Proceedings of the I·R·E

A Journal of Communications and Electronic Engineering

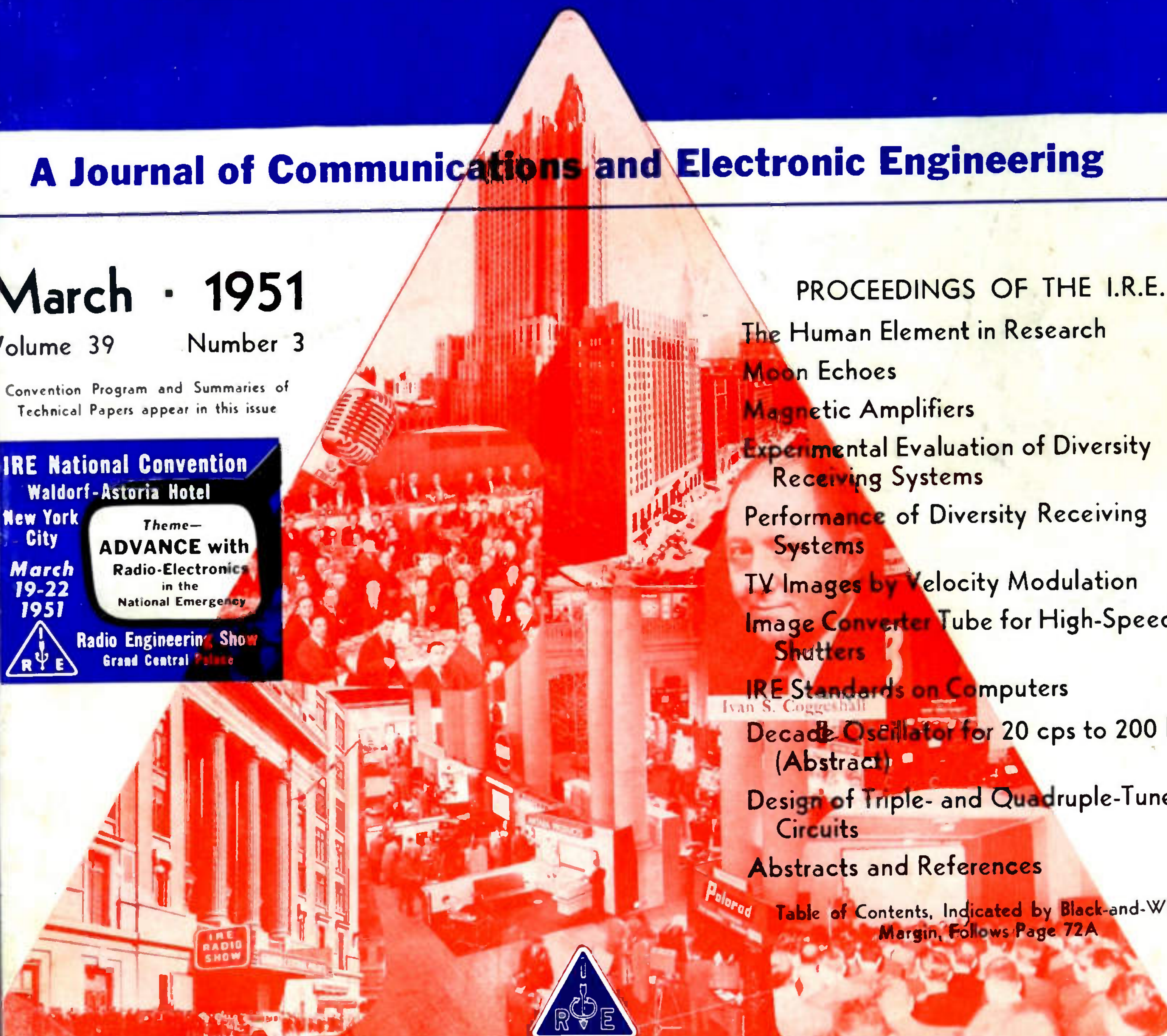
March · 1951
Volume 39 Number 3

Convention Program and Summaries of Technical Papers appear in this issue

IRE National Convention
Waldorf-Astoria Hotel
New York City
March 19-22 1951

Theme—
ADVANCE with Radio-Electronics in the National Emergency

Radio Engineering Show
Grand Central Palace



PROCEEDINGS OF THE I.R.E.

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The IRE Standards on Electronic Computers: Definitions of Terms, 1950, appear in this issue

The Institute of Radio Engineers

What to SEE at

The Radio Engineering Show

March 19-22, 1951 at Grand Central Palace, New York

267 Exhibits of Radio-Electronic Equipment

Firm — **Booth**

Ace Engineering & Machine Co., Inc., Philadelphia, Pa. — 350, 352
The series 40 Ace Cell Type Screen Room, 10' x 8' x 10'. Panel construction permits moving or enlarging.

Advance Electric & Relay Corp., Burbank, Calif. — 221
Represented by Wally Swank.

Aerovox Corp., New Bedford, Mass. — 62
Electrolytic, mica, paper and metallized paper capacitors.

Aircraft Marine Products, Inc., Harrisburg, Pa. — 273
Solderless terminals and connectors, tools, amplifilm, dielectric material, capitrons, and radar pulse networks.

Airtron, Inc., Linden, N.J. — 356
All types electronic components. Flexible and rigid waveguides, microwave test equipment, slotted-sections, dummy loads, waveguide switches and shielded wired assemblies for ignition, thermocouple and electrical control circuits.

Alden Products Co., Brockton, Mass. — N-3
Components for plug-in Unit Construction. Introducing new Alden Basic Chasis design. Non-interchangeable Bases and Sockets. Static Magnetic Memory, new component for digital computor techniques. Injection molded engineering specialties.

Alfax Paper & Engineering Co., Brockton, Mass. — 374
High speed, direct, inertialess recording. Operational recorders for monitoring—multi-trace and multi-channel instrument recorders. Pulse recording. High speed facsimile recording.

Allegheny Ludlum Steel Corp., Brackenridge, Pa. — 25, 26

Allied Control Co., Inc., New York, N.Y. — 279
Relays—Electrical.

Alpha Metals, Inc., Brooklyn, N.Y. — 326
Cem-Tri-Core "energized" rosin filled solder.

Altec Lansing Corp., New York, N.Y. — 309, 311
Audio equipment, microphones, amplifiers, loudspeakers, audio and power transformers, includes dynamic cardioid, capacitor microphones, high quality amplifiers ranging from 15 to 75 watts power, industrial and sound system amplifiers from 15 watts to 250 watts, loudspeakers from 8" cone to 15" duplex and theatre speakers, transformers from radio replacement to large high-quality types, transformers to JAN or MIL specifications.

American Lava Corp., Chattanooga, Tenn. — 64
Ceramic insulators for radio, television, radar, electronic components, wire communications, control equipment and household appliances.

American Phenolic Corp., Chicago, Ill. — 111, 112
Coaxial cables polyethylene and teflon, 300 ohm twin-lead, RF connectors, AN connectors and fittings, Industrial connectors, AN conduit and fittings, Communication FM and TV antennas, Radio Components and hardware, TV antenna rotator, plastics for electronics.

American Smelting & Refining Co., Whiting, Ind. — 334
See Federated Metals Division.

Firm — **Booth**

American Structural Products Co., Sub. of Owens-Illinois Glass Co., Toledo, Ohio — 89, 90
Display shows properties of glass and a series of "live" exhibits. Products shown are cathode ray tube bulbs, hardened insulators, glass blocks, tubing, rod and miscellaneous electronic glass parts.

American Television & Radio Co., St. Paul, Minn. — 202
ATR DC-AC inverters, battery eliminators, auto radio vibrators, heavy duty vibrators, vibrator power supplies, rectifier power supplies.

Amperex Electronic Corp., Brooklyn, N.Y. — 10, 11, 12
High power transmitting tubes of all types for communication, industrial and special purposes; x-ray tubes; fixed capacitors, G-M counters, magnetrons; miniature ultra high frequency tubes and subminiature types.

Anchor Metal Co., New York, N.Y. — N-21
Shurflo rosin core solder, a new development in cored solders that is particularly adapted to all solder connections where corrosion is an important factor. Also bar solder, solid wire solder, solder preforms, lead and tin products.

Andrew Corp., Chicago, Ill. — N-9
Transmission Lines, Antenna Equipment, VHF and UHF antennas, FM & TV transmitting antennas, phasing & coupling equipment, HF antennas & distribution equipment, tower lighting equipment.

Anton Electronic Laboratories, Inc., Brooklyn, N.Y. — 380
Full line of newly developed precision radiation counters, using entirely new engineering and manufacturing principles. Corona discharge voltage regulator tubes on engineering display. Radically new portable radiation survey meter.

Arnold Engineering Co., Marengo, Ill. — 25, 26
Permanent magnet materials: cast magnets, alnico I, II, III, IV, V, VI, XII, X-900 sintered magnets: alnico II, IV, V, VI, X-900, Remalloy Vicalloy, Remalloy (Comol), Cunico, Cunife, Cast Cobalt Magnet steel. High Permeability materials: Deltamax Toroidal cores, Supermalloy toroidal cores, powdered molybdenum Permalloy toroidal cores, Permendur.

AS EXHIBITED AT THE Radio Engineering Show, Grand Central Palace, New York City — Our 1951 Advance — March 19-22 1951

Six Million Dollars Worth of Components, Tools and Materials

Firm — **Booth**

Atomic Instrument Co., Cambridge, Mass. — 377
Nuclear measurement apparatus.

Audio Devices, Inc., New York, N.Y. — 316
Display of recording discs, recording and play back points and magnetic recording tape and film. Audiodiscs, Audiopoints, Audiotape and Audiofilm. Industrial film will be shown on the manufacture of Audiotape.

Automatic Electric Sales Corp., Chicago, Ill. — 290
Miniature telephone type relays and stepping switches for guided missiles, aircraft, etc.

Avion Instrument Corp., New York, N.Y. — 333
Avitron subminiature electronic assemblies, magnetorque magnetic particle clutches and brakes, guided missile components, gyros, servomechanisms, analog computers and high speed digital computers.

Ballantine Laboratories, Inc., Boonton, N.J. — 100
Sensitive electronic voltmeters. Decade amplifiers, voltage multipliers, shunt resistors.

Barker & Williamson, Inc., Upper Darby, Pa. — N-2
Coils, capacitors and components and test equipment.

Barry Corp., Watertown, Mass. — 284, 285
Shock mountings, vibration isolators, aircraft mounting bases.

Bendix Radio Division of Bendix Aviation Corp., Towson, Md. — 14 to 17
G.C.A. talkdown trainer which permits training of pilots and ground operators in techniques employed in talking down aircraft to safe landings when radar is used. Also used for evaluation of electronic flying aids.

Berkeley Scientific Corp., Richmond, Calif. — 378
Electronic instrumentation for industry and research. Events-Per-Unit-Time Meter, Timer Interval Meter, electronic counters presettable to any desired number, nuclear scalers, count rate meters, counting rate computers, double pulse generators.

Berlant Associates, Los Angeles, Calif. — 314
Recording equipment, Concertone magnetic tape recorder.

Bird Electronic Corp., Cleveland, Ohio — 244
Termaline RF wattmeters, coaxial switches, aircraft antennas, antenna filters, Termaline dummy loads.

Bliley Electric Co., Erie, Pa. — 251
Quartz crystals, crystal ovens, frequency standards.

Boesch Manufacturing Co., Inc., Danbury, Conn. — 306
Coil winding machinery for the winding of toroidal coils, paper interleaf transformer coils, bobbins and windows.

Boonton Radio Corp., Boonton, N.J. — 276, 277
Types 160-A and 170-A Q-Meters, 202-B FM Signal Generator, 202-C Mobile Signal Generator, 202-D Telemetering Signal Generator, 206-A Mobile Signal Generator, 207-A Univerter, 211-A Omni-Range Signal Generator, 212-A Glide Slope Test Set, 110-A and 110-B QX-Checkers.

(Continued on page 20A)

Proceedings of the I.R.E. March, 1951, Vol. 39, No. 3. Published monthly by The Institute of Radio Engineers, Inc., at 1 East 79 Street, New York 21, N.Y. Price per copy: members of the Institute of Radio Engineers $1.00; non-members $2.25. Yearly subscription price: to members $9.00; to non-members in United States, Canada and U.S. Possessions $18.00; to non-members in foreign countries $19.00. Entered as second class matter, October, 26, 1927, at the post office at Menasha, Wisconsin, under the act of March 3, 1879. Acceptance for mailing at a special rate of postage is provided for in the act of February 28, 1925, embodied in Paragraph 4, Section 412, P. L. and R., authorized October 26, 1927.

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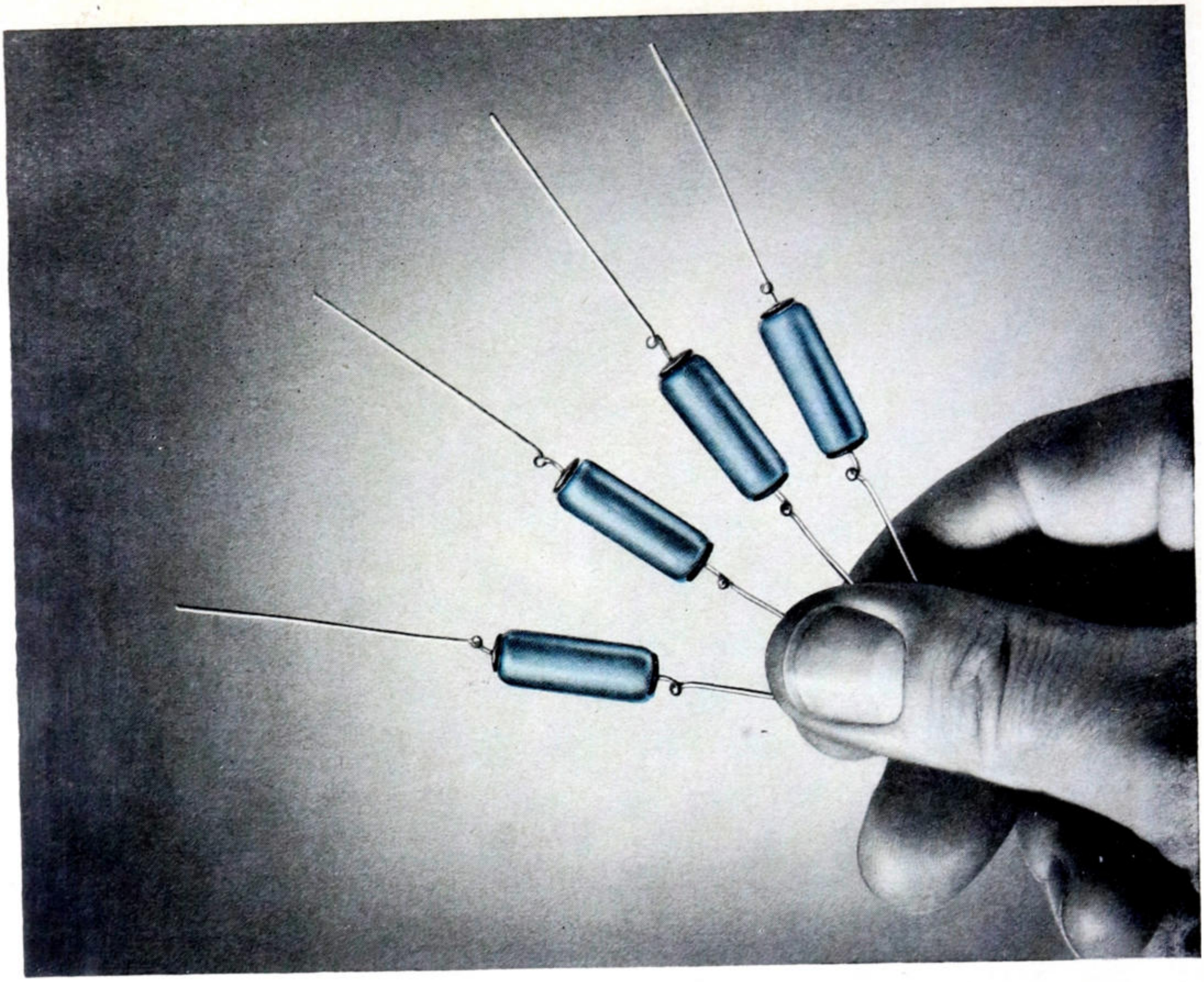


These are Tantalytic Capacitors

Here is one of the fastest moving developments in electronics in recent years—General Electric's amazing new electrolytic-type capacitors. These Tantalytic capacitors have small size, excellent low-temperature characteristics, long operating life and in many cases, can replace bulky hermetically-sealed paper capacitors. Ratings presently available for consideration range from .02 mu f up to 12 mu f at 150 v dc. Units pictured are 1.0 mu f at 150 volts, a size that is already on order in quantities of several hundred thousand.

Other features of G-E Tantalytic Capacitors include:

- No known limit to shelf life.
- An operating temperature range from −55°C to +85°C.
- Exceedingly low leakage currents.
- Ability to withstand severe physical shock.
- Completely sealed against contamination.

If you have large-volume applications where a price of 3 to 5 times that of hermetically-sealed paper capacitors is secondary to a combination of small size and superior performance—get in touch with us. Your letter, addressed to Capacitor Sales Division, Bldg. 42, Room 304, General Electric Company, Pittsfield, Mass. will receive prompt attention.

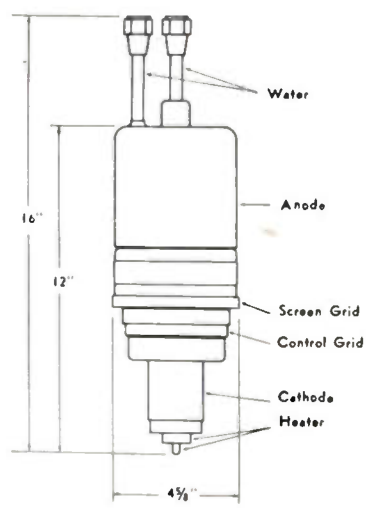
Apparatus Department, General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

407-300

TYPE 4W20000A POWER TETRODE
CLASS-B LINEAR AMPLIFIER—TELEVISION SERVICE
TYPICAL OPERATION (Per tube, 5-Mc. Bandwidth, 216 Mc.)

Peak Synchronizing Level Load Impedance	400 Ohms
Effective Length of Plate Line	Quarter Wave
D-C Plate Voltage	5500 Volts
D-C Plate Current	7.1 Amps
D-C Screen Voltage	1000 Volts
D-C Screen Current	600 Ma.
DC- Grid Voltage	—310 Volts
Peak R-F Grid Input Voltage (approx.)	485 Volts
Plate Power Input	39.1 Kw.
Plate Dissipation	19.0 Kw.
Plate Power Output	20.1 Kw.



For the practical approach to high-power TV through channel 13, here is the tube . . . the new Eimac 4W20000A power tetrode.

Among the features of the 4W20000A are a unipotential cathode of thoriated tungsten heated by electron bombardment, a water-cooled anode rated at 20 kw dissipation, and coaxially arranged terminals.

This new tube's potential applications are not limited to TV service. Data on typical operation in class-C telegraphy or FM telephony as well as class-B linear TV amplifier service are included in a comprehensive data sheet . . . available for the asking.

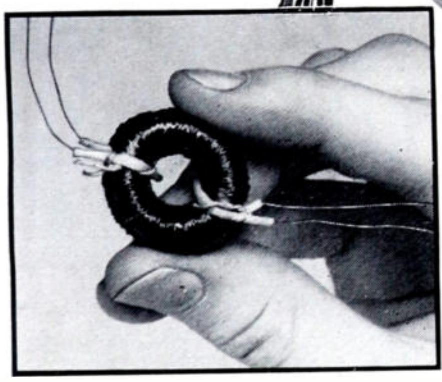
Eitel-McCullough, Inc.
San Bruno, California
Export Agents: Frazar & Hansen, 301 Clay St., San Francisco, California

Follow the Leaders to Eimac TUBES

279

SEE THE 4W20000A at the March IRE Show, Booth 36

IT'S "LOADED" WITH BETTER TELEPHONE SERVICE



Twenty of the Bell System's newest small loading coils—like the one at the left—are housed in the long black case, mounted in a cable splice. This type of installation permits the economical extension of city cables to serve out-of-town subscribers.

MANY more wires can be crowded into a cable sheath when the wires are fine. But normally, wires don't transmit as well when they are fine and closely packed.

Bell engineers long ago learned to make wires do better work by loading them with inductance coils at regular intervals. The coils improve transmission and let messages travel farther. But originally the coils themselves were large, heavy and expensive. The cases to hold them were cumbersome and costly too.

So year after year Bell scientists squeezed the size out of coils. To make magnetic cores of high permeability they developed Permalloy. Tough but extra-thin insulation permitted more turns to a core.

New winding machines were developed by the Western Electric Company. Coil size shrunk to one-fiftieth. Some—like the one shown above—can be mounted right in cables themselves.

The 15,000,000 coils in the Bell System today mean thinner wires, more wires in a cable—more economical service for you. They demonstrate once more how Bell Telephone Laboratories work continually to add to your telephone's value.

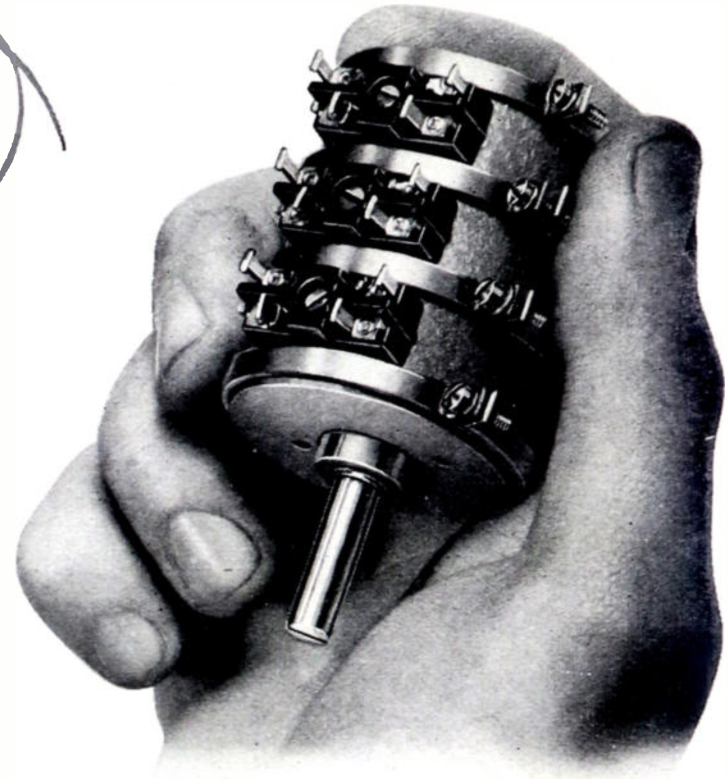
BELL TELEPHONE LABORATORIES

WORKING CONTINUALLY TO KEEP YOUR TELEPHONE SERVICE BIG IN VALUE AND LOW IN COST

Here's Fairchild's Newest Potentiometer!

TYPE-746 PRECISION POTENTIOMETER OFFERS:

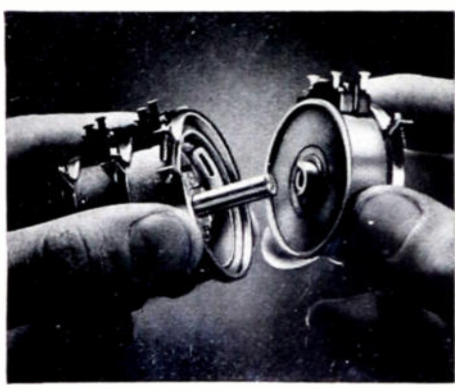
- **Low Torque**
- **Accurate Phasing**
- **Quick Replacement**
- **Ganging up to 20 on a shaft**

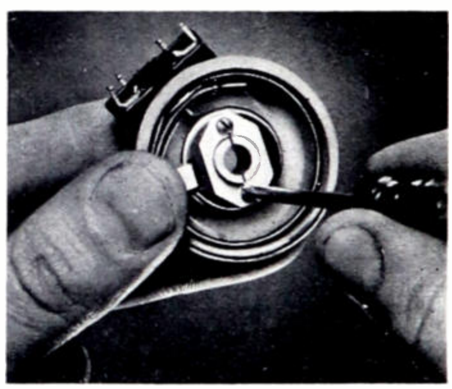


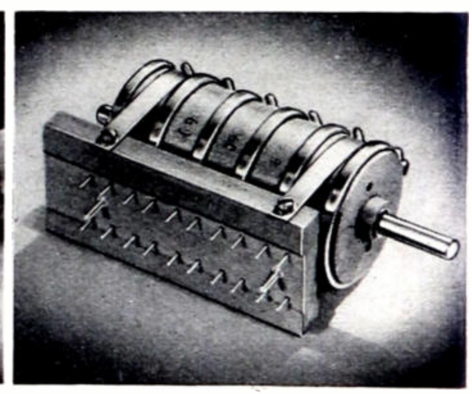
The finest we've ever built! That's our idea of the new "746". It's got lower torque, a new more accurate phasing adjustment, and a new method of ganging that makes it easy to put as many as twenty cups on a single shaft. Individual cups in a gang are easily replaced if necessary.

The new potentiometer is available with linear or non-linear windings to meet your specifications. Its attractive case is made of grey anodized aluminum.

The "746" is just one of the complete Fairchild family of precision potentiometers. What are your requirements? Write, giving details, to *Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Boulevard, Jamaica 1, N.Y.* Dept. 140-13H.







EASY REPLACEMENT

To replace a unit in a "746" gang, loosen connecting-band screws, remove "cup," slip new "cup" under bands, and tighten screws. This feature pays off in experimental work where circuit elements are changed periodically.

ACCURATE PHASING

A new type phasing adjustment is simpler and more accurate. A retainer plate clamps shaft to wiper arm. To adjust for phasing, loosen two screws, set the arm to the correct position, then tighten screws.

FLEXIBLE DESIGN

Typical of the special consideration Fairchild gives to its customers' special requirements is this plug-in version of the "746." Where fast servicing is a must, the advantages of this "quick-change" unit are quite apparent.

SPECIFICATIONS

Accuracy (overall resistance)—±.5% (linear), ±1.0% or better (non-linear)

Mechanical accuracy—
- concentricity (shaft to pilot)—.0015 in. FIR max.;
- radial play—.0009 in. FIR max.;
- shaft—centerless ground stainless steel to .2500 diam. (+.0000, −.0005 in.);
- pilot hub—machined to .5000 (+.0000, −.0005 in.)

Torque—1.5 oz-in.

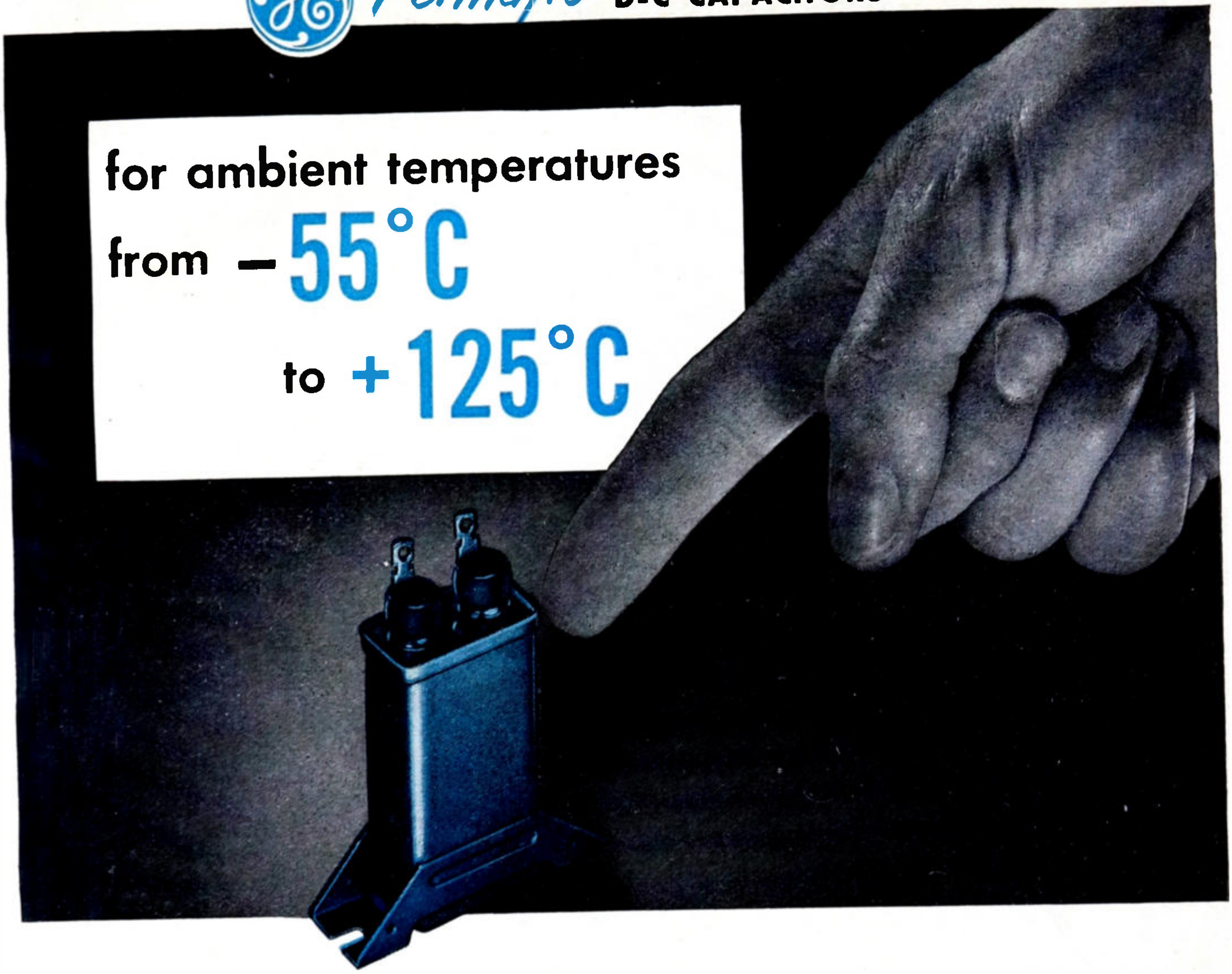
Dimensions—diameter 1.750 max.; length (1 cup) .800 in. ±.009 in.; added length per unit ganged .580 in. ±.002 in.

Case—grey anodized aluminum

FAIRCHILD
PRECISION POTENTIOMETERS

SEE THE TYPE 746 AND OTHER FAIRCHILD PRECISION POTENTIOMETERS AT THE RADIO ENGINEERING SHOW, BOOTH 238-239

Permafil D-C CAPACITORS



General Electric Permafil capacitors are designed for use at extremes in temperature—in high ambients—or in high altitudes where extreme cold is encountered. They are suitable for all blocking, by-pass and filtering applications.

These capacitors, while using paper dielectric, are treated with a plastic compound that retains its electrical stability at both high and low operating temperatures. Units are available in case styles CP-53, 61, 63, 65 and 70, as covered by specifications JAN-C-25—in ratings of .05 to 2.0 muf, 400 volts DC. Containers are metallic and are sealed with G-E long-life all-silicone bushings.

For full information on Permafil capacitors see your local G-E representative. Or write *Apparatus Department, General Electric Company, Schenectady 5, New York.*

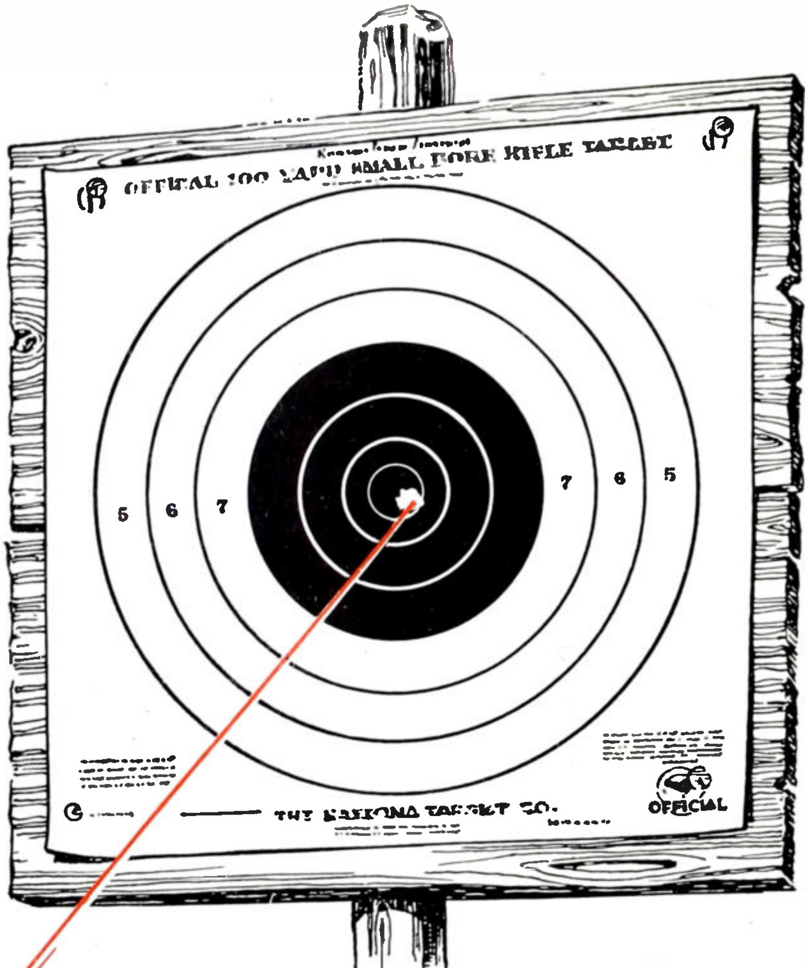
Where space or weight are especially important

Permafil capacitors will average about 1/10 the size and weight of liquid-filled capacitors when designed to operate at 125° C.

Where short-life characteristics are permissible additional savings in size and weight are possible. If you have a short-life capacitor application in mind, G-E engineers would like to discuss it with you.

GENERAL ELECTRIC

407-302



BULLS-EYE!

You hit the bulls-eye when you call upon Sprague application engineers to help you with critical capacitor problems.

Skilled in applying the essentials of capacitor design to save space and cost in complex military and civilian electronic equipment, Sprague engineers are ready to serve you.

If standard capacitors can solve your problem, they have the industry's most complete line from which to recommend. If you need a special electrical or mechanical design to best solve your circuit or production problems, they will gladly work out the details without cost or obligation.

Time is of the essence today. If you have a capacitor, interference filter, or pulse network problem, contact SPRAGUE by 'phone, wire, or mail without delay.

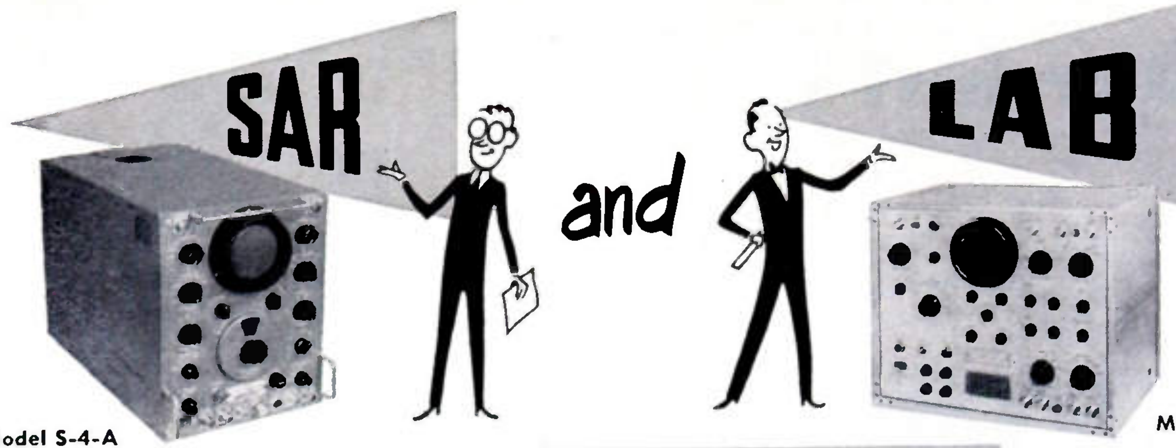
SPRAGUE®

PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT

SPRAGUE ELECTRIC COMPANY

NORTH ADAMS, MASSACHUSETTS

See Us at Booths 27-28 I.R.E. Show



Model S-4-A

Model S-5-A

WATERMAN PIONEERING

WATERMAN INTRODUCES

TWO NEW CATHODE RAY OSCILLOSCOPES

Compact, Portable Instruments For Precision Pulse Measurement Adaptable To All Electronic Work, Including TV . . .

The PULSESCOPE

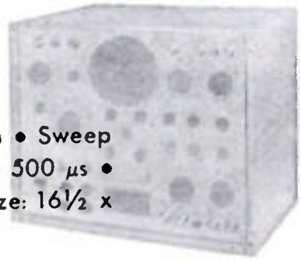
TO PORTRAY THE ATTRIBUTES OF THE PULSE:
SHAPE, AMPLITUDE, DURATION AND TIME DISPLACEMENT

Video Amplifier up to 11 MC • Video Delay 0.55 μs
Pulse Rise and Fall Time Better Than 0.07 μs

S-4-A SAR PULSESCOPE

Video Sensitivity 0.5 v p to p/in. • S Sweep 80 cycles to800kc, either trigger or repetitive • A Sweep 1.2 μs to 12,000 μs • R Delay 3 μs to 10,000 μs, directly calibrated on precision dial • R Pedestal or Sweep 2.4 μs to 24 μs • Internal Crystal Markers 10 μs and 50 μs • Size: 9⅞ x 11¼ x 10¼ • Weight: Less than 32 pounds.

S-5-A LAB PULSESCOPE



Video Sensitivity 0.1 v p to p/in. • Sweep 1.2 μs to 120,000 μs with 10 to 1 expansion • Sweep either trigger or repetitive • Internal Markers synchronized with sweep from 0.2 μs to 500 μs • Trigger Generator and built-in precision amplitude calibrator • Completely cased • Size: 16½ x 14⅛ x 17½ • Weight: Less than 60 pounds.

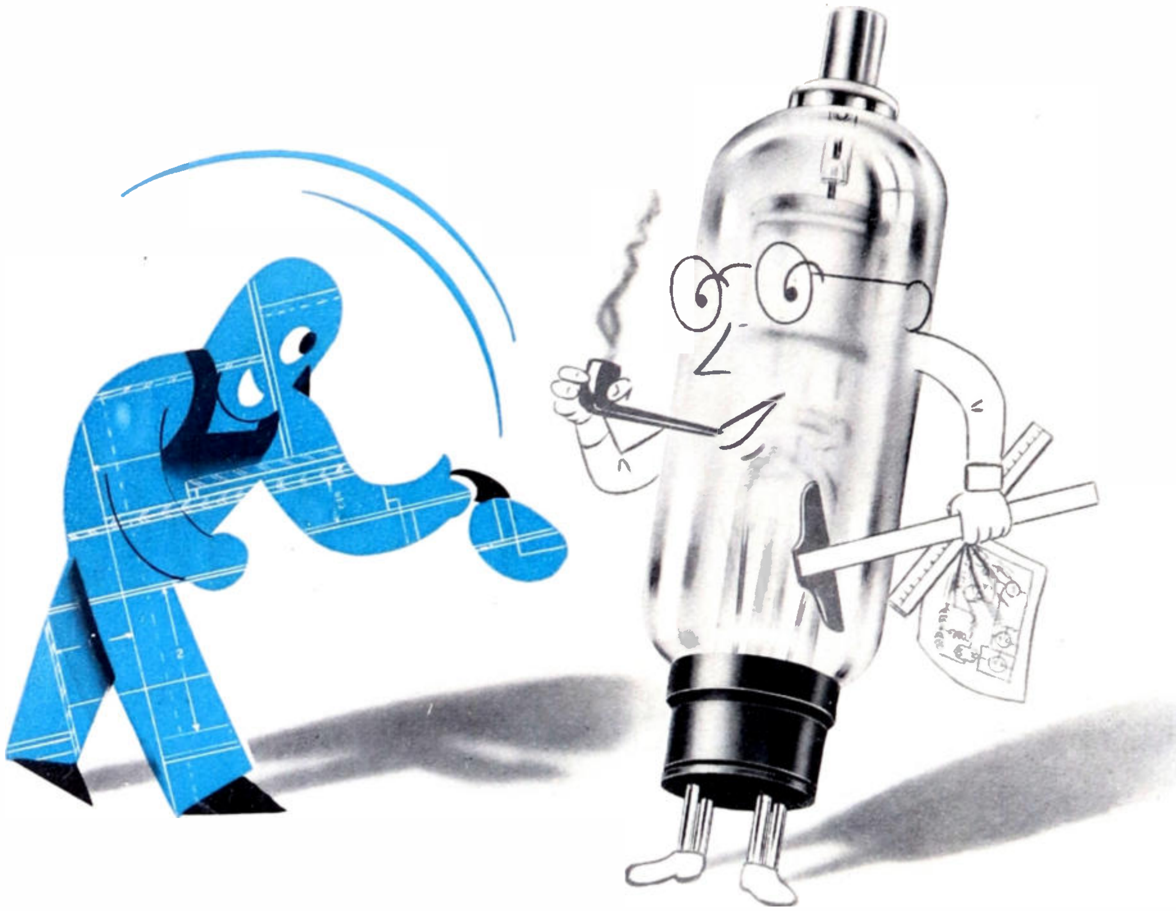
See these two NEW PULSESCOPES ...at the

Radio Engineering Show
Grand Central Palace
New York City
BOOTH 29
March 19-22 1951

CABLE ADDRESS:
POKETSCOPE, PHILA.

WATERMAN PRODUCTS

Our hat is off



to the I. R. E. engineers

Engineering is a conservative and modest profession, and rare is the occasion on which electronic engineers are publicly acclaimed. Yet these men are making priceless contributions to industrial progress and national defense.

Since we serve a large number of the country's radio-electronic equipment manufacturers, we have come to know and respect their engineering personnel.

It is, in a large measure, to these men that we are indebted for helping us maintain our reputation as perfectionists in sheet metal fabrication. Their exacting demands and advanced designs keep us ever alert to match their high standards in our own performance.

Gentlemen, we doff our hat in well deserved tribute. Let us shake your hands at Booths 49-50 at the I. R. E. Show.

KARP METAL PRODUCTS CO., INC.

223 63rd STREET, BROOKLYN 20, NEW YORK

Specialists in Fabricating Sheet Metal for Industry

Announcing

WAVEGUIDE TEST EQUIPMENT

2,600 to 18,000 mc!

The revolutionary new *-hp-* waveguide test equipment shown on the following pages represents the practical, economical adaptation of a new, fresh concept of waveguide instrumentation. Emphasis throughout is on functional simplicity and low cost; instruments are offered as individual basic components. Most equipment is based on entirely new designs developed either in the *-hp-* laboratories or by Varian Associates, microwave equipment and electron tube specialists.

Full frequency coverage from 2,600 mc to 18,000 mc is offered in 6 waveguide sizes: 3″ x 1½″, 2″x 1″, 1½″x ¾″, 1¼″x ⅝″, 1″x ½″, .702″x .391″. Instrumentation is now available in most of these sizes. Complete instrumentation for these frequencies will be provided during the forthcoming year.

HEWLETT-PACKARD COMPANY

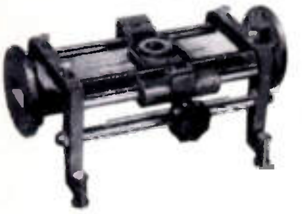
2178D PAGE MILL ROAD · PALO ALTO, CALIFORNIA, U.S.A.

Sales Representatives in all principal areas.

Export: Frazar & Hansen, Ltd., San Francisco, Los Angeles, New York City

Broad-Band Waveguide Test Equipment!

-hp- 809/810 Slotted Sections



Slotted sections are one of the most important measuring instruments in waveguide engineering. They are essential to the measurement of impedance, reflection and other transmission characteristics.

A single precision carriage (-hp- 809B) mounts either slotted waveguide sections or coaxial sections covering the frequency range from 4.0 to 12.4 kmc. This results in maximum flexibility and minimum cost for complete frequency coverage. The carriage travels on a new 3-point, ball-bearing suspension system; and waveguide or coaxial slotted sections may be quickly interchanged. Carriage operates in conjunction with -hp- 442A Broad-Band Probe and -hp- 440A Coaxial Detector. -hp- 810B Waveguide Slotted Sections are available in sizes: 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½". -hp- 806A Coaxial Slotted Section is available for frequency range 3.0 kmc to 12.0 kmc. -hp- S810A Waveguide Slotted Section, of conventional design, is available in size 3" x 1½" to cover the frequency range 2.6 to 3.9 kmc.

-hp- 280A, 281A Adaptors, Waveguide to Coaxial

For transition between waveguide and coaxial systems. Each adaptor covers the full waveguide range with a VSWR not exceeding 1.5. -hp- 280A with flexible cable, 3" x 1½" only. -hp- 281A, with Type N Jacks, sizes 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½".

-hp- 370 Attenuators, Fixed

Fixed attenuation characteristics of 6, 10 or 20 db. For reducing power level, isolating system units and reducing reflection. Max. VSWR 1.15. Sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

-hp- 375A Attenuators, Variable Flap

For introducing variable power differences in a waveguide, or isolating power sources and loads. Consists of slotted waveguide section in which matched plate is moved. Max. VSWR 1.15. Sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

-hp- 380A Attenuators, Calibrated Variable

For use between 2,600 and 3,950 mc to create known attenuations or isolate sources and loads. Each instrument accurately calibrated at 3,000 mc. Max. VSWR 1.15. Sizes: 3" x 1½". (Other sizes to be announced.)

-hp- 485A Detector Mounts

For measurement of power between frequencies 2.6 to 18.0 kmc in conjunction with -hp- 430A Power Meter and Sperry 821 barretter. Also may be employed to measure relative level, or detect rf energy using a Type 1N21 crystal. Each mount is semi-tuned by means of a movable short. Additional tuning may be provided if desired by means of -hp- 870A Slide Screw Tuner or -hp- 880A E-H Tuner. Sizes: 3" x 1½" (for use with barretter only), 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x 1½", .702" x .391".

-hp- 840A, 841A Waveguide Tees

Rectangular series or shunt tees for coupling waveguide systems, as when dividing power or introducing impedances. Model 840A Series Tees branch from wide face of waveguide. Model 841A Shunt Tees branch from narrow face. Sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

Providing a new standard of broad-band operation plus traditional -hp- speed, accuracy, convenience and economy, for all types of precision microwave measurements.

BOOTHS 40, 41

See this new equipment at the I.R.E. Show or write your -hp- sales representative or factory for details.

-hp- 845A Hybrid Tees

Four-arm, rectangular hybrid tee. Composed of series and shunt tee constructed at same point in waveguide. Possess many properties of bridge circuit. Used for rapid determination of VSWR; as impedance transformer; as a bridge, etc. Sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

-hp- 920A Adjustable Shorts

Adjustable choke-type short for tuning or introducing reactance in combination with detecting sections, series, shunt or hybrid tees. Sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

HEWLETT-PACKARD INSTRUMENTS

Simple Design, Multi-Purpose Operation!

-hp- 715A Klystron Power Supply

Versatile power supply for operation of all types of low-power klystron oscillators in test-bench experiments. Beam voltage 250 to 400 v. at 50 ma. max. Reflector voltage 10 to 900 v. at 5 μamps. Internal square wave modulation, 1,000 cps; also provision for external modulation. 6.3 volt, 1.5 amp. filament supply.

-hp- 530A Frequency Meters

General purpose reaction type frequency meter covering the entire waveguide frequency band. Consists of a high "Q" resonant cavity tuned by a plunger. Micrometer scale indicates plunger position. Accuracy ±0.10%. Ranges: 5.85 to 8.20 kmc (1½" x ¾") and 8.2 to 12.4 kmc (1" x ½"). (Other sizes to be announced.)

-hp- 870A Slide Screw Tuners

For flattening waveguide systems. Consists of slotted waveguide section and adjustable probe on sliding carriage. Varying position and peneration of probe sets up VSWR which can be adjusted to cancel existing VSWR in system. VSWR values up to 20 can be tuned with an accuracy of VSWR 1.02. Sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

-hp- 880A E-H Tuners

Matching section for tuning high power systems or for tuning systems where low leakage is essential. Consists of hybrid waveguide tee with moveable choke type shorts placed in shunt and series arms. Sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

-hp- 440A Coaxial Detector

-hp- 440A Coaxial Detector, a tunable crystal and bolometer mount, may be used as an rf detector for coaxial systems operating over the frequency range, 2.4 kmc to 12.4 kmc. A single adjustment provides rapid tuning. Equipment mates with Type N connectors and operates either with silicon crystal or bolometer.

-hp- 442A Broad-Band Probe

This probe may be combined with -hp- 440A to provide a highly sensitive, easily tuned detector for use with slotted sections. A micrometer depth adjustment provides quick control of rf coupling. This combination is specifically designed to operate with -hp- 809B and 810A/B Slotted Waveguide equipment.

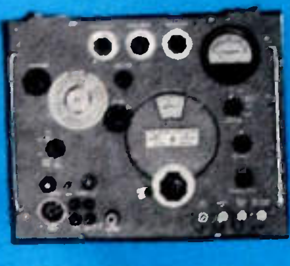
-hp- 910A Low Power Terminations

For use wherever matched load is required, as in measurement of reflection, discontinuities or where waveguide must be properly terminated. Consists of tapered piece of resistive material terminating a waveguide section in its characteristic impedance. Max. VSWR 1.06. Average power 1 watt, sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝". Average power 1/2 watt, sizes: 1" x ½", .702" x .391".

-hp- 912A High Power Terminations

Used as dummy loads for high-power transmitters. Dissipate large amounts of power without undesirable reflection. VSWR less than 1.1. Forced air cooling required when operating at 50% rating or above. 250 watts average power, size: 3" x 1½". 100 watts average power, 1" x ½". (Other sizes to be announced.)

In addition to waveguide equipment shown on these pages, -hp- offers the basic coaxial equipment used in major microwave research and development projects throughout America.



-hp- 616A UHF Signal Generator
1,800 to 4,000 mc. Output range 0.1 μv. to 0.223 v. (1 mw). Continuously variable, direct reading, no adjustments during operation

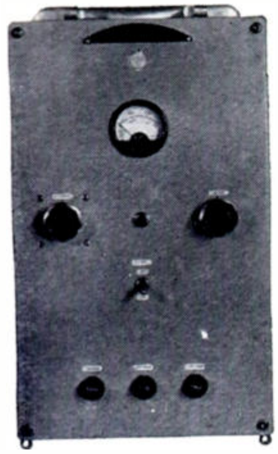
-hp- 618A SHF Signal Generator
3,800 to 7,600 mc. Output range 2.23 μv. to 0.223 v. (1 mw). Continuously variable, direct reading, no adjustments during operation.

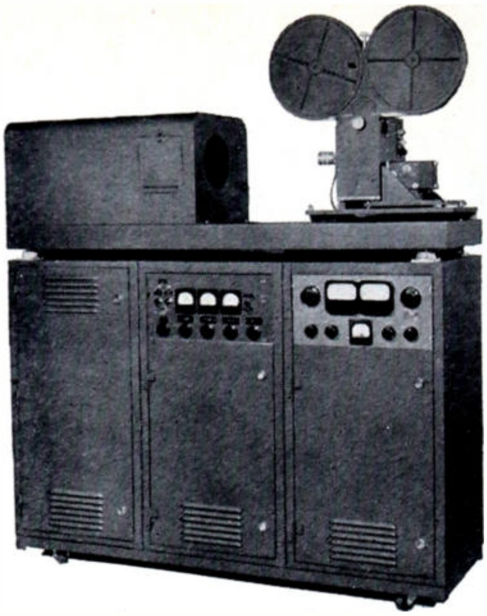
-hp- 805A/B Slotted Line
Highly stable, exclusive, parallel plane design. 500 mc to 4000 mc. Model 805A, VSWR 1.04, 50 ohms impedance for flexible cables; 805B, VSWR 1.02, 46.3 ohms impedance, for ⅞" rigid coaxial line.

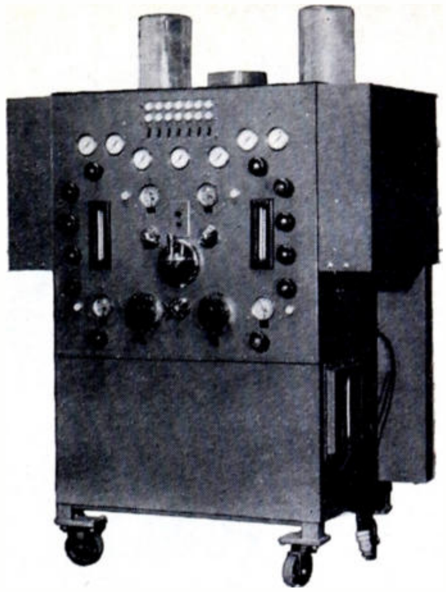
-hp- 430A Microwave Power Meter
Automatic, instantaneous power readings in db or milliwatts. No calculations, no adjustments. Use with any microwave bolometer mount.

-hp- 415A Standing Wave Indicator
High-gain amplifier operating at fixed audio frequency. Reads VSWR and db direct. 70 db calibrated range. Normal frequency 1,000 cps; others available, 300 to 2,000 cps.

HEWLETT-PACKARD (hp) INSTRUMENTS







Single-Unit Sync Generator Requires No Adjustment

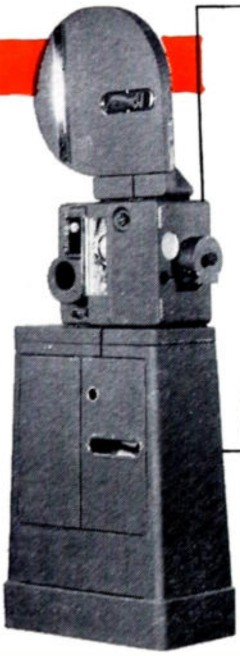
This unit, complete with power supply, is packaged for field use, may be removed from case for rack mounting. With binary counting circuits and pulse width controlled by delay lines, it provides circuit reliability better than present studio equipment and eliminates operator adjustments.

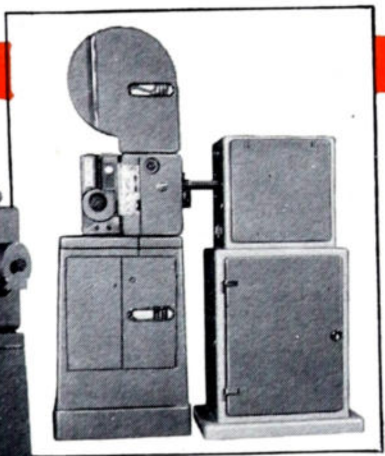
Video Recordings of Live-Program Quality

Precision electronic shutter provides steady interlace and eliminates shutter bar. High-fidelity sound recorded on the film simultaneously. New vacuum gate camera runs continuously without emulsion pile-up. Telecast recording looks and sounds like a live show.

Film Permanently Processed in 40 Seconds

The GPL Rapid Processor develops, rinses, fixes, washes, dries and waxes 16-mm film synchronously as it comes from the Recorder, or its own feed magazine. This facilitates rebroadcasts to other time zones. Operation is fully automatic, gives uniform, highest quality results.





First Professional Sync Projector for 16-mm Film

Designed for TV studio use. Has the reliability of professional 35-mm equipment. Sharper, steadier pictures, finer sound. Uniform illumination, ample light, with 100 foot-candles delivered to camera tube. May be used with any full-storage type film pick-up or with new special GPL Photicon Film Camera for greater sensitivity, freedom from shading, simplified control.

New "3-2" Projector Works with Any Image Orthicon Camera

A portable unit of tremendous utility. Used with standard studio or field cameras without special phasing, it makes transmission of motion pictures as simple as stills. Handles film features with results comparable to specialized iconoscope chains. Projects rear-screen effects. Projects commercials to cameras in the field, eliminating expensive studio stand-by facilities. For preview work, its synchronous motor simplifies sound scoring.

General Precision Laboratory

INCORPORATED

PLEASANTVILLE NEW YORK

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"FOR PERMEABILITY

a core made of CARBONYL IRON POWDER means compact size and efficient performance....."

"**Permeability** plus **stability**—these two qualities determine the ability of a radio receiving set to select and hold clear reception on a particular wave band. In household, portable and automotive receivers, compact size and weight reduction also become important factors . . . . . In the making of both RF and IF coils we have come to rely upon cores made of Carbonyl Iron Powders. We can trust their uniform quality and uniform crystal structure to hold the permeability within plus or minus 1% over a period of years."

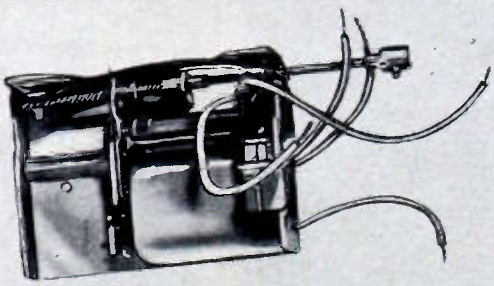
THE F. W. SICKLES COMPANY
CHICOPEE, MASSACHUSETTS

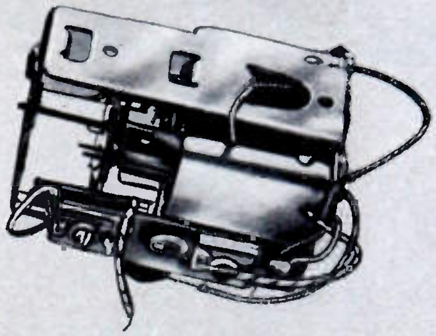
FOUNDED IN 1921—under the name of Radio Development Co.,—the F. W. Sickles Company are today the world's largest makers of radio coils. Several hundred different models of RF and IF coils—made by this firm—are now in daily use by manufacturers of electronic equipment, as well as by amateurs, experimenters, radio service men and government agencies, both here and abroad.

The Sickles endorsement of Carbonyl Iron Powders is extremely gratifying to us . . . It is also important evidence for the consideration of any receiver or equipment manufacturer. Let us send you the book described at the right. It will cost you nothing to get the facts . . . Ask your core maker, your coil winder, your industrial designer, how G A & F Carbonyl Iron Powders can improve the performance or reduce the size of the equipment you make. The possible gains and savings are far greater than here indicated.

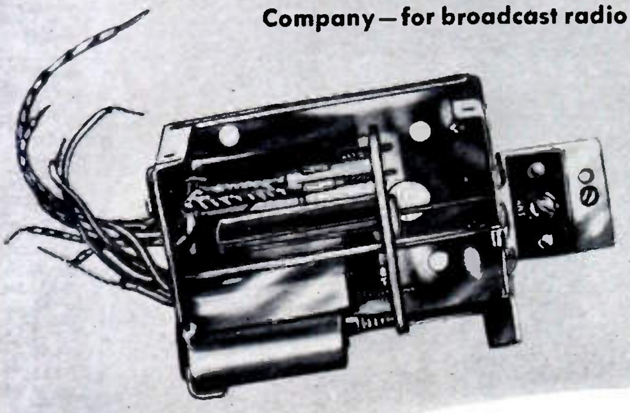
G A & F® Carbonyl

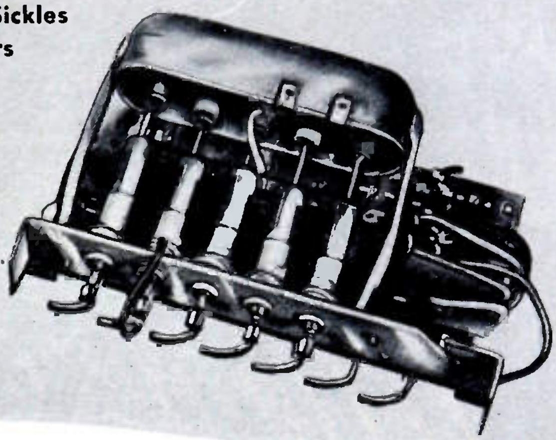
TUNING...





Precision tuning units—made by The F. W. Sickles Company—for broadcast radio receivers





THIS FREE BOOK – fully illustrated, with performance charts and application data – will help any radio engineer or electronics manufacturer to step up quality, while saving real money. Kindly address your request to Department 35.

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Iron Powders...

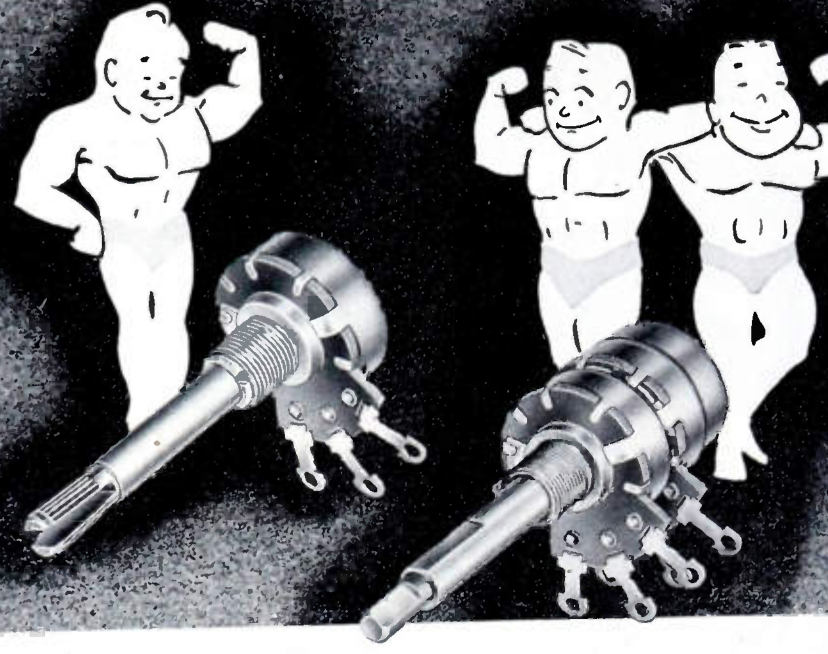
MEMBER mpa METAL POWDER ASSOCIATION

What to see at the Radio Engineering Show

(Continued from page 1A)

Firm	Booth
Borg Equipment Division—The George W. Borg Corporation, Delavan, Wis. Micropot—Ten Turn Potentiometer, Microdial, Ten Turn Counting Dial.	272
W. H. Brady Co., Chippewa Falls, Wis. Self-sticking identification products, wire markers, colored wire markers, parts identification markers, pipe & conduit markers, safety signs, printed "scotch" roll tape, masks & stencils, bin markers, special self-sticking markers made to customer's specifications, coil markers, instruction labels, product and trade mark identification markers, wiring assembly markers, inspection labels, balancing tapes, etc.	258
Brentano's Technical Department, New York, N.Y. Books of all publishers in the fields of radio, television, electronics and radar, including nucleonics, atomic engineering, computers and their related fields.	259
British Industries Corp., New York, N.Y. Garrard record changers and phono units. Ersin multicore solder.	270
Brooks & Perkins, Inc., Detroit, Mich. Magnesium fabricated products for radar reflectors and control boxes, portable electronic cases, deep drawn magnesium stampings and assemblies, welded frame assemblies, pressurized radar housings, magnesium plotting equipment and furniture.	343
Browning Laboratories, Inc., Winchester, Mass. Model OJ-17 Oscillosynchroscope, Model GL-22A Sweep Calibrator, Model ON-5 Oscillosynchroscope, Model MD-25 FM Modulation Monitor, Models RV-10A FM Tuner, RJ 12B FM-AM Tuner, RJ-20A FM-AM Tuner.	S-12, S-13
Brujac Electronic Corp., New York, N.Y. Two Precision Cathode Ray Oscilloscopes have been developed for the observation of random pulse transient or repetitive phenomena in the DC to 15 Mc range. The Labscope incorporates calibrated sweep speeds from 1 sec/cm to 0.1 microsec/cm, amplitude calibration, and coaxial mounting of related controls. Two models are available, one employing the 5YP CR tube (4000 volts accelerating) and the other, the 5XP CR tube (12,000 volts accelerating).	N-20
Brush Development Co., Cleveland, Ohio Industrial and research instruments, magnetic recording equipment and components, synthetic piezo-electric crystal elements. "Hypersonic" generators and ceramic piezo-electric elements and transducers.	70, 71
Burlington Instrument Co., Burlington, Iowa Display AC and DC electrical indicating instruments, portable instruments, and generator voltage regulators.	228
Bussmann Manufacturing Co., St. Louis, Mo. Buss and Fusetron fuses of all types for the protection of radio, television and electronic equipment of all kinds.	371
Caldwell-Clements, Inc., New York, N.Y. "Tele-Tech," a television and telecommunications engineering magazine, and "Radio & Television Retailing," a merchandising and servicing trade magazine.	249
Calidyne Co., Winchester, Mass. Vibration measuring equipment, Electrodynamic shaker, calibrators and power supplies, High Sensitivity Accelerometer, Vibrascope, Vibration Meter, Calivolters.	N-12
Cambridge Thermionic Corp., Cambridge, Mass. Terminal boards; terminals (lugs); slug-tuned coils, slug-tuned coil forms, phenolic and ceramic; insulated terminals, phenolic and ceramic; electronic hardware.	287
Camloc Fastener Corp., New York, N.Y. Quick-operating fasteners, one-quarter turn, latches, and quick release.	339
Cannon Electric Development Co., Los Angeles, Calif. Electrical connectors, multi-contact plugs and receptacles for radio and electronic circuits.	250

(Continued on page 26A)



WILKOR

FIRST IN THE INDUSTRY WITH CARBOFILM RESISTORS

AND NOW

FIRST AGAIN WITH BORO-CARBOFILM RESISTORS

- ★ Greatly Increased Range of Resistance
- ★ Temperature Coefficient as Low as 20 Parts Per Million Per Degree C
- ★ Increased Stability
- ★ Lower Noise Level

Attention All Electronic Engineers

We are in production on the most advanced development in the history of resistors. It is the BORO-CARBOFILM RESISTOR. After over two years of intensive laboratory work the introduction of Boron in the making of Deposited Carbon Resistors has been perfected.

The result of this new development assures greatly increased range of resistance, temperature coefficient as low as 20 parts per million per degree C, greater stability and lower noise level.

What This Means to You

Briefly, this makes it possible for you to use the new, much improved BORO-CARBOFILM RESISTOR in place of larger and more costly wire-wound types. It also provides access to resistance ranges heretofore impossible to attain in film-type resistors. With their low temperature coefficient and small aging you will find wide-spread use for these new resistors in communications and nearly all types of electronic applications. Remember the name "BORO-CARBOFILM". Available in ¼, ⅓, ½, 1 and 2-watt sizes.

In writing, kindly give your requirements in sizes and volume.

BORO-CARBOFILM RESISTORS are made under license arrangement with Western Electric Co., Inc.

WILKOR PRODUCTS, INC.

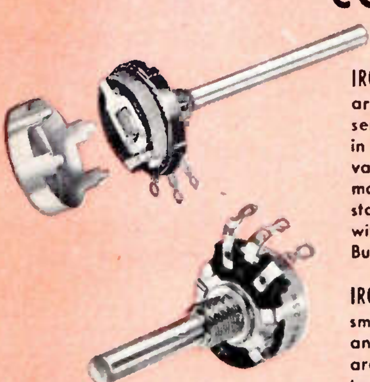
2882 Detroit Avenue · Cleveland 13, Ohio

A complete line

for resistors too!

Unusual *combinations of characteristics* required in today's critical electronic circuits demand a complete range of resistor types. Specializing in resistors, IRC makes the widest line in the industry. This means ease of procurement—a single dependable source of supply for *all* your resistance needs. It also means unbiased recommendations—no substitution of units "just as good". IRC's complete line of products; complete research and testing facilities; complete network of licensees for emergency production—all add up to complete satisfaction for you.

CONTROLS



IRC Type W Wire Wound Controls are designed for long, dependable service and balanced performance in every characteristic. These 2-watt variable wire wound units provide maximum adaptability to most rheostat and potentiometer applications within their power rating. Catalog Bulletin A-2.

IRC New Type Q Controls feature small 13/16" size, rugged construction and superior performance. Increased arc of rotation permits same resistance ratios successful in larger IRC Controls. Catalog Bulletin A-4.

PRECISION RESISTORS

IRC Precision Wire Wounds offer a fine balance of accuracy and dependability for close-tolerance applications. Extensively used by leading instrument makers, they excel in every significant characteristic. Catalog Bulletin D-1.

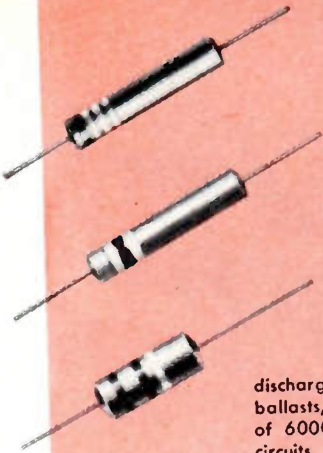
IRC Deposited Carbon PRECISTORS combine accuracy and economy for close-tolerance applications, where carbon compositions are unsuitable and wire-wound precisions too expensive. Catalog Bulletin B-4.

IRC Matched Pairs provide a dependable low-cost solution to close-tolerance requirements. Both Type BT and BW Resistors are available in matched pairs. Catalog Bulletin B-3.

IRC Sealed Precision Voltmeter Multipliers are suitable and dependable for use under the most severe humidity conditions. Each consists of several IRC Precisions mounted and interconnected, encased in a glazed ceramic tube. Catalog Bulletin D-2.

is essential

INSULATED COMPOSITION and WIRE WOUND RESISTORS



IRC Advanced Type BT Resistors meet and beat JAN-R-11 Specifications of 1/3, 1/2, 1 and 2 watts—combine extremely low operating temperature with excellent power dissipation. Catalog Bulletin B-1.

IRC Type BW Wire Wound Resistors are exceptionally stable, inexpensive units for low range requirements. Have excellent performance records in TV circuits, meters, analyzers, etc. Catalog Bulletin B-5.

IRC Type BTAV High Voltage Resistors, developed for use as discharge resistors in fluorescent "Quick Start" ballasts, withstand momentary peak surge of 6000 volts. Also suited to TV bleeder circuits. Catalog Bulletin B-1.

HIGH FREQUENCY and HIGH POWER RESISTORS

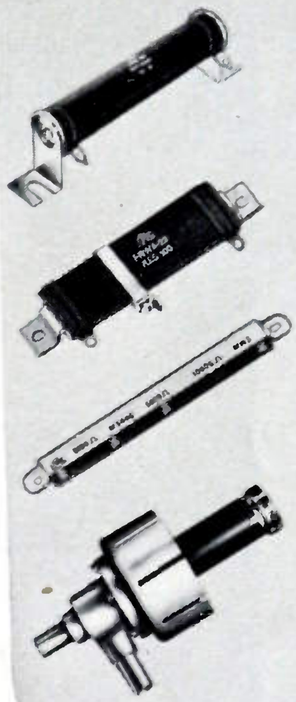
IRC Type MP High Frequency Resistors afford stability with low inherent inductance and capacity in circuits involving steep wave fronts, high frequency measuring circuits and radar pulse equipment. Available in sizes from 1/4 to 90 watts. Catalog Bulletin F-1.

Type MV High Voltage Resistors utilize IRC's famous filament resistance coating in helical turns on a ceramic tube to provide a conducting path of long, effective length. Result: Exceptional stability even in very high resistance values. Catalog Bulletin G-1.

IRC Type MVX High Ohmic, High Voltage Resistors meet requirements for a small high range unit with axial leads. Engineered for high voltage applications, MVX has exceptional stability. Catalog Bulletin G-2.

IRC Type MPM High Frequency Resistors are miniature units suitable for high frequency receiver and similar applications. Stable resistors with low inherent inductance and capacity. Body only 3/8'' long. Catalog Bulletin F-1.

POWER RESISTORS



IRC Fixed and Adjustable Power Wire Wounds give balanced performance in every characteristic—are available in a full range of sizes, types and terminals for exacting, heavy-duty applications. Catalog Bulletin C-2.

IRC Type FRW Flat Wire Wound Resistors fulfill requirements of high wattage dissipation in limited space—may be mounted vertically or horizontally, singly or in stacks. Catalog Bulletin C-1.

IRC Type MW Wire Wound Resistors offer low initial cost, lower mounting cost, flexibility in providing taps, and saving in space. Completely insulated against moisture. Catalog Bulletin B-2.

IRC Type LP Water-Cooled Resistors for TV, FM and Dielectric Heating Applications. Cooled internally by high velocity stream of water; adjustable to local water pressure and power dissipation up to 5 K.W.A.C. Catalog Bulletin F-2.

Wherever the Circuit Says -\/\/\/-

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

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- ☐ Bulletin A-2 (W)
- ☐ Bulletin A-4 (Q)
- ☐ Bulletin B-1 (BT)
- ☐ Bulletin B-1 (BTAV)
- ☐ Bulletin B-2 (MW)
- ☐ Bulletin B-3 (M/P)
- ☐ Bulletin B-4 (DC)
- ☐ Bulletin B-5 (BW)
- ☐ Bulletin C-1 (FRW)
- ☐ Bulletin C-2 (PWW)
- ☐ Bulletin D-1 (WW)
- ☐ Bulletin D-2 (MF)
- ☐ Bulletin F-1 (MP)
- ☐ Bulletin F-1 (MPM)
- ☐ Bulletin F-2 (LP)
- ☐ Bulletin G-1 (MV)
- ☐ Bulletin G-2 (MVX)

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What to see at the Radio Engineering Show

(Continued from page 20A)

Firm — **Booth**

Capitol Radio Engineering Institute, Washington, D.C. — 357
A complete library of CREI text material.

Carboloy Co., Inc., Detroit, Mich. — 61
Carboloy Permanent magnets (Alnico and other types.) Exhibit to show some of the steps taken to provide a high quality permanent magnet. Some visitor participation demonstrations to illustrate Carholoy quality.

Carter Motor Co., Chicago, Ill. — S-18
Display of dynamotors, dc to ac converters, magmotors, and small rotary power supply equipment for mobile radio.

Centralab, Division of Globe-Union, Inc., Milwaukee, Wis. — 232, 233
Ceramic capacitators, printed electronic circuits, controls, switches, special ceramics, and components.

Century Geophysical Corp., Tulsa, Okla. — 354
Flight test recording oscillographs, miniature oscillographs, galvanometers, vibration amplifiers, refraction seismograph equipment. Miniature seismometers, miniature reflection seismograph amplifiers and cable fault detector.

C.G.S. Laboratories, Stamford, Conn. — 369
Airborne instrumentation mechanisms, microwave development, test equipment, electronic and remote controls.

Chicago Rivet & Machine Co., Bellwood, Ill. — N-7
Rivets, tubular and split; automatic rivet setting machines, single and multiple setting, adjustable centers.

Cinch Manufacturing Corp., Chicago, Ill. — 255, 256
Tube sockets and shields, connectors, terminal strips, lugs, clips, brackets, etc.

C. P. Clare & Co., Chicago, Ill. — 204
Telephone type relays. open and hermetically sealed, spring driven stepping switch, and sensitive relays meeting AN requirements for use in aircraft and other electronic apparatus.

Clarostat Mfg. Co., Inc., Dover, N.H. — 254
Fixed wire wound resistors, variable wire wound resistors, variable carbon resistors, attenuators, television and radio components.

Cleveland Container Co., Cleveland, Ohio — 207
Clevelite and Cosmalite laminated paper base phenolic tubing, coil forms and television deflection yoke sleeves. Kraft, acetate and combination tubing.

Sigmund Cohn Corp., New York, N.Y. — 283
Filament wire and ribbons, grid wires, electroplated wires, precious metals in sheet, wire, ribbon and other forms. Rhodium plating solutions and gold cyanide. Galvanometer suspension strip, enameled fine wire and etched wire.

Coil Winding Equipment Co., Oyster Bay, N.Y. — 355
Machinery to wind all types of coils, lattice, single layer. bobbins, paper inserted. New this year, a machine to determine the gear set-up for universal winding, also a machine to pi wind in multiple on dummy resistor forms.

Collins Radio Co., Cedar Rapids, Iowa — 75 to 80
Airborne communication and navigation equipment. Ground station communication equipment. Broadcast transmitters and speech equipment. Amateur transmitters and receivers.

Communication Products Co., Keyport, N.J. — 18, 19, 20
Seal-O-Flange transmission lines. Q-Max compositions and finishes. AM-FM-TV antennas. tower hardware. rf switches, Auto-Dryaire Dehydrators.

Condenser Products Co., Chicago, Ill. — N-17
Capacitors, power supplies, pulse-forming networks.

Consolidated Engineering Corp., Pasadena, Calif. — 384, 385
Leak detector for checking any vacuum or pressure system for minute leaks. Record-

(Continued on page 27A)

What to see at the Radio Engineering Show

(Continued from page 26A)

Firm — **Booth**

ing oscillograph and amplifying equipment for recording measurement of such phenomena as vibration, stress, strain, acceleration, torque, etc. Micromanometer for pressure measurement in the Micron range.

Continental Carbon, Inc., Cleveland, Ohio — 224
Resistors; "Nobleloy," fixed, non-wire wound types, wire wound low power types. Suppressors; resistor type, auto radio ignition, and oil burner types.

Continental Electric Co., Geneva, Ill. — 375
Line of phototubes, lead sulfide cells, rectifiers, thyratrons, TV picture tubes, Tru Vac gauges.

Cornell-Dubilier Electric Corp., South Plainfield, N.J. — 73, 74
Capacitors; vibrators; TV, FM, and auto antennas, and antenna rotators; vibrator converters; inverters; and battery power supplies.

Corning Glass Works, Corning, N.Y. — 30, 31, 32
All-glass television tubes, metallized glass components for radio and television, glass parts for all types of electronic tubes.

Cossor (Canada) Ltd., Halifax, Nova Scotia, Canada — 223
Twin-beam oscilloscopes, cameras and drives. Vacuo junctions, thermocouples, wire and cables.

R. W. Cramer Co., Centerbrook, Conn. — 359
Interval timers, reset timers, time delay relays, cycle timers, pulse timers, duplex cycle timers, percentage timers, multicontact timers, running time meters. Synchronous motors, differential clutch motors, chart drives, reversible motors.

Curtis Development & Manufacturing Co., Chicago, Ill. — 221
Represented by Wally Swank

Cyclohm Motor Corp., Racine, Wis. — 221
Div. of Howard Industries, Inc.
Represented by Wally Swank

Daven Co., Newark, N.J. — 94B, 95
Distortion of noise meters, vacuum tube voltmeters, a complete line of standard and miniature attenuators, low contact resistance rotary selector switches, precision wire-wound resistors. Test and measuring equipment.

Bryan Davis Publishing Co., Inc., New York, N.Y. — 288
"Television Engineering" magazine, "Service" magazine.

Dial Light Co. of America, Inc., New York, N.Y. — 46
A display of warning and signal pilot light assemblies.

Distillation Products Industries, Division of Eastman Kodak Co., Rochester, N.Y. — 241, 242
Vacuum gauges, vacuum pumps, rotary tube exhaust equipment, cathode ray tube exhaust equipment, high vacuum gasketing material, special clock and fine instrument lubricant.

Wilbur B. Driver Co., Newark, N.J. — 342
Nickel chrome, copper and stainless steel resistance wire; wire winding equipment.

Allen B. DuMont Laboratories, Inc. Clifton, N.J. Tube Division — 125
Cathode-ray tubes.

Allen B. DuMont Laboratories, Inc. Clifton, N.J. Instrument Division — 126 to 128
A line of cathode-ray oscillographs, industrial cathode-ray tubes. A line of oscillograph-record cameras. Associated equipment.

Allen B. DuMont Laboratories, Inc., E. Paterson, N.J. Electronic Parts Division — 124
New input tuners and deflection yokes.

Allen B. DuMont Laboratories, Inc., Clifton, N.J. Television Transmitter Equipment Division — 120 to 123
Universal color scanner; new type image orthicon TV camera.

Dumont Electric Corp., New York, N.Y. — 327
Fixed Capacitors.

DX Radio Products Co., Inc., Chicago, Ill. — 345A
Toroids, deflection yokes, transformers, tuners, speakers, ion traps.

(Continued on page 60A)

Truscon Tower Engineering is the answer!

Meeting tower construction emergencies of all kinds . . . solving tower problems big and small . . . being *on the job* with knowledge and skill that *gets the job done . . . that's the type of service which has made Truscon a world leader in radio tower engineering!*

Truscon experience embraces all types of topographical and meteorological conditions . . . and supplying many different tower types: guyed or self-supporting ...tapered or uniform in cross-section...for AM, FM, TV, or microwave applications.

Your phone call or letter to any convenient Truscon district office, or to our home office in Youngstown, will bring you immediate, capable engineering assistance. Call or write today.

TRUSCON STEEL COMPANY
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Subsidiary of Republic Steel Corporation

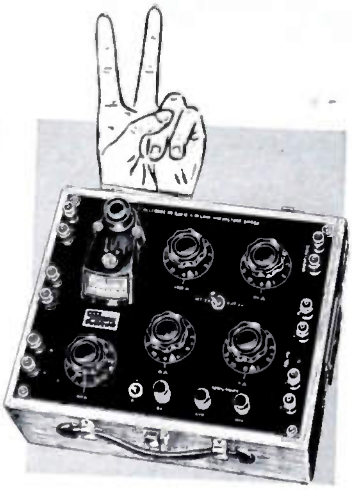
[See the Truscon Exhibit, Booth 230, Institute of Radio Engineers Show]

TRUSCON TOWERS
SELF-SUPPORTING AND UNIFORM CROSS SECTION GUYED
TRUSCON COPPER MESH GROUND SCREEN

HERE'S *Fast, Accurate* LAB OR PRODUCTION *Testing!*

A QUICK CHECK OF LOW RESISTANCE CONNECTIONS, BONDS, CONTACTS, etc.

Shallcross low resistance test sets greatly facilitate comparison tests between 2 and 800,000 micro-ohms. Their uses range from testing the electrical conductivity of bonds, welds and seals to contacts, filaments, armatures or for making any measurement under 1 ohm. Suitable units are available for either field, laboratory or production line use. Write for Bulletin LRT-1.



KELVIN plus WHEATSTONE RANGES IN ONE HANDY BRIDGE

Why pay for two instruments when one will do *both* jobs? Providing both Kelvin and Wheatstone ranges from 0.0001 ohm to 11.11 megohms, this Shallcross No. 638-R combined bridge is highly accurate and outstandingly convenient. Priced at only a little more than a single bridge with a limited range, it is a typical example of Shallcross instrument efficiency and economy.

DECADE RESISTANCE BOXES TO MATCH YOUR NEED... exactly

Over 40 Shallcross standard Resistance Boxes provide the widest assortment available today. Types range from 1 to 7 dials from 0.01 ohm to 111 megohms and are available in styles, sizes and prices for practically any laboratory or production testing need. Write for Bulletin.

SHALLCROSS

SHALLCROSS MANUFACTURING COMPANY

Collingdale • Penna.

Something New

SPECIAL DELAY LINES

Lumped delay lines "tailored" to specific applications have been announced by the Shallcross Manuacturing Co., Collingdale, Pa. A typical unit consists of eight pie-section low-loss filters having a rise time of 0.04 microseconds and a total delay of 0.3 microseconds. Maximum pulse voltage is ± 100 volts and impedance is 500 ohms. Cutoff frequency is 8.5 megacycles and the maximum operating frequency approximately 2 megacycles based on a pulse delay error of not more than 2%. The unit consists of eight universally-wound coils of 3-strand #41 Litz wire and nine low T.C. silver mica capacitors. Many other types can be supplied.

NEW SHALLCROSS WHEATSTONE-MEGOHM BRIDGE

The new Shallcross 635-A Wheatstone-Megohm Bridge is a versatile direct-reading instrument for accurate measurements between 10 ohms and 1,000,000 megohms. It can be used to measure resistance elements and insulation resistance and to determine volume resistivity of materials. The instrument is basically a Wheatstone Bridge used in conjunction with a d-c amplifier. Two built-in power supplies operating on 115 volts, 60-cycles automatically provide the correct bridge voltages for the high and low ranges. Full information is available from the Shallcross Manufacturing Co., Collingdale, Pa.

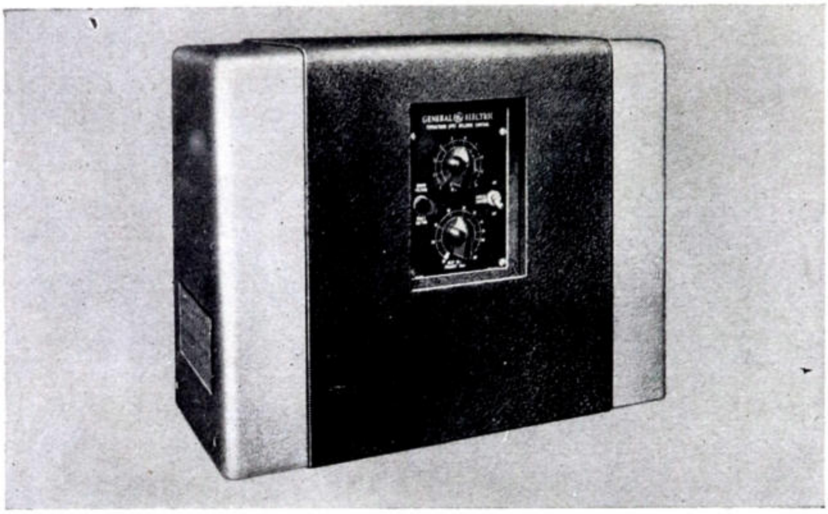
METAL-ENCASED RESISTORS

Flat, metal-encased, Type 265-A wire-wound power resistors introduced by the Shallcross Manufacturing Company, Collingdale, Pa. are space wound, have mica insulation, and are encased in aluminum. At 175°C. continuous use they are conservatively rated for 7½ watts in still air and 15 watts mounted flat on a metal chassis. Write for Bulletin 122.

SEE US AT BOOTHS 280-281, I.R.E. SHOW

ELECTRONICS

Designers



MAKE 16 GROUND CONNECTIONS IN 1 MINUTE!

Low-resistance joints that hold at over 125°C easily made with

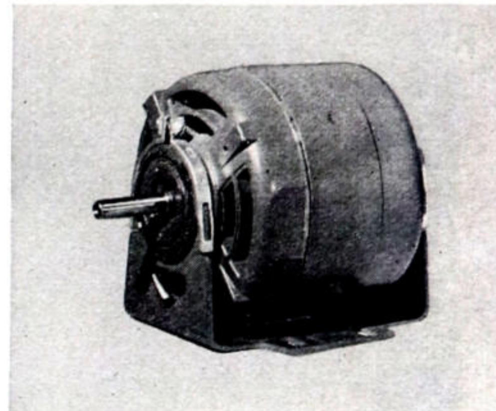
G-E PRECISION CONTROL FOR RESISTANCE WELDERS

Operators are making sixteen ground connections a minute to a television-receiver chassis with G. E.'s precision-control resistance welding method.

The compact electronic spot-welding control shown here has been specifically designed for use in conjunction with small bench welders or tongs and thus is ideally suited for many of the otherwise expensive assembly operations encountered in the manufacture of electronic equipment.

The panel provides for welding-current to control the amount of heat produced in the welds. Once set, successive welding currents remain constant to assure accurate and consistent welding of connections.

Complete data in Bulletin GEA-4175.



NEW! Unit-Bearing Motor for fans and blowers

- all angle operation
- improved appearance
- provision for 4-way mounting
- quiet operation
- requires no additional lubrication
- adjustable-speed operation available

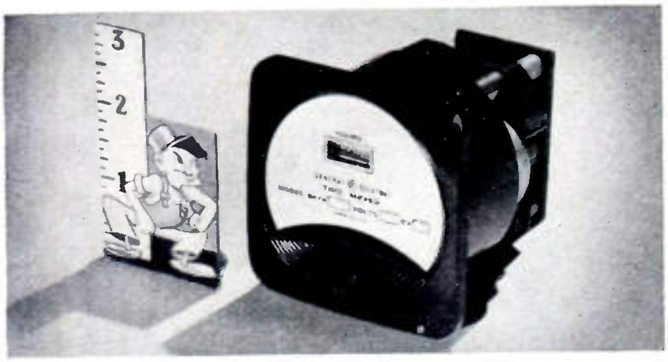
Available in ratings from 25 millihorsepower to 1/12 horsepower to match many fan or blower sizes, this new G-E unit-bearing motor uses a new lubrication system and bearing design that permit reliable operation in any position. For extremely quiet operation, resilient cradle-base or end-ring mounting may be supplied. Suitable control is available for two-speed or adjustable-speed operation. More data in Bulletins GEA-5338 and GEC-219A.

GENERAL ELECTRIC

667-11

Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS

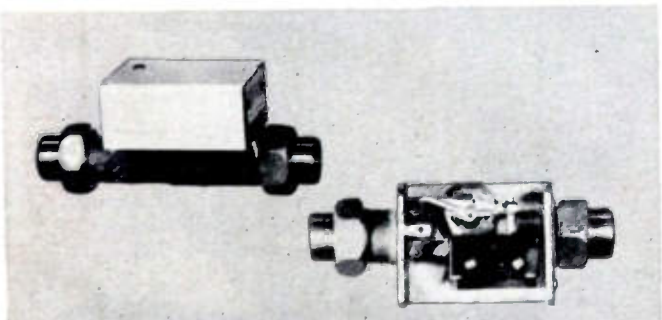


replace tubes BEFORE THEY FAIL! —record life with G-E time meters

A vacuum tube can usually be replaced *before* it fails if you have an accurate indication of operating time on the electronic device on which the tube is used.

G-E time meters, with dependable Telechron* motor drive, record operating time in hours, tenths of hours, or minutes, and are supplied for 115-, 230-, or 460-volts. The molded Textolite† case harmonizes with other G-E 3½-inch instruments mounted on the same panel. For more information, including dimensions, write for Bulletin GEC-472.

*Reg. T. M. Telechron, Inc. †Reg. T. M. General Electric Co.

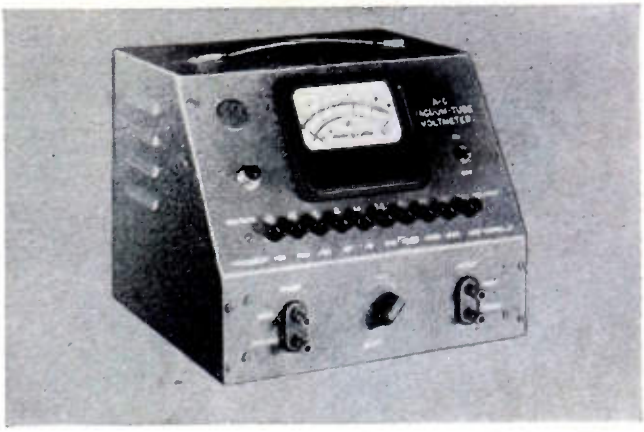


sure protection against overheating!

This G-E flow interlock opens the electric circuit of your water-cooled components when water flow is lower than a preset minimum, closes it when flow is above this point.

Depending on adjustment, the interlock will actuate the electric contact for any flow between ½ and four gallons per minute. Cut-in, cut-out differential is 0.1 gpm.

Ratings: 10 amps, 120 or 240 volts a-c; maximum water-line pressure is 125 lb./sq. in. Unit is bronze with standard ½-inch fittings, is easy to install and adjust. See Bulletin GEC-411.



select 10 ranges INSTANTLY with this HIGH SENSITIVITY VTVM

CALIBRATED RANGES: .001 to 300 volts (10 cycles to 1.5 mc.); −52 to +52 db (ref. level −1 mw at 600 v.)

Just about everything you could ask for in a high-sensitivity vacuum tube voltmeter! Frequency range of this G-E Type AA-1 instrument is substantially flat from 10 cycles to one megacycle with voltage ranges of 0-.01, 0-.03, 0-0.1, 0-0.3, 0-1.0, 0-3.0, 0-10, 0-30, 0-100, 0-300, decibels from −52 to +52 in 10 ranges.

Ten-position pushbutton switch instantly selects range without passing through intermediate stages. This vacuum-tube voltmeter is stable, has high impedance input, uses full-wave rectification, and has an amplifier output of 3 volts. More in Bulletin GEC-461.

General Electric Company, Section B 667-11
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

Indicate
√ for reference only
X for planning an immediate project

- ☐ GEA-4175 Welding control
- ☐ GEA-5338 Fan motors
- ☐ GEC-219A Fan motors
- ☐ GEC-411 Flow interlock
- ☐ GEC-461 Vacuum-tube voltmeter
- ☐ GEC-472 Time meters

Name ________________

Company ________________

Address ________________

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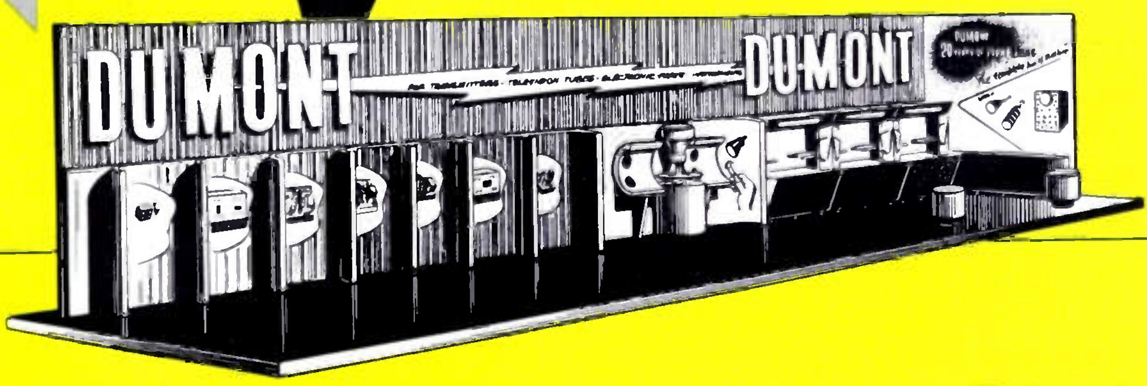
DUMONT

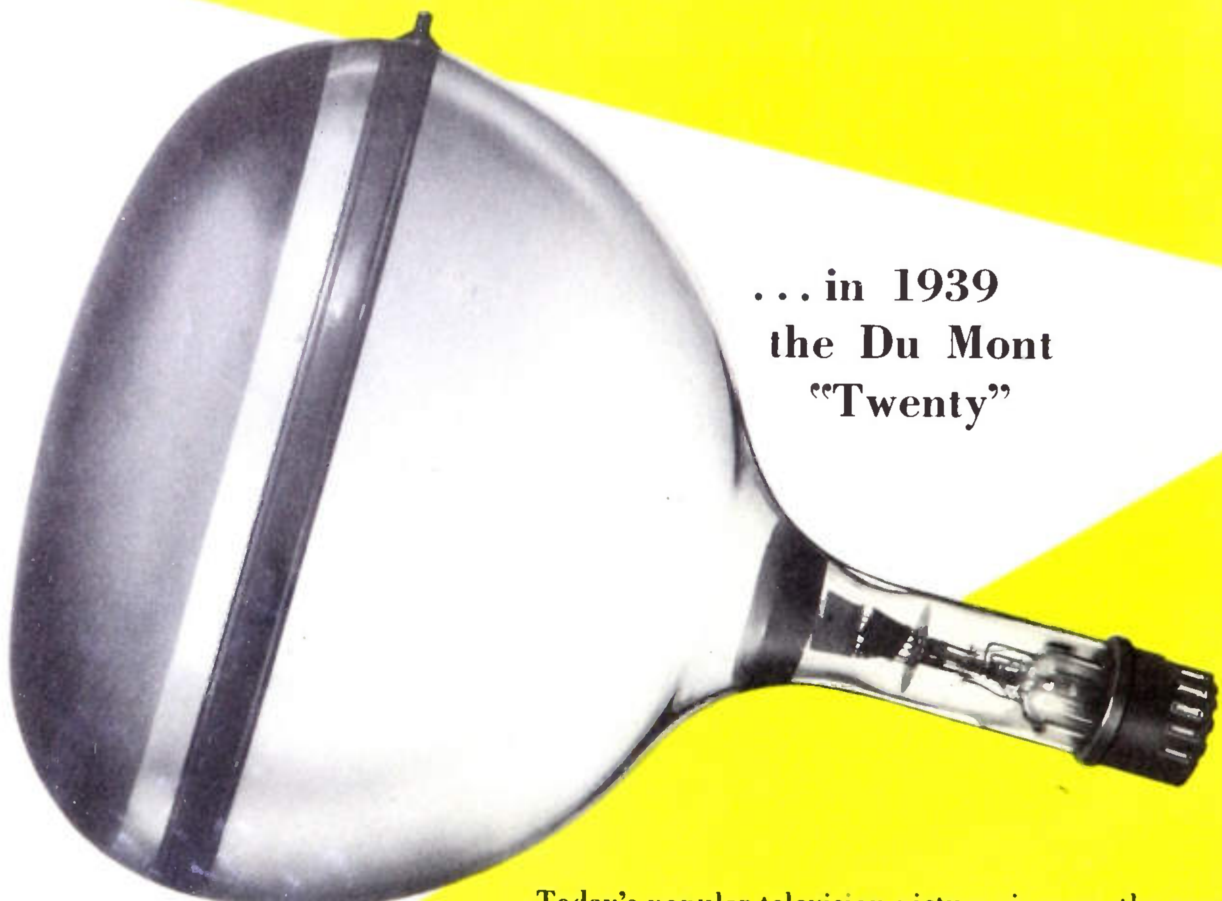
20th YEAR AS PIONEER

Proof at the I.R.E. show



DUMONT pioneering in

Cathode-ray Tubes...*brought big pictures from the beginning*



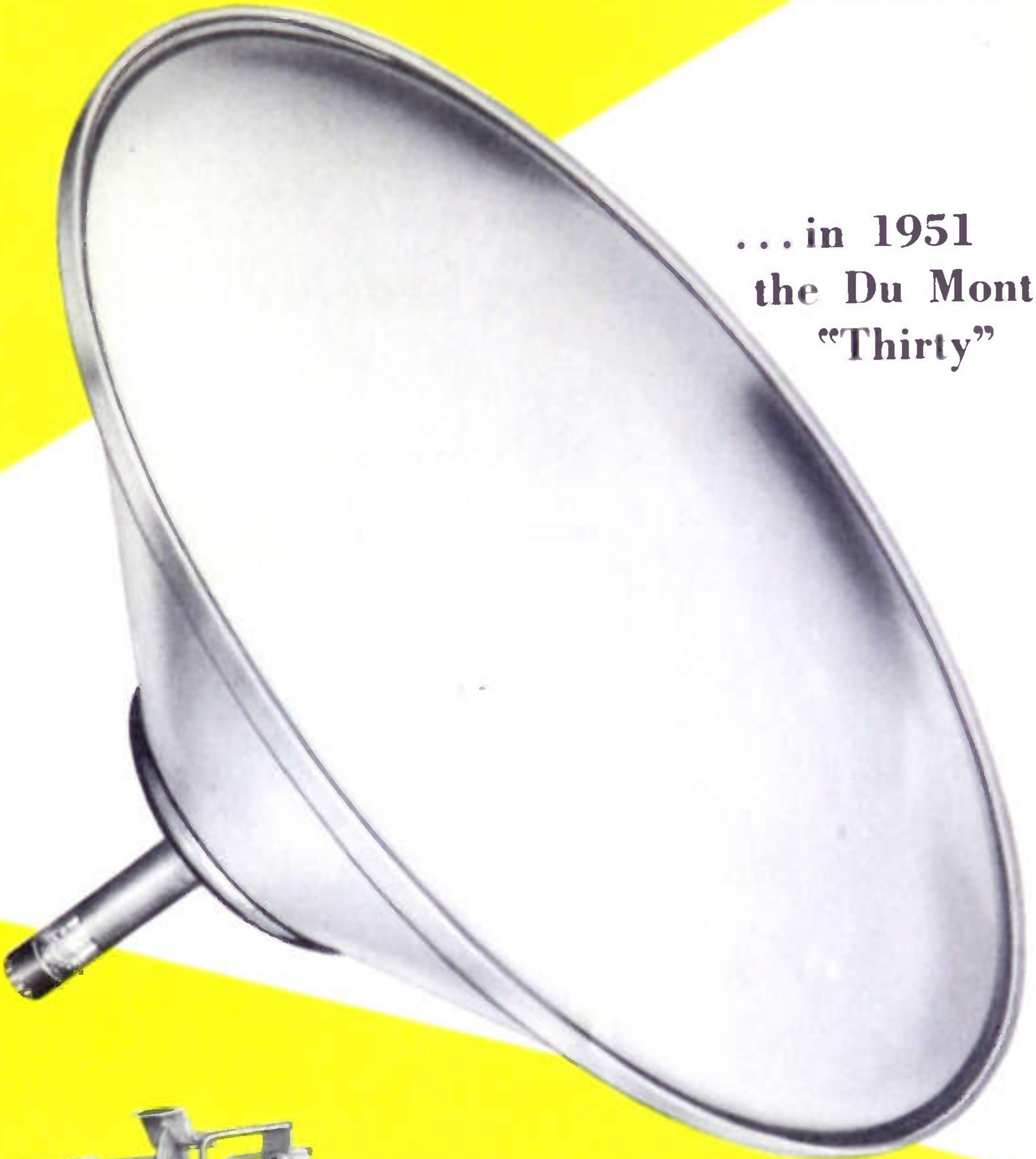
...in 1939
the Du Mont
"Twenty"

Today's popular television picture sizes are the result of Du Mont's 20 years of pioneering in the cathode-ray tube field. In 1939 when television first became a commercial reality, Du Mont produced the 20AP4 Teletron.* It was this tube that showed the public, as well as the industry, that such size was not only practical but also the *right* size. While others were limiting their tube sizes to 7 and 10 inches, Du Mont was gaining the experience that is the reason for the acknowledged leadership Du Mont enjoys today in *BIG* picture tube sizes.

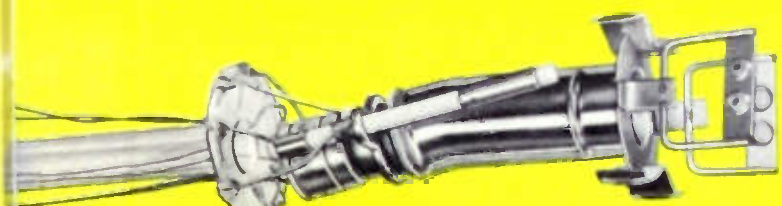
*TRADE-MARK

20th YEAR AS PIONEER

...when nobody dared!



...in 1951 the Du Mont "Thirty"



the Du Mont Bent-Gun used in all current Teletrons

Du Mont went on to introduce the popular 19 and 17 inch sizes that are the standards for today's receivers.

Du Mont now produces a complete line of *BIG* picture tubes in all the popular sizes climaxed in the new 30″ Teletron. This latest design provides a picture of approximately 550 square inches, while the overall length is only 23½″.

Most of today's leading TV receiver manufacturers call on this unparalleled knowledge in the design and manufacture of *BIG* picture tubes to assure the uniformly high quality they demand in their receivers.

ALLEN B. DU MONT LABORATORIES, INC.

