 90-Mc than for 45-Mc radiation.

621.396.828 509
Some Fundamental Considerations Concerning Noise Reduction and Range in Radar and Communication—S. Goldman. (*Proc. N.E.C.* (Chicago), vol. 3, p. 191; 1947.) Summary only. Analysis of noise reduction in FM, pulse-width modulation, multichannel signaling, and radar serves as a background to the general theory. The distinction between random noise and signals, and the significance of selectivity and coherence, are discussed. A probability measure of noise level is introduced and theory is developed which deals adequately with radar range problems. Maximum range in communication is shown to be independent of the type of modulation, for a given total energy.

621.397.62 510
R.F. Input Circuits for TV Receivers—F. R. Norton. (*Tele-Tech*, vol. 7, pp. 28–31, 57; October, 1948.) Idealized performance characteristics are shown graphically and discussed. Detailed diagrams of various experimental and commercial circuits are given.

621.396/.397].62.001.4 511
Television and FM Receiver Servicing [Book Review]—M. S. Kiver. D. Van Nostrand, New York, N. Y., 1948, 203 pp., $2.95. (Proc. I.R.E., vol. 36, p. 1273; October, 1948.) A practical treatment.

STATIONS AND COMMUNICATION SYSTEMS

621.391.64:621.327.44 512
Dynamic Properties of the Infrared Cesium Arc—J. M. Frank and W. S. Huxford. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 525–536; 1947.) The dynamic electrical properties of the Type CL-2 lamp have been determined for frequencies from 50 cps to 1 Mc. See also 2353 of 1948 (Frank, Huxford, and Wilson).

621.395.47 513
Analysis-Synthesis Telephony with Special Reference to the Vocoder—R. J. Halsey and J. Swaffield. (*Jour.* IEE (London), part III vol. 95, pp. 391–406; September, 1948. Discussion, pp. 406–411.) Full paper: summary noted in 2910 of 1948.

621.396.4:621.396.97 514
Program Transmission over Broadband Carrier Systems—R. W. Chesnut. (*Bell Lab. Rec.*, vol. 26, pp. 377–382; September, 1948.) A new system is described for high-grade program transmission, with a pass band of 40 to 8,000 cps. Block diagrams of the equipment are given.

621.396.41 515
Theoretical Analysis of Various Systems of Multiplex Transmission—V. D. Landon. (*RCA Rev.*, vol. 9, pp. 433–482; September, 1948.) Continuation of 3246 of 1948. The power requirements for a 10-Mc maximum bandwidth and the actual bandwidth requirements of eighteen different systems are calculated and tabulated. The susceptibility of the different systems to impulse noise, cross modulation, interference, and selective fading is analyzed and theoretical and practical results for several systems are compared.

621.396.41:621.396.619.16 516
A 96-Channel Pulse Code Modulation System—C. B. Feldman. (*Bell Lab. Rec.*, vol. 26, pp. 364–370; September, 1948.) Discussion of the relative merits of pulse-code modulation and other systems, and brief description of an experimental system and its mode of operation. See also 2366 of 1948 (Meacham and Peterson).

621.396.61./.62].029.63:621.396.931 517
The Citizens Radio Service—R. E. Samuelson. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 272–283; 1947.) The present FCC regulations are outlined, the advantages and limitations of low-power uhf systems and the propagation characteristics for 465-Mc waves are discussed and suitable equipment is described. See also 3511 of 1948 (Lurie) and back references.

621.396.619.13:621.396.3/.5 518
The Possibility of Transatlantic Communication by Means of Frequency Modulation—L. B. Arguimbau and J. Granlund. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 644–653; 1947.)

621.396.619.16 519
General Considerations in Pulse-Count Modulation—S. Metzger and D. D. Grieg. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 457–467; 1947.) Discussion of fundamental properties and operating principles of this system, and of the relation between distortion and the number of quantization levels.

621.396.619.16:621.385.832:621.396.41 520
Beam Deflection Tube for Coding in PCM—Sears. (*See* 576.)

621.396.65 521
Communication by Means of Reflected Power—H. Stockman. (Proc. I.R.E., vol. 36, pp. 1196–1204; October, 1948.) A short-distance communication system is discussed in which the carrier power is generated at the receiving end and the transmitter replaced by a mechanically modulated reflector. A very-high-gain transmitting antenna producing a practically parallel beam incident upon a mirror large compared to λ is desirable. Some experimental results and methods of modulating the reflector are given. The system is not considered practicable at present.

621.396.7+621.397.2 522
Engineering Arrangements for Broadcasting the Olympic Games—L. Hotine. (*BBC Quart.*, vol. 3, pp. 174–181; October, 1948.) A plan of the broadcasting center and a schematic diagram showing the technical arrangements are given. The center incorporated 8 studios, 20 recording rooms, 8 disk-reproducing cubicles, 11 disk-editing rooms, the control room and the television control and production rooms. Provision was made for 36 simultaneous broadcasts. 52 commentators' positions were installed, each of which had the following services available through headphones: (a) BBC (Home), (b) BBC (Light), (c) public address system, (d) local effects, (e) output from control position to which commentator was connected, (f) control operator's telephone, and (g) TIM clock.

621.396.712 523
Pattern for F.M. Profits: Part 2—Organization—R. B. Gervan. (*FM and Telev.*, vol. 8, pp. 29–30, 65; September, 1948.) The Rural Radio network maintains 6 FM stations in New York State. Each transmitter is at least 2,000 feet above sea level, and coverage is complete over a wide area. See also 494 above.

621.396.931 524
Bridged Circuits Facilitate Police Radio—(*Tele-Tech*, vol. 7, pp. 28–29, 94; July, 1948.) A FM radio-telephone system used by New York State Police. It consists of radio and telephonic links between troopers, sub-stations, and headquarters, 41 fixed transmitting and receiving stations, 363 mobile transmitting-receiving sets and 42 walkie-talkies are linked by switching and bridge circuits without mutual interference. Each bridge includes a reversible amplifier, operating in either direction and controlled by a switch on a hand telephone.

621.396.931:621.396.619.23 525
The Miller F.M. Circuit and Its Use in Railroad Radios—Bargellini (*See* 343.)

621.396.97 526
War-Time Broadcasting—(*Jour. IEE* (London), part IIIA, vol. 94, no. 16, pp. 871–874; 1947.) Discussion on 2086 of 1948 (Bishop).

621.396.97:621.316.729 527
The Problem of Synchronization in Broadcasting on Medium or Long Waves—S. Lacharnay. (*Onde Élec.*, vol. 28, pp. 308–321; August and September, 1948.) The general conditions are considered under which a field due to three waves, a carrier and its two sidebands, can be detected by classical methods without undergoing distortion. Three practical conditions are found: (a) of amplitude, (b) of phase, and (c) of overmodulation. The interference of the fields of two synchronized transmitters is studied. Consideration of the distortion shows that satisfactory reception is only possible in the immediate neighborhood of the two transmitters. A case of particular interest is that of two low-power transmitters covering a small district of about 100 km^2. With suitable low-frequency phase control, reception is possible throughout the district. A frequency stability within 1 part in 10^7 is adequate; greater stability than this gives no improvement in reception. The case of more than two powerful transmitters remains to be considered, and also the question of a network of synchronized transmitters serving a wide district, taking account of the possibility of using directive antennas.

621.396.97:621.396.81 528
Circular Polarization in F-M Broadcasting—C. E. Smith and R. A. Fouty. (*Electronics*, vol. 21, pp. 103–107; September, 1948.) Experimental field-strength measurements in 36 typical homes confirm the theoretical advantages of circular polarization over horizontal polarization. Antenna development is discussed.

621.396.619.13 529
Frequency Modulation: Vol. 1 [Book Review]—A. N. Goldsmith, A. F. Van Dyck, R. S. Burnap, E. T. Dickey, and G. M. K. Baker (Eds). RCA Review, Princeton, N. J., 1948, 515 pp., $2.50. (Proc. I.R.E., vol. 36, p. 1273; October, 1948.) Vol. 7 of the RCA Technical Book series, containing papers published by RCA authors between 1936 and 1947.

SUBSIDIARY APPARATUS

621–526 530
A High-Capacity Servo-System for the Control of a Testing Machine—H. W. Katz and

H. C. Roberts. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 295–308; 1947.)

621.314.67:621.385.2.032.216 531
Power Diodes—E. G. Rowe, R. E. B. Wyke, and W. MacRae. (*Electronic Eng.* (London), vol. 20, pp. 214–218, 254–259, and 285–291; July to September, 1948.) Detailed discussion of the various factors involved in the design of high-vacuum rectifiers with oxide-coated cathodes, with an account of production and routine test methods. A system of rating for such rectifiers is presented which enables the constants of the associated circuits to be found directly from tables and curves.

621.352.7 532
Magnesium Batteries—(*Metal Ind.* (London), vol. 73, p. 286; October 8, 1948.) The electrochemical principles that suggest the advantages of using Mg instead of Zn in primary cells, are described by R. Fichter (533 below). With Mg in the MnO_2/C type of cell, the terminal voltage is 2.2 volts and the theoretical capacity is 4.8 Wh/gm, which is 4 times that of the cell with Zn as the negative electrode. Developments in America include the Mg/AgCl/Ag batteries made by the Burgess Battery Co. (see 3295 of 1947). A Mg/C cell with chromic acid as the electrolyte has been patented by the Dow Chemical Co. A cell capable of regeneration, with Mg and Pb sulphate or halide and a neutral salt electrolyte is described in a patent by the Compagnie Générale d'Électricité. Experiments by the Aluminum Industrie A. G. (Chippis) show that surface treatment of the Mg containers in a dichromate-nitric acid bath not only increases the corrosion resistance but also raises the cell voltage to 2.6 to 2.7 volts. As regards output, 2 such cells are equivalent to 3 cells of the Zn type. The electrolyte used in these cells contains 20 per cent $Na_2S_2O_8$, 6 per cent Na_2SO_4, 0.2 per cent NaHO and 0.5 per cent $K_2Cr_2O_7$. The containers are made from a Mg/Al alloy, containing 6 per cent Al, which can be extruded by impact without preheating.

621.352.7 533
Galvanic Elements Using Magnesium—R. Fichter. (*Chimia* (Zürich), vol. 1, pp. 141–146; July 15, 1947.) The full paper referred to in 532 above.

621.396.68:621.314.653 534
Sealed Ignitrons for Radio-Transmitter Power Supplies—Zuvers. (*See* 556.)

621.317.7+621.526+621.316.72+518.5 535
Electronic Instruments [Book Review]—Greenwood, Jr., Holdam, Jr., and MacRae, Jr. (*See* 454.)

TELEVISION AND PHOTOTELEGRAPHY

621.397 536
The Chemistry of High-Speed Electrolytic Facsimile Recording—H. G. Greig. (PROC. I.R.E., vol. 36, pp. 1224–1235; October, 1948.) A brief survey of various processes.

621.397.331.2 537
The Eriscope Camera Tube—B. France. (*Electronics*, vol. 21, p. 130; October, 1948.) A description of the functioning of a television camera tube in which the formation of the electrical image and scanning are separate operations, as with the image orthicon, and, therefore, can be designed independently for maximum efficiency. Tests indicate that the ériscope has a greater resolution than the image orthicon, with a definition of 800 to 1,000 lines, but is less sensitive particularly with artificial light. See also 1776 of 1948.

621.397.331.2:535.65 538
Color Measurement and Specification in Television Picture Tubes—E. B. Fehr. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 458–567; 1947.) The quantitative results obtainable by spectrophotometry or by relative transmission through filters are preferred to those given by the Munsell matching system.

621.397.331.2:621.385.832 539
The Chromoscope—A New Color Television Viewing Tube—A. Bronwell. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 549–557; 1947.) For another account see 2937 of 1948.

621.397.331.2:621.397 5 540
Electro-Optical Characteristics of Television Systems: Part 3—Electro-Optical Characteristics of Camera Systems—O. H. Schade. (*RCA Rev.*, vol. 9, pp. 490–530; September, 1948.) Part 1, 2940 of 1948; part 2, 3261 of 1948.

621.397.335:621.317.79:621.396.615 541
Television Synchronizing Signal Generator—Baracket. (*See* 448.)

621.397.5 542
Television Definition and Bandwidth—H. L. Kirke. (*BBC Quart.*, vol. 3, pp. 171–173; October, 1948.) The definition of a television system is improved by increasing the number of lines only when this is accompanied by a corresponding increase in the bandwidth. Tables show the relationship between bandwidth, number of lines, and horizontal and vertical definition.

621.397.6:621.395.625.6 543
Television Transcriptions—T. T. Goldsmith, Jr., and H. Milholland. (*Electronics*, vol. 21, pp. 68–71, October, 1948.) Discussion of the recording of television images on film direct from a cathode-ray monitor.

621.397.62 544
Television Front Ends—A. D. Sobel. (*Electronics*, vol. 21, pp. 76–79; September, 1948.) Discussion of the rf stage and of oscillator and mixer problems; current design trends are noted. Methods of measuring performance and of tuning are also considered.

621.397.62 545
R.F. Input Circuits for TV Receivers—Norton. (*See* 510.)

621.397.62:621.396.665 546
Automatic Gain Controls for Television Receivers: Parts 1 and 2—Wendt and Schroeder; and Wendt. (*See* 351 and 352.)

621.397.8 547
London Television Transmissions Received Perfectly in France—G. Giniaux. (*TSF Pour Tous*, vol. 24, p. 237; September, 1948.) Television pictures from London are regularly received in Calais, 153 km from London, with a stability which is not reached with some receivers no more than 4 km from the Eiffel tower. Synchronization is definitely better than for the Paris transmissions, as is to be expected, since the distance from Calais to Paris is 230 km. The antenna is about 25 meters above ground level and consists of a vertical doublet provided with a reflector and also a horizontal counterpoise. No preamplifier is found necessary.

621.396/.397].62.001.4 548
Television and FM Receiver Servicing [Book Review]—Kiver. (*See* 511.)

TRANSMISSION

621.396.61 549
A New 50-kw FM Transmitter—C. J. Starner. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 615–629; 1947.) Description of the RCA Type BTF-50A, a transmitter for the frequency range 88 to 108 Mc. The output stages are self-contained coaxial-type units using air-cooled grounded-grid triodes.

621.396.61 550
The Pack Transmitter—J. L. Hathaway and W. Hotine. (*RCA Rev.*, vol. 9, pp. 483–489; September, 1948.) Description and circuit diagram of a portable, low-power, crystal-controlled transmitter for frequencies of 25 to 32 Mc and with a range of 1 to 20 miles.

621.396.61 551
Pattern for FM Profit: Part 6—Transmitters—D. K. De Neuf. (*FM and Telev.*, vol. 8, pp. 40–43; September, 1948.) Description of the 6 Rural Radio Network 250-watt transmitters operating on frequencies around 100 Mc. The stations are linked by radio and no land lines are used. The distance between adjacent transmitting stations is 46 to 75 miles. A 50-watt mobile transmitter with a range of 50 miles enables any broadcast to reach all parts of the network. A studio/transmitter link included in the system was described in 3516 of 1948 (Nigg). See also 494 above.

621.396.61 552
300 Watt Type SK23A Short-Wave Transmitter—K. Lutz. (*Brown Boveri Rev.*, vol. 35, pp. 91–94; March and April, 1948.) A low-power, general-purpose transmitter for either stationary or mobile operation. The basic unit consists of a crystal oscillator, an output stage and power supplies. Additional units such as a modulator, a variable-frequency oscillator, and remote control equipment can be added to meet all operating requirements.

621.396.61 553
The TGS571 Transmitter—C. P. Cooper. (*Marconi Rev.*, vol. 11, pp. 78–86; July to September, 1948.) The basic design requirements for a general-purpose remotely controlled transmitter are discussed and their application to the case of a 500-watt transmitter with a continuous frequency coverage from 2.5 to 20 Mc is considered.

621.396.61:621.396.712(494) 554
The New 200 kW Medium-Wave Transmitter for the Swiss National Broadcasting Station at Beromunster—K. Seiler. (*Brown Boveri Rev.*, vol. 35, pp. 77–81; March to April, 1948.) Anode modulation of the class-C output stage is achieved by a specially developed modulation transformer enabling greater efficiency to be obtained than that possible with class-B operation of the former 100-kw transmitter. The tubes are heated by ac, so that rotary converter equipment is unnecessary. A detailed account will be published when the installation is completed.