CATHODE-RAY TUBE DIVISION

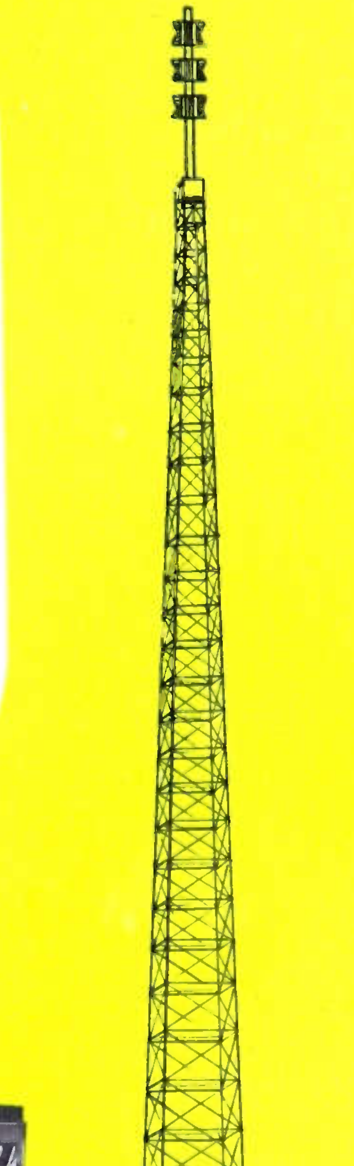
750 Bloomfield Avenue
Clifton, N. J.

20th YEAR AS PIONEER

An early pioneer in the development of television transmitting equipment, Du Mont's faith in the future of television has been fully justified. As a product of this faith, Du Mont is a leading manufacturer of television transmitting equipment.

Shown below is the new Du Mont all air-cooled, high- or low- band, 5 KW Oak Transmitter. The cumulative result of 6 years' experience with air-cooled transmitters, the Oak Transmitter has already had a highly successful debut with 18 months' field use on high-band operation. For most economical television broadcast operation investigate the Du Mont Oak Series Transmitter. The low initial cost, low installation cost, low operating cost and low-cost tube complement of the Oak Series Transmitter, add up to the lowest overall cost TV transmitting operation yet possible for a broadcast station.

Come see the 5 KW Oak Transmitter at the WABD installation in the Empire State Building during the IRE show, March 19 through March 22.



DUMONT pioneering in Oscillography

has been the greatest single influence in

Concept, Design and Application!

THE TYPE 3RP-A
The modern, 3" flat-face cathode-ray tube which combines short length with high sensitivity; is free from trapezoidal distortions, and provides high light output.

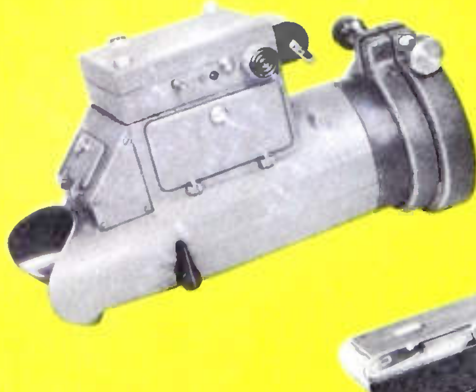
THE TYPE 5SP-
Dual-beam cathode-ra tube makes possible th presentation of two relate or independent phenomen on a single screen.

THE TYPE 5YP-
The newest design in 5" cathode-ray tubes which provides high sensitivity for high frequency applications at low and medium accelerating potentials.

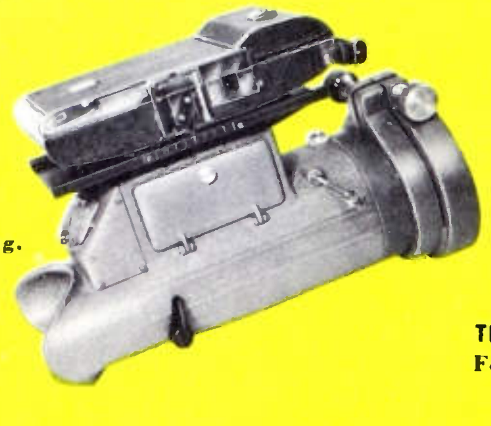
THE TYPE 5XP-
The multi-band intensifier principle and special deflection plate construction provide extreme sensitivity and high light output in a high-voltage cathode-ray tube.

OSCILLOGRAPH-RECORD CAMERAS

. . . for fulfillment of oscillographic techniques where permanent records are desired, Du Mont offers a complete line.



THE TYPE 295
For single-transient recording.



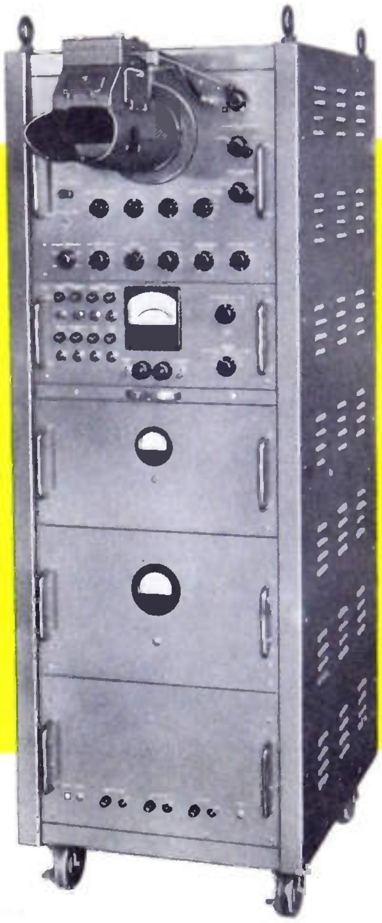
THE TYPE 297
For finished-print recording.

THE TYPE 321
For moving-film recording.

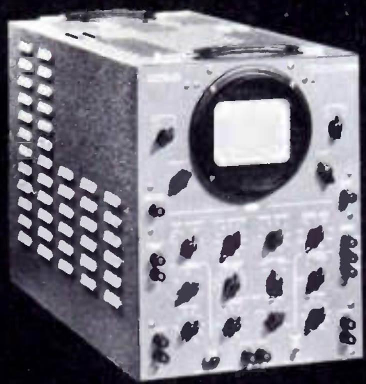
YEAR AS PIONEER 20th

THE TYPE 304-H
Sets a new standard of performance for general-purpose oscillography by providing high-gain AC and DC amplifiers, triggered sweeps, and other new circuit developments.

THE TYPE 293
The Type 293 is designed for use in the standard impulse testing of high-voltage transmission equipment, and presents on the hot-cathode, sealed-off cathode-ray tube an accurate portrayal of the test impulse.



TYPE 303
w, quantitative, wide-band, eral-purpose cathode-ray lograph, incorporating time amplitude calibration. sweep nsion, and signal delay.



THE TYPE 294-A
With high-voltage cathode-ray-tube operation and wide-band amplifiers, Type 294-A is especially suited for observing and recording high-speed transient signals.

DISTRIBUTED AMPLIFIER
Development of the transmission-line-coupled, wide-band amplifier has extended the application of the cathode-ray oscillograph to frequencies beyond 150 megacycles.

ALLEN B. DU MONT
LABORATORIES, INC.

INSTRUMENT DIVISION

1000 Main Avenue
Clifton, N. J.

write for catalog

more tuner per dollar...

DU MONT

SERIES T3C

INPUTUNER*

for TV-FM

PERFORMANCE UNSURPASSED!

DUMONT

FIRST WITH THE FINEST IN TV COMPONENTS

Electronic Parts

ALLEN B. DUMONT LABORATORIES, INC.
ELECTRONIC PARTS DIVISION
EAST PATERSON, N. J.

20th YEAR AS PIONEER

Literature on request. Available through leading distributors. Let us quote on quantity requirements.

PLUS *complete coverage of standard FM broadcast band in addition to TV channels*

PLUS *continuous tuning action (Mallory-Ware Inductuner**) offering utmost in dependability*

PLUS *detent action for quick-click station selection*

PLUS *interchangeability — mechanically and electrically — with most switch-type tuners*

PLUS *simplest operation yet — covers all TV and FM channels — in four turns*

PLUS *dual-dial occupying same panel area as indicating devices used on most switch-type tuners*

*Trade-Mark
**RTM PRM CO., INC.

ee our complete line of electronic components at the I.R.E. show

the Volt-Ohm-Milliammeter that needs no introduction!

A RAULAND EXCLUSIVE!

New

"Tilted-Offset" Gun

WITH

INDICATOR ION TRAP

Solves one production line problem

Rauland's new Electron Gun offers two production line advantages which TV engineers have welcomed—advantages that help shave pennies off production costs and save minutes on production lines.

The superior design of Rauland's new Tilted Offset Gun eliminates one Ion Trap Magnet, cutting use of rare magnet alloy 50%. Yet, it gives better results—bending the electron beam only once and assuring maximum sharpness of focus.

Even more important is the exclusive Indicator Ion Trap which this gun features. In a matter of seconds—without even seeing the front of the picture tube—the single Ion Trap magnet is adjusted with absolute accuracy.

The magnet is simply moved until a vivid green glow on the anode tube is reduced to minimum. There is no need whatever for any equipment—any skill—any trained judgment. Actually, adjustment is made faster than test equipment could be attached.

To get the benefits that only Rauland offers, specify Rauland tubes with these exclusive advantages. For further information, write to . . .

RAULAND

The first to introduce commercially these popular features:

Tilted Offset Gun

Indicator Ion Trap

Luxide (Black) Screen

Reflection-Proof Screen

Aluminized Tube

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THE RAULAND CORPORATION

Perfection Through Research

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BALLANTINE

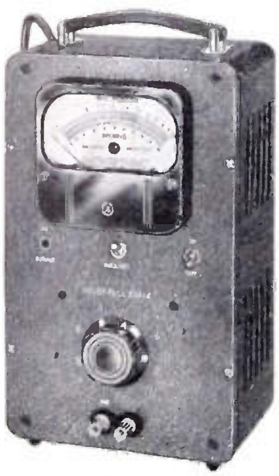
STILL THE FINEST IN ELECTRONIC VOLTMETERS

MODEL 300

MODEL 302B

MODEL 304

MODEL 305



MODEL 310A

MODEL	FREQUENCY RANGE	VOLTAGE RANGE	INPUT IMPEDANCE	ACCURACY
300	10 to 150,000 cycles	1 millivolt to 100 volts	1/2 meg. shunted by 30 mmfds.	2% up to 100 KC 3% above 100 KC
302B Battery Operated	2 to 150,000 cycles	100 microvolts to 100 volts	2 megs. shunted by 8 mmfds. on high ranges and 15 mmfds. on low ranges	3% from 5 to 100,000 cycles; 5% elsewhere
304	30 cycles to 5.5 megacycles	1 millivolt to 100 volts except below 5 KC where max. range is 1 volt	1 meg. shunted by 9 mmfds. on low ranges. 4 mmfds. on highest range	3% except 5% for frequencies under 100 cycles and over 3 megacycles and for voltages over 1 volt
305	Measures peak values of pulses as short as 3 microseconds with a repetition rate as low as 20 per sec. Also measures peak values for sine waves from 10 to 150,000 cps.	1 millivolt to 1000 volts Peak to Peak	Same as Model 302B	3% on sine waves 5% on pulses
310A	10 cycles to 2 megacycles	100 microvolts to 100 volts	Same as Model 302B	3% below 1 MC 5% above 1 MC

MODEL 220
BATTERY OPERATED DECADE AMPLIFIER gives exact voltage gains of 10 or 100, permitting a corresponding increase in voltmeter sensitivity from 10 to 100,000 cycles.

PRECISION SHUNT RESISTORS

Four different types of Precision Shunt Resistors, varying from 1 to 1000 ohms, permit the Voltmeters to be used to measure currents from 1 ampere to one-tenth of a microampere.

MULTIPLIERS

Five different types of Multipliers, whose input resistance varies from 5 to 40 megohms, permit the voltage range of the Voltmeters to be increased 10 or 100 times.

1300A

1300B

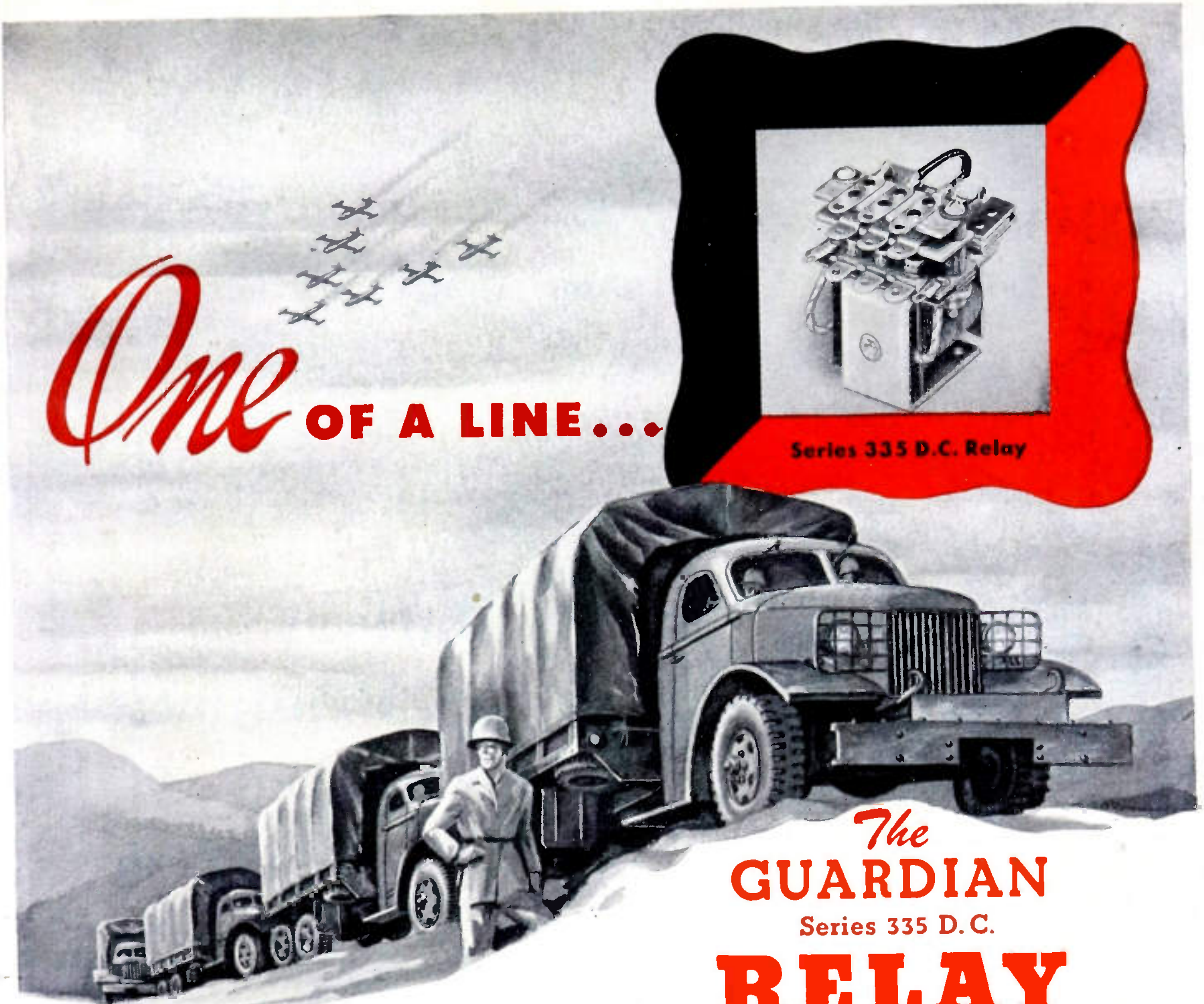
BALLANTINE pioneered circuity and manufacturing integrity assure the maximum in

SENSITIVITY • ACCURACY • STABILITY

- All models have a single easy-to-read logarithmic voltage scale and a uniform DB scale.
- The logarithmic scale assures the same accuracy at *all* points on the scale.
- Multipliers, decade amplifiers and shunts shown above extend range and usefulness of voltmeters.
- Each model may also be used as a wide-band amplifier.

For further information, write for catalog

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY,



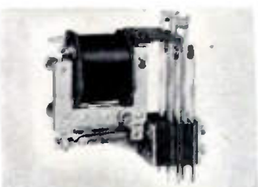
One OF A LINE...

The GUARDIAN
Series 335 D.C.
RELAY

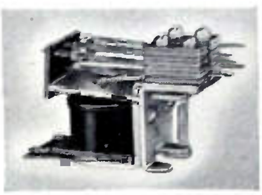
The A.N. CONNECTOR TYPE *mounting is approved by the Army and Navy as standard hermetic seal termination equipment. This type of mounting is particularly adaptable where shielded or cabled circuits are a necessity. Vibration-proof mounting with quick connect and disconnect is insured.*

Approved—distinguished by spectacular performance in truck train communications and thousands of flying echelons—The Guardian Series 335 D.C. Relay! Hermetically sealed or with conventional open and special mountings, unit offers a wide variety of applications. Series 335 D.C., built to rigorous aviation standards, meets the 10-G Vibration Test and the Mil-R-6106. Generous coil winding area permits single windings up to 15,000 ohms. Parallel and double windings available.

Maximum voltage: 220 V.D.C. Power requirement: Normal, 3½ watts. Max.-resistance standard unit: 12,000 ohms. Applicable to time delay attract up to .06 second and release up to .01 second. Contact rating: ¼" dia. silver, 12 amps. at 24 V.D.C. inductive load. Combinations up to 3 P.D.T. with 12 amp. contacts. Bakelite insulated, tested at 1500 V.—60 C.



Series 30 A.C.



Series 210 A.C.—215 D.C.

Series 220 A.C.

Series 595 D.C.

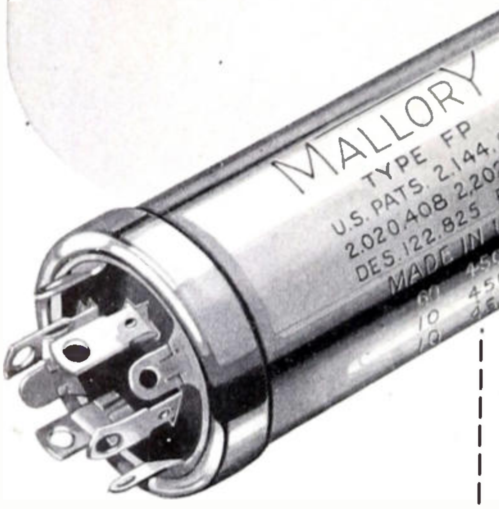
Series 610 A.C.—615 D.C.

WRITE OR WIRE... FREE CATALOG, SPECIFIC RECOMMENDATIONS, NO OBLIGATION.

GUARDIAN G ELECTRIC

1628-C W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY



Mallory Precision Production

pays off again in "shelf-life" demonstration

When you specify Mallory Capacitors for television receivers or other equipment where heat is a problem, you can be sure they will stand the test. Mallory FP Capacitors are designed to give long, trouble-free performance at 85°C.—naturally they give even longer service at normal temperatures. In addition, Mallory FP Capacitors are famous for their long shelf life. Write for your copy of the FP Capacitor Engineering Data Folder.

When a large radio and television manufacturer found it necessary to fall back on a supply of two-year-old capacitors, they found that every one of the Mallory Capacitors was ready for immediate use—without re-working of any kind. Because of the scrupulously careful manufacturing methods pioneered by Mallory, they were completely free of corrosion.

Mallory Capacitors have consistently set new high standards of dependability which far exceed normal specifications.

That's service beyond expectations!

P.R. MALLORY & CO., Inc.

MALLORY

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

SERVING INDUSTRY WITH

Electromechanical Products
Resistors *Switches*
TV Tuners *Vibrators*

Electrochemical Products
Capacitors *Rectifiers*
Mercury Dry Batteries

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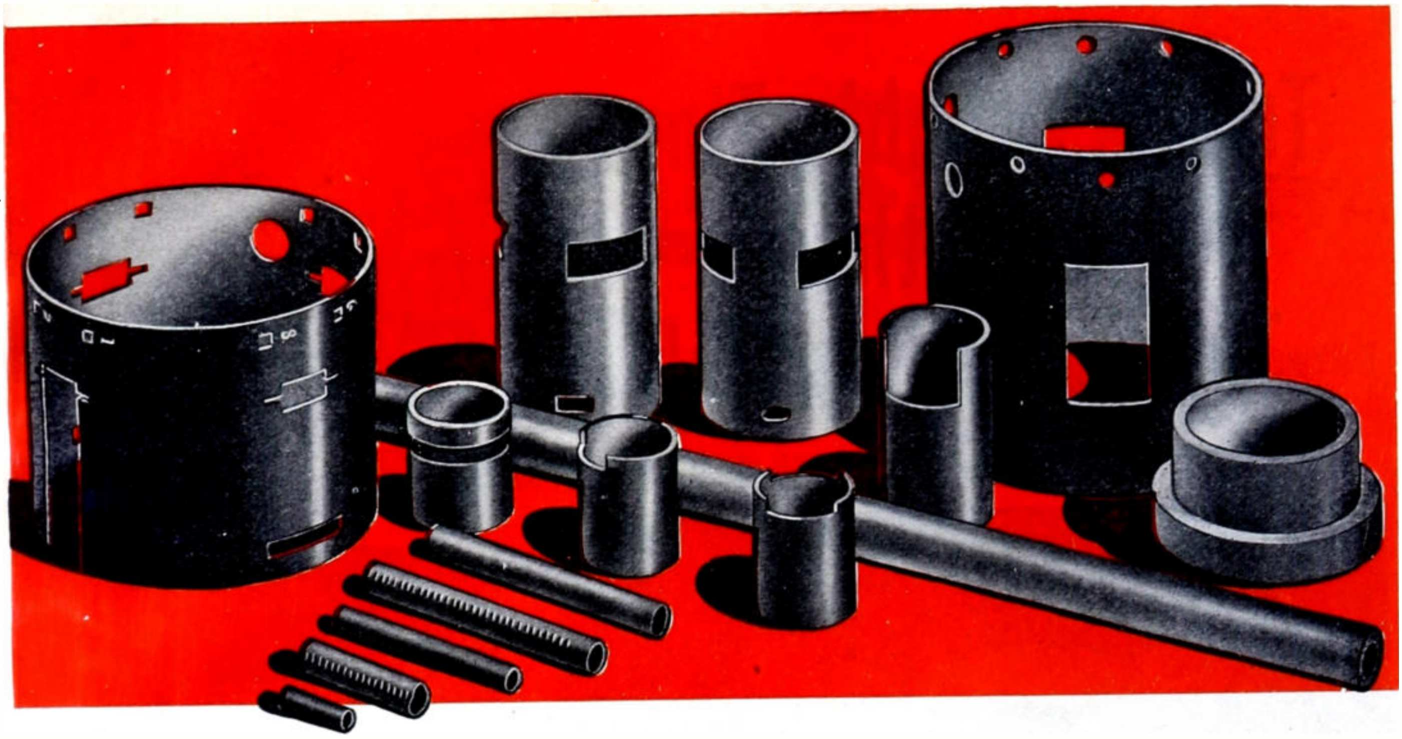
Welding Materials



CLEVELITE* and COSMALITE*

PHENOLIC TUBING

Why Pay More?

ALSO USED WIDELY BY MANUFACTURERS OF ELECTRICAL EQUIPMENT . . . FOR ITS HIGH DIELECTRIC STRENGTH . . . LOW MOISTURE ABSORPTION . . . STRENGTH, LOW LOSS AND GOOD MACHINEABILITY.

AVAILABLE IN DIAMETERS, WALL THICKNESSES AND LENGTHS TO MEET ENDLESS SPECIAL OR NEW ADAPTATIONS.

INQUIRIES ARE GIVEN IMMEDIATE ATTENTION.

ASK FOR SAMPLES

AS EXHIBITED AT THE
Radio Engineering Show
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Our Booth #207
March 19-22 1951

Meets the Most Exacting Specifications!

— • • • —

A Grade for Every Need:

CLEVELITE

Grade E . . . . Improved post cure fabrication and stapling.
Grade EX . . . . . . Special grade for TV deflection yoke sleeve.
Grade EE . . . . . . Improved general purpose.
Grade EEX . . . . . Superior electrical and moisture absorption properties.
Grade EEE . . . . . Critical electrical and high voltage applications.
Grade XAX . . . . Special grade for government phenolic specifications.

COSMALITE

Grade SP . . . . . . Post cure fabrication and stapling.
Grade SS . . . . . . General purpose.
Grade SSP . . . . . General purpose—punching grade.
Grade SLF . . . . . Thin wall tubing—high dielectric and compression strength.

CLEVELAND PHENOLIC TUBING

THE FIRST CHOICE OF THE RADIO AND TELEVISION INDUSTRIES.
EXCELLENT SERVICE AND PROMPT DELIVERIES ASSURED.

* Trade Marks

The CLEVELAND CONTAINER Co.
6201 BARBERTON AVE. CLEVELAND 2, OHIO

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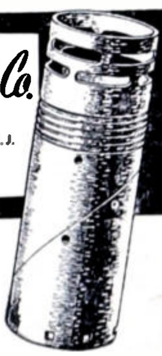
ABRASIVE DIVISION at Cleveland, Ohio
CANADIAN PLANT: The Cleveland Container, Canada, Ltd., Prescott, Ontario



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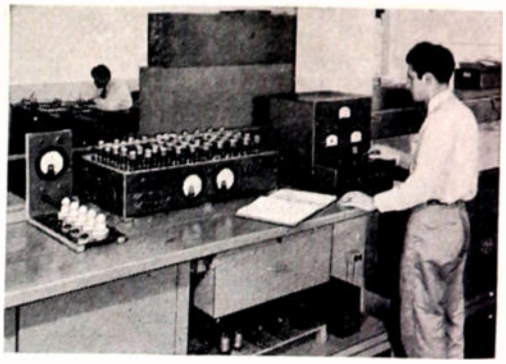
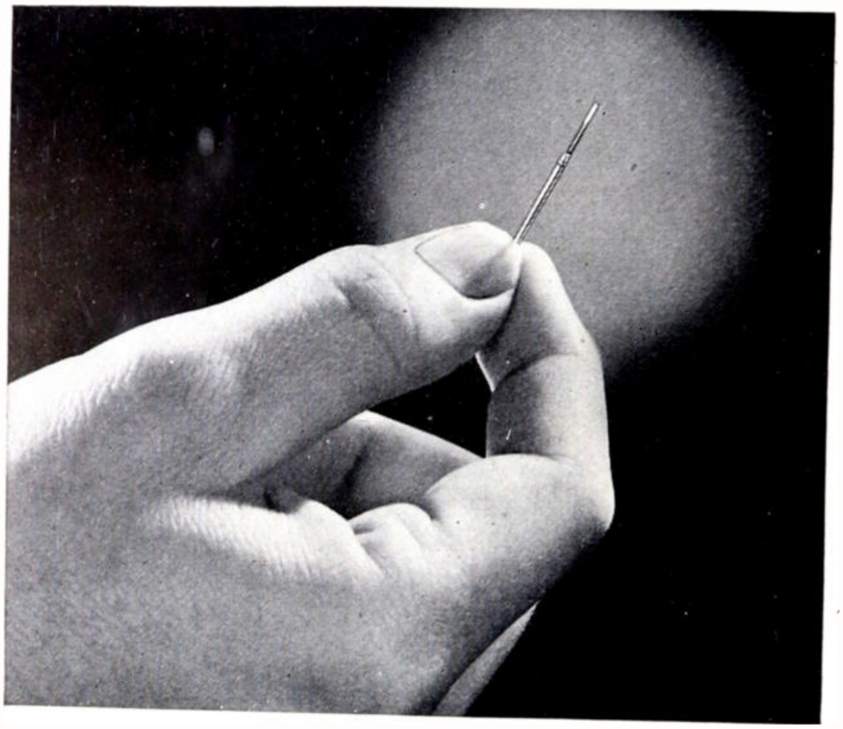
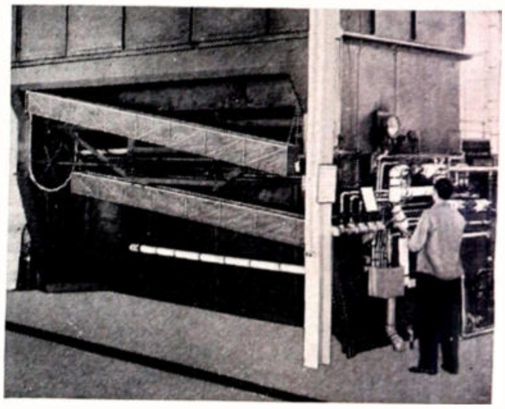
NEW ENGLAND	R. S. PETTIGREW & CO., 968 FARMINGTON AVE. WEST HARTFORD, CONN.
CANADA	WM. T. BARRON, EIGHTH LINE, RR #1, OAKVILLE, ONTARIO

Trim Assembly Time with the Tube with the Tab



Electronic Engineering — Life test rack and emission test set. Checking Superior assembled standard diodes under simulated customer conditions to determine if material meets minimum requirements.





To guard against contamination by processing lubricants, Superior tubing is thoroughly degreased before each annealing operation.

Part of inspection procedure on Lockseam Nickel Cathodes as they come off the production machine. Each cathode must undergo many rigid tests before being approved.

● Superior's pioneering in tubing technology is constantly at work to bring electronic manufacturers new developments—to help them produce better equipment, faster, at lower costs. Newest of these improvements is the integral tabbed round Lockseam* cathode. It is designed to eliminate a welding operation, cut assembly time, and provide superior performance.

These integral tabbed round Lockseam* cathodes may be valuable to you . . . but whether they are or not one thing is sure. If you use Seamless or Lockseam* cathodes in your product a Superior tube is available to do a Superior job. Our research and engineering facilities are ready at all times to help solve your tubing problems.

For more information about Superior Tubing and its possible place in your operation write to Superior Tube Co., 2500 Germantown Ave., Norristown, Pa.

Which Is The Better For Your Product . . .

SEAMLESS . . . ? The finest tubes that can be made. Standard production is .010″ to .121″ O.D. inclusive, with wall thicknesses of .0015″ to .005″. Cathodes with larger diameters and heavier walls will be produced to customer specification.

Or LOCKSEAM*. . . ? Produced directly from thin nickel alloy strip stock. .040″ to .100″ O.D. in standard length range of 11.5 mm to 12 mm. Round, rectangular or oval, cut to specified lengths, beaded or plain.

Superior

THE BIG NAME IN SMALL TUBING

All analyses .010″ to ⅝″ O.D.
Certain analyses (.035″ max. wall) Up to 1⅝″ O.D.

**Mfd. under U. S. Pats.—SUPERIOR TUBE COMPANY • Electronic Products for export through Driver-Harris Company, Harrison, New Jersey.*

HERMETICALLY SEALED

SOLA *Constant Voltage* TRANSFORMERS

FOR USE ON MIL-T AND JAN PROJECTS

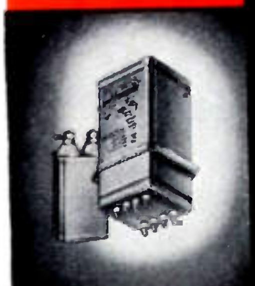
The patented SOLA Constant Voltage Principle provides the following advantages over ordinary transformer design: regulation within ±1% with total primary variations as great as 30% . . . automatic, instantaneous regulation . . . freedom from moving parts, maintenance and manual adjustments . . . self-protection against short circuit. They are available in a complete range of capacities and special types (such as frequency compensated or with harmonic filter).

Today's complex electrical and electronic defense equipment requires unfailing accuracy and dependability under extreme conditions of humidity, heat, mechanical shock and other adverse conditions. To meet those needs SOLA voltage regulators can be provided in hermetically sealed housings which conform to defense specifications for grades 1, 2 or 3 hermetic sealing. Splash proof design housings are provided for large units where hermetic sealing is not feasible.

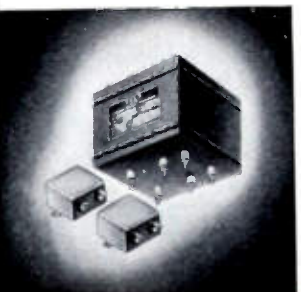
SOLA Constant Voltage Transformers were widely employed during World War II wherever continuous precision performance of electrical and electronic units was mandatory. Typical defense applications include: observation and fire-control, radar, omni-directional ranges and other navigation aids, X-ray equipment, flight and navigation trainers, and photo-electric devices.

SOLA Constant Voltage Transformers are made under one or more of the following Patents: 2,143,745; 2,212,198; 2,346,621.

Often the precise voltage input upon which a device's design was predicated is not available. Yet, input voltage level must continuously meet design requirements for satisfactory performance. You can guarantee optimum performance for your unit by stabilizing input voltage with a SOLA Constant Voltage Transformer.



Typical types of Hermetically Sealed SOLA Constant Voltage Transformers



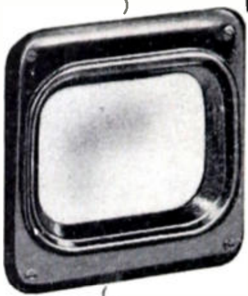
The engineers and sales representatives of the SOLA Electric Company will be glad to discuss the application of SOLA Constant Voltage Transformers to your specific requirements. Your phone call or letter will receive our prompt attention.

See the standard SOLA regulators and many new developments at Booth Number 21, I.R.E. Radio Engineering Show in New York.

SOLA *Constant Voltage* TRANSFORMERS

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC COMPANY, 4633 W. 16th Street, Chicago 50, Illinois

SPEED UP



SPECTRUM ANALYSIS from AF to UHF with Easier-to-Use PANORAMIC INSTRUMENTS

You'll collect data more quickly, simply, objectively . . . with the help of Panoramic instruments. Unexcelled for laboratory, research and production applications requiring spectrum or waveform analysis.

Spectral components are seen graphically on a cathode-ray tube as sharp vertical reflections distributed horizontally in order of frequency. Deflection height directly indicates component or signal level.

Whatever your problem—analyzing waveform distortions, noises, characteristics of AM, FM or pulsed signals, vibrations, spurious oscillations or modulation, response characteristics of filters or transmission lines or monitoring many frequency channels simultaneously—you'll find a Panoramic analyzer to answer your needs.

● *Complete Display of these and other Panoramic instruments in operation at the*

IRE SHOW
BOOTH N-6

SPECTRUM ANALYSIS FROM AF TO UHF
with easier-to-use
PANORAMIC INSTRUMENTS

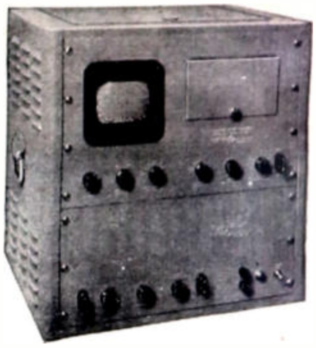
PANORAMIC SONIC RESPONSE INDICATOR G-2
for More Accurate Frequency Response Measurement

Used with Model AP-1, the G-2 allows visual inspection of the amplitude vs. frequency characteristic of systems in the range between 40 and 20,000 cps. May be used for research, development or production line testing of frequency response characteristic of amplifiers, speakers, filters, transmission lines, receivers.

The G-2 is advantageous for study of systems in which the presence of noise or non-fundamental components obscure or distort the output at the exploring frequency.

- Calibrated log frequency scale
- Linear or log (60 db range) amplitude scale
- Slow, 1 cps sweep rate
- 10-step attenuator with 100 db range selects output voltages between 50 microvolts and 5 volts
- *3 selectable output impedances; 100 ohms; 500 ohms; 3000 ohms*

PANORAMIC SONIC ANALYZER, MODEL AP-1
Automatic Waveform Analysis in Only 1 Second

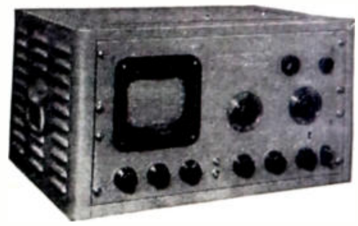


Here is your answer for truly simple high speed analysis of vibrations, harmonics, noises, acoustics and intermodulation under static or dynamic conditions. AP-1 automatically separates and measures frequency and magnitude of complex audio wave components.

Frequency Range	40-20,000 cps, log scale
Input Voltage Range	500uV-500V
Voltage Scale	Linear and two decade Log
Resolution	Optimum throughout frequency range

Presentations easily photographed or recorded. Can be calibrated for determining level of individual sound or vibrational components.

PANORAMIC ULTRASONIC ANALYZER, MODEL SB-7
A New Direct Reading Spectrum Analyzer

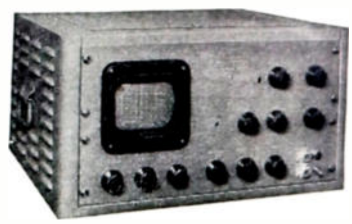


An invaluable instrument for channel monitoring, telemetering, medical studies, and for investigating ultrasonic waveform content and ultra audible noises and vibrations, the SB-7 allows overall observation of a 200KC wide band or highly detailed examination of selected narrow bands.

Frequency Range: 2KC-300KC, linear scale
Scanning Width: Continuously variable, 200KC to zero
Amplitude Scale: Linear and two decade Log.
Input Voltage Range: lmV-50V

Resolution: Continuously variable from 2KC to better than 500 CPS.

PANADAPTOR, SA-8 PANALYZOR SB-8
For RF Spectrum Analysis where Maximum Resolution is a "Must"



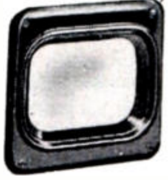
Available in several types with maximum scanning widths ranging from 200 KC to 10 MC, both the SA-8 and SB-8 feature . . .

- Continuously Variable Resolution from 100KC to 100cps
- Synchronous and Non-synchronous Scanning
- Long Persistence Displays plus Intensity Grid Modulation for Analysis of Pulsed RF Signals
- Continuously Variable Scanning Width from Maximum to Zero

PANADAPTOR SA-3, SA-6 PANALYZOR SB-3, SB-6
For General RF Spectrum Analysis

Recognized as the fastest and simplest means of investigating and solving such RF problems as frequency stability, modulation characteristics, oscillations, parasitics and monitoring under static or dynamic conditions, these models are available in over a dozen different types, designed to meet your particular application. Panadaptor units operate with superheterodyne receivers which tune in the spectrum segment to be observed.

PANORAMIC RADIO PRODUCTS INC.



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WRITE TODAY FOR COMPLETE SPECIFICATIONS AND PRICES.

FERRAMIC

Cores

by

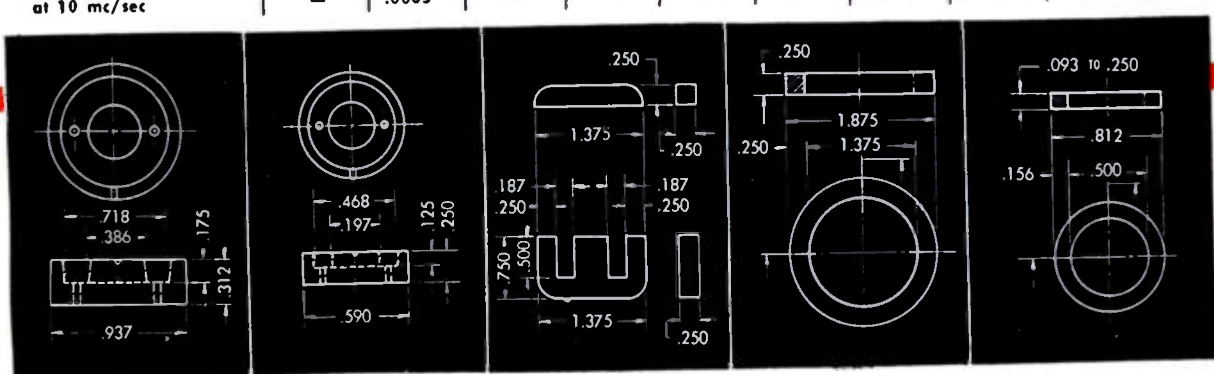
GENERAL CERAMICS

Ferramics are soft magnetic materials featuring:

HIGH PERMEABILITY
HIGH VOLUME RESISTIVITY
HIGH EFFICIENCY
LIGHT WEIGHT
ELIMINATE LAMINATIONS

TYPE OF FERRAMIC MATERIAL

PROPERTY	UNIT	A 34	B 90	C 159	D 216	E 174	G 254	H 419	I 141	J 472
Initial permeability at 1mc/sec	–	15	95	220	410	750	410	850	600	330
Maximum permeability	–	97	183	710	1030	1710	3300	4300	1010	750
Saturation flux density	Gauss	840	1900	3800	3100	3800	3200	3400	1540	2900
Residual magnetism	Gauss	615	830	2700	1320	1950	1050	1470	660	1600
Coercive force	Oersted	3.7	3.0	2.1	1.0	0.65	0.25	0.18	0.40	.80
Temperature coefficient of initial permeability	%/°C.	0.65	0.04	0.4	0.3	0.25	1.3	0.66	0.3	0.22
Curie point	°C.	280	260	330	165	160	160	150	70	180
Volume resistivity	Ohm-cm	$1x10^9$	$2x10^5$	$2x10^3$	$3x10^7$	$4x10^5$	$1.5x10^8$	$1x10^4$	$2x10^5$	–
Loss Factor: at 1 mc/sec	–	–	.00016	.00007	.00005	.00008	.00008	.00030	.0003	.000055
at 5 mc/sec	–	.0004	.0011	.0008	.0012	.002	.00075	.00155	.005	–
at 10 mc/sec	–	.0005	–	–	--	–	.0017	.00275	–	–



BOOTH 47 at the IRE SHOW

GENERAL CERAMICS and STEATITE CORP.

GENERAL OFFICES and PLANT: KEASBEY, NEW JERSEY

MAKERS OF STEATITE, TITANATES, ZIRCON PORCELAIN, FERRAMICS, LIGHT DUTY REFRACTORIES, CHEMICAL STONEWARE, IMPERVIOUS GRAPHITE

Mr. Manufacturer:

To get the best delivery on OHMITE resistance components, tailor your needs to these "standard" OHMITE items...

RHEOSTATS

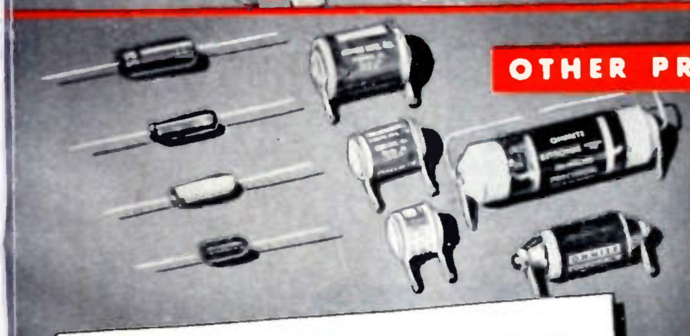
The Ohmite series of standard, close control rheostats is the most extensive available—so it is easy to select a size to fit your application. There are ten sizes, ranging from 25 to 1000 watts, with many standard resistance values in each size. All models have the Ohmite all-ceramic construction, with winding permanently locked in vitreous enamel, and smoothly gliding metal-graphite brush.

RESISTORS

The extensive range of Ohmite types and sizes makes possible an almost endless variety of standard resistors to meet your needs. The Ohmite line includes more than 60 core sizes, in a wide range of wattage and resistance values. There are also 18 types of resistor terminals available. Included in the standard Ohmite line are fixed, adjustable, tapped, non-inductive, and precision resistors. Specially developed vitreous enamel provides years of unfailing performance.

TAP SWITCHES

Ohmite tap switches are supplied in five standard models, rated at 10, 15, 25, 50, and 100 amperes, a.c. They combine high current capacity and a large number of taps with unusual compactness. Their sturdy, one-piece ceramic bodies provide permanent non-arcing insulation. Their heavy silver-to-silver contacts have a self-cleaning action and provide continuous, dependable contact with low resistance. Ohmite tap switches are supplied in enclosed or open, shorting or non-shorting types.



OTHER PRODUCTS

Ohmite offers an extensive line of standard precision, non-inductive resistors in ½- and 1-watt sizes, in the standard type, vitreous-enameled type, or hermetically sealed in glass. They have an accuracy of ±1%. Ohmite non-inductive vitreous enameled resistors are also available in standard 50-, 100-, and 160-watt sizes in a wide range of resistance values. In addition, Ohmite provides radio-frequency plate chokes, power line chokes, and dummy antennas.

Write ON COMPANY LETTERHEAD FOR CATALOG AND ENGINEERING MANUAL NO. 40

Be Right with **OHMITE**®

OHMITE MFG. CO., 4862 Flournoy St., Chicago 44, Ill.

RHEOSTATS • RESISTORS • TAP SWITCHES

To: PRIME CONTRACTORS and SUB CONTRACTORS on GOVERNMENT WORK . .

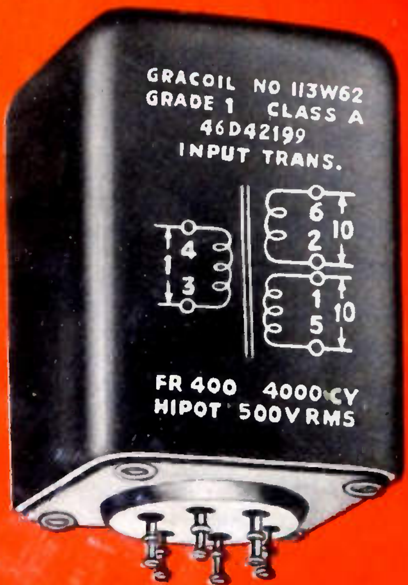
Invitation

TO RECEIVE A

PRODUCTION SAMPLE *Transformer*

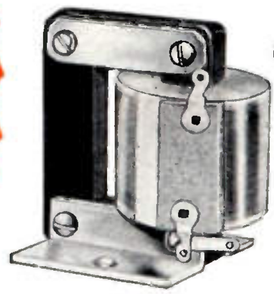
BUILT TO YOUR SPECIFICATIONS

this is our offer to you . . .



WE WILL, without cost or any obligation whatever, design a PRODUCTION SAMPLE transformer (hermetically sealed to JAN-T-27 or MIL-T-27 Government specifications), or open type construction, if unit is to be used for awarded prime or sub-contract work. Our approach stresses quality of product, efficiency in service and an alertness to techniques that discard the old for more functional methods.

James M. Blacklidge
PRESIDENT



SEND YOUR B/P SPECIFICATIONS

GRAMER
TRANSFORMER
CORPORATION
2734 N. PULASKI ROAD • CHICAGO 39, ILLINOIS

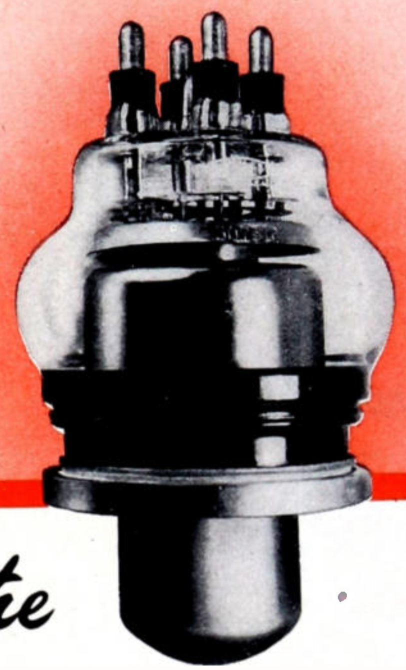
If you use the 880 you will get

BETTER PERFORMANCE

LOWER OPERATING COSTS

and LONGER LIFE . . .

. . . with the



ML-5658

THE ML-5658 is an improved and directly interchangeable version of the widely used 880. Designed originally as a better, more rugged tube for electronic heating equipment, it has since found extensive use in the high power broadcast field and in such exacting applications as cyclotron and synchrotron oscillators.

The ML-5658 incorporates in its design many of the outstanding features developed by Machlett Laboratories for all its industrial tubes. Typical of these design and process improvements which have given broadcast and industry better, more dependable tubes are:

1. Kovar-to-glass seals. The elimination of the inherently weak feather-edged copper seal —increasing seal strength and providing greater stability of the internal electrode structure.

2. An improved, stress-free, self-supporting filament structure which substantially eliminates filament distortion, provides uniform filament emission throughout tube life and reduces the complexity and the hazards of the older spring-supported filament construction.

3. A unique pre-exhaust treatment of all parts and the thorough, high voltage exhaust of each tube on Machlett's special high voltage, high temperature exhaust system.*

These, and many other improvements in tube design and processing, provide for every installation which uses or contemplates the use of an 880 type tube, a far more rugged longer lived tube in the ML-5658. It will directly replace the 880 with *no* electrical or mechanical changes and will provide better performance, longer tube life and more economical operation.

The ML-5658, like other Machlett industrial tubes, is available with the Machlett automatic seal water jacket.† This new jacket eliminates the use of tools and the hazard of tube breakage and water leakage. The jacket cannot be opened unless the water pressure is off, nor closed unless the tube is properly installed.

Complete technical data on both tube types is available upon request. Write direct to Machlett Laboratories, Inc., Springdale, Connecticut.

* Patent No. 2,324,559. † Patent applied for.

Westrex

Export Distributor

Distributed by GraybaR

Machlett Industrial and Broadcast Tubes will be exhibited at the 1951 I.R.E. Show

Booth 96-97

OVER 50 YEARS OF ELECTRON TUBE EXPERIENCE

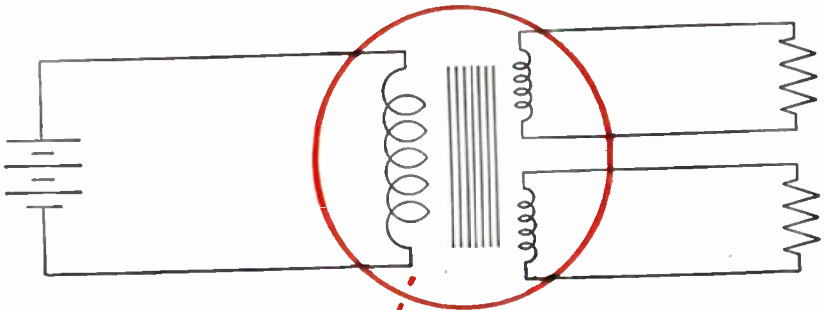
MACHLETT

What to see at the Radio Engineering Show

(Continued from page 27A)

Firm	Booth
Hugh H. Eby, Inc., Philadelphia, Pa. Radio, television, and electronic components.	346
Eitel-McCullough, Inc., San Bruno, Calif. New transmitting type vacuum tubes for CW and pulse services, including the 4W20,000A power tetrode capable of 20 kw peak output in TV service on channel 13.	36
Electric Motor Corp., Division of Howard Industries, Inc., Racine, Wis. Represented by Wally Swank	221
Electrical Industries, Inc., Newark, N.J. Hermetic Seals, glass-to-metal sealed terminals and multiple headers for hermetically sealing transformers, relays, guided missiles, and electronic equipment in general.	212
Electrical Reactance Corp., Franklinville, N.Y. Hi-Q ceramic capacitors, trimmers, choke coils, wire wound resistors.	63
Electronic Associates, Inc., Long Branch, N.J. Plotting boards, precision recording of X vs Y etc., on the "Variplotter Models" 205B and 205C, secondary time standards, UHF generating equipment, function generating equipment, sine-cosine potentiometers to specification, and introducing an automatic curve follower which will follow a previously drawn or plotted line to an approximate accuracy of one tenth of one percent of full scale.	98, 99
Electronic Instrument Co. Inc., Brooklyn, N.Y. Testing and measuring equipment, Eico Multi-Analyst electron tracer.	362
Electronic Measurements Co., Eatontown, N.J. Power supplies, voltage regulated output types.	N-4
Electronic Mechanics, Inc., Clifton, N.J. Glass bonded mica (or) "Mykroy" also "Teflon," and "Kel-F." We mold, extrude and fabricate the above.	328
Electronic Tube Corp., Philadelphia, Pa. Model H42A Strainalyzer, an improved four channel cathode-ray dynamic strain recorder. Cathode-ray tubes, multi-gun, standard, and special purpose. Oscilloscopes, cathode-ray multi-channel. Amplifiers, dc. Electronic equipment, special design.	274, 275
El-Tronics, Inc., Philadelphia, Pa. Nuclear measurement equipment.	379
Empire Devices, Inc., Bayside, L.I., N.Y. UHF impulse generator, controlled impulse, less than 0.001 microsecond, flat to 1,000 Mc. Resistive attenuators and terminations of low VSWR to 4,000 Mc. Noise and field intensity meter, 20 to 400 Mc incorporating standard impulse noise source, slideback and meter indication, true peak measurements. Broadband VHF and UHF crystal mixers.	349
Engineering Research Associates, Inc., St. Paul, Minn. Magnetic storage systems.	304
Erie Resistor Corp., Erie, Pa. Erie Ceramicons, ceramic trimmers, button silver mica capacitors and electronic sub-assemblies.	91
Fairchild Camera & Instrument Corp., Jamaica, L.I., N.Y. Precision linear and non-linear potentiometers. Oscillo-record cameras, Fairchild-Polaroid oscilloscope cameras.	238, 239
Federal Telecommunication Laboratories, Nutley, N.J. Electronic test equipment.	34
Federal Telephone & Radio Corp., Clifton, N.J. Transmitting, industrial, and rectifier tubes, TV picture tubes, selenium rectifiers, high frequency cables, and mobile radiotelephone equipment.	33

(Continued on page 126A)



a DC transformer?

Certainly...

Bendix Specialized Dynamotors are made for the Job!

Whenever DC power is required at other than the supply voltage, Bendix* Specialized Dynamotors function as DC transformers. They can be wound for any input or output voltage between 5 and 1200 volts, and they can deliver power up to 500 watts. Multiple outputs can be supplied to correspond with several secondaries on transformers, and their output voltages can be regulated within close limits regardless of input voltage or load variations. Bendix Specialized Dynamotors are tailored to the exact requirements of each application by the design of the windings used in standardized frames. This reduces the cost, size and weight to an absolute minimum, consistent with the operational requirements. Compliance with Government specifications is assured by the choice and treatment of materials and the basic design. *A complete description of your requirements will enable our engineers to make concrete recommendations . . . All orders are filled promptly and at moderate cost.*

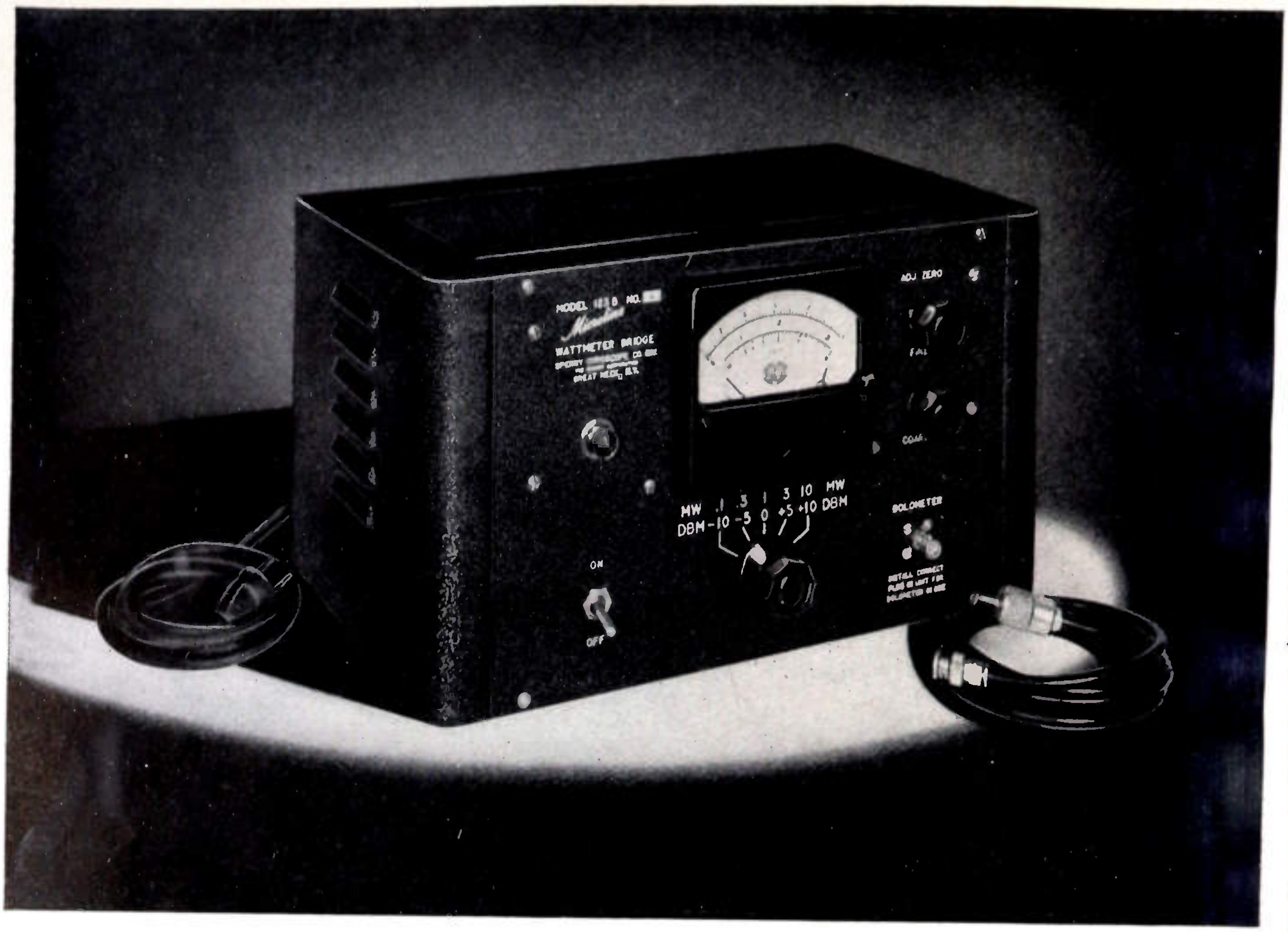
*REG. U. S. PAT. OFF.

RED BANK DIVISION OF
BENDIX AVIATION CORPORATION
RED BANK, NEW JERSEY
Export Sales: Bendix International Division, 72 Fifth Avenue, N. Y. 11, N. Y.

Write for this colorful and informative book—it's free. You'll find it loaded with facts and figures about all types of dynamotors.

RED BANK DIVISION

Bendix AVIATION CORPORATION



ACCURACY AND FLEXIBILITY WITH NEW WATTMETER BRIDGE

Another addition to Sperry's complete line of microwave test and measuring equipment, *Microline*, is a new, highly-accurate Wattmeter Bridge. Model 123B is extremely versatile and will not be made obsolete by future requirements in bolometer operating resistance.

► With accuracy to which power dissipated in the bolometer element can be measured to ± 3% of the full scale reading, this meter is capable of operation with either thermistor or barretter. This is possible by the selection of the proper plug-in unit (listed in table at right).

► Model 123B is calibrated in both milliwatts and DBM. Five power ranges are available 0-0.1, 0.3, 1.0, 3.0 and 10.0 milliwatts. Pulse power, as well as c-w power, can be measured with this bridge and appropriate bolometers.

► Write our Special Electronics Department for further details.

Model 123B Wattmeter Bridge is supplied with any one of the following plug-in units:

200B for 200 ohm barretter operation

125B for 125 ohm barretter operation

200T for 200 ohm thermistor operation

135T for 135 ohm thermistor operation

100T for 100 ohm thermistor operation

Visit our booths 57-58-59 at the Radio Engineering Show, March 19-22.

SPERRY GYROSCOPE COMPANY

DIVISION OF THE SPERRY CORPORATION, GREAT NECK, NEW YORK · CLEVELAND · NEW ORLEANS · NEW YORK · LOS ANGELES · SAN FRANCISCO · SEATTLE

OVER **90%** of the TRANSMISSION MEASURING SETS Used Today Are Made by

DAVEN

Not only is the Daven Company the largest supplier of transmission measuring sets, but it is also a source for every needed type of instrument for the measurement of the transmission characteristics of communication systems. It furnishes units to check all types of broadcast equipment and audio devices for commercial and industrial use as well as for organizations such as utilities, telephone and power companies. Therefore, whatever your requirements are in this field, write to Daven for complete catalog material, and outline your own particular problems for specific assistance from our engineering staff.

DAVEN TRANSMISSION MEASURING SET 7A

Equipment specially designed for use by utilities, telephone and power companies. May be directly applied to measuring gains or losses through amplifiers, repeaters, attenuating networks or communication lines.

TRANSMISSION SECTION

GENERATED FREQUENCIES: 500, 1000, 2500 cycles per second.
OUTPUT LEVEL: –13, 0, +4 and +10 dbm.
INPUT and OUTPUT IMPEDANCE: 600 ohms over entire frequency range.

RECEIVING SECTION

FREQUENCY RESPONSE: Within ±1.0 db from 50 to 15,000 cps.
AMPLIFICATION RANGE: –10 to +30 db in 2 db steps.

DAVEN TRANSMISSION MEASURING SET 11A

A moderately priced instrument for broadcast equipment. A simplified, accurate, direct reading instrument, designed to make measurements in accordance with FCC regulations.

FREQUENCY RANGE: 20 CY to 20 Kc.
ACCURACY: ±0.1 db, 20 CY to 20 Kc.
RANGE OF LEVEL:
+ 4 to –110 db }
–10 to –124 db } in steps of 0.1 db.

APPLICATIONS:
(a) Audio gain and loss measurements.
(b) Measurements of matching and bridging devices.
(c) Complex circuit measurements.
(d) Measuring mismatch loss.
(e) Frequency response measurements.

THE DAVEN CO.

195 CENTRAL AVENUE • NEWARK 4, NEW JERSEY

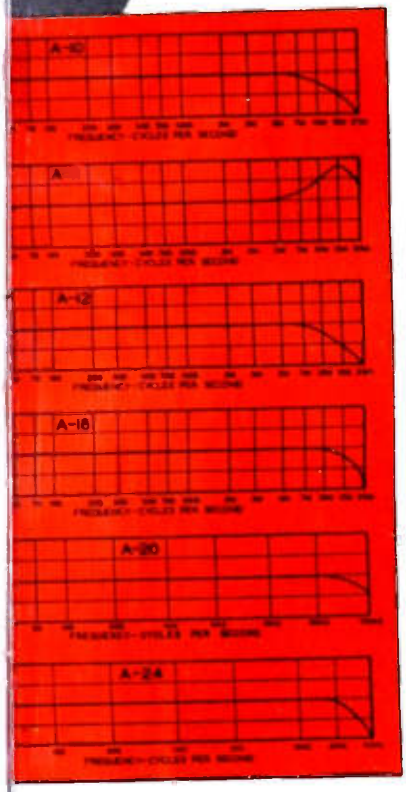
Visit Daven at the I.R.E. SHOW Booths 94B and 95.

ULTRA COMPACT UNITS...OUNCER UNITS

HIGH FIDELITY . . . . SMALL SIZE . . . . FROM STOCK

UTC Ultra compact audio units are small and light in weight, ideally suited to remote amplifier and similar compact equipment. High fidelity is obtainable in all individual units, the frequency response being ± 2 DB from 30 to 20,000 cycles.

True hum balancing coil structure combined with a high conductivity die cast outer case, effects good inductive shielding.



Type No.	Application	Primary Impedance	Secondary Impedance	List Price
A-10	Low impedance mike, pickup, or multiple line to grid	50, 125/150, 200/250, 333, 500/600 ohms	50 ohms	$15.00
A-11	Low impedance mike, pickup, or line to 1 or 2 grids (multiple alloy shields for low hum pickup)	50, 200, 500	50,000 ohms	16.00
A-12	Low impedance mike, pickup, or multiple line to grids	50, 125/150, 200/250, 333, 500/600 ohms	80,000 ohms overall, in two sections	15.00
A-14	Dynamic microphone to one or two grids	30 ohms	50,000 ohms overall, in two sections	14.00
A-20	Mixing, mike, pickup, or multiple line to line	50, 125/150, 200/250, 333, 500/600 ohms	50, 125/150, 200/250, 333, 500/600 ohms	15.00
A-21	mixing, low impedance mike, pickup, or line to line (multiple alloy shields for low hum pickup)	50, 200/250, 500/600	50, 200/250, 500/600	16.00
A-16	Single plate to single grid	15,000 ohms	60,000 ohms, 2:1 ratio	13.00
A-17	Single plate to single grid 8 MA unbalanced D.C.	As above	As above	15.00
A-18	Single plate to two grids. Split primary	15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio	14.00
A-19	Single plate to two grids 8 MA unbalanced D.C.	15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio	18.00
A-24	Single plate to multiple line	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	15.00
A-25	Single plate to multiple line 8 MA unbalanced D.C.	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	14.00
A-26	Push pull low level plates to multiple line	30,000 ohms plate to plate	50, 125/150, 200/250, 333, 500/600 ohms	15.00
A-27	Crystal microphone to multiple line	100,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	15.00
A-30	Audio choke, 250 henrys @ 5 MA 6000 ohms D.C., 65 henrys @ 10 MA 1500 ohms D.C.			10.00
A-32	Filter choke 60 henrys @ 15 MA 2000 ohms D.C., 15 henrys @ 30 MA 500 ohms D.C.			9.00

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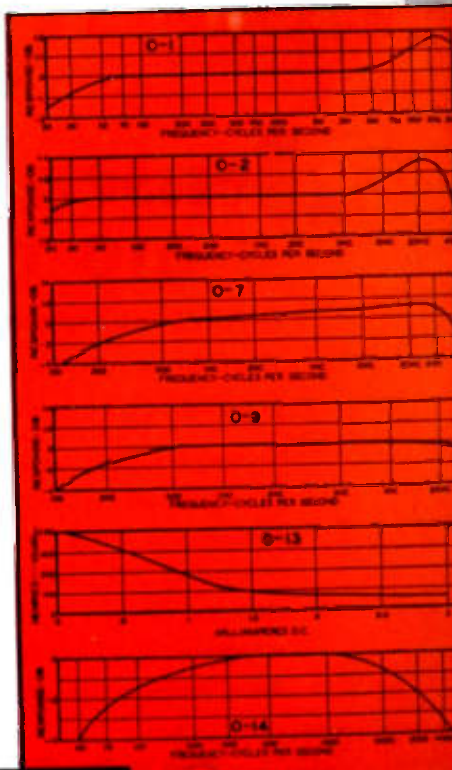
Type No.	Application	Pri. Imp.	Sec. Imp.	List Price
0-1	Mike, pickup or line to 1 grid	50, 200/250 500/600	50,000	$13.25
0-2	Mike, pickup or line to 2 grids	50, 200/250 500/600	50,000	13.25
0-3	Dynamic mike to 1 grid	7.5/30	50,000	12.00
0-4	Single plate to 1 grid	15,000	60,000	10.50
0-5	Plate to grid, D.C. in Pri.	15,000	60,000	10.50
0-6	Single plate to 2 grids	15,000	95,000	12.00
0-7	Plate to 2 grids, D.C. in Pri.	15,000	95,000	12.00
0-8	Single plate to line	15,000	50, 200/250, 500/600	13.25
0-9	Plate to line, D.C. in Pri.	15,000	50, 200/250, 500/600	13.25
0-10	Push pull plates to line	30,000 ohms plate to plate	50, 200/250, 500/600	13.25
0-11	Crystal mike to line	50,000	50, 200/250, 500/600	13.25
0-12	Mixing and matching	50, 200/250	50, 200/250, 500/600	12.00
0-13	Reactor, 300 Hys.—no D.C.; 50 Hys.—3 MA. D.C.		6000 ohms	9.50
0-14	50:1 mike or line to grid	200	½ megohm	13.25
0-15	10:1 single plate to grid	15,000	1 megohm	13.25



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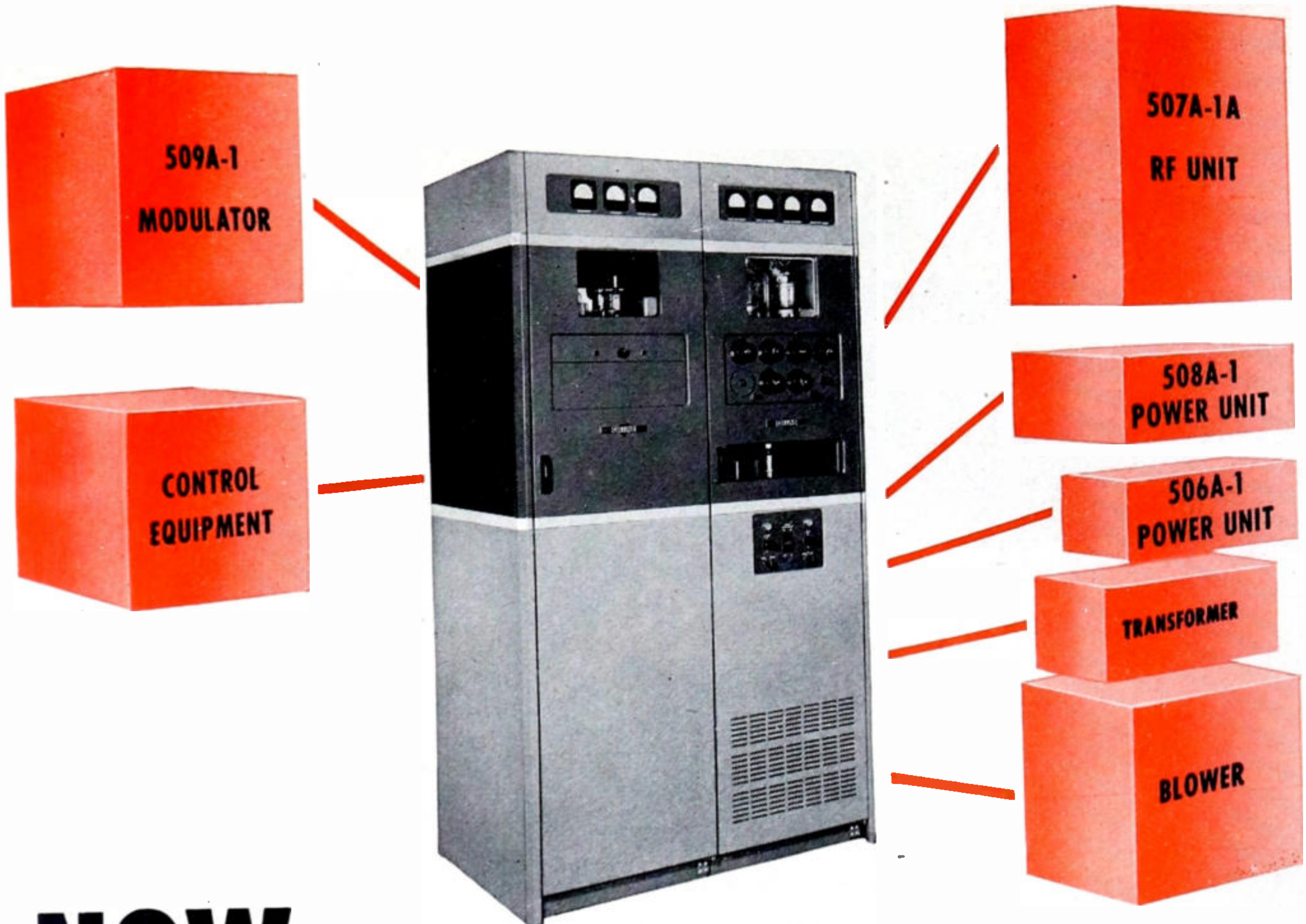

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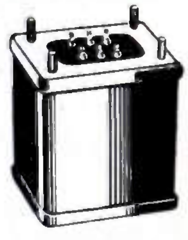

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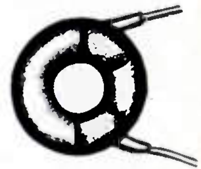

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Chairmen of Recently Formed IRE Sections

Palmer H. Craig

MIAMI SECTION

Palmer H. Craig, Chairman of the Miami Section, was born on January 10, 1901 at Cheviot, Ohio. He was graduated with honors from the University of Cincinnati in 1923 with the B.A. degree, and received the M.A. degree in 1924 and the Ph.C. degree in 1926.

Dr. Craig, who has had wide experience as a teacher, research physicist, and consulting engineer, has been affiliated with the University of Florida as head of the department of electrical engineering. He was supervisor of the War Research Laboratory of the University during the years 1943–1946, and chief engineer of radio station WRUF at Gainesville. He was also radio supervisor of the State of Florida under the Federal E.S.M.W.T. program.

He is presently director of Electronics Research Laboratory, and has been professor of engineering of the University of Miami, Coral Gables, Fla., since 1947.

Mr. Craig is also a member of the American Physical Society, the American Society for Engineering Education, and a Fellow of the American Institute of Electrical Engineers. The inventor of many electronics devices, he holds numerous patents, and is a registered professional engineer.

Robert E. Moe

EVANSVILLE-OWENSBORO SECTION

Robert E. Moe, Chairman of the recently formed Evansville Owensboro Section, was born in Appleton, Wis., on April 2 1912. He was graduated from the University of Wisconsin in 193. with the B.S. degree in electrical engineering.

Mr. Moe joined the General Electric Company in May, 1934, a a student engineer, and was transferred to the receiver engineerin department in Bridgeport in 1935, with assignments in componen engineering, broadcast and television receiver design, and from 1941 to 1944, in government radar design.

He was in charge of design activities on radar receivers and indicators for the Government division of the Electronics Department at Syracuse, N. Y., from 1944 to 1948, and assumed his present duties as division engineer in the receiving tube division in January, 1949.

Mr. Moe has held office in two other IRE sections, the Connecticut Valley Section and the Syracuse Section. He has served on the Papers Review Committee for a number of years.

He is a member of Eta Kappa Nu and Tau Beta Pi, and is registered as a professional engineer in the States of New York and Kentucky.

One of the major accomplishments of communication engineers, and a most spectacular and valuable achievement, is television broadcasting. Its problems, genesis, status, and potentialities are capably analyzed in the following guest editorial by the President of the Television Broadcasters Association, the Vice-President of WOR-General Teleradio, and a Fellow and former Director of the Institute.—*The Editor.*

The Tide of Television

J. R. POPPELE

The arrival of television as a full-blown industry must come as a source of great satisfaction to the engineering fraternity. Like telephony, wireless, and radio, television was born, nurtured, molded, and brought to fruition in the minds, hearts, and hands of engineers and scientists.

Pride of accomplishment is an engineer's great reward. He moves from one object to another with insatiable curiosity and zest. His work, apparently, is never done, since the fulfillment of one task invariably leads to another. Having tackled a tough problem and surmounted it, he moves almost immediately to another challenging chore.

In that progressive movement lies the secret of television's success. First principles of visual scanning trace back to the late nineteenth century. Once the objective became clear, it excited the interest and curiosity of others, who picked up the challenge and toiled endlessly in the pursuit of a solution.

The brain and brawn, the heartaches and despair of momentary failure, and the ecstatic lift that accompanies success of a mission are written into the history of television development in broad, indelible terms. Names like Nipow, Braun, Campbell-Swinton, DeForest, Jenkins, Baird, Zworykin, Ives, Alexanderson, DuMont, and Farnsworth will live in the annals of engineering for their monumental contributions to the art of television broadcasting and reception. Each had a hand in shaping TV's destiny; the cumulative effort brought about the great new industry which has taken the nation by storm.

Forty years ago when I chose engineering as a profession, wireless telegraphy was considered the great engineering achievement. Within ten years, radio broadcasting, on a scale undreamed of at the turn of the century, began to develop.

The audion, truly a miracle of science, turned the "trick." Yet, the arduous labors that took radio out of the crystal stage era, out of battery-operated receivers to a national radio service of immense proportions and later to an international broadcasting service, were not achieved overnight by a single individual, but by thousands of engineers who set an objective and pursued it to its ultimate achievement.

It was almost predestined that television would evolve from this continuous process of development, since farsighted men envisioned just such an accomplishment even while they labored to harness the ethereal waves for powerful aural transmission.

Today, despite the dark clouds that hover over a world praying for peace, television has achieved a place among the nation's top ten industries and will continue to thrive. As it grows, it makes possible a service to the public unique in modern history. It informs, entertains, delights, and enlightens millions —in a manner that can be understood by anyone—pictorially!

Although we are proud of our accomplishments in this marvel of electronic magic, we have only scratched the surface of what may come in the future. Each generation brings with it an even greater mental capacity for coping with what may sometimes appear to be the impossible.

Who knows, perhaps children now attending kindergarten will some day bring us new glories in television not even imagined today. In an atmosphere of free enterprise and unhampered individual initiative, great things are bound to evolve. This aura of freedom has made the United States the most fruitful nation in the world. This we cherish above all else. The tide of television will ebb and flow with the nation's fortunes, but it is a tide that will go on endlessly.

The Human Element in Research and Industry*

WALTER H. KOHL†, SENIOR MEMBER, IRE

Summary—**This short article reemphasizes the need for "social engineering" as contrasted with the prevailing competence in the field of "technical engineering." Practical steps are enumerated for the establishment of a favorable atmosphere in which human beings can effectively and happily operate in the laboratory and factory. This covers suggestions for a reorientation on the part of the "worker" as well as on the part of management. The remarks are of a very general nature and applicable to all industries, but the experience on which they are based was gained in the electron-tube field.**

RESEARCH is done by people. When the results lead to industrial applications, men and women turn the researcher's findings into tangible products in the factory. Everybody knows that this is so, but for a long period, especially during the beginning of the nation's industrial development, interest was centered around the material aspects of this transformation of thoughts into things until "The Material Age" became a byword of our time. Of recent years, the human factor has been emphasized more and more frequently. Many volumes have been written on this subject and these lines are only to emphasize again that there exists a problem of "social engineering" as well as one of "technical engineering." Observations during a prolonged career in the electron-tube industry, in the laboratory, the factory, and as administrator, make it appear that a reemphasis is not altogether amiss.

Originality of thought remains the keystone on which the structure of our technological society rests and on which progress and survival depend. The conception of an original idea, the finding of a basic principle, is essentially an individual effort. At the same time, it is often the last link in a chain of events which is tied to time, history, stimulation by others, and many fortuitous circumstances. This creative act is also the first link in another chain which projects into the future toward the ultimate aim of practical realization. When the problem has been stated—always the most difficult step—and a sound approach to its solution is indicated, a group effort will bring the most rapid solution. To gather the right people for a given task force is the challenging privilege of the director of research. To give loyal support to the group is the responsibility of the members of the team. This demands subordination without submission, personal tact, tolerance, and fair play—in other words, all the requirements of a truly democratic society. There is no sense in any one of the group pretending that he knows all the answers and that the other members are incompetent. The advice of the craftsman and technician should be sought freely by the engineer to ensure the practicability of his design and, incidentally, to give his assistants a share in the project at an early stage of the development. Contributions by others should be recognized freely and the originality of an invention clearly established in the records with the consent of all concerned, in order to avoid arguments at a later stage when it comes to the filing of a patent claim. There is also no justification in prescribing the lines of attack on the problem too narrowly and in not welcoming new suggestions if they are at all promising. The group should be provided with all facilities that are reasonably necessary and should not be encumbered by red tape. In research, an informal, loose organization is of great value, although it can be overdone at the expense of a satisfactory rate of progress, particularly in larger organizations where the director will find it difficult to keep in personal contact with all groups. Periodic reports by the group leaders then become necessary in order to inform the management of the state of affairs and provide a basis for future direction.

A misconception prevails in some administrative quarters about the intricacy of many problems and the proper allocation of funds. Fortunate indeed is the company which has technically qualified people at the top. They will listen very sympathetically to the pleadings of their chief engineer or their director of research. Unfortunately, the problems of tube manufacture and those connected with new developments are not generally appreciated. It is better not to embark on a project if sufficient funds are not available than to insist on having the work done in a haphazard manner. It is not implied here that new investigations always require large amounts of expensive equipment. It is necessary, however, that new procedures are tested under carefully controlled conditions, so that they can be successfully reproduced. More often than not, mysterious effects make their appearance which require extensive investigation before they are brought under control. All this takes time, people, and money. There are times, on the other hand, when too much money can do equal harm, especially when it comes from the public purse. It will lessen the incentive to apply all possible ingenuity to the job and will encourage wastefulness in material and manpower. There is evidently a happy middle road to be followed.

In order to get a job done, human beings have to become excited about it. This response presupposes a certain alertness on the part of the worker and an interesting job. In addition, it requires a fair return for the effort. Fortunately, these conditions apply to a large extent in the electron-tube industry. Many of the tasks

* Decimal classification: R005. Original manuscript received by the Institute, December 11, 1950.

This paper was prepared for PROC. I.R.E. from an epilogue originally written by the author for his forthcoming book, "Materials Technology for Electron Tubes," now in press with Reinhold Publishing Corp., New York, N. Y. On second thought it was removed from the manuscript in order to reach a wider audience in this form.

† Collins Radio Company, Cedar Rapids, Iowa.

require a great deal of skill and the personnel is of better than average intelligence. Routine operations should be left to the less skilled, but an effort should be made to provide variety wherever it is appreciated. There are, of course, people who like routine jobs, but one should also not overlook the possibility that an apparently dull person may respond to an opportunity and discover latent qualities in himself that have never been tapped. A sympathetic job selection is thus required. It is unfair to keep anyone employed on a job for which he is ill suited when a transfer to a different activity for which he is better qualified may result in greater satisfaction to all concerned.

The various difficulties that do arise in the co-ordination of people are remedied more easily when the group is small. There prevails in it a sort of family atmosphere where each member knows the other's qualities and shortcomings and can readily make allowance for them. The problem is to transfer this close-knit personal relationship to a larger body of people, or to replace it by a similar sense of allegiance to the company at large. The attainment of this objective requires a very conscious effort on the part of the management. This usually results in a variety of devices; among these one finds the house organ, sports clubs, insurance systems, credit unions, retirement plans, stock distribution, incentive pay, and so on. What is important in the over-all plan is that everyone knows from past experience that he is being treated fairly and thus willingly contributes his best efforts to the benefit of the whole. It is very desirable that the management from time to time inform all of the working force of the general trend of developments so that full confidence in its policies is maintained.

It is only natural that the growth of an organization requires the weeding out of weak members who impede its progress and normal functioning. Such measures will avoid the creation of a false sense of security on the part of loafers. Rarely should such steps be necessary in regard to employees of long service. It is the company's responsibility to judge the value of a worker early in order to avoid unnecessary hardship. When dismissals become necessary, the reasons for them should be fully explained. Furthermore, a continuous effort should be made towards the further development of the members of all groups by providing job training, educational facilities, and stimulation through travel and attendance at meetings of professional societies.

Another point that requires emphasis is the need for periodic recognition of efforts whenever it is justified. Promotions and pay increases naturally are the most tangible evidence of the management's satisfaction with the services rendered. At the higher levels these raises become, of necessity, less frequent and in adverse times salaries may even have to be reduced. It helps a great deal to maintain morale if the staff member or the worker is drawn into the company's confidence, so to speak, and told which way the wind is blowing for him. To a very large extent, recognition is the life blood on which sincere effort feeds, and often at the disregard of monetary return. A word of praise, assignment of greater responsibility, inclusion at staff conferences, or the granting of special privileges will do much to make the worker feel that he is a trusted member of the family and that the success of the whole depends on his efforts. A sincere interest should be taken in his personal affairs when adversity may put an unusual strain on his shoulders.

It is very unfortunate that the smooth operation of a large organization requires many routines which reduce the individual worker to a number which is handled efficiently by a business machine. This necessary evil should be counteracted by decentralization and personal counsel wherever possible. Although information and general directives are most conveniently distributed by memoranda, an organization should be on its guard against a not altogether rare disease which might be called "memoranditis." It thrives in all climates, disregards age or sex, feeds on reams of paper, and incidentally destroys the morale of the people affected by it. It makes its appearance singly or in multiple copies. The vicious kind feeds on arguments. To send such missiles to the fellow next door, so to speak, is very poor technique. It is much better to talk things out than to write them out. In some cases, arguments of a personal kind have been carried into scientific publications. This is very bad taste indeed and makes one question the sincerity of the writer.

These loose-knit ideas on industrial relations, it is hoped, will remind the reader of his broader responsibilities toward the organization to which he belongs and to society at large. The scientist and engineer have now, in addition to their technical performance, the task of interpreting their work to the public. This is necessary in order to assure a sympathetic response to their ever-expanding ideas and to preserve a favorable climate in which to work, unobstructed by prejudice and restrictions.

Moon Echoes and Transmission Through the Ionosphere*

F. J. KERR†, SENIOR MEMBER, IRE, AND C. A. SHAIN†

Summary—Moon echoes at a frequency of about 20 Mc have been studied, mainly to obtain information on low-angle transmission through the ionosphere. Using a broadcast transmitter in its free time, with fixed aerial systems, thirty experiments were carried out in just over a year, echoes being received in twenty-four cases. Experimental results have been compared with those to be expected from an orthodox ray-theory treatment, and the following major discrepancies were found:

(1) Observed echo intensities were well below theoretical values.

(2) Minimum altitudes, at which echoes were first detected, were unexpectedly high.

(3) Ray deviations of several degrees in a vertical plane apparently occurred.

The anomalous values of echo intensities and minimum altitudes for detection correlate closely with the critical frequency of the F_2 region, suggesting that the anomalies arose in that portion of the ionosphere. The cause may lie in departures from horizontal stratification in the *F* region, or in failure of the ray-theory treatment at very oblique incidence.

The received echoes showed two types of fading. One type was consistent with an ionospheric origin. The second has been shown to be due to the moon's libration, effective reflection taking place over a large proportion of the moon's surface. This, together with the elongation of short pulses on reflection, demonstrates that the moon is a "rough" reflector at this frequency.

I. Introduction

INFORMATION on the ionosphere has until recently been derived almost entirely from studies of radio waves reflected down again to earth. This method cannot give information about the region above the level of maximum ionization, so that little is yet known about this region.

The reception of solar and cosmic radio noise at the earth's surface has demonstrated that radio energy of sufficiently high frequency can penetrate the ionosphere, but several observers have reported anomalous effects (possibly arising in the ionosphere) at low angles of elevation.[1–3] Further, the American group who made the first observations of radio reflections from the moon in 1946[4–6] found large variations and anomalies in the received echo intensity though no conclusions were reached as to whether these were atmospheric or lunar in origin.[7] The use of solar emissions to study ionospheric transmission is handicapped by their great variability when the sun is active, and low intensity when it is quiet, especially at the low frequencies which are of greatest interest for an ionospheric study. A possible alternative is to work with radiation from discrete cosmic sources, but here again a severe limitation is imposed by the low intensity. Moon echoes are more suitable for the purpose, since the source of signal can be controlled, and the variations produced by reflection at the moon can be estimated with sufficient precision.

This paper describes moon-echo experiments carried out on a relatively low frequency, not far above that necessary for penetration of the ionosphere, with the particular object of investigating the structure of the upper part of the ionosphere. Transmissions were made from an Australian broadcasting station in its free time, and by the end of the investigation two receiving stations were operating in Australia, and three in America. The first results have been described in an earlier communication.[8] Echoes were received on most occasions, but the echo intensity level and the time of appearance of echoes after moonrise departed from the expected values. An outline of the experimental results is given, followed by a theoretical discussion of the problems of reflection from the moon's surface and transmission through the ionosphere. The observations and theory are then compared in detail.

II. Experimental Arrangements

A. Transmitter

Special transmissions were made from the high-frequency broadcasting station, Radio Australia, located at Shepparton, Victoria (36.3°S, 145.4°E). The transmitter (21.54 Mc, 70-kw output or 17.84 Mc, 50-kw output) was pulsed by landline signals from the Radiophysics Laboratory receiving station at Hornsby, New South Wales, 600 km away. The most frequently used signals were:

(a) A group of three ¼-second pulses (used in searching for echoes, and for identification of weak echoes).

* Decimal classification: R113.307. Original manuscript received by the Institute, July 6, 1950.

† Division of Radiophysics, Commonwealth Scientific and Industrial Research Organization, Chippendale, N.S.W., Australia.

[1] R. Payne-Scott and L. L. McCready, "Ionospheric effects noted during dawn observations on solar noise," *Terr. Mag.*, vol. 53, pp. 429–432; December, 1948.

[2] J. L. Pawsey, "Solar radio-frequency radiation," *Proc. IEE*, Part III, vol. 97, pp. 290–310; September, 1950.

[3] G. J. Stanley and O. B. Slee, "Galactic radiation at radio frequencies. II—The discrete sources," *Austr. Jour. Sci. Res.*, Series A, vol. 3, pp. 234–250; June, 1950.

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

[5] J. H. DeWitt, Jr., and E. K. Stodola, "Detection of radio signals reflected from the moon," Proc. I.R.E., vol. 37, pp. 229–242; March, 1949.

[6] H. D. Webb, "Project Diana—Army radar contacts the moon," *Sky and Telescope*, vol. 5, pp. 3–6; April, 1946.

[7] In addition to the American work, moon echoes have been observed (at 120 Mc) by Z. Bay in Hungary, but no information on variations of echo intensity was obtained. ("Reflection of microwaves from the moon," *Hungarica Acta Physica*, vol. 1, pp. 1–22; 1946).

[8] F. J. Kerr, C. A. Shain, and C. S. Higgins, "Moon echoes and penetration of the ionosphere," *Nature*, vol. 163, pp. 310–313; February 26, 1949.

(b) A single pulse, 2.2 seconds long (for studying short-period amplitude variations of the echo).

(c) A group of pulses of length 1 millisecond and recurrence frequency 40 cps, extending over a total period of 2.2 seconds (for examining the fine structure of the received echo). These short pulses were generated at Shepparton, and controlled by landline signals.

The pulse group repetition period was 6 seconds in all cases. The time of travel of a radio wave to the moon and back is about $2\frac{1}{2}$ seconds. During some of the later tests, in which attempts were made to receive echoes in America, the timing of the emitted pulses was controlled to a small fraction of a second.

B. Receivers

A modified communications receiver was used at the main receiving point at Hornsby (33.7°S, 151.1°E). The intermediate-frequency bandwidth was normally 70 cps, but was increased to 1 kc during the limited work with millisecond pulses. In the early tests, using self-excited oscillators and regulated supplies, slight retuning was necessary every 10 to 15 minutes. Later, crystal-controlled local and beat frequency oscillators were introduced, giving an over-all frequency stability of about 1 cps over 30 seconds or 10 cps over 30 minutes. This stability was desired in studies of Doppler shifts and short-period fading. Another change carried out after the early tests was the addition of a filter, narrowing the "video" bandwidth to 6 cps with a consequent improvement of visual signal-to-noise ratio by $\sqrt{70/6}$ or 5 db.

The moon echoes were seen against a background of cosmic noise, which was large compared with receiver noise. The sensitivity of the system for the nearly monochromatic moon-echo radiation was therefore dependent primarily on the bandwidths of the filters used, and only to a small extent on the receiver noise factor. These bandwidths were measured by several different methods, and the results obtained were in good agreement.

The cosmic noise background varied with sidereal time and ionospheric conditions, but at the times of the various tests the noise power delivered to the receiver was always within $1\frac{1}{2}$ db of the value:

$$P_N = 2.4 \times 10^{-17} \text{ watt.} \tag{1}$$

The received signals were displayed on a long-persistence cathode-ray tube, with a 6-second time base, and photographed. (No great accuracy was sought in measuring the echo delay-time.) On such a display, the "minimum perceptible signal" is approximately equal to the root-mean-square value of the noise fluctuations. Echoes could also be detected aurally in a loudspeaker, and this method of detection was the more sensitive for weak echoes, by perhaps 2–3 db. The accuracy of estimation of the echo field intensities improved as the tests progressed, in consequence of the gradual improvement of the equipment used. The over-all performance is believed to be known to within ±2 db, at least from July, 1948, onwards.

During the later tests, observations were also made at Rockbank, Victoria (37.8°S, 144.7°E), using the normal receivers of the station, with display and recording equipment similar to that at Hornsby. The over-all sensitivity of the receiving system was 3–4 db less at Rockbank than at Hornsby, mainly on account of the greater bandwidth.

C. Aerial Systems

The transmitting aerial at each frequency was that regularly used by Radio Australia for broadcast transmissions to the United States and Canada. Each aerial is a broadside array of sixteen elements, arranged in four tiers of horizontal radiators, and backed by a similar curtain of reflectors.[9] The maximum of the beam is directed to 63° azimuth, 9° altitude, and the gain over an isotropic radiator is 20 db.

Reception at Hornsby was carried out on an array of two rhombic aerials, directed towards the region of the sky illuminated by the transmitting aerial. The directional diagram and gain of the receiving aerial were calculated by the methods given by Harper.[10] A rough check on these results was obtained from comparisons of signals received on this aerial and on a half-wave dipole from suitable overseas stations. The main features of the diagram were confirmed and the gain shown to be within 1–2 db of the theoretical figure. The effective absorbing area in the maximum direction has been taken as 840 square meters, corresponding to a gain over an isotropic radiator of 17 db at 21.54 Mc. Possible uncertainty as to the reliability of the theoretical characteristics for low-angle reception arises from the situation of the receiving aerial, which is confronted by a ridge 600 yards away, at an elevation of about 5°. It is believed, however, that any effects due to this ridge would be much smaller than the anomalies actually found in echo intensity. This view is supported by the results on distant stations, mentioned above.

The composite directional diagram of the Shepparton-Hornsby system for an infinitely distant source is shown in contour form in Fig. 1, which is plotted in terms of azimuth and altitude at Shepparton.[11] Lines of constant declination and hour angle are given in the same figure, so that the moon's track during each of the test periods can be determined, using the information presented later about the circumstances of each experiment. The approximate altitude of the moon at Hornsby and Rockbank may be obtained by adding +5° and −1.5°, respectively, to the corresponding value for Shepparton. This approximation is sufficiently accurate over the region of interest.

[9] R. B. Mair, A. J. McKenzie, and W. H. Hatfield, "The Shepparton international broadcasting station, 'Radio Australia'," *Telecomm. Jour. Aust.*, vol. 6, pp. 129–141; February, 1947.

[10] A. E. Harper, "Rhombic Antenna Design," D. Van Nostrand Co., New York, N. Y.; 1941.

[11] The diagram was a little different during the first seven tests.

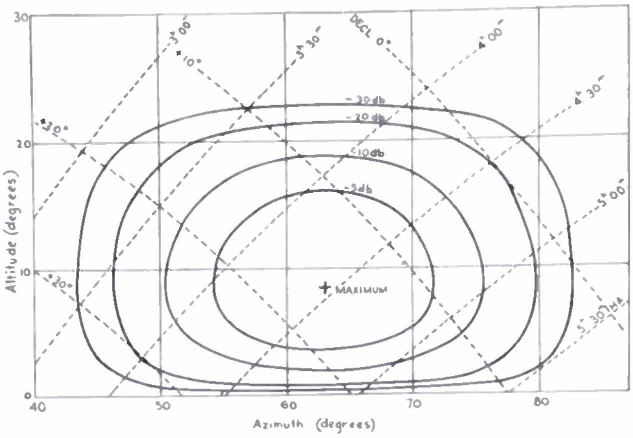


Fig. 1—Composite aerial diagram of the Shepparton transmitter and Hornsby receiver, plotted in terms of azimuth and altitude at Shepparton. Contours of declination and hour angle are also shown.

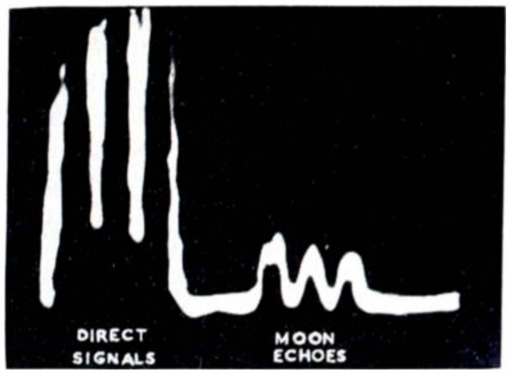


Fig. 2—Sample photographic record, illustrating the results obtained with the group of three short pulses.

The receiving aerial used at Rockbank was one of the normal rhombics of the station.[12] Its gain over an isotropic radiator is 16 db at 21.54 Mc.

D. Operational Limitations

The working time of the system was severely limited. Firstly, observations were restricted to the hours when no broadcasts were scheduled, namely 0230–0540 and 0930–1230, Eastern Australian Standard Time.[13] The latter period was generally unsuitable, as the critical frequency of the F_2 region was normally too high to permit penetration of the ionosphere. Secondly, the moon passes through the aerial beam only on several successive days for two periods each month, and only some of these passages occur at an appropriate time of day.

III. General Results

A. Reception at Hornsby

Observations were made over about a year on every day on which the circumstances were favorable in the 0230–0540 E.A.S.T. period, amounting to 28 days in all. Moon echoes were received at Hornsby on 22 of these days, for an average period of 30 minutes. (In addition, echoes were received on one day at Rockbank and not at Hornsby.) The less suitable 0930–1230 period was used only on two magnetically disturbed days, on one of which echoes were received.

Examples of the photographic records obtained are given in Figs. 2 and 3. The first illustrates the use of the group of three short pulses. At the start of the trace are the signals received directly from the transmitter, by E-region scatter, followed after about $2\frac{1}{2}$ seconds by the three echo pulses, generally unequal in amplitude.

Fig. 3 shows a series of three successive signals of the long pulse type (only the first of these is labelled in the figure). By this method a record of echo intensity is obtained over a series of 2.2-second periods, interrupted by breaks 3.8 seconds long. A longer sample is presented in Fig. 4. These records illustrate the type of fading observed. Smoothed intensity records for all the tests are given in Fig. 5, with the relevant data on the circumstances in each case. Two types of theoretical curve have been added for comparison. It can immediately be seen that the observed intensities were well below the levels expected theoretically, and also that the first appearance of echoes as the moon rose up through the aerial beam was always later than expected.

[12] W. N. Christiansen, "Directional patterns for rhombic antennae" *AWA Tech. Rev.*, vol. 7, pp. 33–51; 1946.

[13] 150° E time.

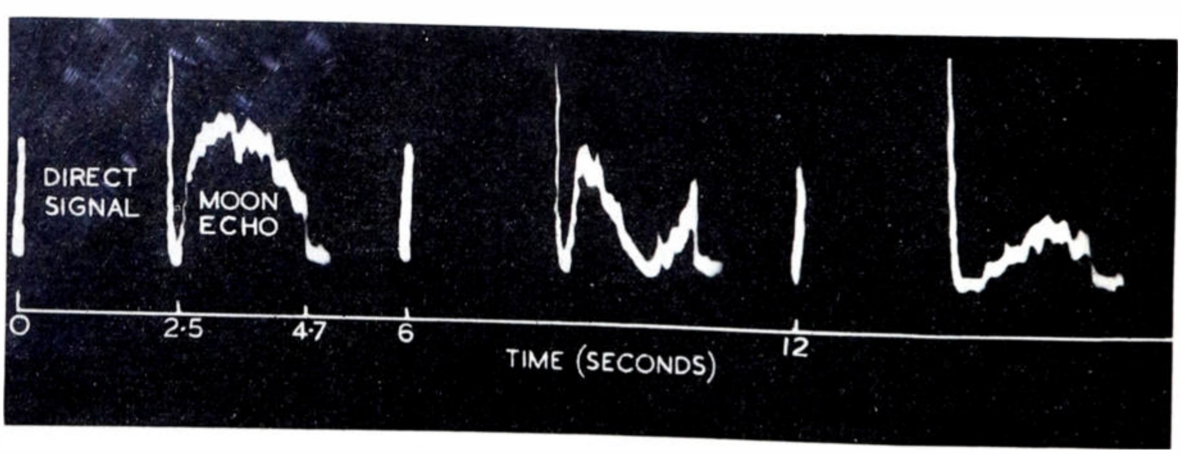


Fig. 3—Three successive echoes obtained with 2.2-second signals, illustrating the rapid fading. The small fluctuations are due to cosmic noise, passed through an intermediate-frequency bandwidth of 70 cps and video bandwidth of 6 cps.

B. Reception at Rockbank

The moon echoes received at Rockbank displayed the same general characteristics as those received at Hornsby, i.e., they were deficient in intensity, the first reception was delayed, and they exhibited similar fading. These results are less reliable than those from Hornsby, as the receiver and display calibrations were not so well known. Also, in many of the observations the moon was passing through side-lobes, where the aerial performance was less certain.

Detailed comparisons between records made simultaneously at Hornsby and Rockbank are of value in relation to possible mechanisms for the short-period fading. Such a comparison, covering a period of 6 minutes, is shown in Fig. 4. The short-period variations are seen to be very different at the two receiving points.

C. Reception in America

During a visit to the United States early in 1948, J. L. Pawsey of this Laboratory arranged co-operation with American organizations in an attempt to receive moon echoes simultaneously at widely separated points on the earth. Receivers were operated in America, in the fifteen tests from July 30 onwards, at the following places:

1. Sterling, Va. (Central Radio Propagation Laboratory, National Bureau of Standards).
2. Riverhead, N. Y. (Radio Corporation of America).
3. Urbana, Ill. (University of Illinois).

This work did not meet with a great deal of success, as the times of the tests (limited by transmitter availability) were all in the middle of the day at these receiving points, so that F_2 critical frequencies were quite

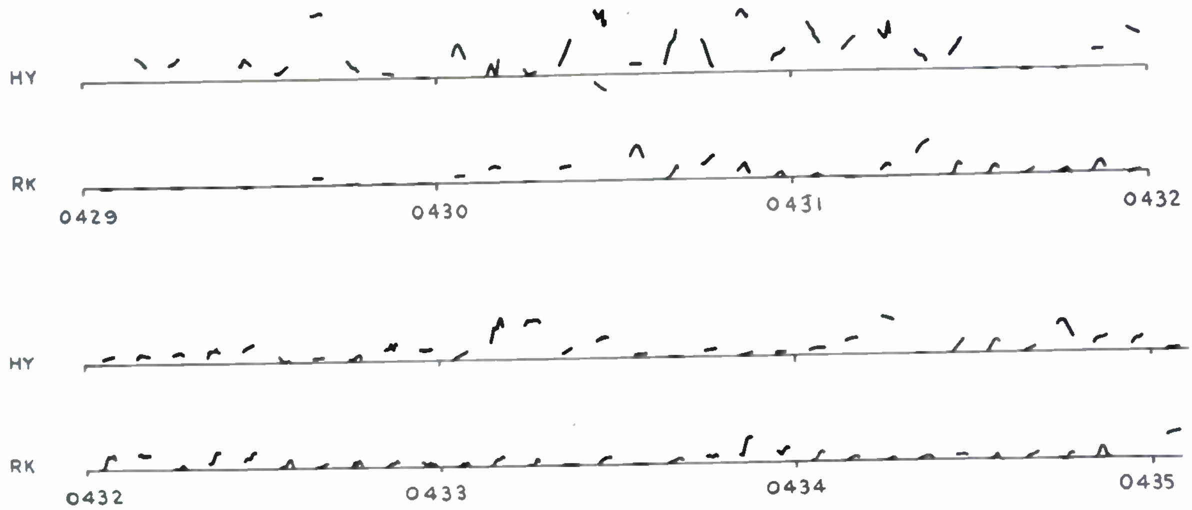


Fig. 4—Simultaneous records of echo strength at Hornsby (HY) and Rockbank (RK), 0429–0435 E.A.S.T., October 29, 1948. The scales are linear in voltage, the Hornsby record being drawn to twice the scale of the Rockbank one.

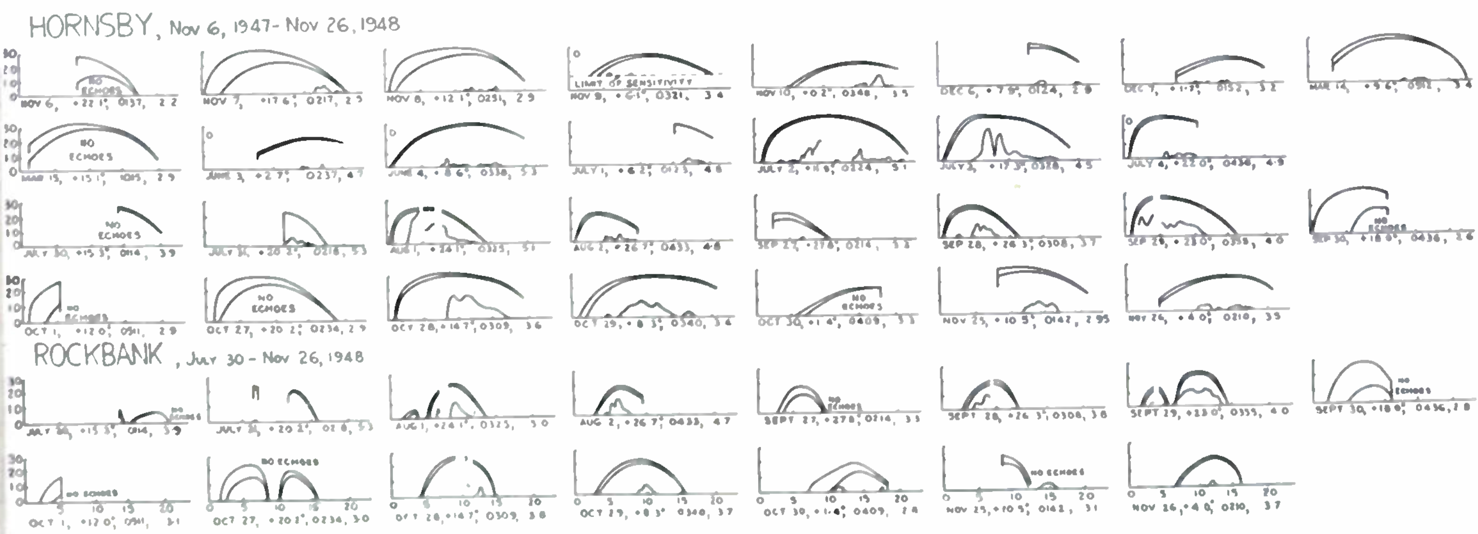


Fig. 5—Results of all tests, in summary form. In each case the three curves, starting from the top are: (a) Theoretical curve, taking into account the aerial diagram. (b) Theoretical curve, taking into account the aerial diagram and expected ionospheric effects. (c) Observed intensities, smoothed over five minutes. Abscissae are moon altitudes at Shepparton; ordinates are intensities in db above the limiting equipment sensitivity. Under the diagram for each test are given the circumstances, namely:—date, geocentric declination of the moon when at 10° altitude, time of moonrise at Shepparton (E.A.S.T.), ratio of operating frequency to $f^\circ_{F_2}$ for the lower of the two rays.

Breaks in the curves indicate periods when accurate records of intensity were not obtained. The symbol D, applying to some tests, means "calibration doubtful."

high. Echoes were received in America, however, on two occasions, August 1 and October 28, although only for short periods in each case.

IV. Theoretical Considerations

A. The Radar Equation

For simplicity it will first be assumed that all of the medium between the surfaces of the earth and the moon is nondeviating and nonabsorbing. This is believed to be very nearly true, except in the ionosphere, whose effect will be discussed later. Effects due to ground reflection and feeder losses have been included in the parameters describing aerial performance. (Numerical values given in this and the next subsection apply to reception at Hornsby.) Let

P_T = transmitter power output = 70 kw
G_T = transmitting aerial gain, relative to isotropic radiator = 100
A_R = absorption cross section of receiving aerial = 840 (meter)^2
d = mean distance of moon from earth = 3.84×10^8 meter
σ = echo cross section of moon, defined by equation (3) below.

The flux density at the moon (power flow per unit area in the transmitted wave) is given by

$$S_M = \frac{P_T G_T}{4\pi d^2}, \tag{2}$$

the scattered wave intensity at the receiving aerial by

$$S_S = \frac{\sigma S_M}{4\pi d^2} \tag{3}$$

$$= 2.0 \times 10^{-30} \times \sigma \text{ watt (meter)}^{-2} \tag{4}$$

and the power delivered by the aerial to the receiver by

$$P_R = A_R S_S \tag{5}$$

$$= 1.7 \times 10^{-27} \times \sigma \text{ watt.} \tag{6}$$

B. Reflection from the Moon—Long Pulses

The case where the pulse-length is large compared with the time of propagation across the moon's depth will first be discussed. After a short build-up period in which the pulse front is spreading over the moon, the whole "illuminated" hemisphere of the moon will be contributing to the received echo. Two limiting types of reflection will be considered, corresponding to the cases of a perfectly smooth and a perfectly rough spherical surface.

Visual inspection indicates that the moon's surface is at least to some degree rough, but this does not necessarily rule out the possibility of the moon's reflecting radio waves as a smooth sphere. For example, reflection could conceivably take place from a region corresponding to the earth's ionosphere. The present observational lower limit to the density of the moon's atmosphere does not preclude this possibility.

Echoes from a smooth and a rough moon will differ in three ways, namely, (1) intensity, (2) fading characteristics, and (3) shape of echo pulse.

The two cases cannot be readily differentiated from the intensity measurements made, since other intensity anomalies were so large. The experimental determination of the type of reflecting surface has been based on a study of the fading, with confirmation from the limited work on the shape of short pulse echoes.

For a smooth, perfectly-reflecting sphere, whose radius is large compared with the wavelength, the incident energy is scattered uniformly in all directions, and the echo cross section is equal to the projected area of the sphere.[14] When the sphere is partially absorbing, as the moon presumably is, the echo cross section will be nearly equal to the product of the projected area (A) and the reflection coefficient for normal incidence (ρ):

$$\sigma \approx A\rho. \tag{7}$$

The moon's surface is believed to consist of rock, with a thin covering of meteoric dust. By analogy with terrestrial conditions, the dielectric constant of the surface material is probably about 5, leading to a power reflection coefficient of 0.15 for normal incidence. Little can be said about the reflection coefficient of a hypothetical lunar ionosphere.

In the alternative case of a large, perfectly rough body, the scattering is no longer isotropic, and the echo cross section will now be given approximately by:

$$\sigma = A\rho D, \tag{8}$$

where D = directivity of the scattered energy in the direction of the receiver.

To a first approximation, the echo from a rough moon can be taken as made up of specularly reflected components from elementary surfaces normal to the incident radiation. Thus all back scattering occurs at normal incidence, and so the corresponding reflection coefficient (0.15) can be used.

Two types of scattering from rough surfaces are discussed in the literature. The first follows Lambert's cosine law, which states that the energy scattered into any direction from a rough surface is proportional to the cosine of the angle between the incident ray and the normal to the surface, and to the cosine of the angle between the scattered ray and the normal. This effect, when integrated over a sphere, gives a directivity in the echoing direction of 8/3.[15]

The second type involves an additional factor, well-known in planetary astronomy, which further increases the directivity. In regions towards the limb of the sphere, each "hill" shadows an area behind it, reducing the effective illuminated area capable of reflection to

[14] K. A. Norton and A. C. Omberg, "The maximum range of a radar set," Proc. I.R.E., vol. 35, pp. 4–24; January, 1947.
[15] D. D. Grieg, S. Metzger, and R. Waer, "Considerations of moon-relay communication," Proc. I.R.E., vol. 36, pp. 652–663; May, 1948.

directions away from the incident direction. The optical directivity of the moon to sunlight is 5.7. (This figure is derived from published data on the variation of apparent illumination with astronomical phase.[16]) The corresponding figure for radio reflection would be less, if the surface irregularities are small, owing to the smaller apparent roughness of a surface for the longer wavelength. The 20-Mc directivity of a rough moon will be taken as 5. The uncertainty involved here is much smaller than the observed anomalies in echo intensity.

Theoretical performance figures can now be specified for the two types of lunar surface, with the moon at the maximum of the aerial diagram, and with ionospheric effects neglected, as shown in Table I.

TABLE I

	Smooth Moon	Rough Moon
Projected area, A[(meter)^2]	9.6×10^{12}	9.6×10^{12}
Echo cross section, σ[(meter)^2]	1.4×10^{12}	$7\ \times10^{12}$
Echo flux density at the receiving aerial, S_E [watt (meter)$^{-2}$]	3.0×10^{-18}	$15\ \times10^{-18}$
Echo power delivered to receiver, P_R [watt]	2.4×10^{-18}	$12\ \times10^{-18}$
Echo-to-noise ratio, pre-detection [db]	20	27
Echo-to-noise ratio post-detection [db]	25	32

C. Reflection From the Moon—Short Pulses

When the pulse is short compared with the time taken to cover a distance equal to twice the moon's radius (11.6 millisecond) only a small portion of the moon will be contributing to the received echo at any given instant. Under these conditions, a considerable difference exists between the behavior of a smooth and a rough sphere.

In the case of the smooth moon, even when it is completely illuminated by the pulse, the echo will come essentially from the first Fresnel zone, i.e., from a slice of the nearest portion of the moon with a radial thickness equal to a quarter wavelength. The contributions of other zones will nearly cancel one another, the net effect being a total field intensity of half that to be expected from the first zone alone.

Since the pulse-length must necessarily be greater than the time associated with the first Fresnel zone, the shortening of the pulse below the dimensions of the moon will have little effect on the echo intensity. Thus the peak intensity of the echo pulse would be nearly the same for short pulses (e.g., 1 millisecond) as for long pulses (e.g., 2.2 seconds). The duration of the echo pulse and hence its total energy would however be different in the two cases, with a consequent worsening of the signal-to-noise ratio for the short pulses, associated with the use of a greater receiver bandwidth.

In the case of a rough sphere reflecting short pulses, the echo pulse will have a long duration, corresponding to the passage of the pulse across the moon, but the instantaneous intensity will be well below that for the long pulses, as only a small portion of the moon's surface will be contributing to the echo at any instant. The shape of the echo pulse will be related to the distribution of radar "brightness" across the moon's disk. For Lambert-type scattering, the brightness would fall off from the center to the edges, according to a cosine relationship. The corresponding theoretical echo pulse-shape for a 1-millisecond incident pulse is shown in Fig. 6(b).

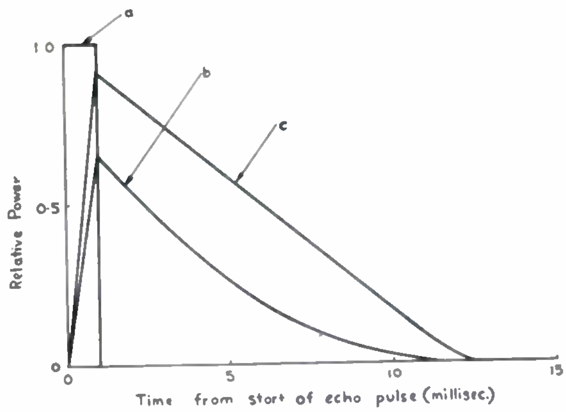


Fig. 6—Shape of echo pulse for a 1-millisecond incident pulse. (a) Smooth moon. (b) Rough moon, Lambert scattering. (c) Rough moon, Lommel-Seeliger scattering. The unit of power is that for a smooth moon and long pulses.

A different distribution of brightness would be obtained when the shadowing effect of the surface irregularities is taken into account. The increased echo directivity in this case, which was mentioned before, arises because a greater proportion of the energy falling towards the edges of the disk is scattered back in the incident direction. Thus there is an increase in the radar brightness at the outer portions of the disk, approaching more closely to the Lommel-Seeliger type scattering, which produces uniform brightness. Markov[17] has in fact found that the distribution of optical luminosity over the disk at full moon is nearly uniform, except for an anomalous increase for a region near the outer circumference of the disk. The theoretical echo pulse-shape for this type of scattering is given in Fig. 6(c).

The unit of echo power in this figure is that for a smooth moon and long pulses. The scales of the curves for a rough moon have been adjusted so that the area beneath each curve is proportional to the corresponding directivity. Thus the three curves are directly comparable. It should be remembered that these shapes apply to the echo pulse entering the receiver, whose finite bandwidth will produce some distortion in the output pulse.

D. Libration of the Moon

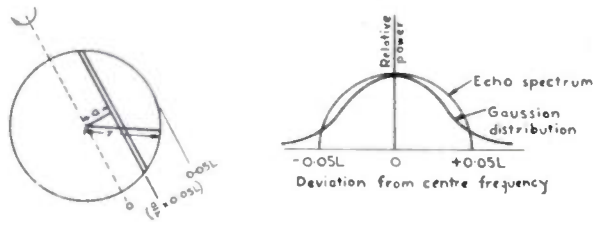
If the moon reflects as a rough object, with the whole disk contributing to the returned echo, the moon's libration would be expected to produce variations in the

[16] H. N. Russell, R. S. Dugan, and J. Q. Stewart, "Astronomy," vol. 1, "The Solar System," p. 173. Ginn and Co., Boston, Mass.; 1945.

[17] A. V. Markov, "Distribution of intensity on the disk of the moon during full moon," *Astron. Jour. USSR*, vol. 25, pp. 172–179; May–June, 1948.

echo about the root-mean-square value derived above. Libration, an apparent oscillation of the moon's face as seen from a point on the earth, arises from the diurnal rotation of the observer on the earth and from variations in the moon's orbit. It amounts to several degrees per day. A libration of $L°$ per day corresponds to a linear velocity at a point on the moon's limb of 0.4 L m/sec, or to a Doppler frequency shift on reflection of 0.05 L cps for a 20-Mc wave. The returned echo will thus extend over a frequency band of finite width,[18] and since the various frequency components are in a random phase relationship, their resultant will be continuously varying, giving the effect of fading.

The expected frequency spectrum can be derived by dividing the moon's projected disk into narrow strips parallel to the axis of libration. Each point of such a strip can be shown to have the same linear velocity towards the earth. This velocity and hence the frequency shift is found to be proportional to the distance of the strip from the axis (Fig. 7(a)).



(a) (b)

Fig. 7—(a) Effect of the moon's libration ($L°$/day). The strip shown produces a frequency displaced $[(a/r)\times 0.05L]$ cps from the center frequency. (b) Frequency spectrum of echo, assuming uniform brightness across the moon's disk, together with the closest-fitting Gaussian distribution.

On the assumption of uniform brightness across the moon's disk (Subsection IV, C), the amount of energy reflected back from an elementary strip is proportional to its area. Hence the power spectrum curve is semicircular in form, i.e.:

$$W(f) \propto \sqrt{1-\left(\frac{f}{0.05\,L}\right)^2} \qquad (9)$$

where f cps = deviation from center frequency.

To test the dependence of the fading speed on the libration rate, it is convenient to represent the former, for a given sample of record, by the mean change of amplitude (regardless of sign) occurring in equal intervals of time,[19] expressed in terms of the mean amplitude for the period.

The relevant theory, for a Gaussian power spectrum, has been worked out by Fürth and MacDonald.[20] Their results can be applied with sufficient accuracy by substituting the best-fitting Gaussian distribution (standard deviation = 0.03 L cps) for the semicircular power spectrum. The semicircular and Gaussian curves are compared in Fig. 7(b). The theoretically-expected relation between fading speed and libration rate is shown in Fig. 8 (full line).

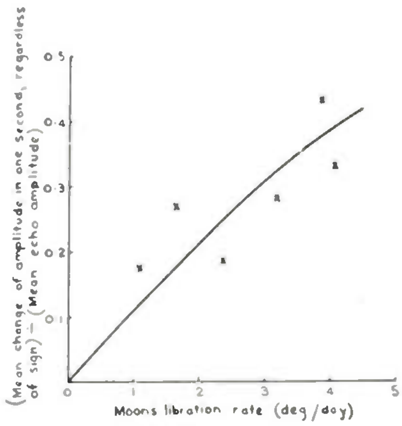


Fig. 8—Relation between speed of rapid fading and libration rate. The full line is the theoretical curve, while the crosses indicate experimental points for six days.

E. Transmission Through the Ionosphere

Before discussing the experimental results on transmission through the ionosphere, a theoretical treatment of the transmission problem will be developed along orthodox lines, neglecting the earth's magnetic field. All but two of the tests took place at nighttime, so that absorption or deviation effects arising in the normal D and E layers may be neglected, leaving only the F and sporadic $E(E_s)$ regions to be considered. The absorption and scattering produced by a cloud-like E_s region is likely to have been small, since the experience of long-distance communication circuits suggests that they are very little influenced by E_s, under conditions in which a strong component coming down from the F region is present.[21]

The properties of rays incident obliquely on the F region and returned to earth again have been studied in detail by several authors, including Appleton and Beynon,[22] who are mainly concerned with the derivation of "maximum usable frequencies" (muf). For our purpose this work indicates a minimum angle of incidence below which energy cannot be reflected back to earth again, but will penetrate the ionosphere. The only published studies of the transmission problem itself are those of Bailey[23] and Bremmer.[24] Bailey treats only the

[18] The center frequency was about 50 cps higher than the transmitted frequency under the conditions of the experiment, owing to Doppler effect associated with relative motion of the observer and moon as a whole. The factors involved in this Doppler shift have been analyzed by A. B. Thomas, "Certain physical constants and their relation to the Doppler shift in radio echoes from the moon," *Aust. Jour. Sci.* vol. 11, pp. 187–192; June, 1949.

[19] One-second intervals, in the middle of the 2.2-second pulses, were used.

[20] R. Fürth and D. K. C. MacDonald, "Statistical analysis of spontaneous electrical fluctuations," *Proc. Phys. Soc.*, vol. 59, pp. 388–403; May, 1947.

[21] A. L. Green and N. Harrison, "Ionospheric forecasting errors in an electron-limited circuit," Ionospheric Prediction Service, Second Supplementary Handbook for use with the Radio Propagation Bulletin, issued June, 1950; Commonwealth Observatory, Canberra.

[22] E. V. Appleton and W. J. G. Beynon, "The application of ionospheric data to radio communication," Great Britain, D.S.I.R., Radio Research Special Report No. 18; 1948.

[23] D. K. Bailey, "On a new method for exploring the upper ionosphere," *Terr. Mag.*, vol. 53, pp. 41–50; March, 1948.

[24] H. Bremmer, "Terrestrial Radio Waves," Elsevier Publishing Company, Inc., Amsterdam, pp. 271–277; 1949.

"ionospheric refraction," or the deviation produced in a ray passing through the ionosphere, and in doing so introduces approximations which are not valid near the critical conditions. Bremmer shows that if a plane wave enters the ionosphere from outside it emerges as a divergent wave, so that the flux density incident on the earth will be less than that in the original plane wave. He studies the reduction in flux density due to this cause and to absorption, in passing through the F region, and shows that the former cause is dominant at sufficiently oblique incidence. His results as they stand are not accurate enough for low angles of elevation over a curved earth, and his treatment must be extended as follows:

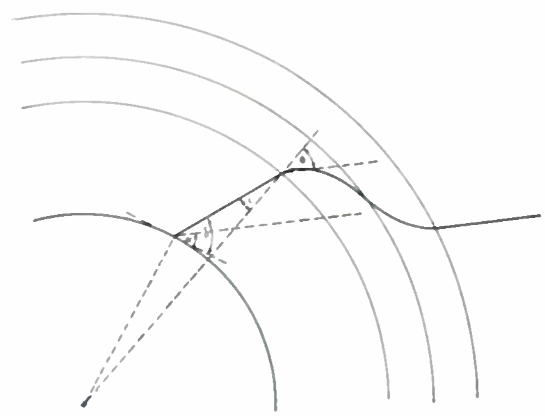


Fig. 9—Trajectory of ray through ionosphere.

Bremmer applies Snell's law to determine the trajectory of a ray through the ionosphere (see Fig. 9), and obtains an expression for the divergence produced by a plane wave coming from outside the ionosphere in a plane wave coming from outside the earth. This is

$$\frac{E}{E_0} = \sqrt{\frac{\sin i}{\sin \theta} \frac{di}{d\theta}}, \qquad (10)$$

where

θ = zenith angle of the extra-terrestrial source at the ionosphere

i = angle of emergence of ray from ionosphere.

This expression can be computed for an assumed distribution of refractive index in the ionized region. Bremmer then discusses the case of a single parabolic layer, neglecting curvature, and presents some typical numerical results.

Curvature can be taken into account by means of a device used by Appleton and Beynon. They replace the curved earth case by an equivalent plane earth case in which the critical frequency f° is reduced to

$$f^\circ - \frac{f^2 y_m}{f^\circ R},$$

where

f = wave frequency

y_m = semithickness of the assumed parabolic region

R = earth's radius.

Use of this equivalence device in Bremmer's expression for a parabolic layer yields the relation between the angles i and θ for a curved parabolic region, and then by means of (10) the distribution of field intensity. The angle of arrival of the ray at the ground (δ) for a given angle of emergence and layer height, and the corresponding altitude of the source at the ground (α) can then be found by geometrical methods.

The field intensity according to this theory is given in Fig. 10 as a function of altitude for a number of values of the ratio of wave frequency to critical frequency, to-

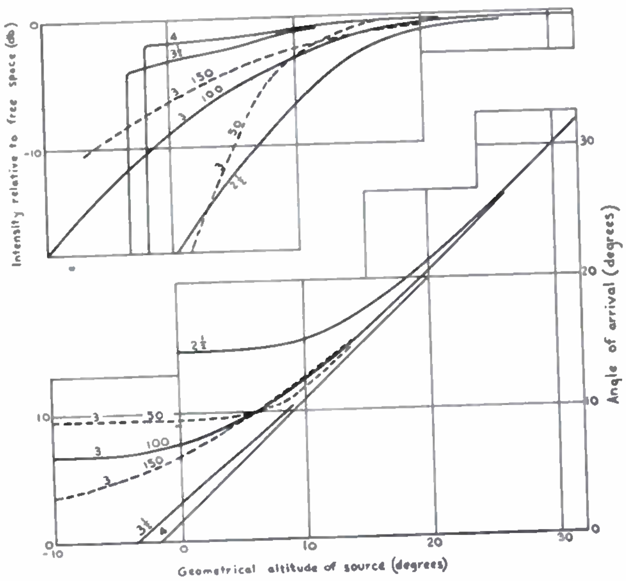


Fig. 10—One-way transmission through F-region (ray theory). (a) Intensity against geometrical altitude. (b) Angle of arrival against geometrical altitude. The full-line curves are for $f/f^\circ_{F_2} = 2\frac{1}{2}, 3, 3\frac{1}{2}, 4$, height = 250 km, semithickness = 100 km and the dashed-line curves for $f/f^\circ_{F_2} = 3$, height = 250 km, semithickness = 50, 150 km.

gether with the theoretical relation between the angle of arrival and the (geometrical) altitude. The angle of arrival is always greater than the altitude, in consequence of ionospheric refraction. In fact, significant field strengths should be obtained in many cases with the source well below the horizon. The angle of arrival at the earth and angle of emergence from the ionosphere both have limiting values, corresponding to the critical ray found from muf considerations.

These curves are all for one-way transmission. In deriving theoretical curves for the conditions of the various moon-echo tests, two such curves must be combined, taking into account the different moon altitudes at transmitter and receiver. Curves obtained in this way are included in Fig. 5 for comparison with the observed echo intensities. The finite angular size ($\frac{1}{2}°$) of a rough moon would produce a slight smoothing of the curves, but this is negligible compared with the observed anomalies.

V. Fading of Echoes and Effects Due to the Moon (Experimental Results)

A. Types of Fading

The fading of the echoes appeared to be of three main types:

(1) Short-period fading over times of the order of seconds.

(2) Variations with periods of the order of minutes.

(3) Variations of the median intensity level from test to test.

Spaced receiver experiments were undertaken as part of the study of the various types of intensity variations. Very little was learned from the simultaneous reception in Australia and America, owing to the unsuitable ionospheric conditions at the American end. Some useful results were obtained, however, from comparisons of the records from Hornsby and Rockbank, 750 km apart.

The day-to-day variations were closely correlated at the two places, but the faster variations of types (1) and (2) showed no such correlation, although the qualitative similarity of the phenomena at the two places was established. This lack of correlation is consistent with the variations originating either in local ionospheric irregularities above the respective receiving sites, or in the moon's libration.[25]

B. Rapid Variations

The rapid variations of type (1) occurred in times of the order of seconds. Since these records were taken after the signals had been passed through a 6-cps low-pass filter, the possibility arises that echo fluctuations of an even more rapid type might have been smoothed out by the filter. The absence of significant frequency components above about 2 cps could however be deduced from the characteristics of the audible echo signal, on which the 6 cps filter did not operate. This conclusion was drawn from the fact that the echo signal gave an impression to the ear of a pure tone[26] (except during some deep fades), and was confirmed by a subsequent study of sound recordings.

It was shown in Subsection IV, D that, if the moon reflects as a rough object, libration would be expected to give rise to fading of echoes. To see whether the rapid fading observed was due to libration, the speed of fading has been compared with the rate of libration for portions of the records on six days. The experimental points of Fig. 8 indicate very good agreement with the theoretical curve for a rough moon, within the experimental uncertainty.

We can therefore conclude that the moon's surface acted as a rough reflector and that the rapid fading observed was due to the effects of libration.

C. Reflection of Millisecond Pulses

Additional evidence on the moon's reflecting properties was obtained by the use of short (1-millisecond) pulses. These experiments were disappointing however, owing to the low echo intensities received. When working with short pulses, a larger receiver bandwidth (1 kc) had to be used. This reduced the sensitivity of the system, raising the threshold to a level which was seldom exceeded by the echo. A moderately clear short-pulse echo pattern was seen on one occasion for about two minutes, but was not photographed successfully, owing to a technical fault. Visual observation showed that the echo pulse was elongated to several times the length of the transmitted pulse, which was in keeping with the hypothesis of a rough moon (see Fig. 6). Thus there are two results indicating that the moon reflected as a rough sphere. In neither case, however, was the accuracy sufficient to distinguish between the Lambert and Lommel-Seeliger types of scattering.

D. Slow Variations

The slow variations of type (2) cannot be due to libration, since it can be shown that, for a fading period of several seconds, medians taken over one or more minutes would seldom depart from the over-all median by more than 1–2 db. Thus another mechanism must be sought to account for this type of fading.

A study of the time intervals between successive maxima (of 1-minute medians) has shown that their frequency distribution was close to that which would be given by a random phenomenon. It is probable that this type of fading was due to the effects of ionospheric roughness.

Ratcliffe[27] has studied the fading obtained on a "single" component reflected from the ionosphere, and attributes it to the beating between elementary waves of slightly different frequencies, scattered from irregularities in continual random motion relative to one another.

The speed of fading is then a function of the random velocities of the scattering centers. Ratcliffe quotes an analysis by S. N. Mitra of the fading of a 4-Mc signal reflected from the *F* region, leading to a value of 5 meters per second for the root-mean-square velocity of the scattering centers.

Similar effects must arise in transmission through an irregular region. These are referred to, but not studied quantitatively, by Ratcliffe. In the transmission case we imagine the irregularities of the region producing deviation of rays, fading of the resultant occurring as the motion of the scattering centers causes the paths of the various rays to change.

For the case of a center moving at 5 meters per second perpendicular to the wave direction, at a distance of 1,000 km from the receiver, it can be shown that the path length of a ray would be changed by a half-wavelength in a time of the order of several minutes. Thus the observed speed of the slow fading is consistent with an ionospheric origin.

[25] Fading due to libration would be essentially similar only for receiver spacings up to several kilometers, since the phase addition of the various components reflected from a rough body as large as the moon is very sensitive to direction.

[26] E. G. Shower and R. Biddulph, "Differential pitch sensitivity of the ear," *Jour. Acous. Soc. Amer.*, vol. 3, pp. 275–287; October, 1931.

[27] J. A. Ratcliffe, "Diffraction from the ionosphere and the fading of radio waves," *Nature*, vol. 162, pp. 9–11; July 3, 1948.

Neither the ionospheric effect discussed in this subsection nor the moon's libration can account for the day-to-day intensity variations, for which a new mechanism must be sought.

VI. Experimental Evidence on Ionospheric Anomalies

A. *Evidence for Vertical Plane Deviation*

Examination of Fig. 5 shows that on many occasions the observed intensity decreased more rapidly in the latter part of the test than does the corresponding theoretical curve. This can be interpreted as an indication that the angle of arrival was significantly greater than the geometrical altitude, rendering the steep portion of the aerial diagram operative at lower altitudes.

After replotting the results in a form more suitable for showing up the effect, the results were found to be consistent with a vertical deviation of 5° for an altitude (Shepparton) of 5°, decreasing to 1°–2° for an altitude of 25°. Evidence of vertical deviation of the same order of magnitude was also obtained from a study of the positions of the minima in the Rockbank curves.

An interesting exception to the general occurrence of large vertical deviation seems to have occurred on March 14, 1948. On this occasion, echoes were detected at a moon altitude 3° greater than the next highest over the whole series of experiments. The unusual feature of this particular test was the presence of a severe ionospheric disturbance, in which $f^\circ_{F_2}$ was reduced from the normal 11 to 7 Mc and the equivalent height recorded at Canberra was 450–500 km. The observed behavior is suggestive of the "holes in the ionosphere" description of the disturbed F region, given by Eckersley,[28] the wave received at 22° being undeviated because it passed through a hole in the region.

B. *Correlation of Median Intensities with Vertical Incidence Data*

The main features of the smoothed experimental results which cannot be accounted for on previous knowledge are the low echo intensities obtained and the lateness of the first detection of echoes from the rising moon. It has been shown above that libration could not account for long-period intensity variations. In both the anomalies, it seems more likely that a cause could be found in the ionosphere than at the moon. An attempt will therefore be made to establish a correlation with some ionospheric parameter.

The points at which the two rays Shepparton—moon and moon—Hornsby penetrated the F_2 and E, regions can be determined approximately for any given time during the tests, from the azimuth and altitude of the moon and the height of the layer concerned. Vertical-incidence ionospheric data were available at 10-minute intervals for most of the test periods from the stations at Brisbane (27.5°S, 153.0°E) and Canberra (35.3°S, 149.0°E). Corresponding values for the estimated penetration points have been obtained by interpolation in both latitude and local time.

The first quantity to be compared with ionospheric data is a median intensity level for each of the tests. To bring all the medians to the same absolute basis, an attempt has been made to take the effect of the aerial directional diagram into account. This can only be done approximately, since the amount of deviation in the ionosphere, and hence the angles of emission and arrival, are not precisely known. To minimize the errors arising in this way, a restricted period of only 20 minutes was used in obtaining each median. A period near the time of optimum aerial performance, but not too near the time of first detection of echoes, was chosen in each case. This is the time when the aerial correction factor shows the smallest rate of change, so that a given vertical plane deviation will then have the smallest effect.

Fig. 11 shows a correlation diagram between the median intensity and the ratio of operating frequency to $f^\circ_{F_2}$. The comparison covers all days for which reliable 20-minute medians could be obtained, excluding tests in which the moon was too far to the side of the aerial diagram, or the calibrations were uncertain. The figure contains points corresponding to the two receiving sites, Hornsby and Rockbank, with dashed lines joining points referring to the same day.

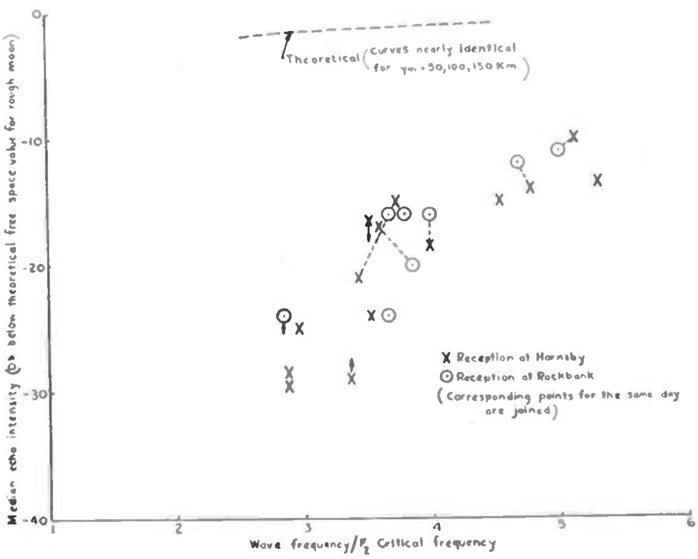


Fig. 11—Relation between median echo intensity and $f^\circ_{F_2}$.

In each case, the value for $f^\circ_{F_2}$ is that obtained for the estimated penetration point of the lower-altitude ray at about the middle of the 20-minute period (i.e., the Shepparton ray for reception at Hornsby, and the Rockbank ray for reception at Rockbank). The conditions for this ray have been regarded as the more significant in limiting penetration, in spite of small differences in the critical frequencies appropriate to the two rays, which generally had an opposing effect.

[28] T. L. Eckersley, "Holes in the ionosphere and magnetic storms," *Nature*, vol. 150, p. 177; August 8, 1942.

This correlation diagram establishes that quite a close relationship exists between median echo intensity and $f^\circ_{F_2}$, and suggests that an important part, if not all, of the deficiency in echo intensity is due to F region effects. (The magnitude of this deficiency can be seen by comparison with the theoretical curve of Fig. 11 which is derived from the ray treatment of Subsection IV, E, for altitudes corresponding to those of the experimental points.)

A similar check has been carried out against E_s data, although this comparison is less valid, since derivation of the ionospheric parameters for the penetration points from the observations at Brisbane and Canberra is not very satisfactory for a patchy layer such as E_s. With this limitation, the comparison showed no correlation between median intensity and f_{E_s}.

C. Limiting Penetration Conditions

The second anomaly in the experimental results was the lateness of the first detection of echoes. Fig. 12 shows a correlation diagram of the moon altitude (the lower of the pair of values) at which echoes were first detected, against the ratio $f/f^\circ_{F_2}$, omitting only those cases in which low angle conditions were unfavorable through considerations of aerial diagram or observing time. Theoretical curves have been added for comparison, for a symmetrical parabolic F_2 region with three values of semithickness. (During most of the tests, the semithickness was about 100 km.)

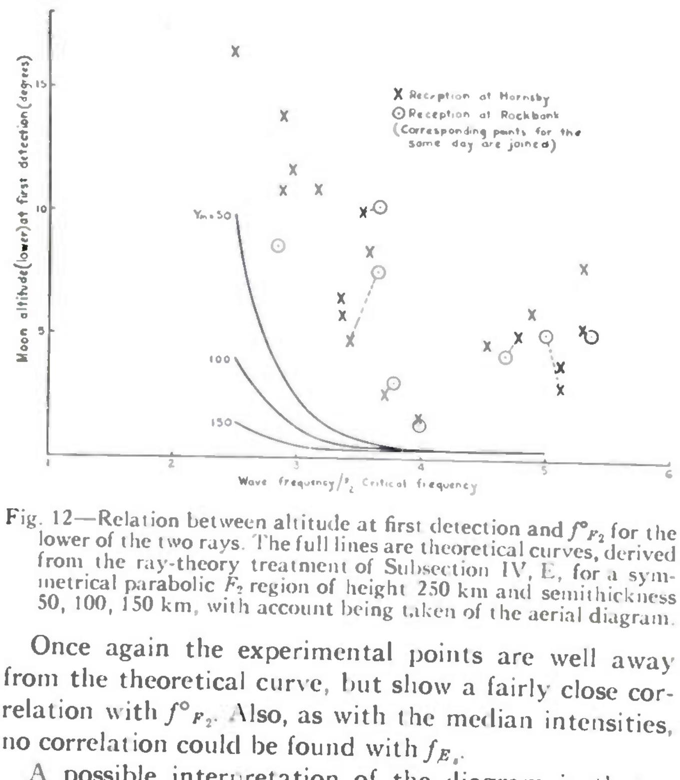


Fig. 12—Relation between altitude at first detection and $f^\circ_{F_2}$ for the lower of the two rays. The full lines are theoretical curves, derived from the ray-theory treatment of Subsection IV, E, for a symmetrical parabolic F_2 region of height 250 km and semithickness 50, 100, 150 km, with account being taken of the aerial diagram.

Once again the experimental points are well away from the theoretical curve, but show a fairly close correlation with $f^\circ_{F_2}$. Also, as with the median intensities, no correlation could be found with f_{E_s}.

A possible interpretation of the diagram is that a simple relation exists between altitude of appearance and critical frequency for the lower values of $f/f^\circ_{F_2}$, which are associated with high limiting altitudes. Then, when the critical frequency falls to a low value, such that $f/f^\circ_{F_2}=4$, a new factor becomes important and prevents the observation of correspondingly low values of limiting altitude. Such a factor could be introduced, for example, by E_s ionization, or by inadequacies in a ray treatment. Reference to Fig. 11 indicates that the diagram of median intensities could be interpreted in a similar way, with the same group of points[29] occupying an anomalous position away from a smooth curve that can be drawn through the rest of the points and up to meet the zero line.

The curves of Fig. 5 show that there is a large difference between the expected and actual altitudes of first detection, amounting to 10° or more. Greater interest however attaches to a comparison between the theoretical and experimental limiting angles of incidence on the F_2 region. Since the latter are not precisely known, all that can be done is to obtain a lower limit to the difference between these angles, corresponding to the case of no deviation. Using a method similar to that described in the earlier paper,[8] this difference has been found to average about 3°. (This corresponds to the lower-altitude ray, in each case.) The actual anomaly between the theoretical and experimental limiting angles of incidence would then exceed this 3° figure by an amount corresponding to the deviation, i.e., by several degrees. Thus the total anomaly is quite large.

It should be pointed out that the difficulty in receiving echoes at low altitudes was not due to the lowered aerial efficiency at these altitudes. The occurrence of vertical deviation means that the angle of emission of the ray would be up near the maximum of the aerial diagram well before echoes were in fact received.

In the earlier paper,[8] some results of observations on 18-Mc solar noise were quoted, in which reception of noise bursts appeared to be possible with the sun's altitude below the theoretical "shadow angle," contrary to the moon echo results. The theoretical results of Subsection IV, E indicate that the cutoff at the F region is far from sharp, as the source altitude varies. Hence the apparent difference between the solar noise and moon-echo results is probably due to the greater intensity range of solar noise bursts, and not to any difference between the two directions of transmission through the ionosphere.

A comparison between the two directions of transmission is obtainable from the results at Hornsby and Rockbank. In the former case the transmitted ray has the lower altitude, in the latter the received ray. Comparison of the altitudes of first detection at the two places gave differences with a median value of 4.8°. This is nearly equal to the 5° which would be expected if the lower altitude ray were the limiting factor in each case, and $f^\circ_{F_2}$ were constant over the region of interest.[30]

[29] The tests represented in Figs. 11 and 12 are a little different, as the choice of suitable days for the two diagrams was based on different criteria.

[30] If α° is the limiting altitude, echoes would appear at Hornsby for a Shepparton moon altitude of α°, i.e., $(\alpha+5)^\circ$ at Hornsby, and would appear at Rockbank at an altitude there of α°.

D. Possible Interpretations

The general conclusion to be drawn from these low-frequency moon-echo experiments is that transmission of radio waves through the ionosphere is more difficult than had been expected on theoretical grounds, at least at low angles. Similar results were obtained by the American group, who studied moon echoes at 111.5 Mc. They report: "Frequently, even with the equipment to all appearances in satisfactory working order, no echoes are observed,"[5] whereas on other occasions echoes of 20 db above noise were received. The day-to-day variations reported by these workers[6] appear to be of the same type as those observed in the present investigation, and so were presumably also of ionospheric origin.

In keeping with these results is the growing evidence that satisfactory long-distance communication can often be maintained on frequencies considerably in excess of the maximum usable frequency (muf) predicted from vertical incidence data.[21,31] Thus, energy is being returned to earth by the ionosphere under conditions in which penetration would have been expected.

Green and Harrison[21] have recently reported an improvement in their muf predictions, obtained by using an empirical correction factor. A simple increase of the muf factor in this way, however, is not sufficient to account for the moon-echo anomalies, particularly in the case of the 111.5-Mc results.

Smith-Rose[31] attributes most muf anomalies to reflection from E_s ionization. Additional evidence on the part played by E_s in oblique-incidence transmission is obtained from the results of Appleton, Beynon, and Piggott.[32] They describe experiments showing that amplitude variations of an *F*-layer first-order echo received at a distance of 685 km are due at least in part to absorption in the passage through the E_s region. Furthermore, any deviation occurring in E_s would be in the same direction as was observed in the moon-echo work, and could also help to account for the muf anomalies, in that E_s deviation would increase the obliquity of incidence on F_2 and hence increase the muf.

However, the correlation of both moon-echo anomalies and muf forecasting errors[21] with $f^\circ_{F_2}$ seem to indicate that F_2 and not E_s is the important region. The authors consider the most likely explanation for the anomalous effects observed in both moon echoes and muf's would be found in an ionization distribution in the F_2 region very different from the symmetrical parabolic model usually assumed.

The theory shows that greater divergence and vertical deviation would be obtained from thinner layers (i.e., higher ionization gradients). The shape of the upper portion of the *F* region is unknown, but the ionization gradient there is physically more likely to be smaller than that of the lower portion. Also, a lower limit to the total thickness of the *F* region is imposed by the known thickness up to the level of maximum ionization. Extension of the theoretical treatment of Subsection IV, E also indicates that a "*G* layer" above the *F* region, with a lower maximum ion density,[33] could not account for the moon-echo anomalies, unless it were very thin, which is physically unlikely at such great heights. Moreover, it could have no effect at all on muf's.

Other experimental evidence that *F*-region refraction is unexpectedly large has been obtained by Payne-Scott and McCready.[1] With receiving equipment on a clifftop, they observed 60-Mc radiation from the sun as it rose over the sea. Using an interference technique, they determined the apparent direction of the source, in relation to the corresponding direction for 200 Mc, which was assumed to be unaffected by the ionosphere.

Deviations of 25 to 55 minutes of arc were obtained, compared with the 12 to 13 minutes calculated from the formula derived by Bailey[23] for a symmetrical parabolic *F* layer. A reexamination of these results shows that the deviation was too great, and its variation with altitude too rapid, to be accounted for by either a nonsymmetrical *F* layer or a *G* layer.

A model involving horizontal irregularities seems more promising. There is increasing evidence that F_2 ionization is not homogeneous. Types of irregularities observed include the roughnesses studied by Ratcliffe,[27] and the pressure movements observed by Munro.[34] If the region were sufficiently unhomogeneous, the secant relation between vertical and oblique incidence propagation would no longer be applicable. Increased divergence attenuation would be expected in oblique transmission, and increased vertical deviation would also be obtained, in the sense observed in both the moon-echo and solar noise work.

The other possible interpretation is that the discrepancies between theory and experiment are due to failure of the ray-theory treatment at very oblique incidence.

VII. Conclusions

The main experimental results from the 21.54-Mc study of moon echoes were:

(a) Echo intensities were lower than the theoretically expected values.

(b) Minimum altitudes, at which echoes were first detected, were unexpectedly high.

(c) The anomalous values of echo intensities and minimum altitudes for detection correlate with $f^\circ_{F_2}$.

[31] R. L. Smith-Rose, "Radio-wave propagation research in the Department of Scientific and Industrial Research during the years 1937–46," *Jour. IEE*, vol. 94, Part IIIA, pp. 879–892; 1947.

[32] E. V. Appleton, W. J. G. Beynon, and W. R. Piggott, "Anomalous effects in ionospheric absorption," *Nature*, vol. 161, pp. 967–968; June 19, 1948.

[33] D. H. Menzel and D. K. Bailey, "The *G*-layer of the ionosphere"; Relations entre les phénomènes solaires et géophysiques; Colloque international tenu à Lyon en 1947; Editions de la Revue d'Optique, Paris, pp. 163–166; 1949.

[34] G. H. Munro, "Travelling disturbances in the ionosphere," *Proc. Roy. Soc.*, A, vol. 202, pp. 208–223; July 7, 1950.

(d) The slow fading was consistent with an ionospheric origin.

(e) The fast fading (order of seconds) was associated with the moon's libration.

(f) Millisecond pulses were elongated on reflection from the moon.

(g) Ray deviations of several degrees in a vertical plane apparently occurred.

From these results it may be deduced that:

(a) The observations are inconsistent with an orthodox ray theory of transmission through a horizontally stratified ionosphere, and the discrepancies are probably due to the effect of irregularities in the F_2 region, or to inadequacies in the ray-theory treatment.

(b) The moon is a "rough" reflector at this frequency, and hence presumably at all higher frequencies.

VIII. Acknowledgments

A. B. Thomas participated in this project for part of the time, developing much of the specialized equipment, and making some of the observations. C. S. Higgins also took a major part in the observing. The authors wish to thank the engineers of the Postmaster General's Department for making available the transmitters of Radio Australia, and the staff of the station for their ready co-operation at all times. Thanks are also due to the Overseas Telecommunications Commission, Australia, for providing receiving facilities at Rockbank, and to the American groups who participated in the project, in particular to Ross Bateman, Central Radio Propagation Laboratory, National Bureau of Standards, who acted as co-ordinator. Ionospheric data were supplied by the Commonwealth Observatory, Mt. Stromlo, and the University of Queensland.

Some General Properties of Magnetic Amplifiers*

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Summary—The magnetic amplifier is discussed in general terms as a carrier system in which there is a modulation gain and a small demodulation loss. Relations are given which show how a magnetic modulator may exhibit a gain.

Some results of calculation and measurement on the type of circuit in which the modulator output consists of the even harmonics of the carrier source for dc signal input are given. It is shown that the ratio of dc gain to response rise time is a constant depending only on the carrier frequency, the losses in the nonlinear core, and its nonlinearity. The conditions for self-oscillation at the carrier even harmonics are also given.

In the course of some work on telegraph repeaters done in the Bell Telephone Laboratories, Inc., a number of years ago, some of the basic properties of magnetic amplifiers were derived. Because of the current interest in this subject, it was thought desirable to publish some of these results. First a general picture of the operation of a magnetic amplifier circuit will be given, then some of the quantitative results of analysis and experiment will be described.

General Picture of Magnetic Amplifier

The magnetic amplifier may be thought of as a complete carrier system having considerable modulating gain and only a small demodulating loss. The output of the magnetic modulator is connected directly to an efficient resistance demodulator input instead of through the usual intervening long transmission line. The carrier source supplies the energy required for amplification as the plate battery does in a vacuum-tube amplifier. A schematic is shown in Fig. 1. The signal input must contain a dc component in order that satisfactory recovery of the signal from the demodulator may be made. In some applications, the demodulator is not used.

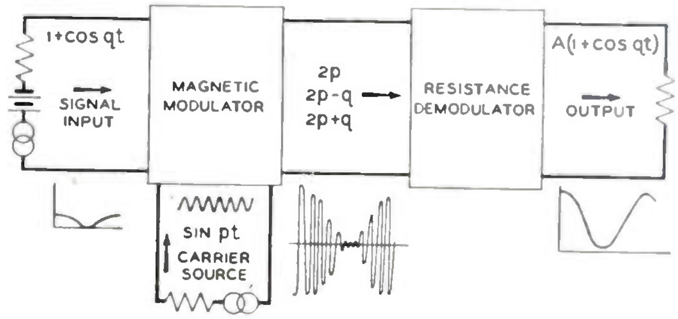

Fig. 1—A magnetic amplifier pictured as a carrier system.

In an ideal magnetic modulator, a modulating gain is possible because the side frequency power is drawn in unequal amounts from the signal generator and the carrier generator. In fact, the ratio of power taken from the carrier source to that taken from the signal source is always as great or greater than the ratio of their respective frequencies if no losses are considered. An important factor in this is the fact that the voltage induced in a winding by varying magnetic flux is proportional to the frequency involved. Another important factor is the 90° phase shift between this voltage and the corresponding flux. Thus, in magnetic modulation when the ratio of carrier to signal frequency is fairly high, it is possible for a small amount of power from the signal circuit to cause a large amount of power to be taken from the carrier source and converted into power at the side frequencies. The interchange of energy between the

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various frequencies brought about by the modulation is described in more detail below. On the other hand, it is impossible, in general, to get a modulating gain with a two-terminal resistance modulator, providing its voltage-current characteristic has a positive slope. The voltage across such a device is in phase with the current and their ratio is independent of frequency in the ideal case.

In an actual magnetic modulator, there are two additional sources of energy absorption in the signal input circuit. One of these is the loss in the magnetic core. This loss increases with frequency, being zero at zero frequency. The other is the loss in the resistance of the signal input winding. This, of course, is not zero at zero frequency and is the only one of the three losses which is effective in determining the dc gain.

Another factor which affects the gain, even of the ideal magnetic modulator, is the inductance of the signal input winding. This inductance, together with the three input losses described above, may be thought of as limiting the bandwidth or rise time of the amplifier response. Ordinarily, the magnetic modulator gain is highest at zero input frequency unless there is positive feedback over a limited frequency band. As will be seen below, the dc gain is roughly proportional to rise time of the response and to the carrier frequency.

An ideal magnetic amplifier is effective at any frequency. Limitations on values of frequency which can be used in a practical magnetic amplifier may arise from consideration of the carrier source and from the fact of core losses. If the carrier frequency is such as to require vacuum tubes for the generation of sufficient carrier power, then for some applications the advantage of the magnetic amplifier is nullified. The influence of losses is discussed below.

It may be noted that a magnetic demodulator would be unsatisfactory in a magnetic amplifier because its loss would cancel the modulator gain. Consequently, a resistance demodulator which can be made to have a small loss nearly independent of frequency in the region of interest, is used.

Ordinarily a full-wave rectifier of copper oxide or selenium serves very well as demodulator. However, when a half-wave detector is used, the resulting direct current and signal, or part of them, flow through the output winding. This has a feedback effect which can be made positive or negative. Feedback can be had also with the full-wave detector, by shunting part of the output signal and dc through a separate winding for the purpose. The effects of this feedback are similar to those in a vacuum-tube amplifier. Signal phase shift through the magnetic amplifier is determined almost entirely by input and output circuits.

Another kind of feedback can occur through the modulation process. If the impedances connected to the magnetic modulator are such that a lower side-frequency current flows in a winding, then some power may be delivered to the input circuit instead of being absorbed from it. This negative resistance effect will increase the gain at certain frequencies and, if large enough, may cause oscillation to take place. The effect is discussed further below.

Because a modulator has a nonlinear voltage-current characteristic, a number of modulation products are generated when a carrier of frequency[1] p, a signal of frequency q, and a dc bias are applied to it. The frequencies of these products are the sum and difference frequencies $np \pm mq$, where m and n are integers and the number $m+n$ is called the order of a modulation product. The new frequencies are the Fourier components of the distorted wave of voltage which is the result of applying the two-frequency wave and bias of current to the nonlinear voltage-current curve of the modulator. Ordinarily, the modulation products of low order have the highest amplitudes; hence, often, the high-order products may be neglected. In the magnetic modulator being considered here, those products for which $m+n$ is even depend for their presence on the direct current. Among them are the carrier even harmonics $2np$ and the side frequencies $(p \pm q)$. If the amplitudes of magnetizing forces of the signal and carrier are Q and P, respectively, the amplitude of the modulation component $np \pm mq$ is proportional to Q^m when Q/P is considerably less than unity.

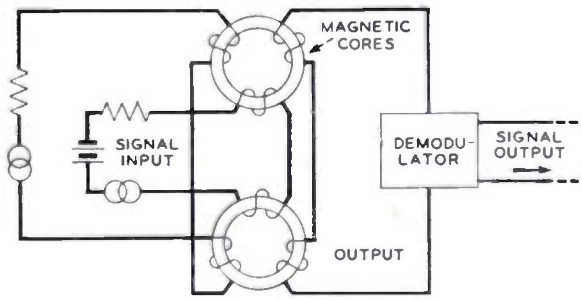

Fig. 2—Arrangement of cores and windings for one type of magnetic amplifier.

In a magnetic amplifier, it is often desirable to select for output certain of the modulation products and to reject others. One way to do this is shown in Fig. 2. All the early work referred to in the opening paragraph was done with this type of circuit. In it, two magnetic cores, as nearly alike as possible, were wound as shown. Or, after the carrier windings have been put on, the two coils are placed together coaxially and the windings connected in series so that the direction of the magnetizing force in one core is opposite to that in the other. Then a single input winding and a single output winding are put on this combination. A cross section through this arrangement may be seen in Fig. 10(b). It is essentially the same as the one shown in Fig. 2. Considering principal modulation products only, the components $(2np \pm q)$ and $2np$ appear in the signal output and input circuits but not in the carrier source circuits. Also

[1] Throughout, the term "frequency" refers to angular frequency in order to avoid the 2π factors.

the components $(2n+1)p$ and $[(2n+1)p \pm q]$ appear in the carrier source circuit but not in the signal output and input circuits.

The amplitudes of the side frequencies $(2np \pm q)$ are proportional to Q and the amplitudes of the even harmonics $2np$ are proportional to the dc bias. Considering one value of n only, the output products $(2p \pm q)$ and $2p$ when applied to a linear rectifier, yield the original signal $1+\cos qt$ at a higher amplitude. Since both of these products are proportional to signal amplitude, output is zero for zero input. Without the balancing of the two cores and the carrier windings, components involving odd multiples of the carrier would appear at the output, even when no signal is present, be rectified, and give some dc output.

It is seen that in this case, the actual carrier frequency is the second harmonic of the carrier source. In a practical circuit other even harmonics to a lesser extent will act as carriers also. This type of circuit, which in certain cases has several advantages over the more commonly used one, was developed by E. T. Burton of these Laboratories who originated the work on magnetic amplifiers here in 1927.[2] The principal application in view then was that of a dc telegraph signal amplifier.

Another way to accomplish the separation of components as described above is to use a three-legged core with suitably disposed windings.[3-5]

The magnetic amplifier circuit most frequently used now has the magnetic modulator in series with a generator and the load. Because of the wide variation of nonlinear coil (magnetic modulator) impedance with dc control, large amounts of ac power in the load may be controlled by small amounts of dc power. Using the carrier terms as we did for the other circuit, the actual carrier frequency here is that of the generator p and the principal side frequencies are $(p \pm q)$. This circuit has been used in two ways. The modulator load may be a demodulator feeding the actual load, in which case the output is an amplified version of the input. Or the demodulator may be dispensed with and the carrier used directly in the load. In the latter case the circuit is sometimes called a transductor.[6-8]

With this second type of circuit, the output is not zero for zero input since the coil impedance does not become infinite. If several stages of amplification are to be used in tandem, additional means must be provided to balance out this residual output.[4] In the first-mentioned type of circuit, the residual output may be made very small by selecting pairs of cores and adjusting the carrier source windings.

Another point of difference between the two types of circuit is in signal distortion. The second harmonic distortion of the signal is considerably smaller in the first-mentioned type unless the bias component of signal is large compared with the variable component.

The gain and output power of the two types are of the same order of magnitude.

In practice, the odd harmonics of the carrier are often allowed to flow in the carrier input circuit since this increases the output. The increase comes about through a straightforward modulation process. The flow of other modulation products in the input and output circuits may increase or decrease the gain, depending on the particular product. The amplitude of one or more of these products may be large because of self-resonance in the input winding when a large number of turns is used to obtain a high sensitivity.

It is desirable to prevent the flow of output components in the input circuit. To accomplish this, choke coils, simple and tuned, and filters have been used in various circumstances. These all have some effect on the input signal, either by introducing a loss or by slowing down the response, or both. Or an undesired resonance may occur. The effect of this part of the input circuit has not been taken into account in any of the calculations described here. An experimental result is given, however.

Consider the properties of the magnetic core which make it suitable for used in a magnetic amplifier. Since the coil with this core must be a modulator, it is necessary for its *B-H* curve to be nonlinear. Also it is desirable for it to have a large saturation flux density and small losses. Higher permeability, apparently giving greater nonlinearity for the same current, brings a disadvantage in the form of increased eddy currents unless the resistivity can be increased at the same time. Eddy currents bring about an appreciable reduction in the permeability from its dc value as well as energy losses. No matter how thin the material, these effects eventually become so large as frequency is increased, that it is impractical to drive the coil hard enough to get the necessary nonlinearity between B and H. Thus the ferrite materials, though having small dc nonlinearity, may be superior to tape at high frequencies.

One difficulty with magnetic amplifiers is that under certain conditions, the side frequencies and even harmonics of the carrier which appear at the output, may be sustained after the signal input has been removed. In the case of the even harmonics, there are certain values of output impedance which permit this unstable situation and others which do not. It is shown below that the boundary between these two sets of values is definite. The conditions for the maintenance of the side frequencies after the removal of the signal are more complicated and have been discussed elsewhere.[9]

[2] United States Patent Nos. 2,164,383 and 2,147,688.

[3] Other core arrangements are sometimes used, but the result is the same.

[4] A. S. Fitzgerald, "Magnetic amplifier circuits," *Jour. Frank. Inst.*, vol. 244, p. 249; October, 1947.

[5] A. Boyajian, "Theory of d.c. excited iron-core reactors," *Trans. AIEE*, vol. 43, pp. 919–936; June, 1924.

[6] A. U. Lamm, "Some fundamentals of a theory of the transductor or magnetic amplifier," *Trans. AIEE*, vol. 66, pp. 1078–1085; 1947.

[7] R. E. Morgan, "The amplistat—a magnetic amplifier," *Elec. Eng.*, vol. 68, pp. 663–667; August, 1949.

[8] L. W. Buechler, "Magnetic amplifiers for shipboard applications," *Elec. Eng.*, vol. 68, pp. 33–37; January, 1949.

[9] J. M. Manley and E. Peterson, "Negative resistance effects in saturable reactor circuits," *Trans. AIEE*, vol. 65, pp. 870–881; 1946.

The foregoing is a brief summary of various aspects of he operation of magnetic amplifiers. In the following, ome quantitative analysis and results will be described riefly and some experimental results given. After this, he effects of some modifications of the simple circuit escribed above will be mentioned.

Analysis

In magnetic modulation, the writer's experience has hown that the best approach is to calculate the flux unction corresponding to some appropriately assumed nagnetizing force function, using a simple *B-H* curve. n deciding what is appropriate, experimental results re very helpful. Where the circuit has a few resonances, ne or two or possibly three sine waves often will give a atisfactory representation of the magnetizing force. When this is done a Fourier series for the flux is computed. From this a Fourier series for the voltage on any winding may be obtained. Then in each mesh, a simple ircuit equation for each significant component of the eries is written. Satisfaction of these equations then letermines the magnitudes and phases of the assumed nagnetizing force waves if the original assumptions vere reasonable.

Where the circuit has a broad frequency characterstic, usually there are too many significant Fourier components in the magnetizing wave for the above method to be satisfactory. Then another approach must be found which deals with the wave forms directly.[10] In the magnetic amplifier problems treated here, the first method of considering a few sine-wave terms has proved useful.

Experience has shown that in problems like this one where the magnetizing wave carries the core fairly well into saturation in both directions, the principal modulation effects can be calculated using a single valued *B-H* curve. This greatly simplifies the work, because it is difficult to deal analytically with hysteresis loops, especially when the magnetizing force contains more than one sine wave.[11] In those cases where the single valued curve can be used, the main effects of the loop are to introduce losses and phase shift with respect to the driving wave. The latter is of little consequence usually, but the former may prevent the finding of accurate solutions to the circuit equations because of the difficulty of computing losses.

A. Open-Circuit Electromotive Forces

The simplest calculation of value is that of the output even-harmonic voltages when no output current is allowed to flow. Here the magnetizing force is

$$H = Q + P\cos pt \tag{1}$$

[10] E. Peterson, J. M. Manley, and L. R. Wrathall, "Magnetic generation of a group of harmonics," *Bell Sys. Tech. Jour.*, vol. 16, pp. 437–455; October, 1937.

[11] R. M. Kalb and W. R. Bennett, "Ferromagnetic distortion of a two-frequency wave," *Bell Sys. Tech. Jour.*, vol. 14, pp. 322–359; April, 1935.

and a satisfactory representation for the *B-H* characteristic of the core when losses are neglected is

$$B(h) = \frac{2B_m}{\pi}\arc\tan h/a \tag{2}$$

This characteristic is shown in Fig. 3(b) where it is seen that B_m is the saturation flux density and a is inversely proportional to the slope for small h.

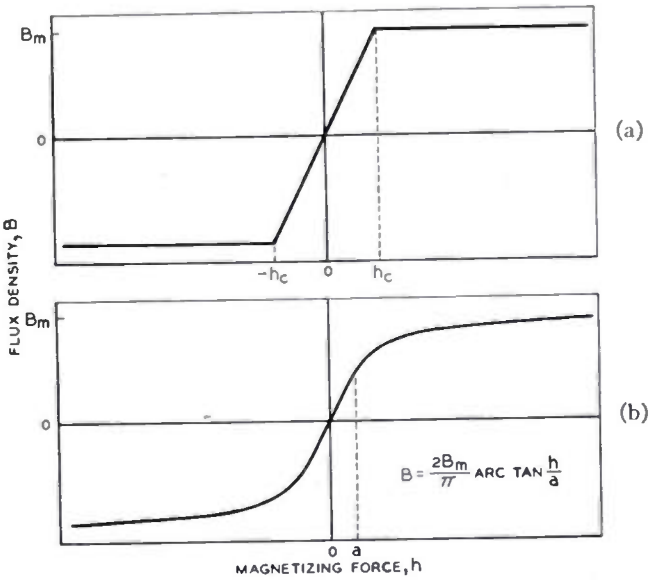

Fig. 3—*B-H* characteristics.

The Fourier coefficients of flux density may be computed in a straightforward way after (1) is put in (2). We have

$$B(H) = b_0/2 + \sum_{n=1}^{\infty}(b_n\cos npt + a_n\sin npt). \tag{3}$$

For the purpose of calculation, it is convenient to express (2) in the infinite integral form. The results are

$$\begin{aligned} a_n &= 0 \\ b_n &= 4B_m/\pi(-)^{(n-1)/2}\text{ real part of } I_n\ n\text{ odd} \\ &= 4B_m/\pi(-)^{n/2}\text{ imaginary part of } I_n\ n\text{ even,} \end{aligned} \tag{4}$$

where

$$I_n = \frac{1}{n}\left\{[1 + (r - jg)^2]^{1/2} - (r - jg)\right\}^n, \tag{5}$$

in which $r = a/P$ and $g = Q/P$. An approximation to this when Q/P is a fair amount less than unity is

$$b_n = \frac{4B_m}{\pi}\frac{[(1 + r^2)^{1/2} - r]^n}{n} \cdot \sin n\left[\sin^{-1}\frac{g}{(1 + r^2)^{1/2}} + \pi/2\right]. \tag{6}$$

A comparison of (5) and (6) for $n=2$ is given in Fig. 4.

The output second-harmonic voltage amplitude is given by

$$e_2 = 2pN_0 2Ab_2 10^{-8} \text{ volts,} \tag{7}$$

where N_0 is the number of turns in the output winding and A is the cross-sectional area in square centimeters of each core. Calculation and measurement of second- and fourth-harmonic electromotive forces were made for a coil having the following properties:

Core: 3.8 per cent chromium permalloy, 3 mils thick; mean diameter, 2.5 cm; cross-section area, 0.022 cm² each.

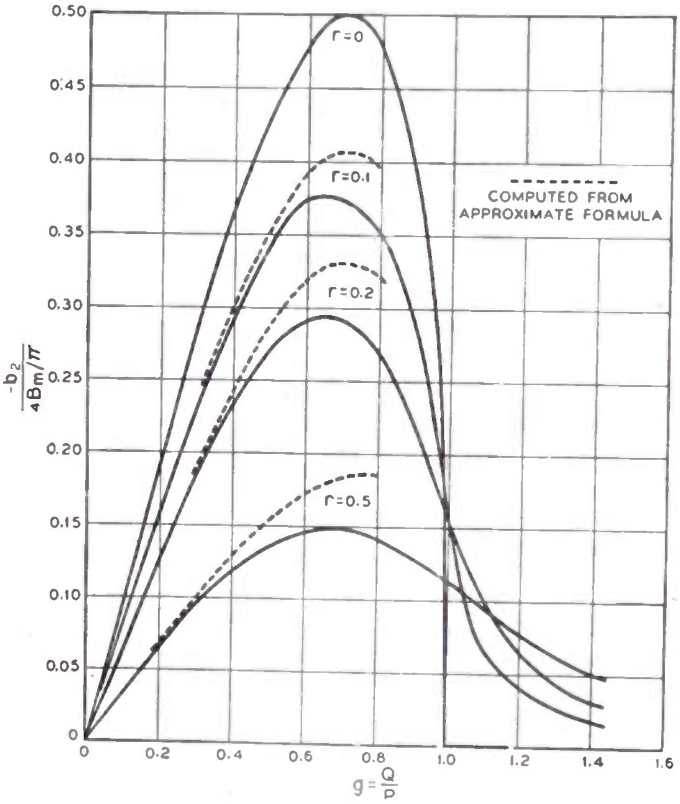

Fig. 4—Second-harmonic flux-density component as a function of bias.

Turns: Carrier, 400 each, input, 4,000; output, 200. Curves of these measured and computed voltages are plotted in Figs. 5 and 6. The agreement is seen to be fairly good except for the smallest value, $P=1$. Probably the reason for this is that the assumed B-H curve (2) is unsatisfactory for small amplitude swings. Calculations have also been made using the straight-line B-H curve of Fig. 3(a) and also using a loop having straight line branches as in Fig. 3(a). The results are essentially the same as those given above.

If a signal term $Q \cos qt$ is added to the magnetizing wave (1), the most important side frequencies at the output are $(np \pm q)$, n being even. Their amplitudes when Q/P is not too large are one-half the value of the nth harmonic amplitude given by (6). In the second type of circuit mentioned above, in which the load is in the carrier source circuit, we are interested in the varia-

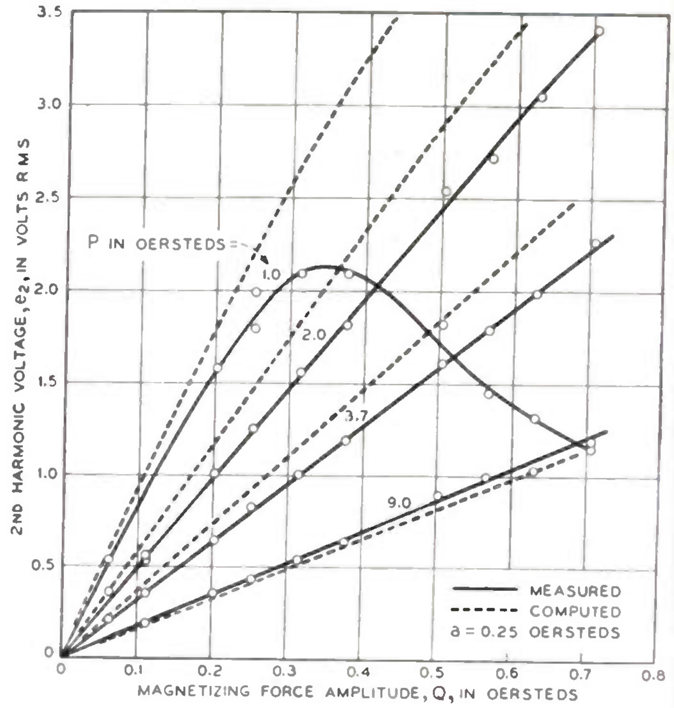

Fig. 5—Measured and computed values of second harmonic voltage.

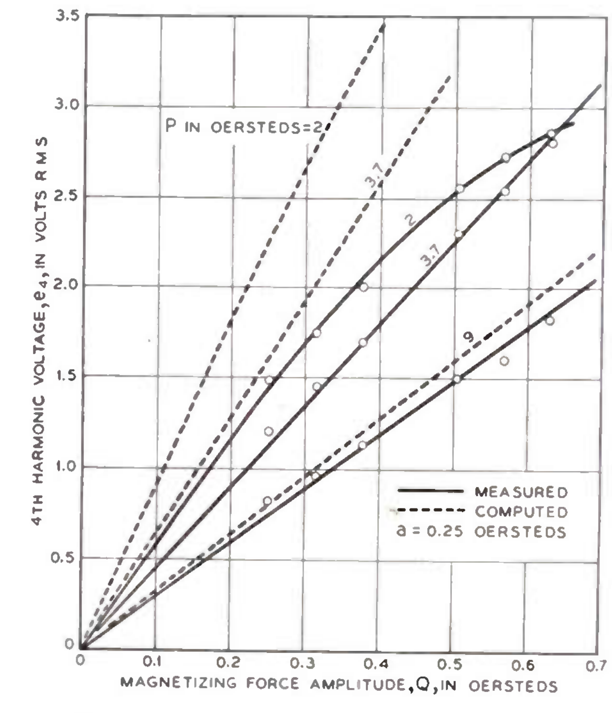

Fig. 6—Measured and computed values of fourth harmonic voltage.

tion of the carrier voltage with dc signal, to take the simplest case. In Fig. 7, the fundamental component of flux is plotted as a function of Q/P for several values of a/P when the magnetizing wave (1) is applied to B-H curve (2). These were computed from

$$\frac{b_1}{4B_m/\pi} = \left(\frac{1+r^2-g^2+[(1-r^2-g^2)^2+4r^2]^{1/2}}{2}\right)^{1/2} - r, \tag{8}$$

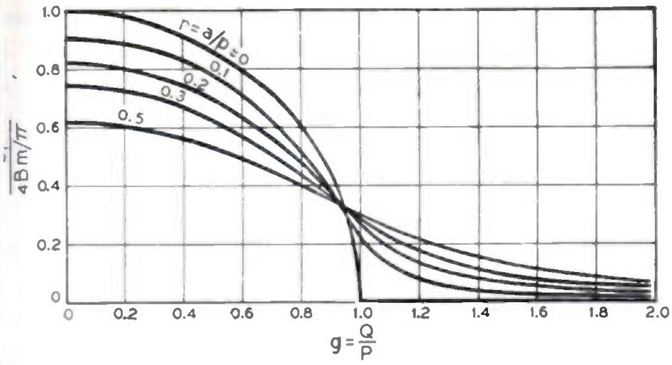

Fig. 7—Fundamental component of flux density as a function of bias.

which was derived from (4) and (5). The fundamental voltage across the coil is then

$$e_1 = pN_1 2Ab_1 10^{-8} \text{ volts.} \qquad (9)$$

3. *Second-Harmonic Output Current*

The difficulty of deriving an analytical expression for the second-harmonic current lies in the fact that the flow of this current affects the amount of second-harmonic generated voltage through intermodulation with the other components. This is a nonlinear feedback effect depending on fifth and higher orders of modulation. So a numerical calculation had to be made, and this was limited to one case.

A *B-H* curve made up of three straight lines as shown in Fig. 3(a) was assumed. The magnetizing force wave is

$$H = Q + P \sin pt + S \sin (2pt + 2\theta), \qquad (10)$$

where S and θ are to be determined. If the flux density is expressed as the Fourier series (3), then

$$R/X_0 = \frac{\pi}{2B_m}\frac{P}{S}(b_2 \cos 2\theta - a_2 \sin 2\theta)$$
$$X/X_0 = \frac{\pi}{2B_m}\frac{P}{S}(b_2 \sin 2\theta + a_2 \cos 2\theta) \qquad (11)$$

must be satisfied if (10) is a solution. In (11), X_0 is a reference value of reactance equal to the reactance of the output winding for very small values of output current. Calculation shows that the inductance corresponding to the reactance X_0 is approximately[12]

$$L_0 = \frac{4N_0^2 2A 10^{-9}}{d}\frac{2B_m}{\pi P} hy. \qquad (12)$$

where d is the mean diameter in centimeters of the core, and the other parameters have the same meaning as before. R and X are resistance and reactance, respectively, of the external output impedance. The coefficients b_2 and a_2 were computed for several values of S/P and θ and their values put into (11). Because of the length of the calculations, they were done for only one

[12] The effective inductance of the carrier winding to the carrier for the same number of turns is approximately twice L_0.

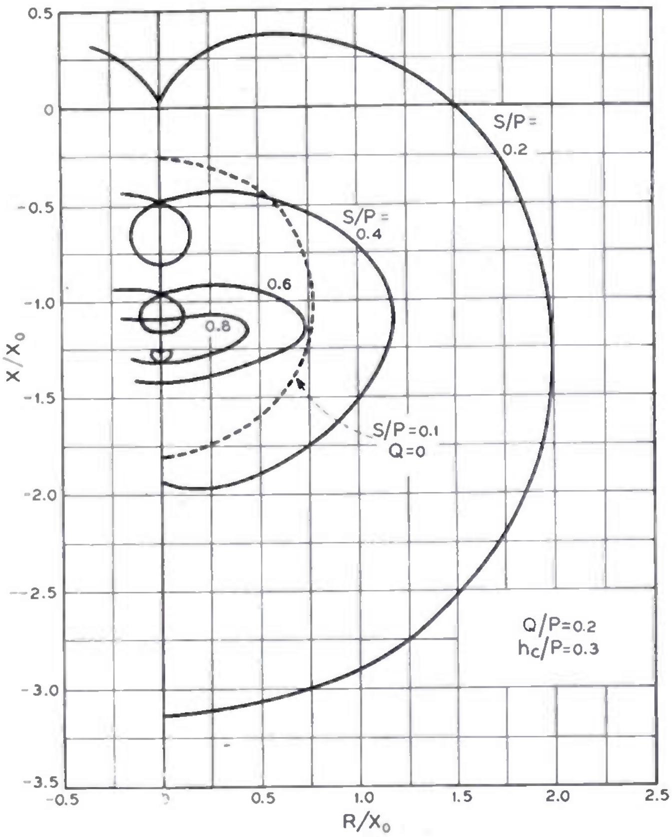

Fig. 8—Second-harmonic current computed as a function of external impedance.

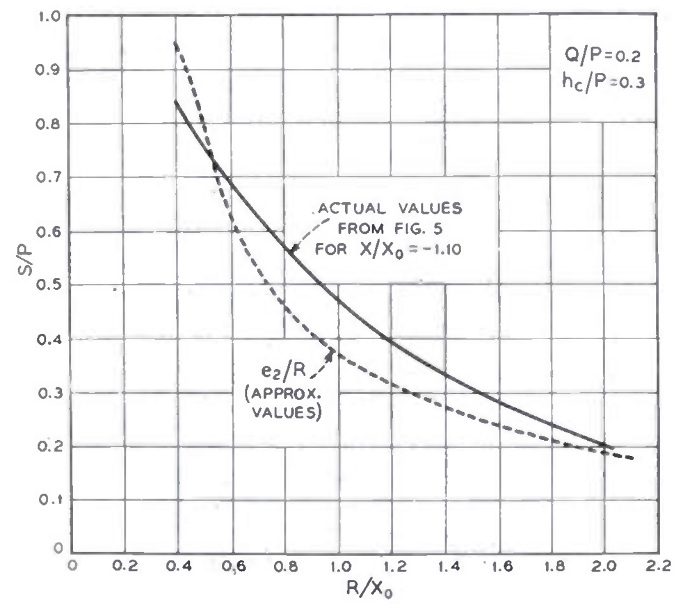

Fig. 9—Second-harmonic current as a function of external resistance for a fixed value of reactance.

value of Q/P, and one value of h_c/P. The results are shown in Fig. 8 where X/X_0 is plotted against R/X_0 for constant values of the amplitude ratio S/P.

If we consider a fixed value of external reactance, second-harmonic current amplitude may be plotted against resistance of the load. Taking $X/X_0 = -1.1$, the output winding inductance is nearly tuned out and the solid curve of Fig. 9 results, the values having been taken from Fig. 8. The dashed curve of Fig. 9 is plotted from

$$i_2 = e_2/R, \tag{13}$$

where e_2 is the open circuit voltage computed in Section *A* above. It is seen that when the output winding inductance is tuned out, a fair approximation to output current may be had from the ratio of open circuit electromotive force and load resistance. This is particularly true for larger values of R where the nonlinear reaction of output current is small.

It should be emphasized that the assumption of a single-valued *B-H* curve above means that all core losses are neglected. Thus, in applying the curves of Figs. 8 and 9, the internal resistance of the output winding would have to be considered part of the external resistance R. No very satisfactory methods have been developed for the calculation of this internal resistance because of the complications of eddy current and hysteresis effects, both of which are nonlinear here. Measurements indicate that this resistance varies approximately inversely with carrier amplitude, as does the inductance, when the carrier amplitude is large enough to magnetize the core somewhat beyond the knee of the *B-H* curve.

C. Direct-Current Gain and Rise Time of Response

The modulating gain from dc to second harmonic output may be computed if a few reasonable assumptions are made. This is very nearly the same as dc gain since the loss in the demodulator is small. Consider the simple equivalent circuit shown in Fig. 10(a). It is

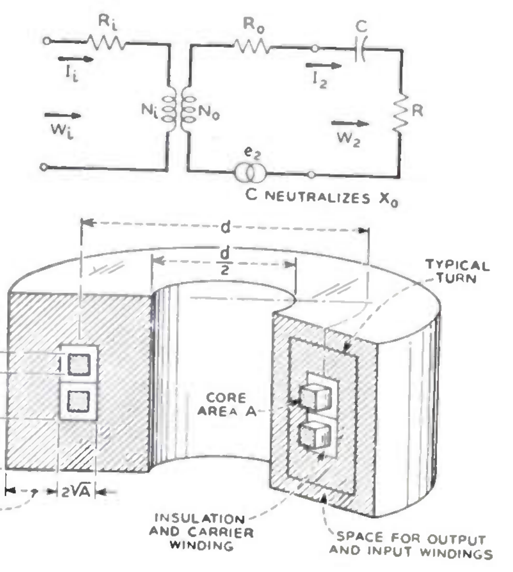

Fig. 10—(a) Simplified magnetic amplifier circuit. (b) Cutaway drawings showing physical arrangement of cores and windings.

assumed that the second harmonic current flowing in the output circuit is given by the approximation suggested in Section *B*, i.e.,

$$i_2 = \frac{e_2}{R + R_0} \tag{14}$$

where e_2 is the open circuit electromotive force as found from (7). We also assume that the internal resistance R of the output winding is some constant fraction D of the reactance X_0 of this winding. Let $R+R_0=X_0$ taking a value which by Fig. 8 will not permit self oscillation. Then second harmonic power is

$$W_2 = \frac{e_2^2}{X_0}\,\frac{1-D_0}{2}, \tag{15}$$

where $D_0=R_0/X_0$. When Q/P is considerably less than unity, a satisfactory approximation for b_2 in (6) yields for e_2

$$e_2 \doteq \frac{16}{\pi}\,10^{-8}\,pB_mN_0A\beta Q/P \tag{16}$$

where

$$\beta = \frac{(\sqrt{1+r^2}-r)^2}{\sqrt{1+r^2}} \tag{17}$$

is a factor depending only on the degree to which the carrier wave swings the core into saturation. X_0 is the reactance of L_0 at frequency $2p$. Hence from (12)

$$X_0 = \frac{32}{\pi}\,10^{-9}\,p\,\frac{N_0^2A}{d}\,\frac{B_m}{P}. \tag{18}$$

Combining (15), (16), and (18) we get for output power

$$W_2 = \frac{4\times 10^{-7}}{\pi^2}\,pB_mv\,\frac{\beta^2Q^2}{P}\,(1-D_0)\text{ watts,} \tag{19}$$

where v is the volume (πAd) of the core in cubic centimeters.

The input power is

$$W_i = I_i^2R_i. \tag{20}$$

R_i is the resistance of the input winding. A calculation for this is made in the Appendix, assuming, as shown in Fig. 10(b), that the inside diameter of the total winding is one-half the mean diameter of the core. This is known to use the winding space to the best advantage. The result is

$$R_i = \frac{54\times 10^{-6}\,N_i^2\alpha}{\pi^2kd} \tag{21}$$

where

$$\alpha = \frac{1+8\sqrt{A}/d}{1-4\sqrt{A}/d} \tag{22}$$

and k is the proportion of output and input turns used for input.

The magnetizing force Q of the input is related to the input current by

$$Q = \frac{0.4N_iI_i}{d}. \tag{23}$$

And so we have for the dc gain

$$G = \frac{W_2}{W_i} = 1.2 \times 10^{-3}\, pB_m v \frac{k}{\alpha d} \frac{\beta^2}{P} (1 - D_0) \cdot \quad (24)$$

hus the dc gain is proportional to carrier frequency, ituration flux density, and core area. The steepness of ie B-H curve enters through β and is a factor of less nportance.

The rise time of response is entirely determined by the se time of current in the input circuit. If there is no xternal resistance in the input circuit, then we may ake for this time

$$\tau = L_i/R_i, \quad (25)$$

L_i being the inductance of the input winding. For a iven inductance, the rise time will be reduced by the ddition of external resistance, but this will reduce the ain because of the increase in W_i. Using the relation of 12) and substituting N_i for N_0, L_i may be computed. This gives

$$\tau = 3 \times 10^{-4}\, B_m v \frac{k}{P\alpha d} \text{ sec.} \quad (26)$$

Combining this with (24), we get the simple expression

$$G/\tau = 4\, p\beta^2 (1 - D_0) \quad (27)$$

which shows that under the conditions noted above, the ise time increases in direct proportion to increases in ain.

Taking an example from some of the early work re- erred to above, consider a pair of molybdenum permal- oy cores each weighing 2.5 grams and having a mean liameter of 3 cm. A reasonable figure for D_0 for these is ./5. Using $P=2$, $r=0.2$, and $k=0.75$, we get

$$G = 0.063p, \qquad \tau = 0.045 \text{ sec.}$$

f the carrier source frequency is 2,000 cycles, then G s about 29 db.

D. General Energy Relations

As mentioned above, it is possible to derive general elations which show how the interchange of energy be- ween the various frequency components occurs in the nodulation process. These show how it is possible to get a modulating gain in a magnetic modulator.

Consider the case where two generators of frequencies p and q are connected to a load Z and a magnetic modu- ator having a single-valued B-H curve. Also assume hat only those current components of frequencies p, q, $mp+nq$, and $mp-nq$ are allowed to flow. Let W_p and W_q be the powers absorbed by the magnetic modulator rom the two generators and W_+ and W_- the powers lelivered to the resistance component of Z at the upper and lower side frequencies, respectively, by the modu- ator. Then it may be shown by processes, which space loes not permit to be reproduced here, that

$$W_p + W_q = W_+ + W_- \quad (28)$$

and

$$W_p = mp\left[\frac{W_+}{mp+nq} + \frac{W_-}{mp-nq}\right]$$
$$W_q = nq\left[\frac{W_+}{mp+nq} - \frac{W_-}{mp-nq}\right]. \quad (29)$$

Relation (28), which states that the sum of the powers absorbed by the modulator is equal to the sum of the powers delivered to the load by the modulator, is to be expected from the conservation-of-energy law. No power is dissipated in the idealized modulator itself since it was assumed to have a single-valued B-H curve, i.e., to be purely reactive. Relation (29) shows that the power taken from each generator depends di- rectly on its frequency. Similar results may be obtained in a generalization in which any number of side-fre- quency pairs are allowed to flow.[13]

When only the lower side frequency $mp-nq$ flows, we see from (29) that W_q is negative, i.e., power is de- livered to the q circuit instead of being taken from it.[14] This is the negative resistance effect which causes re- generation and if it is large enough to overcome the losses in the input circuit, oscillation will occur at fre- quencies determined by the resonances of the circuit.

If only the upper side frequency is allowed to flow, the modulating gain is

$$\frac{W_+}{W_q} = \frac{mp+nq}{nq}. \quad (30)$$

It is difficult to assign a definite value to the ratio W_p/W_q in the more practical case in which both upper and lower side frequencies flow because the ratio de- pends on the values of external resistance and reactance to both upper and lower side frequencies and because of the cross-modulation effects. The negative resistance introduced into the q circuit may or may not be large enough to make W_q negative or zero, depending on the impedance to the lower side frequency and the input circuit losses. If the impedance to the lower side fre- quency is not infinite, there is a regenerative effect, at least so that the ratio W_p/W_q is greater than mp/nq, the value it has when current at only the upper side frequency is allowed to flow.

E. Instability

As mentioned above in the general section, it is pos- sible for an unstable situation to exist in a magnetic

[13] The results (28) and (29) may be obtained under similar condi- tions with a capacitance modulator the voltage of which is some arbitrary nonlinear single-valued function of its charge. A particular case has been worked out in detail by R. V. L. Hartley, "Oscillations in systems with non-linear reactance," *Bell Sys. Tech. Jour.*, vol. 15, pp. 424–444; July, 1936. This was demonstrated by L. W. Hussey and L. R. Wrathall, "Oscillations in electromechanical systems," *Bell Sys. Tech. Jour.*, vol. 15, pp. 424–445; July, 1936.

[14] The relation of the sign of introduced resistance to the side frequency allowed to flow was shown first by R. V. L. Hartley under more restricted conditions. See E. Peterson, "Atomic physics and circuit theory," *Bell Lab. Rec.*, vol. 7, p. 231; February, 1929. Also see footnote reference 9.

amplifier such that even harmonic output persists after the removal of input or arises from some temporary disturbance other than input signal. This is true for both types of circuit discussed above. Ordinarily, even harmonics are not present in a ferromagnetic coil which is being magnetized sinusoidally. However, it has been found experimentally that they do appear under certain output or input impedance conditions.[9]

A calculation similar to that described in Section B was made with the assumed magnetizing force as in (10) except for the absence of bias Q. This is,

$$H \doteq P \sin pt + S \sin (2pt + 2\theta). \qquad (31)$$

From the results, permitted values of X/X_0 and R/X_0 were plotted one against the other as in Fig. 8 for constant values of the amplitude ratio S/P. One of these curves (for $S/P=0.1$) is shown in dashed line on Fig. 8. This curve is nearly semicircular, centered at $X/X_0 = -1$, $R/X_0=0$. Within this curve lie all those for larger values of S/P. Calculation (using the B-H curve (2)) shows that as S/P approaches zero the curves X/X_0 versus R/X_0 approach a limiting curve which is the circle

$$(R/X_0)^2 + (1 + X/X_0)^2 = e^{-8} \sinh^{-1} r. \qquad (32)$$

This limit is just beyond the dashed curve of Fig. 8. Thus if the external impedance connected to the output winding (or one equivalent to it) lies within this circle, instability will result. For impedances outside the circle, generation of an even harmonic without dc input cannot occur. However if the impedance is near the limit, though outside it, the output-input curves shown i Figs. 4, 5, and 6 will be distorted as shown in Fig. 11 These latter curves were obtained experimentally. A mentioned before the internal resistance of the outpu winding must be included in the total circuit resistanc R of Fig. 8. That is, in reducing actual external re sistance, we can never reach the zero value of R.

This effect of output without input, caused by a unstable condition should not be confused with a simila effect caused by a lack of carrier balance. If in the cas where the modulator output consists of the carrier eve harmonics ($2np$) and the side frequencies ($2np \pm q$), th carrier input coils are not perfectly balanced, a smal amount of carrier (p) will be present in this circuit This will be rectified and appear in the signal outpu circuit as a dc component which has no relation to th input.

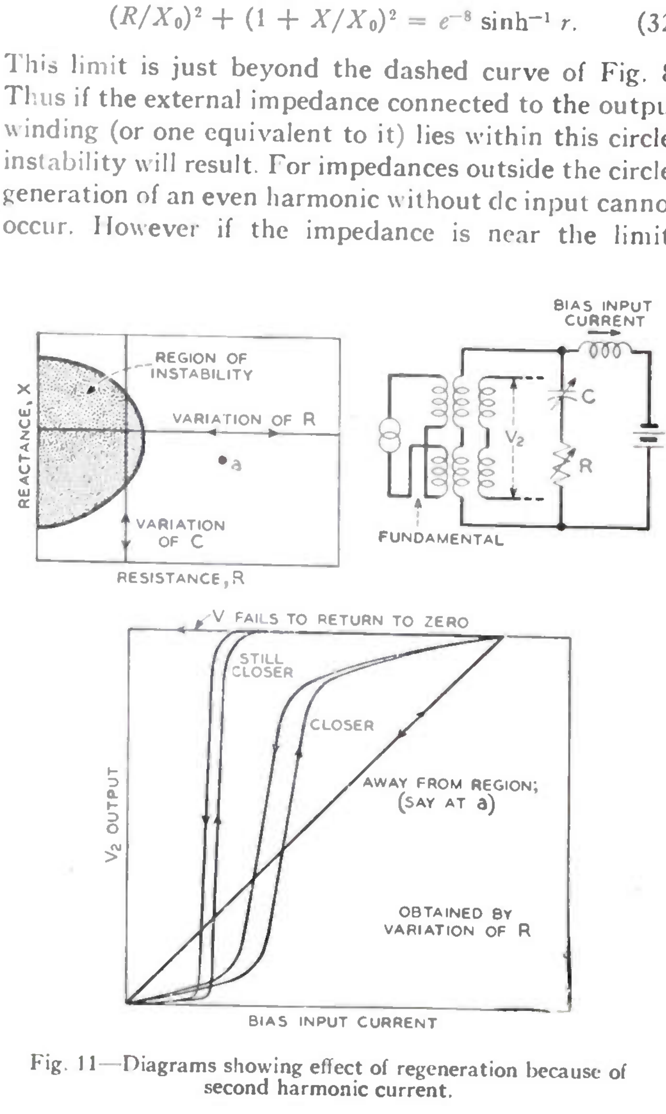

Fig. 11—Diagrams showing effect of regeneration because of second harmonic current.

Effects of Modifying the Simple Circuit Used for Analysis

In the practical use of magnetic amplifier circuits it has been found desirable often to use circuit arrangements somewhat different from the simple one used in the preceding analysis in which only a few current components were allowed to flow. A few experimentally observed effects of the changes are described.

If instead of tuning the carrier input circuit in order to have sinusoidal carrier current, we connect the carrier generator directly to the windings, odd harmonics of the carrier frequency will flow in this circuit. This has the effect of increasing the second harmonic output as shown in Fig. 12 by a factor of about two. A simple computation using a cubic characteristic shows that this increase is the result of a straightforward modulation between the carrier, its third harmonic, and the dc signal. A study of general energy relations as given above shows that the flow of odd harmonics of the carrier increases both W_+ and W_q in such a way that their ratio remains constant.

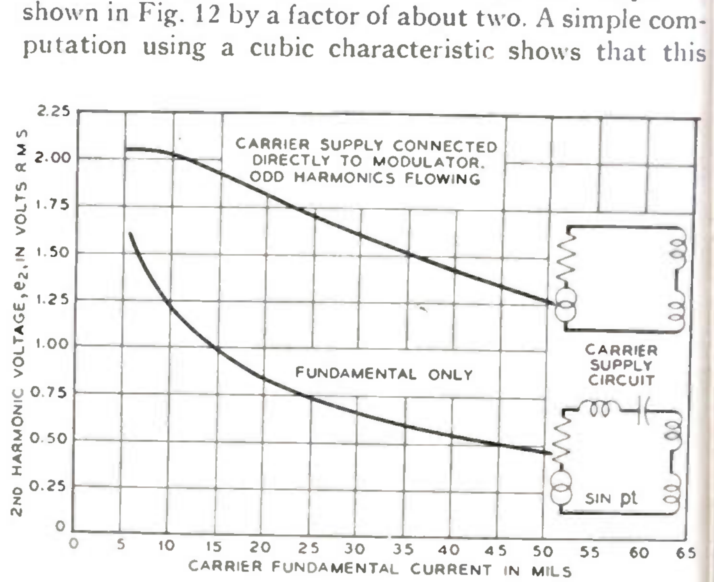

Fig. 12—Effects of supplying carrier current in two different ways.

In order to make the amplifier operate on very small ıput currents, a large number of turns may be used ɪr the input winding. In some of the early work dis-repancies between calculated and measured values ⁄ere traced to self-resonance in the input winding. ’hese resonances allow large circulating currents which, hrough modulation with other components, may either ncrease or decrease the desired output. The same effect nay arise when externally connected impedances reso-ıate with a winding at an important frequency. This is een in Fig. 13 in the case of the input circuit. Since the ›utput winding is equivalent to the input winding ex-:ept for impedance level, the effect is found there also, ıs shown in Fig. 14.

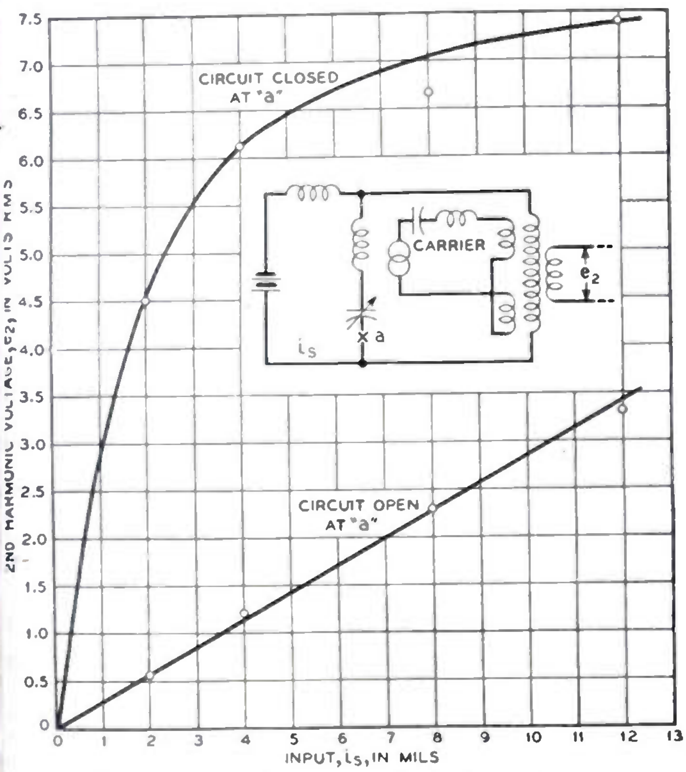

Fig. 13—Effect of a resonance in the input circuit.

Acknowledgment

The writer wishes to acknowledge the help of Miss M. C. Packer in numerical computation, and that of E. Peterson, who was consulted frequently during the project. His basic work in magnetic modulation suggested approaches to many of the problems.

Appendix

Consider the winding for the toroidal coil shown in Fig. 10(b) to be made up of a series of rectangular helices, a typical turn of which is shown. The number of turns in each helix is

$$n_1 = (d/4 - \sqrt{A})/a.$$

The number of helices is determined by the inner diameter of the winding space and is

$$n_2 = (\pi d/2)/a,$$

a being the diameter of the insulated wire. The total number of turns that can be put in this space is then $= Nn_1n_2$. The mean length of turn is

$$l = d + 8\sqrt{A}.$$

The resistance of this winding is

$$R = \rho \frac{8\sqrt{A} + d}{\pi a^2/4} N,$$

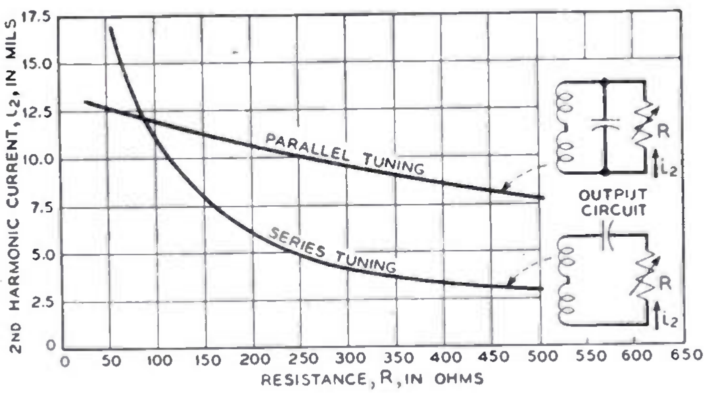

Fig. 14—Effects of two different ways of tuning the output circuit.

ρ being the resistivity. Let k be the fraction of N which is used for input winding. Then eliminating a^2 between the expressions for R_i and N_i, we have for input resistance

$$R_i = \frac{54 \times 10^{-6} N_i^2}{\pi^2 kd} \alpha$$

where

$$\alpha = \frac{1 + 8\sqrt{A}/d}{1 - 4\sqrt{A}/d}.$$

Experimental Evaluation of Diversity Receiving Systems*

JOHN L. GLASER†, ASSOCIATE, IRE, AND S. H. VAN WAMBECK†, SENIOR MEMBER, IRE

Summary—**Methods used in a long-range experimental study of fading with ordinary and diversity receiving systems are discussed. Results are expressed statistically in terms of the nonusable circuit time and also in terms of the number of fades per minute below least usable level.**

Data for this analysis are obtained on semiautomatic equipment which measures the total time the signal spends in each of seven pre-established intervals of signal strength and counts the number of times the signal enters each interval. The instruments thus accomplish at the time of recording a substantial part of the analysis.

THIS PAPER deals with methods being used in a research program to evaluate the performance of diversity receiving systems which are of interest to the Signal Corps. Experimental techniques are described and the statistical concepts which have been adopted for presentation of performance data are discussed with respect to the problem of expressing the reliability of a facility in explicit terms. A review of experimental findings is presented in a companion paper which follows in this issue of the PROCEEDINGS.[1]

Diversity reception is a means for combating the fading of radio signals, so an investigation of it requires the recording and description of the fading encountered with the various systems considered. A high-speed strip recording of signal strength over a single radio channel reveals that signal strength varies in a random manner and that fading does not have a periodic characteristic. Since the frequency of fading and the total range of fading cannot be expressed explicitly with any real meaning, it follows that a mathematical treatment of the problem must be based on statistical concepts.

An established method for describing the fading of a signal is in terms of the probability that the signal amplitude will at a particular instant be less than a designated amplitude. Assuming that the signal at a single antenna is the resultant of many signals arriving in random phase, it can be shown[2] that the probability that the signal amplitude will be less than s is

$$P(s) = 1 - e^{-(s/s_0)^2}$$

where s_0 is the long term, root mean square of the signal amplitude. This function is shown graphically in the curve marked "nondiversity" in Fig. 1.

The improvement afforded by the use of diversity reception results from the fact that the signals received under different conditions do not generally fade together. These different receiving conditions might be attained, for example, with spaced antennas, by use of antennas of different polarization, or by using different frequencies. In the usual system, a separate receiver is used for each channel. The receiver outputs are connected to a circuit which selects the strongest signal as the diversity output. A diversity signal selected in this manner will fall below a particular amplitude only when the signals in all channels are simultaneously below that amplitude.

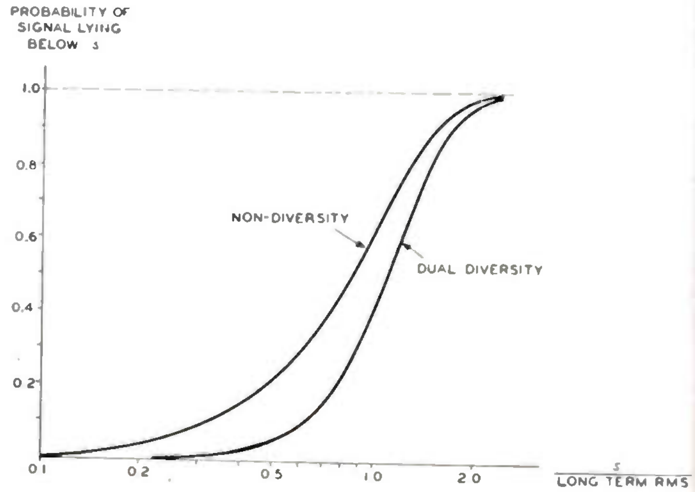

Fig. 1—Curves showing the probability that a nondiversity and a dual-diversity signal amplitude will at any instant be less than a designated amplitude. Uncorrelated Rayleigh distributed fading on the two diversity channels is assumed.

The probability that two independent events will occur at the same time is the product of the probabilities that each will occur by itself. Therefore, if the fading of the two signals in a dual diversity system were completely independent, the probability that the amplitude of both signals would be below a designated amplitude is the square of the probability that each (considered by itself) will be below that amplitude. Therefore, with a dual diversity system with completely independent fading on the two channels, the probability that the combined signal will fall below s is $[P(s)]^2$. The function $[P(s)]^2$ is shown in the curve marked "dual" in Fig. 1. Similarly for triple diversity with completely independent fading this probability is $[P(s)]^3$.

The foregoing discussion assumes, first of all, that the signal is fading with a Rayleigh distribution and, second, that the fading of the two or three channels is completely independent. Based on such assumptions,

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† Washington University, St. Louis, Mo.

[1] S. H. Van Wambeck and A. H. Ross, "Performance of diversity receiving systems," this issue, pp. 256–265.

[2] Lord Rayleigh, "Theory of Sound," vol. 1, p. 41, 2nd ed., Macmillan Co., New York, N. Y.; 1894. (Also Dover Publications, New York, N. Y.; 1945.)

elonek, Fitch, and Chalk[3] made an interesting analyti-al study of diversity improvement. But their analysis id not show what separation of antennas would give his uncorrelated fading nor what correlation exists for articular spacings or between the fading on two differ-ntly polarized antennas. It appears that this informa-ion must be obtained experimentally.

It is conceivable that a program could be directed oward determining a statistic which is a measure of the orrelation between the fading on the several antennas. Presumably such information could then be interpreted n more practical terms to show the actual improvement n transmission capacity resulting from the use of vari-ous diversity systems. There appeared, on the other hand, to be considerable virtue in obtaining statistical esults directly in terms applicable to the problem of engineering a receiving facility.

In selecting the terms in which the experimental re-sults should be expressed, consideration was given to the manner in which diversity systems improve reception. For one thing, diversity reception smooths out the varia-tions in signal strength resulting from fading. However, this can often be accomplished to a sufficient extent with automatic gain control or with limiters. The real value of diversity reception is presumed to lie in the decrease n the probability that the several diversity signals will be lost in the noise at the same time. The diversity im-provement results from the fact that the combining cir-cuit has more than one receiver from which it may select the strongest output and that the combined diversity signal will be unusable only if all of the contributing signals are unusable. If only one receiver contributes to the output at any time, the noise level is that from just one receiver.

[3] Z. Jelonek, E. Fitch, and J. H. H. Chalk, "Diversity reception," *Wireless Eng.*, vol. 24, p. 54; February, 1947.

Having established this as the basis for judging diver-sity performance, the experimental program was di-rected toward determining the fraction of the time for which a diversity signal was below various amplitudes. If, from measurements at a prospective receiving site, a least usable level can be determined, the experimental results will show what per cent lost time will result with the various diversity systems. It was also considered desirable to know how often the signal faded below various levels. The experiments were arranged to give this information also.

Let us consider the matter of unusable time in terms of an example. Fig. 2 shows typical simultaneous record-ings of the fading of a nondiversity and a diversity sig-nal. If the level shown by the solid line were the least usable level, the nondiversity system would have been unusable for a certain fraction of the total time. Also the signal faded below this level a certain average num-ber of times per minute. With a combining system which selects only the strongest signal, the least usable level is the same for the diversity system. The curve here shows the amplitude of the stronger of the two diversity signals. The combined diversity signal will be unusable when this stronger signal is less than the least usable level.

It can also be seen here that the unusable time de-pends upon the location of the least usable level relative to the received signal. If, for example, the transmitter power were increased, both the diversity and nondiver-sity curves here would be shifted upward an appropriate number of decibels, thereby reducing the unusable time. Similarly, if the least usable level is established (as is

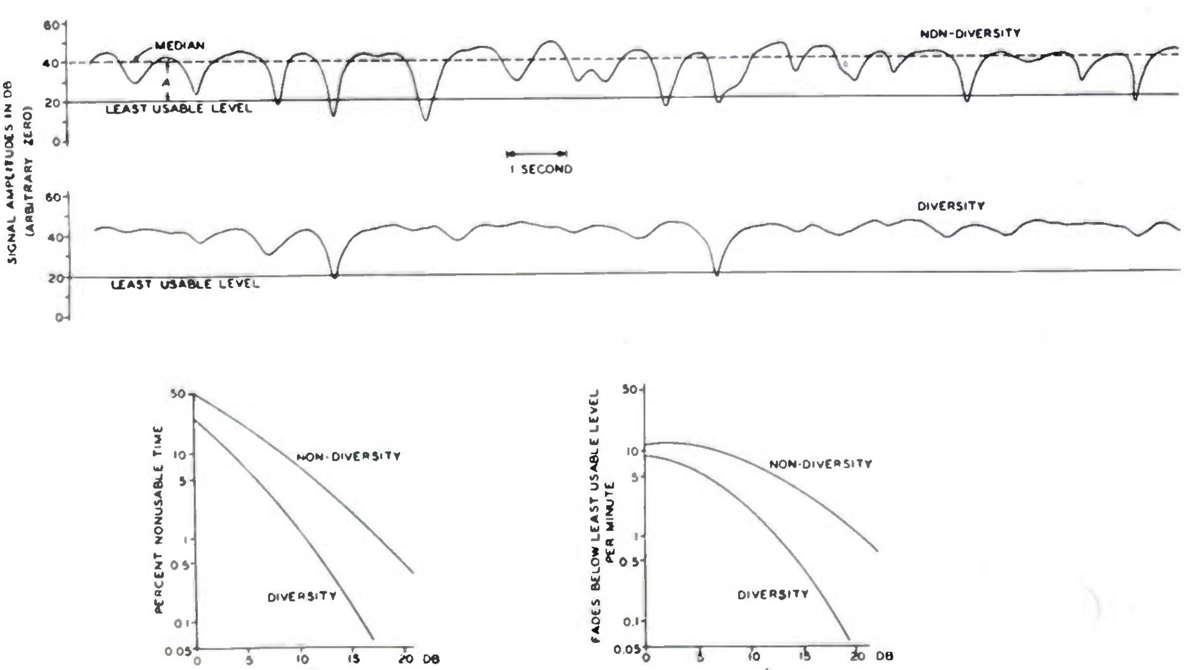

Fig. 2—An example showing the dependance of nonusable time and fades below least usable level upon the strength of the received signal relative to the least usable level.

usually the case) by the interference picked up by the antennas, improved receiving antenna directivity favoring the desired signal and discriminating against the interference will reduce the unusable time.