621.396.61.029.56/.58 555
807s in Push-Pull—D. H. Mix (*QST*, vol. 32, pp. 11–15, 108; August, 1948.) Circuit and construction details of a shielded stabilized transmitter for the amateur bands. 3.5-Mc and 7-Mc crystals are used, followed by a buffer stage to prevent overloading of the crystal. Plug-in coil changing is facilitated by the hinged lid enclosing the whole of the upper part of the oscillator. Harmonic filters are included to prevent interference with television reception.

VACUUM TUBES AND THERMIONICS

621.314.653:621.396.68 556
Sealed Ignitrons for Radio-Transmitter Power Supplies—H. E. Zuvers. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 309–321; 1947.) The use of ignitrons as very fast circuit breakers to protect power supplies becomes economical above about 100 kw. The new tetrode ignitron ML-5630 is rated at 20 kv and 50 amp; six of these in a bridge circuit would supply 3,000 kw dc. Output voltage control is achieved by varying the angle of firing.

621.385 557
Foreign Vacuum Tubes and High Frequency Techniques—B. L. Griffing. (*Proc. N.E.C.* (Chicago), vol. 3, pp. 418–428; 1947.) General discussion of German developments, including metal versus ceramic tubes, Heil's focusing cathode, image storage tubes, and tubes for λ 10 cm λ 3 mm.

621.385:537.53.8 558
Secondary Electron Suppression—J. H. Owen Harries. (*Wireless Eng.*, vol. 25, pp.

275–280; September, 1948.) Theoretical analysis of secondary-electron radiation in microwave cavity tubes requires drastic simplifying assumptions; the undesirable results of secondary-electron emission appear to be reduced over a considerable range of transit angles around $\pi/2$. Measurements of the transfer of power from a modulated electron beam to an electric field in a gap in the presence of secondary electrons at transit angles from zero to π are discussed and compared with the theory. With a recessed target, the transfer efficiency is considerably higher than with a plane target and has a maximum value of about 46 per cent at an optimum transit angle of about 0.3π.

621.385:621.315.2 559
An Ionic Valve for Clearance of Faults in Cables—R. Schmidt. (*Bull. Soc. Franç. Élec.*, vol. 8, pp. 430–432; August and September, 1948.) One type of tube has a tubular glass envelope, 20 to 70 cm long and 3 cm in diameter; the filling is Hg vapor. An oxide cathode is fitted at one end and a cylindrical cup as anode at the other end. Between anode and cathode, there is a set of auxiliary electrodes which serve as a voltage divider; their action is assisted by series capacitors connected between anode and cathode, a spark gap being introduced between the two capacitors nearest the cathode. Only about 19 volts are required to maintain an arc in the Hg vapor in one direction, but no arc can be started in the opposite direction. A tube of length 63 cm and with 9 stages will support a reverse voltage of 200 kv. The operating temperature should be in the range 18°–40°C. Various applications are mentioned.

621.385:621.316.722.1 560
Voltage Reference Tube—(*Elec. Rev.* (London), vol. 143, p. 817; November 26, 1948.) The Mullard 85A1 tube, in a self-regulated constant-current circuit, gives a stable voltage that can be used in many cases as a reference. The ignition voltage is 125 volts and the normal operating voltage 85 volts. Stability is within 0.1 per cent up to 100 hours and within 0.2 per cent up to 1,000 hours. Its low temperature coefficient (−3.5 mV/°C) makes temperature control unimportant.

621.385.029.63/.64 561
The Experimental Development of [3-cm] Traveling-Wave Tubes—J. S. A. Tomner. (*Chalmers Tekn. Högsk. Handl.*, no. 67, 22 pp., 1948. In English.) Output curves show the beam voltage as a function of the focusing magnetic field. The observed and theoretical gains are compared. The effect of the potential of the focusing electrode on the output is also shown. See also 2962 of 1948 (Rydbeck).

621.385.032.216 562
The Relationship Between the Emission Constant and the Apparent Work Function for Various Oxide-Coated Cathodes—H. Jacobs, G. Hees, and W. P. Crossley. (PROC. I.R.E., vol. 36, pp. 1109–1114; September, 1948.) The emission of oxide cathodes on 6 chemically different metal wires was measured over a period of 500 hours. An empirical emission equation was found to be as accurate as, and easier to use than, the conventional Dushman equation; the logarithm of the emission constant was found to be the sum of a constant and a term proportional to the apparent work function.

621.385.032.216:537.533 563
The Emission of Negative Ions from Oxide Coated Cathodes—R. H. Sloane and C. S. Watt (*Proc. Phys. Soc.*, vol. 61, pp. 217–234; September 1, 1948.) Mass versus charge ratios were determined for a large number of negative ions from the different cathodes used. Energy distribution curves are plotted for the more intense ion beams; these permit discrimination between negative ions produced thermionically and those produced by bombardment. Results are also given showing the dependence of the thermionic emission on the cathode temperature, and the variation of this emission with time after changes in cathode temperature, accelerating field, and cathode surface conditions. The results are discussed and compared with those of other workers.

621.385.032.44 564
Series Capacitor Heater Circuits—A. W. Stanley. (*Wireless World*, vol. 54, pp. 332–334; September, 1948.) The advantages of such circuits over series resistor circuits are discussed. There is negligible power loss and better regulation. Graphical methods of determining circuit parameters in particular cases are explained.

621.385.1 565
New Miniature 'Rimlock' Valves for A.C. Receivers—J. Rousseau. (*TSF Pour Tous*, vol. 24, pp. 226–233; September, 1948.) Characteristics and complete data for the ECH41 triode-hexode, EAF41 diode-pentode, EF41 variable-μ high-frequency pentode, EL41 output pentode, and AZ41 rectifier, with circuits suitable for their use. See also 3552 of 1948 (Giniaux).

621.385.2 566
Effects of Hydrostatic Pressure on Electron Flow in Diodes—W. C. Hahn. (PROC. I.R.E., vol. 36, pp. 1115–1121; September, 1948.) A single equation holds from the cathode surface through the potential minimum to the anode if the hydrostatic pressure term, with constant temperature, is included in the electron force equation. From this equation the usual temperature-limited emission formula for maximum current, the space-charge-limited characteristic and the transition region from one to the other may all be deduced. This result is discussed in relation to transport theory.

621.385.2:621.396.822 567
The Behaviour of a Diode Noise Generator at Ultra High Frequencies—A. W. Love. (*Jour. IEE* (Australia) vol. 20, pp. 33–42; April and May, 1948.) Discussion of the effects of internal diode impedance and transit time on the absolute accuracy as a voltage source at uhf. The magnitudes of the effects are determined experimentally at 200 Mc for a Type X-6030 noise diode by comparison with a thermal generator. Noise output is shown to depend on anode voltage, unless this is high enough to ensure complete temperature-limited operation. It is concluded that the X-6030 diode can be used up to about 500 Mc with an error <1 db in noise power output, provided certain precautions are taken. Analysis shows that a diode built as a concentric transmission line and terminated at one end in its characteristic impedance could be used at still higher frequencies.

621.385.2.032.216:621.314.67 568
Power Diodes—Rowe, Wyke, and MacRae. (*See* 531.)

621.385.3 569
A New 100-Watt Triode for 1,000 Megacycles—W. P. Bennett, E. A. Eshbach, C. E. Haller, and W. R. Keye. (PROC. I.R.E., vol. 36, pp. 1296–1302; October, 1948.) The mechanical construction and mass-production methods are described for the grounded-grid triode Type 5588, which has coaxial heater leads and cathode and uses forced-air cooling. Axial length of the electrode structure is about one-quarter inch. The use of the tube as power oscillator and amplifier is discussed, with circuit details.

621.385.3:621.396.615.14 570
Triodes for Very Short Waves—Oscillators—Bell, Gavin, James, and Warren. (*See* 338.)

621.385.3.032.24:621.396.822 571
Negative-Grid Partition Noise—R. L. Bell. (*Wireless Eng.*, vol. 25, pp. 294–297; September, 1948.) In the conventional negative-grid triode, the electrostatic field about the grid is not uniform because of the discrete nature of the grid wires. The effect of this on the fluctuations induced at the grid is analyzed. Variations in pulse shape are shown to cause some uhf noise when the ratio of the grid-winding pitch to the grid-cathode spacing is large.

621.385.38 572
A New Line of Thyratrons—A. W. Coolidge, Jr. (*Proc. N.E.C.* (Chicago), vol. 3, p. 197; 1947.) Summary only. A new method of construction is claimed to meet various requirements of quick heating, high peak-to-average current ratio, wide ambient temperature range, high surge-current rating, dual grid control, compactness, ruggedness, reliability, and low cost. Performance data are included.

621.385.4:537.58 573
Space-Charge Effects in Beam Tetrodes and Other Valves—C. S. Bull. (*Jour. IEE* (London), part III, vol. 95, p. 362; September, 1948.) Discussion on 2668 of 1948.

621.385.831:621.396.822 574
Low-Frequency Noise from Thermionic Valves Working under Amplifying Conditions—E. J. Harris and P. O. Bishop. (*Nature* (London), vol. 161, p. 971; June 19, 1948.) The intensity of this noise varies approximately inversely as the frequency in the range 10 to 1,000 cps. At 1,000 cps, it was not observable above the shot noise. It was remarkably constant for different tubes.

621.385.832 575
Metal Picture Tube—(*Electronics*, vol. 21, pp. 152, 156; October, 1948.) A 16-inch crt with a metal shell, for television receivers. A glass neck houses the electron-gun assembly.

621.385.832:621.396.41:621.396.619.16 576
Beam Deflection Tube for Coding in P.C.M.—R. W. Sears. (*Bell Lab. Rec.*, vol. 26, pp. 411–415; October, 1948.) For the system noted in 516 above. See also 2411 of 1948.

621.385.832:621.396.9 577
Three-Dimensional Cathode-Ray Tube Displays—E. Parker and P. R. Wallis. (*Jour. IEE* (London), part III, vol. 95, pp. 371–387; September, 1948. Discussion, pp. 387–390.) The display of 3-dimensional information is considered with particular reference to a radar system in which a narrow pulsed beam of rf energy is used to explore automatically a volume of space. Truly 3-dimensional displays use a mechanical motion to add a third dimension to the crt screen. Perspective displays simulate the same picture without any moving mechanisms or stereoscopy. Oblique displays obtain the required 3 co-ordinates by combination of 2 or more 2-co-ordinate displays on the same crt. Polychromatic displays use color to represent a spatial co-ordinate. Human operator problems, display sensitivity and applications are also discussed.

621.396.615.141.2:513.761.5 578
Certain Matters Concerning Scaling in the Magnetron with Special Reference to the Relative Efficiency of Magnetrons of Different Sizes—W. F. G. Swann. (*Jour. Frank. Inst.*, vol. 246, pp. 149–157; August, 1948.)

621.396.615.141.2:621.396.615.17 579
Pulser and Water Load for High Power Magnetrons—S. I. Svensson. (*Chalmers Tekn. Högsk. Handl.*, no. 68, 27 pp.; 1948. In English.) The principles of the line-modulator type of pulser using diode charging are discussed and a practical circuit is described. Oscillograph records show the voltage at points in the circuit and the final pulse shape. The water load consists of a concentric line, the inner conductor being tapered for 2 wavelengths and surrounded by water contained in a glass tube. The temperature rise caused by the absorption of rf energy in the water enables peak powers up to 700 kw to be measured.

621.396.615.142.2 580
The Manufacture of a Reflex Klystron—D. L. Hollway. (*Jour. Brit. I.R.E.*, vol. 8, pp. 97–109; May and June, 1948.) See 1519 of 1948.

621.396.645:537.311.33:621.315.59 581
Design of Amplifying Crystal Units—S. Y. White. (*Audio Eng.*, vol. 32, pp. 26–27, 45; September, 1948.) To obtain the maximum power output from an amplifying crystal, a high back voltage is required because the small contact area of the tungsten point limits the current to not more than 20 milliamps. The production of Ge crystals is described briefly and several assembly designs of the unit are shown, using miniature tube base mountings. See also 3065 of 1948 (Rittner), 264 of January (Bardeen and Brattain), 265 of January (Wells and White) and 582 below.

621.396.645:537.311.33:621.315.59 582
Experimental Data on Germanium Crystal Amplifier—S. Y. White. (*Audio Eng.* vol. 2, pp. 32–33, 52; October, 1948.) An investigation of fundamental properties, undertaken in the unfulfilled hope that well-known tube theory could be widely applied to crystal amplifiers. Unexpected results for untreated crystals were: (a) lack of contact control reciprocity for standard 1N34 units; (b) control with negative grid; (c) overshooting to about 500 milliamps produces increased amplification and stability: (d) lack of heating when passing high currents. Characteristics of crystals treated by overshooting and tapping included: (a) increased grid current; (b) reduced plate current; (c) reduced plate impedance; (d) constant percentage change in plate current when controlled by the grid current; (e) plate impedance is independent of plate voltage and grid bias; (f) grid impedance is largely affected by the plate circuit conditions. See also 581 above and back references.

621.396.822 583
Valve Noise and Transit Time—N. Houlding. (*Wireless Eng.*. vol. 25, p. 372; November, 1948.) Comment on 2420 of 1948 (Campbell, Francis, and James).

621.396.822:621.392 584
Some Notes on Noise Theory and Its Application to Input Circuit Design—W. A. Harris. (*RCA Rev.*, vol. 9, pp. 406–418; September, 1948.) The mechanism of noise production in a tube is discussed and an equivalent circuit is analyzed to determine the optimum noise factor under various conditions. The frequencies corresponding to chosen values of noise factor are given for several types of tube, and circuit requirements for obtaining noise factors approximating to the theoretical values are discussed. See also 2336 of 1942 (Herold).

621.385:621.392 585
Vacuum Tube Circuits [Book Review]—Arguimbau. (*See* 355.)

621.385.1 586
Dutch Report on Transmitting Tube Targets in Germany [Book Notice]—B.I.O.S. Miscellaneous Report No. 102. H. M. Stationery Office, London, 54 pp., 4s.6d. Report of tube production methods and problems at the principal works in Germany in 1947. Some tube types are described; test methods are outlined, and test limits given.

621.385.832 587
The Cathod-Ray Tube and Typical Applications [Book Review]—Allen B. DuMont Laboratories, Clifton, N. J., 1948, 63 pp. (Proc. I.R.E., vol. 36, p. 1269; October, 1948.) A nontechnical discussion, of special value as a reference text for students.

621.396.615.141.2 588
Microwave Magnetrons [Book Review]—G. B. Collins (Ed.). McGraw-Hill, New York, N. Y., 1947, 769 pp., $9.00 (*Electronics*, vol. 21, pp. 228, 230; September, 1948.) Vol. 6 of the MIT Radiation Laboratory series. "Upon studying this book, one is impressed with its uniqueness, scope, and general excellence. For a worker in the field of microwave magnetrons, it is unquestionably an essential."

MISCELLANEOUS

061.24:621.396.1 589
J.T.A.C.: Its Purpose and Program—(*Electronics*, vol. 21, pp. 72–75; September, 1948.) The Joint Technical Advisory Committee of 8 engineers has been appointed by the RMA and IRE to advise government bodies and industry on the wise use and regulation of radio facilities.

061.3:01 590
The Royal Society Scientific Information Conference—(*Nature* (London), vol. 162, pp. 279–286; August 21, 1948.) The conference was organized in 4 sections to discuss methods of improving and rationalizing the arrangements for (a) publishing and distributing original scientific papers, (b) issuing and using abstracts, (c) consolidating abstracts and references into continuously cumulative indexes to assist retrospective searching of the literature, and (d) producing and using periodical reviews of progress in specific fields. Summaries of the conference recommendations for each section are included. See also 597 and 598 below.

526.841 591
The Construction of Zenithal-Equidistant Maps—H. T. Mitchell, T. Kilvington, and W. E. Thomson. (*P.O. Elec. Eng. Jour.*, vol. 41, part 2, pp. 85–91; July, 1948.) These maps give the great-circle bearing, distance, and path from their centers to any other point on the earth. Earlier maps of this type were constructed by means of an oblique stereographic graticule for the center in question. More recently, bearings and distances have been obtained by a graphical versus mechanical device, the Navicard, whose use is explained.

621.38/.39 592
The Editors Report on Electronics Park—J. M. (*Electronics*, vol. 21, pp. 77–100; October, 1948.) Description of the organization, arrangements, and facilities available at this General Electric establishment, which serves as a combined headquarters, engineering establishment and manufacturing plant for electronics.