A convenient measure of the least usable level relative to the received signal is the quantity A shown in Fig. 2. The amplitude of the received signal is measured here in terms of its median. This is the value which it exceeds one half of the time. If the per cent unusable time is plotted as a function of A, one obtains curves of the type shown in the lower left corner of Fig. 2. The curves in this figure show the percentage time spent below various signal amplitudes. Signal amplitudes as shown are measured relative to the median.

Similar curves can be drawn for the fading rates. The curves in the lower right corner of Fig. 2 show the average number of fades per minute below the various signal amplitudes. Here again, signal amplitude is given relative to the nondiversity median. That is to say, the abscissa is the quantity A.

Such information as this could be extracted from strip records like the example used in Fig. 2. Although a very short sample is shown to illustrate the principles, many hours of data would be required to give reliable statistical information and the procedure would be costly and slow. For this reason, an instrument was developed which analyzes the fading signals directly in usable terms at the time it is received. A simplified diagram of this instrument is shown in Fig. 3. This instrument determines the time spent in each of seven preset intervals of signal amplitude. These times are indicated on seven electrically operated clocks. Counters connected in parallel with the actuating coils of the clocks show the number of times the signal entered each interval. Because the median signal strength varies from one test to the next, the setting of the intervals bears no fixed relation to the median. The relation of the median to the various intervals during a particular experiment is determined by recording also the signal received with a nondiversity receiving system. The nondiversity and diversity recording is done with the same instrument on a sampling basis, recording the two during alternate ten-minute periods.

Fig. 3 shows also the diversity combining circuit. Selection of the strongest diversity signal is accomplished by use of a common load for the second detectors of the diversity receivers. The voltage developed in this load by the strongest signal biases the detectors of the other receivers so that (except when two signals are about equal) only one signal contributes appreciably to the combined output. The selection of the strongest signal is enhanced by the use of a common automatic gain control with which the gain of all receivers is determined principally by the strongest signal.

The second detector load is in the form of a voltage divider which is switched between the diversity and reference receivers for alternate ten-minute periods. The six taps on this voltage divider are connected to six dc amplifiers whose outputs control the conduction in six pairs of gas tetrodes. These gas tubes are connected in 60-cycle full-wave rectifier circuits whose outputs control a series of relay. With no signal at the input of the

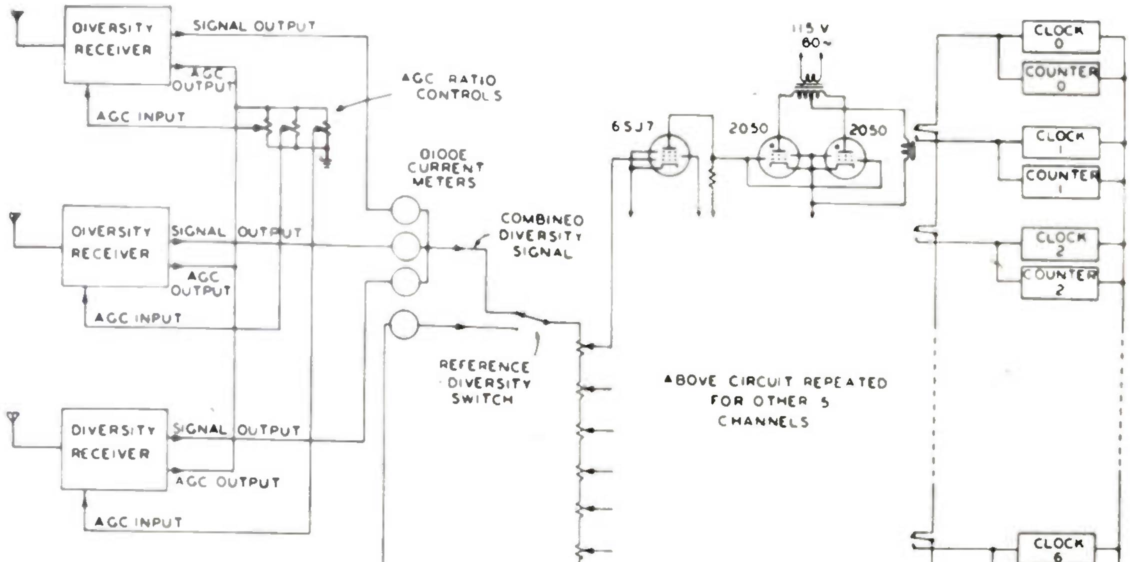

Fig. 3—A simplified diagram of the recording instrument.

receivers, all of the gas tubes are biased to nonconduction. As the input signal increases, a point is reached at which the pair of gas tubes at the top of Fig. 3 begin to conduct, closing the relay associated with this circuit. A further increase of 6 db in the input signal causes the next pair of gas tubes to conduct closing its relay. When the signal amplitude is less than that which causes the first pair of tubes to conduct, the clock marked "0" runs. When the signal amplitude reaches the point at which the first pair of tubes fires, clock "0" stops and the clock marked "1" starts. This same process is continued as amplitude of the signal increases through each of the intervals of signal level.

The taps on the voltage divider are adjusted so that successive channels fire at increments in the signal strength of 6 db measured at the input of the receivers. Thus the sixth channel fires when the receiver input is 30 db above the amplitude which fires the first channel. Calibrating the system in terms of receiver input voltages takes into account the nonlinear response of the receivers with their automatic gain control. Great care is taken to match the response characteristics of the nondiversity and the several diversity receivers. The calibration is therefore valid whether the recording instruments are connected to the diversity or the nondiversity system. If the diversity output is determined by only the strongest input signal, the response of the diversity system is that of each of the diversity receivers alone.

A clock which runs continuously is used to show the total recording time. The sum of the other seven clocks should agree with the reading of this clock providing a check against faulty operation or misreading. Actually there is slightly more lag in stopping the clocks than in starting them, due to the transients in the switching circuits. The total of the clocks for the seven intervals generally exceeds the reading of the continuous clock by one half to two per cent, depending on the rapidity of fading. The time measurements in those intervals where the signal spends most of the time are accurate to within about one per cent, although the percentage error is greater in those intervals where the time is made up of short periods.

The counters indicate the number of times the signal entered each interval. Except at the start and end of a run, the signal must have left each interval as often as it entered it. Each time it leaves an even-numbered interval it enters an odd-numbered interval either above or below it. Therefore, the sum of the counts in all even-numbered intervals should equal the sum of the counts in all odd-numbered intervals. These relations hold as well when the counts have been divided by the total recording time to give counts per minute, providing a check on some of the computations.

The principal reason for recording the nondiversity signal is to determine how the boundaries separating the intervals are situated relative to the median signal strength. It is pure coincidence when the median happens to be one of these boundaries. The median can be determined by plotting on suitable co-ordinates the per cent time spent below each boundary as a function of the signal amplitudes they represent and reading from the resulting curve the level corresponding to 50-per cent time.

Knowing then the relation of the median signal amplitude to the firing levels of the recording instrument, it is possible to plot curves for each test period of the type shown in the lower half of Fig. 2. When the curves obtained from several tests of the same diversity system are plotted on the same chart, the curves do not in general coincide, indicating some variability in the observed performance. As a general rule, the curves do fall into distinct groups. Average performance might be expressed by averaging the ordinates of the several curves. However, the variability in the performance is almost as significant a characteristic of the diversity systems as the typical performance. A number of established measures of variability could be used. A convenient method of showing this is to indicate areas on the graph which include the middle half of the group of curves for a particular diversity system. Examples of this presentation of the interquartile range will be found in the paper which follows.[1]

The problem of diversity system evaluation is by its very nature a statistical problem. We feel that the methods discussed here for presenting the statistical findings are of great practical value. The terms in which diversity improvement has been expressed can be more readily related to the real communication problem than relatively abstract indices that might have been devised. Not only do the results permit comparison of the effectiveness of various antenna arrangements, but they provide also the information for weighing the values of a diversity system against other means for obtaining the same reduction in lost circuit time.

The recording equipment developed for these tests has greatly facilitated the processing of the statistical data by effectively performing a portion of the analysis at the time that the signals are received.

Acknowledgment

The authors wish to acknowledge the contributions of C. F. Klamm, Jr., and F. K. McCaffrey in establishing the statistical concepts and in development of the instrumentation.

Performance of Diversity Receiving Systems*

S. H. VAN WAMBECK†, SENIOR MEMBER, IRE, AND A. H. ROSS‡, SENIOR MEMBER, IRE

Summary—An outline is given of the study of diversity reception being carried out jointly by the Signal Corps Engineering Laboratories and Washington University, the purpose of which is to determine the characteristics, limitations, and relative merits of space, polarization, and frequency diversity systems.

Results are reported on various systems including dual- and triple-spaced-antenna diversity and several forms of polarization diversity. Frequencies in the range of 7 to 16 Mc have been investigated over a 900-mile path between New Jersey and St. Louis, Missouri. Improvement provided by the various diversity systems is presented graphically in terms directly applicable to the design of a transmission facility and the variability in improvement is indicated for its value in estimating departure from mean performance.

Over the past several years the Signal Corps Engineering Laboratory and Washington University have collaborated in a comprehensive investigation of diversity receiving systems. The amount of improvement available from various diversity methods has been established quantitatively and design procedures have been drafted. Developments at this stage of the program indicate that it may be possible to establish quantitative specifications for diversity systems to reduce by practically any desired amount the loss in transmission time due to deep fades.

Diversity receiving methods involve the use of two or more transmission channels which are separately identified at the receiving point and a combining circuit which either selects the strongest available signal or provides an output proportional to some combination of all signals. Separation of the transmission channels may be on a physical basis as with spaced-antenna diversity or on some other basis as in polarization diversity and frequency diversity. Those types of receiving diversity which would be practical for military purposes are to be investigated but the more complex systems such as the multiple-unit steerable antenna will not be considered. This report is limited to spaced-antenna and polarization diversity in the frequency range of 7 to 16 Mc.

A principal object of this investigation is the collection of necessary data for the evaluation of various diversity systems and formulation of procedures for their design. Attention is also being given to the receiving equipment problem to the end that more effective facilities may be developed as a consequence of the program.

To the greatest practical degree the experimental aspects of the program have been planned and implemented to provide data that are accurately representative of propagation behavior and the respective antenna systems and that do not reflect the characteristics of any particular receiving or recording equipment. The large volume of data involved is collected with semiautomatic recorders, thus minimizing the time required for processing and providing numerical information in a form directly applicable to statistical analysis. Details of the equipment and the statistical methods are presented in a companion paper.[1]

The required long transmission lines from antennas to field laboratory are of identical length and are constructed of dual RG/8U cables to reduce pickup on these lines approximately 50 db below the signal level provided by the antennas. Antennas are all half-wave doublets and the horizontal elements are installed at a height of about 45 feet. The single antenna for the reference system is installed 2,000 feet from the center of the area for the diversity arrays. The only antennas in the area at a given time are those required for the particular array being tested. Receivers are matched in gain, in automatic-volume-control characteristic, and in impedance level at the input terminals. All equipment is recalibrated and retuned each hour during recording periods and is further checked by strip oscillograph records and observation during actual operation. A condition is maintained at all times which permits the interchange of apparatus between channels without altering the data to a measurable extent.

A lengthy discussion of the analytical methods used is unnecessary at this point but it may be desirable to review briefly the graphical forms which have been adopted for the presentation of performance curves. Since the fading of radio signals may be described with reasonable accuracy by a Rayleigh probability function, a basic co-ordinate system derived from this type of distribution has been adopted. It possesses the advantage of yielding performance curves for a single-channel system which are straight lines in the ideal case and nearly straight for actual data. Interpolation is facilitated by this linear property. Fig. 1 shows a typical set of curves for a single-channel reference system and a two-channel diversity system. There is no mathematical reason to expect the diversity data to plot as straight lines even though the reference systems may be ideal and yield data having perfect Rayleigh distribution.

Data as recorded are first plotted for each recording period in a set of curves as shown in Fig. 1. In some cases, the data for a full day may be condensed into a single set of curves while in other cases a day may be broken into several periods, the data for each of which will be plotted separately. Data for the period in which the long-term median value of signal strength on the

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† Washington University, St. Louis, Mo.
‡ Signal Corps Engineering Laboratory, Red Bank, N. J.

[1] J. L. Glaser and S. H. Van Wambeck, "Experimental evaluation of diversity receiving systems," Proc. I.R.E., pp. 252–256, this issue.

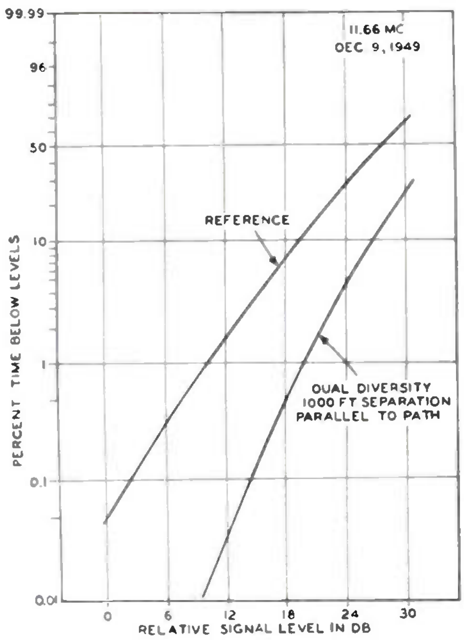

Fig. 1—Typical results plotted on Rayleigh co-ordinates. Data are for a single day.

reference system are essentially constant may be represented by a single set of curves. This follows from the fact that the statistical analysis is based upon the assumption of a constant median value.

A more useful presentation for engineering purposes is obtained when the fading characteristic of a diversity system is referred to the median signal level which would exist without diversity. Fig. 2 shows such curves as derived from a graph such as Fig. 1 and depicts the percentage lost time plotted vertically as a function of the difference between median signal level and other lower levels. This graph only provides statistical information for the region below median level in the reference system but this represents no shortcoming because those situations in which the least usable level exceeds the median are of little or no practical importance.

Data have also been collected on the rapidity of fading or, more specifically, on the number of times per minute that the signal fades downward through various levels. This information may be of great value in the design of equipment where the frequency of fading would be a factor. In Fig. 3 the fades per minute are plotted vertically against signal level below median value.

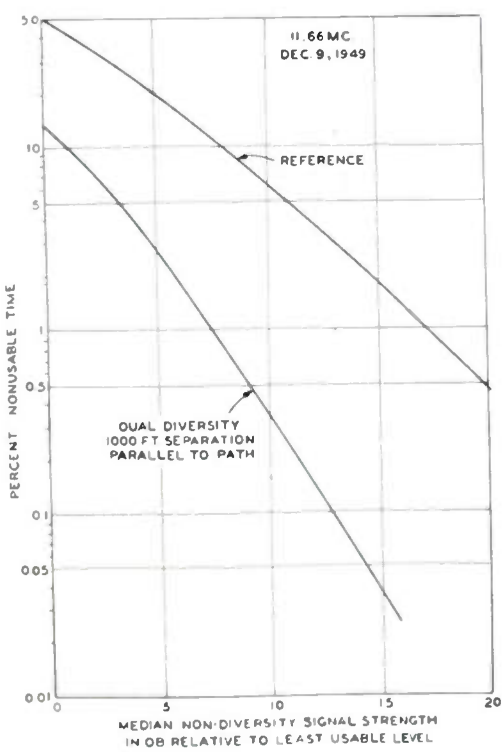

Fig. 2—Typical fading characteristics for a single day relative to median value of signal strength received on the reference system.

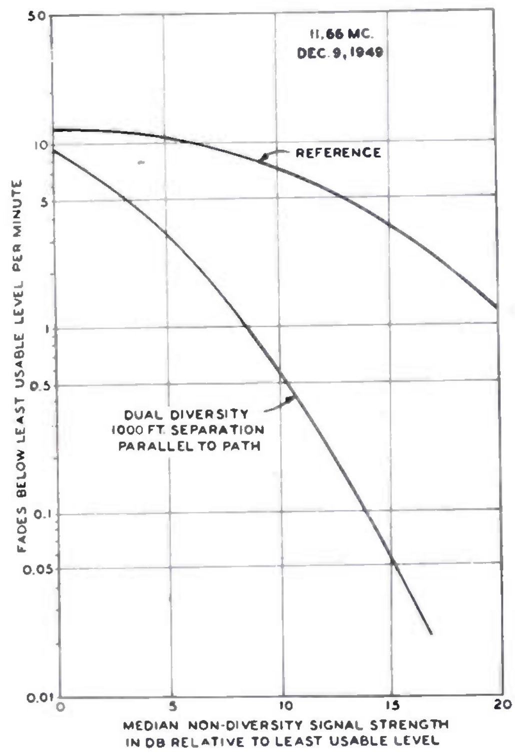

Fig. 3—Typical fading characteristics for a single day depicting the number of fades per minute below the respective levels.

Investigations have been conducted on three frequencies in the range of 7 to 16 Mc. The lower frequency used was 6.915 Mc, the intermediate 11.66 Mc, and the higher 15.72 Mc. Unmodulated carrier has been used exclusively. This is justifiable in the interest of simplicity and in that the results may be readily extended to other systems with modulation, as will be discussed later. Space diversity systems with dual and triple channels have been rather completely investigated and work on these is continuing. Several arrangements for polarization diversity have also been investigated and significant data have been collected.

Experimental work has been under way for nearly two years and has been conducted continuously over that period of time. Approximately 2,000 hours of recording are represented in the reliable data which have been processed up to the present. The particular frequency for use at any time is selected in terms of the propagation characteristics for the path in service.

All data here reported have been collected over the path from Red Bank, New Jersey, to St. Louis, Missouri. This is approximately 900 miles in length and lies in a generally east-to-west direction. Future tests are currently being planned between England and St. Louis, Missouri, for longer path information, from the Panama area to St. Louis for a north-south comparison and over a short path at frequencies below 7 Mc.

A large quantity of data has been collected and is presented in a relatively few charts. As might be expected, there is variability in the data collected for a given configuration from day to day and from season to season. This variability may be due to changes in ionospheric characteristics, to chance sampling of an inherently variable phenomena, and, to less degree, to errors of measurement. For the purposes of this paper, many sets of curves have been reduced to single lines which are representative of the weighted arithmetic mean of available data.

In planning this program it has been recognized that normal fading as encountered most of the time will not account for all losses in transmission. Interference and complete breakdown of ordinary ionospheric behavior are typical influences which cannot be included in thi type of statistical analysis but which will have a ver real effect upon continuity of service over a communica tion facility. This investigation has dealt exclusivel with the problem of normal, short-period fading and th results are applicable in the absence of other influence such as those cited.

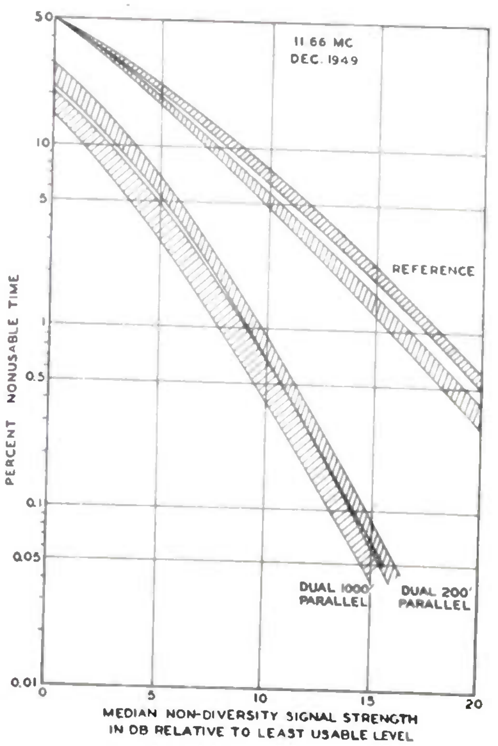

Fig. 4—Performance of dual-spaced-antenna diversity system showing typical variability in data.

The following discussion on performance of the vari ous types of diversity systems is divided into thre sections covering two-antenna, spaced diversity, com monly called "dual"; three-antenna, spaced diversity also termed "triple"; and polarization diversity. Figs. 4 through 10 present various aspects of two-antenna spaced diversity and subsequent figures apply to th other forms.

Representative performance of dual diversity is de picted in Fig. 4. The data on which these curves ar based were collected in December, 1949, for a frequency of 11.66 Mc during daylight hours. The cross-hatched areas represent the zones in which half of the curves for the respective days or periods were located. For one fourth of the time the performance was better than is indicated by the areas and for one fourth of the time the performance was poorer. The expression "interquartile range" is commonly applied to the area within the boundaries shown.[2]

In some cases the interquartile areas are wider than indicated in Fig. 4 while in others they are not so broad. These data may properly be characterized as typical and show the usual order of improvement afforded by dual diversity. The curves indicate, for example, that the reference system will have approximately two-per cent nonusable time if the median signal level is 15 db above least usable. If dual diversity with 200 feet separation is used, the percentage lost time drops to approximately 0.08 per cent and if the separation is increased to 1,000 feet, the lost time will be the order of 0.05 per cent. The increase in spacing from 200 to 1,000 feet contributes very little to the performance of the diversity system.

Fig. 5 presents graphically the information on number of fades per minute with a dual diversity system. It is evident that the number of fades is substantially reduced and that large spacings are not necessary as there is relatively little improvement in going from 100 to 1,000 feet. A single-channel system at this frequency will experience approximately three fades per minute if the median signal strength is 15 db above least usable level. Under the same conditions a dual diversity system will fade 0.2 times per minute which represents an

[2] The two curves for the reference system result from the presentation of data for two separate dates on a single graph where the side-by-side comparison accentuates the variability in characteristics. The reference system has been quite consistent in its performance so it would be expected that a long series of data samples would yield an interquartile range somewhat wider than either in Fig. 4 but not so wide as the total area bounded by the extremes of the two curves. Other cases of this type occur in later figures.

improvement of approximately 15 to 1. Some variability is also obtained in the data on which these curves are based. The single lines shown represent the weighted arithmetic mean.

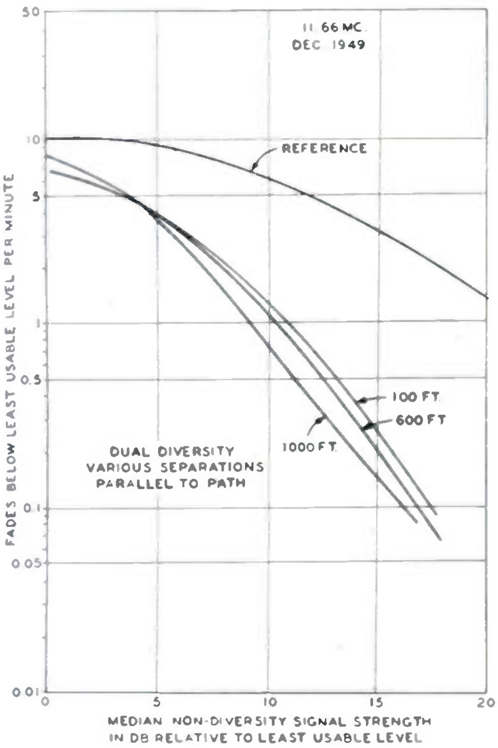

Fig. 5—Performance of dual-spaced-antenna diversity system with respect to fades per minute below respective levels.

In the absence of evidence to the contrary, it might be expected that the performance of a given diversity array would be quite different at different frequencies and seasons of the year. As a matter of fact, the performance seems to be relatively free of such influences as indicated more specifically in Fig. 6. Here are shown performance curves for three frequencies and three seasons which fairly well cover a complete year. The poorest performance was obtained on 11.66 Mc and the best on 7 Mc. More recent data indicate that dual diversity is not always so good as here represented but additional information must be gathered before these latest results can be accurately reported. The curves shown in Fig. 6 are typical of the performance over a total experimental period of approximately two years up to February, 1950.

In so far as time and conditions permit, tests are scheduled in a manner which will provide a maximum of cross checking. For example, it is customary to repeat runs for a given frequency in all seasons for which it is usable and also to repeat on an interval of approximately one year as a long-range check on variability. Tests on dual diversity at 11.66 Mc and with a separation of 1,000 feet parallel to the path were conducted in December, 1948, and were repeated in December, 1949. The results are reported in Fig. 7 which has been drawn to show the interquartile range. It is apparent that there is some variability but this is to be expected in view of the changing ionospheric conditions on a cycle of much greater period. Efforts are being directed toward explicit co-ordination of diversity performance and ionospheric

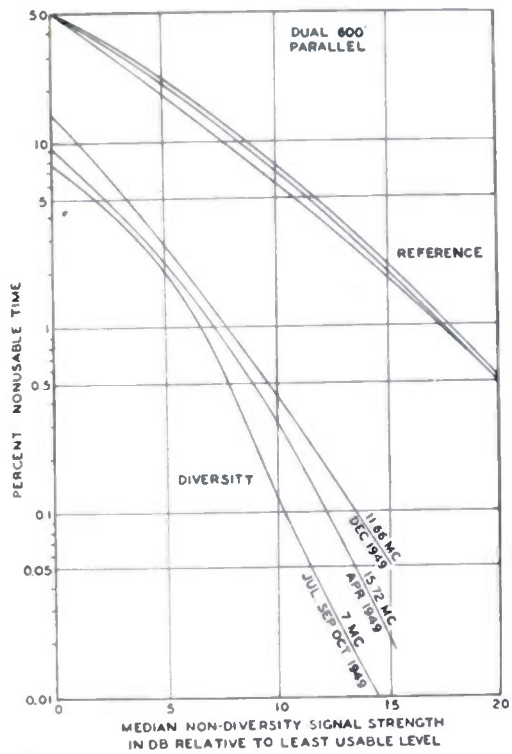

Fig. 6—Performance of dual-spaced-antenna diversity system for various seasons and frequencies.

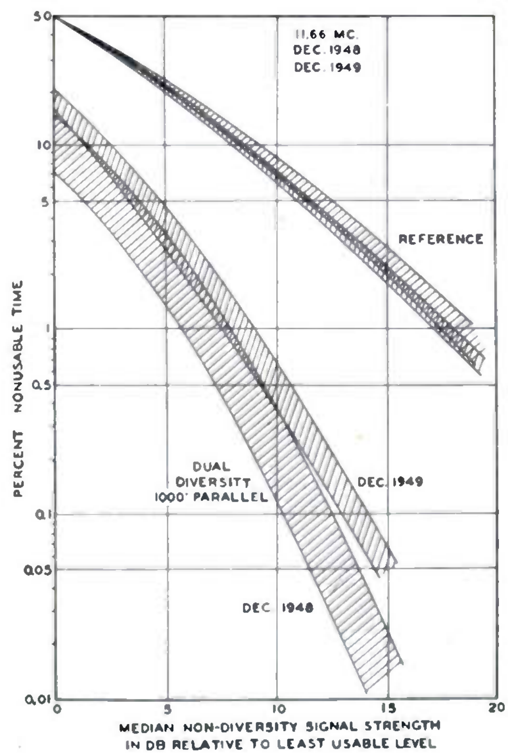

Fig. 7—Difference in performance of dual-spaced-antenna diversity system over interval of one year.

characteristics which will make possible a direct forecast of diversity effectiveness when the ionospheric predictions are established. Some information on this subject is now on hand and will be reported at a later date, together with additional data presently being collected.

It has already been mentioned that large spacings are not appreciably more effective than shorter ones in overcoming the effects of fast fading. Other investigators have indicated that spacings of the order of several miles or more are advantageous in reducing the effects of slow fades.[3] This investigation is limited to fades which occur at the rate of once each minute or more frequently. For such short-period fades a separation of 100 feet between diversity antennas provides a large increase in reliability of service. If the spacing is increased tenfold, the performance is not greatly improved. Fig. 8 is a presentation of data on dual diversity for four different spacings. If the median signal strength

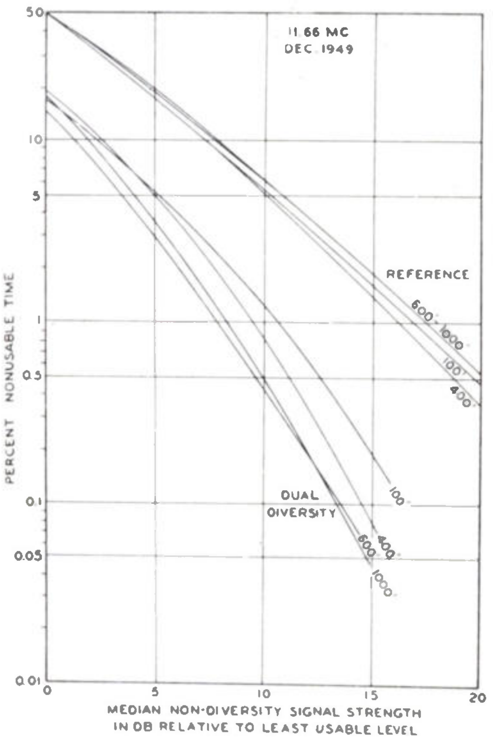

Fig. 8—Effect of antenna spacing on performance of dual-spaced-antenna diversity system.

is 15 db above least usable, the reference system will give approximately two-per cent nonusable time. Dual diversity with 100 feet separation will have only 0.2-per cent nonusable time and with 1,000 feet separation will have 0.05 per cent. The improvement with 100 feet separation is ten to one over the reference system while 1,000 feet separation gives only four to one improvement over 100 feet.

Two hundred feet appears to be the point of sharply diminishing return in improvement per unit distance. This point is more clearly established when the data are presented in the form used in Fig. 9. Spacing has been selected as one of the axes and curves have been drawn for various median signal strengths relative to least usable value. For a median value 15 db above least usable level on the reference system, the principal part of the improvement is obtained in the first 200 feet of separation.

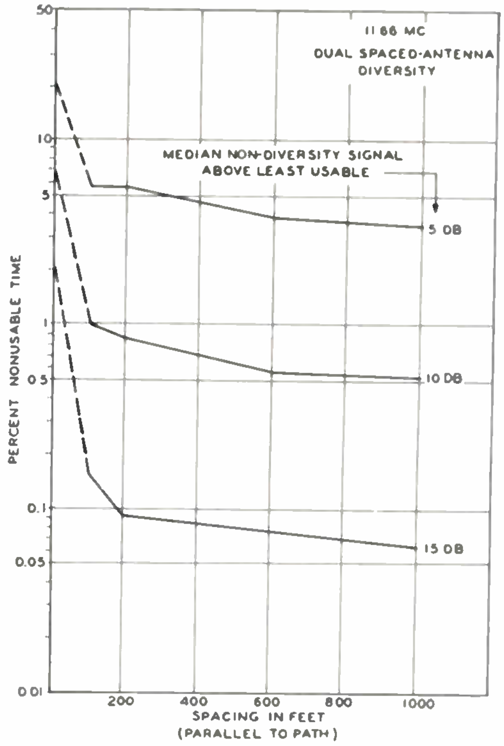

Fig. 9—Influence of spacing on performance of dual-spaced-antenna diversity system.

Since it is possible to arrange diversity antennas in many directions with respect to the arriving wave, the question naturally arose as to what geometric pattern would be the most effective. In the field facilities, provision is made for the erection of antennas along a line parallel to the direction of arrival and also along a line perpendicular to this direction. Resolution of the problem into two principal directions in this manner appeared to offer the simplest experimental means of determining the effect of geometrical placement. It is interesting to note that there is no marked advantage in one direction over the other as demonstrated by the data presented in Fig. 10. These data were collected under carefully controlled conditions which largely eliminated the influences of factors other than orientation. Earlier tests indicated that one direction or the other might have some small advantage but it has since been concluded that these apparent differences were due to changes in other test conditions.

Analysis of triple diversity, predicated upon fading of a single transmission channel in accordance with Ray-

[3] Private communication from S. D. Browning, Mackay Radio and Telegraph Co. Inc., New York, N. Y.

leigh distribution, indicates that there should be considerable improvement over dual. Experimental investigation supports these predictions and indicates that a high degree of reliability can be obtained with such a system. Typical data for a triple diversity system

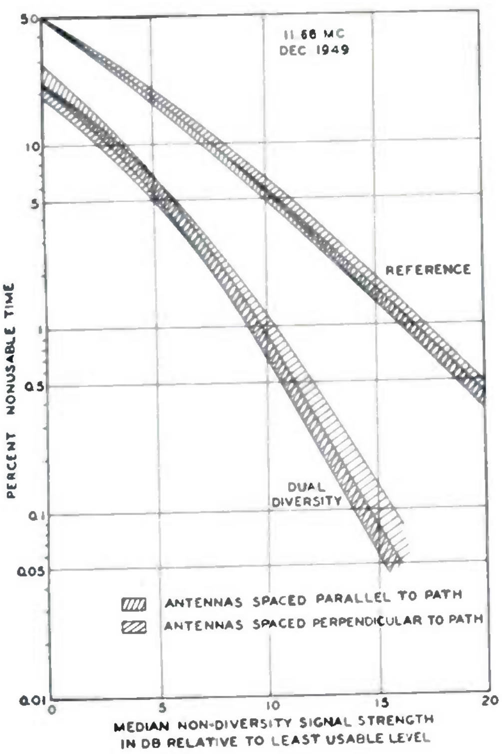

Fig. 10—Effect of orientation of antenna array with respect to signal path on performance of dual-spaced-antenna diversity system.

collected during daylight hours at a frequency of 11.66 Mc in the month of January, 1950, are presented in Fig. 11. The cross-hatched areas represent data lying in the interquartile range for spacings of 200 feet and 600 feet, respectively. The degree of variability indicated is common to the three frequencies here reported and the relative improvement of 600 feet separation over 200 feet is likewise typical. For the ionospheric conditions during the period of these tests, the reference system would have given between one- and two-per cent lost time if the median signal were 15 db above least usable level. For the same strength of signal, triple diversity with 200 feet extreme separation would give only approximately 0.01-per cent lost time or less than one hour in a year of 24-hour per day operation. If the reference system were to provide the same degree of reliability, the median signal would have to be approximately 30 db above least usable as can be estimated by projecting the reference curves to the 0.01-percentage line.

As the frequency is changed, some difference in performance of triple diversity is noted. The curves shown in Fig. 12 are representative of the performance for three frequencies in four seasons of the year. The difference between the performance of 15.72 Mc in April and 7 Mc in July and October is apparently due in part to difference in ionospheric characteristics as some degree of correlation is possible. As with dual diversity, perti-

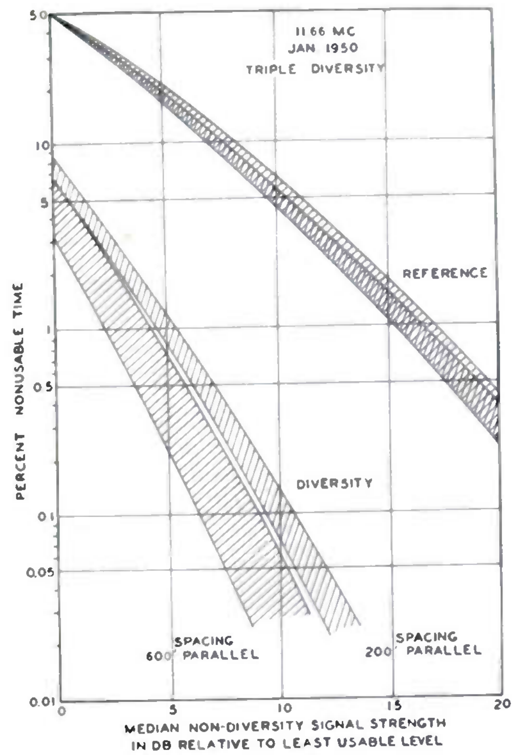

Fig. 11—Performance of triple-spaced-antenna diversity system showing typical variability in data.

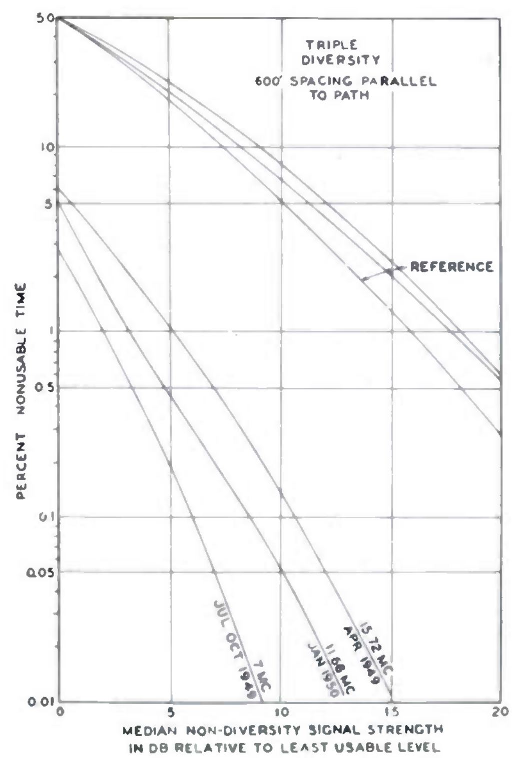

Fig. 12—Performance of triple-spaced-antenna diversity system for various seasons and frequencies.

nent ionospheric information is being collected in an effort to establish a more explicit correlation.

The effectiveness of spacing has also been investigated for triple diversity and typical results are shown in Fig. 13. In all cases reported, the separation in triple diversity is given between extreme antennas. To facilitate comparison, a curve for dual diversity is included, showing its performance for a separation of 1,000 feet. Triple diversity with a separation of only 200 feet between extreme antennas provides substantial improvement over the best dual performance. Further improvement results from increased separation but in this case also there is diminishing return as a separation of 200 feet is exceeded.

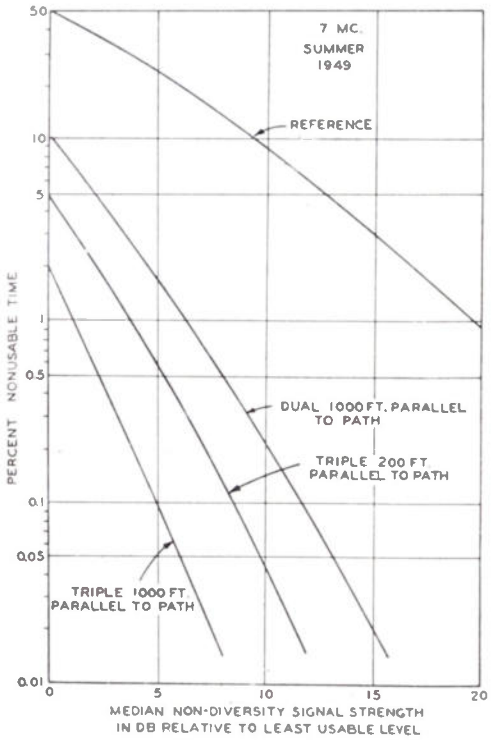

Fig. 13—Effect of antenna spacing on performance of triple-spaced-antenna diversity system. Performance of dual system is shown for comparison.

The reduction in fades per minute is also substantial with triple diversity as clearly indicated by the curves in Fig. 14. A median signal strength 15 db above least usable level will give from 6 to 7 fades per minute on the reference system, something over 0.1 fade per minute with dual diversity and 0.01 fade per minute or less with triple diversity. It may be concluded that the reduction in number of fades per minute bears a close correspondence to the reduction in lost time with the various diversity systems.

The figures quoted above for triple diversity performance become more meaningful when the fades per minute are expressed in terms of some larger reference. For example, 0.01 fade per minute below least usable level corresponds to one fade in one hour and 40 minutes or 14.4 fades in a 24-hour day. Since the expected lost time for the triple diversity system is of the order of 0.01 per cent or 0.14 minute per 24 hours, it follows that there will be the order of 14 fades per day each of approximate duration of 0.01 minute. It will be readily recognized that this order of improvement from the

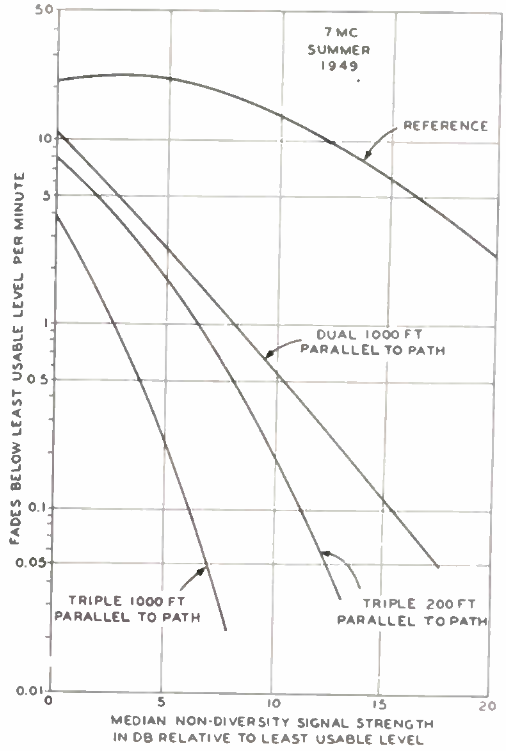

Fig. 14—Performance of triple-spaced-antenna diversity system with respect to fades per minute below respective levels.

effects of normal fades is adequate for all practical purposes where other influences such as interference will usually account for a much larger loss of time.

In many respects, polarization diversity would be desirable, particularly in military communications. Several antenna arrangements for this form of diversity have been tried and considerable data have been collected on the most promising arrangements. The performance of one polarization diversity system is depicted in Fig. 15. The inverted-L arrangement consisted of a horizontal dipole approximately 50 feet above the ground and a vertical half-wave dipole suspended at one end of the horizontal element. Lead-ins were taken from the center of each antenna for a distance of 50 feet or more in a direction substantially normal to the plane of the two antennas. These precautions in the placement of lead-in lines were observed to minimize any possible interference effects due to the presence of the shielded leads in close proximity to the antennas.

The usual performance of dual diversity with 200 feet separation is also shown in Fig. 15 for reference. It appears from these data that polarization diversity is somewhat better than dual but this particular point requires some enlargement. Some evidence now available indicates that the poorest polarization performance is obtained when dual-spaced-antenna diversity gives best results. Conversely, when very poor diversity improvement is obtained with dual spaced antennas, the improvement from polarization diversity is greater. Investigation of this phenomenon has not been completed but the available experimental data are most interesting. Any conclusion as to the relative advantage of

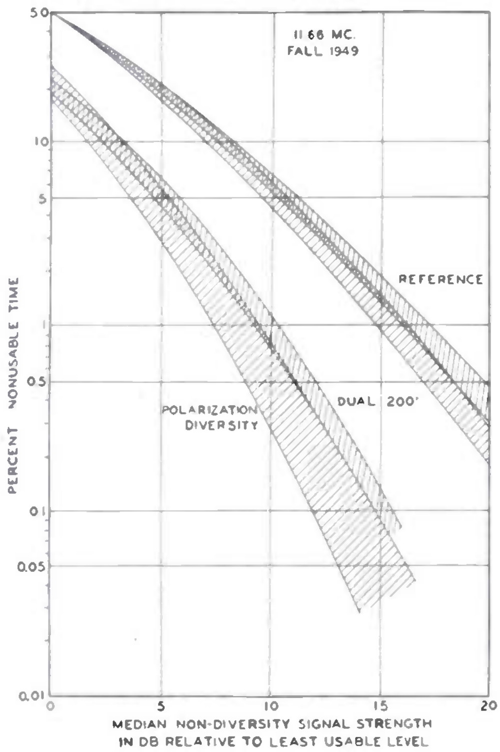

Fig. 15—Performance of inverted-L polarization diversity system showing typical variability in data. Performance of dual-spaced-antenna diversity is shown for comparison.

polarization diversity compared with dual must be drawn with reservations which cannot be accurately expressed at this time.

Polarization diversity is effective in reducing the fades per minute and to about the same degree as spaced dual with separation of 200 feet. This conclusion may be readily drawn from the data plotted in Fig. 16 but is probably subject to the same restrictions as would apply to a conclusion on reduction in percentage lost time.

Polarization diversity has not been consistent in performance and has generally been characterized by a weakness of signal on the vertical element. The vertical component generally contributes to the transmission a relatively small percentage of the time and then only during deep fades of the horizontal component. Discrimination against high-angle signals by the vertical antenna in close proximity to the ground may account for this behavior. Another factor is possibly introduced by the node at high angle in the horizontal antenna pattern at higher frequencies. Further investigation of this entire problem is clearly necessary.

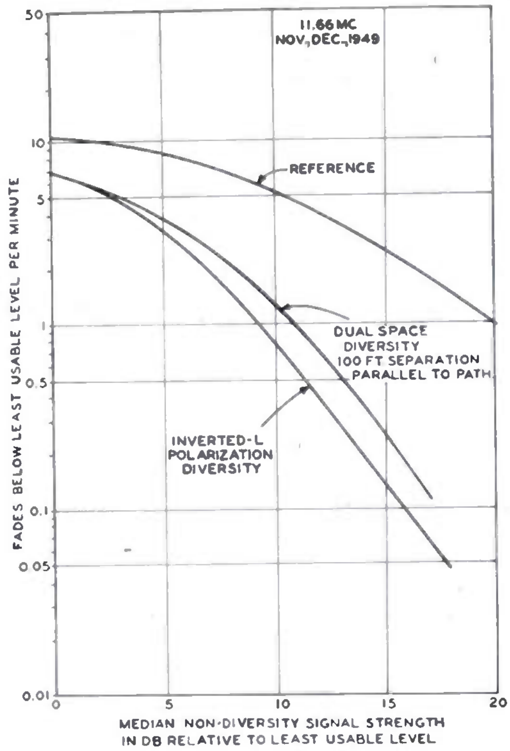

Fig. 16—Performance of inverted-L polarization diversity system with respect to fades per minute below respective levels.

As with the other forms, polarization diversity exhibits some variability with frequency and seasons. Data collected with a T arrangement of antennas on three different frequencies and in three seasons are summarized in Fig. 17. The wide spread between the extreme curves supports the statement made earlier that the performance of this type of diversity has been quite inconsistent. Additional data are being collected to clarify many of the unresolved points so that more reliable conclusions may be reached.

Data have been obtained on four different antenna arrangements for polarization diversity which appeared to have possibilities from a practical standpoint. The inverted-L antenna has already been described. The T antenna is quite similar except that the vertical element is suspended from the center of the horizontal element. An inverted-V antenna was tested because it offers obvious advantages in simplicity of erection. A single pole was used and the two antennas were suspended from the top to opposite points on the ground at angles of 45° to the horizontal. The angle between antennas was thus 90° and the plane of the antennas was made normal to the direction of arrival. An X arrangement was also

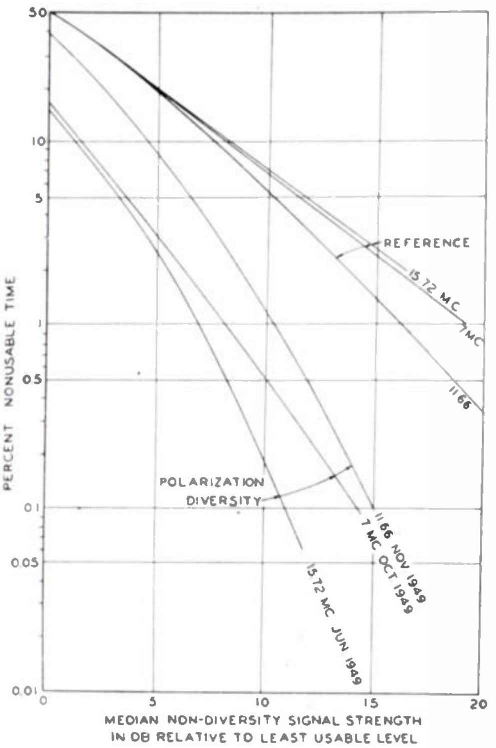

Fig. 17—Performance of T polarization diversity system for various seasons and frequencies.

tried with two poles for support. The antennas were inclined at 45° to the horizontal and were in essentially the same plane. The separation at the centers where the antennas crossed was of the order of one foot.

The relative performance of the above-described antennas for polarization diversity is indicated by the curves in Fig. 18. While some of the differences may be due to normal variability in data, it appears that the inverted-L arrangement has some advantage over the others. All tests were not of the same duration but each was sufficiently long to provide a reasonably dependable sample of data.

Use of an unmodulated carrier in this work is not expected to impose any great limitation on the utility of the findings. Signal Corps Engineering Laboratories have conducted an extensive series of tests on facsimile, voice, and multichannel teletype circuits with several forms of modulation and with various controlled conditions of selective fade. This study indicated that distortion is low and that the percentage accuracy in signal reproduction is greatest when the carrier level is maintained or is restored by exalted carrier techniques. Thus it would appear that any system which maintains the carrier level will have a corresponding high fidelity in the handling of modulated signals.

The investigation here reported has yielded valuable data on the performance of spaced-antenna and polarization diversity. Improvement provided by diversity is expressed in terms directly applicable to engineering design of a radio transmission facility. Triple-antenna space diversity is definitely superior to dual spaced or polarization and it appears that, of the latter two, dual spaced is generally more effective. The particular system to be used for a given installation will be determined by economic factors, reliability required, and allowable complexity at the receiving terminus. Certain unresolved points remain to be clarified and the investigation must be extended to other frequencies, paths, and types of diversity. What has already been accomplished indicates that the selection and design of diversity systems may ultimately be reduced to a reasonably explicit process directly related to performance specifications.

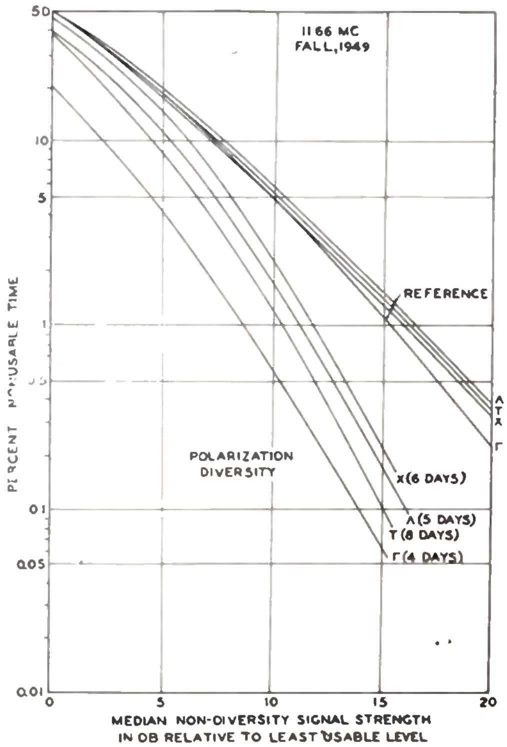

Fig. 18—Comparative performance of various polarization diversity systems. The systems differ only in the physical arrangement of antennas.

Acknowledgment

The authors acknowledge the invaluable contributions of the research staffs at Signal Corps Engineering Laboratories and Washington University and, in particular, of F. K. McCaffrey under whose supervision the data have been collected.

Television Image Reproduction by Use of Velocity-Modulation Principles*

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Summary—The velocity television reproduction system described in this paper uses a combination of standard video principles for image pickup and velocity-modulation methods for picture reproduction. An analysis is presented which indicates the response of the system to a general video signal. It is shown that one form of presentation imparts a three-dimensional appearance to the image. Photographs are presented of standard broadcast television images reproduced on a conventional receiver converted to velocity-modulation reproduction.

I. Introduction

IN THE BASIC velocity-modulation television system, the scanning spots in the camera tube and kinescope move in synchronism. The kinescope beam current is maintained constant, and the horizontal velocities of the spots are varied to produce the changes of brightness in the image. Bright portions of the picture are reproduced by low writing velocities and dark portions are reproduced by high writing velocities. This basic velocity-modulation television system and its variations have received considerable attention in the past.

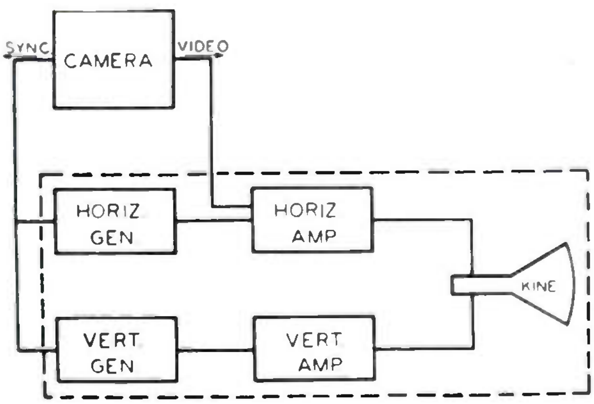

Fig. 1—Experimental velocity-modulation reproduction system.

In the system described in this paper, the camera tube mosaic is scanned with constant velocity and the video signal is obtained in the usual manner. At the receiver the image is reproduced by varying the horizontal velocity of the spot on the screen of the kinescope by superimposing the video signal on the kinescope horizontal deflection voltage. No video voltage is applied to the kinescope grid so that the beam current is maintained constant. The block diagram of this system is shown in Fig. 1.

The quality of images obtained by velocity-modulation reproduction of standard television broadcasts is too poor for entertainment purposes. However, this system has some important features which are described in the following sections.

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II. Basic Analysis

Equations are now presented which express the brightness along a horizontal line of the reproduced image in terms of the video signal generated by a conventional television camera. These equations are based upon the analysis of an ideal system with negligible aperture and transmission distortion. It is assumed that the light output of the kinescope screen is directly proportional to current density. In this classical system, the television camera functions in the normal manner, and a video signal is produced with an instantaneous amplitude proportional to the brightness along the horizontal line on the camera tube mosaic. After this video signal has passed through the appropriate transmission channels and through the video amplifier of the receiver, it is superimposed upon the horizontal sawtooth sweep voltage. The beam current of the kinescope remains constant during the active portion of its trace period.

The instantaneous horizontal position and velocity of the spot are given by

$$x = v_0 t \pm k \cdot F(t) \tag{1}$$

and

$$\frac{dx}{dt} = v_0 \pm k \cdot F'(t) \tag{2}$$

where x is the horizontal distance along the line, v_0 is the constant scanning velocity in the absence of a video signal, t is the time that has elapsed since the spot began scanning the line, $F(t)$ is the video signal generated by the camera, and k is the proportionality constant which relates the video voltage with the resulting deflection on the kinescope screen. Since the brightness of the trace is inversely proportional to the absolute magnitude of the spot velocity, it follows from (2) that

$$B(x) = B_0 / \left| 1 \pm Q \cdot F'(t) \right| \tag{3}$$

where $B(x)$ is the brightness of the trace at a distance x along the scanning line, B_0 is the ambient brightness of the raster in the absence of the video signal, and Q is equal to k/v_0.

In the normal range of operation of this velocity-modulation system, the spot displacement $k \cdot F(t)$ is on the order of one spot diameter and the term $Q \cdot F'(t)$ is less than unity. To a first approximation, therefore, the parametric equations (1) and (3) become

$$x \doteq v_0 t \tag{4}$$

and

$$B(x) \doteq B_0[1 \mp Q \cdot F'(t)]. \tag{5}$$

Equation (4) indicates that for small spot excursions there is negligible positional distortion of the reproduced picture element. Equation (5) indicates that to a first approximation there is produced a pattern whose brightness is proportional to the derivative of the video signal superimposed on a raster of brightness B_0.

III. General Analysis

An entirely different presentation is obtained if some operation is performed on the video signal prior to its insertion in the kinescope horizontal deflection circuit. This is readily achieved through the use of band-pass filters, differentiating and integrating amplifiers, or other wave-shaping circuits. In this case, the parametric equations are

$$x = v_0 t \pm k \cdot G(t) \doteq v_0 t \tag{6}$$

and

$$B(x) = B_0 / \left| 1 \pm Q \cdot G'(t) \right| \doteq B_0[1 \mp Q \cdot G'(t)], \tag{7}$$

where $G(t)$ is the video signal $F(t)$ after passing through the network. A response of particular importance is obtained when $G(t)$ is the integral of $F(t)$, so that

$$B(x) \doteq B_0[1 \mp Q \cdot F(t)]. \tag{8}$$

It is evident from (8) that for signals of small magnitude and of the proper polarity, integration of the video signal produces a true reproduction of the televised image superimposed upon a raster of ambient brightness B_0. The contrast range of this image is obviously very limited. It should be noted that the desired integration may be performed by a standard uncompensated sweep amplifier, or by the inherent integrating action of the television camera tube operating into a high-impedance circuit.

(b) (a) (c)

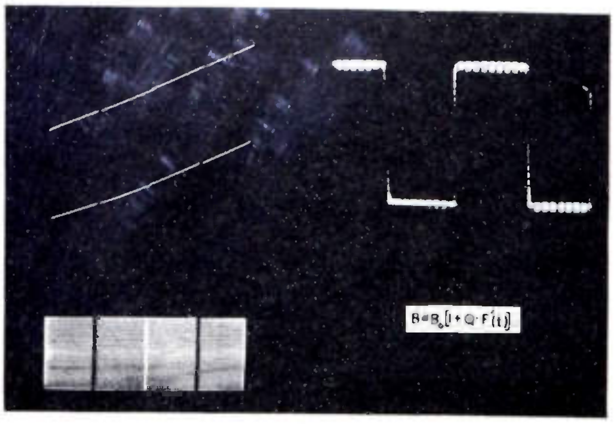


Fig. 2—Velocity reproduction of square-wave signal. (a) Signal superimposed on horizontal sweep voltage, (b) portion of expanded raster, and (c) resulting image.

Let us consider that the video signal $F(t)$ is the square-wave signal shown in Fig. 2(a). The resulting response shown in Fig. 2(c) closely approximates the derivative of the square wave superimposed on a raster of uniform brightness. If this square wave, however, is integrated, it becomes the pyramid wave shown in Fig. 3(a) which produces the square wave of brightness response shown in Fig. 3(c). It is evident that Fig. 3(c) is, to a first approximation, a true reproduction of the original square-wave video signal on a background of uniform brightness. The rasters shown in these photographs were synthesized by use of a standard oscilloscope and an auxiliary sawtooth generator.

(b) (a) (c)

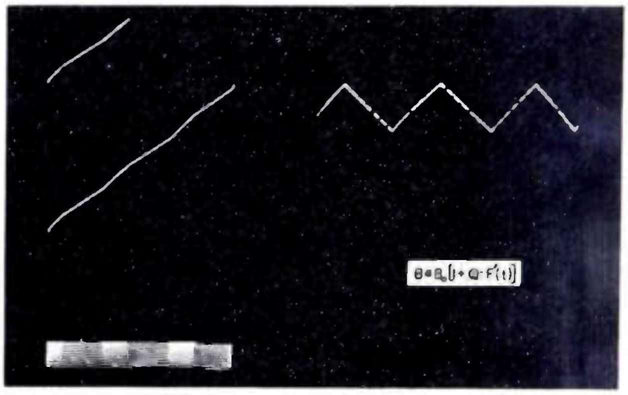
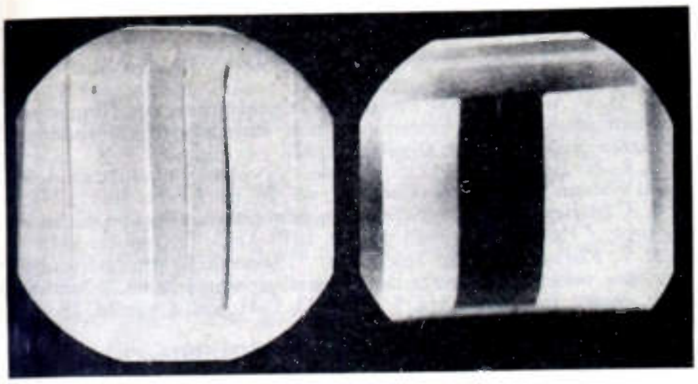


Fig. 3—Velocity reproduction of pyramid signal. (a) Signal superimposed on horizontal sweep voltage, (b) portion of expanded raster, and (c) resulting image.

IV. Overlap Condition

Upon consideration of the basic principles of velocity reproduction, it is seen from (2) that when the magnitude of $k \cdot F'(t)$ is sufficiently large, the spot velocity will become negative. This will result in overlap of the reproduced line, and the retraced portion of the line will receive more than one contribution of brightness in the course of a single line period. This overlap condition is of importance for the reproduction of two-tone subject matter such as printing, maps, and circuit diagrams.

Velocity reproduction employing overlap is compared with standard television reproduction of a vertical black bar with a narrow test wedge in Fig. 4. Velocity reproduction of a standard television test pattern is shown in Fig. 5. This method of presentation results in the outlining of two-tone objects by a light band on one side and a dark band on the other side, so that only the outline of the televised object is visible. The width of these outlining bands is proportional to the magnitude of the video signal, and the relative positions of the bands are determined by the polarity of the video signal. The image has a unique embossed appearance although the original subject matter consists of two-dimensional material.



(a) (b)

Fig. 4—Vertical black bar with narrow test wedge reproduced by (a) velocity modulation and by (b) conventional methods.

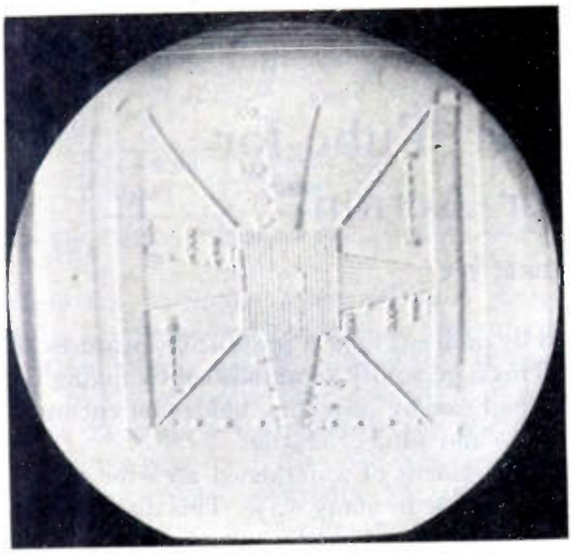


Fig. 5—Standard test pattern reproduced by velocity modulation.

V. Velocity Reproduction of Video Broadcasts

In order to observe velocity reproduction of typical television broadcasts, a 7-inch electrostatic-deflection television receiver was converted for velocity television reproduction. This conversion was accomplished by coupling the video signal into the grid circuit of the horizontal sweep amplifier through a capacitor of two micromicrofarads. The normal video input to the kinescope was disconnected and care was exercised to remove all traces of intensity modulation. A 1,000-micromicrofarad capacitor connected from the vertical sweep generator to the kinescope provided blanking during the vertical retrace period. Fig. 6 is a photograph from a regular television broadcast received on this converted receiver. Since differentiation is inherent in the velocity reproduction process, a considerable amount of detail is present despite the fact that the video signal was amplified by the uncompensated horizontal-deflection sweep amplifier.

VI. Spurious Images in Standard Television Systems

This investigation indicates that spurious coupling between the video and deflection channels in a television camera or receiver will produce a velocity-modulated image superimposed upon the regular picture. A signal of 50 millivolts or less, spuriously coupled into the grid circuit of the horizontal deflection amplifier is sufficient to produce a halo effect which may be erroneously ascribed to excessive high-frequency peaking or to ghost images. This interference may be present in electrostatic or magnetic-deflection receivers due to improper design and construction or failure of component parts. Furthermore, stray voltages derived from the 60-cycle power system, the radio-frequency power supply, or the 4.5-Mc intercarrier beat frequency, may produce velocity-modulation distortion similar in appearance to that caused by stray voltages in the kinescope grid circuit.

Although this paper is principally concerned with velocity modulation in the horizontal direction, it is also recognized that stray signals coupled into camera or receiver vertical deflection circuits will produce spurious displacement of the scanning or writing spots in the vertical direction.

VII. Conclusions

It is felt that the principal importance of this investigation of velocity-modulation reproduction of video signals may be summarized as follows:

1. One form of velocity reproduction imparts a three-dimensional appearance to two-tone subject matter and may have some application for the reproduction of printed material and line drawings or for radar scope displays. However, the three-dimensional effect obtained bears no direct relationship to the true three-dimensional characteristics of the scene being transmitted.

Fig. 6—Velocity reproduction of scene from broadcast received from WSB-TV. This photograph shows some evidence of signal integration performed by the uncompensated sweep amplifier.

2. The observation of standard television broadcasts on a modified receiver indicates that an apparent improvement in resolution may be obtained by the use of the proper degree of velocity modulation in combination with beam-intensity modulation.

3. This investigation indicates a type of picture distortion which may arise in standard television systems due to spurious signals coupled into the horizontal, or vertical, sweep circuits.

Acknowledgment

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Use of Image Converter Tube for High-Speed Shutter Action*

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Summary—**The equipment described provides a means for obtaining high-speed photographs while utilizing a continuous light source. The device may be pulsed once for "one-shot" exposures or repetitively for motion pictures or stroboscope applications. The heart of the equipment is an image converter tube such as the 1P25. Images are impressed on the photocathode and the tube is pulsed electrically for a duration equal to the exposure time desired. The image will then appear on the fluorescent screen and may be viewed directly or photographed.**

I. Introduction

High-speed photography has found considerable use in the development of military projectiles, but the conditions under which these pictures have been taken are very limited. The need for a convenient means of taking such photographs has led to considerable research by various organizations into photographic methods.

The absence of a mechanical shutter which would allow an exposure time in the order of one microsecond, at a predetermined time with respect to the projectile flight, has, to the present, made it generally necessary to eliminate the shutter action entirely and to depend solely upon a light flash of proper duration to give the desired exposure. In such a system, synchronization is accomplished by triggering the light at the desired time of exposure. The camera shutter is then open for a relatively long time during which the film would become exposed by ambient light if preventive measures are not taken. This is generally accomplished by taking the pictures at night or by providing lightproof enclosures for the camera and subject matter.

The requirement of a darkened area for such a system limits its use in many ways. This disadvantage has been overcome somewhat by use of the Kerr cell as a shutter. However, it also has its faults, the most important being its low light efficiency. The use of an image converter tube as a high-speed shutter gives excellent promise of results similar to those of the Kerr cell but with much greater light efficiency.

Image converter tubes available at this time do not have 100-per cent light efficiency when used as high-speed shutters. A tube developed especially for this purpose could easily have a light efficiency exceeding 100 per cent, which compares with an efficiency of less than 50 per cent for the Kerr cell.

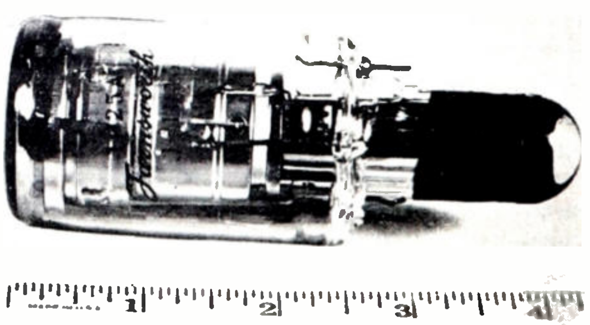

Fig. 1—Image converter tube.

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† Naval Ordnance Laboratory, Silver Spring, Md.

II. Experimental Results

The model which has been used at the Naval Ordnance Laboratory in the experiments to be described, makes use of the 1P25 image converter tube as shown in Fig. 1. This is one of the tubes used during World War II as part of the "Snooperscope" and "Sniperscope," which were used for night observation with infrared sources of illumination. Such uses have been well described in recent magazine articles. The photocathode, which was purposely made most sensitive to infrared light, is at the left end of the tube and the fluorescent screen, which is a green phosphor, is at the right end. Fig. 2 shows how the tube is used to obtain high-speed photographs.

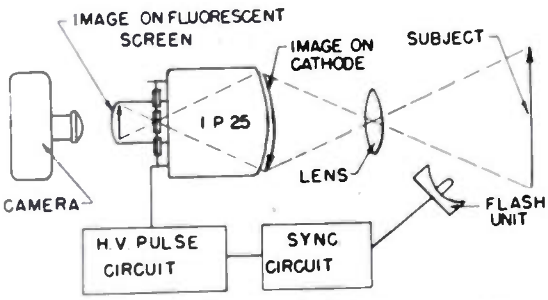

Fig. 2—Block diagram of photographic system.

In operation, an image is focused upon the photocathode by a conventional lens system. The tube is then energized by a high-voltage pulse which is equal, in duration, to the exposure time desired. The negative polarity of the pulse is connected to the photocathode and the positive polarity of the pulse is connected to the accelerator and focusing electrodes. The applied voltage will cause the electrons leaving the photocathode to impinge upon the fluorescent screen and thereby reproduce the image as it appeared on the photocathode. The image will remain upon the fluorescent screen for the duration of the pulse plus an additional period determined by the persistence of the screen. The screen may be viewed as the action takes place or the image may be focused upon a photographic film. Hence, we have a device that may be used similarly to a conventional light shutter, but it should be kept in mind that it is not exactly equivalent to a mechanical shutter or Kerr cell, because the light output originates from a different source than the light input.

Fig. 3 shows a two-microsecond exposure taken of the edge of a wheel which is $9\frac{1}{4}$ inches in diameter and is rotating at 9,000 rpm. Obviously, this photograph does not prove that the exposure time was two microseconds, since a fifteen-microsecond exposure would have been sufficient, but the equipment exposure-time capabilities have been verified by other means such as photographing bullets in flight.

Photographs of small objects have been taken using two-microsecond exposures. Shadowgraphs have been taken using one-half-microsecond exposures. The present limitation upon conventional photographs (light being reflected from the object) is the difficulty in obtaining enough light for adequate film exposures for periods much less than two microseconds.

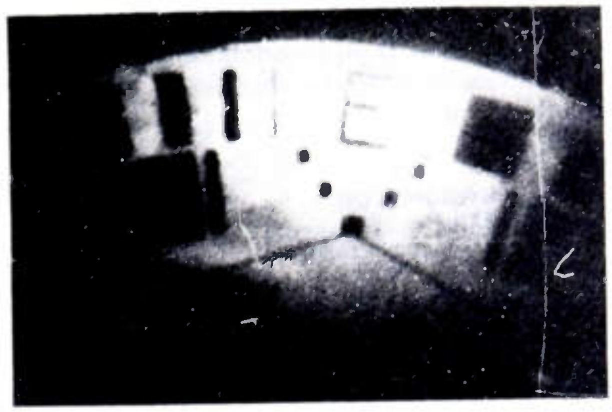

Fig. 3—Revolving wheel, two-microsecond exposure.

Fig. 4 is a two-microsecond exposure shadowgraph. A light bulb, which has been painted black, is placed between the image converter tube and a strong light source. Fig. 5 shows the same light bulb being broken by a hammer.

The image converter tube may be pulsed repetitively up to several thousand times per second. This lends it to stroboscopic use and surpasses ordinary stroboscopes in high repetition rate as well as short pulse duration. A single photoflood lamp will supply ample light for stroboscopically viewing small objects with one-half-microsecond pulses. The repetition rate, in combination with the screen persistence, results in a good light output

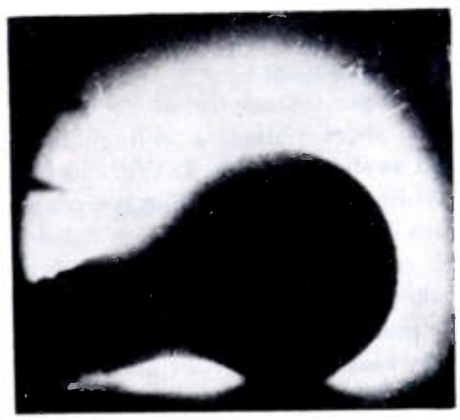

Fig. 4—Two-microsecond-exposure shadowgraph of light bulb.

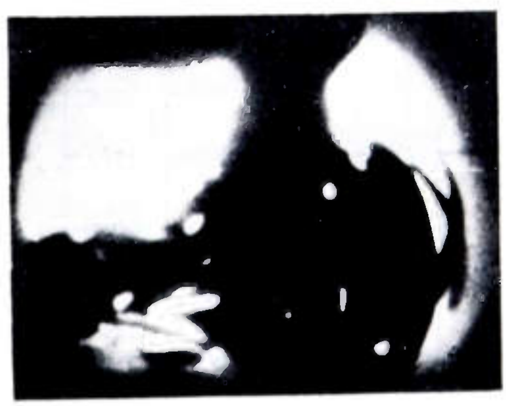

Fig. 5—Two-microsecond-exposure shadowgraph of light bulb being broken by hammer.

with much less subject lighting than required for "one-shot" photographs. It is, therefore, most convenient to use the device as a stroboscope when photographing repetitive action.

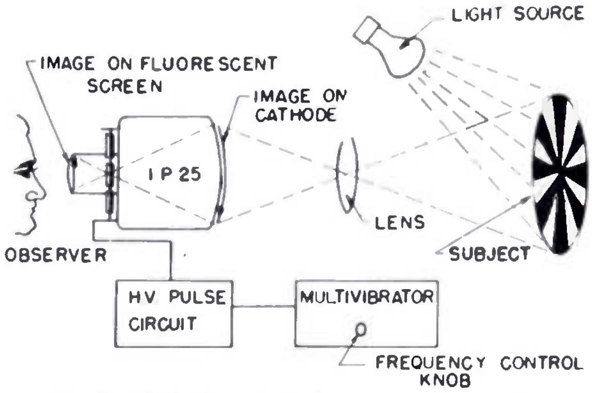

Fig. 6—Block diagram of stroboscopic application.

Thus far the basic principles have been indicated, showing how the tube may be used as a light shutter, but, in practice, further refinements are required to make the apparatus perform satisfactorily.

It was first found necessary to prevent exposure of the photographic film by ambient light which leaked through the tube. These light difficulties were overcome by using an infrared filter ahead of the tube, so that only infrared light was allowed to enter the tube and reach the film. This light was made harmless by the use of orthochromatic film, such as Eastman's Linograph-Ortho, which is insensitive to red. Since the photocathode is peaked for infrared response, the addition of the filter causes very little loss in the intensity of the fluorescent output image.

To obtain proper voltage distribution across the tube electrodes for short pulses, a voltage divider circuit was designed as shown in Fig. 7. With such an arrangement, the voltage divider is effective on short pulses or continuous current. The condenser values are chosen so that their capacity, in combination with their respective electrode capacity, results in the proper apportionment of the pulse voltage. The condensers do not interfere with very long pulses or continuous operation, leaving control, under such circumstances, to the resistors. By keeping the resistors and condensers to their minimum values, no defocusing has been experienced throughout the pulse range from continuous operation to one-half microsecond. The minimum value of the condensers is determined by the interelectrode capacitance between the 600- and 4,000-volt electrodes. No external condenser is used across these points; hence, this capacity can be taken as a basis for computing the values of the other condensers. The minimum value of the resistors is determined by the power-output capabilities of the pulse power source and the power-dissipating abilities of resistors suitable for the circuit.

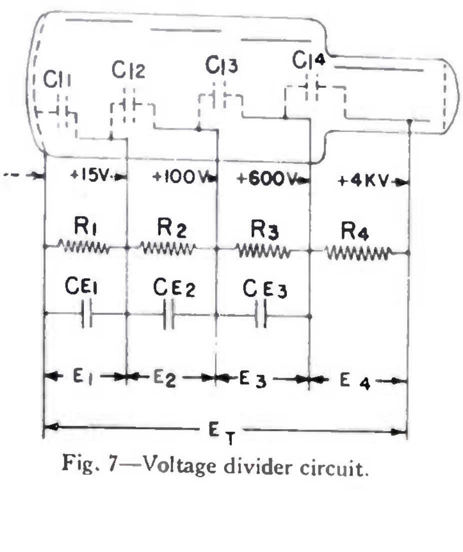

Fig. 7—Voltage divider circuit.

During early experiments, the pulse sources consisted of high-voltage pulse-forming networks discharged through hydrogen thyratrons. It was later found convenient to use a war-surplus radar modulator which has a choice of one-, one-half-, or two-microsecond pulse outputs. The magnetron was removed and a load resistor substituted for it. Practically the entire output of the modulator is dissipated in the load resistor since the image converter tube current is in the order of microamperes and its voltage divider draws only a few milliamperes. The modulator had the advantage over our simple pulse-forming networks of a superior square wave form.

A square wave is required in order to obtain the maximum efficiency for a given exposure time.

III. Conclusion

The present stage of development, for the complete system, is limited by the resolution capabilities of the fluorescent screen (or its size) and the over-all light efficiency of the tube. It is fairly certain that a tube can be built with a larger photocathode and fluorescent screen to give good picture quality and it is also fairly certain that such a tube could have a much greater light efficiency than the 1P25. Therefore, it may be reasonably assumed that such a system can be developed to the point where one- or two-microsecond exposures can be taken, with good quality, using conventional lighting systems.

The use of such a system should considerably reduce the cost of projectile photography as well as provide a much more convenient means. It should also find applications in many instances where flash tubes are now used to stop action. It is also likely that uses will be found where flash tubes will provide all or part of the necessary illumination but where the image converter tube will be depended upon to "stop" the action. An example of such an application would be a condition where there was appreciable continuous light but not enough for the desired exposure. In such a case, it may be most economical to supply the supplemental light with a flash tube having a duration relatively long when compared with the exposure time desired.

It is recognized that this device will not fill all the needs for high-speed photography or stroboscopic observation, but it is expected to be more convenient and economical in some applications and a valuable supplement in others.

Standards on Electronic Computers: Definitions of Terms, 1950*

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Access Time. (1) The time interval, characteristic of a memory or storage device, between the instant at which information is requested of the memory and the instant at which this information begins to be available in useful form. (2) The time interval between the instant at which information is available for storage and the instant at which it is effectively stored.

Accumulator. A device which stores a number and, upon reception of a new number, adds it to the previous contents and stores the sum.

An accumulator may have properties such as shifting, sensing signs, clearing, complementing, and so forth.

Accuracy. The quality of correctness or freedom from error. Distinguished from *precision* as in the examples:

(a) " . . . this procedure measures the precision (reproducibility) of the test, not its accuracy (closeness to the true value)."

(b) A four-place table correctly computed is more accurate but less precise than a six-place table containing errors.

See also: **Precision.**

Adder. A device which can form the sum of two or more numbers, or quantities, impressed upon it.

Adder, Algebraic. *See* **Algebraic Adder.**

* Reprint orders of this Standard, 50 IRE 8.S1, may be purchased while available from The Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y., at $0.75 per copy. A 20-per cent discount will be allowed for 100 or more copies mailed to one address.

Address. Information (usually a number) which designates a particular location in a memory or storage device.

Algebraic Adder. An adder which can form an algebraic sum.

Amplifier, Torque. *See* **Torque Amplifier.**

Analog (in computer work). A physical system on which the performance of measurements yields information concerning a class of mathematical problems.

Analog Computer. A physical system together with means of control for the performance of measurements (upon the system) which yield information concerning a class of mathematical problems. In an analog computer quantities are represented without explicit use of a language.

See also: **Language.**

"And" Circuit. *See* **Gate.**

Arithmetic Element. That part of a computer which performs arithmetic operations.

Synonyms: **Arithmetic Organ** and **Arithmetic Unit.**

Arithmetic Organ. *See* **Arithmetic Element.**

Arithmetic Unit. *See* **Arithmetic Element.**

See also: **Parallel Arithmetic Unit** and **Serial Arithmetic Unit.**

Base (or Radix). *See* **Radix (or Base).**

Binary Cell. An information-storing element which can have one or the other of two stable states.

Binary-coded Decimal System. A system of number representation in which the decimal digits of a number are expressed by binary numbers.

Binary Digit. A digit of a binary number.

See also: **Memory Capacity** or **Storage Capacity.**

Binary Number System. A number system which uses two symbols (usually denoted by "0" and "1") and has two as its base, just as the decimal system uses ten symbols ("0, 1, · · · , 9") and the base ten.

See also: **Positional Notation** and **Radix.**

Binary Point. The radix point in the binary system.

Block. A group of words considered as a unit.

See also: **Word.**

Break Point. A point in a program at which a special instruction is inserted which, if desired, will cause a digital computer to stop for visual check of progress during the initial checking of a problem.

Buffer. (1) An isolating circuit used to avoid reaction of a driven circuit upon the corresponding driving circuit. (2) A circuit having an output and a multiplicity of inputs so designed that the output is energized whenever one or more inputs are energized. Thus, a buffer performs the circuit function which is equivalent to the logical "or."

Bus (in computer work). One or more conductors which are used as a path for transmitting information from any of several sources to any of several destinations.

Carry. (1) A condition occurring in addition when the sum of two digits in the same column equals or exceeds the base of the number system in use. (2) The digit to forwarded to the next column. (3) The action of fo warding it.

Cascaded Carry. A system of executing the carry pro ess in which carry information can be passed on to pla ($N+1$) only after the Nth place has received carry i formation or has itself produced a carry.

See also: **Complete Carry, Partial Carry, Self-i structed Carry, Separately Instructed Carry** and **Stan ing on Nines Carry.**

Cell, Binary. *See* **Binary Cell.**

Character. One of a set of elementary symbols whic may be arranged in ordered aggregates to express info mation.

Check Problem. A problem whose incorrect solutio indicates an error in the operation or programming of computer.

Circulating Memory. A memory consisting of a mea for delaying information and means for regenerating an reinserting the information into the delaying means.

Clear (verb). To restore a storage or memory devic to a prescribed state, usually that denoting zero.

Clock, Master. *See* **Master Clock.**

Code. (1) A system of symbols and rules for use i representing information. (2) Loosely, the set of charac ters resulting from the use of a code. (3) To expres given information by means of a code.

See also: **Language.**

Code, Excess 3. *See* **Excess 3 Code.**

Code, Instruction. *See* **Instruction Code.**

Coded Program. A description of a procedure for solv ing a problem by means of a digital computer. It ma vary in detail from a mere outline of the procedure to a explicit list of instructions coded in the machine's lan guage.

See: **Program.**

Column. In **Positional Notation** a position correspond ing to a given power of the radix. A digit located in an particular column is a coefficient of a corresponding power of the radix.

Synonym: **Place.**

Command. One of a set of several signals (or group of signals) which occurs as the result of an instruction; the commands initiate the individual steps which form the process of executing the instruction.

See also: **Instruction.**

Comparator. A circuit which compares two signals and supplies an indication of agreement or disagreement.

Complement. A number whose representation is derived from the finite positional notation of another by one of the following rules:

(a) True complement—Subtract each digit from the radix less 1, then add 1 to the least significant digit, executing any carries required.

(b) (Radix−1)'s complement—Subtract each digit from the radix less 1.

Complete Carry. A system of executing the carry process in which all carries and any carries to which they give rise are allowed to propagate to completion.

See also: **Cascaded Carry, Partial Carry, Self-instructed Carry, Separately Instructed Carry** and **Standing on Nines Carry.**

Computer. A device which can accept information and supply information and in which the supplied output information is derived from the accepted input information by means of a process of logic.

Note—"Process of logic": Any systematic process of derivation which is demonstrably free from self-contradiction.

Conditional Transfer (of control). In digital computing, an instruction which will, depending upon some property of a given number (or numbers), cause the proper one of two other instructions to be executed.

Control Circuits. The circuits of a digital computer which effect the carrying out of instructions in proper sequence, the interpretation of each instruction, and the application of the proper commands to the arithmetic element and other circuits in accordance with this interpretation.

Correction. The quantity which is added to a calculated value to obtain the correct value.

Counter. (1) In mechanical analog computers, a means for measuring the angular displacement of a shaft. (2) A device capable of changing from one to the next of a sequence of distinguishable states upon each receipt of a discrete input signal.

The term **Counter** is in some cases used to mean **Accumulator.**

Cycle, Major. *See* **Major Cycle.**

Cycle, Minor. *See* **Minor Cycle.**

Cyclic Shift. An operation which produces a word whose characters are obtained by a cyclic permutation of the characters of a given word.

Decimal Number System. The method of positional notation using ten as the radix.

See also: **Positional Notation** and **Radix.**

Decimal Point. The radix point in the decimal system.

Delay-line Memory. A type of circulating memory in which a delay line is the major element in the circulation path.

See also: **Circulating Memory.**

Delay-Line Register. An acoustic or electric delay-line, usually one or an integral number of words long, together with input, output, and circulation circuits.

Differentiator. A device, usually of the analog type, whose output is proportional to the derivative of an input signal.

Digit. One of a definite set of characters which are used as coefficients of powers of the radix in the positional notation of numbers.

Digit, Binary. *See* **Binary Digit.**

Digit, Sign. *See* **Sign Digit.**

Digital Computer. One in which information, numerical or otherwise, is represented by means of combinations of characters in such a way that the number of distinguishable combinations is much greater than the number of distinguishable characters. Thus, a digital computer is one which makes explicit use of a language.

See also: **Language.**

Dispatcher (in computer work). That part of a digital computer which performs the switching determining the sources and destinations for the transfer of words.

Double-Precision Number. A number having twice as many significant digits as are ordinarily used in a particular computer.

Dynamic Sequential Control. A method of operation in which a digital computer, as the computation proceeds, can alter instructions, or the sequence in which instructions are executed, or both.

Electrical Function Switch. *See* **Function Switch.**

Electrostatic Memory. A memory device utilizing electrostatic charge as the means of retaining information, involving usually a special type of cathode-ray tube together with associated circuits.

Electrostatic Memory Tube. An electron tube in which information is retained by means of electric charges.

Synonym: **Storage Tube.**

Equation Solver. A computing device, often of the analog type, which is designed to: (a) Solve systems of linear simultaneous (nondifferential) equations, or (b) find the roots of polynomials, or both.

Error. The quantity which is subtracted from a calculated value to obtain the correct value.

Error, Round-Off. *See* **Round-Off Error.**

Error, Truncation. *See* **Truncation Error.**

Excess 3 Code. A code for numerical data in which each decimal digit d is represented by the binary number $(d+3)$.

Extract Instruction. In a digital computer, the instruction to form a new word by juxtaposing selected segments of given words.

Fixed-Point System. A system of number notation in which a number is represented by a single set of digits and in which the position of the radix point is not numerically expressed.

See also: **Floating-Point System.**

Flip-flop. An electronic circuit having two stable states and ordinarily two input terminals (or types of input signals) each of which corresponds with one of the two states. The circuit remains in either state until caused to change to the other state by application of the corresponding signal.

Floating-Point System. A system of number notation in which two sets of digits are used, the added set being included to denote the location of the radix point.

See also: **Fixed-Point System.**

Flow Diagram. A graphical representation of a sequence of operations.

Function Switch. A network or system having a number of inputs and outputs and so connected that signals representing information expressed in a certain code, when applied to the inputs, cause output signals to appear which are a representation of the input information in a different code.

Function Switch, Many-One. A function switch in which a combination of the inputs is excited at one time to produce a corresponding single output.

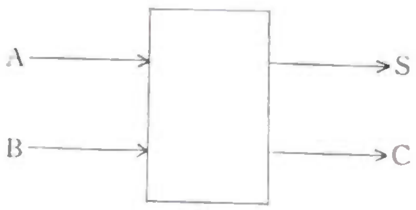
Function Switch, One-Many. A function switch in which only one input is excited at a time and each input produces a combination of outputs.

Function Unit. A device which can store a functional relationship and release it continuously or in increments.

Gate. (1) A circuit having an output and a multiplicity of inputs so designed that the output is energized when and only when a certain definite set of input conditions are met. In computer work, a *Gate* is often called an "and" circuit. (2) A signal used to enable the passage of other signals through a circuit.

Half-Adder. A circuit having two input and two output channels for binary signals (0, 1) and in which the output signals are related to the input signals according to the following table:

Input to A	Input to B	Output from S	Output from C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



(So called because two half-adders may be used to form one adder.)

Holding Beam. A diffuse beam of electrons for regenerating the charges retained on the dielectric surface of an electrostatic memory or storage tube.

Input Equipment. The equipment used for introducing information into a computer.

Inscriber. Input transcriber.

Instruction. Information which, when properly coded and introduced as a unit into a digital computer, causes it to perform one or more of its operations. An instruction commonly includes one or more addresses.

Instruction Code. A code for representing the instructions which a particular digital computer can execute.

See also: **Multiple-Address (Instruction) Code** and **Single-Address (Instruction) Code.**

Instruction, Extract. *See* **Extract Instruction.**

Instruction, Transfer (of control). *See* **Transfer (of control) Instruction.**

Integrator. A device whose output is proportional to the integral of an input signal.

Language. A set of symbols, with rules for the combination of these symbols, which may be used to express information, such that the sum of the number of symbols and the number of rules is much smaller than the number of distinct expressible meanings.

See also: **Code.**

Major Cycle. In a memory device which provides serial access to storage positions, the time interval between successive appearances of a given storage position.

Master Clock. The primary source of timing signals.

Memory. Any device into which information can be introduced and then extracted at a later time. The mechanism or medium in which the information is retained commonly forms an integral part of a computer.

See also: **Storage.**

Memory Capacity. The maximum number of distinguishable stable states in which a memory device can exist is a measure of its capacity. It is customary to use the logarithm to the base two of that number as a numerical measure of the memory capacity. In this case, the unit of memory capacity is a binary digit.

Memory, Circulating. *See* **Circulating Memory.**

Memory, Delay-Line. *See* **Delay-Line Memory.**

Memory, Electrostatic. *See* **Electrostatic Memory.**

Memory Tube, Electrostatic. *See* **Electrostatic Memory Tube.**

Minor Cycle. In a digital computer using serial transmission, the time required for the transmission of one word, including the space between words.

Multiple-Address (Instruction) Code. An instruction in general consists of a coded representation of the operation to be performed and of one or more addresses of words in storage. The instructions of a multiple-address code contain more than one address.

Multiplier (in computer work). A device which has two or more inputs and whose output is a representation of the product of the signed magnitudes represented by the input signals.

Notation, Positional. *See* **Positional Notation.**

Number. (1) Formally: An abstract mathematical entity defined by the rules governing the relations and operations to which it is susceptible. In this sense, a number is independent of the manner of its representation. (2) Commonly: A representation of a number as defined above, such as a "binary number," or a "decimal number," or a sequence of pulses. (3) In a digital machine, a word composed only of digits and possibly a sign.

Number, Double-Precision. *See* **Double-Precision Number.**

Number System. Any system for the representation of numbers.

See for example: **Binary Number System.**

See also: **Number** and **Positional Notation.**

Operand. A word on which an operation is to be performed.

Operation. (1) The activity resulting from an instruction. (2) The execution of a set of commands.

Operation Code. That part of an instruction which designates the operation to be performed.

"Or" Circuit. *See* **Buffer.**

Order. The term **Instruction** is preferred. *See* **Instruction.**

Organ. A portion or subassembly of a computer which constitutes the means of accomplishing some inclusive operation or function, as: **Arithmetic Organ.**

Output Equipment. The equipment used for obtaining information from a computer.

Outscriber. Output transcriber.

Overflow. (1) The condition which arises when the result of an arithmetic operation exceeds the capacity of the number representation in a digital computer. (2) The carry digit arising from this condition.

Parallel Arithmetic Unit. One in which separate equipment is provided to operate (usually simultaneously) on the digits in each column.

See also: **Serial Arithmetic Unit.**

Parallel Transmission. The system of information transmission in which the characters of a word are transmitted (usually simultaneously) over separate lines, as contrasted to **Serial Transmission.**

Partial Carry. A system of executing the carry process in which the carries that arise as a result of a carry are not allowed to propagate.

See also: **Cascaded Carry, Complete Carry, Self-instructed Carry, Separately Instructed Carry, Standing on Nines Carry.**

Place. *See* **Column.**

Plotting Board. A device which plots one or more variables against one or more other variables.

Point, Binary. *See* **Binary Point.**

Point, Decimal. *See* **Decimal Point.**

Point, Radix. *See* **Radix Point.**

Positional Notation. One of the schemes for representing real numbers, characterized by the arrangement in sequence of *digits* (symbols for integers) with the understanding that the successive digits are to be interpreted as the coefficients of successive integral powers of a number called the *radix* or *base* of the notation.

The representation of a real number by the notation

$$A_nA_{n-1}\cdots A_2A_1A_0.A_{-1}A_{-2}\cdots A_{-m},$$

which is an abbreviation for the sum

$$\sum_{i=-m}^{n} A_i r^i,$$

where the . is called the *radix point*, the A_i are integers ($0\leq|A_i|\leq r$) called digits, and r is an integer greater than one called the *radix* (or *base*). The signs of all of the A_i are the same as the sign of the number represented.

In the decimal number system, the radix is ten and the radix point is called the decimal point. In the binary number system, the radix is two and the radix point is called the binary point.

For some purposes the system of notation has been broadened to include the case in which the radix assumes more than one value in a single number system. In this case the notation

$$A_nA_{n-1}\cdots A_2A_1A_0.A_{-1}A_{-2}\cdots A_{-m}$$

is an abbreviation for the sum

$$\left(\sum_{i=1}^{n} A_i \prod_{j=1}^{i} r_j\right) + A_0 + \left(\sum_{i=-m}^{-1} A_i \prod_{j=i}^{-1} \frac{1}{r_j}\right).$$

Several such systems have been used. The biquinary system uses a radix which is alternately two and five for successive values of j. The quinary vicenary system uses a radix which is alternately five and twenty for successive values of j.

For the names of various number systems, as characterized by their radix, see **Radix.**

Precision. Quality of being exactly or sharply defined or stated. A measure of the precision of a representation is the number of the distinguishable alternatives from which it was selected.

See also: **Accuracy.**

Problem, Check. *See* **Check Problem.**

Problem, Trouble Location. *See* **Trouble Location Problem.**

Program. (1) A set of instructions arranged in proper sequence to instruct a digital computer to perform a desired operation (or operations), such as the solution of a mathematical problem or the collation of a set of data. (2) To prepare a program (contrast with "to code").

See: **Coded Program.**

Radix (or Base) (of the positional notation system of numbers). The integer of whose successive powers the digits of a number are the coefficients.

Symbolically: $\cdots +a_2r^2+a_1r+a_0r^0+a_{-1}r^{-1}+a_{-2}r^{-2}\cdots$ is written $\cdots a_2a_1a_0.a_{-1}a_{-2}\cdots$ where r is the radix and the a_i are the integers $0\leq a_i \leq r-1$. For example, in the number π written in the common decimal system, we have: $r=10$; $\cdots a_2=a_1=0$; $a_0=3$; $a_{-1}=1$; $a_{-2}=4\cdots$.

Synonym: **Base.**

See also: **Positional Notation.**

The adjectives used for describing various number systems, as characterized by their radices are given below:

Base or Radix	*Adjective*
Two	Binary
Three	Ternary
Four	Quaternary
Five	Quinary
Six	Senary
Seven	Septenary
Eight	Octonary (loosely called Octal)
Nine	Novenary
Ten	Decimal
Eleven	Undecimal
Twelve	Duodecimal
Thirteen	Terdenary
Fourteen	Quaterdenary
Fifteen	Quindenary
Sixteen	Sexadecimal
Seventeen	Septendecimal
Eighteen	Octodenary

Nineteen	Novendenary
Twenty	Vicenary
Thirty	Tricenary
Forty	Quadragenary
Fifty	Quinquagenary
Sixty	Sexagenary
Seventy	Septuagenary
Eighty	Octogenary
Ninety	Nonagenary
One Hundred	Centenary

These terms are all either derived from the Latin distributives ("ary" endings) or ordinals-cardinals ("imal" endings). The "ary" endings seem more logical and have been chosen except for ten and twelve, where the "imal" usage is prevalent. In the other cases the "imal" word can be found in standard dictionaries while the "ary" word cannot.

Radix Point. The index which separates the digits associated with negative powers from those associated with the zero and positive powers of the base of the number system in which a quantity is represented. For example, *binary point*, *decimal point*.

Read. To extract information.

Register. A device capable of retaining information which is usually a subset of the aggregate information in a digital computer.

Register, Delay-Line. *See* **Delay-Line Register.**

Register, Static. *See* **Static Register.**

Resolver. Means for resolving a vector into two mutually perpendicular components.

Roll Out (verb). To read out of a storage device by simultaneously increasing by one the value of the digit in each column and repeating this r times (where r is the radix) and, at the instant the representation changes from $(r-1)$ to zero: (a) generating a particular signal, or (b) terminating a sequence of signals, or (c) originating a sequence of signals.

Round-Off (verb). To delete less significant digits from a number and possibly apply some rule of correction to the part retained.

Round-Off Error. Error resulting from rounding off.

Routine. A sequence of operations which a digital computer may perform, or the sequence of instructions which determine these operations.

Scale Factor. (1) In analog computing, a proportionality factor which relates the magnitude of a variable to its representation within a computer. (2) In digital computing, the arbitrary factor which may be associated with numbers in a computer to adjust the position of the radix point so that the significant digits occupy specified columns.

Self-instructed Carry. A system of executing the carry process in which information is allowed to propagate to succeeding places as soon as it is generated and without receipt of a specific signal.

See also: **Cascaded Carry, Complete Carry, Partial Carry, Separately Instructed Carry, Standing on Nines Carry.**

Separately Instructed Carry. A system of executing the carry process in which carry information is allowed to propagate to succeeding places only on receipt of a specific signal.

See also: **Cascaded Carry, Complete Carry, Partial Carry, Self-instructed Carry, Standing on Nines Carry.**

Sequential Control. The manner of operation in which instructions to a digital computer are set up in sequence and are fed consecutively to the computer during the solution of a problem.

See also: **Dynamic Sequential Control.**

Serial Arithmetic Unit. One in which the digits of a number are operated on sequentially.

See also: **Parallel Arithmetic Unit.**

Serial Transmission. A system of information transmission in which the characters of a word are transmitted in sequence over a single line, as contrasted to **Parallel Transmission.**

Shift. Displacement of an ordered set of characters one or more columns to the right or left. In the case in which the characters are the digits of a number, in a fixed-point digital computer, a shift is ordinarily equivalent to multiplication by a power of the radix.

Shift, Cyclic. *See* **Cyclic Shift.**

Sign Digit. A character used to designate the algebraic sign of a number.

Significant Digits. The digits of a number can be ordered according to their significance; the significance of a digit is greater when it occupies a column corresponding to a higher power of the radix. The significant digits of a number are a set of digits from consecutive columns beginning with the most significant digit different from zero and ending with the least significant digit whose value is known or assumed to be relevant.

Simulation. The representation of physical systems by computers and associated equipment.

Single-Address (Instruction) Code. An instruction in general consists of a coded representation of the operation to be performed and of one or more addresses of words in storage. The instructions of a single-address code contain only one address.

Standing on Nines Carry. A system of executing the carry process in which it is sensed whether a carry into a given place produces a carry from that place; if so, the incoming carry information is routed around that place.

See also: **Cascaded Carry, Complete Carry, Partial Carry, Self-instructed Carry, Separately Instructed Carry.**

Static Register. A register which retains information in static form.

Storage. (1) Any device into which information can be introduced and then extracted at a later time. The mechanism or medium in which the information is stored need not form an integral part of a computer. (2) The act of storing information.

See also: **Memory.**

Storage Capacity. The maximum number of distinguishable stable states in which a storage device can exist is a measure of its capacity. It is customary to use

l logarithm to the base two of that number as a nu-
rical measure of the storage capacity. In this case, the unit of storage capacity is a binary digit.

Storage Tube. *See* **Electrostatic Memory Tube**

Subprogram. Part of a **Program.**

Subroutine. Part of a **Routine.**

Torque Amplifier. A device possessing input and out- shafts and supplying work to rotate the output shaft positional correspondence with the input shaft with- imposing any significant torque on the input shaft.

Transcriber. Equipment associated with a computing chine for the purpose of transferring input (or out- t) data from a record of information in a given lan- age to the medium and the language used by a digital nputing machine; or from a computing machine to a ord of information.

Transfer (of control), Conditional. *See* **Conditional ansfer (of control).**

Transfer (of control) Instruction. An instruction ich (conditionally or unconditionally) causes the next truction word to be selected from a specified memory ation.

Transfer (of control), Unconditional. *See* **Unconditi- nal Transfer (of control).**

Trouble-Location Problem. A test problem whose incorrect solution supplies information on the location of faulty equipment; used after a check problem has shown that a fault exists.

Truncation Error. Error resulting from the approximation of operations in the infinitesimal calculus by operations in the calculus of finite differences.

Unconditional Transfer (of control). In a digital computer which obtains its instructions serially from an ordered sequence of addresses, an instruction which causes the following instruction to be taken from an address which becomes the first of a new sequence.

Verification. The process of automatically checking one data typing or recording process against another for the purpose of reducing the number of human errors in data transcription.

Volatile. The attribute of a memory device that information is lost in the event of a power interruption.

Word. An ordered set of characters having a meaning and considered as a unit. Digital computers commonly use a fixed word length (that is, a fixed number of characters) which is a characteristic of each computer.

Write. To introduce information, usually into some form of storage.

A Precision Decade Oscillator for 20 Cycles to 200 Kilocycles*

CHARLES M. EDWARDS†, MEMBER, IRE

DURING THE PAST few years numerous technical articles have been written on the subject of oscillator rcuits utilizing resistance-capacitance tun- g elements. The more common types have en designated as bridge-stabilized,[1] paral- T,[2] or phase shift.[3] In most of these treat- ents, the authors have praised the results ich can be obtained by resistance-capacitance tuning, namely, high frequency stability, good wave form, and constant output over a wide frequency range, but have made little mention of the frequency accuracy which could be expected. Some writers have estimated a few per cent as being realizable and there are available commercial units which are reliable to within 2 or 3 per cent. For some applications, frequency accuracy approaching 0.1 per cent is required of oscillators operating in the audio- and carrier-frequency ranges.

An *RC*-type oscillator with a frequency accuracy of 0.1 per cent over a range of 100 cps to 100,000 cps has been developed for a testing application at Western Electric.[4] For the ranges of 20 cps to 100 cps and 100 kc to 200 kc, the accuracy is 0.5 per cent. The unit is composed of three sections: an *RC* oscillator, a power amplifier, and a power supply.

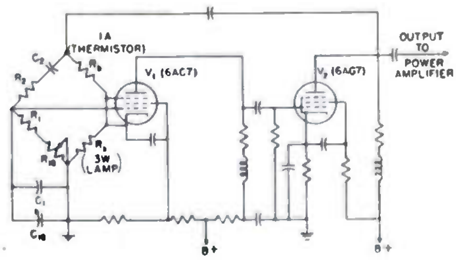


Fig. 1—Simplified version of basic circuit for decade-oscillator design.

Fig. 1 presents a simplified version of the oscillator circuit which consists of a two-stage amplifier with a resistance-capacitance bridge circuit connecting the

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[2] H. H. Scott, "A new type of selective circuit and me applications," Proc. I.R.E., vol. 26, pp. 226– 6; February, 1938.

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[4] The decade oscillator is similar in type to the 51A Oscillator developed at the Bell Telephone Laboratories for use in field testing of carrier systems.

output of V_2 to the input of tube V_1. The main tuning elements in the bridge are C_1, C_2, R_1, and R_2, while C_{1a} and R_{1a} are frequency-trimming elements. Thermistor R_b is a negative-temperature-coefficient stabilizing element and lamp R_k is a positive-temperature-coefficient stabilizing element.