621.396.97 593
The Organization of Broadcasting in the British Zone of Germany—H. Carleton Greene. (*BBC Quart.*, vol. 3, pp. 129–134; October, 1948.) The broadcasting organization in the British Zone is known as the Nordwest deutscher Rundfunk (NWDR). It serves nearly 3,500,000 license holders, is national rather than local in character, and is entirely free from party politics. In the American Zone, each Land has its small radio station with local interests, and commercial broadcasting is permitted. The French radio is frankly an instrument of French policy and cultural propaganda. In the Russian Zone, broadcasting is an instrument of the Socialist Unity Party.

The NWDR consists of 4 stations with transmitters at Hamburg (100 kw), Langenburg, near Cologne, (100 kw), Hanover (20 kw), Berlin (5 kw; a 20-kw station is about to be installed), Flensburg (2½ kw) and Osnabrück (5 kw). Hamburg and Langenburg are synchronized on 332 meters; all the others transmit on 225 meters. A short-wave transmitter at Elmshorn broadcasts in the 41-meter band.

621.396.97 594
Pattern for F.M. Profits: Part 1—Introduction—M. McClintock. (*FM and Telev.*, vol. 8, pp. 28, 65; September, 1948.) Discussion of Rural Radio Network policy for FM operation. FM broadcasting can provide new cultural, technical, and information services without disturbing existing commercial AM broadcasts. See also 494 above.

621.396.97:621.396.619.13 595
Pattern for F.M. Profit: Part 3—Promotion—P. Guterman. (*FM and Telev.*, vol. 8, pp. 31–33, 64; September, 1948.) Discussion of methods used to explain the possibilities of the Rural Radio Network system to potential listeners. The scale of charges for broadcasting time is given. See also 494 above.

621.396.97:621.396.619.13 596
Pattern for F.M. Profits: Part 4—Programming—R. B. Child. (*FM and Telev.*, vol. 8, pp. 34–35; September, 1948.) Rural Radio Network is developing its program to serve the specific habits and preferences of the audience with special attention to the timing of items such as market prices and local weather reports. A typical program schedule is given. See also 494 above.

061.3:001 89 597
[Report of] Royal Society Empire Scientific Conference, June–July 1946 [Book Notice]—The Royal Society, London, 1948, vol. 1, 828 pp., vol. 2, 707 pp., 42s (for the 2 vols.). (*Nature* (London), vol. 162, p. 679; October 30, 1948.) Full report of the Conference noted in 3828 of 1946.

061.3:01 598
The Royal Society Scientific Information Conference, 21 June–2 July 1948: Report and Papers Submitted [Book Notice]—The Royal Society, London, 723 pp. 25s. Full report of the Conference noted in 590 above.

061.3(456.3):621.396 599
Atti del Congresso Internazionale per il Cinquantenario della Scoperta Marconiana della Radio (Proceedings of the International Conference for the Jubilee of the Discovery of Radio by Marconi) [Book Notice]—G. Bardi, Rome, 951 pp. Papers read and speeches made at the Conference are published in full, each in the language of its author(s).

41.323.9:621.396 600
Dictionnaire de Radiotechnique (en trois langues) [Book Review]—M. Adam. Librairie de la Radio, Paris, 700 pp., 530 fr. (*Radio Tech. Dig.*, Franç., vol. 2, p. 183; June to August, 1948.) The main part serves as a French-English-German lexicon and defines and describes clearly each radio term and its derivatives. The second and third parts are respectively German-French and English-French lexicons giving the equivalents of the 1,500 to 2,000 words defined in the first part.

621.396 601
Radio Engineering: Vol. 1 [Book Review]—E. K. Sandeman. Chapman and Hall, London, 1947, 775 pp., 45s. (*Beama Jour.*, vol. 55, pp. 267–268; August, 1948.) As a reference book for the man of experience the work is exceedingly good, and even the first 8 introductory chapters fall within this category .... Radar and television are not included, but otherwise the work is virtually a "bible" on radio engineering. For another review see *Nature* (London), vol. 161, p. 706; May 8, 1948.

621.396(031) 602
The Radio Amateur's Handbook [Book Review]—Headquarters Staff of the American Radio Relay League. American Radio Relay League, West Hartford, Conn., 25th edition 1948, 760 pp., $2 in the United States, $2.50 elsewhere. (Proc. I.R.E., vol. 36, p. 1010; August, 1948; *Wireless World*, vol. 54, p. 168; May, 1948.) Most of the material has been completely rewritten and the over-all plan of the book has been changed. The number of pages is increased by 30 per cent. Vhf is discussed more comprehensively; a table of klystrons has been added to the data on American tubes. Previous editions were noted in 1303 and 3385 of 1947.

SECTION MEETINGS

Baltimore

"Systems Research in its Origin, Organization, and Aims," by F. Hamburger, Jr., The Johns Hopkins University; December 21, 1948.

"A Recording Photometer," by E. J. King, The Johns Hopkins University; December 21, 1948.

"An Audio Sweep Frequency Oscillator," by R. G. Roush, The Johns Hopkins University; December 21, 1948.

Cedar Rapids

"Some Aspects of VHF Propagation," by D. E. Kerr, Massachusetts Institute of Technology; December 15, 1948.

Cleveland

"Physics of Music," by W. Mack, Radio Station WGAR; December 16, 1948.

Dayton

"Electronic Generation of Musical Tones," by J. Jordan, Baldwin Piano Company; January 6, 1949.

Detroit

"Ultra-High Frequency Antennas and Transmission Lines," by R. M. Krueger, American Phenolic Corporation; November 19, 1948.

"The Design and Application of Radio Communication Equipment for Railroads," by C. N. Kimball, Bendix Aviation Corporation; December 17, 1948.

Election of Officers; December 17, 1948.

Houston

"Installation and Operating Problems of TV Station KLEE," by P. Huhndorff, Radio Station KLEE-TV; December 17, 1948.

Louisville

"Design and Manufacture of Home Television Receivers," by E. L. Clark, RCA-Victor Home Instrument; January 14, 1949.

Philadelphia

"Development of a Large Metal Kinescope for Television," by H. P. Steier, RCA Victor Division; January 6, 1949.

Portland

"Microwave Radio Application to Power Systems," by R. F. Stevens, Bonneville Power Administration; January 6, 1949.

Princeton

"The Teleran System of Air Navigation," by J. N. Marshall, RCA Victor Division; January 13, 1949.

Salt Lake

"Microwave Amplification Using Traveling Waves and Electron Waves," by C. F. Quate, Stanford University; December 29, 1948.

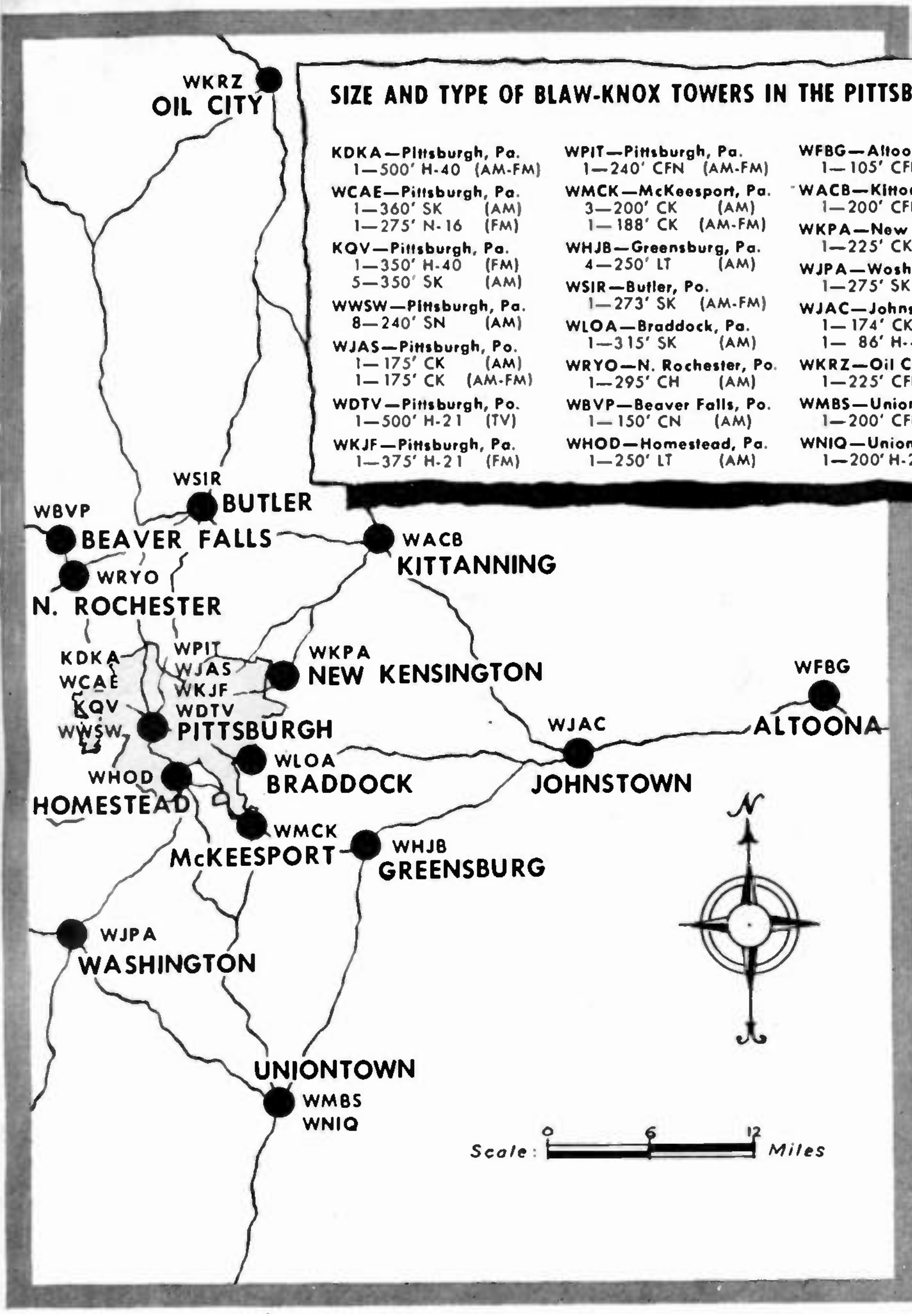
San Diego

"Recent Developments in Sound Recording," by J. G. Frayne, Western Electric Company; December 7, 1948.

"Factors Which Contribute to Pleasantness in Listening," by J. P. Maxfield, United States Navy Electronics Laboratory; January 4, 1949.

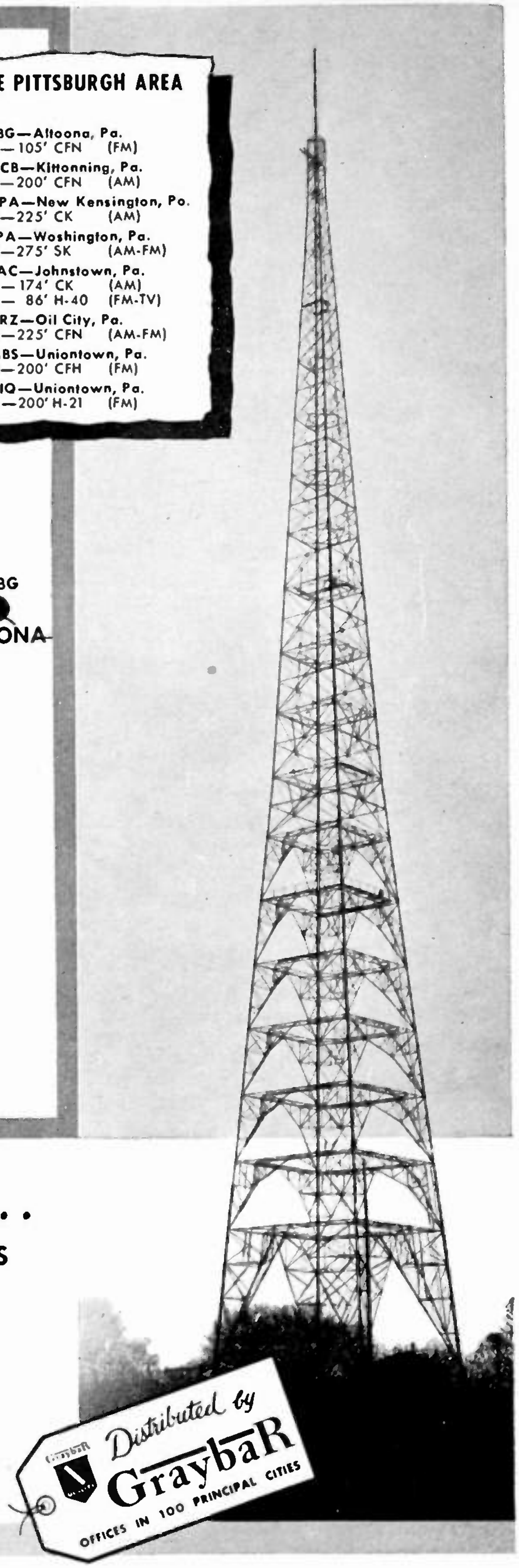
Election of Officers; January 4, 1949.

(Continued on page 38A)



SIZE AND TYPE OF BLAW-KNOX TOWERS IN THE PITTSBURGH AREA

KDKA—Pittsburgh, Pa. 1—500′ H-40 (AM-FM)	WPIT—Pittsburgh, Pa. 1—240′ CFN (AM-FM)	WFBG—Altoona, Pa. 1—105′ CFN (FM)
WCAE—Pittsburgh, Pa. 1—360′ SK (AM) 1—275′ N-16 (FM)	WMCK—McKeesport, Pa. 3—200′ CK (AM) 1—188′ CK (AM-FM)	WACB—Kittanning, Pa. 1—200′ CFN (AM)
KQV—Pittsburgh, Pa. 1—350′ H-40 (FM) 5—350′ SK (AM)	WHJB—Greensburg, Pa. 4—250′ LT (AM)	WKPA—New Kensington, Pa. 1—225′ CK (AM)
WWSW—Pittsburgh, Pa. 8—240′ SN (AM)	WSIR—Butler, Pa. 1—273′ SK (AM-FM)	WJPA—Washington, Pa. 1—275′ SK (AM-FM)
WJAS—Pittsburgh, Pa. 1—175′ CK (AM) 1—175′ CK (AM-FM)	WLOA—Braddock, Pa. 1—315′ SK (AM)	WJAC—Johnstown, Pa. 1—174′ CK (AM) 1—86′ H-40 (FM-TV)
WDTV—Pittsburgh, Pa. 1—500′ H-21 (TV)	WRYO—N. Rochester, Pa. 1—295′ CH (AM)	WKRZ—Oil City, Pa. 1—225′ CFN (AM-FM)
WKJF—Pittsburgh, Pa. 1—375′ H-21 (FM)	WBVP—Beaver Falls, Pa. 1—150′ CN (AM)	WMBS—Uniontown, Pa. 1—200′ CFH (FM)
	WHOD—Homestead, Pa. 1—250′ LT (AM)	WNIQ—Uniontown, Pa. 1—200′ H-21 (FM)



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BLAW-KNOX TOWERS DOMINATE THE AIRWAYS

That "still, small voice in the wilderness" hasn't a chance around Pittsburgh. To be heard above the electronic babble it must come out loud, strong and clear.

Receivers tuned to the stations shown here find clear, sharp signals broadcast via Blaw-Knox Antenna Towers . . . Radio engineers know you can "hear the difference."

BLAW-KNOX DIVISION OF BLAW-KNOX COMPANY
2037 Farmers Bank Bldg., Pittsburgh, Pa.

BLAW-KNOX ANTENNA TOWERS

SECTION MEETINGS

(Continued from page 36A)

SUBSECTIONS

MONMOUTH

"Recent Advances in the Theory of Communication," by C. E. Shannin, Bell Telephone Laboratories; January 19, 1949.

LANCASTER

"Modern Electronic Computers—Their Design and Application" by P. Crawford, Jr., Office of Naval Research; January 12, 1949.

WINNIPEG

"Frequency Allocations," by C. J. Acton, Department of Transportation, Ottawa; October 13, 1948.

STUDENT BRANCH MEETINGS

UNIVERSITY OF ALBERTA—IRE BRANCH

Westinghouse Films "Electronics at Work" and "Summer Storm"; January 11, 1949.