The decade tuning in any one range is accomplished by three dials. Two of the dials have 10 values of resistors related on a decimal basis, with 100 to 1,000 cycles on the first and 10 to 100 cycles on the second. The third dial operates a linear potentiometer for continuous variations between 0 and 10 cycles. The hundreds decade dial has an additional position marked 0.1 cycle to provide for the 20-to-100 cycle range. When the resistors on one dial are added in parallel to those on another, the frequency is the sum of the dials as indicated by the following relations:
with

$$f_1 = \frac{1}{BR_{01}} \quad \text{and} \quad f_2 = \frac{1}{BR_{02}}$$

where

$$B = 2\pi C_0$$

and

$$R_0 = R_1 = R_2, \quad \text{and} \quad C_0 = C_1 = C_2,$$

then

$$f_3 = f_1 + f_2 = \frac{1}{B}\left(\frac{1}{R_{01}} + \frac{1}{R_{02}}\right)$$

Three ranges are provided through varying the capacitors C_1 and C_2 by factors of 10 to provide ×1, ×10 and ×100. An additional resistor is added in parallel to the main tuning resistors when the range dial is thrown to position ×100+100 kc.

Good tracking over the wide frequency range is accomplished by two trimming arrangements and a wide-band amplifier. A number of miniature rheostats, indicated as R_{1a} in Fig. 1, individually adjust each of the resistors on the hundreds and tens decades for trimming at the low end of the frequency range. Similarly, a number of miniature variable capacitors, labeled C_{1a} in Fig. 1, individually adjust the distributed capacity for each position on the hundreds and the tens decades for trimming at the high end of the frequency range.

The wide-band amplifier has a gain of approximately 200 and is compensated for minimum phase shift at the high and low frequency ends of the range. The effects on the oscillator frequency of amplifier phase shift and gain are related by the following approximate expression:

$$\Delta f \simeq \frac{4.5 \sin \theta}{A}$$

where

Δ = change in oscillator frequency f from bridge frequency f_0
θ = amplifier phase shift, including that caused by the feedback capacitor
A = gain of amplifier.

In addition to good frequency tracking and stability, the bridge-stabilized oscillator has good amplitude stability. When the oscillator amplifier changes gain it is readily shown that the percentage change Δ_R in the negative feedback ratio $R_k/(R_k+R_b)$ is

$$\Delta_R = 100\left(\frac{1}{A_1} - \frac{1}{A_2}\right).$$

Thus for amplifier gain changes as great as 100 per cent from 200 to 100, the amplitude of oscillations changes by only 0.5 per cent, when it is assumed that the resistance of the thermally controlled elements in the bridge varies directly in proportion to the voltages across them. In practice, it is found that the thermal elements vary as some power of the voltage output; therefore a 0.5-per cent change in feedback voltage may be accomplished by as little as 0.2 per cent change in output.

The power-amplifier portion of the unit utilizes negative feedback from the output transformer to the cathode of the input tube. The power-supply portion of the unit is arranged for operation on 115 volts, 60 cycles and includes a VR-150 tube for regulating the voltage supplied to the oscillator section.

Figs. 2 and 3 show the mechanical con struction of the unit. Of special interest ar the tuning decades in Fig. 3 showing the ar rangement of main tuning resistors and sma trimming rheostats and capacitors.

Performance results from the oscillat have been good. With monthly checkin frequency alignment can be maintained t within 0.1 per cent. Changes in line voltag from 105 to 115 volts cause less than a 0.1 per cent change in frequency on any of th ranges. Including the output amplifier, th output level is constant to within 1 per cen over most of the frequency range and de viates by only 5 per cent at the extrem edges. Harmonic output is less than 1 pe cent over most of the range with the secon harmonic increasing to about 2 per cent a the extreme edges.

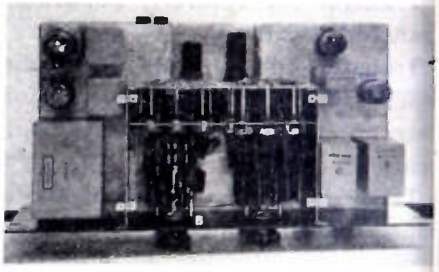

Fig. 3—Top view of decade oscillator showing tuning elements.

Although the top frequency on this oscil lator is 200 kc, the author feels that it shoul be possible to design a resistance-capacitanc oscillator, operating up to one megacycle which is stable and has better than 1 pe cent frequency accuracy. In such an ap plication, extra care would have to be ex ercised in wiring and mechanical stability Carbon tuning elements would probably be required for low phase angle at this high frequency. Therefore, with carbon elements perhaps a constant-temperature oven migh be necessary to maintain good frequency stability.

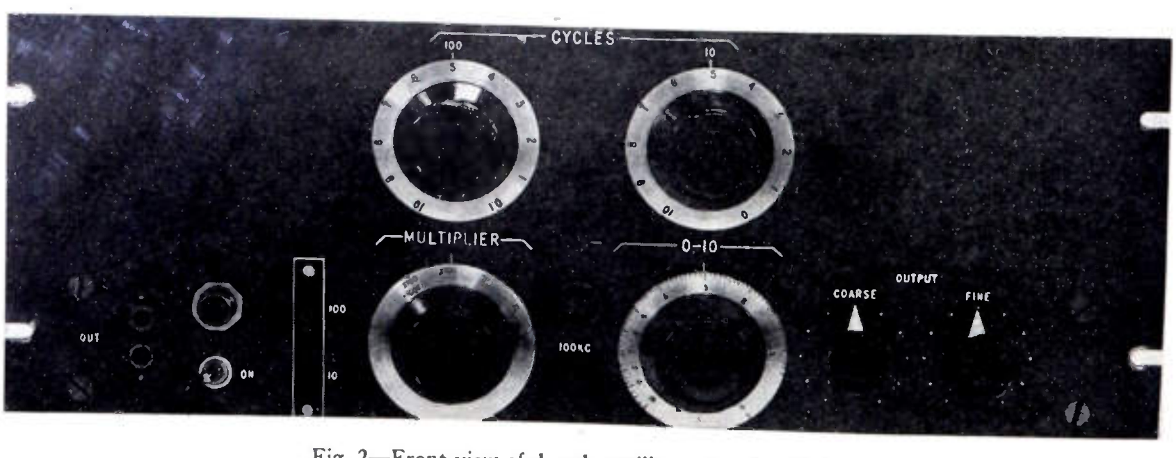

Fig. 2—Front view of decade oscillator showing dials.

The General Design of Triple- and Quadruple-Tuned Circuits*

T. C. GORDON WAGNER†, ASSOCIATE, IRE

Summary—Relatively simple formulas for the design of triple- d quadruple-tuned circuits are developed for the circuit parameters cessary to produce a desired amplitude response. When using ese equations, the designer is given an almost arbitrary choice of cuit Q's. An interesting condition is developed for the physical alizability of triple-tuned circuits.

Introduction

ALTHOUGH the triple-tuned circuit has received considerable attention, particularly in the recent literature,[1-3] the quadruple-tuned circuit has re- ived almost no attention.

The purpose of this paper is to establish concise de- gn formulas for triple- and quadruple-tuned circuits. hese formulas are in a form which permits an almost bitrary choice of circuit Q's and give virtually explicit alues for the coupling coefficients for a given band- idth and peak-to-valley ratio.

Previous analyses of the triple-tuned circuit make re- rictive assumptions on the Q's of the three resonant rcuits, so that the results are inflexible and often im- racticable. As a result of these restrictions, previous uthors seem unaware of the condition

$$|1/Q_3 - 1/Q_1| > 1/Q_2$$

which must be satisfied for a physically realizable de- ign.

The principal advantage of a multiple-tuned circuit ver less complicated circuits may be seen in a compari- on of the attenuation outside the pass band. The at- enuation provided by a properly designed n-tuned cir- uit is given approximately by

$$\tfrac{1}{2}\sigma(2x/x_0)^n, \qquad (1a)$$

where

$$\sigma^2 = E_{\max}^2/E_{\min}^2 - 1$$

s a constant defining the fluctuation in the pass band; and

$$x_0 = (f_2 - f_1)/f_0 \qquad (1b)$$

is the relative bandwidth; and

$$x = f/f_0 - f_0/f \qquad (1c)$$

represents the departure from

$$f_0 = (f_1 f_2)^{1/2}, \qquad (1d)$$

the center frequency.

A Summary of Design Formulas

The notation employed is generally similar to that used in connection with tuned circuit analysis. In addi- tion to the symbols defined by (1a) through (1d) we define

$$a = 1/Q_1, \quad b = 1/Q_2, \quad c = 1/Q_3, \quad d = 1/Q_4, \quad \text{and}$$
$$\alpha^2 = 1 - E_{\min}^2/E_{\max}^2.$$

The design formulas which are to be established are:

Triple-tuned circuit formulas

$$2x_0^3/\sigma = M^3 + 3x_0^2 M, \qquad M = a + b + c,$$
$$K_{12}^2 = [1 + b/(c-a)][M^2 f(a/M) + 0.375x_0^2],$$
$$K_{23}^2 = [1 + b/(a-c)][M^2 f(c/M) + 0.375x_0^2],$$

where, $f(u) = 0.5u^2 - 0.25u + 0.125$.

$f(u)$ which is graphed in Fig. 2 is to be evaluated for $u = a/M$ or b/M. The relation between σ and M is graphed in Fig. 3. Attenuation out of pass band $= 4\sigma(x/x_0)^3$.

Quadruple-tuned circuit formulas

$$x_0^4/\alpha = 0.171(M^2 + x_0^2)(M^2 + 5.85x_0^2),$$
$$M = a + b + c + d.$$

$$(b-d)K_{34}^4 - K_{34}^2\left[\frac{F(-d) - F(-a)}{(a-d)} + (c-a)(a-d)(b-d)\right] + (c-a)F(-d) = 0,$$

$$K_{12}^2 = F(-a)/[(c-a)(d-a) + K_{34}^2],$$

$$K_{23}^2 = \left[\frac{F(-b) - F(-a)}{(a-b)} + K_{12}^2(a+b-c-d)\right]/(d-b),$$

or,

$$K_{23}^2 = \left[\frac{F(-c) - F(-d)}{(d-c)} + K_{34}^2(c+d-a-b)\right]/(a-c),$$

where in the above

$$F(-p) = [M^2 f_1(p/M) + 0.854x_0^2][M^2 f_2(p/M) + 0.1463x_0^2],$$

* Decimal classification: R141.2×R142. Original manuscript re- ceived by the Institute, September 21, 1949; revised manuscript received, June 8, 1950.

† University of Maryland, College Park, Md.

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and

$$\frac{F(-p)-F(-q)}{(p-q)}$$
$$=\tfrac{1}{2}[p+q-0.293M][M^2f_2(p/M)+M^2f_2(q/M)+0.293x_0^2]$$
$$+\tfrac{1}{2}[p+q-0.707M][M^2f_1(p/M)+M^2f_1(q/M)+1.707x_0^2],$$

the two functions f_1 and f_2 being given by

$$f_1(u) = u^2 - 0.293u + 0.1463,$$
$$f_2(u) = u^2 - 0.707u + 0.1463.$$

These functions which are to be evaluated for $u=a/M$, b/M, and so forth are graphed in Fig. 4, and the relation between α and M is graphed in Fig. 5.

Attenuation out of the pass band $=8\alpha(x/x_0)^4$.

The General Electrical Equations

The type of circuit under consideration consists of n resonant loops coupled in sequence, that is,

$$Z_{ij} = 0, \quad \text{when} \quad |i-j| > 1 \quad (i, j = 1, 2, \cdots, n).$$

An alternative representation is n resonant nodes. In order to fix one's ideas, two typical circuits are shown in Fig. 1. If we let Det(Z_{rs}) be the impedance determi-

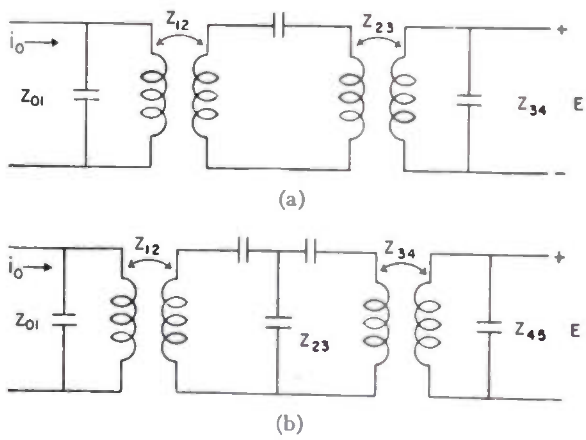

Fig. 1—Typical circuit configurations. (a) Triple-tuned circuit (b) Quadruple-tuned circuit.

nant of a network of the kind illustrated in Fig. 1, we find by conventional loop-current analysis that

$$(Z_{01}Z_{12}Z_{23}\cdots Z_{n\,n+1})i_0E^{-1} = \text{Det}\,(Z_{rs}),$$
$$(r, s = 1, 2, \cdots, n), \quad (3a)$$

where i_0 is the current source, and E is the output voltage; Z_{01} includes the impedance of the generator, and $Z_{n\,n+1}$ includes the impedance of the load.

We shall assume that the bandwidth is small enough so that

A. The losses in each loop may be regarded as arising from a constant series resistance.

B. The mutual impedances $Z_{ij}(i\neq j)$ are pure reactances and may be regarded as constant over the pass band.

C. The n loops are all resonant at the same frequency.

Letting

$$p = jx \quad (3b)$$

we find that Det (Z_{rs}) is a polynomial of degree n in p and

$$Ki_0E^{-1} = p^n + Mp^{n-1} + \sum_0^{n-2} a_Kp^K \equiv F(p) \quad (3c)$$

where K is a constant.

The General Amplitude Response

If we consider the absolute value of E, we see that

$$K^2i_0^2|E|^{-2} = F(p)F(-p) = G(x^2), \quad (4a)$$

where $G(x^2)$ is an nth degree polynomial in x^2. For the desired response the fluctuation of $|E|$ must be limited or for convenience

$$1 \leqq |E_{max}/E|^2 \leqq 1+\sigma^2, \quad \text{when} \quad 0 \leqq x^2 \leqq x_0^2.$$

σ is a measure of the variation of $|E|$ across the pass band. ($\sigma=1$ for example, corresponds to a 3-db variation.) At the same time we want a response for which $|E_{max}/E|^2$ is as large as possible outside the pass band. It may be shown that the nth degree polynomial in x^2, which satisfies both these conditions, is unique and is given by

$$|E_{max}/E|^2 = 1+\sigma^2\cos^2 n\phi, \text{ where } x = x_0\cos\phi. \quad (4b)$$

The coefficient of x^{2n} in (4b) is $4^{n-1}\sigma^2/x_0^{2n}$. Comparing (3c) and (4a) with (4b) yields

$$F(p)F(-p) = \frac{x_0^{2n}}{4^{n-1}\sigma^2}[1+\sigma^2\cos^2 n\phi] \equiv G(x^2). \quad (4c)$$

The coefficients of $F(p)$ depend upon the nQ's and the $n-1$ coupling coefficients. Equation (4c) leads to n relations for the $2n-1$ circuit constants, so that $n-1$ of them may be chosen arbitrarily and the remaining ones are then determined. For practical reasons it is usually convenient to let $n-1$ of the Q's be the natural Q's of the coils; the remaining Q (usually Q_1 or Q_n) and the coupling coefficients are then determined from the design equations.

The Determination of $F(p)$

In order to solve (4c) for $F(p)$, let

$$p_0 = jx_0\cos\theta$$

be a particular root of $F(p)=0$. Then we may write the n roots as

$$p_K = jx_0\cos(\theta+K\pi/n),\ (K = 0, 1, 2, \cdots, n-1), \quad (5a)$$

for these are all roots of $G(x^2)=0$, and the remaining roots are the negatives of (5a). We put

$$M = -\sum_0^{n-1} p_K = -jx_0\sum_0^{n-1}\cos(\theta+K\pi/n), \quad (5b)$$

and find that

$$M = jx_0\frac{\sin(\theta-\pi/2n)}{\sin\pi/2n}. \quad (5c)$$

,

$$M = -(p_K+p_{n-1-K})/2 \sin\left(\frac{1+2K}{2n}\pi\right)\sin(\pi 2/n). \quad (5d)$$

ow calculation of M^2 and $(p_K)(p_{n-1-K})$ reveals that

$$(p_K)(p_{n-1-K}) = M^2 \sin^2 \pi/2n + x_0^2 \cos^2\left(\frac{1+2K}{2n}\pi\right). \quad (5e)$$

t follows that if n is even, we may resolve $F(p)$ into uadratic factors as

$$(p) = \prod_{K=0}^{1/2(n-2)}\left[p^2+2Mp \sin \pi/2n \sin\left(\frac{1+2K}{2n}\pi\right) + M^2 \sin^2 \pi/2n + x_0^2 \cos^2 \frac{1+2K}{2n}\pi\right], \quad (5f(1))$$

nd if n is odd,

$$(p) = \left(p + M \sin\frac{\pi}{2n}\right) \prod_{K=0}^{1/2(n-3)}\left[p^2 + 2Mp \sin\frac{\pi}{2n}\sin\left(\frac{1+2K}{2n}\pi\right) + M^2\sin^2\frac{\pi}{2n} + x_0^2\cos^2\left(\frac{1+2K}{2n}\pi\right)\right]. \quad (5f(2))$$

t remains to determine M. We note (5c) and

$$\sin^2 n\left(\theta - \frac{\pi}{2n}\right) = \cos^2 n\theta = -1/\sigma^2$$

o that

$$M \sin\frac{\pi}{2n} = jx_0 \sin\left(\frac{1}{n}\sin^{-1}\frac{j}{\sigma}\right)$$

or,

$$M = \frac{x_0}{\sin\frac{\pi}{2n}} \sinh\left(\frac{1}{n}\sinh^{-1}\frac{1}{\sigma}\right). \quad (5g(1))$$

$$\frac{1}{\sigma} = \sinh\left[n \sinh^{-1}\left(\frac{M \sin \pi/2n}{x_0}\right)\right]. \quad (5g(2))$$

The Triple-Tuned Circuit

The response of a properly designed triple-tuned circuit may be obtained from (4b) as

$$|E_{max}/E|^2 = 1 + \frac{16\sigma^2 x^2}{x_0^6}\left(x^4 - \frac{3}{2}x_0^2x^2 + \frac{9}{16}x_0^4\right). \quad (6a)$$

Referring to Fig. 1(a) and equation (3a), the electrical equations become

$$Z_{01}Z_{12}Z_{23}Z_{34}i_0E^{-1} = Z_{11}Z_{22}Z_{33} - Z_{12}^2Z_{33} - Z_{23}^2Z_{11}. \quad (6b)$$

With the approximations implied by assumptions A, B, and C, we may write

$$Z_{11} = \omega_0 L_{11}(p+a), \quad Z_{22} = \omega_0 L_{22}(p+b), \quad Z_{33} = \omega_0 L_{33}(p+c),$$

$$Z_{12}^2 = -K_{12}^2\omega_0^2 L_{11}L_{22}, \quad Z_{23}^2 = -K_{23}^2\omega_0^2L_{22}L_{33},$$

where

$$p = jx, \quad a = 1/Q_1, \quad b = 1/Q_2, \quad c = 1/Q_3.$$

Then (6b) takes the form

$$\frac{Z_{01}Z_{34}K_{12}K_{23}}{\omega_0\sqrt{L_{11}L_{33}}} i_0E^{-1} = (p+a)(p+b)(p+c) + K_{12}^2(p+c) + K_{23}^2(p+a) = F(p). \quad (6c)$$

On the other hand, from (5f(2))

$$F(p) = (p + M/2)(p^2 + \tfrac{1}{2}Mp + M^2/4 + 3x_0^2/4), \quad (6d)$$

and equations (5g) become

$$M = 2x_0 \sinh\left(\frac{1}{3}\sinh^{-1}\frac{1}{\sigma}\right) \quad (6e(1))$$

$$2x_0^3/\sigma = M^3 + 3x_0^2M. \quad (6e(2))$$

We identify (6c) with (6d) so that

$$M = a + b + c, \quad (6f)$$

and putting p equal to $-a$ and $-c$ we find

$$K_{12}^2 = \frac{F(-a)}{c-a} = [1+b/(c-a)][f(a/M)M^2 + \tfrac{3}{8}x_0^2]; \quad (6g)$$

$$K_{23}^2 = \frac{F(-c)}{a-c} = [1+b/(a-c)][f(c/M)M^2+\tfrac{3}{8}x_0^2]; \quad (6h)$$

where

$$f(u) = \tfrac{1}{2}u^2 - \tfrac{1}{4}u + \tfrac{1}{8}. \quad (6i)$$

Equations (6e) through (6h) are a complete solution to the design problem, for the bandwidth x_0, and σ determined M from (6e). Now two of the Q's may be almost arbitrarily chosen and the third determined from (6f). The coupling coefficients may then be found from (6g) and (6h).

Two of the Q's may be chosen *almost* arbitrarily. In order to have a physically realizable solution, all of the Q's must be positive and the squares of the coupling coefficients must also be positive. This requires

$$\left|\frac{1}{Q_3} - \frac{1}{Q_1}\right| > \frac{1}{Q_2}. \quad (6j)$$

It is interesting to note that one solution which is very popular in the literature and assumes

$$Q_1 = Q_3$$

blows up completely unless Q_2 is identically infinite.

It often happens in practice that the value of M that can be physically obtained is greater than that which would be permissible from the standpoint of allowable σ. In this case, the realizable σ may be determined from (6e(2)). The computations may be facilitated by a

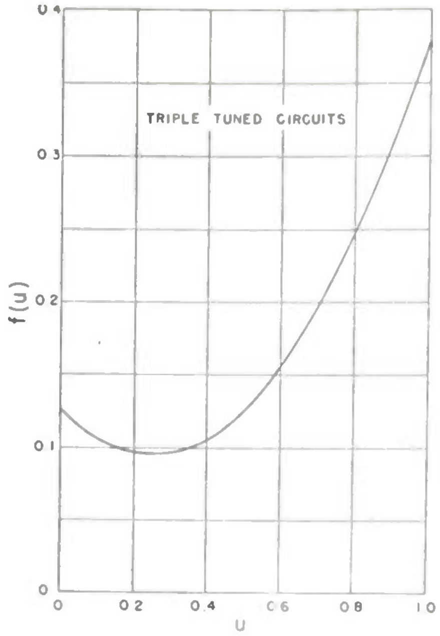

Fig. 2—Design function for triple-tuned circuits.

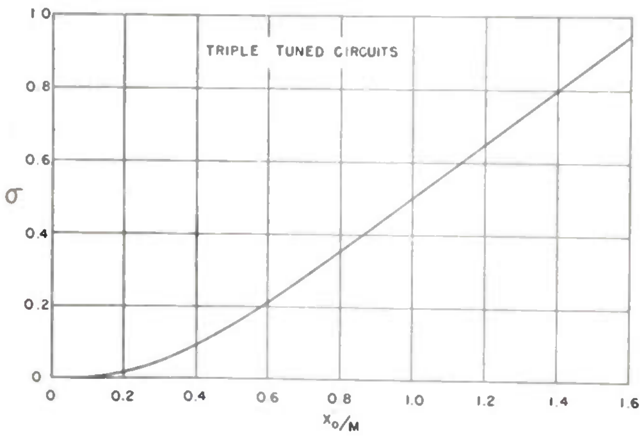

Fig. 3—Flatness parameter for triple-tuned circuits.

graph of (6i). This graph and a graph of (6e) are shown in Figs. 2 and 3.

The Critical and Under-Critical Triple-Tuned-Circuit

We define a critical circuit as one in which the three peaks of the response merge. This design will yield the flattest response at resonance for a given attenuation anywhere off resonance. The equations already obtained may be modified by letting

$$x_0 \to 0, \qquad \sigma \to 0, \qquad x_0^3/4\sigma \to M^3/8.$$

We define under-critical circuits as those for which

$$0 > x_0^2 > -M^2/4$$

In this case all the previous equations still apply.

The Triple-Tuned Gain Bandwidth Product

We put $p=0$ in (4c) and (6e). When $|Z_{01}| = 1/\omega_0 C_{11}$, and $Z_{34} = 1/\omega_0 C_{33}$, we find

$$(f_2 - f_1)E = i_0 \frac{K_{12}K_{23}}{2\pi\sqrt{C_{11}C_{33}}} \times \frac{4\sigma}{x_0^2}. \tag{7a}$$

For a given response, $K_{12}K_{23}$ is a maximum when $a = M$, $b=c=0$. Then

$$(f_2 - f_1)E = \frac{i_0}{2\pi\sqrt{C_{11}C_{33}}} \frac{x_0}{M} \sqrt{\frac{3(M^2 + x_0^2)}{M^2 + 3x_0^2}}. \tag{7b}$$

The Quadruple-Tuned Circuit

We proceed as in the case of the triple-tuned circuit. The electrical equations take the form

$$\frac{Z_{01}Z_{45}K_{12}K_{23}K_{34}}{\omega_0\sqrt{L_{11}L_{44}}} i_0 E^{-1}$$
$$= (p+a)(p+b)(p+c)(p+d)$$
$$+ K_{12}^2(p+c)(p+d) + K_{23}^2(p+a)(p+d)$$
$$+ K_{34}^2(p+a)(p+b) + K_{12}^2K_{34}^2. \tag{8a}$$

On the other hand, from (5f(1))

$$F(p) = \left[p^2 + \left(1 - \frac{\sqrt{2}}{2}\right)Mp + \frac{M^2}{2}\left(1 - \frac{\sqrt{2}}{2}\right) + \frac{x_0^2}{2}\left(1 + \frac{\sqrt{2}}{2}\right)\right]\left[p^2 + \frac{\sqrt{2}}{2}Mp + \frac{M^2}{2}\left(1 - \frac{\sqrt{2}}{2}\right) + \frac{x_0^2}{2}\left(1 - \frac{\sqrt{2}}{2}\right)\right] \tag{8b}$$

while equations (5g) become

$$M^2 = (1 + \sqrt{2})x_0^2\left[\sqrt{1 + \frac{1}{\alpha}} - \sqrt{2}\right]. \tag{8c(1)}$$

$$\frac{1}{\alpha} = |(\sqrt{2} - 1)|\left[\frac{M^2}{x_0^2} + 1\right] \cdot \left[(\sqrt{2} - 1)\frac{M^2}{x_0^2} + \sqrt{2} + 1\right] \tag{8c(2)}$$

where $\alpha^2 = 1 - E^2_{\min}/E^2_{\max}$.

We identify (8a) with (8b) so that

$$M = a + b + c + d. \tag{8d}$$

Putting p equal to $-a$, $-d$, $-b$, and $-c$ we find for K_{34}^2 and K_{12}^2,

$$K_{34}^4 - K_{34}^2\left[\frac{F(-d) - F(-a)}{(b-d)(a-d)} + (c-a)(a-d)\right] + \frac{F(-d)(c-a)}{(b-d)} = 0. \tag{8e}$$

$$K_{12}^2 = \frac{F(-a)}{(c-a)(d-a) + K_{34}^2}. \tag{8f}$$

… for K_{23}^2 we have the two formulations

$$\ldots = \frac{F(-b) - F(-a)}{(a-b)(d-b)} + \frac{K_{12}^2(b+a-c-d)}{(d-b)} \tag{8g}$$

$$\ldots = \frac{F(-c) - F(-d)}{(d-c)(a-c)} + \frac{K_{34}^2(c+d-b-a)}{(a-c)}. \tag{8h}$$

… facilitate computations in the above equations, we … write

$$\ldots(-p) = \left[M^2 f_1\left(\frac{p}{M}\right) + \frac{x_0^2}{2}\left(1 + \frac{\sqrt{2}}{2}\right)\right] \cdot \left[M^2 f_2\left(\frac{p}{M}\right) + \frac{x_0^2}{2}\left(1 - \frac{\sqrt{2}}{2}\right)\right] \tag{8i}$$

$$\frac{\ldots(-p_1) - F(-p_2)}{p_1 - p_2} = \frac{1}{2}\left[\left(p_1 + p_2 - \left(1 - \frac{\sqrt{2}}{2}\right)M\right]\right. \cdot \left[M^2 f_2\left(\frac{p_1}{M}\right) + M^2 f_2\left(\frac{p_2}{M}\right) + \left(1 - \frac{\sqrt{2}}{2}\right)x_0^2\right]$$
$$+ \frac{1}{2}\left[p_1 + p_2 - \frac{\sqrt{2}}{2}M\right] \cdot \left[M^2 f_1\left(\frac{p_1}{M}\right) + M^2 f_1\left(\frac{p_2}{M}\right) + \left(1 + \frac{\sqrt{2}}{2}x_0^2\right)\right], \tag{8j}$$

$$\ldots(u) = u^2 - \left(1 - \frac{\sqrt{2}}{2}\right)u + \frac{1}{2} - \frac{\sqrt{2}}{4},$$

$$\ldots(u) = u^2 - \frac{\sqrt{2}}{2}u + \frac{1}{2} - \frac{\sqrt{2}}{4}. \tag{8k}$$

Equations (8c) through (8h) are a complete solution … the design problem. The bandwidth x_0 and α determine M from (8c); then three of the Q's may be almost arbitrarily chosen and the fourth is determined by (8d); K_{34} may be found from (8e), K_{12} from (8f) and K_{23} from (8g) or (8h). The calculations may be facilitated by graphs of (8k). These graphs and a graph of (8c) are shown in Figs. 4 and 5. The criteria for a physical solution in a form as simple as in the triple-tuned case have not been found; however, a physical solution may always be obtained by a sufficiently large value of a or d.

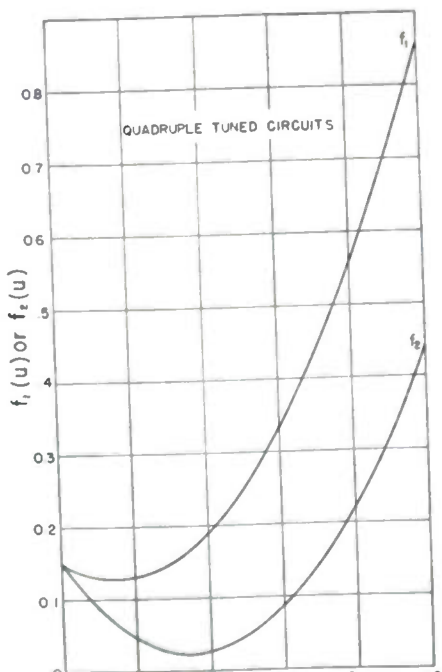

Fig. 4—Design functions for quadruple-tuned circuits.

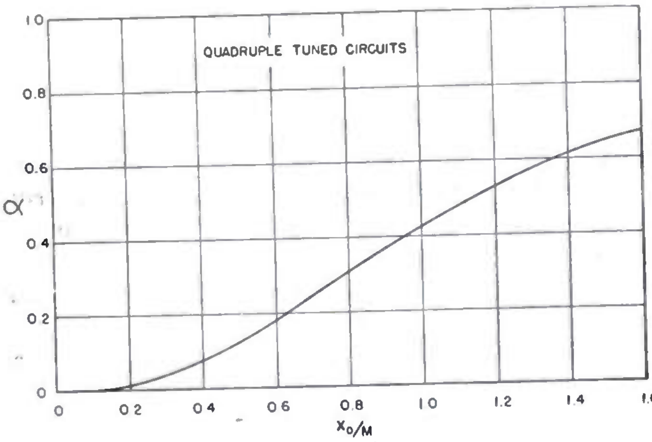

Fig. 5—Flatness parameter for quadruple-tuned circuits.

The design equations of critical quadruple-tuned circuits are obtained by letting

$$x_0 \to 0, \quad \alpha \to 0, \quad x_0^4/8\alpha \to \frac{3 - 2\sqrt{2}}{8} M^4.$$

We define under-critical circuits as those for which

$$0 > x_0^2 > -M^2\left(\frac{1}{2} - \frac{\sqrt{2}}{4}\right)$$

and in this case all the previous equations still apply.

Tuning Procedure

A discussion of multiple-tuned circuits would be incomplete without a method of tuning. A procedure which is both a convenient method for tuning and for setting the coupling coefficients is the following:

(a) All circuits except the first are completely mistuned by short circuiting the coils L_{22}, L_{33}, L_{44}. A vacuum-tube voltmeter is connected to the input and the first circuit is tuned for a maximum indication E_a on the voltmeter.

(b) The short circuit is removed from L_{22}, and the second circuit is tuned for a minimum indication E_b. Then

$$\frac{E_b}{E_a} = \frac{1}{1 + K_{12}^2 Q_1 Q_2}. \tag{9a}$$

(c) The short circuit is removed from L_{33}, and the third circuit is tuned for a maximum indication E_c, then

$$\frac{E_c}{E_a} = \frac{1}{1 + \dfrac{K_{12}^2 Q_1 Q_2}{1 + K_{23}^2 Q_2 Q_3}} \cdot \qquad (9b)$$

(d) The short circuit is removed from L_{44}, and the fourth circuit is tuned for a minimum indication E_d, then

$$\frac{E_d}{E_a} = \frac{1}{1 + \dfrac{K_{12}^2 Q_1 Q_2}{1 + \dfrac{K_{23}^2 Q_2 Q_3}{1 + K_{34}^2 Q_3 Q_4}}} \qquad (9c)$$

All circuits are now in tune and the coupling coefficients have been measured. The only remaining problem is the removal of the voltmeter from the input circuit. One method is to take advantage of the fact that even when the voltmeter is disconnected all circuits but the first are in tune, so that the voltmeter may be removed from the input and used as an indicator in the plate circuit of the output tube, the input now being retuned for a maximum indication.

Staggered Circuits

The factorization of $F(p)F(-p)$ given by (5f) has an interesting consequence. A $2n$ tuned response may be obtained by n double-tuned stages, and a $2n+1$ tuned response may be obtained by one single-tuned stage and n double-tuned stages. All stages are centered at the same frequency, but are staggered with respect to bandwidth. The equations (5f) through (5g) may be regarded as design equations for the general n for circuits of this type. For example, the quadruple tuned response may be obtained by two double-tuned stages with

$$a + b = (1 - \sqrt{2}/2)M,$$

$$K_{12}^2 = \frac{M^2}{2}\left(1 - \frac{\sqrt{2}}{2}\right) + \frac{x_0^2}{2}\left(1 + \frac{\sqrt{2}}{2}\right) - ab, \qquad (10a(1))$$

$$c + d = \frac{\sqrt{2}}{2} M,$$

$$K_{23}^2 = \frac{M^2}{2}\left(1 - \frac{\sqrt{2}}{2}\right) + \frac{x_0^2}{2}\left(1 - \frac{\sqrt{2}}{2}\right) - cd. \qquad (10a(2))$$

The maximum gain backwidth product on a per-stage basis is given by

$$(f_2 - f_1)E = \frac{i_0}{2\pi\sqrt[4]{C_{11}C_{22}C_{33}C_{44}}} \sqrt[4]{8\alpha}. \qquad (10b)$$

This is approximately $\sqrt[4]{4/\alpha}$ times that obtainable with identical stages with the same over-all x_0 and α. The fact that one of the stages has a bandwidth which is wider than the over-all bandwidth is of advantage in some applications. For example, the first stage may be designed to pass both the video and sound components of a television signal.

Two Sample Calculations

In order for the reader to better understand the use of the equations presented above, we give the numerical computations to design a triple-tuned and quadruple-tuned circuit to satisfy the following requirements: A pass band of 15.6 to 16.4 Mc with the fluctuation not to exceed 1 db, an interfering signal at 14 Mc, and an input capacity and output capacity of 5 and 6 mmfd respectively. The plate resistance of the input tube is 4×10^6 ohms. The Q of all coils is 100.

(a) *The Triple-Tuned Circuit.* (Fig. 1(a))

$L_{11} = 20\ \mu h \qquad L_{33} = 16.7\ \mu h$

$f_0 = 16$ Mc. $\qquad x_0 = 0.05$

$a = 0.01 + 2{,}000/4 \times 10^5$

$= 0.015 = 0.250M = 3x_0 \qquad (a - c) = 0.4x_0$

$b = 0.01 = 0.167M = 0.2x_0$

Let $c = 0.035 = 0.583M = 0.7x_0$,

$M = 0.06 = 1.2x_0$

then $R = 1670/(0.035 - 0.01)$ ohms

$R = 66.7 \times 10^3$ ohms

$2/\sigma = (1.2)^3 + 3.6 = 5.33, \quad \boxed{\sigma = 0.375}$

The response is flat to 0.58 db.

$f(0.25) = 0.094 \qquad f(0.583) = 0.150$

$K_{12}^2 = (1 + 0.2/0.4)(1.44\times0.094 + 0.375)x_0^2$

$= 0.765x_0^2 \quad \boxed{K_{12} = 0.875x_0 = 0.0437}$

$K_{23}^2 = (1 - 0.2/0.4)(1.44 \times 0.154 + 0.375)x_0^2$

$= 0.298x_0^2 \quad \boxed{K_{23} = 0.546x_0 = 0.0273}$

with $g_m = 5 \times 10^{-3}$ mhos,

gain $= g_m X_c K_{12} K_{23}(4\sigma/x_0^3)$

$= 5 \times 10^{-3} \times 1800 \times 0.546 \times 0.875 \times 1.5/0.05$

$= 130.$

At 14 Mc $x = 0.267$, hence attenuation of 14 Mc is $1.5\times(0.267/0.05)^3 = 228$.

(b) *The Quadruple-Tuned Circuit.* (Fig. 1(b))

$L_{11} = 20\ \mu h. \qquad L_{44} = 16.7\ \mu h.$

$f_0 = 16$ Mc. $\qquad x_0 = 0.05$

$a = 0.015 = 0.15M = 0.3x_0 \quad (d - a) = 1.0x_0$

$b = 0.01 = 0.10M = 0.2x_0 \quad (d - b) = 1.1x_0$

$c = 0.01 = 0.10M = 0.2x_0 \quad (a - c) = 0.1x_0.$

Let $d = 0.065 = 0.65M = 1.3x_0$

$R = 1670/(0.065 - 0.01) = 30 \times 10^3$ ohms

$M = 0.100 = 2x_0$

$\frac{1}{\alpha} = 0.171(4 + 1)(4 + 5.85) = 8.44, \quad \boxed{\alpha = 0.1185}.$

he response is flat to 0.06 db.

$$(0.15) = 0.125 \qquad f_2(0.15) = 0.061$$
$$(0.10) = 0.127 \qquad f_2(0.10) = 0.085$$
$$(0.65) = 0.376 \qquad f_2(0.65) = 0.112$$

$$(-d) = (4 \times 0.376 + 0.854)(4 \times 0.112 + 0.1465)x_0^4$$
$$= 2.359 \times 0.5945 x_0^4 = 1.401 x_0^4$$
$$(-a) = (4 \times 0.125 + 0.854)(4 \times 0.061 + 0.1465)x_0^4$$
$$= 1.354 \times 0.3905 x_0^4 = 0.529 x_0^4$$
$$F(-b) = (4 \times 0.127 + 0.854)(4 \times 0.085 + 0.1465)x_0^4$$
$$= 1.362 \times 0.4865 x_0^4 = 0.663 x_0^4$$

$$\frac{(-d) - F(-a)}{(d-a)} = \frac{1.401 - 0.529}{1.0} x_0^3 = 0.872 x_0^3$$

$$\frac{(-b) - F(-a)}{(b-a)}$$
$$= \frac{1}{2}(2)(0.25 - 0.293)(0.3905 + 0.4865)x_0^3$$
$$+ \frac{1}{2}(2)(0.25 - 0.707)(1.354 + 1.362)x_0^3$$
$$= -1.278 x_0^3$$

$$_{34}^4 - K_{34}^2 x_0^2(0.872/1.1 + 0.1 \times 1.0)$$
$$+ x_0^4(1.401)(0.1)/(1.1) = 0$$

$$K_{34}^2 = 0.7135 x_0^2 \qquad \boxed{K_{34} = 0.845 x_0 = 0.0425}$$
$$K_{12}^2 = x_0^2(0.529)/(0.7135 - 0.1)$$
$$= 0.862 x_0^2 \qquad \boxed{K_{12} = 0.93 x_0 = 0.0465}$$
$$K_{23}^2 = x_0^2(1.278 - 0.862 \times 1.0)/(1.1)$$
$$= 0.379 x_0^2 \qquad \boxed{K_{23} = 0.615 x_0 = 0.03075}$$

If $L_{22} = L_{33} = 5\ \mu h$,

$$C_{23} = (20 \text{ mmfd})/0.03075 = 650 \text{ mmfd}.$$

With $g_m = 5 \times 10^{-3}$ mhos

$$\text{Gain} = g_m X_c K_{12} K_{23} K_{34}(8\alpha/x_0^4)$$
$$= 5 \times 10^{-3} \times 1800 \times 0.93 \times 0.615$$
$$\times 0.845 \times 0.95/0.05 = 83.$$

At 14 Mc, the attenuation is $0.95 \times (0.267/0.05)^4 = 775$.

Conclusion

We have concerned ourselves, in this paper, with the design of multiple-tuned circuits for optimum amplitude response. One might think that better practical results would be obtained with flat designs. The opposite is actually the case. A small σ requires a large (M/x_0) and consequently large coefficients for $F(p)$, but all the coefficients of $F(p)F(-p)$ with the exception of the constant term are independent of σ. Thus the effect of reducing σ is to require that the differences of large numbers be small numbers.

The design equations for the electrical parameters are expressed in terms of the invariant $F(p)$, so that these equations apply in form for any desired response characteristics, it being only necessary to determine the appropriate $F(p)$.

Discussion on

"Properties of Some Wide-Band Phase-Splitting Networks"*

DAVID G. C. LUCK

Frederick E. Bond[1]: While reading the paper entitled "Properties of some wide-band phase-splitting networks," by David G. C. Luck, it appeared that there might be a simpler mathematical procedure for deriving the relationship between deviation from 90° phase difference and the ratio of the maximum and minimum frequency.

Specifically, consider equation (6) in the above-mentioned paper, which expresses the tangent of half the phase difference as a function of the circuit Q (as defined therein); the quantity r (the square root of the ratio of f_2 to f_1); and f_0 (the geometric mean of f_1 and f_2).

$$\tan \tfrac{1}{2}\psi = \frac{Q\left[\left(\frac{rf_0}{f} - \frac{f}{rf_0}\right) - \left(\frac{f_0}{rf} - \frac{rf}{f_0}\right)\right]}{1 + Q^2\left(\frac{rf_0}{f} - \frac{f}{rf_0}\right)\left(\frac{f_0}{rf} - \frac{rf}{f_0}\right)}.$$

The nature of this function suggests the following change of variables:

* Proc. I.R.E., vol. 37, pp. 147–152; February, 1949.
[1] Coles Signal Laboratory, Red Bank, N. J.

Let

$$f/f_0 = e^x \tag{1}$$

and

$$r = e^y. \tag{2}$$

Then the above expression becomes

$$\tan \tfrac{1}{2}\psi = \frac{4Q \sinh y \cosh x}{1 - 4Q^2(\cosh^2 y - \cosh^2 x)}. \tag{3}$$

Now when $f = f_0$, $x = 0$. Therefore

$$\tan \tfrac{1}{2}\psi_0 = \frac{4Q \sinh y}{1 - 4Q^2 \sinh^2 y}. \tag{4}$$

Combining (3) and (4)

$$\frac{\tan \frac{1}{2}\psi}{\tan \frac{1}{2}\psi_0} = \frac{\cosh x}{1 + M \sinh^2 x} \tag{5}$$

where

$$M = \frac{4Q^2}{1 - 4Q^2 \sinh^2 y} = \frac{4Q^2}{1 - Q^2\left(r - \frac{1}{r}\right)^2}. \tag{6}$$

Note that M is equal to $\sin^2 \frac{1}{2}\sigma$ where σ is defined in equation (11) in the paper under discussion. In equation (5) we have the phase difference expressed as a function of ψ_0 (its value at the mean frequency f_0); x which is equal to $\log_e f/f_0$; and M, which is a function of the circuit parameters Q and r.

In order to find the location of the maxima and minima for the ratio $\tan \frac{1}{2}\psi / \tan \frac{1}{2}\psi_0$, setting the first derivative of equation (5) equal to zero yields

$$\sinh x = 0, \quad \pm\sqrt{\frac{1 - 2M}{M}}. \tag{7}$$

Equation (7) shows immediately that in order to realize the double humps in the curves shown in Fig. 4 of the article in question, M must be less than 1/2 and greater than zero.

To find the values of $\tan \frac{1}{2}\psi_m$, substituting (7) in (5) yields

$$\frac{\tan \frac{1}{2}\psi_m}{\tan \frac{1}{2}\psi_0} = \frac{1}{2\sqrt{M(1 - M)}}. \tag{8}$$

Now to determine the maximum deviation of phase difference from the average value,

$$\frac{\sin \frac{1}{2}(\psi_m - \psi_0)}{\sin \frac{1}{2}(\psi_m + \psi_0)} = \frac{\dfrac{\tan \frac{1}{2}\psi_m}{\tan \frac{1}{2}\psi_0} - 1}{\dfrac{\tan \frac{1}{2}\psi_m}{\tan \frac{1}{2}\psi_0} + 1} = \frac{1 - 2\sqrt{M(1 - M)}}{1 + 2\sqrt{M(1 - M)}}. \tag{9}$$

For the quadrature case, then $1/2(\psi_m + \psi_0) = 90°$ and

$$\sin \tfrac{1}{2}(\psi_m - \psi_0) = \frac{1 - 2\sqrt{M(1 - M)}}{1 + 2\sqrt{M(1 - M)}}. \tag{10}$$

The find $f_{\min}$ and $f_{\max}$, i.e., the frequencies at which $\tan \frac{1}{2}\psi = \tan \frac{1}{2}\psi_0$, thus representing the maximum band spread for a deviation of $\frac{1}{2}(\psi_m - \psi_0)$, equate (5) to unity. Then

$$\cosh x = 1, \quad \frac{1}{M} - 1. \tag{11}$$

The first value of course refers to $f = f_0$ where $x = 0$. The second value refers to both $f_{\max}$ and $f_{\min}$, since $\cosh x$ is an even function of x and x has logarithmic symmetry with f.

From (11)

$$e^x = \frac{f}{f_0} = \frac{1 - M \pm \sqrt{1 - 2M}}{M}. \tag{12}$$

The expression in (12) with the positive sign must refer to $f_{\max}$ since it is always greater than the value using the negative sign. Therefore

$$\frac{f_{\max}}{f_{\min}} = \frac{\dfrac{f_{\max}}{f_0}}{\dfrac{f_{\min}}{f_0}} = \frac{1 - M + \sqrt{1 - 2M}}{1 - M - \sqrt{1 - 2M}}. \tag{13}$$

Using corresponding values of M in equations (10) and (13), the desired relationship between maximum deviation and frequency spread can be obtained and the values in Fig. 6 of Dr. Luck's paper can be checked.

David G. C. Luck[2]: The interest which has led Mr. Bond to work out an alternative to the methods used in my paper is greatly appreciated.

Introducing the substitute variables η and σ, by equations (9) and (11) of my paper, I stated that this was done quite arbitrarily. The same statement applies also to the introduction of θ and ρ by my equations (13) and (18). Various other arbitrary substitutions could, of course, have been used instead.

Mr. Bond chooses to use $\cosh x$ wherever I used $\operatorname{cosec} \eta$, $\sqrt{M}$ where I used $\sin \frac{1}{2}\sigma$, and $\sinh \gamma$ where I used $\cot \rho$. These seem to me to be purely matters of personal preference. There is no need to justify by logic either his preference or mine. Mr. Bond also chooses to stop short of my final substitution (13), which in his notation would be

$$\tan \tfrac{1}{2}\theta = \sqrt{\frac{M}{1 - M}} \cosh x. \tag{A}$$

[2] RCA Laboratories Division, Princeton, N. J.

is final expression (5) for the phase difference-versus-equency characteristic is essentially my equation (12), th x and M substituted for my η and σ. This is again rgely a matter of preference and, as Mr. Bond has own, the essential results can be derived readily from s expression.

It is certainly Mr. Bond's right to make his calcula-ons in any self-consistent way he chooses. However, cannot quite agree that it is simpler to determine aximum and minimum properties by the formal ocesses of taking derivatives, equating them to zero, id substituting back the results, than to determine ese properties by inspection, in the light of common nowledge of the shapes of trigonometric functions. either can I agree that it is simpler to compute nu-erical results from Mr. Bond's quadratic expressions), (7), (8), (9), and (10) than to pick such results ady-made from the nearest trig table, with the aid of y expressions (13), (14), (15), and (16).

Unfortunately, I have not been able to find any really onvenient expression for f_{max}/f_{min}; for comparison with Ir. Bond's equation (13), my notation offers,

$$\frac{f_{max}}{f_{min}} = \left(\frac{1+\sqrt{\cos\sigma}}{1-\sqrt{\cos\sigma}}\right)^2. \tag{B}$$

Also, for slide-rule computation, my expressions (17) and (18) can be written as

$$Q = \frac{\sqrt{\cos\frac{1}{2}\psi_0}}{2\cos\frac{1}{4}\psi_0}\sin\tfrac{1}{2}\sigma \tag{C}$$

and

$$\tan\rho = \frac{\sqrt{\cos\frac{1}{2}\psi_0}}{\sin\frac{1}{4}\psi_0}\sin\tfrac{1}{2}\sigma. \tag{D}$$

The intermediate variables η and σ (or x and y), which disappear from my final expressions, have the virtue of avoiding quadratic solutions in the inverse calculation of frequency ratios from desired phase-difference characteristics. If one accepts computation of quadratic forms anyway, Mr. Bond's x and y seem to lose much of their utility. My introduction of η was based, however, on the further supposition that the graphical form of a cosecant is more generally recognized than that of $f/f_0+f_0/f$, which cosec η replaces. The same justification might apply to Mr. Bond's use of cosh x, if he wishes to derive results, by inspection, from the graphical shapes of known functions.

CORRECTION

Albert S. Richardson, Jr., author of the paper "The remainder theorem and its applications to operational calculus techniques," which appeared on pages 1336–1339 of the November, 1950, issue of the PROCEEDINGS OF THE I.R.E., has brought the following errors to the attention of the editors:

On page 1337, the last three terms of equation (4) should read

$$K_1e^{S_{1q}t} + K_2e^{S_{2q}t} + \cdots + K_qe^{S_{qq}t}$$

instead of

$$K_1e^{S_{1q}t} + K_2e^{S_{2q}t} + \cdots + K_qe^{S_{qq}t}.$$

Also on page 1337, the right-hand side of the last equation on this page should read

$$[e^{+S_{qq}t} - 1]$$

instead of

$$[e^{-S_{qq}t} - 1].$$

Contributors to the Proceedings of the I.R.E.

John L. Glaser (S'42–A'51) was born in St. Louis, Mo., on January 21, 1921. He received the B.S. degree in electrical engineering in 1943 from Washington University in St. Louis. He served with the Antiaircraft Artillery and Signal Corps during World War II. He was also an instructor at the MIT Radar School, as well as a radar and communications officer in the Panama Canal Zone.

John L. Glaser

In 1948, Mr Glaser received the M.S. degree from Washington University, where he is now continuing graduate studies. He has been associated with the Diversity Reception Research Project at the University since 1946. He is a member of Sigma Xi.

❖

Martial A. Honnell (A'40–SM'47) was born at Lyons, France, in 1910. From 1928 to 1930 he was a radio operator with the Radiomarine Corporation of America. He received the B.S. degree in 1934, the M.S. degree in 1940, and the E.E. degree in 1945, all from the Georgia Institute of Technology. Mr. Honnell was on the engineering staff of radio station WGST from 1930 to 1936, and from 1938 to 1943. During 1935 he worked for the Van Nostrand Radio Engineering Service. In 1936 and 1937 he was with the radio division of the Pan American Airways at Miami. He started as an instructor of electrical engineering at Georgia Tech in 1937, and advanced to his present position of professor in charge of communications and electronics courses in 1945.

M. A. Honnell

In addition to his regular teaching duties during the war, Mr. Honnell taught radio navigation in the Civilian Pilot Training Program and he was supervisor of ultra-high-frequency courses and also of a preradar school, under the ESMWT program. He has been a faculty research associate of the Georgia Tech Engineering Experiment Station since 1944.

Mr. Honnell is a member of the American Institute of Electrical Engineers, the National Society of Professional Engineers, Tau Beta Pi, and Eta Kappa Nu.

❖

Alsede W. Hogan (S'41–S'43–M'49) was born on March 31, 1918, in Sumrall, Mass. After receiving the B.S. degree in electrical engineering in June, 1941, from the University of Texas, he was employed by the National Advisory Committee for Aeronautics to design, and supervise electrical installations for the Altitude Wind Tunnel at Cleveland, Ohio.

Alsede W. Hogan

Upon completion of that project, he joined the RCA Victor Division at Lancaster, Pa., as a standardizing engineer for cathode-ray tubes. In 1944 he received a commission in the Naval Reserve and served as a sonar specialist at various shipyards. Upon leaving the Navy he was employed by the U. S. Naval Ordnance Laboratory at Silver Spring, Md. Mr. Hogan is now head of the Systems Section of the Guided Missiles Division.

❖

F. J. Kerr (A'43–SM'49) was born at St. Albans, England, on January 8, 1918. He received the B.Sc. degree from the University of Melbourne in 1937, and the M.Sc. degree in 1940. Since 1940 he has been with the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization in Sydney, Australia. During the war he was engaged in the development of radar antennas and other equipment, and in studies of superrefraction. Recently he has been working in radio astronomy. He is at present spending a period at Harvard College Observatory, Cambridge, Mass., studying solar problems.

F. J. Kerr

❖

Walter H. Kohl (A'35–M'39–SM'43) was born in Kitzingen, Bavaria, Germany, on January 22, 1905. He received his higher education at the Technische Hochschule in Dresden, specializing in engineering physics. In 1928 he graduated with the degree of Dipl. Ing., and in 1930 completed his post-graduate work with the degree of Dr. Ing.

Immediately afterward, Dr. Kohl migrated to Canada and joined the Rogers Radio Tube Company, Ltd. in Toronto, Ontario, late in 1930, as a development engineer. He stayed with that company until 1945. During this time he advanced to project engineer in 1941, to chief engineer, vice-president, and director in 1944. His activities covered a wide field. He was a co-worker on development of the first cathode-ray tubes in Canada (1933); introduced a new process for the application of luminescent screens (1935); and demonstrated the first electron microscope pictures of oxide cathodes and metal surfaces in Canada (1934). This led to his part-time appointment as a special lecturer in electronics at the McLennan Institute of the University of Toronto (1935–1940) and to his work on the development of the first electron microscope on this continent. Dr. Kohl published a book, "The Electron, Microscope," jointly with E. F. Burton in 1942 (2nd ed., Reinhold Publishing Corporation, New York, N. Y., 1946).

Walter H. Kohl

During World War II, he worked on the production of klystrons, TR tubes, power triodes, and special receiving tubes contracted for the Canadian and British Armed Services. He introduced glass-to-metal seals by induction heating to pilot plant production (independent of earlier developments by others) and was responsible for engineering administration.

In November, 1945, Dr. Kohl joined the research division of Collins Radio Company in Cedar Rapids, Iowa, to set up a vacuum-tube laboratory for the further development of resnatrons and other high-power tubes. In 1949 he was appointed Consultant to the Director of Research. He has just completed the manuscript for a book entitled "Materials Technology for Electron Tubes," to be published in 1951 by Reinhold Publishing Corporation, New York, N. Y.

Dr. Kohl was Chairman of the Papers Procurement Committee of the Cedar Rapids Section of the IRE during 1950 and Chairman of the Toronto Section in 1937. He is also a member of the British IRE, the American Physical Society, the American Association for the Advancement of Science, the Electron Microscope Society of America, and the Iowa Academy of Science. He represents his company at the American Society for Testing Materials where he has been a member of Committee B-4, Subsection 8 on Cathodes, since 1945.

❖

Contributors to the Proceedings of the I.R.E.

Jack M. Manley (A'43–SM'49) was born Farmington, Mo., on March 9, 1909. He eived the B.S. degree in electrical engineering from the University of Missouri in 1930. Since 1930 he has been a member of the technical staff of the Bell Telephone Laboratories, Inc. For a number of years, he was concerned mainly with studies of nonlinear electric circuits. More recently he has been working on new multiplex methods for communication systems.

J. M. Manley

Mr. Manley is a member of Tau Beta i, associate member of Sigma Xi, and mem- r of the American Institute of Electrical ngineers.

❖

M. David Prince (S'45–A'50) was born Greensboro, N. C., on March 27, 1926. ie received the B.E.E. degree from the Georgia Institute of Technology in 1946, and served a year as an officer in the United States Navy. He then began graduate study at Georgia Tech while teaching part-time in the mathematics department, and was awarded the degree of M.S.E.E. in 1949. The television research on velocity modulation initiated during his graduate work was continued under he sponsorship of the school of electrical ngineering and the Experiment Station of he Georgia Institute of Technology.

M. David Prince

At the present time, Mr. Prince is on the aculty of the mathematics department, and s continuing with his graduate study in electrical engineering. In January, 1951, Mr. Prince expects to resign his position in the mathematics department to join the staff of the Georgia Tech Experiment Station as a research engineer.

❖

Arthur H. Ross (S'40–A'41–SM'48) was born in Philadelphia, Pa., on May 31, 1902. He received the E.E. degree from Cornell University in 1926, and was a special graduate student at Massachusetts Institute of Technology from 1939 to 1940 and at Rutgers University from 1947 to 1949.

Arthur H. Ross

From 1926 to 1933, Mr. Ross was a member of the engineering staff of the Bell Telephone Company of Pennsylvania. From 1933 to 1939, he was engaged in the design and manufacture of radio communication equipment. Since 1940, he has been a radio engineer with the Signal Corps Engineering Laboratories at Ft. Monmouth, N. J., where he has been engaged in research in the field of high-frequency military radio communication methods and equipment.

❖

C. A. Shain was born in Sandringham, Victoria, Australia, on February 6, 1922. He received the B.Sc. degree from the University of Melbourne in 1943 while serving with the Australian Army. Since 1943 he has been with the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization in Sydney, Australia. He is at present engaged in work on galactic radio noise.

C. A. Shain

❖

S. H. Van Wambeck (A'40–SM'46) was born in Minneapolis, Minn., on August 30, 1910. He received the B.S. degree in mechanical engineering in 1931, and the M.S. degree in electrical engineering in 1936, from Washington University, in St. Louis, Mo. From 1933 to 1935 he was engaged in research and development work on initiating explosives and ballistic test equipment at the Western Cartridge Company, East Alton, Ill. During 1935 and 1936 he was sales correspondent in the special motor division of the Emerson Electric Manufacturing Company, St. Louis, Mo. He served as instructor in electrical engineering at Oklahoma Agricultural and Mechanical College in 1936 and 1937, and in the same capacity at Rice Institute, Houston, Texas, from 1937 to 1942. Here he was also acting chairman of that department in 1941 and 1942. From 1942 to 1946 he was assistant professor in Washington University's electrical engineering department, where he is presently associate professor. During this period, Mr. Van Wambeck was also engaged as consulting engineer by the following organizations: C. H. Guernsey and Company, Oklahoma City, Okla., on electric power systems, from 1937 to 1940; Seismic Explorations, Inc., Houston, Tex., on the development and design of geophysical equipment, 1938 to 1942; Knapp-Monarch Company, St. Louis, Mo., on problems related to the proximity fuze, among other assignments, from 1943 to present; and he was consultant on problems of instrumentation related to wind tunnel and flight test from 1942 to 1944 for the McDonnell Aircraft Corporation in St. Louis. From 1946 to 1949 he served as assistant director of the Diversity Research Project at Washington University and since July, 1949, as Director of the same project.

S. H. Van Wambeck

Mr. Van Wambeck is a member of the American Institute of Electrical Engineers, the Society for the Promotion of Engineering Education, Sigma Xi, and Tau Beta Pi. He was 1945–1946 Vice-Chairman and 1946–1947 Chairman of the St. Louis Section of the IRE.

❖

Thomas Charles Gordon Wagner (A-'48) was born in Pittsburgh, Pa., on January 9, 1916. He received the B.S. degree from Harvard University in 1937, followed by the M.A. and the Ph.D. degrees from the University of Maryland in 1940 and 1943, respectively.

T. C. G. Wagner

Dr. Wagner served as consultant and engineer for Washington Institute of Technology from 1941 to 1946. He was an instructor in mathematics at the University of Maryland from 1938 to 1943, and in 1946 he was appointed associate professor of electrical engineering at that university. Since 1947 he has also been associated with the Davies Laboratories, Inc., of Riverdale, Md. He is a member of Sigma Xi and the American Mathematical Society.

Correspondence

Definition of Information*

During recent years a statistical theory of information has been developed by Shannon and others.[1–6] In this theory the amount of information conveyed by a message is defined in terms of the set of possible messages with their appropriate probability measure. For the case of communication in the presence of noise, the received information depends on the transfer probabilities between the possible transmitted and received messages. If $p(x, y)$ is the probability that message x is transmitted and message y received, then, according to the formula proposed by Shannon, the rate of information transfer is

$$R = \iint p(x, y) \ln \left[\frac{p(x, y)}{p(x)q(y)} \right] dxdy, \quad (1)$$

where $p(x) = \int p(x, y)dy$, and $q(y) = \int p(x, y)dx$. The theory of information deals with the problem of maximizing this rate of information transfer, given certain physical restrictions.

As it is conceivable that a different definition of information might lead one to different criteria for communication-link design, it seems desirable to examine the uniqueness of the definition. The basic defining postulate which the author proposes that the definition of R should satisfy is that R is invariant under any transformation of x and y that merely amounts to a relabeling of the message symbols. In other words, if we consider the arbitrary transformations, $w = f(x)$, $z = f(y)$, (with f the same function in both cases), and calculate the resulting distributions for w and z, then the value of R computed on this new basis should be the same. It can be verified that if R is defined as in (1) the postulate is satisfied. Can the definition of R be modified in a nontrivial way without violating the postulate? By embedding (1) in a certain class of possible definitions it can be shown that, at least for this class of definitions, (1) is the only admissible one. The class of definitions chosen was

$$R = \iint q(y)[F(p(x), x) - F(p_y(x), x)]dxdy, \quad (2)$$

where $p_y(x)$ is the conditional probability that x was transmitted if y was received. $F = F(u, v)$ is a function of two real variables to be chosen in such a way that the fundamental postulate is satisfied. It can be shown that with the usual continuity-type assumptions $F(u, v) = u \ln u$ is the only possible selection within an arbitrary multiplicative constant, this choice leading to the expression (1) for R. Details of the derivation will be submitted to a mathematical journal.

EDGAR REICH
The Rand Corporation
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* Received by the Institute, September 14, 1950.

[1] R. M. Fano, "The Transmission of Information," MIT Res. Lab. El., Tech. Rep. 65, March 17, 1949.

[2] S. O. Rice, "Communication in the presence of noise," *Bell Sys. Tech. Jour.*, vol. 29, pp. 60–93; January, 1950.

[3] C. E. Shannon, "A mathematical theory of communication," *Bell Sys. Tech. Jour.*, vol. 27, pp. 379–423, 623–656; July and October, 1948.

[4] C. E. Shannon, "Communication theory of secrecy systems," *Bell Sys. Tech. Jour.*, vol. 28, pp. 656–715; October, 1949.

[5] C. E. Shannon, "Communication in the presence of noise," PROC. I.R.E., vol. 37, pp. 10–21; January, 1949.

[6] N. Wiener, "Cybernetics," John Wiley and Sons, Inc., New York, N. Y., pp. 74–81; 1948.

Ascertaining the Critical Servo Gain*

One of the basic problems in servomechanism work is finding the critical system gain or gains from the system determinental equation that will produce instability. In this letter I hope to show a simplified method for determining these gains.

The general form of the determinental polynomial is

$$S^n + A_{n-1}S^{n-1} + A_{n-2}S^{n-2} \cdots + A_0 = 0. \quad (1)$$

Now the coefficients of the S terms (A_{n-1} to A_0) are functions of the variable gain K, whose critical values we should like to ascertain. Equation (1) may be factored as in (2) into a number of quadratic factors, and one first-order factor if n is odd.

$$(S^2 + \alpha_1 S + \beta_1)(S^2 + \alpha_2 S + \beta_2) \cdots (S^2 + \alpha_k S + \beta_k)(S + \delta) = 0. \quad (2)$$

At a critical gain, the coefficient of the first-degree term of S in one quadratic factor must vanish, and the constant term in that factor must be greater than zero. Then (2) takes this form:

$$(S^2 + \beta_1)(S^2 + \alpha_2 S + \beta_2) \cdots (S^2 + \alpha_k S + \beta_k)(S + \delta) = 0. \quad \beta_1 > 0. \quad (3)$$

The algebraic expansion of (3) yields the characteristic equation of a servo system at a critical gain whose frequency of sustained oscillation is $\sqrt{\beta_1}/2\pi$.

Example: To illustrate what has been developed, let us take the following determinental equation, and find the K necessary to cause sustained oscillations:

$$S^4 + 255S^3 + 18{,}350S^2 + 285{,}000S + K = 0. \quad (4)^1$$

From (3), the factors of (4) can be written so:

$$(S^2 + \beta_1)(S^2 + \alpha_2 S + \beta_2) = 0 \quad \beta_1 > 0. \quad (5)$$

whose algebraic expansion is

$$S^4 + \alpha_2 S^3 + (\beta_1 + \beta_2)S^2 + \alpha_2\beta_1 S + \beta_1\beta_2 = 0. \quad (6)$$

Expression (6) is then the characteristic equation of any system, at a critical gain, having a fourth-degree determinental equation. We may now equate coefficients of like powers of S in (4) and (6) to obtain the following simple set of simultaneous equations:

$$\alpha_2 = 255 \qquad \alpha_2\beta_1 = 285{,}000$$
$$\beta_1 + \beta_2 = 18{,}350 \qquad \beta_1\beta_2 = K. \quad (7$$

The critical system gain is then 193,000, an the frequency of sustained oscillation is 5.3 cps. This method may also be applied if i is desirable to find the critical value of som variable system component that woul cause sustained oscillations.

ARTHUR SCHLAN
305 Linden Blvd
Brooklyn, N. Y

* Received by the Institute, November 10, 1950.

[1] G. S. Brown and D. P. Campbell, "Principles of Servo-Mechanisms," John Wiley and Sons, Inc., New York, N. Y., page 377, problem 4; 1949.

Telepathic Communication*

A discussion of the possibility of tele pathic communication[1] in other publica tions,[2] more recent speculation in your page regarding remote control of mechanism through reception and amplification o "brain waves,"[3] and "comments on 'psychical physics'"[4] raise the intriguing questio among those trained in the physical science as to the possible mechanisms by which such communication could take place. In this connection the writer suggests that the following lines (written in November, 1949) are appropriate considerations at this point.

Without attempting to question the validity of the data which Rhine and others have interpreted as demonstration of telepathic communication, it can be stated that such communication, if it does take place, must involve a transfer of energy, since energy in some form is required to activate the brain cells.

All methods of transmitting intelligence presently known involve some sort of wave motion, either in a physical medium or as electromagnetic radiation. Since a most noteworthy feature of all cases of reported telepathic communication is the absence of any effect of distance or physical barriers, the first category must be rejected. The electromagnetic spectrum, on the other hand, has been reasonably well explored from less than one cycle to at least 10^{19} cycles per second with no reported cases of telepathic "interference." However, if electromagnetic radiation, and not some hitherto unknown means of energy transfer is to be postulated as the mechanism for telepathy, it should be sought in the extreme hyperfrequency range, as the following considerations will show.

It is well known in the communications field that the rate of transmission of intelligence in a uniform noise space is directly proportional to the bandwidth. Shannon[5]

* Received by the Institute, October 2, 1950.

[1] M. Goldsmith, "The 112th annual meeting of the British Association for the Advancement of Science," *Science*, p. 523; November 18, 1949.

[2] J. Rhine, "New Frontiers of the Mind," Farrar and Rinehart, New York, N. Y.; 1937.

[3] Editorial, "Growth and Amplification," by H. Busignies, PROC. I.R.E., vol. 38, p. 979; September, 1950.

[4] Correspondence, "Comment on 'psychical physics,'" by T. Powell, PROC. I.R.E., vol. 38, p. 1097; September, 1950.

[5] C. E. Shannon, "Communication in the presence of noise," PROC. I R E., vol. 37, pp. 10–22; January, 1949.

Correspondence

as shown that this rate C equals $W \log_2 (P+N)/N$ where W is the bandwidth and P and N transmitter and noise power, respectively. Telegraphic information, for example, may be transmitted with a bandwidth of 100 cycles or less; voice transmission requires 2,000 or so; while visual (video) information requires 6×10^6 cycles per second. Each successive increase in bandwidth permits more information to be transmitted in unit time. Each also requires a higher center frequency in order that a number of simultaneous transmissions may be carried on without interference.

Consider, then, how much more rapidly information could be transmitted by telepathic than by aural or visual means. It is within all our experience that an almost infinitely large number of impressions can occur during a dream, which may require only a fraction of a second for completion. A bandwidth 10^3 times that required for video transmission would not be an unreasonable assumption for telepathy. If, say, a 10^{10} cycle bandwidth is required for a single telepathic transmission it would cover the entire range from subsonics to the experimental radar hyperfrequencies. If now we further allow each person on earth a separate band of 10^{10} cycles for his thought transmission, we must push the upper end of the telepathy frequency spectrum to 10^{19} cycles, even if we used all the lower explored frequencies. More logically, we should start with 10^{19} cycles and continue up to 10^{29}.

If we couple with this suggestion of angstrom unit wavelengths the brain's power dissipation of about 1 watt, and consider that the power output is on the same order of magnitude, it is interesting to ponder on the nature of a radiation system which may direct such energies over many miles of space. Such a radiator could certainly be of molecular dimensions. In attempting such calculations, considerations of absorption alone almost certainly lead to the conclusion that we must hypothesize an entirely new means of energy transmission or abandon the idea of telepathy altogether. Before taking such a step, however, it would certainly be worthwhile to simultaneously investigate an active human brain by electroencephalographic and by sensitive ultrashort-wavelength detection means.

ROBERT J. BIBBERO
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Buffalo, N. Y.

Approximate Theory of the Directional Coupler*

In a note in this journal[1] it was shown to be possible to use Fourier transforms in the theory of inhomogeneous transmission lines. This application of Fourier transforms has been more thoroughly examined in a thesis[2] in which it is shown that a law of nature equivalent to the uncertainty relation of Heisenberg governs the problem of broad banding. Thus it is possible to find the mechanical dimensions of smooth transmission lines replacing arbitrary line discontinuities, such as line transformers, transitions, and the like, which will give small reflections in a broad frequency band. Both continuous inhomogeneous lines (Fourier integrals) and step lines (Fourier series) have been studied in the thesis.

Using the same treatment and considering coupling instead of reflection in the original theory it now appears to be possible to propose an approximate theory of the directional coupler. A simple theory of its operation has earlier been presented by Mumford,[3] who shows that an ordinary directional coupler consisting of two elements may be broad-banded by introducing a number of additional elements equally spaced with coupling factors proportional to the coefficients of the binomial expansion. The calculation is equivalent to that carried out in the thesis when dimensioning a step line with binomial distribution of the point reflections. Following the thesis it is also possible, for instance, to construct a directional coupler which optimizes the relationship between pass-bandwidth and the pass-band level of the reversed wave I_{rev} in the coupled line using the Tchebyscheff polynomials. In Fig. 1 is shown the variation of the coupling factor along the length of the lines and the I_{rev}/I_{max} pattern for an 8-element directional coupler having an allowed amount of I_{rev}/I_{max} of 5 per cent in the pass band.

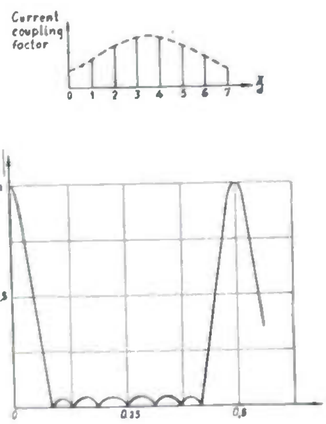

Fig. 1—Diagrams of a directional coupler which optimizes the relationship between pass-bandwidth and the allowed I_{rev}/I_{max} level in the pass band.

In the same way it is theoretically possible to dimension a continuous directional coupler having a variable continuous coupling along the length of the transmission lines and consisting of a slot of varying width. If the current coupled through the slot at the distance y is denoted by $I(y)$, one obtains for the reversed wave in the coupled transmission line

$$I_{rev} = \int_{-l/2}^{l/2} I(y)\cdot e^{-2j\beta y}dy,$$

where

l = the total length of the slot
$\beta = 2\pi/\lambda$
λ = the wavelength.

As there is no coupling at $y/l < -\frac{1}{2}$ or $y/l > \frac{1}{2}$, this integral may be assumed to be a Fourier integral. It is to be observed that the theory is approximate and the eight assumptions stated by Mumford are considered to be valid. The relation between the varying width of the slot and the $I(y)$ function must be obtained by means of calibration. To illustrate the application of this method, Fig. 2 shows the diagrams of two different slot directional couplers, the first with $I(y)$ constant (taper ratio $q=1.0$) and the second with $I(y)$ a Gaussian function ($q=0.01$). The diagrams in Fig. 2(a) are not drawn to scale.

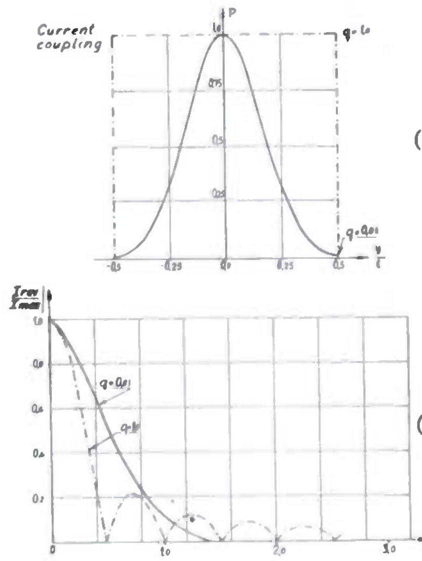

Fig. 2—Diagrams of directional couplers consisting of continuous slots.

Thus it is theoretically possible to construct broad-band directional couplers having prescribed I_{rev}/I_{max} patterns.

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* Received by the Institute, October 30, 1950.

[1] F. Bolinder, "Fourier transforms in the theory of inhomogeneous transmission lines," PROC. I.R.E., vol. 38, p. 1354; November, 1950.

[2] F. Bolinder, "Fourier transforms in the theory of inhomogeneous transmission lines," *Trans. Royal. Inst. Tech.* (Stockholm, Sweden); 1951.

[3] W. W. Mumford, "Directional couplers," PROC. I.R.E., vol. 35, pp. 160–165; February, 1947.

1951 IRE National Convention Program

WALDORF-ASTORIA HOTEL and GRAND CENTRAL PALACE—MARCH 19–22*

PROGRAM

Monday, March 19, 1951

9:00 A.M.–7:00 P.M.—Registration at Waldorf-Astoria Hotel.

11:00 A.M.–9:00 P.M.—Registration at Grand Central Palace.

11:00 A.M.–9:00 P.M.—Radio Engineering Show, Grand Central Palace.

10:30 A.M.–12:00 M.—**Annual Meeting.** Principal Address by Dr. James W. McRae, Bell Telephone Laboratories, Murray Hill, N. J., Jade Room, Waldorf-Astoria Hotel.

2:30 P.M.–5:00 P.M.—"Information Theory." "Television I—Color." "Antennas." "Power Tubes I—Theory." "Frequency Control and Generation." "Communication Systems."

6:30–8:30 P.M.—"Get-Together" **Cocktail Party**, Starlight Roof, Waldorf-Astoria Hotel.

Tuesday, March 20, 1951

9:00 A.M.–7:00 P.M.—Registration at Waldorf-Astoria Hotel.

9:30 A.M.–9:00 P.M.—Registration at Grand Central Palace.

9:30 A.M.–9:00 P.M.—Radio Engineering Show, Grand Central Palace.

10:00 A.M.–12:30 P.M.—Symposium: "Amplification of DC Signals." Symposium: "New Extensions of Network Theory." Symposium: "Panel Discussion on Tube Reliability." "Power Tubes II—Development." "Propagation." Symposium: "Broadcast Transmission Systems."

12:45 P.M.—**President's Luncheon**, honoring President-Elect Coggeshall, Grand Ballroom, Waldorf-Astoria Hotel.

2:30 P.M.–5:00 P.M.—Symposium: "Panel Discussion on Performance of DC Amplifiers." Symposium: "Matching Schools and Industry." "Circuits I—Synthesis and Analysis." "Electron Tubes I—Tubes Employing Electron Beams." "Microwaves I—Waveguides A." Symposium: "Panel Discussion on the Empire State Story."

8:00 P.M.–10:30 P.M.—Symposium: "Recent Advances in Color Television."

Wednesday, March 21, 1951

9:00 A.M.–7:00 P.M.—Registration at Waldorf-Astoria Hotel.

9:30 A.M.–6:00 P.M.—Registration at Grand Central Palace.

9:30 A.M.–6:00 P.M.—Radio Engineering Show, Grand Central Palace

10:00 A.M.–12:30 P.M.—Symposium: "Industrial Instrumentation." "Computers I." "Circuits II—Filters." "Electron Tubes II—Special Tubes and Techniques." "Microwaves II—Waveguides B." Symposium: "Some Systems Problems of Air Traffic Control."

2:30 P.M.–5:00 P.M.—"Electronic Instrumentation." "Computers II." "Circuits III—General." "Broadcast and TV Receivers." "Microwaves III—Antennas and Artificial Dielectrics A." "Radar and Navigation."

6:45 P.M.—**Annual IRE Banquet** (dress optional), Grand Ballroom, Waldorf-Astoria Hotel.

Thursday, March 22, 1951

9:00 A.M.–2:30 P.M.—Registration at Waldorf-Astoria Hotel.

9:30 A.M.–9:00 P.M.—Registration at Grand Central Palace.

9:30 A.M.–9:00 P.M.—Radio Engineering Show, Grand Central Palace.

10:00 A.M.–12:30 P.M.—"Nuclear Science." "Television II." "Circuits IV—Amplifiers." Symposium: "Telemetering Systems." "Microwaves IV—Antennas and Artificial Dielectrics B." "Audio."

2:30 P.M.–5:00 P.M.—Symposium: "Nuclear Reactors." "Television III—Receivers." "Circuits V—Oscillators." Symposium: "Simulation as an Aid to Design of Remote Control Systems." "Microwaves V—Generators and Amplifiers." Symposium: "Loudspeakers."

* One technical session will be held each morning and afternoon in the Belmont-Plaza Hotel Moderne Room, 49 Street and Lexington Avenue, New York, N. Y.

IRE Committee and Professional Group Meetings

Antennas and Propagation Group: *Chairman*, Newbern Smith; Tuesday, March 20, 8:30 A.M.–10:00 A.M., Maroon Room, Grand Central Palace.

Audio Group: *Chairman*, Leo L. Beranek; Thursday, March 22, 8:30 A.M.–10:00 A.M., Blue Room, Grand Central Palace.

Broadcast Transmission Systems Group: *Chairman*, Lewis Winner; Tuesday, March 20, 9:30 A.M.–10:00 A.M., Blue Room, Grand Central Palace.

Circuit Theory Group: *Chairman*, J. G. Brainerd; Tuesday, March 20, 8:30 A.M.–10:00 A.M., Grand Ballroom, Waldorf-Astoria Hotel.

Instrumentation Group: *Chairman*, Ernst Weber; Tuesday, March 20, 8:30 A.M.–10:00 A.M., Moderne Room, Belmont Plaza.

Nuclear Science Group: *Chairman*, M. M. Hubbard; Thursday, March 22, 8:30 A.M.–10:00 A.M., Moderne Room, Belmont Plaza.

Professional Groups Committee: *Chairman*, W. R. G. Baker; Wednesday, March 21, 8:30 A.M.–10:00 A.M., Jade Room, Waldorf-Astoria Hotel.

Quality Control Group: *Chairman*, R. F. Rollman; Tuesday, March 20, 8:30 A.M.–10:00 A.M., Astor Gallery, Waldorf-Astoria Hotel.

Radio Telemetry and Remote Control Group: *Chairman*, W. J. Mayo-Wells; Thursday, March 22, 8:30 A.M.–10:00 A.M., Jade Room, Waldorf-Astoria Hotel.

Vehicular Communications Group: *Chairman*, Austin Bailey; Thursday, March 22, 8:30 A.M.–10:00 A.M., Maroon Room, Grand Central Palace.

Sections Committee: *Chairman*, J. F. Jordan; Tuesday, March 20, 5:00 P.M.–7:00 P.M., Jade Room, Waldorf-Astoria Hotel.

Standards Committee: *Chairman*, J. G. Brainerd; Thursday, March 22, 8:30 A.M.–10:00 A.M., Jade Room, Waldorf-Astoria Hotel.

Women's Program

Monday, March 19, 1951

Registration in East Foyer, Waldorf-Astoria Hotel.

2:30 P.M.–4:30 P.M.—Party in the Jansen Suite, Waldorf-Astoria Hotel, Refreshments, "Prizes with Surprises."

Tuesday, March 20, 1951

9:30 A.M.–4:00 P.M.—Guided Tour of Downtown New York, including Television Program, DuMont Studios, Wanamaker's Department Store (Johnny Olsen's Rumpus Room), Broadway between 8th and 10th Streets, with Lunch at Wanamaker's (including transportation).

Wednesday, March 21, 1951

10:30 A.M.–11:30 A.M.—Tour "Behind the Scenes" of Waldorf-Astoria Hotel.

1:00 P.M.–2:15 P.M.—Luncheon and Fashion Show, Sert Room, Waldorf-Astoria Hotel.

2:30 P.M.—Matinee (choice): "Affairs of State" or "Season in the Sun."

Thursday, March 22, 1951

10:00 A.M.–12:00 M.—**Women's Forum**, Jansen Suite, Waldorf-Astoria Hotel. Free to women registered at the convention. *An innovation*—Patterned after engineers' technical sessions, but with speakers whom nontechnical women want to hear!

SPEAKERS

MISS NADINE MILLER, Director of Press and Public Relations of C. E. Hooper, Inc., measurers of the size and reaction of the radio and TV audiences. Her topic: "What Is Your Hooperating?" is the question which haunts the radio stars. She speaks from wide acquaintance with the celebrities and a wealth of experience on the platform.

MISS BEATRICE A. HICKS, a graduate engineer, a member of the Institute, President of the Society of Women Engineers, and executive of Newark Controls. She is admirably equipped to speak on the subject: "Why Women Become Engineers," and to appraise the status of a profound educational change which ultimately may affect IRE.

MRS. DOUGLAS HORTON, the former Captain Mildred McAfee, USNR, organizer and wartime commander of the U. S. Navy WAVES, and the first woman to serve on the Board of Directors of the National Broadcasting Company. Her experience and attainments qualify her to speak authoritatively of women in industry and the armed forces and services, and their position under conditions of national emergency.

SUMMARIES OF TECHNICAL PAPERS

Information Theory

C. E. Shannon, *Chairman*
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

1. A STORAGE TUBE AS AN AMPLITUDE DISTRIBUTION ANALYZER

R. E. Nienburg and T. F. Rogers
(Air Force Cambridge Research Laboratories, Cambridge, Mass.)

The increased interest in the statistical approach to information transmission theory has encouraged investigators to search for a technique that will yield statistical distributions of various complex signals in the presence of noise. Until now, devices that measure the amplitude distribution of a signal have required a very large number of sampling operations and consequently have been expensive in terms of measurement time. By utilizing the "memory" capabilities of a storage tube, it is possible to realize the amplitude distribution of any function that is a stationary time series, in the form of a continuous curve on an oscilloscope; the process is dynamic and practically instantaneous.

2. CROSS-CORRELATION AND THE OPTIMUM SIGNAL-TO-NOISE RATIO FOR PERIODIC SYSTEMS

M. Leifer and N. Marchand
(Sylvania Electric Products Inc., Flushing, L. I., N. Y.)

The method of North and of Van Vleck and Middleton for achieving the maximum signal-to-noise ratio by filtering is reviewed. For reference, a continuous-wave unmodulated system is used where the receiver noise bandwidth and the signal power at the receiver input are given. After a discussion of the informational aspects of the situation, it is shown how the statistical approach, employing cross-correlation functions achieves the optimum signal-to-noise ratio. The interference rejection properties of a cross-correlation receiver are discussed.

3. DETECTION OF REPETITIVE SIGNALS IN NOISE BY CORRELATION

Y. W. Lee and L. G. Kraft
(Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass.)

The theory of wave-form detection by cross correlation is given. It is shown that a limiting case of cross correlation is equivalent to the method of "integration." Experimental results obtained from the MIT electronic correlator show signal-to-noise ratio improvements of 40 db (from −20 db to +20 db). A comparison of radar A-scope pictures completely masked by noise and clear cross-correlated presentations is made. The theory of detection by correlation is considered with respect to filtering by conventional methods. The paper includes the theory and technique of detection of multiple repetitive signals in random noise.

4. ERROR REDUCTION IN THE DETERMINATION OF ELECTRONIC SYSTEM PARAMETERS

L. S. Schwartz
(Hazeltine Electronics Corporation, Little Neck, L. I., N. Y.)

In electronic system studies it may be necessary to make a satisfactory estimate of the most probable value of a time-varying parameter. Difficulty may be faced in meeting this requirement if the estimate must be made in limited time. If the time-varying parameter does not strictly constitute a stationary random process, the difficulty may be only partly overcome no matter how large the number of measuring equipments. The reason that the difficulty is only partly overcome is examined and quantitative relations between observed and correlated errors are derived for the case of the arithmetic mean.

5. CODING PROCESSES FOR BANDWIDTH REDUCTION IN PICTURE TRANSMISSION

A. E. Laemmel
(Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

Many pictures have special properties which allow the use of coding processes for the purpose of saving either channel bandwidth or time of transmission. For example, a weather map consists of a network of black lines on a white background, the black area being considerably less than the white. Modern communication theory allows a calculation of just how much saving an ideal coding scheme can achieve when such restrictions are placed on the complexity of the picture. Several coding methods will be discussed and compared to the ideal. Block diagrams of the apparatus required will also be given.

Annual Meeting

Monday, March 19
Jade Room, Waldorf-Astoria Hotel
10:30 A.M.

This opening meeting of the convention is for the entire membership. The meeting will feature as the principal speaker Dr. James W. McRae, Bell Telephone Laboratories, Murray Hill, N. J.

Television I—Color

T. T. Goldsmith, *Chairman*
(Allan B. DuMont Laboratories, Inc., Passaic, N. J.)

6. COLORIMETRY IN TELEVISION

F. J. Bingley
(Philco Corporation, Philadelphia, Pa.)

The paper describes those phases of the science of colorimetry that are particularly applicable to color television systems. The influence of receiver primaries on the gamut of reproduced colors is discussed, and the channel voltage demands at various parts of the chromaticity diagram are deduced. The choice of transmitter spectral response characteristics for over-all fidelity of reproduction is described. Some interesting new graphical and geometrical methods of analysis are shown. The philosophies of packaging of color information for transmission are considered, and some new methods disclosed.

7. SUBJECTIVE SHARPNESS OF ADDITIVE COLOR PICTURES

M. W. Baldwin, Jr.
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

This is a report on the first numerical results to come from a laboratory experiment on the subjective sharpness of additive three-color pictures. The sharpness factor is isolated by using out-of-focus projection (of lantern slides) instead of actual television transmission.

An observer's acuity for defocus is greatest for the green component and least for the blue component, in an additive three-color picture. When the same picture is reproduced in monochrome (white, red, green, or blue) at the same brightness, his acuity for defocus is equal to that found for the green component.

8. COLOR MULTIPLEXING BY SINE-WAVE FUNCTIONS

Nathan Marchand
(Sylvania Electric Products Inc., Bayside, L. I., N. Y.)

Multiplexing of the three color signals necessary for color television is accomplished using sine waves at the sampling frequency for each color. By phase shifting each sine wave and combining it with a dc term, three orthogonal functions are obtained. Each of these is modulated by a color signal. They are then combined and transmitted. The transmitted signal is the exact equivalent of pulse sampling. At the receiver, mixing the received signal with one of the sine-wave orthogonal functions will separate out the desired color signal.

Note

No papers are available in preprint or reprint form nor is there any assurance that any of them will be published in the Proceedings of the I.R.E., although it is hoped that many of them will appear in these pages in subsequent issues.

9. MEASUREMENT AND CONTROL OF COLOR CHARACTERISTICS OF FLYING SPOT COLOR SIGNAL GENERATOR

R. Moore, J. Fisher, and J. Chatten
(Philco Corporation, Philadelphia, Pa.)

The color fidelity of the Flying Spot Generator is affected by the spectral output of the cathode-ray-tube light source, the reflectance characteristics of the dichroic mirrors, and the spectral response of the three photomultiplier tubes. A measurement technique to evaluate the color fidelity of the generator will be described in this paper. This consists of a motor-driven light chopper placed between the light source and the slide holder, and the use of narrow-band interference filters having a known spectral transmission and bandwidth also placed in the optical path. Readings of red, green, and blue photomultiplier-tube outputs are taken for each interference filter used by means of a narrow-band electrical filter. From these data the performance of the color generator may be calculated, and trim filters with electrical matrix networks may be added so the taking characteristics will be the desired primary curves.

10. PERFORMANCE OF CARRIER SYNCHRONIZING CIRCUITS FOR COLOR TELEVISION RECEIVERS

E. M. Creamer, Jr., and M. I. Burgett
(Philco Corporation, Philadelphia, Pa.)

Dot-sequential color television pictures require the satisfactory reception of phase reference information concerning the color carrier. Certain aspects of transmitter operation and receiver tuner and intermediate-frequency amplifier design contribute significantly to successful determination of this phase reference. Results of objective and limited subjective tests show the effect of random and impulse noise on the operation of several carrier abstraction circuits and the resultant color picture. Color carrier static phase shift limits for various signal-to-noise ratios are determined by observed picture degradation. Benefits from pick-off noise protection and time gating in achieving ultimate circuit performance are indicated.

11. A SIMPLE PATTERN GENERATOR FOR COLOR TELEVISION SIGNALS

R. P. Burr, W. R. Stone, and R. O. Noyer
(Hazeltine Electronics Corporation, Little Neck, L. I., N. Y.)

The current interest in color television systems has, among other things, produced the need for a simple means of generating color television signals. In the early stages of the present monochrome television system, complete camera chains were soon discarded in favor of the simpler and more reliable monoscope pattern generator as a general laboratory and test line video-signal source.

The purpose of this paper is to describe a simple source of color television signals which may be added to an existing television installation with a minimum of effort. Satisfactory performance may be obtained for either simultaneous and dot-sequential systems employing current monochrome standards or the recently standardized field-sequential system.

Antennas

P. Carter, *Chairman*
(RCA Laboratories Division, Princeton, N. J.)

12. THE DESIGN AND USE OF THE AUTOMATIC ANTENNA PATTERN RECORDER

J. W. Tiley
(Philco Corporation, Philadelphia, Pa.)

The general problem of microwave antenna pattern recording is discussed. Particulars of a recently built automatic pattern recorder, using a commercially available servo amplifier, a logarithmic attenuator of novel design, plotting on "standard" antenna pattern paper with speeds of 180° in two minutes, and with angular errors not greater than a tenth of a degree are given. The philosophy of the circuit design is discussed.

The major sources of error in a pattern measurement set-up are given and the practical findings of the author in tests involving several years of time and covering many of the usual types of antennas are discussed.

13. STAGGER-TUNED LOOP ANTENNAS FOR WIDE-BAND LOW-FREQUENCY RECEPTION

D. K. Cheng and R. A. Galbraith
(Syracuse University, Syracuse, N. Y.)

This paper describes a system of stagger-tuned high-Q loop antennas designed for 100-kc loran pulse reception. The individual loop-antenna outputs are first added in a summing amplifier. Two methods, one analytical and one graphical, of determining the resultant response of the summing amplifier with stagger-tuned input channels are developed. Based upon the theoretical analysis, an experimental antenna array is then designed, which confirms its capability of achieving a wide bandwidth with small dimensions. The possibility of obtaining an array having omnidirectional reception properties is discussed and a squaring scheme of accomplishing this is also described.

14. THEORY OF THE CONCENTRIC-SLOT ANTENNA

T. Morita
(Harvard University, Cambridge, Mass.)

The object of this investigation is the study of the far-zone electromagnetic field produced by a concentric-slot antenna. The concentric-slot antenna consists of two concentric circular gaps made in an infinitely conducting plane. The inner slot is driven while the outer slot is a parasite tuned by a short-circuiting plunger. Expressions are obtained for the self- and mutual admittance of the slots. From these results the ratio and phase difference of the electric field in the two apertures are obtained as functions of the tuning of the parasitic slot. The field pattern is then calculated by the classical Kirchhoff approximation. Experimentally determined patterns are presented to verify the theory.

15. OPTIMUM CURRENT DISTRIBUTIONS FOR ANTENNA ARRAYS WITH CIRCULAR SYMMETRY

Raymond H. DuHamel
(University of Illinois, Urbana, Ill.)

A procedure is developed for determining a continuous circular current distribution which will produce an optimum field pattern in the sense that for a given side-lobe level the beam width is minimum. The optimum patterns are derived from Tchebyscheff polynomials in a manner similar to that used by Dolph and Riblet for a broadside array. A method for determining the minimum number of radiators to approximate the continuous current distribution to a prescribed accuracy is given. The procedure is also applied to a circular array of antennas around a cylinder and to other arrays with circular symmetry.

16. DIRECTIONAL ANTENNA ARRAYS OF ELEMENTS CIRCULARLY DISPOSED ABOUT A CYLINDRICAL REFLECTOR

R. F. Harrington
(Ohio State University, Columbus, Ohio)
W. R. LePage
(Syracuse University, Syracuse, N. Y.)

An antenna system with controllable directional properties can be obtained by disposing a system of properly phased current elements about a circular conducting cylinder. A general analysis is given, leading to formulas for the field patterns of such an array. The analysis is applicable to any distribution of amplitude and phase of the current elements, but the beam-co-phasal case is emphasized. The solution is obtained by summing the known pattern function for a single element with reflector, over all the elements of the array.

Power Tubes I—Theory

E. L. Chaffee, *Chairman*
(Harvard University, Cambridge, Mass.)

17. CALCULATIONS FOR CLASS-C AMPLIFIERS WITH A REACTIVE LOAD

D. A. Cawood
(Sylvania Electric Products Inc., Flushing, L. I., N. Y.)

The object of this paper is to present a graphical-analytical method for the design of class-C amplifiers in circuits with a complex plate load impedance. The necessity of plotting elliptical operating paths in the trial-and-error procedure is eliminated. Simple formulas give the required elliptical parameters and the angles of grid and plate current flow. It is assumed that the constant plate-current characteristics are a family of parallel straight lines over the region of operation.

18. THE EFFECT OF SECONDARY EMISSION IN POWER TUBES

Hsiung Hsu
(General Electric Company, Owensboro, Ky.)

Methods have been developed to deter-iine the secondary currents by utilizing the g-log chart reported by Chaffee. The fect of the secondary currents on the in-anteous power dissipations and on the perating condition of power amplifiers as been analyzed.

The space-charge limitation of the sec-ndary current has been found to be of iuch greater significance than the effect of ie initial velocities of the secondary elec-ons. The observations give a satisfactory xplanation of the discrepancy in the earlier nalysis of the space-current distribution iade de La Sabloniere and Hamaker.

9. REFLEX RESNATRON OPERATION AND ITS IMPLICATION FOR BANDWIDTH

M. Garbuny and G. E. Sheppard
(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

The action of the reflex resnatron in-roduced in the accompanying abstract is xplained and quantitatively described in erms of transit-time phenomena of the re-ected electron bunches. In particular, late modulation results from deviations rom the resonance condition for the transit imes. The repeated interaction of the elec-ron beam with the cavity field permits the ombination of the high efficiencies of esnatron operation with low shunt resist-inces and allows, therefore, wide band-vidth. Experimental evidence for the heoretically expected bandwidth and effi-iency behavior at varying reflex conditions s presented, performance data are compared vith conventional resnatron operation, and mproved utilization of the principles in-volved is discussed.

20. THE MULTIBEAM ELECTRON COUPLER—AN IMPROVED SPIRAL-BEAM ELECTRON TUBE FOR THE MODULATION AND CONTROL OF POWER AT UHF

C. L. Cuccia
(RCA Laboratories Division, Princeton, N. J.)

The electron coupler is a spiral-beam tube utilizing new principles for the control and modulation of power at ultra-high frequencies. It is placed between the generator and the load and acts as a unilateral control impedance—simulating very closely the control properties of vacuum tubes at low frequencies with the exception of the fact that it does not amplify. The electron couplers to be discussed are 1-kw tubes of improved cavity design in the 800-Mc range utilizing several electron beams, in which new methods of modulation have been incorporated resulting in good linearity characteristics, bandwidth in excess of 5 Mc, and requiring control voltages of less than 50-volts swing to control the power into the output over a range of 98 per cent of maximum.

21. A NEW SINGLE-CAVITY RESONATOR FOR A MULTIANODE MAGNETRON

J. S. Needle, G. Hok, G. R. Brewer, and H. W. Welch
(University of Michigan, Ann Arbor, Mich.)

A new magnetron which operates as a symmetrically driven coaxial-line oscillator is described. Design equations for this structure have been developed and several tubes have been constructed for operation at 14 cm. Performance data from one of these tubes are included, showing operation in the desired mode with continuous-wave output of 150 watts. The feasibility of wide-range tuning appears to make this magnetron unique, although emphasis to date has been directed toward the development of a non-tunable magnetron. A tunable magnetron of this basic design is now in the early stage of development.

Frequency Control and Generation

W. H. Doherty, *Chairman*
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

22. THE GENERATION OF SINGLE-SIDEBAND SUPPRESSED-CARRIER SIGNALS BY A NEW BALANCING METHOD

H. M. Swarm
(University of Washington, Seattle, Wash.)

Single-sideband suppressed-carrier signals have been obtained by combining the outputs of two AM modulators and a carrier-cancellation amplifier. Both the carrier and modulating signals applied to the two modulators differ in phase by 90°. The carrier is thus cancelled after modulation and without the use of balanced modulators.

Fewer adjustments are required for this method than in other conventional methods. The sideband cancelling adjustments are practically independent of the carrier-cancelling adjustments, thus making the desired over-all operation easier to maintain.

An automatic carrier suppression circuit may be incorporated to maintain the carrier below a prescribed level.

23. PRECISION FREQUENCY GENERATORS USING SINGLE-SIDEBAND SUPPRESSED-CARRIER MODULATORS

H. R. Holloway and H. C. Harris
(Sylvania Electric Products Inc., Bayside, L. I., N. Y.)

Often the need arises to develop a signal whose frequency does not bear a direct harmonic relation to a given frequency standard or to that of another signal source. The necessity also arises for a means to continuously shift the phase of a given signal any amount with respect to a comparison signal. Since the single-sideband suppressed-carrier modulator is a useful device for the generation of the sum or difference of two frequencies, this paper presents an analysis and design criteria for an electronic single-sideband suppressed-carrier modulator, and an electromechanical design which meets the need for both a single-sideband suppressed-carrier modulator and a continuously variable phase shifter.

24. STABILIZED VARIABLE FREQUENCY TRANSMITTER EXCITER FOR MILITARY HF EQUIPMENT

John Bush
(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

The design of a tunable transmitter exciter is presented for use with or as part of high-frequency transmitters. The need for crystals for each assigned frequency of operation is eliminated without the attendant complexity and difficulties of heterodyne mixer, synthesizer, IGO, and other known systems.

The exciter covers a tuning range of 1 to 32 Mc and provides a choice of on-off telegraph (A-1); frequency shift teletype (F-1); phase-modulation telephony (F-3); or dc frequency shift facsimile or radiophoto (F-4) emission.

Automatic-frequency-control techniques utilizing a novel modulation cancellation method permit stabilization of output frequency at all points in the modulation cycle.

25. WIDE-RANGE DIRECT-READING PRECISION FREQUENCY METER AND SIGNAL SOURCE

B. Parzen
(Federal Telecommunication Laboratories, Inc., Nutley, N. J.)

This paper describes a compact instrument for rapid and precise frequency measurements between 50 cps and 1,000 Mc. It consists of a signal source capable of being set to any frequency between 0 to 30 Mc, two beat detectors for comparing the unknown frequency with the frequency of the signal source, and the necessary power supplies for mains operation. The 2-volt output of the signal source is also available as a jack for use as a precision frequency generator.

The frequency of the signal generator is directly indicated on 8 dials arranged on a decade basis. The desired frequency is obtained by merely setting the dials by means of the associated knobs in a manner strictly analogous to setting up a desired resistance on an 8-place decade resistance box. The frequency is dependent only on a single 100-kc crystal and a 10-kc range interpolation oscillator. An over-all accuracy of better than 1 part in a million plus 3 cps is obtained.

26. CRYSTAL CONTROL OF A 4-KW, 1,036-MC TRANSMITTER

J. W. Clark, R. W. Kane, W. G. Abraham, N. P. Hiestand, and S. F. Varian
(Varian Associates, San Carlos, Calif.)

This talk will describe a transmitter which was designed and built by Varian Associates for Central Radio Propagation Laboratory in connection with their study of the propagation characteristics of micro-

wave radiation. The transmitter radiates a continuous power of 4-kw at 1,036.8 Mc with a frequency stability of one part in 10^7. Ninety-nine per cent of this energy is contained within a band 20 cycles wide. The output tube in the transmitter is a Varian Associates X-25 klystron, a three-cavity amplifier tube. This tube is driven by a frequency multiplier chain which in turn is excited by a General Radio 100-kc frequency standard. The layout of the transmitter will be described and the design of the klystron tube will be discussed in detail.

27. FREQUENCY STABILIZATION SYSTEM FOR MEASUREMENT OF MICROWAVE REFRACTION OF GASES

W. F. Gabriel
(Naval Research Laboratory, Washington, D. C.)

The method is based upon a double-loop frequency-stabilized klystron oscillator system in which a high-Q resonant cavity (into which the gases are introduced) is the controlling element. One frequency control loop is a fast-acting all-electronic servo which corrects the oscillator against rapid fluctuations from the cavity resonance frequency. The other frequency control loop is a slow-acting motor servo which integrates out the small, steady-state frequency error left by the electronic loop. Frequency control to better than one part in 10^8 has been obtained and used in making accurate index of refraction measurements.

Communication Systems

A. G. Clavier, *Chairman*
(Federal Telecommunications Laboratories, Inc., Nutley, N. J.)

28. AM—FM ANALOGY

H. C. Harris
(Sylvania Electric Products Inc., Bayside, L. I., N. Y.)

In order to simplify some types of frequency-modulation calculations, this paper presents the "amplitude equivalent" of a FM wave. This concept is applied to the calculation of spectral distribution and to the solution of the network response to FM signals. Both aperiodic and periodic signals are considered and special emphasis is placed upon the steady-state analysis of periodic FM systems. The "amplitude equivalent" is found to be most helpful when the modulation of the signal is characterized by rectangular shapes. In these cases the method outlined is exact; however, in general, the method is approximate to any desired accuracy.

29. SURVEY OF ELECTRONIC COMMUTATION METHODS

Robert S. Butts
(Melpar, Inc., Alexandria, Va.)

Several time-division systems of multichannel radio communication and telemetering have been described in recent papers. In this paper, a comparative analysis is made of several methods of electronic commutation of the signal sources. The analysis is intended to provide a summary of methods to aid the system designer in selecting the most applicable method for a particular system. The analysis includes such factors as speed, sensitivity, cross talk, input power, size, and reliability. Methods included are: thyratron and multivibrator rings, binary-counter-driven matrices, delay lines, polyphase transformers, Scott "T" transformers, and rotary beam tubes.

30. HIGH-FREQUENCY RADIO COMMUNICATION SYSTEM UTILIZING PHASE-MODULATION TRANSMISSION AND SINGLE-SIDEBAND RECEPTION

H. F. Meyer and H. Y. Littlefield
(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

A high-frequency radio system is described wherein a conventional continuous-wave transmitter is phase modulated and single-sideband reception is accomplished by detection of the first-order sideband components of the transmitted signals. Multichannel frequency-division telegraph signals were transmitted over the system and tests were made to determine the optimum values of modulation index for four-, eight-, twelve-, and sixteen-channel operation. The system provides freedom from amplitude distortion produced by multipath transmission and offers the feature of frequency diversity without increased bandwidth.

Theoretical and experimental comparisons are made between this system and a system of single-sideband transmission and reception.

31. ECHO DISTORTION IN THE FM TRANSMISSION OF FREQUENCY-DIVISION MULTIPLEX

W. J. Albersheim and J. P. Schafer
(Bell Telephone Laboratories, Inc., Deal, N. J.)

The composite multiplex signals generated by frequency-division methods long standard in telephone communication can be transmitted by the new transcontinental broad-band FM radio relays. Signal intermodulation by echoes must be minimized. It is investigated in this paper experimentally and analytically.

Two types of echoes are considered:

(1) weak echoes with delays exceeding 0.1 microsecond, caused mainly by mismatched long lines, and
(2) powerful echoes with delays shorter than 0.01 microsecond, caused by multipath transmission and leading to selective fading. Using random noise signals, the distortion is evaluated as function of various parameters of the echo, the base band and the radio-frequency modulation.

32. MANAGEMENT ASPECTS OF ELECTRONIC SYSTEMS ENGINEERING

R. I. Cole
(Watson Laboratories, AMC, Red Bank, N. J.)

This paper cites that in the rapid growth of electronics engineering, management has not always appreciated the full magnitude of the "systems engineering" problem. In setting forth what alert management should attempt to accomplish, the systems engineering influence in research and development is discussed in some detail. In this regard particularly is it significant that more care must be given to the planning of features that make for simpler maintenance in large complicated systems. Installation problems are dealt with briefly and particular emphasis is given to the noise reduction problem within the systems in order that the best optimum *repeatable* results are obtained. Lastly, the engineering management phases are treated from the standpoint of management assuming greater responsibility to see that proper engineering emphasis is given to proper maintenance of installed systems.

SYMPOSIUM

Amplification of DC Signals

(Organized by Professional Group on Instrumentation)

I. G. Easton, *Chairman*
(General Radio Company, Cambridge, Mass.)

33. THE SERVOMODULATOR: A LOW-LEVEL DC INSTRUMENT

G. M. Attura
(Industrial Control Co., New York, N. Y.)

This paper describes a modification of the chopper-type modulator which has resulted in two commercial instruments for very low-level dc measurements. Their basic action is to convert the unknown dc voltage into an ac signal, whose value is then metered by an ac vacuum-tube voltmeter, or displayed on a cathode-ray oscilloscope.

To be acceptable as general-purpose laboratory instruments, the following features must be engineered into their design: internal noise level approaching the limiting thermal noise, gain stability with changes in amplifier gain and chopping cycle, some insensitivity to power line pickup in the input leads, and a high input resistance. The methods by which this is accomplished are described.

Due to the very low level of dc attainable, some precautions must be observed by the user: input circuit shielding, location away from strong magnetic fields, low noise power mains, and single ground system.

34. TRANSIENT RESPONSE OF SELF-SATURATING MAGNETIC AMPLIFIERS

E. J. Smith
(Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

There is no natural definition for "transient response" of a magnetic amplifier. From an applications point of view, the transient response of the cyclic average or rms load current, following a step change in control circuit voltage, is the most significant description of the transient behavior. An approximate analysis of the full-wave and double circuits, based upon "cyclic verage" units of current and flux, and applicable to transients of relatively long luration, is shown to give satisfactory results when compared with test data obtained with a brush recording oscillograph and a special electronic "cyclic integrating" levice. In particular, the important effects of ac voltage, and of load, rectifier, and control circuit resistances are brought out. As expected, the computed results are less accurate in the range of fast time response several cycles of the supply frequency), but are nevertheless useful, even in this range.

35. DIRECT-CURRENT AMPLIFIERS EMPLOYING MAGNETTORS

E. P. Felch, V. E. Legg, and F. G. Merrill
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

The behavior of magnetic modulators has been well known for many years. Their practical application for the amplification of low-level direct currents, however, has awaited the development of satisfactory techniques for reducing their noise level and improving their stability. As an outgrowth of wartime progress toward improved magnetometers for submarine detection from aircraft, a device called a magnettor has been produced which represents a significant improvement in these respects over previously available magnetic modulators. Direct current amplifiers have been build employing magnettors as dc to ac converters. These amplifiers exhibit low noise levels and high stability in the microvolt region and are linear over a range of greater than 50 db.

In this paper the design and operation of magnettors are discussed and a typical application is described.

36. SOME ASPECTS OF MAGNETIC AMPLIFIER TECHNIQUE

R. Willheim and F. E. Butcher
(Electro Methods, Ltd., London, England)

An evaluation of several aspects of magnetic amplifier design practice in Great Britain is presented. Items discussed include the use of *U* and *E* laminations, the calculation of performance from E-I charts, push-pull circuit arrangements, the calculation of time constants of single and two-stage amplifiers, and conditions for nonoscillatory behavior.

The author will describe performance aspects of specific circuit design, and will include a list of successful applications to instrumentation and control problems.

37. DRIFT COMPENSATION IN DC AMPLIFIERS FOR ANALOGUE COMPUTERS

W. E. Ingerson
(Bell Telephone Laboratories, Inc., Whippany, N. J.)

The use of dc rather than ac amplifiers in analogue computers has many advantages. The only serious disadvantage has been drift.

Rather than try to eliminate drift at the source, it is simpler to compensate for it. A method of drift compensation is described which substantially eliminates drift in a number of dc amplifiers simultaneously. This method consists of sampling the voltage at the first grid of the dc amplifier with a mechanical switch, amplifying the error signal in a pulse amplifier, and distributing an amplified compensating voltage to an appropriate point in the dc amplifier, so as to reduce the input grid voltage to zero.

SYMPOSIUM

New Extensions of Network Theory

(Organized by Professional Group on Circuit Theory)

W. H. Huggins, *Chairman*
(Air Force Research Laboratory, Cambridge, Mass.)

38. SIGNAL FLOW GRAPHS

S. J. Mason
(Massachusetts Institute of Technology, Cambridge, Mass.)

The functional relationships entering a linear or nonlinear analysis problem may be expressed in the form of a signal flow graph. The graph aids visualization of the character of a given set of equations and systematizes their solution. For linear problems the graph itself, as contrasted with the original equations, may be manipulated to obtain the desired solution.

In addition to its use in practical problems, the flow graph approach provides the base for a unified body of feedback theory In particular, the statements and proofs of a variety of feedback theorems become very simple and direct when carried out in the language of flow graphs.

39. SOME BIOLOGICAL APPLICATIONS OF RANDOM NETS

A. Rapoport
(Committee on Mathematical Biology, The University of Chicago, Chicago, Ill.)

A random net is defined as an aggregate of points connected by directed line segments where, in general, several lines may issue from each point, such that only the probabilities of specific connections are known. If all connections are equi-probable, the "connectivity" of a random net may be defined and computed. This is the probability that a "path" exists between an arbitrary pair of points. The concept of connectivity can be applied to neural nets (in the mathematical biology of learning phenomena); to epidemiology (in the mathematical theory of contagion) or its social analogue (the spread of rumors); to genetics (in the probabilistic theories of ancestral trees); and so forth.

40. SOME EFFECTS OF COMMUNICATION PATTERNS ON THE PERFORMANCE OF SMALL TASK-GROUPS

A. Bavelas
(Massachusetts Institute of Technology, Cambridge, Mass.)

Experiments have been made with groups of five persons who have a specific task to perform and are constrained to use certain channels of communication. The effects of different patterns on speed and accuracy of performance, and on leadership and morale are shown to be significant. An attempt is made to explain these results in terms of the probability that information present at one point will be at some other point at a specified time.

41. ELECTRIC NETWORK MODELS FOR PROBLEMS OF PROBABILITY

W. E. Bradley
(Philco Corporation, Philadelphia, Pa.)

It is shown that the equations of state transitions with constant mean probability (Markov Processes) are analogous to those describing certain electrical networks and that physical comprehension of such problems and their method of solution is sometimes facilitated by the use of such a model. Particularly useful are the methods of transient analysis commonly used in electric circuit theory for the prediction of future states of a Markov system when the initial state is known. As an example of the method, it is applied to the simple statistical problem of the probability distribution of the count of particles arriving with constant mean probability.

SYMPOSIUM

Panel Discussion on Tube Reliabilty

(Organized by Professional Group on Quality Control)

E. D. Cook, *Chairman*
(General Electric Company, Schenectady, N. Y.)

42. Representatives from industrial users, government services, and tube manufacturers will present their viewpoints in regard to this important subject.

Panel Members

a. M. A. Acheson (Sylvania Electric Products Inc., Kew Gardens, L. I., N. Y.)
b. C. R. Banks (Aeronautical Radio, Inc., Washington, D. C.)
c. R. J. Framme (Wright Field, Dayton, Ohio)
d. J. E. Gorham (Signal Corps Engineering Laboratories, Belmar, N. J.)
e. N. H. Green (Radio Corporation of America, Harrison, N. J.)
f. J. W. Greer (Bureau of Ships, Navy Department, Washington, D. C.)
g. F. D. Langstroth (Philco Corporation, Lansdale, Pa.)
h. H. E. May (Motorola, Inc., Chicago, Ill.)
i. R. E. Moe (General Electric Company, Owensboro, Ky.)
j. A. L. Samuel (International Business Machines, Poughkeepsie, N. Y.)

Power Tubes II—Development

I. E. Mouromtseff, *Chairman*
(Upsala College, East Orange, N. J.)

43. A COAXIAL POWER TRIODE FOR 50-KW OUTPUT UP TO 110 MC

R. H. Rheaume
(Machlett Laboratories, Inc., Springdale, Conn.)

Use of a novel tube assembling and vacuum sealing technique, a thoriated cathode, and a reentrant anode in an integral water jacket have made possible the development of a coaxial ring seal power triode giving 50-kw rf output up to 110 Mc. The frequency bandwidth obtainable with this tube is suitable for television transmission. Increased power output ratings are available for lower frequencies.

Design requirements are examined for optimum electrode geometry, minimum capacitance and inductance of electrode terminal leads with maximum rf current carrying capacity, high rates of heat dissipation, high rf conductivity of the vacuum seals, and other desiderata. Mechanical features are discussed, and the circuit performance of the tube is analyzed for various applications.

44. A HIGH-POWER TETRODE

Clayton E. Murdock
(Eitel McCullough, Inc., San Bruno, Calif.)

Described is a high-power tetrode of unique design particularly well adapted for television transmission in the vhf region up to 216 Mc. The tube uses a new unipotential, thoriated tungsten cathode which is heated by electron bombardment. The coaxial terminal arrangement of the tube is ideally suited for use in cavity circuits. Improvements in tetrode geometry and tube design for high power are described. The paper gives the general electrical characteristics and operating conditions for TV service.

45. THE REFLEX RESNATRON

Glenn E. Sheppard, M. Garbuny, and J. R. Hansen
(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

The design, construction, and performance of a new device known as a "reflex resnatron" is discussed. Structurally this device is a tetrode consisting of two opposed nosed-in cavities. The electrodes of the tube are so arranged that good electron beam focussing is obtained. The electron flow is axial with respect to the cavities. As an amplifier this device produces outputs in excess of a kilowatt at a frequency of 560 Mc. The bandwidth of this device is suitable for television. Modulation is obtained in a unique manner.

46. TRANSMITTING TUBE SUITABLE FOR UHF TELEVISION

Wayne G. Abraham, F. L. Salisbury and S. F. Varian
(Varian Associates, San Carlos, Calif.)
and
Marvin Chodorow
(Stanford University, Stanford, Calif.)

This talk will describe a newly developed sealed-off klystron amplifier tube suitable for use in the final amplifier stage of a uhf television transmitter. The tube is capable of a continuous power output of 5 kilowatts. It has a bandwidth of 6 Mc and a power gain of 200 times. The tube is conservatively designed; the service life expected is several thousand hours. The tube is so made that the entire cathode structure can be replaced in the event of a failure.

47. FREQUENCY-MODULATED HIGH-EFFICIENCY KLYSTRON TRANSMITTER

Marvin Chodorow and S. P. Fan
(Microwave Laboratory, Stanford University, Stanford, Calif.)

Theory and measurements of a 2-gap, single-cavity klystron intended for use in microwave relay links is described. This tube has most of the useful characteristics of a reflex klystron as a frequency-modulated oscillator, but has many advantages not possessed by the reflex tube. Multiple transit hysteresis, as well as other types, is entirely absent; the mode is much smoother than on reflex tubes; and the efficiencies and power obtainable are much greater. Frequency modulation is obtained by modulating the drift tube voltage which controls the transit time between the two gaps. A power of 18 watts has been obtained at 10 cm with an efficiency of about 22 per cent.

Propagation

A. E. Cullum, Jr., *Chairman*
(Consulting Radio Engineer, Dallas, Tex.)

48. SELECTIVE FADING OF MICROWAVES

A. B. Crawford and W. C. Jakes, Jr.
(Bell Telephone Laboratories, Inc., Holmdel, N. J.)

Observations of selective fading in a 450-Mc band centered at 3,950 Mc have been made as part of a study of microwave propagation over two line of sight paths in New Jersey. Much of the observed fading can be explained in terms of multiple path transmission in which path differences up to 7 feet were evident. These measurements were supplemented by angle of arrival observations at 1.25-cm wavelength.

A computer of the analogue type was built for simulating the more complicated selective fading patterns.

Movie films will be presented to illustrate selective fading and angle of arrival data.

49. PROPAGATION STUDIES AT MICROWAVE FREQUENCIES BY MEANS OF VERY SHORT PULSES

O. E. De Lange
(Bell Telephone Laboratories, Inc., Deal, N. J.)

Microwave pulses with a duration of about 0.003 microsecond were transmitted over a 22-mile path from Murray Hill, N. J., to Holmdel, N. J., in order to determine the effects of the transmission medium upon such pulses. During "fading" periods multipath transmission effects with path differences as great as 7 feet were observed, as well as some other effects. A microwave frequency of 4,000 Mc was employed.

This experiment was suggested as an adjunct to one in which propagation studies were being made by the frequency sweep method. Results obtained by the two methods are generally in agreement.

50. LOW-FREQUENCY IONOSPHERIC SOUNDINGS WITH ATMOSPHERICS

William J. Kessler and Wallace F. Zetrouer, II
(University of Florida, Gainesville, Fla.)

The use of atmospherics pulses, produced by remote and local lightning discharges, for ionospheric measurements below 100 kc is described. A discussion on the characteristics of lightning discharges as pulse radiators and the spectrum of the radiated field is included.

Oblique-incidence measurements made during the night with sounding pulses produced by lightning discharges originating in remote thunderstorms over a wide range of distances yield reflection heights in the vicinity of 85 kilometers. A limited number of vertical-incidence soundings with pulses obtained from overhead thunderstorms gives a mean reflection height of about 90 km over Gainesville, Fla.

51. THE EFFECT ON PROPAGATION OF AN ELEVATED ATMOSPHERIC LAYER OF NONSTANDARD REFRACTIVE INDEX

L. H. Doherty
(Cornell University, Ithaca, N. Y.)

It is shown by the method of geometrical optics that elevated layers whose gradient of refractive index differs from standard may radically affect the field of a transmitter placed above the layer. Departures from the standard atmosphere which are so slight that they are often present may result in serious difficulty in communication between aircraft when both are flying above the layer. A tri-linear refractive index model of the atmosphere is treated in some detail. It is shown that above the layer this results, within a certain range of distances, in a decrease of field strength. Following this "radio hole" there is a region of interfering rays and the resulting interference pattern is shown. The effect of some nonlinear refractive index models is indicated. Comparisons are made with experimental results.

SYMPOSIUM

Broadcast Transmission Systems

(Organized by Professional Group on Broadcast Transmission Systems)

R. W. Hodgkins, *Chairman*
(Station WGAN, Portland, Me.)

52. MASTER CONTROL FACILITIES FOR A LARGE STUDIO CENTER

R. H. Tanner
(Northern Electric Company, Ltd., Belleville, Ont., Canada)

A study of the Master Control requirements of a 21-studio center in Montreal, capable of feeding eight outgoing network lines and five transmitters, and the methods ed to fulfill them. A preset switching stem, using an unusually small number of lays, is employed in conjunction with an tensive visual and aural monitoring sysm, based on the "crossbar" switch first signed for automatic telephony. The same pe of switch is used in a system which lows each recording operator to select stantly any one of fifty program sources. addition, a dialling system extends a milar choice to fifty executive offices ound the building.

3. ELECTRONIC INSTRUMENTATION AM, FM, AND TV BROADCASTING HROUGH USE OF THE CATHODE-RAY OSCILLOGRAPH

P. S. CHRISTALDI
(DuMont Laboratories, Clifton, N. J.)

The cathode-ray oscillograph is the most nportant single tool at the disposal of the roadcast engineer. It is useful in the conuct of routine measurements at the broadasting station, for signal monitoring puroses, and is indispensable in the making of roof-of-performance tests on installations, required by the Federal Communications ommission.

This paper will describe some of the roadcast station measurement techniques mploying the modern cathode-ray oscilloraph. Methods for making use of the athode-ray oscillograph in conducting outine equipment tests, in making actual easurements, and in satisfying the measirement requirements as promulgated by he FCC will be discussed.

It is felt that the cathode-ray oscillograph is not as widely applied in broadcasting as it might be, and an attempt will be nade to show the broadcast engineer how imply and effectively it can be employed.

54. PERFORMANCE OF SECTIONALIZED BROADCASTING TOWERS

CARL E. SMITH
(United Broadcasting Company, Cleveland, Ohio)

With a sectionalized tower, high-angle adiation can be minimized and groundwave radiation can be maximized. For example, with a two-section tower the top section can be fed by a conductor shielded within the lower section. This terminal plus a connection to the ground and the lower section gives a three-terminal network which can be properly fed at the base.

Theoretical and experimental results show an equivalent power increase over a quarter-wave antenna of 113 per cent and 59 per cent, respectively, for a 213° tower. This affords an inexpensive way of effectively increasing the power of a radio broadcasting station.

55. INCREASED ECONOMY AND OPERATING EFFICIENCY OF TELEVISION BROADCAST STATIONS THROUGH SYSTEMIC DESIGN

R. A. ISBERG
(Electronic Systems Consultant, KRON-TV, San Francisco, Calif.)

The operating efficiency of a television station is largely dependent upon its initial planning with respect to floor plans and equipment layout. The number of operating personnel is directly affected by these factors along with the program structure.

Independent television stations operating in small markets must face one or more years of red ink operation before their income will pay operating expenses. During this initial phase of operation it is especially desirable to concentrate all operating activities in one location for maximum utilization of man power.

A number of innovations in system engineering were instituted at KRON-TV. Studio and film facilities are provided at the transmitter building and all control equipment including transmitter control panels are grouped into a U-shaped console. This console affords an efficient working area for two men who have all the equipment requiring adjustment within an arm's reach.

56. TECHNICAL CONSIDERATIONS OF TELEVISION RECORDING

G. EDWARD HAMILTON
(American Broadcasting Company, New York, N. Y.)

Television Recording presents the problem of integrating two complex variables: the sciences of motion picture and television techniques. The prime problem is to weigh the merits and limitations of both processes in order to realize the optimum results from the sublimation of the two.

Television recording is required to reproduce into the input of the television transmitter a replica of the original signal scheduled for this type of transmission. Factors affecting this requirement include system resolution, brightness range, film and film development characteristics, system gamma, and others. System element transfer characteristics must be weighed individually and collectively in order that corrective measures may be introduced where required.

Tuesday PM

SYMPOSIUM

Panel Discussion on Performance of DC Amplifiers

(Organized by Professional Group on Instrumentation)

ERNST WEBER, *Chairman*
(Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

57. A panel qualified to discuss design, performance, and application aspects of dc amplifiers of many types will present brief prepared remarks. Following this the audience will be invited to participate with questions and comments aimed at bringing out the capabilities of existing designs and the problems still requiring solution.

SYMPOSIUM

Matching Schools and Industry

(Organized by Education Committee)

E. L. BOWLES, *Chairman*
(Massachusetts Institute of Technology, Cambridge, Mass.)

58. EDUCATIONAL REQUIREMENTS FOR DEVELOPMENT ENGINEERS IN ELECTRONIC AND COMMUNICATION TECHNOLOGY

M. J. KELLY
(Bell Telephone Laboratories, Inc., New York, N. Y.)

The expansion of research in the physical sciences has provided new knowledge which is having a profound effect on electronic and communication technology. This new situation has shifted the emphasis in scientific training from practice to fundamentals. The need for graduate programs in schools, and training programs on the graduate level in development laboratories is therefore emphasized.

The problems facing universities, technical schools and development laboratories will be discussed, and the Bell Telephone Laboratories' training program described.

59. MAKING ENGINEERING EDUCATION PROFESSIONAL

B. R. TEARE, JR.
(Carnegie Institute of Technology, Pittsburgh, Pa.)

Engineering education, like engineering practice, may be either professional or subprofessional. Engineering education is made professional through developing in the student the capacity for the orderly, analytical treatment of problems that are new to him and by preparing him to continue to learn after he leaves college, rather than by choice of subject matter and distribution of hours among different courses. Professional situation problems and problems to teach the art of learning from experience are powerful tools for these purposes. Examples are given.

60. USING TESTS TO SELECT ENGINEERS

WARREN G. FINDLEY
(Educational Testing Service, Princeton, N. J.)

Undergraduate colleges of engineering find tests of mathematical aptitude or achievement, comprehension of scientific materials, and spatial visualization, in that order, most helpful in selective admissions. Best selection is obtained when test results are used in conjunction with previous school records.

Testing for admission to graduate study in engineering presents the added problem of adapting procedures to the specialized branches. New tests stress ability to apply knowledge, creative talent, biographical information.

In selecting engineering graduates for industrial positions, tests are most useful as supplements to other types of evidence and in proportion as previous testing data are lacking.

61. ORIENTING THE ENGINEER IN INDUSTRY

E. W. BUTLER
(Federal Telephone and Radio Corporation, Clifton, N. J.)

Our industrial civilization is becoming more complex each year in its economic and social as well as its technical aspects. At the same time greater concentration on the technical curriculum is required in engineering schools.

As a result, there is a tendency to severely restrict or eliminate the time available to acquaint the student with the nontechnical aspects of industry. He, therefore, enters industry unprepared to solve the nontechnical problems.

The author feels that both the technical schools and industry must give wider recognition to this situation. The paper discusses the writer's observations of engineers' problems outside the scope of their technical training and offers suggestions as to how the university and industry may work together to better the situation.

Circuits I—Synthesis and Analysis

J. G. Brainerd, *Chairman*
(University of Pennsylvania, Philadelphia, Pa.)

62. NETWORK SYNTHESIS APPLIED TO FEEDBACK CONTROL

John G. Truxal
(Purdue University, Lafayette, Ind.)

The principles of network synthesis are applied to the synthesis of servomechanisms. From the specifications, the poles and zeros of a suitable over-all system function are determined. The second step involves the determination of the poles and zeros of the open-loop transfer function by simple analytical and graphical relationships. Finally, the compensation networks are found. The synthesis procedure, in addition to permitting the designer control over both the time-domain and the frequency-domain behavior of the system—either considered as a filter or as a system subjected to multiple disturbances—is based on several relationships between pole and zero positions and system performance which clarify certain aspects of the general servomechanism synthesis problem.

63. NETWORK SYNTHESIS BY THE USE OF POTENTIAL ANALOGUES

R. E. Scott
(Massachusetts Institute of Technology, Cambridge, Mass.)

The synthesis of lumped-parameter passive networks is greatly facilitated by the use of the two-dimensional potential analogue. Two devices utilizing this principle will be described. The first machine plots *gain* and *phase* functions continuously on the face of a cathode-ray tube. It is useful for obtaining experimentally the locations of poles and zeros to give a desired gain and phase response. The second machine yields the *real* and *imaginary* parts of the network function. Properly processed these functions give the transient response of the network, and the device can be used in the problem of synthesis for a prescribed transient response.

64. TRANSFER RATIO SYNTHESIS BY *R-C* NETWORKS

John T. Fleck
(Cornell Aeronautical Laboratory, Buffalo, N. Y.)
and
Philip F. Ordung
(Yale University, New Haven, Conn.)

The problem considered in this paper is that of the realization of a transfer ratio, $E_{\text{output}}/E_{\text{input}}$, which is restricted to have only real negative zeros and poles, with a ladder type of network that contains only resistors and capacitors. The relationship of the driving point and transfer admittance to the elements of a ladder network are reviewed. Then a method is advanced whereby the driving-point and transfer admittances of the ladder may be determined from the transfer ratio. Finally, the method of synthesis of the driving-point admittance as a ladder network that realizes the desired transfer ratio is developed.

65. ELECTRICAL-MECHANICAL EQUIVALENT NETWORK SYNTHESIS

Albert A. Gerlach
Armour Research Foundation, Illinois (Institute of Technology, Chicago, Ill.)

The problem of forward loop compensation in linear servomechanisms is considered with particular emphasis on position control systems. The open loop transfer function of the necessary physical components of the system is reduced to linear and quadratic factors, and the synthesis of network complements for the individual factors is proposed. It is shown that the parallel network configuration is well suited for complementing a pair of complex poles. An example of the use of linear and quadratic compensation to reshape the transfer locus of a typical position control servomechanism is given. The conclusions are that any linear, lumped parameter, minimum phase system may be compensated to any degree desired; the limiting factor being the noise susceptibility of the compensating networks. Nonminimum phase systems may be compensated up to an all-pass function.

66. LINEAR NETWORK NEIGHBORHOOD EQUIVALENCE

D. R. Crosby
(RCA-Victor Division, Camden, N. J.)

This is a mathematical study of the sense in which electrical nets may be equivalent. Three particular kinds of equivalence are discussed.

It is shown that the classical theorems concerning linear nets frequently hold for a single frequency, and thus only establish point equivalence.

Neighborhood equivalence is the more significant equivalence when the net behavior over a narrow band of frequencies is of interest. To assume that two nets have neighborhood equivalence when they only have point equivalence may lead to serious error. Some theorems and applications of neighborhood equivalence to transmission lines and simple lumped circuits are shown.

67. CONSTANT-RESISTANCE VARING-PARAMETER NETWORKS

L. A. Zadeh
(Columbia University, New York, N. Y.)

The input impedance of a linear varying-parameter (variable) network is in general a function of time and frequency. A constant-resistance network of this type is defined as one whose input impedance is independent of both time and frequency, i.e., is a constant. A general theory of constant-resistance networks of the linear varying-parameter type is outlined. In particular, it is shown that any self-dual variable network is a constant-resistance network. Several variable constant-resistance structures, among them the lattice and the bridged-tee, are analyzed and the possibility of using these networks as constant-resistanse modulators is indicated.

Electron Tubes I—Tubes Employing Electron Beams

B. E. Shackelford, *Chairman*
(Radio Corporation of America, New York, N. Y.)

68. THE DESIGN OF 90°-DEFLECTION PICTURE TUBES

H. Grossbohlin
(Allen B. DuMont Laboratories, Inc., Clifton, N. J.)

The desirability of higher deflection angle picture tubes is evident from the reduction in tube cost and cabinet size which can be effected.

High deflection angle means greater deflection and focus power requirements and a tendency to greater spot distortion. Careful design of the tube body and of the wall contour permits more efficient yoke design, minimizing deflection power requirements. It is shown that the short tube length permits redesign of the electron gun in such a way as to reduce spot distortions to the point where picture quality is comparable to present tube types. A description of a 90° deflection tube so designed is given.

69. THE ROTATING BEAM METHOD FOR INVESTIGATING ELECTRON LENSES

D. E. George, R. G. E. Hutter, and M. Cooperstein
(Sylvania Electric Products Inc., Bayside, L. I., N. Y.)

A technique is described whereby electron lenses, either magnetic or electrostatic, can be investigated regarding their optical properties. The method uses a circularly rotating electron beam. This rotation can be accomplished by either electromagnetic or electrostatic deflection. This method minimizes space charge effects and alignment problems.

Applications of the method to magnetic lenses are given. These include the measurement of spherical aberration, location of the magnetic axis, and qualitative evaluation of the symmetry of a magnetic lens. A deription of the apparatus is given and rcuit diagrams of the sweep generators resented.

). A MINIATURE TRAVELING-WAVE TUBE FOR THE LOWER UHF BAND

ROBERT ADLER
(Zenith Radio Corporation, Chicago, Ill.)

The traveling-wave tube described is a ide-band, low-noise exponential amplifier or frequencies between 100 and 1,000 Mc. : combines principles of conventional grid-ontrolled tubes and traveling-wave tubes. ts helix, wound like a control grid, is aralleled by a long cathode. Each incre-iental part of the helix controls a corre-ponding part of the electron stream, which raverses the helix diametrically and de-vers energy to the other side by space-harge coupling. A weak magnet field enders the tube directional, giving it gain in ne direction and loss in the other.

Gains of 10 db per inch have been meas-red and more should be obtainable. Noise gures are promising. Bandwidth is about 5 per cent of center frequency.

Construction and performance of ex-erimental models are given and alternative orms, as well as their applications, reviewed.

1. GENERATION OF SIDEBANDS DUE O GAIN AND PHASE SHIFT MODULA-TIONS IN A TRAVELING WAVE TUBE AMPLIFIER

M. ARDITI, A. G. CLAVIER, AND P. PARZEN
Federal Telecommunication Laboratories, Inc., Nutley, N. J.

It has been proposed to use the traveling-vave tube amplifier (TWTA) in wide-band adio relay systems. The TWTA, when de-igned for a low noise figure could be used in traight through radio-frequency repeaters. t could also be used as a buffer amplifier etween the transmitter and the antenna rovided a sufficiently high output signal to oise ratio is obtained. An evaluation of this atio for AM and FM signals is given taking ccount of the generation of side-bands due o gain and phase-shift modulations. Similar onsiderations are applied to the use of the TWTA as a wide-band converter of high ain and large output powers.

72. BEAM ANALYZER

L. R. BLOOM, D. F. HOLSHOUSER, H. S. WU, AND W. W. CANNON
(University of Illinois, Urbana, Ill.)

Recent developments in millimeter waves ave stressed the importance of tightly unched beams. It has become necessary to tudy the bunching effects in general. A "beam analyzer" is suggested which meas-ures velocity and density distribution along he beam.

Velocity distribution is obtained by pro-ecting the beam through a chromatic ylindrical lens. Density spread is obtained by injecting the electrons through a strong lectric field which is varying with the same requency as that of the pulsed beam.

From the pattern on the cathode-ray creen, one can then determine the density pread. Thus, the modulation of the beam with respect to velocity and density modulation is completely defined.

Microwaves I—Waveguides A

R. BOWN, *Chairman*
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

73. DEVELOPMENT OF WAVEGUIDE SWITCHES FOR COMMERCIAL AND MILITARY APPLICATIONS

T. N. ANDERSON
(Airtron, Inc., Linden, N. J.)

This paper gives a discussion of the various means for accomplishing switching in waveguide circuits. A discussion is given of the advantages of the various types of construction and the electrical performance which may be achieved using these. The development of waveguide switches which have reflections equivalent to ordinary transmission line components and are capable of broad band operation at power levels equivalent to that of rigid waveguide is given. Both military and civilian applications for waveguide switches are discussed along with technique employed for obtaining the required mechanical and electrical performance. The various drive mechanisms which have been developed for use with these switches are also discussed. A discussion of a commercial application of a waveguide switch for extremely stringent electrical requirements is discussed (broadband VSWR less than 1.02 and crosstalk in excess of 90 db) and the mechanism employed in its construction is described.

74. LOW-LOSS WAVEGUIDE TRANSMISSION

S. E. MILLER AND A. C. BECK
(Holmdel Radio Research Laboratory, Bell Telephone Labotatories, Inc., Red Bank, N. J.)

Above 5,000 Mc, the use of circular electric waves in round waveguides is attractive for low-loss transmission from the standpoint of minimizing guide size and delay distortion, but is subject to the restrictions inherent in a multimode medium. Experiments conducted on a 500-foot 4.732 inch inside-diameter line indicate that the small attenuations theoretically attainable using circular electric waves can be approximated in practice. Observed losses are somewhat above the theoretical values due to mode conversion and roughness of the waveguide wall. Under certain conditions, mode conversion can also result in signal distortion.

75. DOMINANT WAVE TRANSMISSION CHARACTERISTICS OF A MULTI-MODE ROUND WAVEGUIDE

A. P. KING
(Holmdel Radio Research Laboratories, Bell Telephone Laboratories, Inc., Red Bank, N. J.)

This paper presents some dominant wave transmission characteristics of multimode round waveguide lines in the 4 kMc range of frequencies. The use of such waveguide lines offers the advantages: (1) lower transmission losses than obtainable with single mode rectangular waveguide, and (2) the relative ease of making good joints.

Possible mode conversion effects, including dominant mode elliptical polarization, have been examined and found to be innocuous. As a result, cross-polarized dominant waves can be used to provide two reasonably independent signalling channels at the same frequency in one pipe.

The experimental results obtained with a straight line 2.812 inches inside diameter and 150 feet long is given.

76. RADIAL PROBE MEASUREMENTS OF MODE CONVERSION IN LARGE ROUND WAVEGUIDE WITH TE_{01} MODE EXCITATION

M. ARONOFF
(Holmdel Radio Research Laboratory, Bell Telephone Laboratories, Inc., Red Bank, N. J.)

Measurements of mode conversion in 2-inch inside diameter and 4.736-inch inside diameter round waveguide excited with TE_{01} energy were made at 9,000 Mc. A short probe sampled the radial electric field around the inner periphery of the waveguide wall and the resultant response indicated the presence of the undesired modes. Mode conversion caused by waveguide ellipticity, surface imperfections (scratches, bumps and holes), and imperfect joints was measured and found to agree well with available theory.

The technique described has been found useful in electrically testing the worth of individual sections of commercially drawn waveguide for use in transmitting the circular electric wave.

77. A BROADBAND MICROWAVE QUARTER-WAVE PLATE

A. J. SIMMONS
(Naval Research Laboratory, Washington 25, D. C.)

Differential phase shift between two orthogonal TE_{11} waves in circular hollow waveguide is achieved with a reflectionless array of capacitive pins. Using transmission-line theory, an analysis of such a structure is made and, under the assumption that the pin susceptance varies with frequency as $j\omega C$, a broad-band 3-pin array acting as a quarter-wave plate may be designed. Such an array, which is only one inch long at X band has been tested. A voltage ellipticity ratio of less than 1.1 and VSWR less than 1.2 is maintained over a 12 per cent band.

78. THE PRECISION MEASUREMENT OF THE EQUIVALENT CIRCUIT PARAMETERS OF DISSIPATIVE MICROWAVE STRUCTURES

A. A. OLINER AND H. KURSS
(Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

The precision method to be described analyzes a general dissipative terminal structure into a simplified equivalent circuit consisting of two resistive and two reactive parameters between specified reference planes.

The network parameters are determined independently of any absolute distance measurements, which generally involve the greatest source of error. The method is based on A. Weissfloch's idea of utilizing a network with separated lossy and lossless parts.

The input data obtained for different settings of a variable short-circuiting plunger at the output side are plotted in the reflection coefficient plane and fitted analytically by the best possible circle. From the location of the center and the radius of this circle, two resistive network parameters and an input reference plane shift are determined. The remaining lossless portion of the network is analyzed precisely by the tangent relation method yielding a shunt network.

SYMPOSIUM

Panel Discussion on the "Empire State Story"

(Organized by Professional Group on Broadcast Transmission Systems)

F. MARX, *Chairman*

(American Broadcasting Company, New York, N. Y.)

79. A detailed discussion of the electronic, electrical, architectural, and mechanical constructional features of the Empire State broadcasting facilities by a group of specialists who are specifically involved in the activity.

PANEL MEMBERS

a. O. B. HANSON (National Broadcasting Company, New York, N. Y.)
b. F. G. KEAR (Kear and Kennedy, Washington, D. C.)
c. W. F. LAMB (Shrieve, Lamb and Harmon, New York, N. Y.)
d. B. H. RICHARDSON (Starrett Bros. and Ekin, New York, N. Y.)
e. H. GIHRING (Radio Corporation of America, Camden, N. J.)
f. T. E. HOWARD (Station WPIX, New York, N. Y.)
g. R. D. CHIPP (DuMont Television Network, New York, N. Y.)
h. F. MARX (American Broadcasting Company, New York, N. Y.)

SYMPOSIUM

Recent Advances in Color Television

A. G. JENSEN, *Chairman*

(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

80. The subject will be covered in a co-ordinated series of papers by a panel of several leading engineers from companies currently engaged in color television research. The speakers and their topics will be:

A. PRINCIPLES OF ADDING COLOR TO TELEVISION

W. T. WINTRINGHAM

(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

B. COLOR TELEVISION AS A MULTIPLEX PROBLEM

D. B. SMITH

(Philco Corporation, Philadelphia, Pa.)

C. SPECTRUM UTILIZATION IN COLOR TELEVISION

R. B. DOME

(General Electric Company, Syracuse, N. Y.)

D. SOME LABORATORY EXPERIENCES WITH A COLOR TELEVISION SYSTEM

A. V. LOUGHREN

(Hazeltine Electronics Corporation, Little Neck, L. I., N. Y.)

SYMPOSIUM

Industrial Instrumentation

(Organized by Professional Group on Instrumentation)

H. L. BYERLAY, *Chairman*

(Detroit Tank Arsenal, Center Line, Mich.)

81. FOUR-GUN OSCILLOSCOPE

M. A. ZINIUK

(Holley Carburetor Company, Detroit, Mich.)

The "four-gun oscilloscope" was developed to present four separate tune variables on one screen. The unit consists of DuMont K1027 four-gun cathode-ray tube mounted in a six-foot steel cabinet. In this cabinet are four separate deflection amplifiers (vertical), preamplifiers, high voltage supplies, a patch panel, and a common horizontal tune base. A mechanical timing-pip device superimposes on one trace timing-pips at 1/20, 1/10, 1/5, 1/2, or 1-second intervals.

A 4×5-inch camera is mounted on the face of the tube, with an automatically operated shutter which is actuated at the beginning and terminating ends of the sweep signal. Sweep frequencies available are 10 seconds to 100 cps.

82. AUTOMOTIVE ELECTRONIC TEST EQUIPMENT

R. J. L. BUTTERER AND T. S. BOLTON

(Hastings Manufacturing Company, Hastings, Mich.)

Electronic test equipment is being developed for diagnosing and locating faults in internal combustion engines. Using a cathode-ray tube as an indicator, only two connections to the engine's ignition system are required, one to a single high-tension lead and another to the breaker points of the primary circuit. The latter circuit is connected to the vertical deflection plates of the cathode-ray tube and variation in the display are associated with specific troubles. The device, an ignition monitor, is suitable for both magneto and battery ignition systems without auxiliary equipment. Patterns representing types of ignition troubles will be presented.

83. THE VIBROTRON—A NEW TRANSDUCER

JOHN OHMAN AND PAUL M. ERLANDSON

(Southwest Research Institute, San Antonio, Tex.)

The basic principles of the vibrating string have been used to develop a new type of transducer with an extremely wide variety of applications in the measurement of pressures, temperatures, and other physical quantities. The Vibrotron uses a wire tensioned in a magnetic field and forced to vibrate by passing a current through the wire. Variations in quantities measured are translated into changes in output frequency, providing convenience for telemetering uses. Many physical forms of vibrating string transducers have been tested. Methods of compensation for variations in ambient conditions have been found, so that secondary frequency standards may be provided.

84. ELECTRONIC RELAYS IN AUTOMATIC PROCESS CONTROL SYSTEMS

R. W. GREENWOOD

(Minneapolis-Honeywell Regulator Company, Philadelphia, Pa.)

Electronic devices have gained preference over mechanical devices in the operation of automatic control systems because they are faster, more precise and simpler to maintain. Typical devices such as the electronic continuous self-balancing potentrometer, vane-type controller and electronic relay are described. Their application to various control systems used in the electronics industry itself in connection with the annealing of television tubes, control of lacquer drying ovens, and control of high-frequency inductance heating furnaces for outgassing vacuum tubes are discussed.

85. NEW TECHNIQUES IN IMPULSE TESTING

WILLIAM G. FOCKLER

(Allen B. DuMont Laboratories, Passaic, N. J.)

For several years now the impulse-testing laboratories have used the cold-cathode oscillograph. Although it has been more than adequate, its many disadvantages have discouraged more widespread use of impulse-testing techniques in industry. With the development of the hot cathode permanently sealed type of tube several years ago, it was possible to achieve writing rates equivalent to those obtained with the cold-cathode oscillograph. The Type 5RP cathode-ray tube, a sealed off, high-voltage type, has the brightness and definition required for recording the impulse wave shapes. The development of this tube has been followed by the development of the necessary circuits to operate the tube and also meet the rigid standards of the impulse-testing field. A discussion of these standards, the problems in meeting them, and descriptions of circuits for operating the Type 5RP will be presented in this paper.

Computers I

E. R. PIORE, *Chairman*

(Office of Naval Research, Washington, D. C.)

86. THE RAYTHEON SELECTION MATRIX FOR COMPUTER AND . SWITCHING APPLICATIONS

KENNETH M. REHLER
(Raytheon Manufacturing Company, Waltham 54, Mass.)

This paper outlines the design requirements for the three selection matrices used the Raytheon computer, discusses circuit tails, presents the procedure for self-ecking the selections as made, and lists rtain advantages of the design. Photo-aphs are used to clarify circuit details, id to illustrate the constructional and ickaging techniques.

Previous types of selection matrix input ivers employing bi-stable elements such as p-flops inherently produce a selection when ey should be non-selecting or "reset." To ercome this difficulty a new simple type matrix input-column driver has been de-loped which is tri-stable. It can be fully et on both sides.

'. SATURABLE REACTORS AS SUBSTITUTES FOR ELECTRON TUBES IN HIGH-SPEED DIGITAL COMPUTERS

JAMES G. MILES
(Engineering Research Associates, Inc., St. Paul, Minn.)

Saturable reactors offer prospects as reli-ble, permanent, low power, active circuit ements for drastically reducing the num-er of electron tubes required in high-speed igital computers. Magnetic-amplifier type ip-flops are described which are operated by igger pulses of less than one microsecond uration and at repetition rates up to 400,-)0 pulses per second. Illustrations show pplications of magnetic flip-flops as ounters and registers for binary-coded umbers, and as magnetically controlled ating devices. Core configurations are de-ribed and core material characteristics are ritically compared. Desiderata of integrally ssociated magnetic amplifier circuit com-onents such as rectifiers are set forth.

88. FERROMAGNETIC CORES FOR THREE-DIMENSIONAL DIGITAL STORAGE ARRAYS

WILLIAM N. PAPIAN
(Servomechanisms Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.)

Recently developed "rectangular" hys-eresis-loop magnetic materials permit ompact information-storage assemblies vhere the selected storage cell is located by he intersection of three space-co-ordinate lanes. The selection switching is inherent n the array based on each core's ability to listinguish between several values of excit-ng current.

Quantitative data, and the dependence of performance on hysteresis-loop shapes, re given in terms of "information-reten-ion" and "signal" ratios. A metallic core vith excellent signal ratios and a 20-micro-econd response time, and a ferritic core vith fair signal ratios and a ½-microsecond esponse time bracket the results to date.

89. DEPENDABLE SMALL-SCALE DIGITAL COMPUTER

J. J. CONNOLLY
(Teleregister Corporation, New York, N. Y.)

The manipulation of large amounts of stored data, with relatively simple arithmetical operations, at reasonable speeds and with the utmost dependability, is the problem presented in inventory accounting systems applicable to department stores, mail order houses, railroads, airlines and all common carriers as well as government services wherever large inventory records are required.

A system having the above characteristics has been constructed and proven itself in dependability.

The system employs a magnetic drum with storage capacity in the millions of binary digits, and input, selection or translation, programming, arithmetical and output functions.

Plug-in subassembly construction, the use of the magnetic drum for translation, category storing as well as programming, and circuit design based on weighted variations in operating conditions and rate of component deterioration, are factors which contribute to dependability with minimum maintenance.

90. AN ASYNCHRONOUS CONTROL FOR A DIGITAL COMPUTER

D. H. GRIDLEY
(Naval Research Laboratories, Washington, D. C.)

The sequential control circuits of the Naval Research Laboratory Electronic Digital Computer have been designed for asynchronous operation under the surveillance of checking circuits. A given electronic control element within a sequence transmits an action-initiating signal to the operation circuits, and an operation-complete signal must be received from the activated circuits before the advance to the next control element of the sequence is made. If the operation-complete signal is not received, the computer is stopped and the status of most operational elements may be displayed by indicators. A general discussion of the sequence-control and checking circuits will be given to indicate the method of detecting errors in high-speed computer operation.

Circuits II—Filters

W. E. BRADLEY, *Chairman*
(Philco Corporation, Philadelphia, Pa.)

91. TIME DOMAIN FILTERS

JAMES SNYDER
(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

In the study of gunfire, there arises the problem of discriminating between muzzle blast and the shock wave generated by the bullet. Solutions based on frequency discrimination are not feasible because of the well known shock excitation of filters; neither are simple amplitudes methods applicable. The problem and methods of dealing with it are discussed and consideration given to the extension of the methods to the general problem of discrimination between dissimilar transients.

92. PULSE RECEPTION FILTERS

D. L. WAIDELICH
(University of Missouri, Columbia, Mo.)

Filters used in the reception of pulses must as nearly as possible maximize the signal to noise ratio, as well as fulfill other less important requirements. An *RC* filter was chosen for compactness, and an analysis of its response to pulses was made. Curves of gain, signal-to-noise ratio and shift of the response peak were obtained in such a form that they are suitable for design use. With the aid of these curves circuit parameters for the best signal-to-noise ratio may be determined. Experimental results were found to agree closely with the predicted results.

93. OPTIMUM NONLINEAR FILTERS

HENRY E. SINGLETON
(General Electric Research Laboratory, Schenectady, N. Y.)

Standard forms for synthesizing arbitrary invariant finite state transducers consist of storage elements combined with sets of comparison and coincidence devices. The system transfer function of an arbitrary nonlinear system may be characterized by certain higher order autocorrelation functions of the input and crosscorrelation functions between the input and output. The optimum mean-square filter, when based on a multi-dimensional series expansion of the system function, is expressed in terms of higher-order correlation functions. Only if the probability distributions of the signal and noise are Gaussian, does the filter reduce to a linear device. For finite state filters the criterion of minimum probability of error is employed, and the design equations represent surfaces in a hyperspace.

94. NONLINEAR SAMPLING FILTERS

WARREN D. WHITE
(Airborne Instruments Laboratory, Mineola, L. I., N. Y.)

H. E. Singleton, of MIT, has shown that, for the case of a filter operating from sampled input data, it is possible to obtain an optimum system operator in the form of a multi-dimensional Taylors series. Following this lead, the author shows that the optimum system operator can be expressed in closed form and that special relations exist when the input can be expressed in terms of Markoff processes. It is shown that, in general, the ideal filter requires an infinite memory capacity. Practical approximations are possible, however, in which only a finite memory capacity is required. One such practical filter is considered in detail and compared with the optimum linear filter.

95. STATISTICAL FILTER THEORY FOR FEEDBACK SYSTEMS SUBJECT TO SATURATION

GEORGE C. NEWTON, JR.
(Massachusetts Institute of Technology, Cambridge, Mass.)

A theory for the design of compensating networks for feedback-control systems and filters is developed herein. The novel feature of this theory is its consideration of saturation and transient performance in addition to the usual steady-state behavior. This theory is essentially an extension of the researches of Wiener and Lee in statistical methods for filter design. Saturation is handled by limiting the rms signal levels at critical points in the linear model used as the design basis for the physical system. Transient performance is handled by limiting the integral-square errors to a set of transient signals.

96. ELECTRONIC FILTER

Howard T. Sterling

(The Electronic Workshop, Inc., New York, N. Y.)

A new electronic filter circuit is described, with response characteristics substantially identical to those of a conventional constant-k filter. Simple resistance-capacitance networks are used as the frequency-determining elements. Such a filter with a slope of 18 db/octave beyond cutoff (equivalent to a conventional full-section constant-k filter) can be constructed with only three ganged elements. Cutoff frequency is variable over a wide range, and damping is independent of frequency. Tolerance of circuit elements and tracking tolerance on the ganged elements is relatively uncritical. The circuit has the further advantage of high input impedance and low output impedance.

Electron Tubes II—Special Tubes and Techniques

G. D. O'Neill, *Chairman*

(Sylvania Electric Products Inc., Bayside, L. I., N. Y.)

97. THE PLASMATRON, A CONTINUOUSLY CONTROLLABLE GAS TUBE

E. O. Johnson and W. M. Webster

(RCA Laboratories Division, Princeton, N. J.)

The "plasmatron," a new type of low-impedance electron tube, is described. This tube utilizes an independently produced gas discharge plasma as a conductor between a hot cathode and an anode. Continuous modulation of the anode current can be affected by varying either the conductivity or the effective cross-section areas of this plasma. The first method is accomplished by the modulation of an electron ionizing beam which changes the plasma density and hence its conductivity. The second method makes use of the gating action of positive ion sheaths which surround the wires of a grid located between the anode and cathode. The plasmatron appears to have considerable promise for such applications as motor drive, loudspeaker drive, and the many other uses which require the high current and low voltage operation that the high-impedance vacuum tube cannot supply.

98. SWITCHING TIME LIMITATIONS IN HYDROGEN THYRATRONS

J. B. Woodford, Jr., and E. M. Williams

(Carnegie Institute of Technology, Pittsburgh, Pa.)

The switching time in thyratrons is shown to be described by

$$\Delta t_{ab} = \frac{1}{\alpha E_0} \log_e \frac{b(1-a)}{a(1-b)} + \frac{L}{R} \log_e \frac{1-a}{1-b}$$

in which Δt_{ab} is time of transition between the fractions a and b of total change in load voltage, α a tube parameter, E_0, anode supply voltage, and L and R load parameters. The tube parameter α must be experimentally determined; however, examples of its variation between tubes and dependence on pressure are given. Cavity enclosures are necessary to minimize circuit inductances and with such enclosures commercial hydrogen thyratrons have switching times of two to six milli-microseconds.

99. A NEW TYPE HEATER CATHODE TUBE FOR PORTABLE BATTERY-OPERATED EQUIPMENT

George W. Baker

(Kip Electronics Corporation, New York, N. Y.)

The heater of this new heater cathode-type tube operates at 1.25 volts and at a current equivalent to that required by filament-type tubes used in battery operated equipment. This tube permits the use of circuits requiring separately insulated cathodes in dry battery-operated equipment. The first tube made in pilot plant quantity is Kip type KP53, a double diode in a subminiature T2 envelope. Samples of these tubes will be shown.

100. NEW VACUUM-TUBE MATERIALS

E. B. Fehr and A. P. Haase

(General Electric Company, Owensboro, Ky.)

A new spacer material which shows great promise as an effective substitute for mica in vacuum tube applications has been developed. This material when treated chemically and thermally, possesses mechanical and electrical properties similar, and in some cases superior, to mica. This paper treats the development and application of this new material and reports experience obtained with it in a number of tube types.

A new anode material for use in vacuum tubes has been investigated. This material is compared with those presently used, and application experience and life test information are presented.

101. PROPERTIES OF INTERFACES IN METAL TO CERAMIC SEALS

W. A. Christoffers and R. P. Wellinger

(University of Illinois, Urbana, Ill.)

The thickness of the interface resulting from the bonding of metals to ceramics has been increased by ionic diffusion, which is intensified by passing a current through the interface. This has made it possible to determine the mechanical and electrical properties of this critical layer. Appreciable changes in tensile strength of the seal and interface material have been observed. The electrical conductivity stays approximately the same as that of the ceramic. This process, in addition to enlarging the interface so that its properties can be studied provides a new means of making metal to ceramic seals. It also shows the limitations of ceramics used in tube construction under extreme conditions of temperature and electric field.

Microwaves II—Waveguides B

H. A. Wheeler, *Chairman*

(Wheeler Laboratories, Great Neck, L. I., N. Y.)

102. ON THE EXCITATION OF SURFACE WAVES

Georg Goubau

(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

The total field excited on any waveguide consists of the regular wave and a supplementary field which provides for the continuity of the total field at the point of excitation. In the case of open waveguides the supplementary field is a radiating field which, however, shows an orthogonality to the field of the regular wave similar to that which occurs in closed waveguides. Thus the amplitude of a surface wave which is excited by a dipole or any other power source can be determined easily by means of the reciprocity theorem. The method is demonstrated in several examples.

103. INTERACTION BETWEEN SURFACE WAVE TRANSMISSION LINES

Allan A. Meyerhoff

(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

An important question in connection with surface wave transmission lines is the interaction between them or with other wires which may act like surface waveguides. This question is treated for two parallel lines with the provision that the coupling is small. The problem is related to the problem of coupled circuits; the space variable for the currents in the lines corresponds to the time variable for the currents in the circuits. When the two lines are identical there is maximum interaction as is the case for identical circuits. The theoretical treatment is supplemented by the consideration of several typical examples.

104. A NEW DIRECTIONAL COUPLER PERMITTING FULL POWER TRANSFER

K. Tomiyasu and S. B. Cohn

(Sperry Gyroscope Company, Great Neck, L. I., N. Y.)

A new directional coupler capable of transferring up to the total power from one waveguide to another is described and analyzed. This coupler which can carry nearly the maximum power of the waveguide has been used as a high-power divider as well as in a high-power attenuator. The coupling element is a long slot containing a grid of wires in the common narrow wall of the two waveguides. The power transfer is propor- tional to sine-squared of the normalized length of the coupling region. The quantita- tive theory developed for this coupler agrees closely with the results.

5. MULTI-ELEMENT DIRECTIONAL COUPLERS

S. E. Miller and W. W. Mumford
(Holmdel Radio Research Laboratory, Bell Telephone Laboratories, Inc., Red Bank, N. J.)

Directional couplers using coupling ele- ments spaced a quarter wavelength and tapered in accordance with the coefficients of the binomial expansion produce maxi- mum directivity in the vicinity of the design frequency. By departing from these ideal conditions, somewhat less directivity can be achieved over a broader frequency band. High directivities over very broad bands can be achieved by using many coupling elements. Experimental results indicate that the theoretical possibilities are readily achieved.

There is presented a simple theory ac- counting for the performance when a signifi- cant amount of power is extracted from the main line, and some experimental results are noted.

6. THE EFFECT OF RADIATION ON THE Q OF RESONANT SECTIONS OF UNSHIELDED PARALLEL-WIRE TRANSMISSION LINE

R. A. Chipman,
(McGill University, Montreal, Que., Canada)
E. F. Carr,
(General Electric Co., Syracuse, N. Y.)
and
N. A. Hoy
(General Electric Co., Syracuse, N. Y.)

Using a parallel-wire line extending ver- tically above a metal "ground" plane, Q values have been measured for both open- and short-circuit terminations at the top of the line, with and without a large copper tube surrounding the line. Resonant line- lengths up to several wavelengths were used, at frequencies between 300 and 1,200 Mc.

Radiation losses greatly exceeded ohmic resistance losses in every case. Representing them by a "radiation resistance" at a cur- rent loop, this resistance varied roughly as the square of the line spacing in wavelengths, but only slightly with line length.

Some agreement with theory has been found.

SYMPOSIUM

Some Systems Problems of Air Traffic Control

Donald G. Fink, *Chairman*
(*Electronics* Magazine, McGraw-Hill Publishing Company, New York, N. Y.)

107. WEATHER

N. A. Lieurance
(U. S. Weather Bureau, Washington, D. C.)

This paper will discuss the effects of meteorological phenomena—wind, icing, re- duced visibility, etc.—on the operation of aircraft and on the minimum interval between successive aircraft arrivals or de- partures. The need for more accurate and reliable localized forecasts, especially short term ones, will be indicated and the results of a study of short term forecasting at Wash- ington National Airport will be summarized. Requirements for better weather measuring instruments and possible measuring tech- niques will be discussed.

108. AIRCRAFT AND AIRPORT CHARACTERISTICS

L. P. Tabor
(The Franklin Institute, Philadelphia, Pa.)

The dispatch with which aircraft can land at any airport depends on a number of variables: among them are runway-taxiway configuration, flight and taxi characteristics of aircraft, minimum safe separation dis- tance between aircraft and type of control exercised. The Franklin Institute has de- signed a simulator capable of analyzing various proposed traffic control systems taking these variables into account. The re- sults of an analysis of several systems will be presented. Also to be discussed is a program for the measurement, at several airports, of the important aircraft flight and taxi characteristics. The outline of this experi- mental program will be presented along with results to date.

109. ECONOMIC DEMAND

F. B. Lee
(Civil Aeronautics Administration, Washington, D. C.)

From economic studies there emerges a pattern which clarifies the dependence of the amount of air traffic on the size, location, and economic character of communities. From this pattern it is possible to predict the demand (passenger, mail, and cargo) which will be placed on individual air- ports and air routes in the future. These predictions set the requirements of volume and distribution of air traffic which an elec- tronic control system must satisfy.

This paper will also discuss the traffic delays experienced at major U. S. air ter- minals and the effect which surveillance radar has had in reducing the number of aircraft delayed and the magnitude of de- lay. The expected effect of new aids such as airborne transponders and automatic radar displays will be presented.

110. HUMAN ENGINEERING

P. M. Fitts
(Ohio State University, Columbus, Ohio)

Although there is a persistent trend toward automaticity, part of the task of air navigation and traffic control will un- doubtedly be performed by human opera- tors. This fact imposes certain requirements on the design of mechanical and electronic components for the system. The present paper discusses the implications of three general requirements based on human capacities and limitations: those based on the capacity of a human operator in handling information and making decisions; those based on the capacity of a human operator in responding quickly to directional and spatial information and in manipulating controls; and those based on the capacity of men and machines to function as a system.

Much information is already available about how human beings perform air naviga- tion and traffic control tasks, and much re- mains to be found out by research. Princi- ples governing the design of information dis- plays and communication equipment will be reviewed briefly in order to illustrate the state of present knowledge.

111. TRAFFIC CONTROL THEORY

D. H. Ewing
(Air Navigation Development Board, Washington, D. C.)

This paper will summarize the results of several study projects on this subject spon- sored by the Air Navigation Development Board. Included will be a discussion of the amount and type of control to be exerted at the various stages of aircraft flight in order to minimize delays en route and in terminal areas.

Electronic Instrumentation

F. Hamburger, Jr., *Chairman*
(The Johns Hopkins University, Baltimore, Md.)

112. MICROWAVE METHODS IN GAS ANALYSIS

Joseph Weber
(U. S. Naval Ordnance Laboratory, White Oak, Md., and University of Maryland, College Park, Md.)

The composition of certain gas mixtures can be determined by microwave measure- ments on single resolved collision broadened spectral lines. The mole fraction of an ab- sorbing gas in a mixture is uniquely deter- mined by a measurement of the area under- neath an absorption line. The limitations im- posed by adsorption and presently available klystrons are discussed.

The composition of binary gas mixtures can be determined by measurement of the peak absorption coefficients if the collision cross sections are known. A microwave spec- troscope is also effective in the analysis of isotopic gas mixtures because isotopic sub- stitution shifts the absorption lines by rela- tively large amounts.

Apparatus for utilizing microwave spec- troscopy as an analytical tool is described, experimental results are presented, and com- pared with those obtainable by a mass spec- trograph.

113. SPARK-OVER OF AIR AT RADIO FREQUENCIES

W. Caywood, Jr.
(Carnegie Institute of Technology, Pittsburgh, Pa.)

Radio-frequency sparkover characteris- tics of air at atmospheric pressure are of great importance to radio engineers dealing with problems of air insulation. It is well known that breakdown strength of air is less at radio frequencies than at power frequen- cies. There has been considerable disagreement in the literature, even for relatively simple, nearly uniform field configurations of the amount of the difference.

This paper contains:

(a) A brief review of the theory of ac breakdown, showing the reason for a dependence on frequency.

(b) New, accurate experimental values of breakdown at up to two megacycles. These provide reliable data for high-frequency power transmission lines and similar applications.

(c) A new, experimentally derived relationship between gap length and frequency. It is shown that if a plot is made of (spark-over voltage) ÷ (air density) as a function of (frequency) × (gap length)$^{\sqrt{2}}$, all data taken lie on one single curve.

114. X-RAY LIQUID LEVEL GAGE

JOHN E. JACOBS AND ROBERT F. WILSON
(Coolidge Laboratory, General Electric X-Ray Corporation, Milwaukee, Wis.)

A liquid level gage has been developed using semi-conductors as X-ray detectors that is capable of gaging the level of a liquid in thick-walled steel vessels to a close precision. The gage may be used for inspection of filled containers or as a control element for the filling process. By virtue of the natural amplification of the semi-conductor detector the required instrumentation is greatly simplified.

115. NOISE FIGURE STANDARDS

M. SOLOW, I. W. HAMMER, AND P. H. HAAS
(The National Bureau of Standards, Washington, D. C.)

Noise figure standards to 30 Mc are now available at the National Bureau of Standards. Establishing these standards required generalizing the theory of noise figures and determining the uniqueness and accuracy of noise figure measurements.

The technique used to verify the theory was to show the invariance of the equivalent noise resistance of a special four-terminal network from measurements of its noise figure with a temperature limited diode. This was done at 4.3, 12, and 30 Mc. The limits of error for noise figure measurements with the present equipment is ±0.2 decibel.

This theory and technique have other applications; one is the impedance measurement of two-terminal networks.

116. NEW LIMITS FOR LOW-LEVEL RF ENERGY MEASUREMENTS

W. K. VOLKERS
(Millivac Instruments, New Haven, Conn.)

At low voltage or energy levels rf crystal diode detection follows a square law. By combining a large unmodulated "excitation" signal identical in frequency and phase with a small modulated signal the limit for low level rf energy measurements can be drastically lowered. The method described employs a special crystal diode probe having an excitation terminal and a dual signal generator producing both the unmodulated excitation signal and the modulated signal for measurements. Small fractions of a billionth of a watt can thus be measured over practically all high- and low-frequency ranges. The method improves the already excellent voltage measuring sensitivity of the well known probe-and-tuned-amplifier-combination by more than twenty decibels.

Computers II

J. W. FORRESTER, *Chairman*
(Massachusetts Institute of Technology, Cambridge, Mass.)

117. A SAMPLING ANALOGUE COMPUTER

JOHN BROOMALL AND LEON RIEBMAN
(Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.)

The sampling analogue computer has already found a number of applications and conceivably can be used in many other cases where the accuracy of the result need not exceed 0.1 per cent of "full scale." The theory of operation has been covered elsewhere. This paper discusses the use of the sampling computer in determining W from $W = KYZ/X$ where K is a system constant, X, Y, and Z are independent input variables and W is the computed result or answer.

A particular mechanization of the computer is given together with a review of sources of error and suggestions for further improvements.

A pulse-to-dc converter is described to permit use of any number of these computers in tandem.

118. A TIME DIVISION MULTIPLIER FOR A GENERAL-PURPOSE ELECTRONIC DIFFERENTIAL ANALYZER

R. V. BAUM AND C. D. MORRILL
(Goodyear Aircraft Corporation, Akron, Ohio)

An electronic device for producing the products of two variable voltages is described. Sources of systematic error are briefly analyzed and the methods used to reduce such errors are discussed. The characteristics of the multiplier are summarized and compared with those of the servo-multiplier usually employed in analogue computers. Finally, the use of this multiplier in a high speed differential analyzer to solve nonlinear ordinary differential equations is illustrated.

119. A HIGH-SPEED PRODUCT INTEGRATOR

ALAN B. MACNEE
(University of Michigan, Ann Arbor, Mich.)

A high-speed product integrator has been developed. A one-hundred point solution is obtained on a cathode-ray tube screen every 1.67 seconds. The product integrator employs components of an electronic differential analyzer together with a set of motor driven potentiometers. This product integrator has been used for the evaluation of solutions of the Fourier, Schlomilch, and superposition integral equations. An accuracy of the order of 2 per cent is achieved.

120. PLUG-IN UNITS FOR DIGITAL COMPUTATION

G. GLINSKI AND S. LAZECKI
(Computing Devices of Canada, Ltd., Ottawa, Ont., Canada)

To widen the scope of application of high-speed electronic digital data handling systems, the development of individual computer "units" has been undertaken. These units may be assembled into various systems of varying degree of complexity.

The "S" series of units, some of which are described in this paper, provides basic units for a serial digital computer. This "S" series consists of such basic units as: amplifiers, binary scalers, buffers, cathode followers, decoders, delay lines, flip-flops, gates, half-adders, matrices, memory, oscillators, etc.

As an example of simplification introduced by unitized construction, it was possible to build a relatively complex data handling system (4,000 units) out of 50 basic functional units.

121. A FIVE-DIGIT PARALLEL CODER TUBE

J. V. HARRINGTON AND K. N. WULFSBERG
(Air Force Cambridge Research Laboratories, Cambridge, Mass.)
AND
G. R. SPENCER
(Philco Tube Laboratory, Cambridge, Mass.)

A cathode-ray type coder tube which will convert a signal voltage into a five-digit parallel binary code is described. The coding pattern is obtained by printing a material of low secondary emission ratio on metal target segments having a high secondary emission ratio. The pattern is segmented "digitwise" so that the code signals may be obtained in parallel, and the coding pattern is derived from the so-called "cyclic" system, which is self-quantizing.

Circuits III—General

R. L. DIETZOLD, *Chairman*
(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

122. A LINEAR OPERATIONAL CALCULUS OF EMPIRICAL FUNCTIONS

R. G. PIETY
(Phillips Petroleum Corporation, Bartlesville, Okla.)

An operational calculus (based on the generating functions of DeMoivre and Laplace) is derived to evaluate the convolution and also its inversion, between empirically obtained functions. The operations are carried out by the ordinary algorithms for multiplication and division of polynomials. The cross and auto correlations of time series are similarly computed. A time series is represented by a polynomial in x where the coefficients of the successive powers of x are equal to the values of the time series at successive equal intervals of time. The development of a function in terms of the translated values of another (obtainable with generating functions) is applied to network synthesis.

123. PULSE TRANSFORMER CONSIDERED AS A WIDE-BAND NETWORK

M. GUNTHER RUDENBERG
(Raytheon Manufacturing Company, Waltham, Mass.)

The method of distribution, already suc-

eful for amplifiers, is applied to the analy-
and design of an improved pulse trans-
ner having a resolution of only a few
imicroseconds. There is no stray ca-
itance limit, and with proper matching
significant resonances exist. The matrix
lysis applied to two practical examples,
nverting pulse transformer and a 75–300
h uhf network. Design involves matching
edances and traveling-wave velocities in
windings. Bandwidths up to 500 Mc
e measured, but the method also applies
udio frequencies. Ultra-thin iron lamina-
is are not required to achieve the excel-
high-frequency response. Practical
its set by skin effect losses occur at micro-
re frequencies.

124. SINGLE-TAPPED COIL DELAY LINE

S. G. LUTZ
(ew York University, New York, N. Y.)

Sonar lag lines and radar delay lines are ntical in theory but exacting sonar re- rements justify more complex structures. lowing a survey of desirable lag line prop- eies, those configurations involving not re than one singly tapped coil per section listed and compared, showing that they a all special cases of a section, termed 4, including all distributed capacitances of enter tapped coil plus two capacitances to und. This section is a low-pass-band-pass er which sometimes can be made conflu- , or whose low-pass delay characteristic be compensated by adjusting the loca- ns of the band-pass cutoff frequencies. A rve matching technique is presented for ing this.

125. NICKEL ACOUSTIC DELAY LINE

T. F. ROGERS
Air Force Cambridge Research Labora- tories, Cambridge, Mass.)
AND
S. J. JOHNSON
Anderson-Shaw Laboratories, Hartford, Conn.)

The effect of a magnetic field upon a ckel acoustic delay line has been studied an attempt to affect a nonmechanical ethod of changing its delay time. Changes delay of up to 3 per cent at 1,000 oersteds ve been noted and can be explained on the sis of a change in the velocity of propaga- n of the 1 Mc transverse (shear) sonic aves used. Accompanying the change in locity is a profound change in the trans- ittivity throughout the nickel line; at high ld strengths output signals have been ted over 100 times in amplitude of those ceived at $H=0$.

126. AMPLIFIER SYNTHESIS ON EQUAL-RIPPLE BASIS

DEFOREST L. TRAUTMAN AND J. A. ASELTINE
(University of California, Los Angeles, Calif.)

This paper describes a method of design- g bandpass amplifiers with equal-ripple Chebyshev) response yielding design data terms of pole and zero locations in the omplex-frequency plane. No restriction is laced on the type of coupling between tages, and bandwidth may be as large as desired with no approximations necessary in the design.

The method consists of mapping the bandpass frequency plane onto a transform plane where the pass bands appear as a circle. The poles placed symmetrically on another circle whose radius is a function of the ripple desired provide the required equal-ripple response. The inverse mapping yields their locations in the bandpass frequency plane, and is distorted by the correct amount to accommodate the zeros required by the various interstage coupling networks.

Broadcast and TV Receivers

J. D. REID, *Chairman*
(American Radio and Television, Inc., North Little Rock, Ark.)

127. WIDE-ANGLE DEFLECTION YOKE DESIGN

H. THOMAS
(Allen B. DuMont Laboratories, Inc., East Paterson, N. J.)

In order to describe the variable and interdependent factors bearing on deflection yoke design, the first part of this paper discusses the main yoke performance characteristics; e.g., sensitivity, spot and pattern distortion, neck shadow, and linearity. The electrical features and mechanical dimensions bearing on these characteristics are then correlated to the normal operating conditions, to heating, shrinkage, cross coupling, and manufacturing cost. The compromises necessary to obtain a balance between sensitivity and neck shadow and between spot and pattern distortion are developed in detail, with a final suggestion toward some means to standardize yoke performance measurements.

128. SEMI-AUTOMATIC FABRICATION OF AUDIO AND VIDEO EQUIPMENT

W. H. HANNAHS, R. BAHR, JR., AND J. CAFFIAUX
(Sylvania Electric Products Inc., Bayside, N. Y.)

Design principles are given for arriving at functional structures for electronic subassemblies and complete equipment, the objectives of the designs being a reduction of labor in the fabrication of mass produced items. In three examples—an AM radio, a television IF strip and an interphone amplifier—application is made of modern etching, stamping, and other printed-circuit techniques.

129. UHF CONVERTER

B. F. TYSON
(Sylvania Electric Products Inc., Flushing, L. I., N. Y.)

During the introductory period of uhf television broadcasting, converters will be required for reception of uhf stations on existing vhf receivers. A uhf converter is described which features simplicity of operation and low cost. The converter is designed so that at the time of installation its local oscillator is preset to a fixed frequency and uhf stations are selected with the regular vhf receiver controls.

Performance characteristics are given including conversion efficiency, noise figure, and local oscillator stability. The possibilities of interference from harmonics of the vhf receiver local oscillator are examined and other limitations in the operation of the converter are explained.

130. POWER SUPPLIES FOR TELEVISION RECEIVERS

A. M. LEVINE AND S. MOSKOWITZ
(Federal Telecommunication Laboratories, Inc., Nutley, N. J.)

The characteristics of voltage doublers and triplers using selenium rectifiers and having load currents from 100 to 500 milliamperes are discussed. These characteristics include output voltage regulation and ripple factor.

Since the voltage-doubler type of power supply is more economical, the receiver designer should attempt to reduce the direct-current-circuit voltage requirements to a maximum of 285 volts. Methods of meeting this condition include the use of high-efficiency deflection components such as Ferrite core transformers and deflection yokes and the elimination of negative bias voltages.

Several examples of receiver design are described in which the direct-voltage requirements have been reduced, yet allowing full 70-degree deflection.

131. RADIO RECEIVER SUBMINIATURIZATION TECHNIQUES

GUSTAVE SHAPIRO
(National Bureau of Standards, Washington, D. C.)

A subminiature radio receiver, tuning from 190 to 550 kc, has been developed. Total volume of this twelve-tube unit is 55 cubic inches. This compactness is made possible by fourteen new components, including rf inductors and IF transformers using high temperature litz, glass dielectric capacitors, tantalum electrolytic capacitors, and audio inductors wound with ceramic insulated wire. Linearity of permeability tuning is accomplished through the use of a nonlinear screw drive. Design and fabrication techniques, which make this receiver adaptable to quantity production, will be discussed.

Microwaves III—Antennas and Artificial Dielectrics A

A. G. HILL, *Chairman*
(Massachusetts Institute of Technology, Cambridge, Mass.)

132. THE STUDY OF ARTIFICIAL DIELECTRICS OF THE OBSTACLE TYPE

CHARLES SUSSKIND
(Yale University, New Haven, Conn.)

The analysis of artificial dielectrics consisting of arrays of small metallic elements has been considerably extended by several workers, both in this country and abroad. In determining the "bulk" properties (such as permittivity, permeability, and refractive index) of these media analytically, various methods of attack can be employed; in addition, experimental measurements on a small sample can be frequently utilized to predict the performance of microwave prisms, lens antennas, etc. This paper presents a survey of the analytical and practical techniques now used in the design of artificial dialectrics, as well as an outline of further problems and possible methods of solution.

133. ISOTROPIC ARTIFICIAL DIELECTRIC

Russell W. Corkum
(Air Force Cambridge Research Laboratories, Cambridge, Mass.)

Isotropic artificial dielectric media composed of a three-dimensional cubic array of metal or dielectric spheres have been investigated.

Theoretical expressions using the Clausius-Mosotti relation have been derived for the index of refraction, dielectric constant, and magnetic permeability of this type of dielectric. These quantities are independent of frequency, so long as the size of the spheres and the spacing between spheres are small compared to the wavelength within the resulting dielectric media.

Samples using steel and fuzed-quartz spheres have been fabricated and the dielectric properties measured in rectangular waveguide at a frequency of 5,000 Mc. Standard waveguide techniques are readily adaptable to this type of dielectric.

Experimentally determined values of the dielectric properties are in good agreement with theoretical values, and the theoretical expressions are assumed valid.

134. A VIRTUAL SOURCE IN MICROWAVE OPTICS

Kenneth S. Kelleher
(Naval Research Laboratory, Washington, D. C.)

Many principles from optics can be carried over directly into the microwave field. One of these, the concept of a virtual source, is discussed in this paper. An electromagnetic horn, used as a real source, is placed in the neighborhood of an imaging reflector to produce a virtual source. The imaging reflector is so designed that as the horn moves at a uniform rate on a circular path, the virtual source moves at approximately the same rate on a nearly linear path. The reflector design is investigated by geometrical optics methods, as well as by an experimental arrangement utilizing parallel plates and a focusing objective.

135. EXPERIMENTAL PROTOTYPE OF THE RINEHART-LUNEBERG LENS

Ellen C. Fine
(Air Force Cambridge Research Laboratories, Cambridge, Mass.)

Propagation of electro-magnetic waves in the *TEM* mode between parallel conducting surfaces is along geodesics on the mean surface. The application of this principle by R. F. Rinehart to the derivation of the geodesic analogue to the Luneberg dielectric disk is reviewed.

The theoretical surface of revolution may be used in the design of a metal plate antenna, by the addition of a toroidal bend or conical skirt termination.

Experimental results are presented for a thirty-six inch diameter model at 9,100 and 2,800 Mc. The radiation patterns exhibited uniformly good characteristics for all positions of the feed on the periphery.

136. PROPAGATION OF MICROWAVES BETWEEN PARALLEL CONDUCTING SURFACES

K. S. Kunz
(Case Institute of Technology, Cleveland, Ohio)

The propagation of microwaves in the *TEM* mode between parallel conducting surfaces filled with a medium of varying index of refraction, n, is along rays that minimize the optical path length along the mean surface. Since the optical path length is determined both by the index n and the curvature of the mean surface, there is always a family of surfaces with equivalent focussing properties. Two important cases are: (1) a flat surface with variable n; (2) a curved surface with $n=1$ everywhere. The latter permits one to construct practical analogs of devices requiring a variable index of refraction.

137. PHASE SHIFT OF MICROWAVES IN PASSAGE THROUGH PARALLEL-PLATE ARRAYS

D. J. Epstein
(Laboratory for Insulation Research, Massachusetts Institute of Technology, Cambridge, Mass.)

The phase shift experienced by a normally incident wave in its passage through a parallel-plate slab has been measured for slabs of various thickness and plate-spacing. A range of thickness $\lambda/4$ to 4λ has been covered, and the plate spacing has been varied from 0.66λ to 0.96λ. Measurements were carried out at various frequencies in the *K*-band range using an interferometer technique. The experimental results exhibit general agreement with the theory of Carlson and Heins. The slight discrepancy which does exist appears due to the finite thickness (0.020 inch) of the plates used.

Radar and Radio Navigation

J. A. Pierce, *Chairman*
(Harvard University, Cambridge, Mass.)

138. ON THE MEASUREMENT OF THE RADAR ECHOING AREAS OF CONDUCTING BODIES

J. R. Mentzer
(Ohio State University Research Foundation, Columbus, Ohio)

In this paper, various aspects of the technique of measurement of radar areas by means of models are discussed. These include the following: (1) Means of measuring the absolute sensitivity of a continuous-wave reflection measuring system, and (2) a discussion of a theoretical and experimental determination of the scattering properties of finite cylinders of infinite conductivity in an incident plane-wave field.

139. POLARIZATION PROPERTIES (TARGET REFLECTIONS

E. M. Kennaugh
(Ohio State University Research Foundation, Columbus, Ohio)

The dependence of radar echoing ar upon antenna polarization may be utilized three ways: (1) to improve target echo r sponse, through increased echo area and r duction of echo area fluctuations; (2) to di criminate against undesired targets l proper choice of polarization; and (3) identify classes of targets by their polariz tion characteristics. A method of represen ing the polarization transforming properti of radar targets by use of a polarizatio sphere is discussed. Echo areas become pr portional to chord lengths, and polarizatio transformations are defined by geometric operations. Applications to specific problem are made, using this simplified method analysis.

140. THE USE OF CIRCULAR POLARIZATION AS A MEANS OF REDUCING RADAR PRECIPITATION RETURN

Warren D. White
(Airborne Instruments Laboratory, Mineola, L. I., N. Y.)

Under the sponsorship of Watson Lal oratories, Air Materiel Command, a series experiments has been performed to evalua the effectiveness of circular polarization as means of reducing or eliminating precipit tion return from air search radar display Incidental to the experiments, considerab development was necessary on means fo producing a radar beam which was circu larly polarized throughout.

Results of the experiments are presente in some detail. Precipitation returns hav been reduced by as much as 30 db with onl 6- to 8-db loss on aircraft signals. Considera tion of the effect of ground reflections an other matters, however, limits the practica gain in aircraft to precipitation ratio t about 15 db.

141. AN ICW SYSTEM FOR DISTANC MEASUREMENT

J. Lyman, G. B. Litchford, and C. Grunsky
(Sperry Gyroscope Company, Great Neck, L. I., N. Y.)

The initial development of a method fo aircraft distance measurement using inter mittent continuous-wave phase compariso technique will be described. With this tech nique, a short (1/60th second) transmissio is made with a duty cycle of 1/3 per cent During this transmission, two low and high (1.2 and 18.6 kc) tone modulations are sen to a co-operating station from which dis tance is to be measured. The loop phase change which takes place on each modula tion is a coarse and fine measurement of the time of flight of the radio wave and hence a direct measurement of distance. By variabl frequency telemetering, distance informa tion is obtained at both co-operating sta tions, during the 1/60-second transmission period. The experimental system at 5,000 Mc requires 150 kc of spectrum for each group of aircraft.

Apparatus will be described and prob- lns concerning instrumentation and dis- ıy will be discussed.

2. EFFECTS OF VERTICAL RADIA- TION PATTERN ON OMNIRANGE- BEACON CHARACTERISTICS

S. PICKLES
ederal Telecommunication Laboratories, Inc., Nutley, N. J.)

A counterpoise was used with an omni- nge-beacon vertical antenna to reduce opagation toward the imperfect ground d nearby reflecting objects and to tilt the diation pattern upward to favor transmis- on to aircraft. Ground and flight measure- ents over a site that was not particularly od showed substantial improvement with counterpoise ten wavelengths in radius d little advantage with a shorter counter- ise of one wavelength. This indicated that antenna and counterpose located at a gh elevation will provide greater useful nge than the antenna alone near the ound in a region free of trees as was previ- sly considered best.

Nuclear Science

F. J. GAFFNEY, *Chairman*
(Polytechnic Research and Development Company, Brooklyn, N. Y.)

143. A DELAYED COINCIDENCE SCINTILLATION SPECTROMETER

F. K. MCGOWAN
(Oak Ridge National Laboratory, Oak Ridge, Tenn.)

A delayed coincidence scintillation spec- ometer is an instrument which measures e lifetime of metastable states of nuclei in the time region 5×10^{-10} to 10^{-4} sec., the ergy and type of radiation announcing the rmation of the metastable state, and the ergy of the radiation resulting from its de- y. An instrument employing anthracene osphor, 5,819 photomultipliers, wide-band nplifiers, fast coincidence circuits, linear nplifiers, and differential pulse-height se- ctors will be described in detail. Typical perimental results from an investigation of etastable states of nuclei decaying with illimicrosecond half-lives will be presented.

144. TIMING UNIT AND PULSE DEFLECTOR GENERATOR FOR FOR 145-INCH SYNCHRO- CYCLOTRON

E. M. WILLIAMS, C. H. GRACE, AND L. W. JOHNSON
(Carnegie Institute of Technology, Pittsburgh, Pa.)

The 145-inch Carnegie Institute of Tech- ology Synchrocyclotron employs an elec- ostatic beam deflector. This deflection sys- m requires a pulse of approximately 60 kv, 0 megawatts peak power, and 0.036 micro- cond duration. The pulse is timed to a action of a cycle of the radio-frequency ac- lerating voltage or with an accuracy of bout 0.01 microsecond. Details of the tim- g circuits, a novel cascade cavity-enclosed ydrogen-thyratron pulser and test results re described. Factors affecting timing ac- uracy are discussed in detail.

145. DESIGN AND CONSTRUCTION OF A BILLION-VOLT LINEAR ELECTRON ACCELERATOR

MARVIN CHODOROW, E. L. GINZTON, JOHN JASBERG, ROBERT KYHL, RICHARD NEAL, AND PAUL PEARSON
(Microwave Laboratory, Stanford University, Stanford, Calif.)

This paper concerns the design and construction of the first 80 feet of a 220-foot linear electron accelerator to produce billion-volt electrons. The accelerator operates at a frequency of 3,000 Mc, and the power is supplied by klystrons, each delivering 10 megawatts of pulse power, fed into the accelerator at intervals of ten feet. The klystrons are run as amplifiers to insure proper phase relations in the separate operating sections. Various components of the accelerator, and preliminary results will be described.

146. PRECISE MEASUREMENT AND REGULATION OF MAGNETIC FIELDS WITH RADIO-FREQUENCY TECHNIQUES USING NUCLEAR RESONANCE

H. A. THOMAS
(National Bureau of Standards, Washington, D. C.)

Protons in a water sample placed in a magnetic field H will absorb energy from a small radio-frequency coil surrounding the sample if the coil is excited at the resonance frequency, $fo = \gamma H/2\pi$ where γ is a known constant. This resonance phenomenon may be used to measure magnetic field strengths to an accuracy of one part in forty thousand and to regulate magnetic fields to within a few parts per million with relatively simple radio-frequency apparatus. This paper includes a brief discussion of the phenomenon and the radio-frequency techniques involved.

147. A HIGH-PRECISION MAGNETIC-FIELD MEASURING INSTRUMENT

R. W. KANE, E. C. LEVINTHAL, AND E. H. RODGERS
(Varian Associates, San Carlos, Calif.)

This paper will be concerned with the description of an instrument using the principles of nuclear induction designed to measure and control magnetic fields with a precision much greater than heretofore available. Essentially the technique reduces the problem of measuring magnetic fields to one of measuring frequencies.

Using these principles, fields have been controlled to 0.0002 per cent. Relative measurements of the field are possible to the same accuracy and the absolute value of a field in gauss can be determined to Bureau of Standards precision. The instrument can indicate field inhomogeneities as small as 0.003 gauss per cm and thus permits rapid shimming of magnetic fields to achieve large very homogeneous regions.

The design of the instrument will be described, and practical problems encountered and solved in its application will be discussed.

Television II

R. M. BOWIE, *Chairman*
(Sylvania Electric Products Inc., Bayside, L. I., N. Y.)

148. PARALLEL OPERATION OF VACUUM TUBES AT UHF TO OBTAIN HIGH TRANSMITTER POWER

W. H. SAYER, JR., AND ELLIOTT MEHRBACH
(Allen B. DuMont Laboratories, Inc., Passaic, N. J.)

In order to obtain a transmitter power output of 1 kw in the uhf television band (475–890 Mc) it has been found necessary to use multiple operation of low power tubes at this time. This paper describes methods of multiplexing triodes and tetrodes in coaxial-type cavities at these frequencies. A discussion of the design of these circuits mechanically and electrically will show the feasibility and simplicity of using multiple low-power tubes. Performance data of a transmitter operating at a 1-kw power level at 600 Mc are included. Slides showing details of mechanical construction of amplifiers and frequency multipliers will be shown.

149. AN ULTRA PORTABLE TELEVISION PICKUP EQUIPMENT

L. E. FLORY, W. S. PIKE, J. E. DILLEY, AND J. M. MORGAN
(RCA Laboratories, Inc., Princeton, N. J.)

A completely portable industrial television pickup equipment will be described. Utilizing the Vidicon photoconductive pickup tube, the equipment is completely self-contained, battery operated, and can be carried as a back pack with a hand-held or tripod-mounted camera, cable connected to the pack. An ultra-high-frequency transmitter serves to link the unit with its base over short distances. A sound channel is provided by pulse modulation at line frequency. A radio link in the opposite direction serves for issuing instructions and provides a means of transmitting a reference frequency for control of the synchronizing generator. The equipment will be demonstrated as a part of the paper.

150. THE TECHNIQUE OF DOT ARRESTING FOR TELEVISION TRANSMISSION USING DOT INTERLACE

K. SCHLESINGER
(Motorola, Inc., Chicago, Ill.)

The improvement of horizontal detail by dot interlace may be realized by applying synchronous sweep-velocity modulation to the line scan in both terminals. This dot-arresting technique may be assisted by some additional intensity modulation of the scanning beams.

The dot-arresting method is highly compatible in that it requires no modifications of equipment beyond the addition of synchronized dot-deflection.

The paper presents the theory of dot arresting and shows practical circuits for its application. A monoscope picture generator is used to test the performance of dot arresting as compared to straight horizontal interlace and conventional scanning. Several photographs are presented to report the results of these tests.

In conclusion, the application of dot arresting to color TV reception is discussed.

151. A SWEEP FREQUENCY METHOD FOR MEASURING THE TRANSMISSION-AMPLITUDE CHARACTERISTIC OF A TELEVISION TRANSMITTER

J. Ruston
(Allen B. DuMont Laboratories, Inc., Passaic, N. J.)

The method of measurement described enables the complete transmission-amplitude characteristic to be displayed on the screen of a cathode-ray oscillograph when the transmitter is operating under normal conditions of modulation. The relative response at any sideband frequency, above or below the carrier, can be measured directly on the oscillograph screen.

The equipment is relatively simple and can be conveniently assembled in a compact unit for routine transmitter testing or built into the transmitter as an aid in tuning.

Circuits IV—Amplifiers

J. R. Ragazzini, *Chairman*
(Columbia University, New York, N. Y.)

152. RF AMPLIFIER DESIGN FOR LOW NOISE FIGURE

R. Guenther
(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

Based on matrix algebra, a general amplifier theory is developed which permits the treatment of all types of amplifiers. Single-stage amplifiers, as well as cascade arrangements, are described. Impedance gain and noise figure are derived for the most common radio-frequency amplifier circuits. The noise figure is considered with emphasis on minimizing it and on comparison of different circuits. Graphs are given for determining the optimum noise figure and the associated amplifier characteristics for numerical calculations. The treatment includes the tube capacities which are not tuned out by the tuned circuits. Numerical examples demonstrate the use of the graphs for design purposes and in determining the absolute minimum of the noise figure of a particular tube and circuit.

153. HF AMPLIFIERS WITH DIRECT COUPLING

E. L. Crosby, Jr., and K. F. Umpleby
(Bendix Aviation Corporation, Baltimore, Md.)

This paper proposes the use of a type of direct coupling in order to further the presently important objectives of compactness, simplicity, and reliability in high-frequency amplifiers. This has been accomplished simply by the "removal" of a considerable number of components. The high-frequency intermediate-frequency amplifier and the radar video amplifier have been used in the study of this technique. An example of the design for a unit of each type is given in detail. It appears that circuits of these types are suitable for use in television receivers. Also described is a unit comprising an intermediate-frequency amplifier, detector and video amplifier having an over-all gain of 130 db, bandwidth of 3.2 Mc, and measuring $\frac{3}{8}''\times 2\frac{1}{2}''\times 4\frac{1}{4}''$. It is believed that a new order of compactness and reliability has been achieved in these amplifiers. The paper discusses the advantages and limitations of the method and an appendix treats of the effect of series reactance in the by-pass capacitors.

154. DISTRIBUTED AMPLIFICATION: ADDITIONAL CONSIDERATIONS

J. Weber
(U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md., and University of Maryland, College Park, Md.)

It is known that the input conductance resulting from transit time and cathode lead inductance often limits the gain-bandwidth product obtainable with distributed amplifiers. Several methods have been investigated for neutralizing this input conductance and their range of usefulness is discussed. These methods have been successfully employed in the design of an amplifier employing 6AK5 tubes. This amplifier has a 400-Mc bandwidth and is described. The neutralization affected the gain only slightly.

An investigation of power-distributed amplifiers has been made, and some of the results are summarized. It is convenient to employ long single-stage amplifiers as power amplifiers. Phase characteristic inequality imposes limits on the maximum realizable gain-bandwidth product, and relations are deduced for the allowable tolerances. The "power paradox" is discussed and explained with reference to plate dissipation requirements.

155. DISTRIBUTED AMPLIFICATION FOR PULSES

G. F. Myers
(Naval Research Laboratory, Washington, D. C.)

This is a discussion of broad-band distributed-line amplification as applied to the construction of a low-gain 100-Mc amplifier capable of producing a 100-volt video driving signal for a fast-sweep oscilloscope. Pulse amplification is the primary consideration and methods of saving power and simplifying the circuit will be discussed. Importance of tube selection and importance of selection of type of filter to be used will be illustrated. The underlying idea is simplicity and dependability in an amplifier that can readily be duplicated.

156. CATHODE-COUPLED CLIPPER RESPONSE

P. F. Ordung and H. L. Krauss
(Yale University, New Haven, Conn.)

This paper discusses the factors affecting the speed of response of the cathode-coupled clipper circuit when it is driven by essentially rectangular pulses. The effect of various circuit capacitances on the output wave form is demonstrated. The transient build-up time for the circuit tested is shown to b approximately 50 millimicroseconds, inc cating that sine waves with frequencies high as 10 Mc could be clipped with fa wave form. Oscillograms of the various vol ages present in the clipper circuit are give

SYMPOSIUM

Telemetering System

(Organized by Professional Group on Telemetry and Remote Control)

W. J. Mayo-Wells, *Chairman*
(Applied Physics Laboratory, The Joh Hopkins University, Silver Spring, Md.

157. TELEMETRY AND THE GUIDED-MISSILE PROGRAM

C. H. Hoeppner
(Raytheon Manufacturing Company, Waltham, Mass.)

The use of mobile telemetry in the guide missile program is presented in its gener aspects. Methods by which data are gene ated, transmitted, received, recorded, ar reduced are discussed. The progress mac during the last decade, the diversity of d velopments, and the standardization pro ress of the Research and Developme Board are presented as historical backgrour to present-day test-range procedures. Tl problems encountered in present telemete ing developments and general principles operation which must be applied are ou lined. A number of the newly develope equipments together with their salient fe tures are discussed.

158. FM/FM TELEMETRY

M. V. Kiebert, Jr.
(Ramond Rosen Engineering Products, Inc Philadelphia, Pa.)

FM/FM telemetering systems are de scribed with general circuit details of bot the transmitting and receiving ends of th link outlined. Both high-speed and lov speed sampling with associated data prese vation are delivered and described as t analysis techniques. Magnetic data storag and associated problems are briefly ou lined. General design criteria for syste linearity and signal-to-noise requiremen for a given accuracy under a given conditio are outlined. The basic design of critic transmitting and receiving system elemen such as subcarrier oscillators and discrim nators are outlined along with some of th design problems associated with each ele ment.

159. TECHNIQUES AND APPLICATIONS OF FM/FM TELEMETRY

W. J. Mayo-Wells
(Applied Physics Laboratory, The John Hopkins University, Silver Spring, Md.)

Realizing the impossibility of doin justice to any one technique or applicatio of the FM/FM system to radio telemetr programs, it has been thought better to pro vide a guide to the present trends in thi field.

Such problems as commutation and de commutation, magnetic recording, and au matic data analysis will be discussed and ogress noted.

A second paper, by another user, will ovide a description of the subassemblies d some of the presently used receiving stan equipment, so only techniques for esblishing a near 100 per cent reliability of lemetering airborne subassemblies will be scribed in this paper.

160. THE CASE FOR PWM/FM TELEMETRY

J. R. Kauke
(Douglas Aircraft Corporation, Santa Monica, Calif.)

A versatile telemetering system employg time-division multiplexing is described. This system has not been employed dely in the past, but as a result of its sucssful use it is growing in popularity and ay be adopted as an alternative to the DB standard FM/FM system.

The method of operation is described in tail and its capabilities are stated.

The signals may be recorded at the reiving station either on magnetic tape or m, and monitored visually on an oscillope. The system, though limited to a modate data rate, offers advantages of operaonal simplicity, low cost, and small size. It is the further unique advantage of efficient itomatic data reduction.

161. PTM TELEMETRY

A. H. Nelson
(General Electronics Laboratories, Inc., Boston, Mass.)

The properties of various types of pulsene modulation are discussed and comred. The advantages of PTM for high-caicity telemetering applications are outed. An historical review of the developent of PTM telemetering for missile apications is presented. Various PTM sysms are briefly described with special emasis on system techniques. Results of ght tests on some equipments are noted. he limitations of PTM are discussed and e potentialities of this type of modulation r future development in telemetering apications are assessed.

Microwaves IV—Antennas and Artificial Dielectrics B

H. A. Zahl, *Chairman*
(Signal Corps Engineering Laboratories, Fort Monmouth, N. J.)

62. THE HALF SPACE AS A SPHERICAL TRANSMISSION LINE

L. Felsen and N. Marcuvitz
(Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

The virtue of a spherical mode analysis of e far electromagnetic field in a half space cited by a small slot in an infinite plane is scussed. If the slot is rectangular and fed y a rectangular wave guide propagating the $_{10}$ mode, it is shown that the far field in the alf space can be closely approximated by ree spherical modes. Since the dominant (dipole) mode carries practically all the radiated power, the half space is considered as a single-mode transmission line, and the equivalent circuit for the slot coupling the rectangular guide to the spherical guide is computed analytically and measured experimentally. Results are compared. The equivalent circuit can be utilized to determine the impedance properties of obstacles in the half space.

163. THE CALCULATION OF PROGRESSIVE-PHASE SHAPED-BEAM ANTENNAS

Allen S. Dunbar
(Stanford Research Institute, Stanford, Calif.)

The critical examination of the diffraction integral for the progressive-phase antenna having both nonuniform phase and amplitude distributions leads to certain conclusions regarding the shape of the diffraction pattern. A method, which is a generalization of the energy principle formulated by Chu, is described for the calculation of a progressive-phase antenna to produce a specified shaped pattern from an assumed amplitude distribution. Specialization of the diffraction integral shows that beam shaping may be achieved by controlled variation of the amplitude alone, and several trial functions are examined. Some conclusions regarding curved progressive-phase antennas are given. Experimental data in support of these results are presented.

164. PHYSICAL LIMITATIONS ON MINIMUM SIDE LOBES IN BROADSIDE ARRAYS

J. Ruze
(Air Force Cambridge Research Laboratories, Cambridge, Mass.)

The side-lobe radiation of antenna arrays may be reduced by properly tapering the current distribution. It is possible to choose the side-lobe level as low as desired and great side-lobe suppression is obtained without an excessive loss of antenna gain. However, as the permitted side-lobe level is decreased the antenna currents must be maintained ever more precisely to realize this low radiation.

A theory will be presented relating the distribution of side-lobe magnitude as a function of current precision, and of the size of the array. Further laboriously computed pattern data will be compared with the simpler statistical predictions.

165. THE BEHAVIOR OF MICROWAVES IN FOCAL REGIONS

Francis J. Zucker
(Air Force Cambridge Research Laboratories, Cambridge, Mass.)

While geometric optics is of great usefulness in the design of microwave radiating systems, it is well known that it does not suffice for the description of phenomena on the border of the geometric shadow and in the neighborhood of foci and caustics.

The present discussion extends the work of Debye, Picht, and others in describing diffraction effects in focal regions. A fairly complete description is given of amplitude, phase, and energy relations near a geometrical focus. The exact transition from the geometric to the wave picture is exhibited for microwave systems with and without aberration.

166. A MICROWAVE SCHMIDT SYSTEM

H. N. Chait
(Naval Research Laboratory, Washington, D. C.)

A novel antenna system having good wide-angle characteristics has been developed using the techniques of Schmidt optics. The far-field radiation patterns of this antenna system indicate that it is possible to sweep a 3° beam through plus or minus 10 beamwidths with a side-lobe level of 19 db or less, and a maximum loss of 2 db in antenna gain. The antenna consists of a horn feed, a circular reflector, and a Schmidt-type lens to correct for the aberrations of the reflector. The off-axis performance of this system has been studied both experimentally and theoretically. The conformance of the Schmidt with the Abbe sine law and the location of the minimum circle of confusion are also discussed.

Audio

B. B. Bauer, *Chairman*
(Shure Brothers, Inc., Chicago, Ill.)

167. A SINGLE-ENDED PUSH-PULL AUDIO AMPLIFIER

Arnold Peterson and D. B. Sinclair
(General Radio Company, Cambridge, Mass.)

An audio amplifier circuit for push-pull operation of two output tubes that provides a direct output to a grounded load is described. This circuit preserves the distortion cancelling features of push-pull operation but avoids any necessity for close magnetic coupling between halves of a split primary of an output transformer, and it simplifies the application of feedback from the output stage to preceding single-ended stages. Methods for using this circuit with triode and beam-power output tubes are given, and the ultimate possibility of eliminating the output transformer for driving a loudspeaker is discussed.

168. THE APPLICATION OF DAMPING TO PHONOGRAPH REPRODUCER ARMS

William S. Bachman
(Columbia Records Company, Inc., New York, N. Y.)

Large forces are developed at the stylus tip of a conventional phonograph reproducer arm due to excitation of the resonance of the arm mass with the suspension compliance. This paper presents an analysis of the problem and describes a reproducer arm design in which mechanical resistance is introduced in the pivots. By this means, control of the arm resonance is obtained without increasing the stylus tip impedance of the reproducer.

169. TRANSIENT TESTING OF LOUDSPEAKERS

O. K. Mawardi
(Harvard University, Cambridge, Mass.)

A transient technique for the testing of loudspeakers is presented. It is shown that a study of the response to a unit impulse function may reveal significant characteristics of loudspeakers. The results obtained by the present technique are shown to be in substantial agreement with the steady-state methods of measurements.

170. A PRACTICAL SPEECH SILENCER FOR RADIO RECEIVERS

R. C. Jones
(Polaroid Corporation, Cambridge, Mass.)

An automatic device will be described which sets a relay one way when the input is speech and the other way when the input is music. The device, termed an "automatic music-speech discriminator," may be used to silence the radio when the program material is speech, and not otherwise. When so employed, the device silences speech after one or two syllables and reactivates the speaker on the radio about one second after the last syllable of speech. The device will be demonstrated on speech, orchestral music, operatic music, and "singing commercials."

SYMPOSIUM

Nuclear Reactors

(Organized by Professional Group on Nuclear Science)

M. M. Hubbard, *Chairman*
(Massachusetts Institute of Technology, Cambridge, Mass.)

171. WHAT IS NUCLEAR ENGINEERING?

Alvin M. Weinberg
(Oak Ridge National Laboratory, Oak Ridge, Tenn.)

Since the discovery of nuclear fission, no useful mechanical energy has been extracted from uranium principally because of the many technological difficulties encountered, the lack of motivation, and the enormous economic backing necessary for such a development. The deteriorating post-war political situation has now supplied the motivation and the necessary economic aid. Consequently, the investigation of military requirements for atomic powered vehicles, more nuclear fuel, and more powerful bombs, is being expedited.

The situation is not hopeless. The world may regain its senses and return to peaceful ways when nuclear technology can be applied solely for peaceful uses.

172. THE REACTOR AS A RESEARCH TOOL

D. J. Hughes
(Brookhaven National Laboratory, Upton, L. I., N. Y.)

The chain reacting pile is extremely useful as a research tool because it produces high intensities of neutrons of a wide range of energies. The neutron flux (number of neutrons per cm^2 per second) available in research reactors is as high as 10^{13}. Many methods are used to select neutrons of particular velocities for specific measurements, such as mechanical shutters, crystal diffraction, and mirrors. The highest energy neutrons (about 10 million electron volts) are those emitted in the uranium fission and lower energies are produced by collisions of the fission neutrons with moderator nuclei (graphite or heavy water).

173. BACKGROUND RADIATION MONITORING FOR CONTROL OF AN AIR-COOLED PILE

Frederick P. Cowan
(Brookhaven National Laboratory, Upton, L. I., N. Y.)

Since small concentrations of radioactive argon are discharged from an air-cooled pile, radiation monitoring stations are desirable in the vicinity. Operation of the pile is based on the records of such stations and on meteorological predictions of atmospheric dilution. Detection devices utilized in the Brookhaven stations include several G-M counters, an ionization chamber with associated electrometer and a continuous dust monitor. Data is recorded photographically and on charts. Normal background amounts to about ½ mr per day on the ion chamber, 30 c/m on a thin glass-walled G-M tube 10 inches long and 15 c/m on a similar tube with 1½ inches lead shield. Peaks due to rainfall and the effect of snow cover are clearly apparent. Sizable peaks in natural dust activity are caused by temperature inversions. The apparatus has been in service for 2 years and has a data collection efficiency of 85 to 90 per cent. Only small increases in the average background beyond the BNL site boundary result from operation of the pile.

174. INSTRUMENTATION IN THE BROOKHAVEN NUCLEAR REACTOR

J. E. Binns
(Brookhaven National Laboratory, Upton, L. I., N. Y.)

The useful product of the nuclear reactor is neutrons; the unwanted byproducts are heat, dangerous radiations, and dangerous radioactive substances. Instrumentation has been provided for the measurement and control of these products and byproducts, as well as for the measurement of certain parameters used in the experimental study of the pile. Considerations of safety have received special attention.

Television III—Receivers

A. V. Bedford, *Chairman*
(RCA Laboratories Division, Princeton, N. J.)

175. SYNCHROFLECTION: A HORIZONTAL DEFLECTION SYSTEM POSSESSING INHERENT NOISE IMMUNITY

W. K. Squires and K. R. Wendt
(Sylvania Electric Products Inc., Flushing, L. I., N. Y.)

Contemporary television deflection output circuits require accurately timed driving wave shapes. Noise alters this timing, displacing the scanning lines. Factors contributing to this noise susceptibility and contemporary solutions are described. The noise susceptibility is largely dependent on the method of supplying energy to the deflection coils. The energy may be supplied so as to attain noise immunity. A simple circuit is described which does this. Advantages and limitations of experimental synchroflection circuits are evaluated. A practical system is described. Several circuit configurations are considered and measurements of their noise immunity given. Practical design formulas are developed. The use of a thyratron output tube is considered and a gas tube circuit having good performance and extreme simplicity is described.

176. INTERNAL TELEVISION RECEIVER INTERFERENCE

Bernard Amos and William Heiser
(Allen B. DuMont Laboratories, Inc., East Paterson, N. J.)