UNIVERSITY OF ARIZONA—IRE-AIEE BRANCH

"New Electrical Horizons," by W. C. Smith, General Electric Company; December 16, 1948.

CALIFORNIA STATE POLYTECHNIC COLLEGE—IRE BRANCH

"Job Hunting Through Letters," by J. P. Riebel, California State Polytechnic College; January 10, 1949.

UNIVERSITY OF CALIFORNIA—IRE-AIEE BRANCH

"Blowing Fuzes," by N. S. Beyer, Bussman Fuse Company; November 18, 1948.

"Magnetic Tape Recorders," by H. Lindsay, Ampex Tape Recording Company; December 15, 1948.

"New Horizons in Electrical Engineering," by W. C. Smith, AIEE Board Member; January 6, 1949.

CASE INSTITUTE OF TECHNOLOGY—IRE BRANCH

Election of Officers; January 4, 1949.

Forum, "Job Opportunities," J. W. Bird, RCA; F. H. Knapp, Bell Telephone; and T. Friedman, Radio Station WXEL; January 12, 1949.

"Application of Radar to Aircraft Operations," by G. Brodie, National Advisory Council on Aeronautics; January 18, 1949.

COLUMBIA UNIVERSITY—IRE-AIEE BRANCH

"Serendipity," by W. C. White, General Electric Company; December 11, 1948.

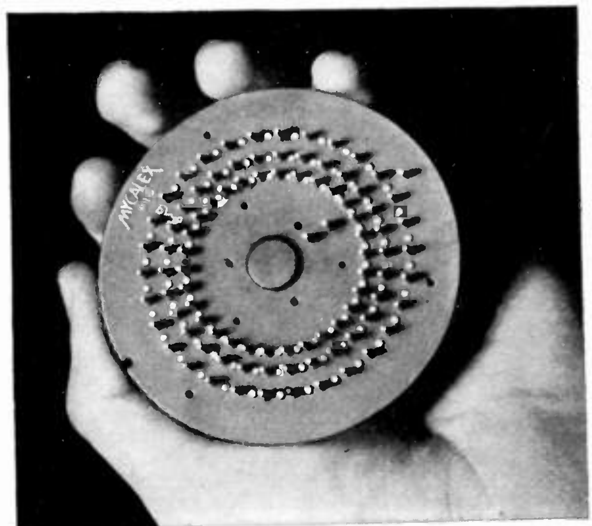
ILLINOIS INSTITUTE OF TECHNOLOGY—IRE BRANCH

"Aircraft Blind Landing Systems," by G. Doland, Student, Illinois Institute of Technology; January 6, 1949.

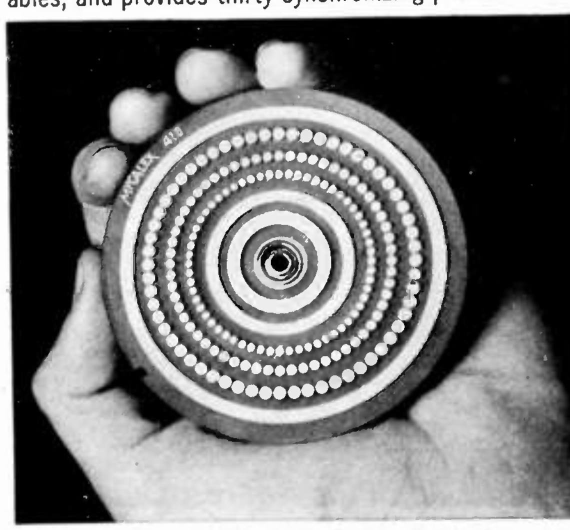
(Continued on page 40A)

MYCALEX 410 MAKES HISTORY

ets astonishing high operational ecord for telemetering commutator sed on aeronautical research proj-cts . . . MYCALEX 410 only insula-ion to fill exacting requirements.



Illustrated are top and bottom views of the MYCALEX 410 molded insulation commutators manufactured to the specifications of Raymond Rosen Engineering Products, Inc., for Air Material Command and Navy telemetering projects. This commutator, with 180 contacts and 3 slip rings of coin silver, samples sixty channels of information such as air speed, altitude, angle-of-attack, temperature, pressure, voltage and other variables; and provides thirty synchronizing pulses.



To February 7,1949, more than 200 hours of maintenance free, high speed, clean signal telemetering commutator performance has been logged on MYCALEX 410 Units. . . . Experience indicated four hours was optimistic . . . specifications hoped for ten hours . . . and the challenging problem was solved by MYCALEX 410 molded insulation.

SPECIFICATIONS TO BE MET IN PRODUCING MYCALEX 410 MOLDED INSULATION COMMUTATORS FOR TELEMETERING

O.D. 2.996″ + .000 — .002 • Location of 3 slip rings and the 3 contact arrays from the center has a total tolerance of ± .001. • Contact spacing 6° apart ± 1 minute. • Parting line thicknesses on insulation body are + .002 —.000. • Concentricity between ball bearing bushing and O.D. .0015. • Assembly height from face of slip rings and contacts to Mycalex 410 has tolerance of + .002 —.000. • Every contact must be tested from its neighbor contact for infinity on a 500 volt megger meter • Plate ambient —20° C. to + 100° C. • Plate to operate at 95% humidity must not warp, crack, change in dielectric constant or resistivity • Contacts to resist high temperatures and must not loosen when repeatedly heated by soldering.

PECIFY MYCALEX 410 for Low Dielectric loss. . . . High Dielectric strength. . . High Arc Resistance. . . . Stability over wide Humidity and Temperature hanges. . . . Resistance to High Temperatures. . . . Mechanical Precision. . . Mechanical Strength. . . . Metal Inserts Molded in Place. . . . Minimum ervice Expense. . . . Cooperation of MYCALEX Engineering Staff.

MYCALEX 410 molded insulation is designed to meet the most exacting requirements of all types of high frequency circuits. Difficult, involved and less complicated insulation problems are being solved by MYCALEX 410 molded insulation . . . the exclusive formulation of MYCALEX CORP. OF AMERICA . . . our engineering staff is at your service.

SINCE 1919 MYCALEX THE INSULATOR TRADE MARK REG. U. S. PAT. OFF.

MYCALEX CORP. OF AMERICA

"Owners of 'MYCALEX' Patents"

Plant and General Offices, CLIFTON, N. J. *Executive Offices*, 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

STUDENT BRANCH
MEETINGS

(Continued from page 38A)

STATE UNIVERSITY OF IOWA—IRE BRANCH

"Photo-Flash," by R. Dahlin, Student, State University of Iowa; January 5, 1949.

"Types of Switches and Broadcast Switching," by J. A. Green, Collins Radio Company; January 12, 1949.

JOHN CARROLL UNIVERSITY—IRE BRANCH

"Electronics in the Field of Seismology," by E. F. Carome, Student, John Carroll University; November 27, 1948.

"Applications of Electronics in Physical Chemistry," by E. B. Thomas, John Carroll University; November 29, 1948.

"Basic Theory of Operation of Radar Systems," by T. J. Dugan, Student, John Carroll University; January 18, 1949.

LAFAYETTE COLLEGE—IRE-AIEE BRANCH

"The Oscilloscope," by J. Wilson, Student, Lafayette College; January 13, 1949.

"James Maxwell," by D. R. Albus, Student, Lafayette College; January 13, 1949.

"Summer Employment with Pennsylvania Power and Light," by W. Rohland, Student, Lafayette College; January 13, 1949.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY—IRE-AIEE BRANCH

Election of Officers; October 20, 1948.

Motion Pictures, "Crystal Clear and Coaxial," from the American Telegraph and Telephone Co.

"The Opportunities in Government Work in the Naval Ordnance Laboratory and the Bureau of Standards," by R. Weller, Naval Ordnance Laboratory, and J. Hilsenrath, Bureau of Standards; December 15, 1948.

"Construction and Installation of WBZ Television," by S. V. Statig, Radio Station WBZ-TV; November 3, 1948.

MICHIGAN STATE COLLEGE—IRE-AIEE BRANCH

"Favorite Misconceptions of Electrical Engineers," by W. Richter, Allis-Chalmers; January 19, 1949.

UNIVERSITY OF MICHIGAN—IRE-AIEE BRANCH

"Industrial Applications of Rototrol Regulators," by M. H. Fisher, Westinghouse Electric Corporation; January 12, 1949.

MISSOURI SCHOOL OF MINES—IRE-AIEE BRANCH

"Prospects of Television and the IRE," by T. A. Hunter, Hunter Manufacturing Company; January 6, 1949.

Election of Officers; January 6, 1949.

COLLEGE OF THE CITY OF NEW YORK—IRE BRANCH

"FM Tuners," by C. L. Fruchter, Student, College of the City of New York; December 14, 1948.

"Television Design and Production Techniques," by S. Napolin, Pilot Radio Corporation; December 21, 1948.

Election of Officers; January 4, 1949.

Report on Field Trip to radiostation WABD.

NEW YORK UNIVERSITY—IRE BRANCH

"Stamped Wiring," by M. Ackerman, Franklin Airloop Corporation; December 18, 1948.

"Sunspots and Their Effect on Radio Reception and Transmission," by J. H. Nelson; RCA Communications; December 18, 1948.

"Watch Tick Analyzer," by G. Stewart, American Time Company; December 18, 1948.

(Continued on page 42A)

When it's

HEAT

you have to beat

Specify

"NOFLAME-COR"

the TELEVISION hookup wire

by

CORNISH

- ✓ Flame Resistant
- ✓ Heat Resistant
- ✓ High Dielectric
- ✓ High Insulation Resistance
- Easy Stripping
- ✓ Facilitates Positive Soldering
- ✓ Also unaffected by the heat of impregnation—therefore, ideal for coil and transformer leads

RUBBER	75°
PLASTIC	80°
"NOFLAME-COR"	90°

COMPLETE ENGINEERING DATA AND SAMPLES ON REQUEST

approved by Underwriters Laboratories at

90° CENTIGRADE — **600** VOLTS

Proven BEST by exhaustive tests! Leading producers of television, F-M, quality radio and all exacting electronic applications specify our Underwriter Approved "NOFLAME-COR" as a MUST. Immediate delivery. All sizes, solid and stranded. Over 200 color combinations.

"made by engineers for engineers"

CORNISH WIRE COMPANY, Inc.

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15 Park Row, New York 7, N. Y.

1237 Public Ledger Bldg., Philadelphia 6

MANUFACTURERS OF QUALITY WIRES AND CABLES FOR THE ELECTRICAL AND ELECTRONIC INDUSTRIES

STUDENT BRANCH MEETINGS

(*Continued from page 40A*)

University of North Dakota—IRE-AIEE Branch

"The Field of Utility," by R. A. Billingsly, Northern States Power; January 12, 1949.

Polytechnic Institute of Brooklyn—IRE Branch

"Selenium Rectifiers," by E. Steiker, Federal Telephone and Radio Corporation; November 18, 1948.

Princeton University—IRE-AIEE Branch

"The Present Status of Television," by R. D. Kell, Radio Corporation of America; October 13, 1948.

"The Applications of Servo-Mechanisms in Industry," by M. A. Edwards, General Electric Company; December 15, 1948.

St. Louis University—IRE Branch

"Opportunities in the Public Utilities Field," by M. E. Skinner, Union Electric Company of Missouri; December 9, 1948.

Syracuse University—IRE Branch

"Commercial Television Equipment," by D. W. Pugsley, General Electric Company; January 12, 1949.

University of Wisconsin—IRE Branch

"Electronics in Medicine (Electroencephalography," by W. Gilson, University of Wisconsin; December 14, 1948.

MEMBERSHIP

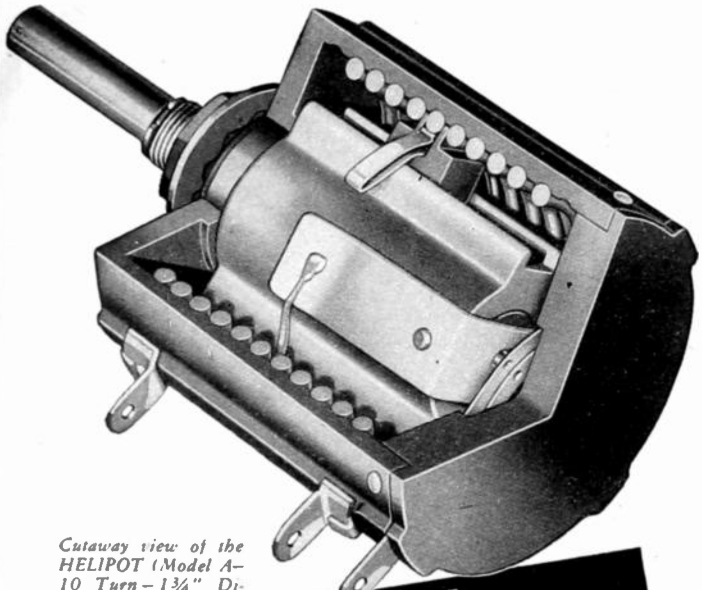
The following transfers and admissions were approved and will be effective as of March 1, 1949:

Transfer to Senior Member

Babits, V. A., 180 Eighth, Troy, N. Y.
Bassett, D. M., 520 Corona Ave., Dayton 9, Ohio
Beckwith, J. R., Serapio Rendon #39, Mexico, D. F., Mexico
Brown, H. A., 8 Fieldcourt, Bronxville, N. Y.
Frommer, J. C., 1525 Teakwood Ave., Cincinnati 24, Ohio
Gorham, J. E., 1312 Fourth Ave., Asbury Park, N. J.
Houston, G. P., 3000 Manhattan Ave., Baltimore 15, Md.
Jacob, F. N., 5843 N. Rockwell St., Chicago 45, Ill.
Jarrett, M. G., 416 Seventh Ave., Pittsburgh 19, Pa.
Kurshan, J., RCA Laboratories, Princeton, N. J.
Maiden, R. M., 126 Danbury St., S.W., Washington 20, D. C.
McDowell, R. B., 2415 W. Cameron Rd., Falls Church, Va.
McGee, W. F., c/o Aeronautical Radio de Mexico, S. A., Morelos 37, Mexico, D. F., Mexico
Moffat, W. H., 49 Clove Rd., New Rochelle, N. Y.
Muntz, W. E., 176 Forest Hill Dr., Syracuse, N. Y.
Pierce, F. W., 2415—19 Ave., Rock Island, Ill.
Robinson, R. O., Jr., 8912 First Ave., Silver Spring, Md.
Shannon, C. E., Bell Telephone Laboratories, Murray Hill, N. J.

(*Continued on page 44A*)

For new simplicity, wide range, and high accuracy in the control of modern electronic circuits...



Cutaway view of the HELIPOT (Model A–10 Turn – 1¾" Diameter)

THE BECKMAN Helipot

(Trademark of the HELIcal POTentiometer)

Provides *many times* greater resistance control in *same* panel space as conventional potentiometers!

IF YOU are designing or manufacturing *any type* of precision electronic equipment be sure to investigate the greater convenience, utility, range and compactness that can be incorporated into your equipment by using the revolutionary HELIPOT for rheostat-potentiometer control applications... and by using the new DUODIAL turns-indicating knob described at right.

Briefly, here is the HELIPOT principle... whereas a conventional potentiometer consists of a *single* coil of resistance winding, the HELIPOT has a resistance element *many times* longer coiled *helically* into a case which requires no more panel space than the conventional unit. A simple, foolproof guide controls the slider contact so that it follows the helical path of the resistance winding from end to end as a single knob is rotated. Result... *with no increase in panel space requirements*, the HELIPOT gives you as much as 12 times* the control surface. You get far greater accuracy, finer settings, increased range—with maximum compactness and operating simplicity!

COMPLETE RANGE OF TYPES AND SIZES

The HELIPOT is available in a complete range of types and sizes to meet a wide variety of control applications...

MODEL A: *5 watts, 10 turns, 46" slide wire length, 1¾" case dia., resistances 10 to 50,000 ohms, 3600° rotation.*

MODEL B: *10 watts, 15 turns, 140" slide wire length, 3¼" case dia., resistances 50 to 200,000 ohms, 5400° rotation.*

MODEL C: *3 watts, 3 turns, 13½" slide wire length, 1¾" case dia., resistances 5 to 15,000 ohms, 1080° rotation.*

MODEL D: *15 watts, 25 turns, 234" slide wire length, 3¼" case dia., resistances 100 to 300,000 ohms, 9000° rotation.*

MODEL E: *20 watts, 40 turns, 373" slide wire length, 3¼" case dia., resistances 150 to 500,000 ohms, 14,400° rotation.*

Also, the HELIPOT is available in various special designs... with double shaft extensions, in multiple assemblies, integral dual units, etc.

Let us study *your* potentiometer problems and suggest how the HELIPOT can be used – possibly is already being used by others in your industry – to increase the accuracy, convenience and simplicity of modern electronic equipment. No obligation, of course. Write today outlining your problem.

**Data for Model A, 1¾" dia. Helipot. Other models give even greater control range in 3" case diameters.*

THE BECKMAN Duodial

The inner, or Primary dial of the DUODIAL shows exact angular position of shaft during each revolution. The outer, or Secondary dial shows number of complete revolutions made by the Primary dial.

A multi-turn rotational-indicating knob dial for use with the HELIPOT and other multiple turn devices.

THE DUODIAL is a unique advancement in knob dial design. It consists essentially of a primary knob dial geared to a concentric turns-indicating secondary dial—and the entire unit is so compact it requires only a 2" diameter panel space!

The DUODIAL is so designed that – as the primary dial rotates through each complete revolution – the secondary dial moves one division on its scale. Thus, the secondary dial counts the number of complete revolutions made by the primary dial. When used with the HELIPOT, the DUODIAL registers *both* the angular position of the slider contact on any given helix as well as the particular helix on which the slider is positioned.

Besides its use on the HELIPOT, the DUODIAL is readily adaptable to other helically wound devices as well as to many conventional gear-driven controls where extra dial length is desired without wasting panel space. It is compact, simple and rugged. It contains only two moving parts, both made entirely of metal. It cannot be damaged through jamming of the driven unit, or by forcing beyond any mechanical stop. It is not subject to error from backlash of internal gears.

TWO SIZES—MANY RATIOS

The DUODIAL is now available in a 2" diameter model and soon will also be available in a new 4¾" diameter model for main control applications. Standard turns-ratios include, 10:1, 15:1, 25:1 and 40:1 (ratio between primary and secondary dials). Other ratios can be provided on special order. The 10:1 ratio DUODIAL can be readily employed with devices operating *fewer* than 10 revolutions and is recommended for the 3-turn HELIPOT. In all types, the primary dial and shaft operate with a 1:1 ratio, and all types mount directly on a ¼" round shaft.

Send for this HELIPOT AND DUODIAL CATALOG!

Contains complete data, construction details, etc., on the many sizes and types of HELIPOTS... and on the many unique features of the DUODIAL. Send for your free copy today!

THE **Helipot** CORPORATION, SOUTH PASADENA 6, CALIFORNIA

MEMBERSHIP

(Continued from page 42A)

Sherman, K. S., 1832 East 90 St., Cleveland 6, Ohio
Shofstall, N. F., 906 Lancaster Ave., Syracuse, N. Y.
Smith, J. W., 3734 C. Ave., N.E., Cedar Rapids, Iowa
Tillman, J. E., Box 5800, Sandia Base, Albuquerque, N. Mex.
Trucksess, D. E., 463 West St., New York 14, N. Y.
Tyson, B. F., 45-25 220 Place, Bayside, L. I., N. Y.
Yount, T. L., 9739 Mueck Ter., St. Louis 19, Mo.

Admission to Senior Member

Anderson, B. S., Box 285, R.F.D. 1, Long Branch, N. J.
De Salvo, A. F., 2890 E. 197 St., New York, N. Y.
Franke, J. L., 608 White Horse Pike, Haddon Heights, N. J.
Hicks, C. W., Sandia Base Branch, Albuquerque, N. Mex.
Kirkwood, L. R., 18 Hillcrest Ave., Oaklyn, N. J.
McLaughlin, G., 4320 Moats Dr., R.F.D. 3, Kansas City, Mo.
Smith, S. B., 24 California St., San Francisco 11, Calif.
van der Ziel, A., Department of Physics, University of British Columbia, Vancouver, B. C., Canada

Transfer to Member

Albright, E. L., 123 Monticello Ave., Annapolis, Md.
Albright, W. G., 705 W. Elm, Urbana, Ill.
Bertram, A. A., 211 W. 12 St., New York 11, N. Y.
Brooks, H., 7402½ Arizona Ave., Los Angeles 45, Calif.
Carlat, B. B., 108-32 67 Rd., Forest Hills, L. I., N. Y.
Clark, O., Bell Telephone Laboratories, Whippany, N. J.
Craig, J. H., 835 Carroll Ave., St. Paul 4, Minn.
Gautney, G. E., 301 N. Edison St., Arlington, Va.
Grimm, R. E., 1405 Girard St., N.W., Washington 9, D. C.
Heaviside, M. G., c/o The Manager Pacific Cable Board, Hospital St., Montreal, Que., Canada
Hoyt, W. S., 644 Westport Rd., Kansas City 2, Mo.
Hughes, B. F., 1755 Trinidad, Beaumont, Tex.
Hutchinson, R. B., 200 Carolina, Vallejo, Calif.
Jones, H. G., 3776 Milan St., San Diego 7, Calif.
Kagali, S. T., Mysore Airmec Ltd., Sri Jayachamarajawadiyar Rd., Bangalore City, S. India
Klein, M. E., 1226 Sherman Ave., New York 56, N. Y.
Koch, R. F., 432 Broadway, Cedarhurst, L. I., N. Y.
Miles, R. C., 301 South Atherton St., State College, Pa.
Morse, L. H., Jr., 4736 Oak St., Kansas City, Mo.
Muchmore, R. B., 571½ Oxford Ave., Hawthorne, Calif.
Noe, J. D., 163 Gordon St., Redwood City, Calif.
Pischel, E. F., 5255 W. 96 St., Los Angeles 45, Calif.
Posnikoff, P. W., 54 Fifth St., New Toronto, Ont., Canada
Rider, P. Z., 77 Hartford Ter., New Hartford, N. Y.
Ritz, W. A., 3505 37 St., Mt. Rainier, Md.
Sells, G. B., 7811 N.E. Prescott St., Portland 13, Ore.
Shonerock, R. C., 2643 S. St. Louis Ave., Chicago 23, Ill.
Spiegel, G. W., 377 Hawthorne Ave., Glencoe, Ill.
Stevens, J. E., Box 842, Inglewood, Calif.
Stott, H. B., RCA Victor Division, Bldg. 5-5, Camden, N. J.
Stover, J. S., 3428 McFarlin Blvd., Dallas 5, Tex.
Taylor, F. W., 131 Orvilton Dr., De Witt, N. Y.
Teasdale, R. D., 235 W. 80 St., Chicago 20, Ill.
Wallin, W., c/o T. Fischer, 3847½ N. Kedvale Ave., Chicago 41, Ill.

(Continued on page 46A)

MICROWAVE PLUMBING

10 CENTIMETER

WAVEGUIDE DIRECTIONAL COUPLER, 27 db. Navy type CABV1-47AAN, with 4 in. slotted section ..$42.50
Sq. Flange to rd choke adapter, 18 in. long OA 1½ in. x 3 in. guide, type "N" output and sampling probe ..$32.00
"S" BAND CRYSTAL MOUNT, gold plated, with 2 type "N" connectors ..$12.50
MAGNETRON TO WAVEGUIDE coupler with 721-A duplexer cavity, gold plated ..$45.00
10 CM WAVEGUIDE SWITCHING UNIT, switches 1 input to any of 3 outputs. Standard 1½" x 3" guide with square flanges. Complete with 115 vac or dc arranged switching motor. Mfg. Raytheon. New and complete ..$150.00
721-A TR CAVITY WITH TUBE. Complete with tuning plungers ..$12.50
POWER SPLITTER: 726 Klystron input, dual "N" output ..$5.00
10 CM. McNALLY CAVITY Type SG ..$3.50
WAVEGUIDE SECTION, MC 445A, rt. angle bend, 5½" ft. OA. 8" slotted section ..$21.00
10 CM OSC. PICKUP LOOP, with male Homedell output ..$2.00
TS115/APS-2F 10 CM ANTENNA in lucite ball, with type "N" fitting ..$4.50
OAJ NAVY TYPE CYT66ADL. ANTENNA, in lucite ball, with Sperry fitting ..$4.50
10 CM FEEDBACK DIPOLE ANTENNA, in lucite ball, for use with parabola ..$8.00
10 CM END FIRE POLYRODS ..$1.75 ea.
"S" BAND Mixer Assembly, with crystal mount, pickup loop, tunable output ..$3.00

⅞" RIGID COAX—⅜" I.C.

SLOTTED SECTION, 10 ft. L, 4" Slot ..$8.50
RIGHT ANGLE BEND, with flexible coax output pickup loop ..$8.00
SHORT RIGHT ANGLE bend, with pressurizing nipple ..$4.00
RIGID COAX to flex coax connector ..$3.50
STUB-SUPPORTED RIGID COAX, gold plated 5' lengths. Per length ..$7.00
RT. ANGLES for above ..$3.75
RT. ANGLE BEND 15" L OA ..$4.50
FLEXIBLE SECTION, 15" L. Male to female $4.25
MAGNETRON COUPLING to ⅞" rigid coax, with TR pickup loop, gold plated ..$7.50
⅞" RIGID COAX. Bead Supported ..$1.20 per ft.

⅞" RIGID COAX—¼" I.C.

SHORT RIGHT ANGLE BEND ..$3.00
Rotating joint, with deck mounting ..$15.00
RIGID COAX slotted section CU-60/AP ..$5.00

1.25 CENTIMETER

"K" BAND FEEDBACK TO PARABOLA HORN, with pressurized window ..$30.00
MITRED ELBOW cover to cover ..$4.00
TR/ATR SECTION choke to cover ..$4.00
FLEXIBLE SECTION 1" choke to choke ..$5.00
ADAPTER, rd. cover to sq. cover ..$5.00
MITRED ELBOW and S sections choke to cover ..$4.50

MISCELLANEOUS

DEHYDRATING UNIT, 60 LB. CAP., 115 v. 60 cy oper. 21" x 22" x 15". New and Complete ..$425.00
F 129 SPR-2 Coax Wavetraps ..$12.50

3 CM. PLUMBING

(STD. 1" x ½" GUIDE UNLESS OTHERWISE SPECIFIED)

"X" BAND PREAMPLIFIER, consisting of 2-723A/B local oscillator-beacon feeding waveguide and TR/ATR Duplexer section, including 60 mc. IF amp. ..$47.50
WAVEGUIDE RUN, 1¼" x ⅝" guide, consisting of 4 ft. section with rt. angle bend on one end and 2", 45 deg. bend other end ..$8.00
WAVEGUIDE SECTION, 1¼" x ⅝" choke to choke, 4 ft. long ..$6.75
"X" BAND calibrated attenuator ..$85.00
SHIELDED KLYSTRON tube mounts with rough attenuator outputs ..$90.00
CU 105/APS 31 Directional coupler 25 db. ..$15.00
CU 106 APS—33 Directional coupler, 25 db. ..$15.00
APS-10TR/ATR duplexer section with additional iris flange ..$10.00
Flexible waveguide ..$4.00 per ft.
THERMISTOR: D-164699—for mtg. in "X" Band Guide ..$2.50
45 DEG. TWIST, 6" Long ..$8.50
12" SECTION, 45 deg. twist, 90 deg. bend ..$6.00
11" STRAIGHT WAVEGUIDE section choke to cover. Special heavy construction, silver plated ..$4.50
15 DEG. BEND, 10" choke to cover ..$4.50

5 FT. SECTIONS, choke to cover, silver plated ..$14.50

18" FLEXIBLE SECTION ..$17.50
"E" or "H" PLANE BEND ..$12.50
BULKHEAD FEED THRU ..$15.00
WAVEGUIDE SECTION, CG 251/APS-15A, 26" long choke to cover, with 180 deg. bend of 2½" rad. at one end ..$6.00
ROTARY JOINT with slotted section and type "N" output pickup ..$17.50
WAVEGUIDE SECTION, 12" long choke to cover, 45 deg. twist & 2½" radius, 90 deg. bend ..$5.00
SLUG, TUNER/ATTENUATOR, W.E. guide, gold plated ..$6.50
TR/ATR DUPLEXER section with iris flange ..$8.00
TWIST, 5" 90 deg. choke to cover ..$5.00
WAVEGUIDE SECTIONS 2½ ft. long, silver plated, with choke flange ..$5.75
WAVEGUIDE, 90 deg. bend E plane, 18" long..$5.00
ROTARY JOINT, choke to choke ..$17.50
ROTARY JOINT, choke to choke, with deck mounting ..$17.50
S-CURVE WAVEGUIDE, 8" long cover to choke..$3.50
3" FLEX SECTION. Sq. flange to circ. flange adapter ..$7.50
"X" BAND WAVEGUIDE, 1¼" x ⅝" OD, 1/16" wall aluminum ..per ft. $ .75
TR CAVITY for 724-A TR tube ..$3.50
724-A TR tube (41-TR-1) ..$2.50
APS-15 DUPLEXER SECTION using 1B24 ..$10.00
3 CM WAVEGUIDE, 1" x ½" I.D. per ft. ..$1.50
CIRCULAR CHOKE FLANGES, solid brass ..$.55
SQ. FLANGES, flat brass ..$.55
"T" SECTION (TR-ATR) choke to choke, supplied with circ. or sq. flanges ..$4.50
"X" BAND PRESS. GAUGE SECTIONS, with 15 lbs. gauge and press. nipple ..$18.50
TRANSMISSION LINE PRESS GAUGE ..$3.50
2" FLEXIBLE SECTION, cover to cover ..$5.00
MOUNTING SECTION for Absorp. Wavemeter and Thermistor Mount, Silver Plated, Sq. Flanges ..$6.50

MICROWAVE TEST EQUIPMENT

THERMISTOR BRIDGE: Power meter I-203-A. 10 cm. mfg. W.E. Complete with meter, interpolation chart, portable carrying case as shown ..$72.50
TS 12/AP VSWR METER. Consisting of Slotted Line, and all additional fittings and ampl. for 3CM operation. New and complete ..$450.00
Bell Labs. Dual Mount mixer-beacon assemblies, 2 complete mixer-beacon mounts on gold-plated waveguide section ..$50.00
Slotted Line, Bell Labs. 1⅛" x 5/16" guide, gold plated ..$150.00
TS 108-AP dummy load ..$65.00
W. E. I 138. Signal generator, 2700 to 2900 Mc range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram ..$50.00
3 cm. Wavemeter: 9200 to 11,000 mc transmission type with square flanges ..$15.00
3 cm. stabilizer cavity, transmission type ..$20.00
3 cm. Wavemeter, Micrometer head mounted on X-Band guide. Freq. range approx. 7900 to 10,000 Mc. ..$75.00

POWER EQUIPMENT

STEP DOWN TRANSFORMER: Pri: 440/220/110 volts a.c. 60 cycles, 3 KVA. Sec. 115 v. 2500 volt insulation. Size 12"x12"x7" ..$40.00
PLATE TRANSFORMER. Pri: 117 v. 60 cy. Sec. 17,000 v. @ 144 ma. with choke. Oil immersed. Size: 26"x29"x13" Amertran ..$120.00
FIL. TRANS. UX6899 Pri: 115 v. 60 cy. Sec: Two 5V 5.5A windings 29 KV Test ..$24.50
VOLTAGE REG. Transtat, "Amertram" type PH 2KVA load. Input 90/130 v. 50/60 cycle output 115 v. ..$40.00
KS 6767: Fil. Xfmr. Pri: 115 v. 60 cy. Sec: 2 wdgs 5v. at 5 amp each. 15,000 v. ins. ..$15.00

COMBINATION TRANSFORMERS

T2G167, 650 v. 2 ma: 650 vct 65 ma; 6.4 v. 4 amp; 6.4 v. .6 amp; 2.5 v. 1.75 amp. (Ideal for panadapter applications) ..$5.25
25104, 800 vct. 150 ma: 5 v. 3 amp: 6.3 v. 6.25 amp ..$6.95
KS 8931, 585 vct. 86 ma; 5 v. 3 amp; 6.3 v. 6 amp ..$4.25