Interference resulting from harmonics of the video and sound intermediate frequencies will be described, and an analysis made of the video detector to show the approximate magnitude of these harmonics for representative television signals. An examination of intermediate frequencies in the 26-Mc region will be made to show the location of these harmonics, and to determine an optimum frequency to minimize the number of interfering signals. The reduction in the number of interfering harmonics when an intermediate frequency in the 41-Mc region is used, will be shown and an optimum frequency selected. Finally other means of eliminating any remaining harmonics will be described.

177. AN RF AMPLIFIER FOR THE UHF TELEVISION BAND

B. F. Tyson and J. G. Weissman
(Physics Laboratories, Sylvania Electric Products Inc., Bayside, L. I., N. Y.)

In the design of uhf television tuners it may be necessary to include an rf amplifier stage for improvement of noise figure and reduction of local oscillator radiation. This paper describes an experimental rf amplifier employing a Sylvania type 5768 disk-seal planar triode in a grounded-grid circuit. The amplifier is continuously tunable over the 475- to 890-Mc band and has a power gain of 15 times. When used ahead of a crystal mixer it improves the over-all noise figure by 3 to 4 db and substantially reduces the local oscillator radiation.

178. TELEVISION LINE SELECTOR WITH AUTOMATIC IDENTIFIER

Joseph Fisher
(Philco Corporation, Philadelphia, Pa.)

The television line selector is a device for observing the video voltage wave form of any scanning line in a frame interval. The oscilloscope presentation utilizes a slave sweep with a repetition rate of 30 cps and a sweep duration of 60 μsec. By means of a single control, any line in a television frame

ny be chosen for presentation. A circuit which automatically tracks the selector control identifies the signal being observed by means of a horizontal line on a built in picture tube. Special gating circuits have been incorporated to eliminate jitter. For the accurate measurement of transient response and sync signals a dot generator is incorporated for intensity modulation of the trace. Dots spaced as close as 0.05-μsec apart are available (30 dots per front porch interval).

In addition to its use in video analysis, this equipment has found application in the measurement of the frequency response of television cameras as affected by aperture distortion.

179. DEVELOPMENT OF A HIGH STABILITY UHF TELEVISION TUNER

M. W. Slate, J. P. Van Duyne, and E. G. Mannerberg

(Allen B. DuMont Laboratories, Inc., East Paterson, N. J.)

A tuner for the uhf television channels has been designed, using for both oscillator and rf tuned elements a modified type of semibutterfly circuit. For reasons both of stability and producibility both rotor and stator of these units have been fabricated of glass-bonded mica material, with silvered conducting surfaces.

A developmental 7-pin miniature version of the 6F4 has been used as an oscillator tube, covering the required range with good linearity and thermal drift characteristic. The mixer used has been a uhf germanium crystal diode, which has given reasonably low noise figures.

Over-all design considerations are reviewed, with particular reference to antenna, mixer and oscillator coupling, tracking, dial drive design, and shielding requirements.

Circuits V—Oscillators

W. N. Tuttle, *Chairman*

(General Radio Company, Cambridge, Mass.)

180. OSCILLATOR FREQUENCY INDETERMINANCY

Leon Riebman

(University of Pennsylvania, Philadelphia, Pa.)

This paper extends the theory of oscillators to include the effects of random noise. The oscillator is considered as a highly regenerative amplifier of the tube and circuit noise. A striking result is that no practical oscillator can produce a pure sinusoid, but rather an output over a continuous frequency spectrum.

This analysis shows the close relationship between lock-in range, local oscillator noise, and multifrequency operation.

181. SIMULTANEOUS OSCILLATIONS IN OSCILLATORS

Hans Schaffner

(University of Illinois, Urbana, Ill.)

An oscillator with two degrees of freedom can under certain conditions oscillate simultaneously at two different frequencies. The ratio of the two frequencies may be rational or irrational. For both cases, the conditions necessary for the existence of simultaneous oscillations will be discussed.

Such simultaneous oscillations may occur in high-frequency oscillators. In most cases, they are undesired and their suppression is, for example, one of the major problems in the construction of tunable klystrons. They may, however, also be used for the generation of very high frequencies through harmonic loading.

182. AMPLITUDE STABILIZATION OF OSCILLATORS BY NONLINEAR NETWORKS

Louis Rosenthal

(Rutgers University, New Brunswick, N. J.)

The amplitude of oscillators can be stabilized by means of networks that are nonlinear to the root-mean-square value of applied voltage. These networks consist of elements such as thermistors and lamps. An oscillating system can be broken down into an amplifier and feedback network forming a closed loop. The system statically adjusts itself so that

$$A\beta = 1$$

where A is the gain and β is the static feedback factor. The amplitude stability can be described as

$$\frac{dE}{E} = \frac{1}{1 + AS}\frac{dA}{A},$$

where dE/E is the per-unit change in amplitude corresponding to the per unit change in gain (dA/A). The factor S is the dynamic feedback factor or the slope of the nonlinear feedback characteristic at the operating point.

The nonlinear bridge and potentiometer as stabilizing networks are considered in detail, together with experimental observation.

183. STABILITY OF OSCILLATIONS IN A NONLINEAR SYSTEM

Norman R. Scott

(University of Connecticut, Storrs, Conn.)

Methods of nonlinear-mechanics, particularly those developed by Kryloff and Bogoliuboff, are used to investigate amplitude stability and frequency stability of generalized oscillator circuits. Analysis of an equivalent single-loop oscillator circuit containing a nonlinear negative resistance closed upon a resonant circuit permits determination of amplitude and amplitude stability. Criteria are developed for stability of simultaneous oscillations in multiply-resonant circuits. The method of Kryloff and Bogoliuboff yields no quantitative information about frequency stability, due to failure of convergence of the series representing frequency change, but it is shown qualitatively that reducing the second-order curvature improves frequency stability.

184. TUNED COUPLED CIRCUIT FOR OSCILLATOR APPLICATION

Roy A. Martin and R. D. Teasdale

(Georgia Institute of Technology, Atlanta, Ga.)

A steady-state analysis is given of an important double-tuned coupled circuit to determine the input admittance when the primary Q is high and the secondary Q is low. Particular emphasis is placed on the phase variation of the admittance with frequency. Dimensionless curves of magnitude and phase illustrate the effect of varying the coefficient of coupling and the secondary Q. Mathematical expressions are obtained for the points where the phase passes through zero and are used in a discussion of bandwidth.

SYMPOSIUM

Simulation as an Aid to Design of Remote Control Systems

(Organized by Professional Group on Telemetry and Remote Control)

C. H. Doersam, Jr., *Chairman*

(Special Services Center, Port Washington, L. I., N. Y.)

185. SIMULATION—ITS PLACE IN SYSTEM DESIGN

H. H. Goode

(Aeronautical Research Center, University of Michigan, Ypsilanti, Mich.)

The place of simulation in system design is developed in relation to all other steps in the design process. From this, the relation of simulation to both the analytical attack on the one hand and to a final operational system on the other is developed. The facilities for simulation are then broadly reviewed with a description of presently available analog and digital facilities. This leads naturally to the program to be followed in a simulation setup. In this discussion the pitfalls to be avoided are emphasized. Then simulation of a human link in a system is discussed. Finally, a critique of simulation is given with relation to cost, time, difficulty of execution, treatment of nonlinearities, and noisy inputs.

186. DETAILED SIMULATION OF A THREE-AXIS GUIDED MISSILE SYSTEM (TYPHOON)

A. W. Vance

(RCA Laboratories Division, Princeton, N. J.)

1. General description of the over-all system in block diagram form, including:
   a. The characteristics and limitations of Typhoon in computing the motion of a rigid body.
   b. Aerodynamic function generation characteristics of Typhoon.
   c. The characteristics and limitations of the guidance simulation equipment of Typhoon.
2. The results of the solution of a particular problem are given, with a discussion of the various data.
3. Methods used to avoid and evaluate errors are outlined as follows:
   a. Tests of components.
   b. Search for time lag errors by extension of the time scale.
   c. Comparison with test problems.

187. THE APPLICATION OF THE SIMULATOR TO THE DESIGN OF AUTOMATIC CONTROL SYSTEMS

LEO BOTWIN
(Sperry Gyroscope Company, Great Neck, L. I., N. Y.)

The use of the simulator for both theoretical analysis and design evaluation is illustrated by synthesizing a simplified automatic heading system that includes a ship and associated steering apparatus. After a frequency analysis of the system is made, it is placed on the simulator where setting up problems are considered. Responses for various ship configurations can be run off easily and rapidly. The design is evaluated by studying the actual controller together with the ship dynamics on the simulator. The system frequency response and controller linearity characteristic can be obtained using computer elements. The simulator can be used to determine the ship hydrodynamic coefficients from data obtained during actual field operation of the system.

188. REAL TIME SIMULATION OF FEEDBACK CONTROL SYSTEMS

ALBERT C. HALL
(Bendix Aviation Corporation, Detroit, Mich.)

The increasing complexity of automatic control systems is discussed and the need for augmenting presently available analysis techniques is pointed out.

The effective use of computing machines (simulators) to determine the performance of proposed designs, and methods of application are discussed. However, a more significant application of computing machines is in the development of design techniques. Here the computing machine is used to help the engineer evolve a philosophy of design which will lead to an optimum system. Methods of simplification in the study of complex systems are important, and computing machines are particularly useful here. The solution time of the simulator is significant in determining its scope. The dynamic properties of computing machines are discussed.

189. DIGITAL COMPUTERS IN SIMULATED CONTROL SYSTEMS

JAY W. FORRESTER
(Servomechanisms Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.)

Digital computers should be especially useful in simulating control systems where "logical complexity" excludes use of more conventional equipment. "Logically complex" systems have multiple courses of action which may result from human participation and decisions or from important nonlinearities and double-valued functions in physical equipment. Such circumstances may arise in training of personnel teams, developing military tactics, and studying systems such as air traffic flow which involve a number of relatively free but interdependent participants.

At the other extreme, the digital computer should be useful where generality of the machine and simplicity of setup readily permit simulation studies which would not justify constructing simpler, custom-made, special-purpose equipment.

Microwaves V—Generators and Amplifiers

E. W. HEROLD, *Chairman*
(RCA Laboratories Division, Princeton, N. J.)

190. LOW-DISTORTION FREQUENCY-MODULATION MODULATORS

A. R. VALLARINO AND C. GREENWALD
(Federal Telecommunication Laboratories, Inc., Nutley, N. J.)

The problem of generation of very-low-distortion frequency-modulated signals using high modulating frequencies has been solved by the use of microwave klystron modulators in conjunction with recently developed linearity indicators.

The solution centers on determining the most linear portion of the klystron characteristic by the use of the linearity indicator, as the klystrons are inherently very linear over certain ranges of their characteristics.

Throughout the microwave frequency range, distortions of better than 70 decibels with deviations of ± 1 Mc have been obtained. By the use of the heterodyne method, the carrier-frequency range has been extended downwards to 1 Mc with the same distortions.

191. 1,700- TO 2,400-MEGACYCLE TRIODE AMPLIFIER

E. M. OSTLUND AND H. G. MILLER
(Federal Telecommunication Laboratories, Inc., Nutley, N. J.)

This is a neutralized buffer amplifier with grounded-grid 2C39A triode, intended normally for isolating a mismatched antenna and long cable from a driving klystron. Wide tuning range and long-time stability are featured. Bandwidth is 20 Mc, power gain about unity. Power level 10 to 15 watts, plate efficiency about 22 per cent.

Neutralizing is accomplished by a variable loop coupling directly between input and output cavities, with series stub at one end. Neutralizing is adjusted for linearity of klystron frequency modulation in the presence of a frequency-sensitive load.

Input and output matching are accomplished by two slug coaxial tuners in conjunction with input cap and output fixed loop. The input cavity is a $\frac{3}{4}$ wave coaxial line, tuned by sliding short. The output cavity is a quarter-wave radial line tuned by radial slugs.

192. A *K*-BAND AMPLIFIER KLYSTRON

WAYNE G. ABRAHAM, JOHN W. CLARK, D. L. SNOW, AND S. F. VARIAN
(Varian Associates, San Carlos, Calif.)

Varian Associates type X-15 klystron amplifier tube will be described. This tube is a three-cavity *K*-band amplifier klystron with waveguide input and output which operates at a nominal frequency of 23,000 Mc. It has a power gain of 5 db and a power output of 50 milliwatts. The mechanical structure of the tube will be described and performance curves shown.

193. MODE INTERACTIONS IN MAGNETRON OSCILLATORS

R. R. MOATS
(Sylvania Electric Products Inc., Flushing, L. I., N. Y.)

The magnetron is described in terms of its properties as a feedback oscillator, to show that nonlinear circuit theory may be applied in discussing mode interactions. The interaction of modes in a nonlinear feedback oscillator with two resonances is considered and it is shown that when large amplitude oscillation associated with one mode of resonance is present, this oscillation tends to suppress oscillation associated with the other mode. These theoretical observations are supported directly by measurement of the loading effect of an oscillating mode in a magnetron upon small amplitude externally supplied oscillations in another mode. They are supported also indirectly by observation of the performance of several different types of magnetrons.

194. GUIDING PRINCIPLES IN PRODUCTION OF SUBMILLIMETER WAVES

H. VON FOERSTER AND J. S. SCHAFFNER
(University of Illinois, Urbana, Ill.)

n oscillators operating with frequency-defining resonators where each one obeys the wave-function

$$F_i(t) = \sum_{\nu_i} A_{\nu_i} \cos (2\pi \nu_i t - \phi_{\nu_i}{}^i)$$

can produce a radiation power of

$$P = \left[\sum_i^n F_i \right]^2.$$

This formula breaks up into two terms:

$$P = P_1 + P_2 = \sum_{i=k}^{n} \overline{F_i F_k} + \sum_{i \neq k}^{n} \overline{F_i F_k}.$$

The first term P_1 is always existent and reduces to nP_0, where P_0 is the power produced by a single oscillator. The second term P_2 describes an amount of coherency and vanishes by complete incoherency. The study of the region between complete incoherency ($P_2=0$) and complete coherency $P_2=(n^2-n)P_0$ leads to the discussion of an expression of the form

$$\sum_{\nu_i} \sum_{\nu_k} A_i A_k \cos (\phi_{\nu_i}{}^i - \phi_{\nu_k}{}^k).$$

Certain correlations between the phase-functions and the amplitude-functions define finally the value of P_2.

The application of these considerations to mass-radiators and a theory of high density electron bunches is discussed.

SYMPOSIUM

Loudspeakers

(Organized by Professional Group on Audio)

J. K. HILLIARD, *Chairman*
(Altec-Lansing Corporation, Hollywood, Calif.)

195. AMPLITUDE AND PHASE MEASUREMENTS ON LOUDSPEAKER CONES

M. CORRINGTON
(Radio Corporation of America, Camden, N. J.)

Amplitude and phase measurements ave been made of the mechanical motion at ifferent points on the cone diaphragm for arious critical frequencies. From these the use of various peaks and dips in the sound ressure curve can be determined. Such inrmation is helpful when making changes to nprove the cone design.

196. DESIGN ELEMENTS FOR IMPROVED BASS RESPONSE IN LOUDSPEAKER SYSTEMS

Howard T. Souther
(Electro-Voice, Inc., Buchanan, Mich.)

The history of the art is reviewed and a iort discussion of the current status engaged in. Ideals are posed, principally those ealing with range and distortion requireients.

Subjective requirements are suggested as elated to range response, power and distoron limits. Objective limits of driver units nd space are considered.

Comparative responses of flat baffles, solid enclosures, reflex boxes, horns, and especially folded corner horns are shown. The benefits of acoustic low-pass filters in connection with the last are exposed and equivalent circuits are disclosed.

The economics of low-frequency reproduction are discussed accompanied by construction hints and design data for the experimenter.

197. DIRECT RADIATOR LOUDSPEAKER MOUNTING

Harry F. Olson
(RCA Laboratories Division, Princeton, N. J.)

Variations in the response frequency characteristic of a direct radiator loudspeaker are produced by the resonance and diffraction effects introduced by the mounting arrangement. Variations in the response are also produced by the diffraction effects introduced by the outside configuration of the cabinet. Grills, screens, and cloths used as coverings for loudspeakers introduce variations in the response frequency characteristic due to the lumped acoustical impedance presented by these systems. Experimental data will be given to show the effect of these elements upon the response of direct radiator loudspeakers. Demonstrations will be arranged to show the effect of the mounting arrangement, cabinet and grill upon the response frequency characteristic of a loudspeaker.

198. PHYSICAL AND ELECTRICAL CONSTANTS OF DIRECT-RADIATOR LOUDSPEAKERS

L. L. Beranek
(Acoustics Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.)

This paper presents physical and electrical constants of direct-radiator type loudspeakers of a number of manufacturers. The application of these constants in the design of loudspeaker baffles will be discussed.

1951 IRE Convention Committee

Institute News and Radio Notes

Technical Committee Notes

The Standards Committee, under the Chairmanship of J. G. Brainerd, held a meeting on January 18. A proposed **Standards on Graphical Symbols for Single (one) Line Electrical Engineering Diagrams,** prepared by the **IRE Symbols Committee** in co-operation with **RTMA** and **ASA,** was presented to the Standards Committee. This Committee instructed its representatives on ASA Committees to vote for approval of the proposal. In two months, the Standards Committee will reconsider the proposal with additional material which will have become available. It will then be possible to standardize the use of symbols for publication by the IRE. . . . Arthur F. Van Dyck, the IRE Representative on ASA Sectional **Committee Z17, "Preferred Numbers,"** has written an article on this subject which was published in the February PROCEEDINGS. . . . J. R. Ragazzini will represent the IRE on the **ASA Sectional Subcommittee Z10.14, "Nomenclature for Feedback Control Systems."** . . . A meeting of the **Committee on Electron Tubes and Solid-State Devices** was held on December 8, under the Chairmanship of L. S. Nergaard. This Committee is again making preparation for the **1951 Electron Devices Conference,** to be held at the University of New Hampshire at Durham. H. J. Reich was appointed Chairman of the Conference for 1951. Complete details will be published as they are formulated. The Committee on Electron Tubes and Solid-State Devices is giving serious consideration to the formation of a Professional Group. . . . The **Circuits Committee** held a meeting on December 13. C. H. Page, Vice-Chairman, presided in the absence of the Chairman, W. N. Tuttle. Comprehensive reports on the activities of the various subcommittees were given by their respective Chairmen. . . . A meeting of the **Antennas and Waveguides Committee** was held on December 28, A. G. Fox, Chairman, presiding. The Committee has been concerned with examining the proposed **Standards on Receivers: Definition of Terms,** and has given particular attention to waveguide terms.

Program Announced For IRE National Convention

The complete program of the 1951 IRE National Convention (March 19–22), together with 100-word abstracts of the technical papers, appears on pages 292–315 of this issue. The program consists of: 210 papers presented at 43 sessions; the Radio Engineering Show comprising 267 exhibits; the Annual Banquet that this year is different from menu to program; the President's Luncheon with special tables for Professional Group members; and a "get-together" Cocktail Party in the world-famous Starlight Roof of the Waldorf.

The **Joint Technical Advisory Committee** held a meeting on January 9 under the Chairmanship of J. V. L. Hogan. The Committee approved the reprinting of a limited number of copies of JTAC, Vol. IV, and also the publication of a supplement to Vol. IV, copies of which have been sent to the Federal Communications Commission. Another volume, Vol. VI, has been prepared by the JTAC, and will be available within a short time.

Professional Group Notes

The Institute's Professional Groups are busy with plans for the **1951 National Convention,** as reported in these notes in the February issue. In addition to the symposia and technical meetings being arranged for the Convention, the following Group activities deserve notice in this column:

The **Committee on Professional Groups** held a joint meeting with the **Policy Development Committee** on January 11. The meeting was called at the instigation of the Policy Development Committee in order to discuss the broad question of publication policy as related to Professional Group activity, so that whatever recommendations might be worked out through such a co-operative meeting might be given to the Board of Directors. The members present adopted several suggestions which will be reported to the Executive Committee of the Board of Directors at its next meeting.

On January 9 the IRE approved a petition to form a **Professional Group on Airborne Electronics,** and appointed the initial Administrative Committee. Joseph General, John E. Keto, George Rappaport, and R. J. Shank will serve on the Committee for a three-year term; J. F. Byrne, Ludlow B. Hallman, Charles J. Marshall, and Paul G. Weigert will serve for a two-year term; and G. H. Arenstein, A. S. Brown, J. W. Heyd, and H. Krutter will serve for a one-year term. John E. Keto is the Group's Acting Chairman.

The **IRE Professional Group on Antennas and Propagation** is soliciting papers from its members for the regular joint spring meeting of the United States National Committee of the International Scientific Radio Union (URSI) and the Professional Group. The meeting will be held on April 16, 17, and 18, at the National Bureau of Standards in Washington, D. C., and will celebrate the semicentennial of the founding of the Bureau. Subjects of the technical sessions at this spring's meeting will be: radio propagation, noise, and antennas. Advance registration fee for the meeting will be $2.00 and will include the cost of the program and of the smoker on April 17.

The **Audio Professional Group** is currently conducting a Group-wide election for new officers and new members of the Group's Administrative Committee. Those elected will assume office on July 1, the officers for a one-year term and the new members for a three-year term.

Six hundred and thirty-five new members have been enrolled in the **Professional Group on Broadcast and Television Receivers,** which now has a total membership in excess of 900.

The **IRE Professional Group on Broadcast and Transmission Systems** has added more than 200 new members to its roster, as a result of a recent letter mailed to chief engineers of broadcast stations and of manufacturers of broadcast equipment. This brings the Group's membership to over 1,000.

As a result of the recent organization of the **Professional Group on Circuit Theory,** applications for membership in the Group have been accepted and the membership totals more than 1,200.

A highly successful Conference on High-Frequency Measurements, sponsored by the **IRE Professional Group on Instrumentation** in co-operation with the AIEE and the National Bureau of Standards, was held on January 10, 11, and 12 in Washington, D. C. Five hundred and forty-nine people attended the Conference and 315 people went on guided tours of four Government institutions. At the luncheon held in conjunction with the Conference, T. G. LeClair, President of the AIEE, and I. S. Coggeshall, President of the IRE, presented a scroll to E. U. Condon in commemoration of the fiftieth anniversary of the National Bureau of Standards. Abstracts of papers presented at the Conference appeared in the February issue of the PROCEEDINGS OF THE I.R.E.

The card announcing formation of the **IRE Professional Group on Radio Telemetry and Remote Control** which was mailed to members of the IRE in eight Sections has resulted in 125 applications for membership in the new Group to date, and more are being received each day.

Headquarters has received a petition for formation of a new **Group** in the field of **Industrial Electronics.** It is hoped that the Institute's Executive Committee may take action on the petition early in February. Eugene Mittelmann of Chicago is the Group's promoter.

Voice of America Announces Call for Radio Personnel

The Voice of America has announced continual vacancies now existing in New York City and overseas for experienced radio men, including studio, recording, field (remote pick-ups), maintenance and transmitter technicians.

Applications (Standard Form 57) should be sent to: U. S. Department of State, Personnel Branch, 250 West 57 Street, New York 19, N. Y.

Applicants are urged not to telephone, since the office is not equipped to supply data in answer to such calls.

Television Prize Award Donated by Zworykin

An IRE award has been donated by Dr. Vladimir K. Zworykin to be made annually for twenty times beginning in 1952, "to that member of the Institute, who in the opinion of the Board or its appointed Committee, either shall have made the most important technical contribution to electronic television during the preceding calendar year or the importance of whose contribution to electronic television shall have been realized during the preceding calendar year."

IAS Features Aviation Electronics Conference

A conference on electronics in aviation, sponsored jointly by IRE, IAS, and the Institute of Navigation, was held at the 19th Annual Meeting of the Institute of Aeronautical Sciences on February 1, at the Hotel Astor in New York, N. Y. The program included the following sessions:

Airborne Electronics

D. S. Little, *Chairman*, American Airlines, Inc.

"Problems of Standardization of Electronic Equipment for Aircraft"—Charles R. Banks, Aeronautical Radio, Inc.

"Packaging of Airborne Electronic Equipment"—Orville M. Dunning, Hazeltine Electronics Corp.

"Frequency Allocation for Aviation Electronics"—Edwin Lee White, Federal Communications Commission

Electronics and All-Weather Flying (A Symposium)

Col. J. Francis Taylor, Jr., *Chairman*, Wright-Patterson Air Force Base

Panel Members

Col. A. E. Key, U.S.A.F. Working Group No. 5 Air Co-ordinating Committee

D. S. Little, American Airlines, Inc.

B. R. Moore, Civil Aeronautical Administration

S. P. Saint, Air Transport Association

B. A. Denicke, Air Navigation Development Board

E. A. Cutrell, Air Line Pilots' Association

R. E. Laub, USN, Naval Air Test Facility

J. F. Gill, Air Transport Association

ECPD Report Now Available

Copies of the 18th Annual ECPD Report can now be obtained from the office of Engineers' Council for Professional Development, in the Engineering Societies Building, 29-33 West 39 Street, New York, N. Y., at 50 cents each. One of the most important items in this report is a list of 656 accredited engineering curricula in 142 engineering schools of the country, prepared by the ECPD Committee on Engineering Schools.

IEE Schedules Electrical Instrument Design Conference

The Committee of the Measurements Section of The Institution of Electrical Engineers has arranged a Conference on Electrical Instrument Design, to be held in The Institution Building in London from May 28 to May 30, 1951. The following topics will be discussed: "Trends in Modern Instrument Design and Construction," "The Limits of Measurement Present and Future," "Materials and Components," and "Techniques in the Field of Radiation."

Calendar of COMING EVENTS

1951 IRE National Convention, Waldorf-Astoria Hotel and Grand Central Palace, New York, N. Y., March 19–22

Joint Meeting of the Association for Computing Machinery and the Industrial Mathematics Society, Wayne University, Detroit, Mich., March 27, 28

URSI Spring Meeting, Washington, D. C., April 16–18

IRE Southwestern Conference, Dallas, Texas, April 20–21

1951 New England Radio Engineering Meeting, Sponsored by North Atlantic IRE Region, Copley Plaza Hotel, Boston, Mass., April 21

1951 Convention of SMPTE, April 30–May 4, Hotel Statler, N. Y.

1951 Annual Meeting of the Engineering Institute of Canada, Mount Royal Hotel, Montreal, May 9–11

1951 IRE Technical Conference on Airborne Electronics, Biltmore Hotel, Dayton, Ohio, May 23–25

IRE 7th Regional Conference, Seattle, Wash., June 20–22

1951 Summer General Meeting of AIEE, Royal York Hotel, Toronto, Canada, June 25–29

1951 IRE West Coast Convention, San Francisco, Calif., August 22–24

IRE Board of Directors Make 1951 Appointments

The IRE Board of Directors, at its meeting on January 10, 1951, made the following appointments to the Board for 1951: Secretary—Haraden Pratt; Treasurer—W. R. G. Baker; Editor—Alfred N. Goldsmith; Directors—Donald B. Sinclair, J. A. Stratton, and E. R. Piore.

URSI-IRE Spring Meeting to Be Held in Washington

The IRE Professional Group on Antennas and Wave Propagation and the United States National Committee of the International Scientific Radio Union (URSI) have scheduled their regular Spring Meeting for April 16, 17, and 18 in Washington, D. C. The sessions will take place at the National Bureau of Standards in recognition of the Bureau's semicentennial.

Administrative meetings will be held on Monday, April 16, and the technical sessions will be held on the following days. An inspection trip of the National Bureau of Standards is being arranged for the afternoon of April 16; an informal social evening will take place on April 17, when a summary of the Zurich General Assembly of the URSI will be presented.

Technical sessions, sponsored by the following four URSI Commissions, will be held on radio propagation, noise, and antennas:

Commission 2: Tropospheric Radio Propagation, Chairman, C. R. Burrows, Director of the School of Electrical Engineering, Cornell University, Ithaca, N. Y.; Commission 3: Ionospheric Radio Propagation, Chairman, Newbern Smith, Chief, Central Radio Propagation Laboratory, National Bureau of Standards, Washington, D. C.; Commission 4: Terrestrial Radio Noise, Chairman, J. C. Schelleng, Bell Telephone Laboratories, Deal, N. J.; and Commission 6: Radio Waves and Circuits, including General Theory and Antennas, Chairman, L. C. Van Atta, Research and Development Labs., Hughes Aircraft Co., Culver City, Calif.

Advance registration cards may be obtained from the Secretary, Newbern Smith, National Bureau of Standards, after March 1. The registration fee is $2.00 in advance or $2.50 at the time of the meeting.

Openings Announced for Engineers in California

Scientific and engineering positions in the field of electronics are now available in the following California laboratories: U. S. Navy Electronics Laboratory, San Diego; U. S. Naval Ordnance Test Station, Inyokern, China Lake; U. S. Naval Ordnance Test Station, Pasadena Annex, Pasadena; U. S. Naval Air Missile Test Center, Point Mugu; U. S. Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme; Institute of Numerical Analysis, National Bureau of Standards, Los Angeles.

Further general information may be obtained by writing to the Board of U. S. Civil Service Examiners for Scientists and Engineers, Navy Department, 1030 East Green Street, Pasadena 1, Calif.

IRE People

John B. Merrill (S'48–A'50) has been appointed a general manager of the tungsten and chemical division of the Sylvania Electric Products Inc.

John B. Merrill

Mr. Merrill has been with Sylvania since 1941, when the company purchased the fluorescent powder division of the Patterson Screen Company. In 1943, Mr. Merrill was appointed plant manager at Towanda and the activity was expanded to include the manufacture of tungsten in many forms.

He was named general manager of the tungsten and chemical division when it was created in October, 1945.

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Lawrence C. F. Horle (A'14–M'23–F'25), a former president of the Institute, died after a brief illness on October 28, 1950, at the Barnabas Hospital in Newark, N. J.

L. C. F. Horle

A native of that city, Mr. Horle received his degree in mechanical engineering from the Stevens Institute of Technology in 1914, where he stayed on as an instructor until 1916. During World War I he served as an expert radio aid for the Navy. His subsequent career included the following positions: chief engineer of the de Forest Radio Telephone and Telegraph Company, New York; consultant, Department of Commerce Radio Laboratory, Bureau of Standards, Washington; chief engineer, Federal Telephone and Telegraph Company, New York; and vice-president, Federal Telephone Manufacturing Company, Buffalo. His most important contributions to radio were in the field of standardization of terminology and ratings.

In addition to his long-standing affiliation with the IRE, Mr. Horle was chief engineer of the Radio and Television Manufacturers' Association. In 1948 he received the IRE Medal of Honor for his "contributions to standardization work, both in peace and war."

Donald L. Herr (SM'46), recently appointed head of the guided missile research and development section of the Hughes Aircraft Company, received one of the A. Cressy Morrison prizes for 1950, awarded to him by the New York Academy of Sciences for his paper on electromagnetics, and for his remarkable work in the field of engineering.

The winner of numerous prizes and awards as a student at the Moore School of Electrical Engineering, Mr. Herr maintained an exceptionally high standing in his graduate work as National Tau Beta Pi Fellow and MIT Scholar at the Massachusetts Institute of Technology. He is to receive the doctorate this spring from the Polytechnic Institute of Brooklyn, where he has been an adjunct professor in electrical engineering.

He has been associated with the Bell Telephone Laboratories, the RCA Manufacturing Company, and the General Electric Company in Schenectady, N. Y. Having served for two and one-half years in the Navy as Officer-in-Charge of the Electrical Minesweeping Section of the Bureau of Ships, he received two commendations for his outstanding work, and was named Prize Essayist of the American Society of Naval Engineers in 1945. After World War II Mr. Herr held a prominent position in the Control Instrument Company in Brooklyn, N. Y., and then became a senior engineer of the Reeves Instrument Company in New York, N. Y., where he was responsible for the development of two new analogue computers and the development, design, and large-scale production of new, high-precision analogue computer components. He is the author of more than twenty-five articles, which have appeared in all the principal technological publications.

Mr. Herr is a Fellow of the New York Academy of Sciences, Honorary Member of the American Society of Naval Engineers, member of the American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Ordnance Association, and American Association for the Advancement of Science. He is a past member of the Institute of Aeronautical Sciences, American Mathematics Society, and the American Physical Society. Mr. Herr is also a member of Sigma Xi, Tau Beta Pi, Sigma Tau, Eta Kappa Nu, Pi Mu Epsilon, Delta Phi Alpha and Hexagon Honor Societies, and he appears in *American Men of Science*.

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David R. Hull (A'36–F'47) has been elected by the directors of the Raytheon Manufacturing Company as a vice-president. Captain Hull, U.S.N. (retired), has been assistant manager of the equipment divisions of the company.

Donald B. Harris (SM'45) has been appointed technical assistant to the president of Airborne Instruments Laboratory, Inc., Mineola, L. I., N. Y. Formerly he was executive assistant to the director of research of Collins Radio Co., Cedar Rapids, Iowa.

Donald B. Harris

Mr. Harris, who is the new assistant to **Hector R. Skifter** (A'31–M'36–SM'43), was graduated from Yale University with the B.A. degree in 1922. He was associated with Northwestern Bell Telephone Co. for 23 years, with time out for war assigned duties.

As a member of the National Defense Research Committee, Division 15, Mr. Harris was the principal technical aide at Harvard University's Radio Research Laboratory. During the war he was also a member of three Joint Chiefs of Staff committees where, as at Harvard, he was closely associated with AIL personnel. He concluded his affiliation with Northwestern Bell Telephone as transmission and protection engineer in the Iowa area.

Mr. Harris, who was formerly Chairman of the Cedar Rapids Section of the Institute, has published five papers, and holds or has pending 12 patents. He is a member of the IRE Board of Editors. He belongs also to the American Physical Society, and the American Association for the Advancement of Science.

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Isaac L. Auerbach (S'46–M'49) has joined the staff of the Research Division of Burroughs Adding Machine Company in Philadelphia as a research engineer.

Isaac L. Auerbach

He received the degree of B.S. in electrical engineering from the Drexel Institute of Technology in 1943. Following his graduation he served in the Navy with the Naval Research Laboratory as a radio engineer. He received the degree of M.S. in applied physics from Harvard University.

Prior to joining Burroughs he was senior engineer of design, development, and production at the Eckert-Mauchly Computer Corporation, and engineer in charge of the tube division of the Electronic Tube Corporation. He published a paper recently on the packaging of electronic systems.

He is a member of the Association for Computing Machinery, Eta Kappa Nu, and an associate member of the American Institute of Electrical Engineers.

ndustrial Engineering Notes[1]

:ontrols

The National Production Authority is-ued an order recently establishing a ceiling n the number of defense rated orders that ıanufacturers are required to accept for cer-ain electronic components and parts. Its urpose, NPA explained, "is to prevent un-ecessary disruption of distribution to civil-ın users by equalizing the distribution of efense orders among the electrical com-onent and parts manufacturers." . . . NPA dministrator William H. Harrison stated ecently that his agency planned no direct ction affecting color television. Mr. Harri-on was replying to a week-end telegram rom Frank Stanton, CBS president, who ıas asked for a conference with NPA officials o discuss a resolution in which a group of vholesalers urged NPA to prevent color elevision production. . . . Complete alloca-ion of cobalt, effective February 1, was or-lered by the NPA, and the over-all provi-ion of cobalt for civilian uses in January vas limited to one third the amount of co-alt consumed in January, 1950. This is a harp cut under the 50 per cent allowed in December. Beginning February 1, every ourchase of more than 25 pounds of the trategic material requires NPA approval. Defense and essential civilian production will require almost the total available sup-ply of cobalt, NPA said in issuing an order which places cobalt under allocation, pro-iibits certain uses, and limits inventories. This order is designed both to meet defense requirements and to distribute equitably the remaining supply through normal channels to essential civilian uses. Provision is made in this connection, NPA added, for the needs of new and small businesses. . . . NPA is-sued an order designed to conserve cadmium for defense and highly essential civilian needs, but listed certain electronic com-ponents for which cadmium may be used under specific limitations. Included in the list of cadmium-containing items which may be produced under the new order are: copper-base alloys containing not more than 1½ per cent cadmium for parts inside electronic tubes, resistance welding elec-trodes, multistrand railroad signal bond wire, and shunt wire leads for motors and generators; low melting point alloys for dry-type rectifier elements, fire protective sys-tems, safety devices, electrical fuzes, dental use, and inspection gauges.

TV Picture Tube Production Continues at Peak in November

Production of television tubes in Novem-ber continued at its peak fall rate, running slightly above October. A total of 851,872 cathode-ray tubes were sold to equipment manufacturers in November, and 914,804 were produced for all purposes. Approxi-mately 98 per cent of the tubes sold to set makers were 16 inches or larger, and more than 60 per cent were of the rectangular type.

[1] The data on which these NOTES are based were selected, by permission, from *Industry Reports*, issues of December 1, December 21, December 29, January 5, and January 12, published by the Radio-Television Manufacturers Association, whose helpful attitude is gladly acknowledged.

New Mica, Asbestos Insulation Developed by Naval Laboratory

The Naval Research Laboratory has an-nounced development of two improved elec-trical insulating materials: a mica paper, and domestic asbestos from which impurities are removed by new methods.

The mica paper, the Navy said, is ex-pected to find its greatest application in electrical condensers. The new product "will stand intense heat and is stronger and has greater capacitance than kraft papers," according to a Navy report.

In the asbestos development, the Navy moved to reduce the dependance upon for-eign fibers and developed a procedure in-volving wetting of asbestos fibers instead of the conventional air-fluffing or screening method of cleaning.

Industry Statistics

Television manufacturers shipped 5,661,-000 television sets to dealers in 36 states and the District of Columbia during the first ten months of 1950, according to RTMA reports. RTMA's estimates represent ship-ments by nonmembers as well as Associ-ation members. Sales to dealers in October, 1950, are estimated at 781,000, compared with 928,000 sets shipped in the preceding month.

FCC Actions

The FCC recently adopted its rule-making proposal to permit remote control operation of low-power noncommercial FM broadcast stations under certain conditions. The FCC ruling became effective on Janu-ary 25, 1951. This should be helpful to non-profit educational stations which work on small budgets and cannot employ licensed operators for remote control operation, the FCC said.

Mobilization

Secretary of Defense George Marshall recently directed the Secretaries of the Army, Navy, and Air Force to spread con-tracts across industry as widely as possible. This action is intended to broaden the scope of the military procurement program, and to take up the slack in industries now facing cut-backs because of material shortages.

Officials believe that the new policy, in-cluding more extended use of negotiation in contract letting, will result in military busi-ness for a greater number of electronic manu-facturers. This can include television set producers who have not been able to obtain military contracts.

Possible changes in military electronic specifications to conserve critical mate-rials were discussed during a three-hour formal conference between officials of the NPA Electronics Products Division and Captain Henry E. Bernstein, Director of the Armed Services Electro Standards Agency.

The meeting, which was also attended by a representative of the Electronics Pro-duction Resources Agency and a Signal Corps officer, was called with the view of exploring possible methods of changing JAN specifications to conserve scarce metals. A survey will be conducted among the military agencies on possible changes.

At the same time, NPA officials empha-sized to RTMA that the agency will assist industry engineers in obtaining scarce metals to be used in substitution for other metals, which are more scarce, as the result of new developments in their conservation pro-grams.

Defense Department Requests Law To Control Magnetic Radiations

The Department of Defense has asked Congress to enact a law which would enable the President to control all types of electro-magnetic radiations, including radio and TV stations, which might be used to guide an enemy plane or missile in an attack on the United States. A suggested draft of the proposed bill was submitted to the Armed Services Committees of Congress.

The purpose of the proposed legislation, the Department said, is "to provide the necessary Executive authority to control electromagnetic radiations, not only during hostilities or a proclaimed emergency, but also during time of strained international relationships when a surprise attack on the United States is a possibility." This control would extend to anything "capable of emitting electromagnetic radiations between ten thousandths and one hundred thousand (0.010–100,000) megacycles per second" to the extent he deems such control necessary to safeguard the country.

Current concepts of warfare and recent experience, Defense officials said, demon-strate the necessity to control electromag-netic radiations in the United States, its territories and possessions, during periods of critical international relationships, for the purpose of denying their use to a poten-tial enemy for navigation of piloted or pilot-less aircraft or missiles directed towards targets in the United States.

Signal Corps Announces New Radios Are Under Production

The Signal Corps has announced that "more flexible" and "faster" communication will be brought to the battlefield by a new series of radio sets now in production which are expected to be issued to troops early this year.

The new sets, when connected together in various combinations, produce a variety of completed sets, the Signals Corps said. Thirty different radio sets can be obtained by varying the combinations in the manner of "building blocks."

Applications of this "building block" principle not only makes for flexible com-munications, the Signal Corps explained, but also for economy in procurement. The blocks are manufactured separately, and are de-signed primarily for vehicular use, but may be readily modified with a field kit and used on the ground.

Radio Pioneers—Attention!

This notice is for the information of members of the Institute who are qualified and wish to join the Radio Pioneers but who lack information concerning it. Originally formed in 1942 as the Twenty Year Club, the purposes of the organization are:

> "To establish a membership organization of persons who by their long years of service in the field of Radio desire to become associated for the purposes of friendship and education. The Club shall be a central clearing house for the exchange of information and historical data about the radio industry and shall record in form to be determined facts and data about the history of the radio industry and its traditions for use by this and future generations. It is felt that this organization with the resultant exchange of information would make a valuable contribution to the public interest."

As outlined in the constitution, the purposes are broad enough to enable the Radio Pioneers to undertake almost any task which the Club may desire for the furtherance of the radio industry.

Nineteen hundred and fifty marked the establishment of a Radio Hall of Fame in which the memories of men and women whose contribution have placed them among the immortals will be perpetuated. The first of such awards went to Thomas Alvah Edison. All members are entitled to submit their choice will be voted upon by the committee.

In 1950 the Radio Pioneers inaugurated the radio oral history project which has been undertaken by Columbia University's oral history project, under the direction of Allen Nevins. This vast project will set up a source of material which will be available to all future historians of the industry, or to those writing books which dwell on some phases of radio. The plan is to obtain recorded interviews of outstanding men and women who have pioneered in radio, engineers as well as those in other branches. It is felt that soon many of these will no longer be available for first-hand information. All members are encouraged to send in early anecdotes and "firsts" with which they were connected or concerned.

The requirements for membership are that a prospective member be in good standing, and have served the radio industry for 20 consecutive years or more at the time of making application for membership.

H. V. Kaltenborn, noted commentator and author, is the founder of the Pioneers; this came about when NBC gave him a dinner on April 4, 1942, to commemorate his 20th year in radio. The small original group has grown to more than 600 during the past eight years, particularly during the two years just passed. Officers include: Frank E. Mullen, board chairman of Jerry Fairbanks (TV) Productions, Hollywood, President; Honorary Presidents, David Sarnoff and Lee De Forest; 1st Vice-President, Orestes H. Caldwell; 2nd Vice-President, Arthur B. Church (KMBC, Kansas City); Vice-President and Secretary, Paul W. Morency (WTIC, Hartford); Vice-President and Treasurer, Carl Haverlin (BMI).

Plans are in process to form local chapters in other cities to promote friendship and social intercourse among the pioneer radio fraternity. New members have an opportunity to participate actively in the formation of their local chapters.

Radio Pioneers issues a bulletin periodically, and whenever feasible, an annual membership roster including short biographical sketches of each member.

The Club holds an annual election of officers at a meeting and banquet each April in New York, and during the past year four luncheon meetings have been held by the membership. Membership meetings have been addressed by such men as Herbert Hoover, David Sarnoff, FCC commissioners, Charles F. Kettering, and others.

Membership dues in the Pioneers are $10 annually. The initial cost is $15 of which $10 is for dues and $5 for silver lapel pin of Pioneers insignia. On this occasion the $10 initiation fee is being waived.

If you are eligible, and wish to join, please send for an application blank to Carl Haverlin, Broadcast Music Inc., 580 Fifth Avenue, New York, N. Y.

Books

Essentials of Electricity for Radio and Television by Morris Slurzberg and William Osterheld

Published (1950) by Whittlesey House, McGraw-Hill Book Co., Inc., 330 W. 42 St., New York, N. Y. 475 pages+16-page index+xi pages+354 figures 6×9. $5.00.

This text presents elementary background material on the essentials of electricity as will be required by radio amateurs or students in high school or trade school. It should also prove useful to laboratory assistants and technicians employed in the power or communications industry. It is not suitable, nor is it intended for use by the professional engineer. It is not particularly slanted towards radio, most of the material being common to all electrical engineering, and electron-tube material being very scarce.

Introductory comments are presented on communications during which the need for knowledge of electricity is pointed out. The text follows with some elementary physics of static electricity and discussions of batteries; simplicity often requires that the true situation, too complex for discussion, be greatly compromised. Typical are such statements as "a second factor that affects the capacitance is the thickness of the dielectric, because if its thickness is reduced, fewer distorted electron orbits will oppose the electrostatic field. This results in a greater number of electrons being stored in the conductor, which increases the capacitance" (page 310). Also, the pass-characteristic diagrams of Article 12.2 present an interesting idea which probably is at once helpful to the nondiscerning reader, and confusing to the discerning one. These diagrams show the usual amplitude-versus-frequency curve; however, the area of the diagram below the curve is differently shaded from the remaining area. The area is entitled "frequency band passed," the latter area is entitled "frequencies eliminated."

Simon Ramo
Hughes Aircraft Co.
Culver City, Calif.

Operational Calculus by B. Van der Pol and H. Bremmer

Published (1950) by Cambridge University Press, 51 Madison Ave., New York 10, N. Y. 409 pages+3-page index+xiii pages. 97 pages. 97 figures. 6×10. $10.00.

The use of the Laplace Integral for the solution of problems rests upon the advantage that discontinuous functions of a real variable are transformed to functions of a complex variable which are analytic and may be readily handled. The final solution of the problem depends upon a table of functions and their transforms for the recognition of the original function to which the transformed function arrived at corresponds.

In this book the operational calculus is based on the two-sided or, more usually expressed, bilateral Laplace Integral (taken between minus infinity and plus infinity), contrary to the usual practice where the lower limit is taken as zero. The authors claim for this choice that thereby the class of functions suited to an operational treatment is larger, the transformation rules are simplified, and the whole treatment may be made more rigorous. Multiplication of the given function by the unit function reduces the bilateral integral to the type of problem where a driving force is applied suddenly or a switch is closed. Here, the lower limit becomes zero.

The first half of the book deals with fundamental principles and the establishment of general rules, and the second half, with a variety of applications. An unusual chapter deals with the application to Bessel functions and Legendre functions and developments, not only familiar fundamental relations, but others which are less well known.

The book was written with the pure mathematician especially in mind. The endeavor has been to give the operational calculus a rigorous mathematical basis. Illustrative examples are, for the most part, taken from pure mathematical, rather than technical fields.

The authors have indicated sections of the book which, taken together, form an alost complete course for the "practical" an. However, in the opinion of this reviewer, the engineer may more profitably otain a first course from a more elementary ook in order to appreciate the wealth of aterial in this advanced and scholarly ork.

Attention should be directed especially the compendious list of original and ansforms pairs in the "dictionary" at the nd of the book.

FREDERICK W. GROVER
Union College
Schenectady, N. Y.

he Anatomy of Mathematics by R. B. ershner and L. R. Wilcox

Published (1950) by The Ronald Press Co., Inc., 5 E. 26 St., New York 10, N. Y. 364 pages+44-page ppendix+6-page index+xi pages. $6.

This reviewer has found this a truly deghtful text. It deals with the axiomatic ethod in mathematics. Much of the subject aterial is that dealt with in treatises on odern algebra, e.g., the theory of sets, roups, and fields is developed from the tandpoint of illustrating the logical strucure of mathematics. The development is uch less terse than that customarily enountered in algebraic treatises, a considerale amount of time and effort being devoted o discussion of the logical context of the maerial presented. The authors have chosen eal number theory as a medium for illusrating the concepts and methods developed. n a manner consistent with the philosophy f the axiomatic method, each new mathenatical theory is introduced with a concise abulation of the basis consisting of the unctions, relations, operations, and the like, which remain unchanged. In addition to the asis, the axioms or postulates are clearly tated in each new development. The authors ave demonstrated the method of induction s a powerful tool in proving many theorems hroughout the text.

The book is written in such a manner hat it does not appear to require any mathenatical prerequisites on the part of its readers. Definitions are collected and summarized at convenient intervals throughout the book. The concepts are illustrated by application to many instances in real number systems. An excellent selection of problems is introduced as projects to enable the reader to test his grasp of the subject matter as well as to develop the theories further.

Recognizing the topic limitations imposed by the care and thoroughness with which the authors have developed their subject, this reviewer would like to see this work followed by a companion volume in which the theories are applied to instances chosen from geometry and the physical sciences. The authors are to be congratulated on their excellent work.

LLOYD T. DEVORE
General Electric Co.
Syracuse, N. Y.

Static and Dynamic Electricity (Second Edition) by W. R. Smythe

Published (1950) by McGraw-Hill Book Co., Inc., New York, N. Y. 583 pages+24-page index+7-page appendix+xxi pages. 9×6. $8.50.

This book was first published in 1939. The new edition offers substantial improvements of old material and important additions of new material. The changeover to rationalized mks units, in particular, should make this a more generally useful reference than was the earlier edition.

The author applies basic principles of electricity and magnetism to the solution of a wide variety of challenging problems. The material includes electrostatics, potential distributions, magnetism, induction, network transients, ac circuits, eddy currents, electromagnetic waves and radiation, waveguides and resonators, and relativistic motion of charged particles. The presentation is extremely thorough and many original results are presented. The material is not designed for the neophyte, but it should appeal to research men and to capable graduate students in mathematics, physics, and electrical engineering.

The excellent problems given with every chapter must be considered an integral part of the text, for they frequently contain valuable results. References to useful problems are included in the unusually complete index. Many questions are from the Cambridge University examinations as reprinted by Jean[1] with the possible exception of Weber's recent book.[2]

The application given here of conformal mapping and inversion methods to potential problems is the best treatment known to this reviewer. Two completely new chapters dealing with electromagnetic waves include a complete discussion of boundary conditions in microwave systems. A constant notation is adopted to distinguish phasor, scalar, and vector quantities.

The type setting and proof reading for this book must have been a difficult task. The author and the publishers deserve congratulations on the fine appearance and the freedom from errors. The only slips noted were an incorrect negative sign on page 128 and a misleading, if not incorrect, use of *a* and *b* in Fig. 8.06.

Some of the "modernized" nomenclature appears to be of dubious value. "Electromotance" for electromotive force and "capacitivity" for dielectric constant are uninspired terms at best and will probably find new converts.

Although many books are listed, reference is seldom made to periodic literature, even when classic papers appear apropos.

The material on transients and ac circuits, while interesting, seems rather out of place. The ommission of Chapters 9, 10, and parts of 6 would have left a better integrated treatment and should have permitted a more attractive selling price.

These few objections are relatively minor. This valuable work should prove an authoritative text and reference for many years to come. It warrants careful study by the serious student and research man.

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[1] "Mathematical Theory of Electricity and Magnetism," Cambridge University Press; 1925.
[2] "Electromagnetic Fields," Vol. I, John Wiley and Sons, Inc., New York, N. Y.; 1950.

Response of Physical Systems by John D. Trimmer

Published (1950) by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 240 pages+6-page index+ix pages. 91 figures. 5¼×8¼. $5.00.

In this unusual book, the author has made a generally successful attempt to stress the broad concepts of system, "forcing" (a new term coined to avoid force as too closely linked to mechanical systems) of the system, system response, and the interrelation of these concepts as expressed by a "law." The value or usefulness of a system is then judged by response criteria. One of these is the "error," defined as the instantaneous differences between the desired and the reference quantities, and applying to indicating instruments, servomechanisms, and automatic controls; the other is the "distortion," primarily applying to amplifiers. With the systematic use of this terminology, a very good and detailed treatment by means of classical differential equations is given of first- and second-order systems; higher-order systems are reduced to approximate combinations of independent first and second considerations. The further chapters on feedback and distributed systems, on systems with time-varying parameters, and nonlinear systems can be considered only as brief expositions with special examples. In the appendix a brief treatment of the Laplace transform is given.

The most attractive feature of this book is the emphasis on the point of view and the selection of the examples from widely separated fields such as nuclear reactors, electronics, mechanics, and so forth, unified by the consistent terminology. Though the mathematical treatment is generally good, it is not uniform and occasionally lacking in clarity. Disturbing is the inadvertent mixture of real and complex notation, particularly on page 30, where this makes an equation manifestly incorrect. It is doubtful that students in economics or in sociology will find much of direct use for them, because of the lack of illustrative examples in these fields. For anyone interested in physical systems, this volume should prove very stimulating reading.

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Wave Guides by H. R. L. Lamont

Published (1950) by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 109 pages+2-page index+6-page bibliography+vii pages. 37 figures. 4¼×6¾. $1.50.

This third edition of a book, intended to supply a compact statement on waveguides for individuals of average scientific attainment, has been expanded over previous editions appearing in 1942 and 1946. Basic theory and the more useful expressions are given in a manner to present a perspective view of the subject. Frequently correlations are given between theories or results as appearing in published articles by different authors in various publications.

The bibliography includes publications from all over the world so that further details can be found if the reader should require them. In spite of the book's small size and brevity, it is quite readable and the development of the various chapters follows in logical order. This book fills a need much the same as does a vest pocket book on fundamentals of higher mathematics, which gives the most useful expressions and tables.

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NOTE: The Institute of Radio Engineers does not have available copies of the publications mentioned in these pages, nor does it have reprints of the articles abstracted. Correspondence regarding these articles and requests for their procurement should be addressed to the individual publications, and not to the IRE.

The Annual Index to these Abstracts and References, covering those published in the PROC. I.R.E. from February, 1950, through January, 1951, may be obtained for 2s. 8d postage included from the *Wireless Engineer*, Dorset House, Stamford St., London S. E., England. This index includes a list of the journals abstracted, together with the addresses of their publishers.

The number in heavy type at the upper left of each Abstract is its Universal Decimal Classification number and is not to be confused with the Decimal Classification used by the United States National Bureau of Standards. The number in heavy type at the top right is the serial number of the Abstract. DC numbers marked with a dagger (†) must be regarded as provisional.

ACOUSTICS AND AUDIO FREQUENCIES

534.2:551.553 267

The Fine Structure of Atmospheric Turbulence in Relation to the Propagation of Sound over the Ground—E. G. Richardson. (*Proc. Roy. Soc. A*, vol. 203, pp. 149–164; September 22, 1950.) Simultaneous measurements of the fluctuations in sound intensity at a distance from a steady source, and of the atmospheric turbulence at points along the sound path, are used to discuss the relation between sound scattering and intensity of turbulence. The effect of the latter on the phase relations between signals received at two points is demonstrated.

534.212 268

The Propagation of a Sound Pulse in the Presence of a Semi-infinite, Open-ended Channel: Part 2—W. Chester. (*Proc. Roy. Soc. A*, vol. 203, pp. 33–42; September 7, 1950.) The asymptotic behavior of the disturbance at great distances from the wave front is discussed. For an incident Heaviside unit pulse, the wave inside the channel also tends to behave like a unit pulse, the correction term being a function of the distance from the wavefront. The case of an arbitrary pulse is also considered. The results are used to estimate the proportion of energy which returns along the channel when the incident pulse is of finite duration. Part 1: 2683 of 1950. *See* also 1560 of 1950.

534.321.2:621.3.018.78† 269

The Effect of Nonlinear Distortion on the Perception of Mistuning of Musical Intervals—W. Weitbrecht. (*Fernmeldetech. Z.*, vol. 3, pp. 336–345; September, 1950.) An experimental method is described in which pairs of electrically generated tones selected from the common chord of C in the octave 523.25–1046.50 cps, on the tempered and again on the just scale, are presented to listeners after passage through a pentode circuit of known adjustable nonlinear-distortion factor. The presentation of the properly tuned combination is alternated with the same combination mistuned, the listener stating whether or not he can hear a difference. Results are shown in charts. The harmonics and combination tones in the audio output are also observed objectively. The response of the ear to extraneous sounds is discussed. Characteristic differences are noted for different musical intervals.

534.321.9:621.315.616 270

Propagation of Low Frequency Ultrasonic Waves in Rubbers and Rubber-like Polymers—P. Hatfield. (*Brit. Jour. Appl. Phys.*, vol. 1, pp. 252–256; October, 1950.) Experiments covering a frequency range 50–350 kc and temperature range 0–60° are described. The velocity of low-amplitude ultrasonic waves varies from 1.1×10^5 to 1.8×10^5 cm in different rubbers at room temperature; absorption varies from <0.1 to 2 db per cm at 50 kc and from 0.7 to 11 db per cm at 350 kc. Applications of these materials as acoustic lenses and as ultrasonic transmission media are discussed.

534.782.07 271

The Phonetic Steno-sonograph—J. Dreyfus-Graf. (*Onde élect.*, vol. 30, pp. 356–361; August and September, 1950.) *See* 1330 of 1950.

534.845 272

Absorption of Sound by Porous Materials—C. Zwikker. (*Research* (London), vol. 3, pp. 400–407; September, 1950.) The control of reverberation by pure porosity effects is examined theoretically for normal incidence of the sound waves on a wall of infinite extent. The coefficient of sound absorption can be determined in terms of the wave impedance and propagation constant, which can be measured by interferometer methods. They may also be deduced if the porosity, specific flow resistance, thickness and structure factor (a factor depending upon the angle between the cell axes and the normal to the front surface) are known. See also 1569 of 1949 (Zwikker, van den Eijk, and Kosten) and back reference.

621.395.61 273

The Tube Microphone—H. J. Griese. (*Arch. elektrotech. Übertragung*, vol. 4, pp. 259–266; July, 1950.) Description and analysis of operation of a microphone in which the sound pickup member, of spherical or exponential-horn shape, is connected to the transducer by a slender tube. Directional diagrams and frequency-response curves are shown and discussed, and various constructions are illustrated.

621.395.61:621.396.645 274

The Brief-Case Field Amplifier—Hathaway and Kennedy. (*See* 312).

621.395.623.7 275

Sensitivity, Directivity and Linearity of Direct-Radiator Loudspeakers—H. F. Olson. (*Audio Eng.*, vol. 34, pp. 15–17; October, 1950.) Discussion of the characteristic curves of direct-radiator dynamic loudspeakers shows that rigid large-angle cones with suspensions of high mechanical resistance produce more uniform frequency response and directional characteristics than loudspeakers with light vibrating systems which, though possessing greater sensitivity and giving greater intensity directly in front of the cone, have considerably greater nonlinear distortion. The heavier type also handles much greater power without overloading.

621.395.623.7 276

A New Loudspeaker of Advanced Design—D. J. Plach and P. B. Williams. (*Audio Eng.*, vol. 34, pp. 22–23, 65; October, 1950.) The loudspeaker comprises three independently driven reproducers, covering the whole audio range to above 18 kc, with crossover at 600 cps and 4 kc. In the low-frequency unit a 3-inch voice coil drives a 15-inch plastic diaphragm shaped like the mouth of a horn, into the throat of which the mid-frequency unit is inserted. This uses a dished plastic diaphragm driving through an annular gap into a horn formed by part of the magnet system of the low-frequency unit. The flare of this horn passes smoothly into that of the low-frequency diaphragm, which thus acts as an extension of the mid-frequency horn and provides good loading, resulting in smooth response at high efficiency down to and below the crossover at 600 cps. The high-frequency unit is independently mounted in the front of the assembly. It also has a flared horn, the diameter of the mouth being 1.5 inches. Tests indicate the high quality of the reproduction of all types of broadcasting material.

621.395.623.7.001.4 277

Transient Testing of Loudspeakers—M. S. Corrington. (*Audio Eng.*, vol. 34, pp. 9–13; August, 1950.) A theoretical discussion of the relation between the sound-pressure curve of a loudspeaker and its transient response to a suddenly applied unit sine wave is illustrated by experimental results on a 12-inch loudspeaker. It is concluded that the unit sine wave is preferable to the unit impulse as a test, the former being more selective and easier to interpret, since it emphasizes the ringing of peaks of nearly the same frequency as its own.

ANTENNAS AND TRANSMISSION LINES

1.315.21:621.397.5 278

High Frequency Cables in Television—R.C. ildner. (*Jour. Telev. Soc.*, vol. 6, pp. 65– ; April–June, 1950.) A survey of the proper- :s of balanced and unbalanced transmission ies.

1.315.61 279

Conductance of Insulators for Aerial Lines Carrier Frequencies—Gregoretti. (*See* 379.)

1.392:[621.3.015.7†:621.314.2 280

Pulse Transients in Exponential Trans- ission Lines—E. R. Schatz. (Proc. I.R.E., l. 38, pp. 1208–1212; October, 1950.) The lse response of exponential transmission lines analyzed and it is suggested that such lines ay be used advantageously as pulse trans- rmers for short, rapidly rising pulses, par- :ularly where high power is involved. A bsequent paper will discuss design problems id experimental results.

1.392.09 281

Surface-Wave Transmission Line—G. Gou- .u. (*Radio & Telev. News, Radio-Electronic* *g. Suppl.*, vol. 14, pp. 10–11, 30; May, 1950.) paper published by Sommerfeld in 1899 scribes a surface wave guided by a cylindrical nductor of finite conductivity. The field of ch a wave extends very far from the conduc- r but can be concentrated closer to the con- ictor by reducing the phase velocity. Such reduction can be achieved by applying a electric coating to the conductor, or by odifying its surface by cutting a screw read throughout its length. Under such nditions the wave mode differs from Som- erfeld's wave both in the extent and structure the field, and finite conductivity is no longer essential condition for the existence of the nradiating wave mode. Experiments show at this mode can be easily excited on dielec- ic-coated or threaded wires, with an efficiency to 90 per cent. For excitation, a metal horn connected to the outer conductor of the axial feeder and the wire to the inner con- ictor. At the receiving end an identical rangement is used. Losses in such a system e discussed; there is an optimum thickness the dielectric coating for which the insertion ss is a minimum. Experiments at 2.0 kMc th a Cu wire 2.6 mm in diameter and of ngth about 38 m verified this conclusion. irther experiments at 1.6 kMc on an enam- led wire 3.2 mm in diameter and 183 m long, pported at points about 24 m apart, gave a easured loss of 5 db, which is in good agree- ent with the calculated value of 4.5 db. The pports, and the bends in the wire due to the pports, had no measurable effect on the tenuation. The corresponding attenuation r RG-8/U cable is 70 db. The horns used ere the same in all the experiments and had aperture of 33 cm. The greatest observed crease of attenuation due to raindrops col- cting on the wire was <1.5 db.

1.396.67 282

An Antenna Analyzer—A. C. Todd. (*Elec- nics*, vol. 23, pp. 82–87; September, 1950.) he polar diagram in the horizontal plane of an ray of vertical grounded antennas is calcu- ted by an electronic computer and presented rectangular or polar co-ordinates on the reen of a cr tube. Results are in good agree- ent with those obtained by ordinary calcula- n methods, which take a much longer time.

1.396.67:621.317 283

Short-Wave Installations with Controllable irectional Characteristics and their Applica- n to the Measurement of Angles of Inci- nce—Kotowski, Schüttlöffel, and Vogt. ee 432.)

621.396.67:621.397.6 284

Designing the Bridgeport U.H.F. Antenna—R. M. Scudder. (*Electronics*, vol. 23, pp. 76–80; November, 1950.) The development and construction are described of a television antenna sensibly omnidirectional in the horizontal plane with a voltage SWR <1.15 in the band 529–535 Mc. The antenna consists of a linear array of vertical $\lambda/2$ slots in a tube of diameter $10\frac{3}{4}$ inches, with coaxial feed, and has an over-all height of 40 ft. Its power gain is 17 and vertical beam width 3°. See also 2425 of 1950.

621.396.671 285

The transmission and Reception of Elliptically Polarized Waves—G. Sinclair. (Proc. I.R.E., vol. 38, p. 1216; October, 1950.) Correction to paper abstracted in 1341 of 1950.

621.396.671 286

Asymmetrically Driven Antennas and the Sleeve Dipole—R. King. (Proc. I.R.E., vol. 38, pp. 1154–1164; October, 1950.) General expressions for impedance and current distribution of asymmetrically driven, cylindrical antennas are derived from an integral equation, which is solved by the method of successive approximations. An approximation for the impedance is obtained which involves a series combination of the known impedances of symmetrically driven antennas. Impedance and current distribution of a cylindrical $3\lambda/4$ antenna, driven $\lambda/4$ from one end, are evaluated and its wide-band properties are discussed.

Expressions for the impedance and current distribution of a sleeve dipole are readily obtained from the foregoing, since the sleeve dipole with its image is equivalent to two asymmetrically driven antennas. Impedance and current distribution are determined for a $3\lambda/4$ sleeve dipole above a conducting plane, when it is driven $\lambda/4$ from the plane; its wide-band properties are much superior to those of a simple dipole.

621.396.677 287

Dielectric Directive Radiators—P. Mallach. (*Fernmeldetech. Z.*, vol. 3, pp. 325–328; September, 1950.) A discussion of end-on radiators, particularly the tubular type. Radiators made of materials with dielectric constants ranging from 2.5 to 64 were investigated. An experimental setup for obtaining the radiation pattern is described, and the effect of variation of dimensions and form is shown in graphs. The tubular dielectric radiator is smaller than the equivalent horn; the dielectric-rod radiator even smaller. See also 1604 of 1949.

621.396.679.4:621.315.212 288

Coaxial Feed System for Antennas—J. F. Clemens. (*Electronics*, vol. 23, pp. 154, 182; October, 1950.) A variation of the "delta match" method enables any unbalanced coaxial cable to be used to feed balanced horizontal antennas. Formulas are given for calculating the total inductive reactance between feed points and the length of shorted cable required for resonance. Results obtained with experimental antennas at 300 Mc and 29 Mc are described.

CIRCUITS AND CIRCUIT ELEMENTS

621.314.2 289

Optimum Use of Nickel Alloy Steels in Low-Level Transformers—L. W. Howard. (*Audio Eng.*, vol. 34, pp. 20–21, 50; October, 1950.) Discussion of the design and manufacturing problems involved in the production of small transformers for various low-level applications. The transformers are as small as possible and are hermetically sealed. For the lowest levels three nickel-steel magnetic shields interleaved with copper shading rings are used. Owing to their low saturation point, these steels are not suitable for high-level applications, for which silicon steels are preferred.

621.314.2.018.424† 290

Design of Broad-Band Transformers for Linear Electronic Circuits—H. W. Lord. (*Elec. Eng.*, vol. 69, pp. 1020–1025; November, 1950.) Paper presented at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June, 1950. Analysis and design data are given for modulation transformers intended to operate with negligible variation of gain and phase and with low distortion. Generalized frequency-response curves are given for a range of relevant circuit parameters. The performance of a typical 3-w transformer is in close agreement with theory over the frequency range 20,000–30,000 cps.

621.314.3† 291

A Review of Transductor Principles and Applications—R. Feinberg. (*Proc. IEE* (London), Part II, vol. 97, pp. 628–644; October, 1950.)

621.316.8:621.396.822 292

A Note on the Identity of Thermal Noise and Shot Noise—B. Meltzer. (*Phil. Mag.*, vol. 40, pp. 1224–1226; December, 1949.) The noise in a given frequency range in an ohmic conductor, originally calculated by Nyquist, can be rigorously treated as pure shot noise. A new expression kT/Re is obtained for the average direct current in either direction in a circuit of resistance R in temperature equilibrium, the current being carried by elementary charges of magnitude e.

621.316.8:621.396.822 293

The Statistical Analysis of Electrical Noise—D. K. C. MacDonald. (*Phil. Mag.*, vol. 41, pp. 814–818; August, 1950.) Recent papers by Meltzer on electrical noise (see 2141 of 1950 and 292 above) are criticized. In particular, no distinction was made between average and mean-square values of the statistical variables. The results of a general discussion of the statistics and frequency spectrum of fluctuations are applied to determine particle velocity in Brownian motion; agreement with Exner's observations is satisfactory.

621.318.572 294

Speed of Electronic Switching Circuits—E. M. Williams, D. F. Aldrich, and J. B. Woodford. (Proc. I.R.E., vol. 38, p. 1180; October, 1950.) Correction to paper abstracted in 1353 of 1950.

621.318.572 295

32-Channel High-Speed Commutator—N. Alpert, J. Luongo and W. Wiener. (*Electronics*, vol. 23, pp. 94–97; November, 1950.) An electronic switching device for information channels, using a system of binary counters and gating tubes to obtain a sampling rate of 1,000 per second.

621.319.45:546.883 296

Tantalum Electrolytic Capacitors—M. Whitehead. (*Bell Lab. Rec.*, vol. 28, pp. 448–452; October, 1950.) Capacitors of the conventional foil type using tantalum instead of aluminium, and a new type in which the anode is a highly porous cylinder of sintered tantalum are described. The advantages of the tantalum capacitors are brought out in a general discussion of their properties, including their relatively small size, low permissible operating temperature and high leakage resistance.

621.392 297

Note on a Useful Extension of Thévenin's Theorem—L. Tasny-Tschiassny. (*Proc. IEE* (London), Part I, vol. 97, p. 234; September, 1950.) "*Theorem:* If an impedance Z be connected between two terminals of a network, the potential difference between any second pair of terminals will be equal to that between the terminals of two generators, operating in parallel and having internal electromotive forces equal to the voltages across the second pair of terminals when $Z=\infty$ and when $Z=0$, and internal impedances, equal to the Thévinin impedance of the network measured between the first pair of terminals, and to Z, respectively.

"*Corollary:* The current in any branch of the network, any Thévinen impedance, an equivalent Y impedance, or an equivalent Δ impedance in the network will, for any value of Z, be numerically equal to the terminal voltage of the two generators, if their internal electromotive forces are made numerically equal to the currents, or impedances concerned, when $Z=\infty$ and when $Z=0$, respectively."

621.392.4:621.316.727· 298

A Study of the Cathode-Degeneration Phase Inverter—S. Malatesta. (*Alta Frequenza*, vol. 19, pp. 145–148; June, 1950.) Calculation of this circuit, in which anode and cathode voltages vary in phase opposition, is simplified by considering the anode current as a function of a voltage which is the difference between the grid voltage and the mean of the anode and cathode voltages.

621.392.4:621.316.727 299

Wide-Range Phase Control with Constant Attenuation by Adjustable Impedance in a Resistance-Loaded Bridged-Tee Network—M. G. Pawley. (*Bur. Stand. Jour. Res.*, vol. 45, pp. 193–200; September, 1950.) Equations are developed and the necessary relations between circuit constants are deduced for phase control by means of an adjustable resistor, inductor, or capacitor connected in a selected branch of a bridged-T network. Various applications of such phase-shifting networks are mentioned.

621.392.43 300

The Design of Frequency-Compensating Matching Sections—V. H. Rumsey. (Proc. I.R.E., vol. 38, pp. 1191–1196; October, 1950.) The general problem of transforming an impedance which changes with frequency into a resistance nearly independent of frequency is considered. A simple procedure for the general solution is evolved and design formulas for the appropriate matching section are derived. The formulas give the parameters of the matching section in terms of the loads at selected frequencies. The technique is mainly applicable to cases where the half-bandwidth is small compared with the center frequency; it can be applied to any type of transmission line whose characteristic impedance is known.

621.392.5 301

The Parameters of a Passive Four-Pole that May Violate the Reciprocity Relation—B. D. H. Tellegen and E. Klauss. (*Philips Res. Rep.*, vol. 5, pp. 81–86; April, 1950.) The properties of these quadripoles at a given frequency are investigated theoretically and the conditions are determined for a quadripole to be passive. See also 980 and 2745 of 1949 and 1879 of 1950 (Tellegen).

621.392.5.018.1 302

Design of Single-Frequency Phase-Shifting Networks—L. G. Fischer. (*Elec. Commun.* (London), vol. 27, pp. 227–230; September, 1950.) A series of design curves is given from which the necessary data may be obtained for designing the most suitable network to meet any specific requirement. Full allowance is made for the loading effect due to the shunting of each section by the succeeding one.

621.392.52:621.397.61 303

Linear-Phase-Shift Video Filters—G. L. Fredendall and R. C. Kennedy. (*RCA Rev.*, vol. 11, pp. 418–430; September, 1950.) A paper intended primarily to guide designers through the necessary steps in the calculation of the values of capacitors and inductors in the Bode linear-phase-shift filter which satisfies approximately the specified attenuation conditions through the cutoff region and within the pass band. Application of linear-phase-shift filters in the production of "mixed highs" in the dot-sequential system of color television is described. Band-pass and band-stop filters with linear phase shifts are also considered briefly.

621.392.53:621.396.645.2 304

Anode-Load Compensation Network—C. Chalkoub. (*Câbles & Trans.* (Paris), vol. 4, pp. 325–335; October, 1950.) In wide-band amplifiers the inductor often added in series with the load resistor to eliminate the effect of stray tube capacitances may be supplemented by a series capacitor and parallel inductor to extend the useful frequency range of the amplifier further. The relation between the two types of circuit is established, so that the equations for one may be derived from those for the other. Sets of curves to facilitate design of the compensating network are given, with numerical examples. In fixed-frequency amplifiers the use of the single inductor may be satisfactory when the phase change to be corrected is less than about 35°. In the case of an oscillator comprising two or more resonant circuits used at their resonance frequency, only one of these should have a high Q value, all the others being suitably damped.

621.392.6:621.395 305

Theory of $2n$-Terminal Networks with Applications to Conference Telephony—V. Belevitch. (*Elec. Commun.* (London), vol. 27, pp. 231–244; September, 1950.) Networks composed of resistors and ideal transformers, simultaneously matched at all their terminal pairs to a given set of resistors and with prescribed losses between the various pairs of terminals, are treated. A method of design based on the efficiency matrix is applied to 6-terminal and some important classes of 8-terminal networks. Results in the theory of transformer networks are applied to the design of new networks of practical importance for conference telephony. Matched nondissipative networks interconnecting n telephone circuits and giving a loss of $10 \log_{10} (n-1)$ db between all their terminal pairs are constructed for various values of n. Transformer networks suitable for interconnecting 4-wire circuits are also discussed.

621.395.665.1 306

Compressor/Expander Units of l'Administration Française des P.T.T.—M. Lagarde, P. Herreng, and A. Gauvenet. (*Câbles & Trans.* (Paris), vol. 4, pp. 308–318; October, 1950.) The conditions which such devices should satisfy are examined, and systems using (a) Cu_2O rectifiers, (b) tube rectifiers are discussed with reference to stability, degree of compression and distortion. The discussion justifies the selection of the Cu_2O type, and a technical description is given of the units actually used, which have a compression factor of about 1.8 and input and output impedances of 800Ω.

621.396.6 307

New Techniques for Electronic Miniaturization—R. L. Henry, R. K. F. Seal, and G. Shapiro. (Proc. I.R.E., vol. 38, pp. 1139–1145; October, 1950.) Problems arising from miniaturization are considered, with special emphasis on those due to high operating temperatures, which necessitate special types of resistor and the use of a solder with a high melting point. General techniques for conventional and printed circuits are discussed and three types of miniature wide-band high-gain intermediate-frequency amplifiers, suitable for radar applications, are described in detail. Methods and techniques of production are also outlined.

621.396.611.4:621.314.222 30

The Transmission Properties of the Cavit Resonator as Interstage Transformer—A Kach. (*Arch. elekt. Übertragung*, vol. 4, pp 301–308; August, 1950.) A detailed analysis emphasizing the importance of inherent losse in the cavity. The equivalent quadripole con stants are derived, the resonator with its inpu and output couplings being regarded as three-winding transformer. Conditions de termining resonance, attenuation, matching and bandwidth are examined. Optimum op erating conditions can be attained merely b varying the degree of coupling. The theory i confirmed by measurements on the input cir cuit of a microwave receiver, using a frequenc of 2 kMc.

621.396.615 30

A New *RC* Oscillator Circuit—M. H Crothers. (*Radio & Telev. News, Radio Electronic Eng. Suppl.*, vol. 14, pp. 12–14, 25 May, 1950.) Description and theory of th operation of a 2-stage "π-coupled" amplifie with a *RC* feedback network. The circuit re quires fewer components than the norma type of cathode-coupled feedback amplifie and greater stability is claimed for it.

621.396.619.23+621.396.645].029.64 31

A New Microwave Triode: Its Performanc as a Modulator and as an Amplifier—A. E Bowen and W. W. Mumford. (*Bell Sys. Tech Jour.*, vol. 29, pp. 531–552; October, 1950. Details are given of equipment using th Type-1553-416A triode (510 below) in micro wave links operated at 4 kMc. Using the tub as a modulator, 10–20 mw output power an a bandwidth of 20 Mc were obtained. As a amplifier, average figures are: gain 9 db, band width 103 Mc between half-power points, nois figure 18 db, power output (for 3-db gain 455 mw. A 10-stage cascade amplifier gave 90 db gain, 16-db noise factor and 44-Mc band width between the 0.1-db points.

621.396.645 31

"Williamson" Type Amplifier Using 6A5's—J. H. Beaumont. (*Audio Eng.*, vol. 34, pp 24–26; October, 1950.) Description, with cir cuit diagram and components list, of a high fidelity audio amplifier using miniature tube in direct-coupled pairs, driving a push-pul output stage giving a nominal output of 6 w.

621.396.645:621.395.61 31

The Brief-Case Field Amplifier—J. L Hathaway and R. C. Kennedy. (*RCA Rev.* vol. 11, pp. 411–417; September, 1950.) De tailed description of miniature equipment fo sound-broadcasting pickup.

621.396.645.29:518.3 31

Cathode-Follower Response—R. H. Baer (*Electronics*, vol. 23, p. 114; October, 1950. A chart shows the permissible video-frequenc pulsed input voltage in terms of that calcu lated for low-frequency sinusoidal input.

621.396.645.018.424† 31

A Distributed Power Amplifier—A. P Copson. (*Elec. Eng.*, vol. 69, pp. 893–898 October, 1950.) The basic theory of the typ of transmission line used in distributed-ampli fication units is presented and a descriptio is given of voltage and power amplifiers usin Type-807 beam tetrodes. The response curv is flat to within 1 db from 20 cps to 30 Mc but the upper limit can be extended whe tubes with short anode and grid leads at op posite ends of the envelope are available; hig transconductance and low shunt capacitanc are also required.

621.396.654.018.424†:621.317.755 31

Wide-Band Amplifier for Cathode-Ray Oscilloscope Observation of Transient Phenomena—P. Schmid and E. Baldinger. (*Helv Phys. Acta*, vol. 23, pp. 478–481; September 1

. In German.) A 12-stage RC amplifier a rise time of 1.3×10^{-8} sec (from 10 per to 90 per cent output voltage) and amplification factor 360.

396.645.37 316

Graphical Solution for Feedback Amplifier—L. D. Barter. (*Electronics*, vol. 23, pp. 214; November, 1950.) Derivation of equation for the variation of the gain feedback amplifier with frequency, and application to typical one- and two-stage amplifiers, with graphical solution for the latter a.

396.662 317

Cascade-Connected Attenuators—R. W. Beaty. (*Bur. Stand. Jour. Res.*, vol. 45, pp. 3-235; September, 1950.) When two or more separated attenuators are connected in series, total attenuation will not, in general, be the of the attenuations of the individual units, owing to mismatch at the junctions. An abac given from which the limits of the error due mismatch can be determined from reflection coefficients found by means of voltage SWR measurements at the junctions. Summary of Proc. I.R.E., vol. 38, p. 1190; October, 1950.

396.665 318

Automatic Audio Gain Controls—J. L. Hathaway. (*Audio Eng.*, vol. 34, pp. 27–29; October, 1950.) A discussion of the development of control apparatus for broadcasting transmitters. Two RC circuits with appropriate time constants are used in series to operate a single program-controlled stage. A small capacitor is charged by single peaks the control rectifier voltage and gives rapidly acting limiting, while a much larger capacitor is slowly charged and controls average level. An additional refinement provides for the momentary suspension of control, achieving certain sound effects.

397.645.018.424† 319

Video Amplifier Design—R. C. Moses. (*Radio & Telev. News, Radio-Electronic Eng. Suppl.*, vol. 14, pp. 15–18, 28; May, 1950.) Discussion of compensation circuits enabling amplitude and phase characteristics essentially flat over the whole video band to be obtained.

.392 320

Electric Circuit Theory [Book Review]—Tropper. Publishers: Longmans Green & Co., London, England, 164 pp., 15s. (*Elec. Times*, vol. 118, p. 426; September 14, 1950.) A review of fundamental aspects, valuable to advanced engineering students and engineers. No knowledge of mathematics beyond elementary differential calculus is assumed.

.392:517.432.1 321

Heaviside's Electric Circuit Theory. [Book Review]—H. J. Josephs. Publishers: Methuen & Co., London, England; J. Wiley & Sons, Inc., New York, N. Y., 2nd ed. 113 pp., 1950, $2.25. (*Electronics*, vol. 23, pp. 146, 150; November, 1950.) "A concise and clear treatment of the various fundamental methods as worked out by Heaviside and extended by Carson, Bromwich, and others." See also 2535 of 1946 and 63 of 1947.

GENERAL PHYSICS

5081±621.3.081 322

Symposium of Papers on the M.K.S. System of Units—(*Proc. IEE* (London), Part I, vol. 97, pp. 235–258; September, 1950. Discussion, pp. 258–272.) The full text is given of the following papers read before the Institution of Electrical Engineers on March 30, 1950: The M.K.S. or Giorgi System of Units: The Case for its Adoption—L. H. A. Carr; The Rationalization of Electrical Units and Effect on the M.K.S. System—G. H. Rawcliffe; The Rationalization of Electrical Theory and Units—H. Marriott and A. L. Cullen; Rationalized M.K.S. Units in Electrical Engineering Education—E. Bradshaw.

534.26±[535.42:538.56 323

On the Theory of Diffraction—W. Franz. (*Proc. Phys. Soc.* (London), vol. 63, pp. 925–935; September 7, 1950.) "A new method is described for calculating the diffraction of an acoustical or electromagnetic wave by successive approximations. Kirchhoff's theory is a special case of the first step in the new method which, unlike Kirchhoff's, is not restricted to black screens, and applies to long waves as well as short ones."

535.22 324

A Determination of the Velocity of Light—E. Bergstrand. (*Ark. Fys.*, vol. 2, pp. 119–150; October 10, 1950. In English.) The principle of Fizeau's toothed-wheel method was used but modern refinements included a Kerr cell between crossed nicols switched by an 8.2-Mc oscillator. The path distance was usually about 8 km. A detailed description is given of the equipment and measurements. The final value deduced for the velocity in vacuo is 299,793.1 ±0.25 km per sec. This is well within the limits of Essen's value of 299,792.5±3 km per sec. for radio waves (1751 of 1950) and also of Aslakson's value, derived from shoran measurements, of 299,792.4±2 km per sec (2610 of 1950).

535.42:538.566 325

Diffraction from an Irregular Screen with Applications to Ionosphere Problems—Booker, Ratcliffe, and Shinn. (*See* 428.)

537.214 326

Energy in Electrostatics—W. B. Smith-White. (*Nature* (London), vol. 166, pp. 689–690; October 21, 1950.) Confusion existing in the literature between the notion of energy as a physical entity and as a mechanical potential-energy function is considered, and a formula derived by Guggenheim for an electrostatic system containing dielectrics is modified to make it true generally.

537.311.31 327

The Theory of the Transport Phenomena in Metals—E. H. Sondheimer. (*Proc. Roy. Soc. A*, vol. 203, pp. 75–98; September 7, 1950.) Exact expressions are obtained for electrical conductivity and other transport magnitudes of monovalent metals, assuming the electrons to be quasi-free, and these and other formulas are critically discussed.

537.311.31 328

Size Effect Variation of the Electrical Conductivity of Metals—D. K. C. MacDonald and K. Sarginson. (*Proc. Roy. Soc. A*, vol. 203, pp. 223–240; September 22, 1950.) Results of conductivity measurements on thin wires of pure Na of varying diameter in the absence and presence of magnetic fields are compared with (a) values calculated, using the general statistical theory of metals, for the case of wires with square cross section, (b) results of a theoretical investigation of the alteration in conductivity produced in metal films by the application of transverse magnetic fields.

537.312.62 329

The Surface Impedance of Superconductors and Normal Metals at High Frequencies: Parts 4 and 5—A. B. Pippard. (*Proc. Roy. Soc. A*, vol. 203, pp. 98–118 and 195–210; September 7 and September 22, 1950.) Measurements on single crystals of tin described in parts 1–3 (1014 of 1948) are extended to 9.4 kMc and results analyzed.

537.312.62:538.6 330

Field Variation of the Superconducting Penetration Depth—A. B. Pippard. (*Proc. Roy. Soc. A*, vol. 203, pp. 210–223; September 22, 1950.) Experimental investigations on superconducting tin and interpretation of results.

537.312.8:539.23 331

The Influence of a Transverse Magnetic Field on the Conductivity of Thin Metallic Films—E. H. Sondheimer. (*Phys. Rev.*, vol. 80, pp. 401–406; November 1, 1950.)

537.525.029.64 332

Microwave Gas Discharges—M. A. Biondi. (*Elec. Eng.*, vol. 69, pp. 806–809; September, 1950.) AIEE Winter General Meeting paper, 1950. The discharge in a gas excited at microwave frequencies is discussed from a purely physical viewpoint. Some results of experimental investigation are given and a formula for the complex conductivity is developed from the known properties of electrons and ions.

537.527.4 333

Positive Point-to-Plane Spark Breakdown of Compressed Gases—T. R. Foord. (*Nature* (London), vol. 166, pp. 688–689; October 21, 1950.) Account of an experimental investigation of anomalous decrease of spark breakdown potential with increase of pressure in air, N_2 (oxygen-free), "freon 12" and SF_6. The occurrence of the phenomenon appears to depend on the presence of (a) a divergent field and (b) a gas which forms negative ions.

537.56:538.56 334

The Refractive Index and Classical Radiative Processes in an Ionized Gas—K. C. Westfold. (*Phil. Mag.*, vol. 41, pp. 509–516; June, 1950.) Hartree's classical methods are used to find the effect of the refractive index on the emission and absorption of radio waves in an ionized medium with no magnetic field, and to confirm the results of Smerd and Westfold (95 of February). A quantum theory interpretation is also given.

537.562:537.311 335

The Electrical Conductivity of an Ionized Gas—R. S. Cohen, L. Spitzer, Jr., and P. M. Routly. (*Phys. Rev.*, vol. 80, pp. 230–238; October 15, 1950.) "The interaction term in the Boltzmann equation for an ionized gas is expressed as the sum of two terms: a term of the usual form for close encounters and a diffusion term for distant encounters. Since distant encounters, producing small deflections, are more important than close encounters, consideration of only the diffusion term gives a reasonably good approximation in most cases and approaches exactness as the temperature increases or the density decreases. It is shown that in evaluating the coefficients in this diffusion term, the integral must be cut off at the Debye shielding distance, not at the mean interionic distance. The integro-differential equation obtained with the use of this diffusion term permits a more precise solution of the Boltzmann equation than is feasible with the Chapman-Cowling theory. While one pair of coefficients in this equation has been neglected, the remaining coefficients have all been evaluated, and the resultant equation solved numerically for the velocity distribution function in a gas of electrons and singly ionized atoms subject to a weak electrical field. Special techniques were required for this numerical integration, since solutions of the differential equation proved to be unstable in both directions. For high temperatures and low densities the computed electrical conductivity is about 60 per cent of the value given by Cowling's second approximation."

538.114 336

Ferromagnetic Domains—H. J. Williams. (*Elec. Eng.*, vol. 69, pp. 817–822; September, 1950.) A résumé of existing knowledge. Domain sizes and shapes are due to the tendency of the ferromagnetic system towards a state of minimum energy.

538.221 337

Ferromagnetism at Very High Frequencies. Part 3—Two Mechanisms of Dispersion in a Ferrite—G. T. Rado, R. W. Wright, and W. H. Emerson. (*Phys. Rev.*, vol. 80, pp. 273–280; October 15, 1950.) "The magnetic spectrum of a ferrite is shown to contain two regions of pronounced dispersion. One occurs at radio frequencies, resembles a resonance, and is proved to be due to domain-wall displacements; the other occurs in the microwave range, exhibits typical resonance characteristics, and is attributed to domain rotations." Part 2: 1994 of 1949 (Johnson and Rado).

538.52/.53 338

Calculation of Currents Induced in a Solid Sphere: Self Inductance and Mutual Inductance with an Endless Solenoid—A. Colombani. (*Compt. Rend. Acad. Sci.* (Paris), vol. 231, pp. 570–572; September 18, 1950.) Corresponding formulas to those previously given for a spherical shell (2766 of 1950) are derived for a solid sphere within an endless solenoid.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.53:551.510.535 339

The Influence of High-Altitude Winds on Meteor-Trail Ionization—C. D. Ellyett. (*Phil. Mag.*, vol. 41, pp. 694–700; July, 1950. Mechanisms whereby winds can cause changes in meteor-trail positions are discussed in the light of observations from different sources. Assuming that fluctuation rate depends on frequency, short- and medium-period fluctuations of meteor trail echoes can be correlated with phase and amplitude variations of waves reflected from the ionosphere. A causal connection is suggested. See also 359 below.

621.396.9:523.53 340

The Fluctuation and Fading of Radio Echoes from Meteor Trails—Greenhow. (*See* 359.)

523.72±523.74]:621.396.822 341

The Solar Atmosphere and the Origin of Radiofrequency Radiation—S. A. Korff and Y. Beers. (*Phys. Rev.*, vol. 80, pp. 489–490; November 1, 1950.) Short discussion of the physical conditions prevailing in the sun's atmosphere. The tendency in some recent papers to attach too much physical significance to the "equivalent noise temperature" T is deprecated, since T is only a measure of the available power of a noise source and gives no information regarding the mechanism of the source.

523.72:621.396.822 342

Solar Radiation of Wavelength 1.25 Centimetres—J. H. Piddington and H. C. Minnett. (*Aust. Jour. Sci. Res., Ser. A*, vol. 2, pp. 539–549; December, 1949.) Observations covering a period of about six months are described. The observed average intensity corresponded to a black-body temperature of 10^4° K, with a maximum error of about ±5 per cent. Day-to-day variations were $< \pm 3$ per cent, which was the limit of observational accuracy. Short-period fluctuations were $\nless \pm 5$ per cent, even during intense solar activity. The distribution of intensity over the solar disk, measured by a method analogous to the Michelson interferometer technique, was consistent with 84 per cent of the radiation coming from a uniform disk and 16 per cent from a narrow annulus surrounding it.

523.72:621.396.822 343

Solar Radiation at a Wavelength of 3.18 Centimetres—H. C. Minnett and N. R. Labrum. (*Aust. Jour. Sci. Res., Ser. A*, vol. 3, pp. 60–71; March, 1950.) Observations were made daily from November 24, 1948, to March 1, 1949. An accurate measurement of received intensity was made by one technique, and a continuous record over several hours was made by a less accurate method. The estimated equivalent black-body temperature was 19,300° K ±7 per cent for the quiet sun; temperature increments per unit increase of sunspot area were less than for longer microwaves. Observations were also made during the eclipse on November 1, 1948, to investigate the distribution across the disk. Results were consistent with either 74 per cent of the radiation coming from the visible disk and the remainder from a bright ring round the circumference, or the whole of the radiation coming from a uniform disk of diameter 1.1 times that of the visible disk.

523.72.029.6:621.396.822 344

Radio-Frequency Radiation from the Quiet Sun—S. F. Smerd. (*Aust. Jour. Sci. Res., Ser. A*, vol. 3, pp. 34–59; March, 1950.) The chromosphere and the corona are considered as two regions of uniform temperature with a discontinuity at the boundary; because of uncertainty regarding these temperatures, a range of values is considered. The intensity distribution across the emitting disk is derived for frequencies from 60 to 30,000 Mc, and the size of the radio-frequency disk is estimated from that of the optical disk. The apparent temperature (an equivalent measure of the flux density at the earth) has a maximum as a function of frequency for each coronal temperature, and as a function of coronal temperature for each frequency. All observed apparent temperatures correspond to chromosphere temperatures from 10^4 to 3×10^4 °K and corona temperatures from 2.5×10^5 to 3×10^6 °K. The effects of a possible general solar magnetic field are small in relation to those due to uncertainties regarding temperature.

523.752:621.396.822 345

The Derivation of a Model Solar Chromosphere from Radio Data—J. H. Piddington. (*Proc. Roy. Soc. A*, vol. 203, pp. 417–434; October 10, 1950.) The basic data used are recent radio measurements of disk temperature at frequencies between 600 and 24,000 Mc. The coronal contribution to this is calculated and subtracted to give the chromospheric component. Finally an expression is derived giving separately the two components as functions of frequency and position on the disk; the values obtained are in reasonable agreement with experimental observations.

The radio results are combined with data on the intensities of spectrum lines at various levels in the chromosphere to obtain the distribution of electron density and temperature. A marked departure from conditions of hydrostatic equilibrium is indicated.

523.78 "1948.11.1":621.396.822 346

Measurements of Solar Radiation at a Wavelength of 50 Centimetres during the Eclipse of November 1, 1948—W. N. Christiansen, D. E. Yabsley, and B. Y. Mills. (*Aust. Jour. Sci. Res., Ser. A*, vol. 2, pp. 506–523; December, 1949.) Measurements were made at three well-separated places in Australasia. Abrupt changes in the slope of the flux-density curves were correlated with the covering and uncovering of small areas of great radio brightness, viz., sunspots past and present, and one prominence; these areas contributed about one-fifth of the total received power. Of the remaining four-fifths, about 40 per cent originated outside the visible disk. No effects of any general solar magnetic field were detected.

523.78 "1948.11.1":621.396.822 347

Solar Radiation at a Wavelength of 10 Centimetres, including Eclipse Observations—J. H. Piddington and J. V. Hindman. (*Aust. Jour. Sci. Res., Ser. A*, vol. 2, pp. 524–538; December, 1949.) Observations were made at Sydney both before and after the eclipse of November 1, 1948, and conditions during the eclipse were related to the varying day-to-day level of radiation intensity. The distribution over the solar disk was determined, the most intense radiation coming from near the limb and some radiation from beyond the limb. At least one small high-intensity area was located. The excess of circularly polarized component, either right- or left-hand, observed at eclipse maximum was smaller than the value to be expected for a general solar magnetic field of 50 gauss at the poles.

523.854:621.396.822 34

Galactic Radiation at Radio Frequencies. Part 1—100 Mc/s Survey—J. G. Bolton and K. C. Westfold. (*Aust. Jour. Sci. Res., Ser. A*, vol. 3, pp. 19–33; March, 1950.) "An antenna array with a 17° beamwidth, on an equatorial mounting, was used to plot the distribution of intensity over the section of the celestial sphere between declination +30° and −90°. The method of eliminating the effect of the antenna polar diagram from the observations is described and the final distribution, expressed in terms of equivalent black-body temperature is presented in galactic co-ordinates on a series of equal-area charts."

537.562:537.311 34

The Electrical Conductivity of an Ionized Gas—Cohen, Spitzer, and Routly. (*See* 335.)

550.381 35

The Origin of the Earth's Magnetic Field—E. C. Bullard. (*Observatory*, vol. 70, pp. 139–143; August, 1950.) The Halley Lecture for 1950. Halley's work is outlined and various mechanisms are considered which might possibly account for the existence of the earth's magnetic field and its secular variation. The preferred hypothesis assumes a mechanism resembling that of a self-excited dynamo, the motion of the earth's fluid conducting core producing effects similar to those due to the motion of the dynamo rotor. Electric currents would thus be generated in the core and these could account for the main field, their variations due to the effects of irregular whirls and eddies near the surface of the core could also explain the secular variations of the field. The nature of the field within the core to be expected on such a hypothesis is discussed and the possible value of solar observations in this connection is pointed out.

550.381 35

The Experimental Determination of the Geomagnetic Radial Variation—S. K. Runcorn, A. C. Benson, A. F. Moore, and D. H. Griffiths. (*Phil. Mag.*, vol. 41, pp. 783–791; August 1950.) "Theories of the origin of the dipole components of the earth's main magnetic field are of two types: distributed theories attribute it to a fundamental property of rotating matter, core theories to current systems within the core. The variation with depth below the surface of the horizontal field intensity is different for the two theories. Experimental values are given for this variation, obtained by measurements in coal mines, which are near to the values predicted by a core theory, and significantly different from those predicted by a distributed theory. The magnetic effects of the sedimentary rocks and magnetic anomalies due to the basement rock are shown to have negligible effects on the measurements."

550.384 35

"Sudden Commencements" in Geomagnetism—W. Jackson. (*Nature* (London), vol. 166, pp. 691–692; October 21, 1950.) Two types of normal sudden commencement are recognized, according as the main movement is not, or is, preceded by a smaller movement in the opposite direction. To investigate Ferraro and Parkinson's suggestion (1142 of 1950) that the frequency of occurrence of the second type may be a function of geomagnetic latitude, this frequency was computed from available magnetograms for 1946–1948 for S.a. The result did not confirm the above suggestion, but is not regarded by the author as completely decisive.

5.384.4 353
Lunar Diurnal Variation of the Vertical Component of the Earth's Magnetic Field at V-Joyeux—P. Rougerie. (*Compt. Rend. Acad. Sci.* (Paris), vol. 231, pp. 787–788; October 16, 1950.)

5.510.535 354
Methods for the Determination of the Ionization Distribution beyond the Maximum of the *E* Layer—K. Bibl. (*Naturwiss.*, vol. 37, pp. 373–374; August, 1950.) Information regarding the ionization distribution in the region between the *E* and *F* layers can be obtained from a knowledge of the variation with frequency of the delay of the *F*-layer reflection with reference to the *E*-layer limiting frequency. For a given ionization distribution, the delay depends only on the ratio f/f_{cE} and on the thickness of the *E* layer, hence the latter can be found from delay-frequency curves. Using hourly records for the first half of 1949, a value of 35 km is found for the mean half-thickness of the *E* layer, whereas reflection measurements give a value of about 25 km for the thickness of the lower half. This indicates a more gradual decrease of electron density towards from the middle layer than in the lower half. The theory is developed to enable the true height to be assigned to any reflection.

5.57:621.317.318† 355
A Method of Measurement of the Charges Carried by Small Electrified Particles—L. Bidard and C. Lafarque. (*Compt. Rend. Acad. Sci.* (Paris), vol. 231, pp. 786–787; October 16, 1950.) An absolute method for charges on particles of fog, mist, or rain.

LOCATION AND AIDS TO NAVIGATION

6.396.9+621.396.6 356
S.B.A.C., Farnborough—(*See* 447.)

6.396.9+621.396.933 357
A New Basis for the Analysis of Radio Navigation and Detection Systems—N. L. Harvey. (*Sylvania Technologist*, vol. 3, pp. 1-18; October, 1950.) Certain developments in the theory of information transmission are applied to radiolocation systems. A brief explanation is given of the basic principles that (a) the transmission and receiver bandwidths are mutually independent system parameters, (b) the system resolution is the Fourier transform of the power spectrum, and (c) the type of modulation used to generate the spectrum is unimportant.

621.396.9 358
The Use of Dummy Reflecting Objects in Radar Technique—C. Stüber. (*Arch. elekt. Übertragung*, vol. 4, pp. 275–279; July, 1950.) An account of devices such as Al-foil dipoles and corner reflectors used by the Germans in the second World War for antiradar camouflage purposes.

621.396.9:523.53 359
The Fluctuation and Fading of Radio Echoes from Meteor Trails—J. S. Greenhow. (*Phil. Mag.*, vol. 41, pp. 682–693; July, 1950.) The fluctuations of meteor echoes were investigated simultaneously on frequencies of 36 and 72 Mc. The flutter period for short-period fluctuations varies inversely with frequency and is independent of the type or velocity of the meteor. This is consistent with distortion of the trail due to winds in the ionosphere. A few cases of longer-period fluctuations have been observed on 36 Mc only.

621.396.9:621.396.828 360
Integration-Noise Reducer for Radar—W. J. Cunningham, J. C. May, and J. G. Skalnik. (*Electronics*, vol. 23, pp. 76–78; September, 1950.) The video output of a radar receiver is fed through a gating circuit and integrated. A radar echo appears as an increase in the integrated signal. The duration, pulse-recurrence frequency, and time delay of the grating wave form are adjustable. Improvements in signal-to-noise ratio of between 5 and 17 db are obtained.

621.396.932 361
An Improved Marine Radar Equipment—(*Engineer* (London), vol. 190, p. 160; August 11, 1950.) Short general description of the Marconi "Radiolocator IV," an instrument for detecting suitable targets up to a range of 40 miles. In switching from shorter to longer ranges the pulse length is automatically lengthened, giving higher definition on the shorter ranges and brighter illumination of targets on the longer. Two self-contained remote-display units may be added.

621.396.933 362
Pulse Navigation Systems—W. L. Barrow. (*Jour. Brit. I.R.E.*, vol. 10, pp. 313–321; October, 1950.) Reprint. See 648 of 1950.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.583:621.385 363
Getter Materials for Electron Tubes—Espe, Knoll, and Wilder. (*See* 499.)

535.215.1 364
The Photoeffect in Alkali/Germanium Compounds—N. Schaetti and W. Baumgartner. (*Helv. Phys. Acta*, vol. 23, pp. 524–528; September 1, 1950. In German.)

535.215.1 365
Photoelectric Changes Induced in SrO and BaO by Ultraviolet Irradiation—J. E. Dickey and E. A. Taft. (*Phys. Rev.*, vol. 80, p. 308; October 15, 1950.) The observed photoemission of SrO is plotted against time, for an irradiation $h\nu = 5.80$ ev. There was rapid initial rise, with saturation after some minutes. The mechanism involved is discussed briefly.

535.37 366
Luminescence Spectra of Different Types of Phosphor under X Rays and Cathode Rays, specially at Low Temperatures—H. N. Bose. (*Proc. Nat. Inst. Sci.* (India), vol. 16, pp. 365–366; September-October, 1950.) Luminescence spectra of various alkali halides and some simple organic compounds, under cathode-ray and X-ray excitation, have been studied at ordinary and low temperatures. With impurity-activated alkali halides the luminescence spectrum of the parent lattice is not much affected by the presence of the characteristic band of the impurity. The results indicate that emitting centers are created by the irradiation, and also by the presence of impurities. With the organic compounds, interesting variants of ultraviolet luminescence have been observed.

535.37:546.47.284 367
On the Fluorescence and Phosphorescence Emission Spectra of Manganese-Activated Zinc Silicate—J. H. Schulman and C. C. Klick. (*Jour. Opt. Soc. Amer.*, vol. 40, pp. 622–623; September, 1950.) Observations are reported which indicate that the fluorescence and phosphorescence emission spectra of Zn_2SiO_4-Mn are identical. This result contradicts conclusions by Nagy (ibid., vol. 40, p. 407; 1950).

538.221 368
Ferromagnetic Spinels for Radio Frequencies—R. L. Harvey, I. J. Hegyl, and H. W. Leverenz. (*RCA Rev.*, vol. 11, pp. 321–363; September, 1950.) An account of the structure, synthesis, properties, and uses of ferrites.

538.221 369
Theory of Magnetic Anisotropy in Alnico V—J. E. Goldman and R. Smoluchowski. (*Phys. Rev.*, vol. 80, pp. 302–303; October 15, 1950.)

538.221:538.652 370
The Magnetostriction of Fe/Pt Alloys—N. S. Akulov, Z. I. Alizade, and K. P. Belov. (*Compt. Rend. Acad. Sci.* (URSS), vol. 65, pp. 815–818; April 21, 1949. In Russian.) Curves are shown for various alloys, the highest value of magnetostriction being found for the system 46 per cent Fe/54 per cent Pt. The effect of different treatments on this alloy is studied.

538.221:538.652 371
Single-Crystal Magnetostriction Constants of an Iron/Cobalt Alloy—J. E. Goldman. (*Phys. Rev.*, vol. 80, pp. 301–302; October 15, 1950.)

538.221:621.317.4.042.15 372
Study of Magnetic Powders at Radio Frequencies—P. Abadie, I. Épelboim, and B. Pistoulet. (*Compt. Rend. Acad. Sci.* (Paris), vol. 231, pp. 762–764; October 16, 1950.) Results of various measurements using a resonance technique at frequencies up to 24 kMc indicate the normal and anomalous properties of composite powders of dielectric and magnetic materials under conditions of gyromagnetic relaxation.