OIL CONDENSER

1.5 MFD., 6000 vdc ..$12.50
1 MFD., 25,000 volts ..$99.50
.25 MFD., 20,000 vdc ..$17.50
10 MFD., 1000 vdc ..$1.79
3x10 MFD., delta connected synchro-capacitor, 90 v. 60 cycles ..$4.95
.1 MFD., 6000 vdc, 25F509G2 ..$6.50

INVERTERS

PE 218-E: Input: 25-28 vdc. 92 amp. Output: 115 v. 350-500 cy. 1500 volt-amps. Dim: 17" x 6½" x 10". New, export packed ..$49.95
PE 218-H: Same as above, except size: 16½" x 5¾" x 10" ..$49.95
PE 218-H: Used, good cond. ..$25.00
PE 206: Input: 28 vdc. 38 amps. Output: 80 v. 800 cy. 500 volt-amps. Dim: 13" x 5¾" x 10½". New ..$12.50
GE 5D21NJ3A: Input: 28 vdc. 35 amp. Output: 115 v. 400 cy. 485 volt-amps. Dim: 9" x 4½" diameter. New ..$49.95

MAGNETRONS

TUBE	FREQ. RANGE	PK. PWR. OUT.	PRICE
2J31	2820-2860 mc.	265 KW.	$25.00
2J21-A	9345-9405 mc.	50 KW.	$25.00
2J22	3267-3333 mc.	265 KW.	$25.00
2J26	2992-3019 mc.	275 KW.	$25.00
2J27	2965-2992 mc.	275 KW.	$25.00
2J32	2780-2820 mc.	285 KW.	$25.00
2J38 Pkg.	3249-3263 mc.	5 KW.	$35.00
2J39 Pkg.	3267-3333 mc.	87 KW.	$35.00
2J40	9305-9325 mc.	10 KW.	$65.00
2J49	9000-9160 mc.	58 KW.	$85.00
2J55 Pkg.	9345-9405 mc.	50 KW.	$35.00
2J61	3000-3100 mc.	35 KW.	$65.00
2J62	2914-3010 mc.	35 KW.	$65.00
3J31	24,000 mc.	50 KW.	$55.00
5J30			$39.50
714AY			$25.00
718DY			$25.00
720BY	2800 mc.	1000 KW.	$50.00
720CY			$50.00
725-A	9345-9405 mc.	50 KW.	$25.00
730-A	9345-9405 mc.	50 KW.	$25.00

Klystrons: 723A/B $12.50; 707B W/Cavity $20.00; 417A $25.00; 2 K.41 $65.00

MAGNETRON MAGNETS

GAUSS	POLE DIAM.	SPACING	PRICE
5200	21/32 in.	¾ in.	$17.50
4850	¾ in.	⅝ in.	$12.50
1500	1⅝ in.	1½ in.	$12.50
D161392*	1⅝ in.	1 5/16 in.	$12.50

* Mfr's Number.

TUNABLE PKGD. 'CW' MAGNETRONS

QK 61 2975-3200 mc. — QK 62 3150-3375 mc.
QK 60 2800-3025 mc. — QK 59 2675-2900 mc.
New, Guaranteed ..Each $65.00

PULSE EQUIPMENT

MODULATOR UNIT BC 1203-B

Provides 200-4,000 PPS. Sweep time: 100 to 2,500 microsec. in 4 steps, fixed mod. pulse, suppression pulse, sliding modulating pulse, blanking voltage, marker pulse, sweep voltages, calibration voltages, fil. voltages. Operates 115 vac. 50-60 cy. Provides various types of voltage pulse outputs for the modulation of a signal generator such as General Radio 804B or 804C used in depot bench testing of SCR 695, SCR 595, and SCR 535. New as shown ..$125.00
MIT. MOD. 3 HARD TUBE PULSER: Output Pulse Power: 144 KW (12 KV at 12 amp). Duty Ratio: .001 max. Pulse duration: .5, 1.0, 2.0 microsec. Input voltage: 115 v. 400 to 2400 cps. Uses 1-715-B, 1-829-B, 3-'72's, 1-'73. New ..$110.00
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 KV (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
APS-10 MODULATOR DECK. Complete, less tubes ..$75.00
APS-10 Low voltage power supply, less tubes ..$18.50

PULSE NETWORKS

15A-1-400-50: 15KV, "A" CKT, 1 microsec, 400 PPS, 50 ohms imp. ..$42.50
G.E. 25E5-1-350-50P2T, 25 KV, 5 sections, "E" circuit, 1 microsecond pulse length, 350 PPS, 50 ohms impedance ..$45.00
G.E. 6E3-5-2000-50P2T, 6KV, "E" circuit, 3 sections, .5 microsecond, 2000 PPS, 50 ohms impedance ..$6.50
G.E. 3E (3-.84-810; 8-2.24-405) 50P4T: 3KV, "E" CKT Dual Unit: Unit 1, 3 Sections, .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
7.5E3-3-200-67PT. 7.5 KV, "E" Circuit, 3 microsec, 200 PPS, 67 ohms imp., 3 sections ..$12.50

DELAY LINES

D-168184: .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
Delay Line, 5 microsec. max., 12 taps, 500 ohms imp. ..$6.50

PULSE TRANSFORMERS

G.E.K.-2745 ..$39.50
G.E.K.-2744-A ..$39.50
W.E. D166173 III-Volt input transformer, W.E. Impedance ratio 50 ohms to 900 ohms. Freq. range: 10 kc to 2 mc. 2 sections parallel connected, potted in oil ..$36.00
W.E. KS 9800 Input transformer. Winding ratio between terminals 3-5 and 1-2 is 1.1:1, and between terminals 6-7 and 1-2 is 2:1. Frequency range: 380-520 c.p.s. Permalloy core ..$6.00
G.E. K2731 Repetition Rate: 635 PPS. Pri. Imp: 50 Ohms. Sec. Imp: 450 Ohms. Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output: 28 KV PK. Peak Output: 800 KW. Bifilar 2.75 Amp. ..$64.50
W.E. D169271 III Volt input pulse Transformer $27.50
G.E. K2450A Will receive 13KV. 4 micro-second pulse on pri., secondary delivers 14KV. Peak power out 100KW GE ..$45.00
G.E. K2748A Pulse Input, line to magnetron ..$36.00
9280 Utah Pulse or Blocking Oscillator XFMR Freq. limits 790-810 cy-3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1 1/8 x 19/32" ..$1.50

MEMBERSHIP

(*Continued from page 44A*)

Weissman, J. G., 40-22 Lawrence St., Flushing, L. I., N. Y.
White, E. S., 189-02 64 Ave., Flushing, L. I., N. Y.
Williams, J. K, 173 Fairlawn Ave., Toronto, Ont., Canada

Admission to Member

Burbank, S. R., R.C.A.F. Station, Clinton, Ont., Canada
Chatterjee, S. D., Ballygunge Place, 91, Calcutta, P.O. Ballygunge, India
Chrystie, H., 385 Putnam Ave., Cambridge 39, Mass.
Clewell, D. H., Magnolia Petroleum Company, Box 900, Field Research Laboratories, Dallas 1, Tex.
Dennager, W. A., 5430 Thrush Ave., St. Louis 20, Mo.
Doylen, D. H., 722 North Broadway, Milwaukee 2, Wis.
Files, C. O., 7908 Newton, Overland Park, Kans.
Fox, E. M., Box 883, La Jolla, Calif.
Ghosh, J., Communication Officer, Calcutta Airport, Dumdum, India
Gleiter, W. C., Box 241, Hatboro, Pa.
Gold, B., 2159 Morris Ave., New York 53, N. Y.
Hogan, A. W., 4827 Indian Lane, Berwyn, Md.
Holmes, E. G., 511 Petroleum Bldg., Houston, Tex.
Kneen, W., 7519 S. Coles Ave., Chicago 49, Ill.
Massey, A. P., 205 Crestmoor Circle, Silver Springs, Md.
McNickle, R. E., 912 New Holland Ave., Lancaster, Pa.
Meagher, R. E., 206 S. Fair St., Champaign, Ill.
Oepkes, D. J., 173 Heezerweg, Eindhoven, Holland
Ratz, A. G., 24 Kent St., Ajax, Ont., Canada
Rollert, C. R., 5804 Kenwood, Kansas City, Mo.
Shoup, J. P., 329 N. Chama Ave., Albuquerque, N. Mex.
Stevens, D. L., 17 Dunster St., Cambridge, Mass.
Westcott, H. S., Jr., 238 "D" St., Sandia Base Branch, Albuquerque, N. Mex.
Wylie, D. L., 829 South 30, Omaha, Neb.

The following elections to the Associate grade were approved and are effective as of February 1, 1949:

Aoyama, C., 3120 Broadway, New York, N. Y.
Arent, E. V., 795 Sycamore St., Buffalo 12, N. Y.
Aronwitz, L., 1593 Bedford Ave., Brooklyn 25, N. Y.
Aymond, E. F., 4310 Maple Ave., Dallas 9, Tex.
Beaupre, D. M., Royal Canadian Air Force (J.A.S.), Manitoba, Canada
Bertschy, H. R., 131 Burnett Ave., Maplewood, N.J.
Bowling, H. S., 4242 Albans Rd., Houston, Tex.
Braun, M., 364 W. 26 St., New York 1, N. Y.
Brown, D. G., 6620 Sprague, Philadelphia 19, Pa.
Bruns, R. W., Box 185, Angola, Ind.
Buchholz, F. G., 7341 W. Rascher Ave., Chicago, Ill.
Buttner, J. G., 803 S. Argentina St., Juarez, Chihuahua, Mexico
Carnuccio, J. N., 5050 N. Broadway, Chicago, Ill.
Claus, O. R., Jr., 2116 Southland Rd., Baltimore 7, Md.
Cohan, H. R., 88-69 20 Ave., Brooklyn, N. Y.
Crespo, J. M., Route 2, Box 47, Pittsburgh, Calif.
Daigle, W. A., 4832 Del Mar Ave., San Diego 7, Calif.
Das, S. S., Purunahata Sahi, P.O. Baripada, Orissa, India
Davis, F. H., 3185 Florecita Dr., Altadena, Calif.
DeCatur, J. A., Jr., 725 Hawthorne St., N.E., Grand Rapids, Mich.
Degebeffe, H. A., 1450 Belle Plaine, Chicago 13, Ill.
Drozt, P., 1451 N. Leavitt St., Chicago 22, Ill.
Drysdale, R. R., 2447 N. New England Ave., Chicago 35, Ill.

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Membership

(*Continued from page 46A*)

Everett, J. A., 312A Entwistle St., China Lake, Calif.
Ferris, A. B., 123-A Hornet St., China Lake, Calif.
Fisher, L. L., Station A, Box 6000, Albuquerque, N. Mex.
Foley, J. L., Box 66, N.O.T.S., China Lake, Calif.
Freeman, C. F., B.O.Q. 29, N.C.O.T.S., China Lake, Calif.
Froehlich, C., 640 W. 153 St., New York 31, N. Y.
Gehmlich, A. P., 2049 W. 69 Place, Chicago 36, Ill.
Geiger, R. F., 471 Napoleon Ave., Columbus 9, Ohio
Gennett, D. F., Jr., 3720 N. Wayne Ave., Chicago 13, Ill.
Gentile, A. J., Y.M.C.A. Hotel, 826 So. Wabash Ave., Chicago 5, Ill.
Getman, C., 125 W. St. Clair, Cincinnati 19, Ohio
Goldsmith, T. H., 3138 Westover Dr., S.E., Washington, D. C.
Greenwald, H. W., 4042 Lafayette Ave., St. Louis 10, Mo.
Grivet, P. A., 135 Boulevard St. Michel, Paris 5, France
Hammond, R. W., 1602 Broadbridge Ave., Stratford, Conn.
Hansel, R. J., 3621 N. Lavergne Ave., Chicago 41, Ill.
Harvey, D. E., 807 S. Spaulding, Chicago 24, Ill.
Harris, J. F., Upjohn St., Ridgecrest, Calif.
Hartig, H. L., 229 N. Vincent Ave., Minneapolis 5, Minn.
Hemphill, F. A., 2677 N. Lincoln Ave., Chicago 14, Ill.
Herman, S. R., 4177 N. Montreal, Milwaukee 9, Wis.
Herrick, K. P., 2516 Fulton St., Toledo 10, Ohio
Honda, T., 4126 S. Ellis, Chicago 15, Ill.
Jackson, B. B., B.O.Q. B7, U.S.N.O.T.S., China Lake, Calif.
Kalish, H. M., 898 Cauldwell Ave., New York 56, N. Y.
Keeler, R. J., Department of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va.
Kellock, J. H., Jr., 942 Carteret uve., Trenton, N. J.
Kimball, G. D., 228 Upjohn St., Ridgecrest, Calif.
Klett, H. F., 117 Woodward St., Angola, Ind.
Kozloff, V. S., 312 W. Jefferson St., New Carlisle, Ohio
Krstenansky, J. S., 4411 N. Kenneth, Chicago 30, Ill.
Kutzley, V. J., 103 S. Warren Ave., Columbus 4, Ohio
Langdon, J. G., 309 E. Tamarack Ave., Inglewood, Calif.
Larsen, C. L., Box 604, China Lake, Calif.
Lebell, D., 10429 Eastborne Ave., Los Angeles 24, Calif.
Lerner, I. S., 603 S. Eighth, Ponca City, Okla.
Linvill, J. G., 52 Massachusetts Ave., Cambridge 39, Mass.
Love, E. J., 9264 Boleyn, Detroit 24, Mich.
Mathison, W. W., 206A Brynes St., China Lake, Calif.
McDaniel, L. W., 232 E. Lavaca, Beaumont, Tex.
McDougall, R. H., c/o Chief Engineer, G.P.O. Annexe, Pretoria, Transval, South Africa
Mead, W. A., Production Research Division, Continental Oil Company, Ponca City, Okla.
Merriam, R. T., 413-B Princeton, China Lake, Calif.
Morgan, W. O., Route 1, Oak Harbor, Ohio
Nash, O. A., 2508 Holloran, Fort Worth, Tex.
Newhart, E. L., 102 Second St., Trenton, N. J.
Noel, C. A., Unit 3, Apt. 10, Veterans Village, Stillwater, Okla.
Nozick, S., 268 S. Second St., Brooklyn 11, N. Y.
Ocko, R., 2014 E. Genesee St., Syracuse 10, N. Y.
Parkin, T. R., 53-B Dewey St., U.S.N.O.T.S., China Lake, Calif.
Peterson, D. F., 1503 W. Thomas St., Chicago 22, Ill.
Petters, J. F., 203 N. Harrison St., Ludington, Mich.

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Membership

(Continued from page 47A)

Pettinato, J. D., WQAN-FM, The Scranton Times, Scranton, Pa.
Prosser, H. K., 2 Halsbury Rd., Victoria Park, Cardiff, Glam, Wales
Ragni, V. F., 300 S. James Rd., Columbus, Ohio
Rajan, S. S., 15 Pinjala Subrananiam Rd., T'Nagar. Madras, India
Rawlins, C. D., 629 Colfax St., Evanston, Ill.
Rogers, R. N., 444 Broadway, Albany, N. Y.
Rokoszewski, J. S., 1903 W. Evergreen, Chicago 22, Ill.
Ruvo, S. M., 3011 Olinville Ave., New York 67, N. Y.
Sellars, R. F., U.S.S. Harwood DD861, c/o F.P.O., San Francisco, Calif.
Silberg, W. F., 1316 E. 19 Ave., Columbus 11, Ohio
Spano, A., 2830 N. Mozart St., Chicago 14, Ill.
Swearingen, T. J., 90-23 171 St., Jamaica, L. I., N. Y.
Taris, C. M., 11 Adams Ave., Cranford, N. J.
Vanous, J. A., 1030 Fourth Ave., S.E., Cedar Rapids, Iowa
Weidemann, H. K., 26 Chesapeake St., S.W., Washington, D. C.
Wichels, J., Jr., 2211 45 Ave., San Francisco, Calif.
Wittmann, R. C., 3110 East Ave., Berwyn, Ill.

The following transfers to Associate grade were approved to be effective as of January 1, 1949:

Altschuler, H. M., 316 W. 88 St., New York 24, N. Y.
Arneth, A. P., Jr., 1702 Orchard St., Alexandria, Va.
Ashton, D., 88 Plymton St., Waltham 54, Mass.
Austin, C. L., 4024 Aurora St., Coral Gables, Fla.
Baldwin, J. H., 5062 Granville St., Vancouver, B. C., Canada
Barnaby, R. H., 43 Jackson Rd., West Medford, Mass.
Baugh, C. W., Jr., 3032 Blackridge Ave., Pittsburgh 21, Pa.
Brand, C. W., 1025 Sevilla Ave., Coral Gables 34, Fla.
Braun, W. E., 143 Oakwood Ave., Bogota, N. J.
Breitwieser, G. F., Jr., CGC Campbell, Stapleton, S. I., N. Y.
Brooks, C. E., 507 W. 38 St., Norfolk 8, Va.
Brown, B. J., 1342 Woodruff Ave., W. Los Angeles, Calif.
Brown, J. S., Electrical Engineering Department, Syracuse University, Syracuse 10, N. Y.
Burke, J. J., 5022 Ladd Ave., Los Angeles 32, Calif.
Bush, N. E., 39 Skyline Dr., Duquesne, Pa.
Canty, E. T., 54 Hampton Rd., Lindenhurst, L. I., N. Y.
Cochran, E. V., 45 Lexington Ave., Dayton 7, Ohio
Corey, B. W., 154 W. 75 St., New York, N. Y.
Cosgriff, R. L., 169 E. 13 Ave., Columbus, Ohio
Daum, A., 2343 Morris Ave., New York 53, N. Y.
Davis, D. P., 4 Mitchell St., W., Berea, Johannesburg, South Africa
Delany, E. B., 25 Birch St., Lindenhurst, L. I., N. Y.
Dolin, R., 187 Hendrix St., Brooklyn 7, N. Y.
Donaldson, M. R., Box 306, Georgia Tech, Atlanta, Ga.
Donsbach, W. R., 1617 Sulphur Spring Rd., Arbutus 27, Md.
Dorsett, J. W., Jr., 4552 Wells Pkwy., Riverdale, Md.
Dorwart, R. J., 2625 Boylston Ave., N., Seattle 2, Wash.
Drexler, J. J., 29 Missouri Ave., Dayton 10, Ohio
Duncan, J. R., 16711 Parthenia St., San Fernando, Calif.
Evans, A. G., 44 Parkview, Indianapolis, Ind.
Fishman, M., 626 Main St., Haverhill, Mass.
Fulton, W. L., Jr., 14 W. Preston St., Hampton, Va.
Garfinkel, A. R., 2411 N. 57 St., Philadelphia 31, Pa.
Gleimer, L., 667 Union Ave., New York 55, N. Y.
Grant, W. P., 226 W. 70 St., New York 23, N. Y.
Harris, K. B., 19 Laxis Ave., Mt. Dennis, Ont., Canada

(Continued on page 49A)

Membership

(Continued from page 48A)

Hartnett, E. J., 210 Charles Ave., Staten Island 2, N. Y.
Healey, D. J., Shawan Rd., Cockeysville, Md.
Heath, G. F., Warner, N. H.
Hennies, S. R., 4258 W. 101 St., Inglewood, Calif.
Hochman, S., 1780 East 13 St., Brooklyn 29, N. Y.
Hogle, R. C., 302-B Hickory Lane, East Lansing, Mich.
Hulbert, S. G., 2550 Broadway St., San Diego 2, Calif.
Hutchinson, P. T., Box 152, State College, Miss.
Jones, D. V., 947 James St., Syracuse 3, N. Y.
Kelley, G. G., 100 Underwood Rd., Oak Ridge, Tenn.
King, L. H., 213-01 Hillside Ave., Queens Village 8, N. Y.
Lamb, J. G., 219 K St., Salt Lake City, Utah
Lanier, H. H., 1 Osgood Ave., New Britain, Conn.
Linhardy, R. J., 4382 Carpenter Ave., New York, N. Y.
Lutzker, L., 21 Bennett Ave., New York 33, N. Y.
Lynch, F. W., 5008 17, N.E., Seattle 5, Wash.
MacDermid, B. W., 57 Corbin Ave., Jersey City 6, N. J.
Martin, G. C., 515 East 39 St., Baltimore 18, Md.
Martin, J. L., Research & Development, c/o Atlantic Refining Co., Dallas, Tex.
Matte, G., Department of National Defence (Army), C.S.R.D.E., Ottawa, Ont., Canada
Miller, J. B., Unit 15-E, Badger, Wis.
Moynihan, J. D., 84 Willard Ave., Bloomfield, N. J.
Myers, G. T., 5956 Loretta Ave., Philadelphia 24, Pa.
Nagel, J., Jr., Box 37, Allenhurst, N. J.
Pivan, D. B., WMOR-FM, 188 W. Randolph St., Chicago 1, Ill.
Poarch, M. F., 1113½ W. North St., Lima, Ohio
Prudent, G. H., 1368 Collidge Ave., Cincinnati 30, Ohio
Rabin, G. C., 245 Lenox Rd., Brooklyn 26, N. Y.
Randall, J., Box 6, Cedar Rapids, Iowa
Riceman, S., 70 Wallingford Rd., Brighton 35, Mass.
Ringer, H. N., 1012 Garfield Ave., Palmyra, N. J.
Robinson, A. S., 59 Radnor Rd., Great Neck, L. I., N. Y.
Robinson, L. P., 2800 Tola Ave., Altadena, Calif.
Rosenberry, W. W., 1100 Mississippi Ave., S.E., Washington 20, D. C.
Salisbury, D. L., 275 North Third West, Provo, Utah
Sawyer, H. F., Box 436, Sunnyvale, Calif.
Schmidt, L. M., 320 Buckingham Ave., Syracuse 10, N. Y.
Schwartz, M., 1977 Prospect Ave., New York 57, N. Y.
Seestedt, H. C., 99 "Z" Flavet I, Gainesville, Fla.
Segal, S., 384 Commonwealth Ave., Boston, Mass.
Smith, W. H., 274 Morris Ave., Inwood, L. I., N. Y.
Solomon, C. K., 851 Tappan Ave., Ann Arbor, Mich.
Spink, W. O., 600 Terrace Plaza Bldg., Cincinnati, Ohio
Stempnitzky, L., c/o Brandeis University, Waltham 54, Mass.
Stevens, F., Jr., 76½ W. Arbor, Long Beach, Calif.
Stroud, S. G., 221 N. Ave. 52, Los Angeles 42, Calif.
Stumpf, R. J., 426 W. Roses Rd., San Gabriel, Calif.
Svendsen, E. C., 1772 Laurel Ave., St. Paul 4, Minn.
Thomasson, H. B., 1269 New Hampshire Ave., N.W., Washington 6, D. C.
Tom, H., 875 Sacramento St., Apt. 101, San Francisco, Calif.
Tweedale, J. W., 1114 S.E. Malden, Portland, Ore.
Weinberger, H. L., 2812 Suffolk Ave., Baltimore, Md.
Welkowitz, W., Electrical Engineering Department, University of Illinois, Urbana, Ill.
Westman, H. P., Jr., 416 Chestnut St., West Hempstead, L. I., N. Y.
Wilkendorf, A. M., 644 W. 25 St., Houston 8, Tex.
Wise, A., Brookhaven National Laboratory, Upton, L. I., N. Y.

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.

ELECTRONIC ENGINEERS—PHYSICISTS

A leading electronics company in Los Angeles, California offers permanent employment to persons experienced in advanced research and development. State qualifications fully. Box 545.

ENGINEERS—PHYSICISTS

Southwestern state college engaged in research, development and operation in guided missile field has openings for graduate electrical engineers or physicists with experience in electro-mechanical devices, telemetering, audio, RF, VHF and antenna design. Salary depends on education and experience which should be fully described in first letter. Box 554.

COMMUNICATIONS—ELECTRONICS ENGINEER

Work will involve aeronautical communications and aircraft electronic projects. Some development work but primarily application engineering. Box 555.

ENGINEERS AND PHYSICISTS

An expanded program of research has created opportunities in the fields of acoustics, hydrodynamics, electronics, mechanics and mathematics. Positions flexible enough to permit part-time college teaching if desired. Opportunity for graduate study. Salary commensurate with experience. Appointments carry academic rank ranging from Research Assistant to Professor. Inquiry invited. P.O. Box 30, State College, Pa.

ELECTRICAL AND ELECTRONICS ENGINEERS

The Engineer Research and Development Laboratories of the Corps of Engineers, located at Fort Belvoir, Virginia, has a continuing need for electrical and electronics engineers to fill positions involving design and development and paying entrance salaries, depending on grade, of from $3727.20 to $6235.00 per annum. Applications should be mailed to the Civilian Personnel Office, Bldg. 211, Fort Belvoir, Virginia.

ELECTRICAL ENGINEERS

1 experienced engineer wanted for each of the following: radar pulse circuit; circuit development; radar modulators; radar devices; radar receivers; radar indicator circuit design and development. Send resume in confidence to Box 556.

ELECTRONICS ENGINEER MANAGER

Openings in equipment Development Department of Electronics Division, Boston, Mass. for graduate engineer with ability to administer and direct an engineering activity. An electrical engineer

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POSITIONS OPEN

specialized in communications or electronics preferred, with industrial or equivalent in radar or communications systems design. Responsible for development and manufacture of microwave X & K band radar systems, FM test equipment, industrial and laboratory test equipment, and electronic computers. Boston or New York interviews will be arranged for qualified applicants submitting complete resume including salary requirements to Supervisor of Employment, Sylvania Electric Products, Inc. Industrial Relations Dept. 500 Fifth Ave.. New York 18, N.Y.

MAGNETRONS DEVELOPMENT ENGINEER

An opening at our Electronics Division, Boston, Mass., for a Senior Engineer, to work in the tube development engineering group as a design and process engineer on magnetrons. Will be in charge of a project and have one or more engineers and technicians reporting to him. Will be responsible for manufacturing the tube after it has been designed in small quantities. B.S. in E.E. or physics required, and two to three years experience in the use of vacuum systems, and considerable experience on microwave type metal tube assembly. Furnish full particulars in writing regarding age, education, experience, present salary and salary requirements to: Supervisor of Employment, Sylvania Products, Inc. Industrial Relations Dept. 500 Fifth Ave., New York 18, N.Y.

ELECTRONICS ENGINEER SECTION HEAD

Our Electronics Division, Boston, Mass., is seeking a graduate electrical engineer (S.B. or S.M. electronics option preferred) to supervise a group of 17 engineers and several technicians working on X & K band radar and other electronic equipment development, including computers. Early interviews will be granted qualified applicants with actual experience in design of large scale electronics equipment and administration of engineers. Mail complete resume to Supervisor of Employment, Sylvania Electric Products, Inc. Industrial Relations Dept. 500 Fifth Ave., New York 18, N.Y.

ELECTRICAL ENGINEER

Nationally known Chicago company is in need of a high grade, experienced electrical engineer. He must be a college graduate with a B.S. in E.E. and have a high scholastic record. Should have from two to five years experience in electronics, preferably with a minimum of two years in the design of audio amplifiers. In reply give all particulars and state expected salary. Box 558.

SENIOR RADIO ENGINEERS

Must have good fundamental training, experience in circuit design and test of government-type portable and mobile transmitters and receivers. Write fully to Government Contract Dept., Pilot Radio Corporation, 3706-36th Street, Long Island, City, N.Y.

(Continued on page 52A)

POSITIONS OPEN

(Continued from page 51A)

ELECTRONIC ENGINEERS

College graduates with 3-5 years of development engineering experience in circuit design. Well versed in magnetic circuits, non-linear circuit operation and electronic theory. Send résumé and all particulars to Personnel Department, General Precision Laboratory, Inc., Pleasantville, New York (30 miles north of New York City).

ENGINEERS AND PHYSICISTS

Unusual opportunity for engineers or physicists familiar with SCR-584 radar, electronic computers, or synchronization and timing. Desirable beach location. Many advantages. For application forms write Rt. 1, Box 118, Oxnard, California.

VACUUM TUBE ENGINEER

Vacuum tube engineer (starting salary $6235.20) to head well equipped and well staffed vacuum tube development shop in Government laboratory. Requires engineer or physicist with several years broad experience in vacuum tube development and construction and a genuine interest in developing new tube making techniques. Box 559.

ELECTRONIC ENGINEER

To work on challenging control projects of an electrical, electro-mechanical and electronic nature. Good pay with excellent future with an established New England company of top rating for young man with necessary background who has initiative and imagination. Apply Box 560.

DESIGN ENGINEERS

We have several immediate openings for design or development engineers. Mechanical and electrical engineers with considerable experience in design of instruments or control preferred. Excellent opportunities with leading manufacturers of automatic controls. Attractive salary. Location: Minneapolis. Contact J. A. Johnson, Employment office, Minneapolis-Honeywell Regulator Company, 4th Avenue and 28th Street, Minneapolis 8, Minnesota.

RADIO PROJECT ENGINEER

Graduate engineer with at least 5 years recent experience in design and development of low power oscillator and amplifier circuits as used in signal generators in the very high frequency range. Must be familiar with theoretical concepts and calculations of the circuit components, as well as practical design and layout work. Applicant should have initiative and supervisory ability and be capable of assuming full responsibility for project. Apply by letter only. Address Personnel Dept. Federal Mfg. & Engineering Corp., Brooklyn 5, N.Y.

ELECTRONIC AND SALES ENGINEERS

Recently established and rapidly expanding company has openings for Junior Electronic Engineers in development and field engincering. Also openings for sales engineers in south, southeast, Pennsylvania and New England. Attractive remuneration. Company specializes in industrial electronics, instrumentation and control. Write giving full details to Fielden Electronics, Inc., Huntington Station, N.Y.

(Continued on page 53A)

POSITIONS OPEN

ELECTRONICS RESEARCH ENGINEER

Electronics research engineer experienced in electronics as well as engineering sciences and physics for research and development work in connection with motor and generator control equipment. Excellent opportunity with large manufacturer in New York City. Please write, giving complete education and experience. Replies will be held in confidence. Our employees know of this ad. Box 561.

WANTED PHYSICISTS ENGINEERS

Engineering laboratory of precision instrument manufacturer has interesting opportunities for graduate engineers with research, design and/or development experience on radio communication systems, Servomechanisms (closed loop), electronic & mechanical aeronautical navigation instruments and ultra-high frequency & microwave technique.

WRITE FULL DETAILS TO

EMPLOYMENT SECTION

SPERRY GYROSCOPE COMPANY

DIVISION OF SPERRY CORP.

Marcus Ave. & Lakeville Rd.

Lake Success, L.I.

★ ★ ★ ★

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.

TECHNICAL EXECUTIVE

Engineering physicist, M.A., Gold medallist, 30, experienced in radio, radar and X-ray, Division manager Montreal branch of European concern wants change to progressive North American concern that can use his talents not necessarily in these fields. Box 203 W.

ELECTRONIC ENGINEER

Currently engaged in production, design and development work for capacitor manufacturer, desires position in electronic industry within Chicago area. B.S.E.E. January 1948 Illinois Institute of Technology. Communications major. Age 25. Married. Two years Navy electronics experience including supervision of Radio Teletype station. Box 204 W.

ELECTRONIC ENGINEER

B.S.E.E. January 1949. College of the City of New York. Age 23. Single. 2 years experience as Navy electronic technician. Location immaterial if near graduate school. Box 214 W.

(Continued on page 54A)

Radio Corporation of America

RCA VICTOR DIVISION

Camden, N. J.

has career positions open for ELECTRONIC ENGINEERS

with experience in development and design of radio frequency test and measuring equipment such as sweep generators, oscilloscopes, oscillators, receiver circuit alignment apparatus. Familiarity with ultra-high frequency technique is especially required.

write to—

Employment Manager

Personnel Division

RCA Victor Division

Camden, New Jersey

ENGINEERS – ELECTRONIC

Senior and Junior, outstanding opportunity, progressive company. Forward complete résumés giving education, experience and salary requirements to

Personnel Department

MELPAR, INC.

452 Swann Avenue

Alexandria, Virginia

Positions Wanted

(Continued from page 53A)

RADIO ENGINEER

B.S.E.E. June 1949, University of Cincinnati. Age 31. Married. Experience: 2½ Co-op in Quality control and television production; 9 months advanced development high frequency guided missile electronic equipment; 2½ years Army as Communications Chief in Air Forces; 8 years in managerial and executive field. Desires position as research or development engineer with a progressive firm in the eastern or central states. Member of Tau Beta Pi and Eta Kappa Nu. Box 215 W.

TELEVISION ENGINEER

Graduating American Television Institute of Technology, January 1949 with B.S.T.E. Age 28. Married, 1 child. Past supervisory experience. Desires sales or development engineering. Box 216 W.

MICROWAVE ENGINEER

Experienced in wave guide and antenna work; seeks responsible position with a future. New York City or Long Island. Box 217 W.

ELECTRICAL ENGINEER

Advanced experience in development and production of magnetic amplifiers for all applications. Vast experience in electronic, control and magnetic devices fields. Will accept position with good opportunity. Box 219 W.

RADIO ENGINEER

B.S.E.E. 1943, University of Illinois, Tau Beta Pi, Eta Kappa Nu. M.I.T. electronics, A.U.S. radar officer. Radio Engineer, P-5, Eighth Army, Japan, 1946-48. Now in graduate study, Northwestern Technological Institute. Age 38. Box 228 W.

ENGINEER

B.S.E.E. in communications, February 1949, University of Iowa. Age 22. Single. 1st class radiotelephone license. 24 months part time work in 5 KW AM station. 1½ years U.S. Navy. Desires work with future in radio, TV or electronics. Box 229 W.

TECHNICAL WRITER—SALES ENGINEER

Technical writer, B.S.E.E. Columbia University. Experienced electronic and electrical equipment. 1 year as radio instructor, 3 years sales management experience plus business degree. Desires technical writing or sales engineering position in New York area, permanent connection. 29 years old, married, aggressive, best references. Call Lu-8-9164 mornings or write Box 230 W.

ENGINEER

B.S.E.E. June 1949, Kansas State College. Age 28. Married, no children. 3 years Army Signal Corps, Press Wireless School. 2 years installation of communications equipment. 5 years experience in broadcasting. 1st class telephone license. Eta Kappa Nu. Desires position in television station. Box 231 W.

(Continued on page 55A)

Positions Wanted

(Continued from page 54A)

JUNIOR ENGINEER

B.S. radio and television engineering. American Television Institute of Technology, January 1949. Age 23. Married, no children. Desires position in research or design. Anywhere in U.S. Box 233 W.

TEACHING—PHYSICIST

Harvard Ph.D. expected June 1949 or a little later in theoretical physics. Some electronics background. Desires academic position with research possibilities. Box 234 W.

TELEVISION ENGINEER

Graduated American Television Institute of Technology October 1948 with B.S.T.E. Age 31. Married. 1st class F.C.C. license. 4 years maintenance Army radar equipment. Have been teaching advanced television for 15 months. Desires position as development or T.V. station engineer. Have a thorough understanding of R.C.A. and DuMont television equipment. Box 235 W.

INDUSTRIAL ELECTRONICS

B.S., B.E., M.E. June 1949, Yale. Age 24. Married. Desires job in industrial electronics. 2 years industrial engineering experience. Box 236 W.

COMMUNICATIONS ADMINISTRATOR

Communications and radio officer with experience in large size ships of the Fleet available in southwestern United States. 8 years experience Naval Communications Service, 12 years utility company, thoroughly conversant with communication problems. Age 43. Married. Own home. College training. Hold FCC license. Would consider airline, railway, transportation and oil companies, also sales with established company. Brochure available upon request. Box 237 W.

ELECTRONIC ENGINEER

B.E.E. Age 35. 2 years project engineering. Army, Navy project experience, 2 years Navy electronics, 3 years general engineering experience. Box 238 W.

ELECTRICAL ENGINEER

Graduate electrical engineer. Industrial experience with magnetic and electronic control. Army experience, radar repair and maintenance. Desires servomechanism research and design work. Member of Tau Beta Pi, Eta Kappa Nu. Box 239 W.

ASSISTANT PROFESSOR OR RESEARCH ENGINEER

E.E. degree. Lt. USNR, graduate work at Naval Academy. P. G. School Electronics Engineering. 2 years E.E. teaching all subjects. Desires position as assistant professor or research engineering. Middle west or south area. All offers carefully considered. Box 240 W.

(Continued on page 56A)

Positions Wanted

ELECTRONIC ENGINEER

B.S.E.E., University of Texas, August 1948, communications major. 2 years experience as Navy electronics technician, partly with guided missiles; 2 years commercial radio servicing; 6 months experience in microwave design. Further details on request. Prefer position in southwest. Box 241 W.

ELECTRONIC ENGINEER

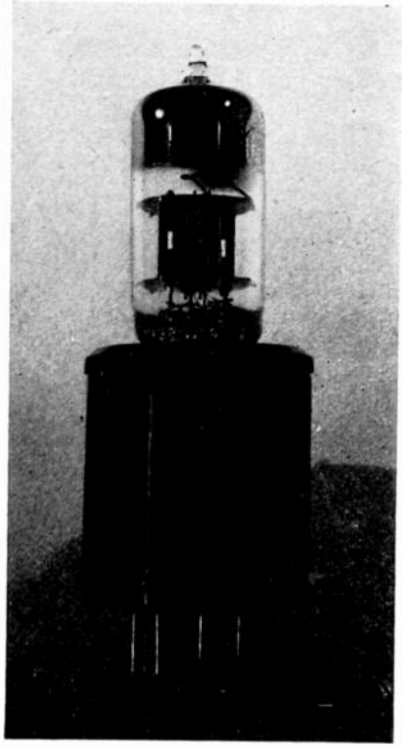
B.S. radio and electronic engineering, June 1949. Married, 3 children. Age 24. Air force communications and radar maintenance officer. 1st class phone license. Prefer west coast. Box 242 W.

News—New Products

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

New Binary Scaler

General Electric Co., Syracuse, N. Y., offers a new binary scaler for high-speed counter or nuclear work, known as the 4SN1A1, capable of functioning at speeds up to 200 kc. In applications involving in-



dustrial counting, interval timing, and repeat cycling, all will find this new scaler useful because of its plug-in-design and high-speed operation. A 12AT7 tube plugs into the top of the binary scaler, completing the unit. A resolution time of 5 microseconds and output impedance of 27 kilohms are the characteristics of the unit, which fits the standard octal socket. The Specialty Products Div. of the makers will supply full data to interested users.

(Continued on page 57A)

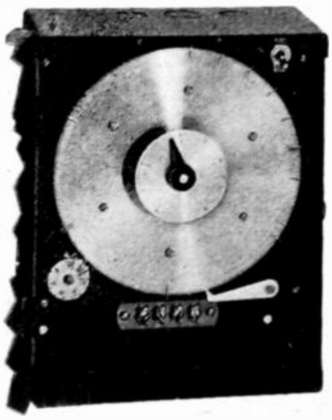
News—New Products

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

(Continued from page 56A)

Timer for Audio Program Control

Montgomery Mfg. Co., 549 W. Washington St., Chicago, Ill., have a timer that is applicable to the control of audio installations and wired-music program installations, because of the accuracy with which it can be set.



Units of 2½ minutes or more can be controlled from the timing mechanism, which is small in size, considering the flexibility with which it has been designed. From a single operation to a full week's program can be handled, which will be repeated until the clock is reset for a new program cycle.

Recent Catalogs

Test Equipment Sales Co., Inc., 216 N. 12th St., Philadelphia, Pa. have offered their bulletin 2610 on the test equipment products of a group of prominent manufacturers. Carefully grouped as to the makers, detailed descriptions enable engineers and purchasing agents to easily select their needs for oscillographic equipment, af and rf signal generators and from a wide selection of meters, both of conventional design, and of the high-sensitivity vacuum-tube-voltmeter variety. Comprehensive combination of data makes this bulletin a valuable file piece.

George J. Maki, Moraga, Calif., has published technical data on his new model RC-55 Frequency Shift Radioteletype Converter. This unit couples to the radio receiver, and through patented circuit configurations converts the narrow shift of frequency used for print or space signals in teletype printers to direct-current operating potentials. Use of pentode discriminator tubes, the incorporation of medium Q circuits, and special biasing arrangements make for stable operation of the decoder. Controls are held to a minimum, but include a milliammeter and electron-ray tube, to give visual indication of the proper functioning of the apparatus in use.

(Continued on page 58A)

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 57A)

Precision Radiation Instruments, Inc. 1101 N. Paulina Ave., Chicago 22, Ill., has mailed a new catalog descriptive of their portable Geiger-Mueller survey meter finding application in all instances where danger to personnel exists in the field of radiation from isotopes or X-ray radiation. A copy is free, for the asking.

Hammarlund Mfg. Co., 460 W. 34 St., New York 1, N. Y., will add the name of all those who request it to their mailing of a forthcoming new capacitor and component catalog, which is about due to leave the hands of the printer. Detailed drawings of the physical size of all components is included as a help to design and drafting engineers, so that they will be able to determine the physical applications of the new and smaller components which will be available from Hammarlund in the near future.

E. F. Johnson Co., Waseca, Minn., has a new catalog ready for the amateur describing their new series of plug-in swinging-link rf transmitting inductors. It is of interest, too, to the designer of low-powered commercial transmitting installations and laboratory equipment.

(Continued on page 59A)

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 58A)

Recent Catalogs

Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena, Calif., have a detailed catalog of their analytical instruments for scientific research and industrial tests. Comprising isotope radiation detectors, electrical computers, and vibration and spectrographic devices, the field covered is wide. A copy will be mailed to interested users who address the company on their corporate stationery.

Enjay Co., Inc., 15 W. 51 St., New York 20, N. Y., has a booklet describing Vistanex (polyisobutylene) as to its processing and compounding. Of interest to the design engineer and those working the plastics, it describes chemical, mechanical, and application details of this new synthetic compound. A copy will be sent to the interested engineer, by addressing the company, which is a division of the Standard Oil Company of New Jersey.

The Aluminum Association of America, 420 Lexington Ave., New York 17, N. Y., has a "Materials & Methods Manual, #35" describing all manner of aluminum alloy castings, considering problems of design, choice of cast, and chemical considerations. This can be had upon request to the association.

Ettco Tool Co., 594 Johnson Ave., Brooklyn 6, N. Y., have a bulletin describing their automatic tapping and threading attachments that fit a drill press and serve to thread and tap small parts. These units are automatic and rapid in operating, working on the sensitive clutch principle, and are easily used by inexperienced operatives. Production engineering staffs will find this story of interest in large-scale factory production operations.

Reliable Electric Co., 3145 Carroll Ave., Chicago 12, Ill., have compiled an extensive looseleaf catalog on their wiring and cable splicing devices, telephone-line protection equipment, and cable frame termination racks. While not many radio items are included, the engineer working with high-tension equipment, will be interested in the devices enabling cable branching to take place in plant wiring systems, and interbuilding power distribution networks. Separate bulletins or the complete catalog, will be supplied to those interested upon written request, addressed to the attention of E. Freimuth of Reliable Electric.

Fish-Schurman Corp., 230 E. 45 St., New York 17, N. Y., have a bulletin on their F-S Multi-Layer interference films which are useful to the optical engineer pioneering in tricolor television work. This bulletin describes two types of these films, which can either split the beam or transmit it in toto. A copy will be sent gladly upon request.

Hazeltine Electronics Corp., 58 25 Littleneck Parkway, Little Neck, L. I., N. Y. announce Bulletin 14, descriptive of television test equipment of their design

(Continued on page 60A)

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 59A)

Recent Catalogs

and manufacture. Interested engineers will find this bulletin to contain specific data on 10 more-detailed engineering data reports on the equipment under consideration, copies of which will be sent upon written request to the company. The line is so complete that it affords a complete laboratory installation for production and service testing of video equipment. Centralized generating apparatus, with remote-test-position equipment for several simultaneous test and alignment operations, are the features incorporated in this line of precision devices.

Radio Corporation of America, Harrison, N. J., have issued data bulletins on their two latest additions to the klystron line of uhf tubes. the 2K26 and 2K56. They are single-resonator reflex-type tubes, used mainly as local oscillators in microwave receiving equipment, as frequency-modulated sources in low-powered transmitters, or as pulsed oscillators for response-testing equipment. They are identical in appearance and in power output, (100 milliwatts) but differ in the portion of the spectrum in which they operate.

Amperex Electronic Corp., 25 Washington St., Brooklyn 1, New York, announce a comprehensive 296-page catalogue of their complete line of electronic tubes, The communication, industrial electromedical, and amateur fields are all served by the products of Amperex, described in this bulletin. Each section has a descriptive introduction, preceding the detailed listing of the individual characteristics of all tubes and vacuum capacitors made by this firm. So complete is its form of presentation that it forms a

(Continued on page 61A)

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 60A)

designing reference work. The Amperex organization will provide a copy to those who apply in writing, stating their business connection on their letterhead.

Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill., has just published their 1949 catalogue of radio and electronic components and completed communication units. In 180 pages they have listed the products of the country's leading manufacturers in a compact form, for ready reference by the buyer, design engineer, sound installation man, or amateur. Copies may be had free, for the asking.

National Carbon Co., 30 E. 42 St., New York, N. Y. has announced a new Eveready 1005-E primary battery for hearing-aid use. The possibilities of this new air-cell have not yet been fully explored, in the radio and electronic field, aside from the hearing-aid application. The cell operates on a principle different from the usual "A" battery (Leclanche type), and features a stable output voltage over 90% of its useful service life, contrasted to the usual flashlight cell. They have published descriptive material and performance graphs, pictorially showing the results, when submitted to standardized ASA testing procedures. Copies of this report are available to test engineers, upon request, who will find this cell applicable to many miniature instruments in the industry.

Weller Manufacturing Co., Easton, Pa., have just released a comprehensive catalogue bulletin on their line of instant-heating soldering guns. Industry acceptance of these versatile units has caused many new models to be added to the line, to meet the demand from the industry. Copies of the bulletin can be had for the asking.

High-Voltage Cathode-Ray Oscillograph

The type 248-A oscillograph can now be operated at accelerating potentials up to 14,000 volts without modification, according to its manufacturer **Allen B. Du-Mont Labs., Inc.,** 1000 Main Ave., Clifton, N. J.

Merely by the addition of a suitable external power supply, such as the Du-Mont type 263-B, the accelerating potential applied to the 248-A may be increased from 2,000 or 4,000 volts, applied internally, to 14,000 volts.

This increase is accomplished by the incorporation of the type 5RP-A high-voltage cathode-ray tube.

Deflection sensitivity changes result from the higher accelerating potential. The new deflection factor at 14,000 volts, using type 263-B power supply is 0.15 rms volt per inch.

Photographic writing rates of the order of 69 inches per microsecond can now be recorded when using the increased accelerating potential.

(Continued on page 62A)

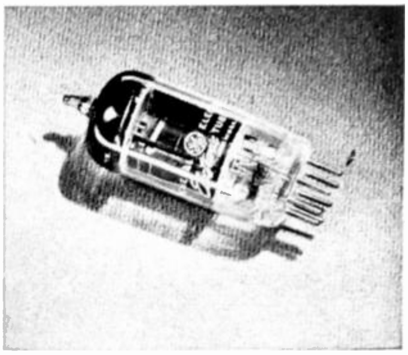
News—New Products

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

(Continued from page 61A)

Miniature Tube for Industrial Applications

A new 7-pin miniature electronic tube, type GL-5610, to be used for industrial purposes where small size is a factor, has been announced by the **Tube Division, General Electric Co.,** Electronics Park, Syracuse, N. Y.



This tube may be used to operate a relay in a circuit for heating control or many other industrial operations.

Under maximum ratings the plate voltage is 300 volts, with a plate dissipation of 3.0 watts.

Its typical operation characteristics include the following: heater voltage, 6.3 volts; plate current, 17 ma; plate resistance, 3500 ohms.

The physical dimensions of the GL-5610 are: diameter, ¾"; over-all length, 2⅛"; seated height, 1⅞".

Precious-Metals Weight Calculator

A new firm, **Secon Metals Corp.,** 228 E. 45 St., New York 17, N. Y., engaging in the sale and processing of platinum and other nonferrous metals manufactured in the forms of sheet, wire, and foil for industrial application, as well as custom forms for particular needs, is now offering a precious-metals weight calculator.

This calculator rapidly computes the weight of platinum, palladium, gold, and silver in the forms of sheet, wire, tubing, and circles. Answers are computed in Troy ounces. It will also determine the weight per foot and number of feet per Troy ounce of wire.

This is accomplished by a calculator which operates on the slide-rule principle. One or two settings and the problem is solved.

INDEX AND DISPLAY ADVERTISERS

DISPLAY ADVERTISERS


New RCA 16-inch direct-view television tube fills gap between popular 10-inch tubes and the projection-type receivers.