538.632:546.87 373
The Electrical Conductivity of Bismuth Fibres: Part 2—Anomalies in the Magneto-Resistance—B. Donovan and G. K. T. Conn. (*Phil. Mag.*, vol. 41, pp. 770–782; August, 1950.) Experimental results are reported which are considered to constitute the first unequivocal evidence of the existence of a longitudinal Hall coefficient.

621.314.6:537.311.33 374
On the Back Current in Blocking-Layer Rectifiers—J. H. Gisolf. (*Phil. Mag.*, vol. 41, pp. 754–769; August, 1950.) The theories of Davidov and Schottky are not applicable to the case of large back currents. Mathematical analysis is given which permits the calculation of the resistance to back currents, with allowance for the influence of the field on the threshold energy. The current-voltage characteristic can be obtained in particular cases by numerical integration. Examples given include comparisons between Se rectifiers and crystal detectors. The effect of artificial barrier layers such as a thin film of lacquer, on the electrical properties of rectifiers is briefly discussed. The rectifier effect is strongly favored by an increase of the current density.

621.315.592†+621.315.61 375
Modern Theories on Dielectrics and Semiconductors—S. Teszner. (*Bull. Soc. franç. élect.*, vol. 10, pp. 367–378; August, 1950.) Discussion of the theory by which such materials may be classified according to their internal structure, and qualitative study of the mechanism of conduction in crystalline solids, the effect of impurities on conductivity, and orbital, ionic, and molecular polarization and their connection with dielectric constant. See 3445 of 1950.

621.315.592:537.311.33 376
Theory of Relation between Hole Concentration and Characteristics of Germanium Point Contacts—J. Bardeen. (*Bell Sys. Tech. Jour.*, vol. 29, pp. 469–495; October, 1950.) "The theory of the relation between the current-voltage characteristic of a metal-point contact to *n*-type germanium and the concentration of holes in the vicinity of the contact is discussed. It is supposed that the hole concen-

tration has been changed from the value corresponding to thermal equilibrium by hole injection from a neighboring contact (as in the transistor), by absorption of light, or by application of a magnetic field (Suhl effect). The method of calculation is based on treating separately the characteristics of the barrier layer of the contact and the flow of holes in the body of the germanium. A linear relation between the low-voltage conductance of the contact and the hole concentration is derived and compared with data of Pearson and Suhl. Under conditions of no current flow, the contact floats at a potential which bears a simple relation, previously found empirically, with the conductance. When a large reverse voltage is applied the current flow is linearly related to the hole concentration, as has been shown empirically by Haynes. The intrinsic current multiplication factor a of the contact can be derived from a knowledge of this relation."

621.315.592:537.311.33 377

Theory of the Flow of Electrons and Holes in Germanium and Other Semiconductors—W. van Roosbroeck. (*Bell Sys. Tech. Jour.*, vol. 29, pp. 560–607; October, 1950.) "A theoretical analysis of the flow of added current carriers in homogeneous semiconductors is given. The simplifying assumption is made at the outset that trapping effects may be neglected, and the subsequent treatment is intended particularly for application to germanium. In a general formulation, differential equations and boundary-condition relation in suitable reduced variables and parameters are derived from fundamental equations which take into account the phenomena of drift, diffusion, and recombination. This formulation is specialized so as to apply to the steady state of constant total current in a single cartesian distance co-ordinate, and the properties of solutions which give the electrostatic field and the concentrations and flow densities of the added carriers are discussed. The ratio of hole to electron concentration at thermal equilibrium occurs as parameter. General solutions are given analytically in closed form for the intrinsic semiconductor, for which the ratio is unity, and for some limiting cases as well. Families of numerically obtained solutions dependent on a parameter proportional to total current are given for n-type germanium for the ratio equal to zero. The solutions are utilized in a consideration of simple boundary-value problems concerning a single plane source in an infinite filament."

621.315.592:621.314.6 378

***P-N* Junctions prepared by Impurity Diffusion**—R. N. Hall and W. C. Dunlap. (*Phys. Rev.*, vol. 80, pp. 467–468; November 1, 1950.) By providing a nonlinear distribution of impurities with distance from the barrier, rectifiers can be constructed combining the good forward characteristic corresponding to a large impurity gradient with the high reverse breakdown voltage corresponding to a small impurity gradient.

621.315.61 379

Conductance of Insulators for Aerial Lines at Carrier Frequencies—G. Gregoretti. (*Alta Frequenza*, vol. 19, pp. 137–144; June, 1950.) Conductance measurements were made on various types of insulator, after exposure to bad weather, at 50, 100, and 150 kc; results are recorded. Partial metallization of a pyrex insulator considerably reduced the variation of its leakage conductance with atmospheric conditions.

621.315.612 380

The Dielectric Constant of Inhomogeneous Dielectrics—G. M. Jonker. (*Chem. Weekbl.*, vol. 46, pp. 266–268; April 22, 1950.) A simple discussion of the dependence of the dielectric constant of ceramic materials on the porosity. The pore formation depends on the heat treatment; during sintering, the initially irregularly shaped pores run together to form rounded cavities. Measured values of the dielectric constant for material sintered at different temperatures are compared with values given by Böttcher's formula.

666.1.037.5 381

High-Temperature-Lamp Seals—E. J. G. Beeson. (*Elec. Times*, vol. 118, pp. 605–608; October 19, 1950.) A description is given of the molybdenum-foil seal, which is in common use but is inconveniently large and costly when large currents (150 amp or more) have to be carried. The construction of a quartz/molybdenum-thimble seal of the Houskeeper type is described, which has been developed for very-high-wattage mercury- and gas-discharge lamps.

MATHEMATICS

517.564 382

On the Characteristic Values of Spheroidal Wave Functions—C. J. Bouwkamp. (*Philips Res. Rep.*, vol. 5, pp. 87–90; April, 1950.) The first five terms of a power series expansion are given for the characteristic values of such functions of which both order m and degree n are integral and $n \not< m$. Numerical values are given for the case where $m=1$.

517.942.82 383

Note on the Inversion of the Laplace Transform—B. Gross. (*Phil. Mag.*, vol. 41, pp. 543–544; June, 1950.) The "pair property" of the Fourier transform is shown to exist also for the Laplace transform for particular classes of functions.

519.21:621.396.822 384

Some Statistical Functions useful for the Study of Background Noise—A. Blanc-Lapierre. (*Compt. Rend. Acad. Sci.* (Paris), vol. 231, pp. 566–567; September 18, 1950.) Starting from a random time series with a Poisson distribution, three theorems are established relating to nonstationary aleatory functions which occur in the theoretical treatment of background noise.

681.142 385

SEAC. The National Bureau of Standards Eastern Automatic Computer—(*Tech. Bull. Nat. Bur. Stand.*, vol. 34, pp. 121–127; September, 1950.) A general description of the computer is given, with examples of its application in optical-lens design and on the solution of a partial differential equation representing the flow of heat through a chemically reactive material. The present input-output unit uses a manual keyboard for direct input and a teletype printer for direct output, with a hexadecimal system (base 16) for both numbers and instructions. For indirect operation punched paper tape is used, with an input and output rate of 30 words per min., which can be increased to 10,000 words per min. by the use of magnetic wire or tape. The present memory unit is a serial type consisting of 64 acoustic delay lines. The addition of a parallel system of 45 electrostatic tubes with a greatly reduced access time is in progress.

681.142 386

The N. B. S. Computer Program—*Tech. Bull. Nat. Bur. Stand.*, vol. 34, pp. 128–129; September, 1950.) An outline of the various phases of the program on digital computers, including fundamental research, engineering development, design and construction, and technical services. In addition to SEAC, a second machine, the NBS Western Automatic Computer (SWAC) has been completed in the NBS laboratories at Los Angeles. Five other large-scale computers are under construction by industrial firms for various government services.

51:[621.396/.397 387

Radio and Television Mathematics [Book Review]—B. Fischer. Publishers: Macmillan, New York, N. Y., 440 pp., 1949, $6.00. (Pro I.R.E., vol. 38, p. 1230; October, 1950.)

512.9 38

Grundzüge der Tensorrechnung in Analytischer Darstellung—Teil 1: Tensoralgebr (Analytical Presentation of the Fundamenta of Tensor Calculus. Part 1: Tensor Algebra [Book Review]—A. Duschek and A. Hoc rainer. Publishers: Springer Verlag, Vienn 129 pp., 1948 (*Elektrotechnik Berlin*, vol. p. 264; July, 1950.) Second impression of useful practical textbook.

517.43 38

Calcul Opérationel [Book Review]— Labin. Publishers: Masson et Cie, Par 145 pp., 1949, 780 fr. (*Proc. Phys. Soc.* (London), vol. 63, p. 1046; September 1, 195 "This work may be regarded as a list of gener rules of the operational calculus . . . The subject is treated from the viewpoint of Lapla transform and complex variable . . . [It] recommended to those who have an adequa knowledge of the underlying mathematic theory."

517.93:534.014.1/.2 3

Non-Linear Vibrations in Mechanical a Electrical Systems [Book Review]—J. Stoker. Publishers: Interscience Publishe 273 pp., 40s. (*Phil. Mag.*, vol. 41, p. 731; Ju 1950.) Deals with the free and forced oscil tions corresponding to solutions of the diff ential equations of Duffing and van der Pol.

MEASUREMENTS AND TEST GEAR

621.3.082 3

British Developments in Instrumentation J. H. Jupe. (*Electronics*, vol. 23, pp. 182, 21 October, 1950.) Brief descriptions of a wi range of instruments, including a photocell d vice for measuring the size of carbon partic in flames, a direct-reading midget magnetom ter using the Hall effect in Ge and with thr ranges covering 0–25,000 gauss, electroi gauges of many types, new photocells, inclu ing one modulated by an alternating field, 15-channel cathode-ray camera with fifte $1\frac{1}{2}$-inch cathode-ray tubes as an integral pa of the unit, and a low-frequency analyzer. echo-free room is also noted.

621.3.083.4:621.396.611.21.012.8 3

Measurement of the Electrical Characte istics of Quartz Crystal Units by Use of Bridged-Tee Network—C. H. Rothauge a F. Hamburger, Jr. (PROC. I. R. E., vol. 38, 1213–1216; October, 1950.) The simplifi equivalent circuit of a crystal with a capaciti load is an effective inductance and an effecti resistance in series; this, in parallel with a network of two equal capacitors and a resist forms a network with a zero transmission f quency. Screening of such a system is relativ simple, as the source and the detector have common earthed terminal. Stray capacitanc are included in the calibration of the netwo capacitors. The accuracy of measurement about 5 Mc was estimated to be within 0.3 p cent for the equivalent series reactance, a within 2.3 per cent for the equivalent ser resistance.

621.317.3:621.396.611.3 3

Principles of Measurements on Coupl Circuits—W. F. Dil. (*Philips Res. Rep.*, vol. pp. 91–115; April, 1950.) Analysis is given o circuit consisting of a tube feeding two tu circuits with capacitive and resistive as well inductive coupling; universal resonance curv are presented. The conditions for symmetri resonance curves are investigated. Methods measuring circuit Q values and coupling coe cients are reviewed. Techniques are suggest for measuring the parameters of coupled c cuits without loss of accuracy due to distu ance of the normal operating conditions.

317.332 394
Conductivity Measurements at Microwave Frequencies—A. C. Beck and R. W. Dawson. (Proc. I.R.E., vol. 38, pp. 1181–1189; October, 1950.) An investigation of skin effect at 9 kMc. The half-power bandwidth of the resonance curve of an open-circuited coaxial line having a wire sample as the center conductor was measured and the loaded Q derived. By measurement of the transmission loss in the specimen holder, a correction factor was obtained, enabling the Q of the sample alone to be calculated. Numerical results are tabulated for various pure metals and alloys showing the effects of different surface treatments on the resistivity at frequencies for which the current penetration depth is small. The results emphasize the importance of a high polish. Electroplated copper and silver deposits, even when polished, were found to have considerably higher resistivities than the solid metals.

317.332 395
Conductivity Measurements at Microwave Frequencies—A. C. Beck. (*Bell Lab. Rec.*, vol. 28, pp. 433–437; October, 1950.) *See* 394 above.

317.335.2†:621.396.619.13 396
Some Experiments on the Use of Frequency Modulation in Electrical Measurements—M. Tombs and J. F. Ward. (*Proc. IEE*, Part I, vol. 97, pp. 645–650; October, 1950.) Capacitance changes are measured by the variation produced in the frequency or phase of a signal from an oscillator normally of high frequency stability. A full description is given of laboratory apparatus used in studying the technique. The results obtained confirmed its value, particularly in respect of stability and sensitivity. Capacitance changes of 5×10^{-4}pF could be measured with a possible error of about 50 per cent. The principal limitation arises from phase fluctuations in the oscillator.

317.384 397
Microwave Power Measurements—R. Sarzi. (*Alta Frequenza*, vol. 19, pp. 115–136; June, 1950.) Discussion of methods based on the resistance variations of heat-sensitive elements, such as thermistors, introduced into waveguides or coaxial lines. An apparatus constructed at the Research Centre for Microwave Physics at Florence and using thermistors is described; results obtained are reported. The power range of this instrument is 5–10 mw, the maximum error being 5–8 per cent.

.317.7:[621.385.3:621.315.59 398
Production Tester for Transistors—L. P. Hunter and R. E. Brown. (*Electronics*, vol. 23, pp. 96–99; October, 1950.) Alternating-current test apparatus for rapid determination of transistor voltage gain, current gain, and input impedance under different bias and load conditions.

.317.714.085.414 399
Design of Log-Scale D.C. Meters—A. Johnson and C. F. Taylor. (*Elec. Eng.*, vol. 69, pp. 877–882; October, 1950.) The mathematical background and underlying principles involved in the design of log-scale dc indicating instruments are given. The characteristics of the flux distribution in the magnet system and means for adjusting it are discussed. Application is made to a photographic exposure meter, where the logarithmic scale is used as a slide rule to give direct indications of exposure times.

.317.725 400
A Valve-Voltmeter Circuit—R. Kitai. (*Electronic Eng.*, vol. 22, pp. 420–422; October, 1950.) Description of apparatus designed for the use of students. Special features are rugged construction, overload protection, and low cost.

.317.725:621.383.5 401
A High-Impedance Voltmeter—T. A. Ledward. (*Electrician*, vol. 145, pp. 467–469; August 25, 1950.) Design and use of Se barrier-layer photocells for amplification of the movement of the pointer of a moving-coil instrument. A light Al vane attached to the pointer moves over a pair of differentially connected Se cells, so that a deflection amplification of 20 to 1 is obtained. The light source and reflector are mounted above the vane, outside the instrument. Low amplification is used for reasons of stability and reliability. Ranges of 10 mv, 100 mv, 1 v, 10 v and 100 v at 1 MΩ per volt are available, and also a 1,000-v range at 0.1 MΩ per volt.

621.317.726.087 402
Chart Recording of Microsecond Pulse Amplitudes—J. T. Dewan and K. W. Allen. (*Rev. Sci. Instr.*, vol. 21, pp. 823–826; October, 1950.) Description of a peak-voltmeter recorder suitable for use in counter circuits.

621.317.733 403
Wien-Bridge Network Modifications—R. Zuidhof. (*Electronics*, vol. 23, pp. 192, 198; September, 1950.) When the network is used as an *RC* oscillator circuit, stray capacitance across the series resistor produces undesirable effects. These can be counteracted by the addition of a trimmer across the series capacitor. This modification results in a more constant output and an extended frequency range.

621.317.755 404
A Fast Sweep Circuit—N. L. Davis and R. E. White. (*Electronics*, vol. 23, pp. 107–109; October, 1950.) Two methods for obtaining an oscilloscope sweep of 100 inches per μs were investigated, one using a modified raster scan and the other using a hydrogen thyratron. The circuits and methods of calibration are described and typical applications of the equipment are illustrated.

621.317.755 405
Automatic Beam Blanker for Oscilloscopes—A. L. Dunn, A. R. McIntyre, and A. L. Bennett. (*Electronics*, vol. 23, pp. 94–95; September, 1950.) A circuit is described in which the sweep itself is used to release the beam and to blank it when the trace is completed. This eliminates background fogging caused by scattered electrons.

621.317.755:621.385.029.63/.64 406
The Travelling-Wave Cathode-Ray Tube—Owaki, Terahata, Hada, and Nakamura. (*See* 503.)

621.317.755:621.396.645.018.424† 407
Wide-Band Amplifier for Cathode-Ray-Oscilloscope Observation of Transient Phenomena—Schmid and Baldinger. (*See* 315.)

621.317.755.029.63 408
An Oscillograph for Decimetre Waves—H. G. Möller. (*Elektrotechnik Berlin*, vol. 4, pp. 246–249; July, 1950.) By introducing a dielectric covering on the deflector plates the full sensitivity of a cathode-ray tube can be retained at higher frequencies. A formula is derived connecting phase velocity with the dimensions of the dielectric for the E_0 mode of operation. Numerical examples are calculated.

621.317.772 409
Precision Phasemeter for Audio Frequencies—J. Kritz. (*Electronics*, vol. 23, pp. 102–106; October, 1950.) The design of the instrument is based on the method of Ragazzini and Zadeh (1724 of 1950). To obtain an accuracy to within 0.1° when measuring the phase difference between two sinusoidal voltages it was necessary to design each section, including the ring-modulator phase-detector bridge, so as to reduce each component error to below 0.01°. Methods are described for self-calibration of the instrument.

621.317.784:621.317.733 410
A Bolometer Bridge for the Measurement of Power at High Frequencies—R. A. Soderman. (*Gen. Radio Exper.*, vol. 25, pp. 1–8; July, 1950.) Description of Type 1651-A bridge. Measurements of power up to 500 mw may be made at frequencies from 5 Mc to over 1 kMc by substitution or direct-reading methods to within ±10 per cent or ±20 per cent, respectively. Thermistor or barretter bolometers with resistances in the range 25–400 Ω may be used.

621.396.615 411
Signal-Generator Output Systems—H. Molinari. (*Bull. schweiz. elektrotech. Ver.*, vol. 41, pp. 798–801; October 14, 1950. In German.) The calibration of the attenuators usually fitted to signal generators is only valid for a particular load impedance. The factors affecting the voltage at the output terminals of a generator are investigated. For accurate knowledge of the terminal voltage, the load impedance, the no-load voltage V, and the internal impedance Z of the generator must be known. Formulas giving V and Z in terms of measured impedances are derived.

621.396.615:621.396.619.13 412
Design for a Wobbulator—M. G. Scroggie. (*Wireless World*, vol. 56, pp. 369–372; October, 1950.) Design and construction details are given of an instrument for use with the simple cro previously described (1458 of 1950). The circuit used is adapted from that of Johnson (1898 of 1949) which has the advantages of giving FM up to 30 per cent and of requiring only one tube.

621.396.615.14 413
A Wide Range Microwave Sweeping Oscillator—M. E. Hines. (*Bell Sys. Tech. Jour.*, vol. 29, pp. 553–559; October, 1950.) Description of a test oscillator using the BTL 1553–416A triode (510 below). A mechanical tuning device varies the frequency continuously at a low audio-frequency rate over the frequency band 3.6–4.5 kMc.

621.396.615.14 414
Microwave Sweep Generator—L. C. Eisaman. (*Electronics*, vol. 23, pp. 101–103; November, 1950.) A Type-6BL6 reflex klystron feeds a resonant cavity tuned by a motor-driven plunger. Frequency sweep is 2.6–3.4 kMc; sweep rate, 8–10 cps.

621.396.826.029.51:535.568.1 415
Polarimeter for the Study of Low-Frequency Radio Echoes—A. H. Benner and H. J. Nearhoof. (*Rev. Sci. Instr.*, vol. 21, pp. 830–834; October, 1950.) A description of the equipment, with a brief note of typical experimental results. A pulse signal at a carrier frequency of 150 kc is received, after reflection from the ionosphere, on crossed loop antennas which separate the two components of the elliptically polarized down-coming wave. By arranging that the cathode-ray tube, to which the loops are connected through balanced amplifying chains, is illuminated only for the desired epoch, a direct picture of the polarization ellipse is obtained. Arrangements are included to enable the sense of rotation to be determined.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.9.001.8 416
Measuring Water Velocity by an Ultrasonic Method—W. B. Hess, R. C. Swengel, and S. K. Waldorf. (*Elec. Eng.*, vol. 69, p. 983; November, 1950.) Description of a method still in the experimental stage. Two 500-kc transducers are mounted at a fixed distance apart downstream. Measurements of the phase angle between the transmitted and received signals are made in quick succession using (a) the upstream, (b) the downstream transducer for transmission and the other for reception. From the two measured phase angles the water velocity is deduced. Average error in tests of the equipment was about 1 per cent.

621.315.212:621.317.39 417
Measuring Cable Eccentricity—(*Elec. Times*, vol. 118, p. 430; September 14, 1950.) Continuous control in the manufacture of cables with extruded insulation is provided by an instrument which indicates any core eccentricity. Operation depends on comparison of the electromotive forces induced in the various coils mounted in a gauge head through which the cable, fed with constant ac, passes.

621.316.718 418
An Electronic Speed Control for the Towing Carriage of a Ship-Model Testing Tank—R. H. Tizard and B. G. V. Harrington. (*Proc. IEE*, Part II, vol. 97, pp. 651–662; October, 1950.) A description of equipment fitted to the carriage of one of the tanks at the National Physical Laboratory. To meet close requirements on the constancy and setting of carriage speed, a closed-loop automatic control system was developed. Details of its original features are given. Mathematical analysis of the system shows that by incorporating a special feedback network the stability is little affected by large variations of gain. Test results after six months' operation show great improvement compared with the manually controlled Ward-Leonard system previously used.

621.317.39:531.717.1 419
The Electronic Measurement of Sliver, Roving, and Yarn Irregularity, with Special Reference to the Use of the Fielden Bridge Circuit—P. H. Walker. (*Jour. Textile Inst.*, vol. 41, pp. 446–466; July, 1950.) Irregularities are determined from measurements of the change of capacitance caused by passing the material through the air gap of a fixed capacitor forming one arm of a bridge, the other arms being provided by a specially wound transformer and a variable balancing capacitor. A selective pentode amplifier is used to increase the sensitivity.

621.38.001.8 420
Symposium on Electronics, London, September 5–8, 1950—*Elec. Times*, vol. 118, pp. 411–417; September 14, 1950.) Summarized accounts of the lectures at the opening ceremony of the conference arranged by the Electronics Group of the Scientific Instrument Manufacturers' Association and of the papers presented at the various sessions, with a review of some of the instruments exhibited.

621.384.6 421
Electronics and the Electrostatic Generator—B. Jennings. (PROC. I.R.E., vol. 38, pp. 1126–1138; October, 1950.) Discussion of the construction and operation of particle accelerators using Van de Graaff electrostatic generators to give the required high voltage.

621.384.612.2† 422
The Synchrocyclotron at Amsterdam—C. J. Bakker. (*Onde élect.*, vol. 30, pp. 347–350; August–September, 1950.) General description, with sectional diagrams and photographs of equipment capable of accelerating protons to 60 Mev.

621.387.4† 423
On the Temperature Variations in Alcohol/Argon-Filled G-M Counters—O. Parkash. (*Phys. Rev.*, vol. 80, p. 303; October, 15 1950.

621.387.4†:549.211 424
Some Properties of Diamond as a Crystal Counter—H. Ess and J. Rossel. (*Helv. Phys. Acta*, vol. 23, pp. 484–487; September 1, 1950. In French.)

621.398+621.317.083.7]:621.395.44:621.311.1 425
Multistation Control, Telemetering, and Communication on Single-Frequency Carrier—W. Derr, T. C. Wren, and J. V. Kresser. (*Elec. Eng.*, vol. 69, pp. 862–867; October, 1950.) Three of the stations of the Sierra Pacific Power Company are controlled from a central station by a power-line carrier system which also provides communication and selective-telemetry facilities.

621.38.001.8 426
Electronics in Engineering [Book Review]—W. R. Hill. Publishers: McGraw-Hill Book Co., New York, N. Y. 274 pp., 1949. (*Electronic Eng.*, vol. 22, p. 445; October, 1950.) "An elementary book of wide scope."

PROPAGATION OF WAVES

535.42:538.56]+534.26 427
On the Theory of Diffraction—Franz. (*See* 323.)

535.42:538.566 428
Diffraction from an Irregular Screen with Applications to Ionosphere Problems—H. G. Booker, J. A. Ratcliffe, and D. H. Shinn. (*Phil. Trans.* vol. 242, pp. 579–607; September 12, 1950.)"An analysis is made of the diffraction effects produced when a plane wave is incident upon an irregular diffracting screen, and the results are applied to the problem of the reflexion of radio waves from an ionosphere which is irregular in the horizontal plane. The nature of the irregular screen is assumed to be given in terms of the variation of electric wave-field in a plane just beyond the screen, and it is assumed that variations occur over the plane in one direction only. It is further assumed that the screen is 'random' in the sense that it is one of an assembly all of which differ from each other, but have statistical properties in common, and deductions are made about the diffraction patterns averaged over the assembly. It is shown that many aspects of the problem can be investigated by use of the theory of 'random' electrical noise as developed by Rice and Uhlenbeck. The angular spectrum (Fraunhofer diffraction pattern) and the Fresnel diffraction pattern are described in terms of their spatial autocorrelation functions, and there is some discussion of a related method of dealing with Fresnel diffraction problems from completely determined screens.

"In Part II of the paper the irregular 'fading' exhibited by a radio wave returned from the ionosphere is discussed in terms of two models in which the facing is assumed to be produced by movements of the diffracting centers in the ionosphere. The temporal autocorrelation function of the amplitude of the irregularly fading signal is related to the velocity of the ionospheric diffracting centers."

538.566 429
On Sommerfeld's Surface Wave—C. J. Bouwkamp. (*Phys. Rev.*, vol. 80, p. 294; October 15, 1950.) Papers on this problem by various workers are very briefly reviewed; in particular the discussion by Kahan and Eckart (2892 of 1949) is criticized and their uniqueness theorem is analyzed and pronounced unsound.

621.396.11 430
A Determination of the Speed of Light by the Resonant-Cavity Method—K. Bol. (*Phys. Rev.*, vol. 80, p. 298; October 15, 1950.) Brief account of work in progress at Stanford University. A cylindrical cavity 4.5 inches high and 9.8 inches in diameter is used and a provisional result of 299.789.3±0.4 km per second has been obtained. There may be a further error due to tarnishing of the cavity walls. See also 1751 of 1950 (Essen).

621.396.11.029.62 431
Propagation of Metric Waves Beyond Optical Range—D. W. Heightman. (*Jour. Brit. I. R. E.*, vol. 10, pp. 295–311; October, 1950.) A qualitative survey of tropospheric and ionospheric wave propagation in the frequency band 30–200 Mc. Theoretical treatment is limited to explanations of the basic principles involved. A knowledge of the easily recognized meteorological conditions associated with
variations in tropospheric propagation is usef
in short-term prediction of radio conditio
Extended ranges are, in general, of little pr
tical value owing to interference from dista
transmitters. A selection of long-term observ
tions over various land and sea paths, bo
tropospheric and ionospheric, is presented
graphical form and results are discussed.

621.396.11.029.62:531.74 4
**Measurement of Small Angles of Elevati
of Incoming Electromagnetic Metre Wav
Part 2: The Comparison Method Using T
Arrays with Different Directional Characte
istics**—L. Pungs and H. Fricke. (*Arch. ele
Übertragung*, vol. 4, pp. 309–315; Augu
1950.) The theory of the method was given
Part 1 [3130 of 1950 (Stenzel)]. The volta
from the two comparison antennas are appli
respectively to the two fixed systems of
goniometer, the orientation of the resulta
field providing a measure of their ratio, a
hence of the angle of elevation of the receiv
wave. Design details are given for antenna s
tems for measurements with 2.4-m waves. T
range of angles measurable with different a
tenna arrangements is discussed. The effect
uneven terrain on the calibration can be eli
nated by providing a horizontal artificial ea
or a series of vertical screens of wire mesh.

621.396.11.029.62:531.74 4
**Measurement of Small Angles of Elevati
of Incoming Electromagnetic Metre Wav
Part 3: The Frequency Dependence of t
Comparison Method**—H. Fricke. (*Arch. ele
Übertragung*, vol. 4, pp. 315–320; Augu
1950.) Part 2: 432 above. To avoid interfer
transmissions it is necessary to be able
operate over a range of frequencies. Analysi
given of the effect on the goniometer calibrat
of varying the frequency, which results
change of (a) the ratio of wavelength to a
tenna dimensions, (b) the radiation coupli
and (c) the effects due to feeder-cable inequ
ties. The theory is confirmed by measureme
made at a mean wavelength of 1.5 m w
±16-per cent variation.

621.396.11.029.62:531.74:621.396.67
**Short-Wave Installations with Controlla
Directional Characteristics and their Appli
tion to the Measurement of Angles of In
dence**—P. Kotowski, E. Schüttlöffel, and
Vogt. (*Arch. elekt. Übertragung*, vol. 4, pp. 2
254, 325–330; July and August, 1950.) The
vantages of electrical over mechanical meth
of controlling antenna directional charact
istics are indicated and the technique of elec
cal control is discussed. A description is gi
of an installation at Brück-am-Main for me
uring angles of incidence; this uses th
rhombic antennas. Measurements on Ameri
and British short-wave broadcast transmissi
are reported; the vertical angles lie betweer
and 41°, the angle of incidence increasing w
wavelength. Deviations from great-circle pa
are also investigated; for the British transm
ter the dispersion of these deviations is sign
cantly greater than for the more distant Am
can transmitters.

621.396.11.029.63/.64
**Propagation of Waves of Frequency 30
10,000 Mc/s**—P. Marié; L. de Broglie. (*Ra
Tech. Dig.* (France), vol. 4, pp. 157–176 a
195–212. Bibliography, pp. 212–213; June a
August, 1950.) The principles of geometr
optics are applied to the case of radio propa
tion over a 200-km sea path between poi
some 500 m above sea level. Regular variat
of the refractive index of the atmospher
taken into account by using the factor of
parent curvature of the earth. Examples of
daily and seasonal variation of this factor
shown graphically. Expressions are deri
for minimum height and radiation angle of
direct ray. Focusing effect and multiple ref
tions at the surface of the sea are discussed a

art is derived indicating the conditions r which these effects may occur. The od of calculating diffraction losses is deéd and two abacs due to Bullington (802 of 9) are reproduced. An illustrative numerical lation is made of the received intensity of M signal under given conditions.

. de Broglie comments in a general way on h application of geometrical optics in the ry of the propagation of radio waves.

396.11.029.64 436

Propagation of U.H.F. and S.H.F. Waves ond the Horizon—K. Bullington. (PROC. E., vol. 38, pp. 1221–1222; October, 1950.) nd-wave field intensities calculated for the s of plane earth, diffraction over a smooth h and over a knife edge, are plotted against rameter defined as the ratio of the clearance the obstacle to the height of the first nel zone. Good agreement is obtained with rimental results at 4–4.6 kMc over both oth and rough paths. The presentation ws the importance of the clearance and the t range of values of field intensity that may r beyond the horizon.

396.826.029.51:535.568.1 437

Polarimeter for the Study of Low Frency Radio Echoes—Benner and Nearhoof. 415.)

RECEPTION

594.6:621.317.7.087 438

The Measurement of Atmospheric Radio e in South Africa in the Low Frequency d—D. Hogg. (*Trans. S. Afr. Inst. Elec.* ., vol. 41, pp. 209–225; discussion, pp. 225– July, 1950.) Full details are given of an omatic recorder in which a vertical anteneeds a superheterodyne receiver tuned to kc and having a bandwidth of 6 kc. The voltage is eventually applied to a cro whose is photographed for 2 minutes every 20 utes. Calibration voltages are applied y. For the recording site near Johannesburg average noise level is 1 or 2 μv per m during day, rising to 20 μv per m and 100 μv per m ing winter and summer nights, respectively. al summer thunder may raise the level to v per m in the afternoon. Graphs are given he median and 95-per cent noise levels for ter, summer, and the equinoxes and also of frequency of occurrence of various noise ls at different times of day. The correlation he observed data with thunderstorm acity is discussed. Agreement of the measured ls with those predicted from data in Report 5 of the U. S. Army Signal Corps is usually d.

.396.621 439

An Advanced Amateur Receiver—R. P. viland. (*CQ*, vol. 6, pp. 12–18, 66; October, 0.) A receiver providing good reception for AM, FM, PM, and ssb with carrier supssion. Proper use of the phasing system of odulation makes possible the selection of er sideband at will, thus enabling unwanted als to be cut out more easily. Application of exalted-carrier principle prevents loss of dulation of the desired signal owing to strong erfering signals. To avoid the complexities oil switching, a series of converters is used h wide-band fixed-tuned high-frequency ges. The oscillator is crystal-controlled and ing is accomplished by a tuner which covers lowest frequency band and becomes a tuned ermediate-frequency system on the higher ds.

.396.621 440

Design, Construction and Final Adjusment an Up-to-Date, High-Fidelity Receiver us- Modern Valves: Part 1—The Low-Frency Amplifier—J. Rousseau. (*TSF pour us*, vol. 26, pp. 342–346; October, 1950.) An put of 8 w is obtained from the 3-stage amplifier, which comprises a Type-6AU6 pentode amplifier, Type-EL41 driver, and two Type-6AQ5 output tubes in push-pull. This choice of tubes is discussed and the selective feedback and coupling circuits are calculated. Circuit diagrams showing component values and details of the baffle mounting of the two loudspeakers are given.

621.396.621:621.317.35 441

On the Energy Spectrum of an Almost Periodic Succession of Pulses—G. G. Macfarlane. (PROC. I.R.E., vol. 38, pp. 1212–1213; October, 1950.) Discussion on 217 of 1950.

621.396.621.029.63 442

Some Design Considerations of Ultra-High-Frequency Converters—W. Y. Pan. (*RCA Rev.*, vol. 11, pp. 377–398; September, 1950.) Two basic converter designs are considered for use at frequencies between 500 and 900 Mc, one using a tuned radio-frequency amplifier, mixer oscillator and intermediate-frequency amplifier, and the other a crystal mixer followed by a grounded-grid intermediate-frequency amplifier. Measurements indicate similar performance characteristics, but the second type is preferable for reasons of cost and simplicity. The influence of the intermediate frequency on the crystal-mixer performance characteristics is discussed. From noise-factor considerations alone, the optimum value of the intermediate frequency is about 40 Mc, but owing to other requirements a value of about 135 Mc is preferable. Some special tuning circuits, and the effect of the method of oscillator injection on matching conditions, mixer loss, and oscillator radiation, are considered. The design and characteristics are described of an experimental converter, continuously tunable through the range 500–700 Mc, developed for uhf television investigations at Bridgeport, Conn. See also 1792 of 1950 (Murakami).

621.396.82 443

Interference Caused by More Than One Signal—R. M. Wilmotte. (PROC. I.R.E., vol. 38, pp. 1145–1150; October, 1950.) A theoretical survey of the factors involved in determining the effect on a wanted signal of several interfering signals, including noise. Suggestions are made toward the solution of the problems involved, and the related problem of determining the service area of vhf and uhf broadcasting systems is discussed.

621.396.822:519.21 444

Some Statistical Functions useful for the Study of Background Noise—Blanc-Lapierre. (*See* 384.)

621.396.828:621.385.2:621.315.59 445

Germanium-Diode Impulse-Noise Limiters—R. C. Moses. (*Sylvania Technologist*, vol. 3, pp. 1–5; October, 1950.) Proper use of noise-limiting circuits results in an improvement of the signal-to-noise ratio when certain types of external noise are present. Shunt, series, and compound limiters including Ge diodes are described and their properties compared; the choice of the type to be used for any particular purpose depends on such factors as the noise conditions likely to be met, the range of signal levels to be used, and the permissible audio-frequency distortion.

STATIONS AND COMMUNICATION SYSTEMS

621.396.3/.5 446

The Overseas Radio Installations at Frankfurt a. M.—F. Ellrodt. (*Fernmeldetech. Z.*, vol. 3, pp. 346–355; September, 1950.) An account in some detail of the telegraphy and telephony transmitting and receiving equipment affording communication in the first place with the U.S.A. Similar 20-kw power amplifiers are provided for all transmitters, with grounded-grid air-cooled Type-RS-720 tubes. Part of the telegraphy traffic is on the frequency-shift system, the special quartz-crystal frequency-control arrangement being described. Multichannel ssb transmission is used, with transmitter frequency range 3.75–23 Mc in three bands. Receivers are of the double-diversity type. See also 2893 of 1950 (Kronjäger).

621.396.6+621.396.9 447

S.B.A.C., Farnborough—(*Electrician*, vol. 145, pp. 580–582; September 15, 1950.) Brief details of some electrical exhibits at the exhibition arranged by the Society of British Aircraft Constructors at the RAE Aerodrome, September, 1950.

621.396.619.13:621.3.018.78† 448

Nonlinear Distortion in Frequency Modulation—L. J. Libois. (*Câbles & Trans.* (Paris), vol. 4, pp. 297–307; October, 1950.) The assumption of a quasistationary condition is justified when the modulation frequency is relatively low, provided that the rate of variation of the instantaneous frequency remains within certain limits. Under these conditions the nonlinear distortion introduced by the following is calculated: (a) nonlinearity of static characteristics of the system; (b) variation of propagation time with frequency within the modulation band; (c) insufficient amplitude limitation before the discriminator; (d) reflections in feeders and multiple transmission paths. While elimination of the effects due to the first three causes imposes severe limiting conditions of operation, feeder reflections and multipath transmission are probably the most troublesome, since they can only be reduced by shortening feeders as much as possible and by using highly directive antennas and well-isolated transmission paths.

621.396.619.14:621.3.018.78† 449

Distortion: Band-Pass Considerations in Angular Modulation—A. A. Gerlach. (PROC. I.R.E., vol. 38, pp. 1203–1207; October, 1950.) An exact open-form solution of the equation for the output signal from a network is derived, the input being an angle-modulated signal. By using transfer functions which are linear exponential functions of frequency a solution in closed form is obtained. Particular examples are examined to determine the effects of the transfer function characteristics on the output signal. The analysis supports the conclusion that linear phase characteristics are more important than flat amplitude characteristics for the reduction of distortion.

621.396.65 450

The TD-2 Radio Relay System—C. E. Clutts. (*Bell Lab. Rec.*, vol. 28, pp. 442–447; October, 1950.) A skeleton description of a relay system with 33 repeater stations, providing two-way communication facilities between New York and Chicago and operating in the band 3.7–4.2 kMc. Each of the six channels available in each direction is 10 Mc wide. An alarm system indicates failure at unattended repeater stations. Automatic arrangements switch on emergency supplies in the event of power failure.

621.396.65:621.397.26 451

Television for Scotland—(*See* 462.)

621.396.7 452

Burnham Radio Station—F. G. Balcombe and D. E. Watt-Carter. (*P. O. Elec. Eng. Jour.*, vol. 43, Part 3, pp. 117–124; October, 1950.) The system for routine communication between ships at sea and London is described: the oceans of the world are divided into areas, each with its own station provided with multiple sending and receiving facilities and linked to London by high-speed point-to-point circuits. Burnham is the area station for the east and middle Atlantic and the Mediterranean, and is linked by land line to London.

All ships report to their local area station and the information is logged at Burnham; out-

going traffic from London is routed accordingly, being sent by transmitters at Portishead and Criggion (or Rugby) under control from Burnham. Incoming traffic is handled at Burnham by 32 receivers on the high-frequency band (4–22Mc) using any antenna selected from a fan-shaped array of high-gain rhombic antennas, supplemented by omnidirectional antennas. On low frequencies four receivers are used with Bellini Tosi crossed loops or a nonresonant T-antenna. There are also available vertical λ/4 antennas resonant at 1.3 and 3 Mc, and a nonresonant inverted L-antenna for the 500-kc frequency band. By an elaborate switching system the amplified signals from any of the antennas may be distributed to any desired combination of the receivers. Ease of working is secured by a comprehensive telephonic intercommunication system.

621.396.712:621.396.619.13 — 453

Low-Frequency Technique in U.S.W. Broadcasting—E. Menzer and H. Voelkel. (*Z. Ver. Dtsch. Ing.*, vol. 92, pp. 653–657; August 21, 1950.) The basic principles of design for an FM broadcasting station are considered and the precautions necessary in obtaining suitable bandwidth, low distortion and noise level throughout the transmission chain are discussed.

621.39 — 454

Electrical Communication [Book Review]—A. L. Albert. Publishers: John Wiley and Sons, Inc., New York, N. Y., 3rd ed., 593 pp., 1950, $6.50. (*Electronics*, vol. 23, pp. 133–134; October, 1950.) ". . . a concise picture of all aspects of modern communication systems . . . not only useful as a text but as a reference book."

621.39.001.11 — 455

The Mathematical Theory of Communication [Book Review]—C. E. Shannon and W. Weaver. Publishers: University of Illinois Press, Urbana, Ill., 117 pp., $2.50. (*Brit. Jour. Appl. Phys.*, vol. 1, pp. 270–271; October, 1950.) The book is in two parts. The first part contains a mathematical analysis, leading to twenty-three theorems, and some detailed expansions and proofs. Part 2 surveys the broad field of the transmission of information. "This book cannot be ignored by anyone with direct professional concern with these applications . . ."

SUBSIDIARY APPARATUS

621–526 — 456

Magnetic-Powder Clutch Servo—S. Wald. (*Radio & Telev. News, Radio-Electronic Eng. Suppl.*, vol. 15, pp. 12A–13A, 26A; September, 1950.) Details are given of the design of a dry-powder magnetic clutch capable of operating at speeds up to 5,000 rpm and transmitting a torque of 48 in.-oz. The frictional drag is 2–3 in.-oz and independent of speed. A circuit is given illustrating its use in automatic tuning of a transmitter.

621–526.001.4 — 457

Modern Servomechanism Testers—G. A. Korn and T. M. Korn. (*Elec. Eng.*, vol. 69, pp. 814–816; September, 1950.) Methods permitting direct reading of amplitude and phase are presented and discussed.

621.3.013.78† — 458

The Performance of Screening Rooms—J. Miedzinski and S. F. Pearce. (*Electronic Eng.* (London), vol. 22, pp. 414–419; October, 1950.) Experiments have been made by the Electrical Research Association on four rotatable rooms, each about 6 feet, 6 inches×6 feet, 6 inches×7 feet, totally screened with perforated or expanded metal, or wire netting, and enclosing a vertical transmitting loop. The range of frequency used was 0.75–24 Mc. Field strengths as the room was rotated were measured at an external point with a modified Type-R.206 army receiver. In general, the highest attenuation is obtained with screening materials having high conductivity, low permeability, and close mesh. Formulas are derived for predicting the attenuation produced by a given screen; these are, in general, confirmed by the experimental results.

TELEVISION AND PHOTOTELEGRAPHY

621.397.24/.26 — 459

Television from France—M. J. L. Pulling. (*Wireless World*, vol. 56, pp. 353–354; October, 1950.) Successful transmissions from Calais used a combination of microwave and meter-wave radio links in series followed by normal telephone-pair and coaxial-cable links to the transmitter in London. Line communication was used for the sound channel. See also *Electrician*, vol. 145, pp. 573–574; September 15, 1950.

621.397.24:621.396.73 — 460

TV on Tour—R. Roques. (*Télévision*, No. 7, pp. 195–198; October, 1950.) Brief description, with circuit diagrams, of a self-contained demonstration unit carried in a 2-ton van.

621.397.26 — 461

High-Speed F.M. Facsimile—J. V. L. Hogan and C. V. Olson. (*FM-TV*, vol. 10, pp. 18–20; 40; October, 1950.) The material for transmission, on a revolving drum, is scanned at a rate of 56.2 square inches per minute. The video signal from the scanner modulates the amplitude of a 13-kc subcarrier which is then converted to a vestigial-sideband AM signal and applied to a FM transmitter. At the receiving end, the subcarrier from the FM receiver is converted into a video signal and fed to a recorder. This uses electrolytic recording paper on a revolving drum, mains-synchronized with that at the transmitter. Special signals are transmitted for a period of about 10 seconds to indicate page separation points.

621.397.26:621.396.65 — 462

Television for Scotland—(*Elec. Times*, vol. 118, p. 421; September 14, 1950.) A brief note on the project for a microwave link to extend the television service to Scotland.

621.397.331.2:778.5 — 463

Television Transmission of Images of Variable Transparency by Non-storage Systems: Present Systems and Proposed New System for High Definition—R. Monnot. (*Onde élect.*, vol. 30, pp. 362–381; August–September, 1950.) Theoretical and practical aspects of nonstorage systems in telefilm technique are discussed. Two particular scanning systems are described: (a) the Farnsworth dissector tube and (b) the "flying spot." Their operation as high-definition systems is discussed and their merits are compared. The proposed new system uses a projector with continuously moving film but without a compensating lens, and combines (a) and (b) for line scan and picture analysis, respectively. The scanning spot takes the form of a short line and the screen is slightly persistent.

621.397.5:535.623 — 464

An Analysis of the Sampling Principles of the Dot-Sequential Color-Television System—RCA Laboratories Division. (*RCA Rev.*, vol. 11, pp. 431–445; September, 1950.) The following appendices to the paper abstracted in 2640 of 1950 are given: (a) reproduction of high-frequency detail with a low sampling rate; (b) transmission of the dot-sequential color-television signal on coaxial cables of restricted bandwidth; (c) the action of the dot-sequential color-television system in the presence of an abrupt red-green transition.

621.397.5:535.623 — 465

Analysis of Dot-Sequential Color Television—N. Marchand, H. R. Holloway, and M. Leifer. (*Sylvania Technologist*, vol. 3, pp. 9–15; October, 1950.) A mathematical analysis is presented of the pulse sampling and sorting processes. Color distortion and cross talk introduced by sideband clipping is examined, and an equivalent sampling and sorting method is described which is more economical than pulse sampling. The mixed highs are shown to have negligible effect on the color presentation, while providing resolution equivalent to present monochrome standards.

621.397.5:535.623 — 466

Frequency-Interlace Color Television—R. B. Dome. (*Electronics*, vol. 23, pp. 70–75; September, 1950. And *FM-TV*, vol. 10, pp. 12–14; 40; October, 1950.) A proposed new system. The video frequencies associated with a monochrome television signal are bunched around harmonics of the line frequency and a large part of the spectrum is unused. Use of this part of the spectrum enables two other colors to be transmitted simultaneously without any increase in bandwidth. In spite of the complexity of the transmitted signal the receiving circuit is simple; it requires no complicated filters and only six more tubes, than a conventional monochrome circuit; it can also be used to receive black-and-white transmissions. The system has not yet been fully tested.

621.397.5:535.88 — 467

Improvements in Large Screen Television Projection—T. M. C. Lance. (*Jour. Tele. Soc.*, vol. 6, pp. 46–56; April–June, 1950.) Paper presented at the International Television Congress, Milan, September, 1949. The development of a projection system for cinema use is described. The position of the projector is restricted by inherent limitations of the Schmidt optical system; the projector must be within 10° of the axis normal to the screen and its distance from the screen has been standardized at 40 feet. The high luminous flux required has been obtained by the adoption of a triode electrode system with an anode voltage of 50 kv and a beam current of 15 ma. In the construction of the cathode-ray tubes, difficulties were encountered due to the high heat dissipation at the screen and the necessity of avoiding electrical discharges. The design of a suitable cathode and electrode system is described and the development of a special phosphor of the mixed-silicates type which is little affected by temperature rise is discussed.

621.397.5(083.74) — 468

Transmission Standards in Television—J. L. Delvaux. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 659–661; August 20, 1949. In French.) Paper presented at the International Conference, Zürich, 1948. Discussion of the various factors affecting the choice of television frequency, bandwidth and line standards with particular reference to the determination of the optimum structure of the television channels for the European network. See also 2346 of 1949.

621.397.5(083.74) — 469

A Comparative Analysis of Certain Television Standards—J. H. Bedford. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 630–632; August 20, 1949. In English.) Paper presented at the International Television Conference, Zürich, 1948. Discussion of British and American practice, with particular reference to the polarity of modulation and to the significance of equalizing pulses.

621.397.5(083.74)(45) — 470

Proposals for the Standardization of Television in Italy, and New Electronic Generator for Television Synchronization—A. V. Castellani. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 608–615; August 20, 1949. In Italian.) Paper presented at the International Television Conference, Zürich, 1948. Summary abstracted in 879 of 1949.

[6].397.5(42) 471
Studio and Outside Broadcasting Television Practice in Great Britain—T. H. [Br]idgewater. (*Bull. schweiz. elektrotech. Ver.*, [vol.] 40, pp. 538–545; August 20, 1949. In [En]glish.) Paper presented at the International [Tel]evision Conference, Zürich, 1948. A general [acc]ount of (a) the equipment used, including [cam]eras and their mountings, (b) studio design [and] lighting, (c) mobile control room equipment, (d) film transmitters, and (e) studio [pro]duction and outside broadcasting operations.

[621].397.5(45) 472
Television in Italy—A. Banfi. (*Bull. schweiz. [elek]trotech. Ver.*, vol. 40, pp. 547–549; August [20,] 1949. In Italian.) Paper presented at the [Int]ernational Television Conference, Zürich, [194]8. A short historical account.

[621].397.6 473
Some Aspects of Television Circuit Technique: Phase Correction and Gamma Correction—T. C. Nuttall. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 615–622; August 20, 1949. [In] English.) Paper presented at the International Television Conference, Zürich, 1948. [Th]e advantages of using phase- and gamma-correction methods are pointed out and [suit]able circuits are described. A gamma [cor]rector combined with a black-level control [circ]uit has been found very effective in a [tel]evision film scanner, with standard films [hav]ing a wide range of contrast. Operation is [qui]te automatic.

[62]1.397.6:621.396.67 474
Designing the Bridgeport U.H.F. Antenna—[Ki]ddler. (*See* 284.)

[621].397.6.018.424† 475
Wide-Band Systems for Television—E. [La]bin. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, [pp.] 623–630; August 20, 1949. In English.) [Pa]per presented at the International Television [Co]nference, Zürich, 1948. See 2342 of 1949.

[62]1.397.61:621.392.52 476
Linear-Phase-Shift Video Filters—Fredendall and Kennedy. (*See* 303.)

[62]1.397.61:621.396.619.13/.14 477
Phase-to-Amplitude Modulation for [U]H.F.-TV Transmitters—W. E. Evans, Jr. (*[El]ectronics*, vol. 23, pp. 102–106; September, [19]50.) The outputs from two phase-modulated [tra]nsmitters driven from the same crystal os[cill]ator are combined so as to produce an AM [sig]nal. It is not necessary for the radio-fre[qu]ency amplifiers to have linear amplitude [ch]aracteristics. The system would be especially [use]ful for high-power (above 500 w) uhf tubes [wh]ich are difficult to modulate by other means. [An] experimental television transmitter on a [fre]quency of 530 Mc with a peak power output [of] 150 w has been operated successfully. A [spe]cially designed dual phase-modulated tube, [pro]ducing a ±45° phase deviation in two [6]5-Mc channels, simplifies the equipment.

[62]1.397.611.2 478
Development of a Super-Inocoscope: the [Ér]iscope—A. Lallemand. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 561–562; August 20, [19]49. In French.) Paper presented at the [In]ternational Television Conference, Zürich, [19]48. A short account of the principles and [co]nstruction of the ériscope. See also 537 of [19]49 (France).

[62]1.397.611.2 479
'[Picture] Analyser' Tubes with Trans[pa]rent Signal-Plate—P. Tarbes. (*Bull. schweiz. [ele]ktrotech. Ver.*, vol. 40, pp. 562–564; August [20], 1949. In French.) Paper presented at the [In]ternational Television Conference, Zürich, [19]48. Different methods of obtaining satisfac[to]ry thin layers of Pt or Pd on mica, by evap[or]ation or cathodic deposition, are discussed. A process which improves the solidity of the deposit and enables it to withstand better the heating effects during the mounting of the screen in its glass container, consists in depositing on the mica by evaporation a thin layer of Cr and then applying a top layer of Pt or Pd by cathodic deposition. Another method of protection is to apply a very thin layer of silica over the metal layer. Iconoscopes with transparent screens and symmetrical sweep are particularly suitable for simple types of equipment where the absorption in the metal layer and the consequent reduced sensitivity are relatively unimportant.

621.397.611.2 480
Image-Storage Problems—F. Schroter. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 564–566; August 20, 1949. In German.) Paper presented at the International Television Conference, Zürich, 1948.

621.397.611.2 481
Light-Transfer Characteristics of Image Orthicons—R. B. Janes and A. A. Rotow. (*RCA Rev.*, vol. 11, pp. 364–376; September, 1950.) The signal-output/light-input characteristics are given for various target voltages and target-mesh spacings. The effects of interelement capacitance and electron redistribution on the transfer curves are considered. The presence of ghost images can be minimized by defocusing by adjustment of the photocathode voltage. Two types of anti-ghost tubes are described briefly.

621.397.611.2:778.5 482
A Non-Storage Picture-Analysing Tube for Film Scanning—N. Schaetti. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 569–570; August 20, 1949. In German.) Paper presented at the International Television Conference, Zürich, 1948. See also 1261 of 1950.

621.397.611.2.001.8 483
New Television Camera Tubes and Some Applications outside the Broadcasting Field—V. K. Zworykin. (*Jour. Soc. Mot. Pic. Telev. Eng.*, vol. 55, pp. 227–242; September, 1950.) The operation and performance characteristics of television camera tubes, from the iconoscope to the image orthicon and vidicon, are briefly described, recent developments being particularly considered. The application of the vidicon in industrial television equipment and possible uses of television technique in astronomy are outlined.

621.397.62 484
Permanent-Magnet Lenses for Television Tubes—B. R. Overton:D. Hadfield. (*Electronic Eng.* (London), vol. 22, pp. 401–402; September, 1950.) Comment on 1787 of 1950 and author's reply.

621.397.62:535.88 485
Large-Screen Television Projection by the Eidophor Method—H. Thiemann. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 585–595; August 20, 1949. In German.) Paper presented at the International Television Conference, Zürich, 1948. Detailed discussion of the principles of the method and illustrated description of the equipment used. Summary noted in 875 of 1949. See also 296 of 1948, which refers to a full account of the method.

621.397.62:535.88 486
Problems of Theatre Large-Screen Television Projection—A. G. D. West. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 595–603; August 20, 1949. In English.) Paper presented at the International Television Conference, Zürich, 1948. See 1523 of 1949.

621.397.62:535.88 487
Philips Projection Television—(*Wireless World*, vol. 56, pp. 365–367; October, 1950.) Test report on a standard production model Type 600A, which uses a 2½-inch cathode-ray tube operated at a final-anode voltage of 25 kv. A Schmidt optical system projects an image on to the back of a built-in screen to give a picture 13½×10 inches. The picture is sufficiently bright for daylight viewing, but due to the screen construction the angle of view is limited to about ±30°. The circuits are conventional, except for the cathode-ray-tube supply, which is obtained through a voltage-tripler rectifier from a 9-kv damped sine wave developed in a ringing transformer connected in the anode circuit of a pentode.

621.397.62:621.396.68 488
Flyback E.H.T.—W. T. Cocking. (*Wireless World*, vol. 56, pp. 279–282 and 313–316; August and September, 1950.) The major disadvantage of this system lies in its rather poor voltage regulation. This causes changes in the picture size and defocusing, as the over-all brightness of the picture alters. The regulation depends upon the scanning circuit itself as well as the rectifier system; the effect of each of these sections is considered separately. Graphs are presented showing, for any required regulation, the ratio of energy in the deflector-coil circuit to the energy drawn from the high-voltage system by the cathode-ray tube. Changes in the Q value of the circuit comprising the deflector coil and transformer have little effect on the regulation, but the available high-voltage for the same circuit capacitance increases with higher Q values. Because of the high source impedance, the regulation with a voltage-doubling rectifier is only slightly poorer than with a half-wave rectifier.

621.397.621.2 489
New Scanning Circuit—P. R. J. Court. (*Wireless World*, vol. 56, pp. 287–290; August, 1950.) A self-driven line-scanning output stage for use in conjunction with an "efficiency diode." The frequency and amplitude controls are not appreciably interdependent, and the output linearity is not affected unduly by the impedance of the output tube, thus permitting the use of almost any type of output pentode or tetrode. The performance is at least equal to that of an equivalent separately driven circuit.

621.397.621.2 490
A Self-Oscillating Line-Deflection Circuit—J. Haantjes. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 633–635; August 20, 1949. In English.) Paper presented at the International Television Conference, Zürich, 1948. A circuit with good linearity and short flyback time which is easily synchronized and requires relatively little power. See also 2934 of 1949 (Haantjes and Kerkhof).

621.397.621.2:621.319.55 491
New Self-Excited Generators for Deflection Currents—R. Urtel. (*Bull. schweiz. elektrotech. Ver.*, vol. 40, pp. 641–644; August 20, 1949. In German.) Paper presented at the International Television Conference, Zürich, 1948. Generators of sawtooth waves with external excitation are first considered and then the necessary modifications for self-excitation. Circuits with automatic switching between positive and negative feedback are described and their action is explained. Waveform diagrams are given in all cases.

621.397.645.018.424† 492
Video Amplifier Design—Moses. (*See* 319.)

621.397.8 493
The Influence of Transmission Bandwidth on Television Picture Quality—J. Schunack. (*Arch. elek. Übertragung*, vol. 3, pp. 301–304 and 323–327, November and December, 1949; and vol. 4, pp. 75–81 and 113–120; February and March, 1950.) The production of picture defects by limitation of transmission bandwidth is explained. Experimental results ob-

tained with various illumination patterns confirm the theoretical conclusions. For maximum picture quality $N_{max} \cdot S = 1$, where N_{max} is the highest transmitted frequency divided by the scanning speed, and S is the length of the scanning aperture edge; this corresponds to a doubling of the usual bandwidth.

621.397.8.029.63 494
Television Transmission and Reception on 480 Mc/s—M. Morgan. (*Jour. Telev. Soc.*, vol. 6, pp. 57–63; April–June, 1950.) For experimental cinema relay links the frequency band 470–490 Mc was chosen because suitable tubes are available and because of the adoption of AM with vestigial-sideband modulation. A general description is given of the transmitting and receiving equipment, which was used in the demonstration following the paper by Lance (467 above) at the International Television Congress, Milan, 1949.

621.397.62.004.5/.6 495
Television Servicing [Book Review]—S. Heller and I. Shulman. Publishers: McGraw-Hill Book Co., New York, N. Y., 434 pp., 1950, $5.50. (*Electronics*, vol. 23, pp. 136, 138; November, 1950.) Includes a service analysis on each portion of the receiver. "These thorough analyses can be used to extremely good advantage by the beginner who lacks the practical approach . . . the book is well worth having."

TRANSMISSION

621.396.619.13 496
Linearization of Modulation Characteristic with Relatively Large Frequency Deviation—R. Šatas. (*Arch. elekt. Übertragung*, vol. 4, pp. 255–258; July, 1950.) Mathematical analysis is given for an FM circuit in which a push-pull arrangement of two tubes with square-law I_a/V_g characteristics is connected as a variable reactance in parallel with the *LC* circuit determining oscillator frequency. Experimental results for the particular case of an FM transmitter with carrier frequency 2 Mc and deviation 150 kc gave good support to the theory. The highest ratio of frequency deviation to carrier frequency attainable with low nonlinear distortion was 0.15–0.25, using reactance tubes of specially suitable type.

621.397.61:621.396.619.13/.14 497
Phase-to-Amplitude Modulation for U.H.F.-TV Transmitters—Evans. (*See* 477.)

621.396.665 498
Automatic Audio Gain Controls—Hathaway. (*See* 318.)

TUBES AND THERMIONICS

533.583:621.385 499
Getter Materials for Electron Tubes—W. Espe, M. Knoll, and M. P. Wilder. (*Electronics*, vol. 23, pp. 80–86; October, 1950.) The requirements of getter materials for use as bulk, coating, or flash getters are specified. The suitability of various metals for each application is discussed with reference to the vapor pressure of the metal and its efficiency as a getter. Over 70 references are given.

537.533:621.385.832 500
Note on the Image Formation in Cathode-Ray Tubes—R. Dorrestein. (*Philips Res. Rep.*, vol. 5, pp. 128–130; April, 1950.) The theory of Gaussian beams is applied to the electron beam in a cathode-ray tube with a conventional type of gun. Neither the paraxial crossover nor the cathode image yields the smallest possible spot, but some intermediate point, the location of which depends on the relative values of the beam radii at crossover and where the cathode image is formed. In practical cases this point nearly coincides with the crossover point.

621.385.029.63/.64 501
Traveling-Wave Tubes: Part 4—J. R. Pierce. (*Bell Sys. Tech. Jour.*, vol. 29, pp. 608–671; October, 1950.) Chapters 12–17, concluding the monograph. Theoretical treatment of power output, transverse motion of electrons, field solutions, magnetron amplifier, and double-stream amplifier. A brief conclusion and a bibliography for 1946–1949 are given. Part 3: 3203 of 1950.

621.385.029.63/.64 502
Travelling-Wave Valves—H. Kleinwächter. (*Elektrotechnik Berlin*, vol. 4, pp. 245–246; July, 1950.) Research work abandoned during the war was concerned with the development of a traveling-wave tube on lines different from present designs. Retardation of the wave was effected by surrounding the evacuated cylinder enclosing the beam with a dielectric-filled waveguide of external diameter increasing in the direction of propagation. Methods of using the transverse electron energy and of increasing the efficiency were also investigated.

621.385.029.63/.64:621.317.755 503
The Traveling-Wave Cathode-Ray Tube—K. Owaki, S. Terahata, T. Hada, and T. Nakamura. (Proc. I.R.E., vol. 38, pp. 1172–1180; October, 1950.) Pairs of repeatedly folded parallel wires are used instead of the conventional deflecting plates, and the phase velocity of the traveling wave and the electron velocity are equalized, thus making the deflection sensitivity independent of frequency. A theoretical analysis of the principle is given; the sensitivity may be easily increased to 0.1 mm per v at 30 kMc. The inversion-spectrum method is used to obtain experimental confirmation of this analysis. Measurements of the degree of AM and observations of uhf voltage wave form are described to illustrate the applications of the tube.

621.385.032.213:546.841-3 504
Thermionic Properties and Activation of Thoria—G. Mesnard. (*Compt. Rend. Acad. Sci.* (Paris), vol. 231, pp. 768–770; October 16, 1950.) Results are discussed of an experimental study of the emission from tungsten filaments with thoria coatings of mean thickness 40μ, immediately after high-temperature activation for 1–2 minutes. Richardson's equation holds for short-period emission within a certain temperature range. Emission increases progressively as the activation temperature is raised. Values of A and ϕ in the equation fall slightly until an activation temperature of about 2,150° K is reached, when they increase, particularly A, in greater proportion than the current, reaching values of 100 amp per cm² and over 2.5 v, respectively. Large current densities are not always obtained, especially when the cathode has been treated with collodion to render it less fragile. To ensure a long life, the operating temperature should not go above 2,000°. A suggested explanation of the observed effects is the formation of insertion atoms of thorium during the progressive crystallization produced by the initial heating.

621.385.032.216:539.167.3.001.8 505
Use of Radioactive Elements in the Investigation of Oxide Cathodes—J. Debiesse. (*Onde Élect.*, vol. 30, pp. 351–355; August and September, 1950.) More detailed account of the work noted in 3592 of 1949 (Beydon, et al.).

621.385.2 506
The Electric Field at a Thermionic Cathode as a Function of Space Current—P. L. Copeland and D. N. Eggenberger. (*Phys. Rev.*, vol. 80, p. 298; October 15, 1950.) The method given by Ivey (780 of 1950) for calculating the field at the cathode of a diode is examined analytically, and it is concluded that the function expressing the ratio of the field in the absence of current to that in the presence of current does in fact depend on tube geometry.

621.385.2.01 507
Theory and Experiments on Electrical Fluctuations and Damping of Double-Cathode Valves—K. S. Knol and G. Diemer. (*Philips Res. Rep.*, vol. 5, pp. 131–152; April, 1950.) The internal resistance and the noise are calculated for tubes with two hot cathodes opposite one another. Measurements on such tubes with indirectly heated cathodes confirm the theoretical calculations and show that, contrary to Fürth's theory (2419 of 1948), the equivalent noise-temperature of such tubes does not exceed the real cathode temperature. Measurements on tubes with directly heated cathodes are not in such good agreement with theory; the slight discrepancies are discussed.

621.385.2:621.315.59 508
The *p*-Germanium Transistor—W. G. Pfann and J. H. Scaff. (Proc. I.R.E., vol. 38, pp. 1151–1154; October, 1950.) A brief description of some characteristics of *n*- and *p*-germanium is given, and also an account of the laboratory preparation and observed properties of the *p*-type transistor, which has a higher cut-off frequency and a lower current multiplication than the *n*-type. The forward current-voltage characteristic of the emitter in very highly resistive *p*-type transistors has a negative-resistance region of the voltage-maximum type so that, if the series resistance is low, when the emitter bias exceeds this maximum a sudden increase in emitter current occurs; this phenomenon has been called the "snap effect."

621.385.3:621.315.59 509
The Transistor as a Reversible Amplifier—W. G. Pfann. (Proc. I.R.E., vol. 38, p. 1222; October, 1950.) The "forming" process which has been used on the *n*-germanium transistor to increase the effectiveness of an electrode as a collector does not seriously reduce its efficiency as an emitter. If the process is applied to both contact points, an improved reversible transistor amplifier is obtained.

621.385.3.029.64 510
Design Factors of the Bell Telephone Laboratories 1553 Triode—J. A. Morton and R. M. Ryder. (*Bell Sys. Tech. Jour.*, vol. 29, pp. 496–530; October, 1950.) A close-spaced planar triode for use at 4 kMc with a gain-bandwidth product of 1,100 Mc. Considerations affecting choice of electrode spacing, input and output circuit elements, and emission current density are discussed in terms of gain-bandwidth and power-bandwidth figures of merit. See also 2964 of 1949 (Morton).

621.385.029.63/.64 511
Traveling-Wave Tubes [Book Review]—J. R. Pierce. Publishers: D. Van Nostrand, New York, N. Y., 223 pp., 1950, $4.50. (Proc. I.R.E., vol. 38, p. 1229; October, 1950.) "A most competent treatment of the theory of the traveling-wave tube, containing the generally accepted basic theory which will serve as a very useful guide to tube designers, and some material of more controversial nature which will inspire many fruitful discussions and will stimulate creative thought." See also 501 above and back references.

MISCELLANEOUS

621.396:061.4 512
Radio Exhibition Review—(*Wireless World*, vol. 56, pp. 432–349, October, 1950.) Reports by members of the technical staff of *Wireless World* on television and broadcasting receiver developments, sound-reproduction equipment, test and measurement apparatus, and miscellaneous exhibits at the 17th National Radio Exhibition, Castle Bromwich. See also 26 of February.

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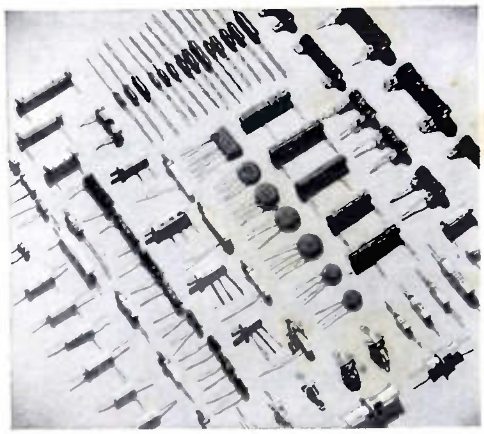

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SECTION MEETINGS

Atlanta

"Tour of Eastern Air Lines Automatic Teletypewriter Switching Center," by R. M. Milikin, Eastern Air Lines; December 15, 1950.

Buenos Aires

"Theory, Design and Measurements on Delay Lines," by C. P. Perez; September 1, 1950.

"Regulated Power Supplies of Tension," by Gerardo Borrego; September 15, 1950.

"The Theoretical Sources of the Lupam," by R. P. McLoughlin; October 6, 1950.

"Carrier Telephony," by Raul Rago; October 20, 1950.

"Basical Principles for the Projects of Central Offices," by F. J. Hart; November 3, 1950.

"Ionosferic Interferences," by Ivo Ranzi; December 10, 1950.

"Five Topics of Television," by A. M. Medina, R. Rago, J. P. Calvelo, J. Weiss, and P. J. Noizeux; December 15, 1950.

Cleveland

"Ceramic Capacitors," by J. C. VanArsdell, Erie Resistor Company; November 8, 1950.

Social Meeting; December 18, 1950.

Des Moines-Ames

"Two-Way Radio Communications and its Aid in Law Enforcement as Used by the State of Iowa," by C. J. Nord, Director, Radio Communication, State of Iowa; November 28, 1950.

Detroit

"Experimental High-Power UHF Resnatron Amplifier," by W. W. Salisbury, Collins Radio Company; May 19, 1950.

"Radio Communications on the Amazon," by Mr. Fox, Radio Station WGAR, Cleveland, Ohio; September 15, 1950.

"Vehicular Noise Suppression," by B. H. Short, Delco-Remy Research Laboratory; October 20, 1950.

"Development and Operation of TV Zoomar Lens," by F. G. Back, Television Zoomar Corporation; November 17, 1950.

"Industrial Color Television," by J. B. Tharpe, Allen B. Dumont Laboratories; December 15, 1950.

"Color Television," by W. L. Everitt, University of Illinois; Janury 12, 1951.

Emporium

"A Definition of Noise Factor," by B. Tyson, Sylvania Electric Company, Inc.; January 9 1951.

Evansville-Owensboro

"A Tunable Miniature Magnetron," by H. W. A. Chalberg, General Electric Company; December 13, 1950.

Hawaii

"Modern Trends in Design of Aviation Electronic and Communication Equipment," by J. Hamilton, Collins Radio Company; January 10, 1951.

Houston

"Electronics in Medicine," by L. G. Grimmett, University of Texas; November 20, 1950.

"The Design of Audio Transformers," by W. E. Lehnert, Audio Development Company; December 12, 1950.

Inyokern

"Capacitor Characteristics and Construction, by L. Poldosky, Sprague Electric Company; February 8, 1950.

"PAM/FM Telemetering System and Data Reduction Techniques," by Mr. Chisolm, Massachusetts Institute of Technology; March 22, 1950.

(Continued on page 76A)

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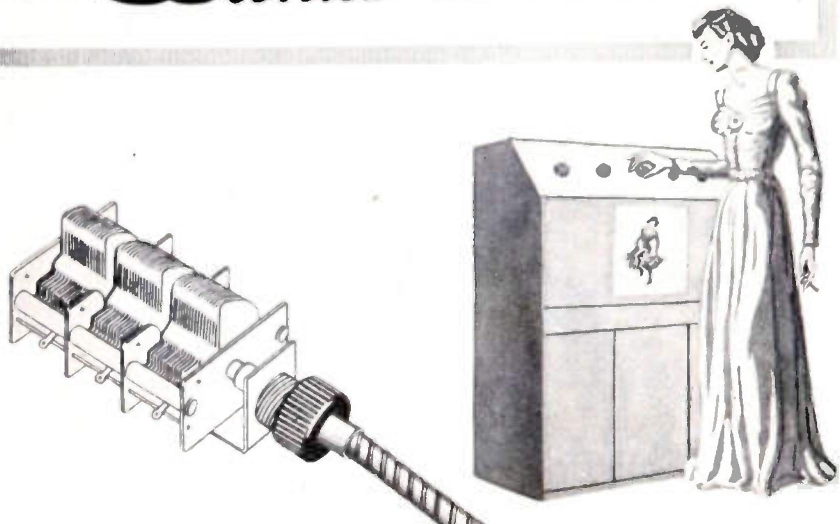
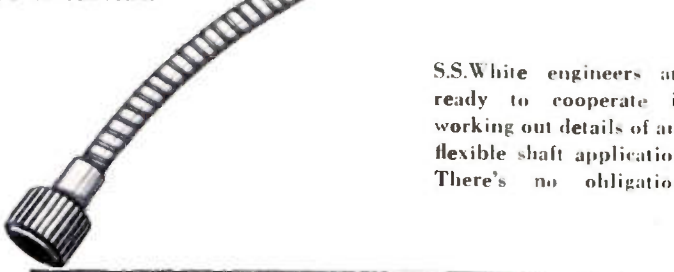




SECTION MEETINGS

(Continued from page 74A)

"Slot Radiators," by Mr. Jassic, Air Borne Instruments Laboratory; April 5, 1950.

"A New Approach to Filter Network Design," by D. L. Trautman, University of California at Los Angeles; May 17, 1950.

"Low Noise Input Circuits," by G. H. Nibbe, Canoga Corporation; September 21, 1950.

"Measurement and Recording of Physical Quantities," by Mr. Robertson, Consolidated Engineering Corporation; October 18, 1950.

"Resonant Interaction Between Radio Waves and Materials," by W. D. Hershberger, University of California at Los Angeles; December 20, 1950.

Los Angeles

"Maintenance of Employee Morale," by H. V. Harris, Pacific Telephone & Telegraph Company, "Governmental Procurement Procedure," by L. Sells, United States Naval Procurement Office, "Training of Engineering and Technical Personnel," by L. L. Galloway, North American Aviation Corporation, and "Priorities," by A. E. Wahlgren, United States Department of Commerce; November 21, 1950.

"Mechanical Radio Frequency Filters," by M. Doelz, Collins Radio Company; December 5, 1950.

Louisville

"The WSM-TV Microwave Relay System," by L. Rawls, Radio Station WSM-TV; December 29, 1950.

"More Waves, More Words, Less Wires," by J. O. Perrine, American Telephone and Telegraph Company; January 3, 1951.

Milwaukee

"Voltage and Current Regulators, Tubes and Circuits," by W. Richter, Allis-Chalmers Manufacturing Company; November 29, 1950.

"Whatever Goes Up Comes Down," by P. Herget, Cincinnati Observatory; December 7, 1950.

Montreal

"The Design of an Automatic Ionosphere Recorder," by F. H. Margolick, Canadian Marconi Company; January 10, 1951.

New York

"The English Economic Background and its Influence on the Radio Industry There," by H. Moss, Electronics Tubes, Limited; December 6, 1950.

Omaha-Lincoln

"A Decade Interval Timer," by T. Hunter; December 7, 1950.

Philadelphia

"The Use of Electronics in Nuclear Physics," by W. C. Elmore, Swarthmore College; January 4, 1951.

Princeton

"Color Television," by A. G. Jensen, Bell Telephone Laboratories, Inc.; December 12, 1950.

"The Magnetic Amplifier," by W. C. Johnson, Princeton University; January 11, 1951.

Rochester

"The Hope for World Peace," by Most Reverend J. E. Kearney, Bishop, Rochester Diocese, Roman Catholic Church; December 20, 1950.

Salt Lake

"Symposium on Color Television," by J. Baldwin, Radio Station KDYL, A. Gunderson, Radio Station KDYL, C. R. Evans, Radio Station KSL, V. Clayton, Radio Station KSL, and E. C. Madsen, University of Utah; December 19, 1950.

(Continued on page 78A)

SECTION MEETINGS

(Continued from page 76A)

SAN ANTONIO

Nominating Committee Report and Electi of Officers; January 26, 1950.

"Radio Astronomy," by C. R. Burrows, Corn University; December 14, 1950.

SAN DIEGO

"Millimeter Wave Generation," by L. M. Fie Stanford University; December 12, 1950.

SCHENECTADY

"Single-Sideband Communication," by D. Norgaard, General Electric Company; January 1951.

SEATTLE

"Single-Sideband Modulation Methods," M. Swarm, University of Washington; Decemb 19, 1950.

TOLEDO

"Strain Gage Instrumentation," by G. Haglund, V. B. Corey, and J. H. Green of Fred Flader, Inc.; December 12, 1950.

TWIN CITIES

"The Automatic Control of Flight Path," D. L. Markusen, Minneapolis-Honeywell Regulat Company; December 6, 1950.

VANCOUVER

"Conducted Tour of Cedar Automatic E change," by A. Hardy, B. C. Telephone Compar Ltd; December 18, 1950.

WASHINGTON

"The Propagation of Meter Radio Waves B yond the Horizon," by J. A. Saxton, National Phy cal Laboratories, England; December 11, 1950.

Annual Joint AIEE-IRE meeting. Demo stration lectures, "Microwave Spectroscopy wi Applications to Chemistry, Nuclear Physics a Frequency Standards," by L. J. Rueger, R. Nuckolls and H. Lyons; National Bureau of Stan ards, "Recording Atmospheric Index of Refracti at Microwaves," by G. Birnbaum, S. J. Kryd and R. R. Larson, National Bureau of Standar and "Measurement of Microwave Field Patter Using Photographic Techniques," by W. E Koc Bell Telephone Laboratories, Inc.; January 1 1951.

WILLIAMSPORT

"Color Television Systems," by C. J. Hirs A. V. Loughren, Hazeltine Electronics Compa January 10, 1951.

SUBSECTIONS

HAMILTON

"Optical Effects with Radio Microwaves," A. B. McLay, McMaster University; December 1 1950.

LONG ISLAND

"New Coupling Circuit for Audio Amplifier by F. H. McIntosh, McIntosh Engineering Co pany; December 5, 1950.

NORTHERN NEW JERSEY

"Production and Measurement of Ultra-Hi Vacua," by D. Alpert, Westinghouse Electric a Manufacturing Company; December 13, 1950.

Procurement Feature

Four desks to help manufacturers get orders, will be staffed by procurement personnel from Munitions, Air Force, Navy and Signal Corps on the third floor, Radio Engineering Show.

U. S. Armed Forces Exhibit

improve your product with —

MYCALEX

THE OUTSTANDING
LOW LOSS
HIGH FREQUENCY
INSULATION
FOR OVER
A QUARTER OF
A CENTURY

MYCALEX is a highly developed glass-bonded mica insulation backed by a quarter-century of continued research and successful performance. Both pioneer and leader in low-loss, high frequency insulation, MYCALEX offers designers and manufacturers an economical means of attaining new efficiencies, improved performance. The unique combination of characteristics that have made MYCALEX the choice of leading electronic manufacturers are typified in the table for MYCALEX grade 410 shown below. Complete data on all grades will be sent promptly on request.

MYCALEX is efficient, adaptable, mechanically and electrically superior to more costly insulating materials

- PRECISION MOLDS TO EXTREMELY CLOSE TOLERANCE
- READILY MACHINEABLE TO CLOSE TOLERANCE
- CAN BE TAPPED THREADED, GROUND, SLOTTED
- ELECTRODES, METAL INSERTS CAN BE MOLDED-IN
- ADAPTABLE TO PRACTICALLY ANY SIZE OR SHAPE

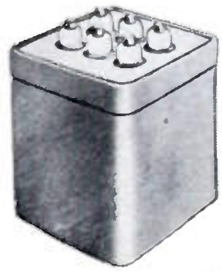
MYCALEX is available in many grades to exactly meet specific requirements

CHARACTERISTICS OF MYCALEX GRADE 410

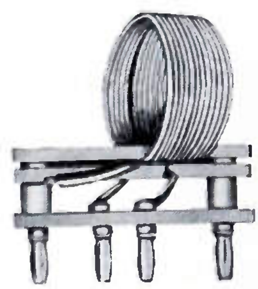
Meets all the requirements for Grade L-4A, and is fully approved as Grade L-4B under Joint Army-Navy Specification JAN-1-10

Power factor, 1 megacycle	0.0015
Dielectric constant, 1 megacycle	9.2
Loss factor, 1 megacycle	0.014
Dielectric strength, volts/mil	400
Volume resistivity, ohm-cm	1×10^{15}
Arc resistance, seconds	250
Impact strength, Izod, ft.-lb/in. of notch	0.7
Maximum safe operating temperature, °C	350
Maximum safe operating temperature, °F	650
Water absorption % in 24 hours	nil
Coefficient of linear expansion, °C	11×10^{-6}
Tensile strength, psi	6000

MYCALEX is specified by the leading manufacturers in almost every electronic category

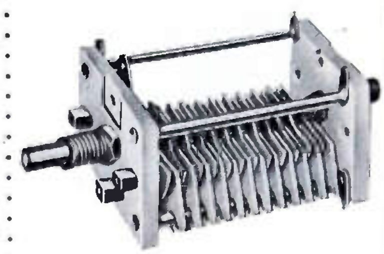


TRANSFORMER WITH MYCALEX-METAL ASSEMBLIES TO GIVE TIGHT SEAL

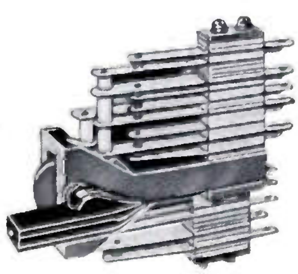


MYCALEX COIL HOLDER AND BASE

TERMINAL BASE ASSEMBLY FOR FIRE DETECTION EQUIPMENT



CONDENSER WITH MYCALEX LOW-LOSS END PLATES



MULTI-POSITION LEVER SWITCH WITH MYCALEX SPACERS

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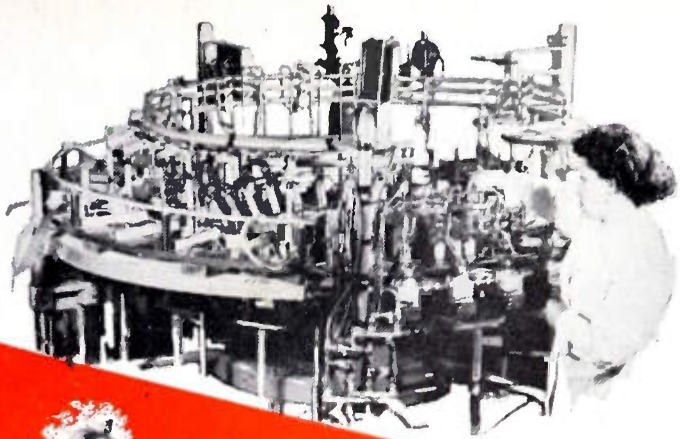
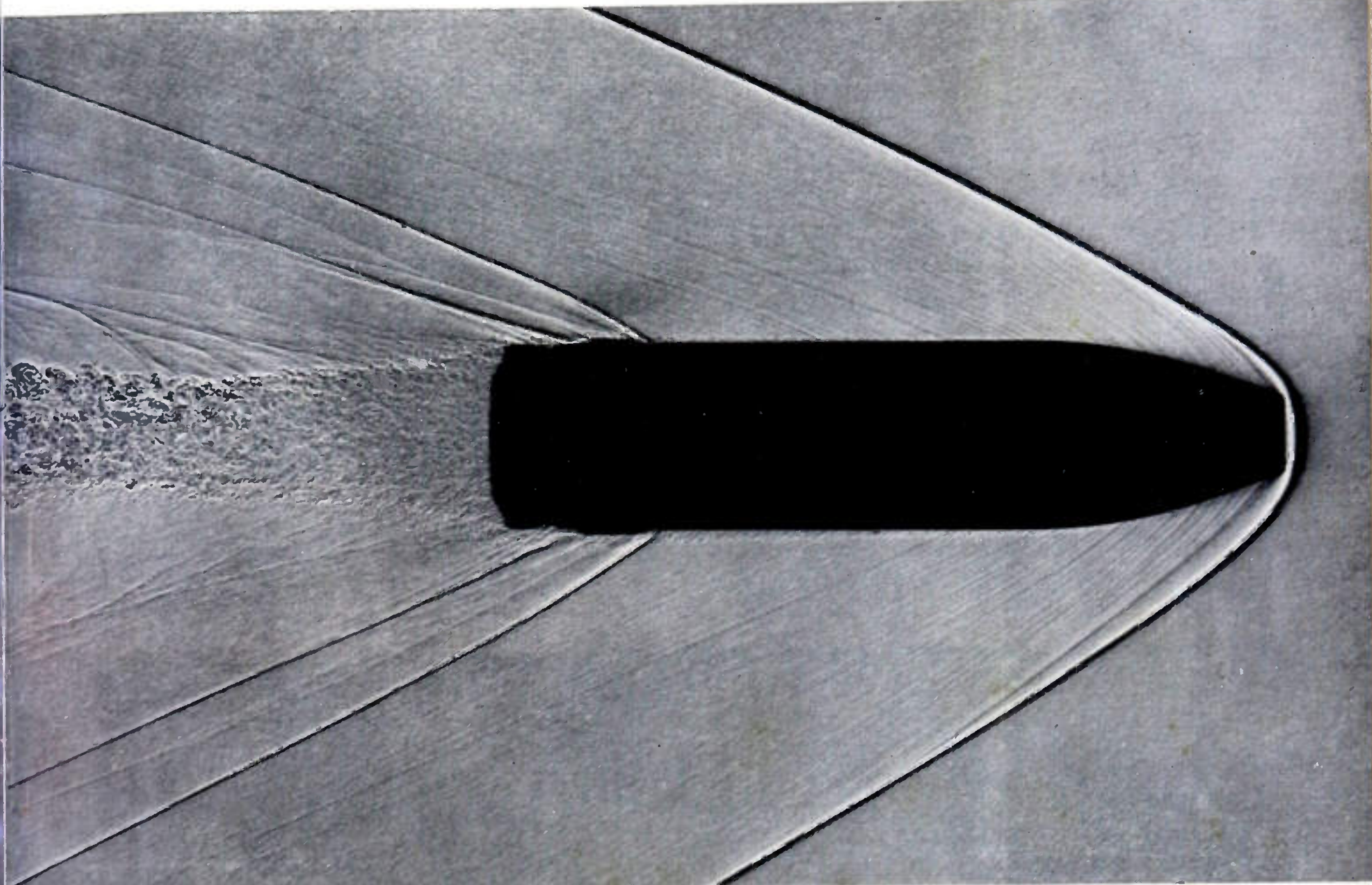


TAKE A MICROSECOND LOOK AT A PROJECTILE IN FLIGHT



Velocity of projectile: Approx. 2800′ per second. Duration of spark light: 12×10^{-7} second.

How Centralab Engineers solved a problem in Electronics for Ultra-High Speed Photography

CERAMIC TUBULAR DIELECTRIC REPLACES 30′ OF STANDARD SOLID DIELECTRIC COAXIAL CABLE—LIGHT INTENSITY BETTERED 900 TIMES

Former Method

Ultra-speed photographs are taken with the light of an electric spark. Former method used 30 feet of co-axial cable transmission line — charged with 10,000 V.—and discharged across a spark gap.

To replace the bulky cable, Centralab developed a tubular ceramic condenser (2″ O.D. x 6½″ long) with silver electrodes fired to the inner and outer surfaces. The condenser is charged (to 10KV) and discharged exactly like the cable — *however with a gain in light intensity of 900 times!* Characteristics of the new Centralab ceramic condenser are:

Centralab Condenser

Dielectric Constant....6000 at 1 megacycle
Capacity ....24,000 mmf.
Velocity propagation....027 x velocity propagation in air.
Impedance....Approx. 1 Ohm
Decay time, peak to 1/e peak....2×10^{-7} second
Rise time, O to peak....1×10^{-7} second
50% of peak limits....1.8×10^{-7} second

CENTRALAB engineers know their electronics and ceramics! This single ceramic development greatly advanced the photo-study of turbulence, ultra-sonic wave structure, and other high-speed phenomena. But this is just one of literally thousands of electronic component problems solved by Centralab. For Centralab engineers have compounded and tested over 20,000 different ceramics. So if you have a problem in electronics — in radio or radar . . . in TV, FM or X-ray — that Centralab Ceramics might solve . . . don't hesitate, call us in today!

You won't regret it for Centralab is the industry's pioneer in Printed Electronic Circuits and carbon controls — the leader in the industry for the widest variety of fine quality ceramic capacitors — high voltage, by-pass coupling or temperature compensating types — in flat, tubular, disc or cylindrical shapes.

Photograph and its technical data is gratefully accredited to Dr. J. C. Hubbard, Messrs. J. A. Fitzpatrick and W. J. Thaler, Dept. of Physics, Catholic U., Washington, D.C.

For more Centralab developments that can help you ➡

Centralab Components

See them at the I.R.E. SHOW — Booths 232-33

PRINTED ELECTRONIC CIRCUITS

— *Are complete or partial circuits* (including all integral circuit connections) consisting of pure metallic silver and resistance materials fired to CRL's famous Steatite or Ceramic-X and brought out to convenient, permanently anchored external leads. They provide compact miniature units of widely diversified circuits — from single resistor plates to complete speech amplifiers. No other modern electronic development offers such tremendous time and cost saving advantages in low-power applications.

Ampec is a full 3-stage, 3-tube speech amplifier. Gives you truly highly efficient reliable performance. Size: 1¼" x 1⅛" x .340" over tube sockets! Widely used in hearing aids, mike preamps and other amplifier applications where small size and outstanding performance counts. Bulletin No. 973 in coupon below.

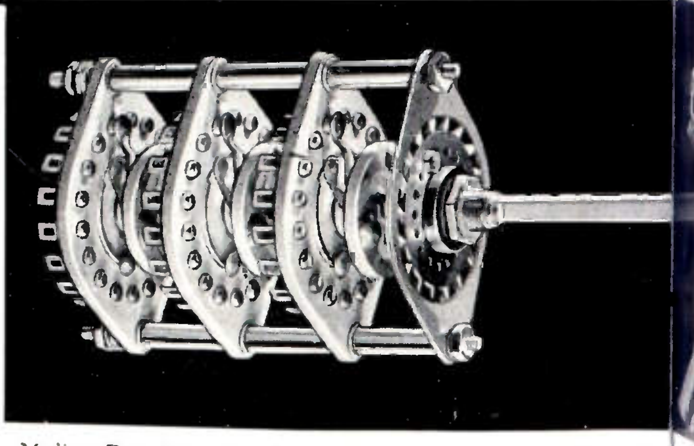
CERAMIC CAPACITORS

Centralab ceramic capacitors give you permanence never before achieved with old-fashioned paper or mica condensers. Ceramics are impervious to moisture, and have unmatched ability to withstand any temperatures normally encountered in electrical apparatus. Ceramics make possible tremendous space saving; many Centralab ceramic capacitors are ⅕th the size of ordinary capacitors. You can rely on Centralab ceramic capacitors for close tolerance, high accuracy, low power factors, and excellent temperature compensating qualities.

High voltage ceramic capacitors. Capacitance: 5 to 500 mmf., 5 KV to 40 KV D.C. working. Ideal for portable or mobile equipment. Primarily designed for high voltage, high frequency gear. For complete information, check Bulletin No. 42-102 in coupon below.

SWITCHES AND CONTROLS

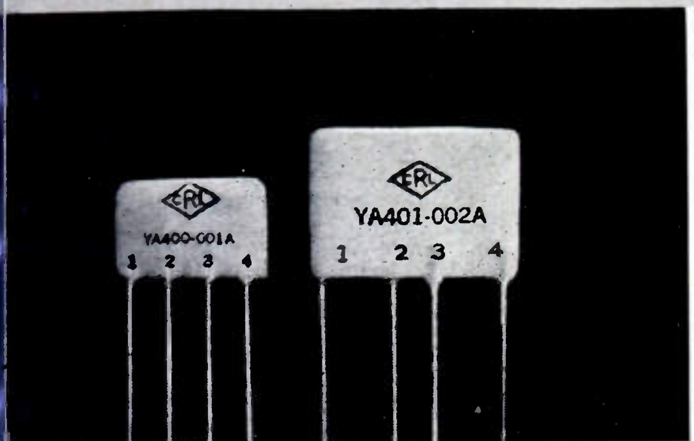
Look to Centralab for standard and special purpose switches — single or multi-section (phenolic or steatite) — single or multi-pole — rotary, slide or lever action — shorting or non-shorting contacts . . . for AM-FM-TV as well as for medium duty power applications. In controls — it's Centralab all the way . . . for Centralab introduced Carbon controls to the electronic industry 25 years ago! New Model 2 Radiohms are America's most modern controls for TV-AM-FM. Centralab Model 1 Radiohm is the outstanding truly miniature unit—the standard of the hearing aid industry.

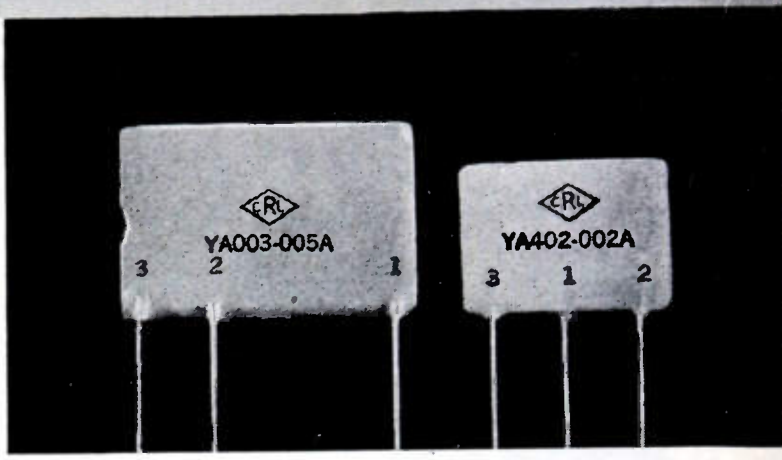


Medium Duty Power Switch for R.F. or 7½ amp. 110-115 V. application. 1, 2 or 3 poles . . . 18 contact sections . . . up to 20 sections per shaft. Contacts, collector rings coin silver mounted on Grade L5 Steatite. Cat. No. 722.

for all Electronic Gear

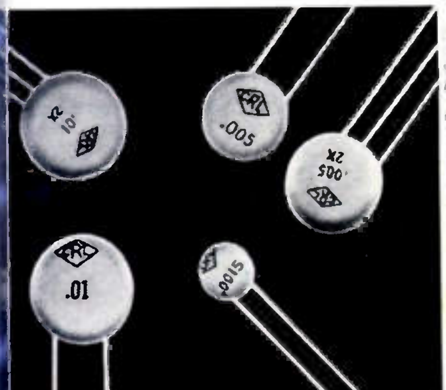
New York City, Grand Central Palace. March 19-22

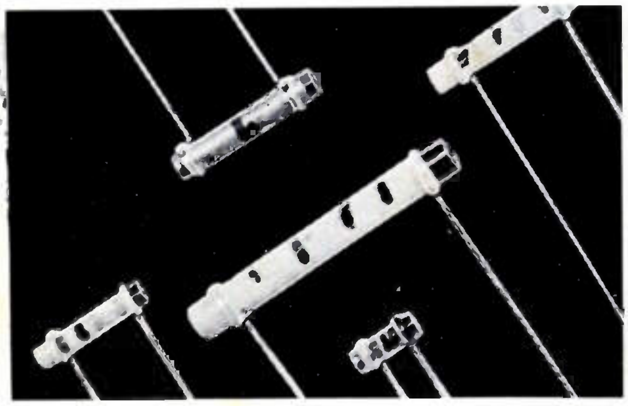


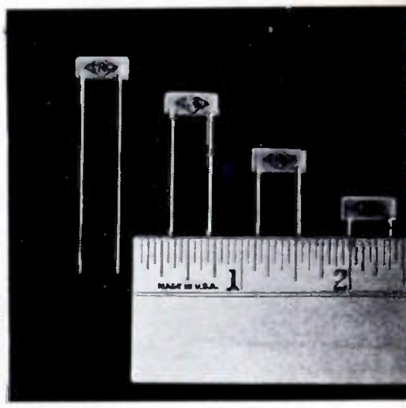


:entralab Triode Couplates save space and weight. They actually eplace 5 components normally used in audio circuits. Triode Cou- lates are complete assemblies of 3 capacitors and 2 resistors bonded o a dielectric ceramic plate. Available in a variety of resistor and apacitor values. Bulletin No. 42-6 in coupon below.

Centralab Vertical Integrators give you big savings in assembly costs, particularly in TV vertical integrator networks. One type consists of 4 resistors and 4 capacitors brought out to 3 leads . . . reducing the formerly required 16 soldered connection to only 3! There's a big saving in the number of parts handled, too! Bulletin No. 42-22.



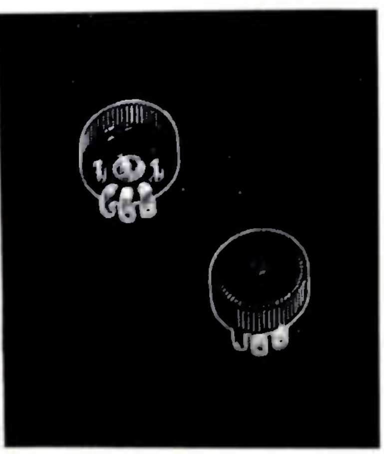




amic Disc Hi-Kap Capacitors hold thick- s to a minimum. Make possible very high acity in extremely small size. Use in HF ass and coupling. Bulletin No. 42-4R.

Tubular Ceramic Capacitors — Type TCZ show no capacitance change over wide range of temperature. Type TCN have special ceramic body to vary capacitance according to temperature. Bulletin No. 42-18.

Min-Kaps are very tiny capacitors used where space is at an extreme premium. Ask for Bulletin No. 42-24.



ew high quality Model 2 Ra- ohms are designed for lower oise level, longer life. Bulletin o. 42-85.

Model "1" *Radiohm* control — 1/10 watt — plain or switch type. No larger than a dime. For miniature use. Bulletin No. 42-19.

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Yes — I would like to have the CRL bulletins, checked below, for my technical library!

☐ 973 ☐ 42-6 ☐ 42-22 ☐ 42-102 ☐ 42-4R ☐ 42-18
☐ 42-24 ☐ 722 ☐ 42-85 ☐ 42-19

Name..

Address..

City.. State..

STUDENT BRANCH
MEETINGS

UNIVERSITY OF ARKANSAS, IRE BRANCH

"M1 Carrier System on Power Lines," J. Edwards, Bell Telephone Company; January 10, 1951.

POLYTECHNIC INSTITUTE OF BROOKLYN, IRE BRANCH (EVENING)

"The Functions of the IRE and AIEE Societies," by A. B. Giordano, Polytechnic Institute of Brooklyn; December 14, 1950.

UNIVERSITY OF COLORADO, IRE-AIEE BRANCH

"Phantom Lines," by S. C. Lorens, University of Colorado; January 10, 1951.

UNIVERSITY OF DETROIT, IRE BRANCH

"What is Facing the Engineer After Graduation," by Mr. Kufler, Ryan Industries; December 19, 1950.

DREXEL INSTITUTE OF TECHNOLOGY, IRE-AIEE BRANCH

Film: "Adventures in Research," "Induction Heating," and "The Banshee." Talk by F. C. Powell on purpose, scope, and requirements for the Prize Paper contest; December 7, 1950.

FENN COLLEGE, IRE BRANCH

"N-1 Carrier System," by O. Henderson, Bell Telephone Company, Inc.; December 14, 1950.

JOHN CARROLL UNIVERSITY, IRE BRANCH

Business Meeting; October 16, 1950.

"The Principles of Seismology," by Rev. H. Birkenhauer, John Carroll Seismological Observatory; October 31, 1950.

"Electronic Design Procedure," by H. C. Nash, John Carroll University" November 14, 1950.

"Electronics in Seismology," by E. F. Carome, John Carroll University; December 19, 1950.

LAFAYETTE COLLEGE, IRE-AIEE BRANCH

"Elementary Radio Servicing," by A. J. Ferron, Student, Lafayette College; December 12, 1950.

"Electrification of Farm Machinery and Practical Amateur Photography," by K. Spencer and H. Lanan, Students, Lafayette College; January 9, 1951.

LEHIGH UNIVERSITY, IRE BRANCH

Tour through the Magnetic Windings Division of the Essex Wire Corporation, Easton, Pa., by A. W. Johnson, Essex Wire Corporation; December 13, 1951.

LOUISIANA STATE UNIVERSITY, IRE-AIEE BRANCH

"Lighting and its Application in Stores, Offices, and Factories," by J. A. Stelly, Gulf States Utilities Company; December 19, 1950.

MANHATTAN COLLEGE, IRE BRANCH

Film: "Jet Propulsion"; November 8, 1950.

MARQUETTE UNIVERSITY, IRE-AIEE BRANCH

"General Principles of the Television System," by L. Hermanson, Student, Marquette University December 7, 1950.

UNIVERSITY OF MARYLAND, IRE-AIEE BRANCH

"Welding," by C. Titus, Westinghouse Electric Corporation; January 9, 1951.

UNIVERSITY OF MICHIGAN, IRE-AIEE BRANCH

"Consulting Engineering," by J. R. North, Commonwealth Associates; December 18, 1950.

"Magnetic Recording," by T. E. Lynch, Brush Development Company; January 10, 1951.

(Continued on page 86A)

(Continued from page 84A)

UNIVERSITY OF MINNESOTA, IRE-AIEE BRANCH

"Corona Discharge Interference," by M. Newman, Research Institute Laboratory; November 29, 1950.

"Electrifying the Paper Industry," by R. D. Borgsdeth, Westinghouse Electric Corporation; December 6, 1950.

Discussion: "Your Electrical Engineering Option," by Associate Professors Cartwright, Becklund, Anderson, University of Minnesota; January 10, 1951.

COLLEGE OF THE CITY OF NEW YORK, IRE BRANCH

Joint Meeting with AIEE: "Analogue Computers," by J. Ragazzini, Columbia University; December 21, 1950.

Joint Meeting with AIEE: "Color Television," by H. C. Harris, Sylvania Electric Corporation; January 4, 1951.

Election of Officers; January 11, 1951.

NORTHEASTERN UNIVERSITY, IRE-AIEE BRANCH

Films: "Commutation of DC Machines" and "Radio-Frequency Heating"; December 21, 1950.

"Opportunities for Graduate Work at Northeastern," by H. K. Brown, Northeastern University; December 28, 1950.

"A New Logomatic Sliderule," by J. F. Ailinger, Consultant, Keuffel & Esser Company; January 4, 1951.

"The Intricacies of a Modern Fire Alarm System," by A. L. Obanion, Fire Alarm Division, City of Boston; January 9, 1951.

UNIVERSITY OF NOTRE DAME, IRE-AIEE BRANCH

"Why Accidents Happen," by G. Holmes, Indiana & Michigan Electric Company; November 1, 1950.

OHIO STATE UNIVERSITY, IRE-AIEE BRANCH

Field Trip: Columbus Sewerage Treatment Plant; December 14, 1950.

"The New Ohio Union," by F. Stecker, Ohio State University; January 11, 1951.

PENNSYLVANIA STATE COLLEGE, IRE-AIEE BRANCH

"Relay Systems," by L. G. McCracken, Pennsylvania State College; November 30, 1950.

First Preliminary Student Prize Paper Competition; December 7, 1950.

Second Preliminary Student Prize Paper Competition; December 14, 1950.

PRINCETON UNIVERSITY, IRE-AIEE BRANCH

Field Trip: RCA Laboratories, Princeton, N. J.; January 5, 1951.

RENSSELAER POLYTECHNIC INSTITUTE, IRE-AIEE BRANCH

"Color Television," by H. F. Hicks, Rensselaer Polytechnic Institute; December 14, 1950.

UNIVERSITY OF TEXAS, IRE-AIEE BRANCH

"Wave Propagation of Very-High Frequencies," by J. A. Saxton, British National Physical Laboratory; January 15, 1951.

UNIVERSITY OF TOLEDO, IRE-AIEE BRANCH

"Relay Systems for Power Distribution Lines," by M. Keck, Toledo Edison Company; December 13, 1950.

Election of Officers; January 9, 1951.

(Continued on page 88A)

STUDENT BRANCH MEETINGS

(Continued from page 86A)

VIRGINIA POLYTECHNIC INSTITUTE, IRE BRANCH

"The Student and Technical Sales," by W Kirkpatrick, Lane Cedar Chest Company, W. A Farris, General Electric Company, and Mr. Thu man, E. I. Dupont Company; December 19, 195

"Training Program for College Graduates Industry," by Mr. Henderson, Dan River Mill Mr. Mack, Westinghouse Electric Corporation, an Mr. Niel, Brunswick Bulk; January 16, 1951.

UNIVERSITY OF VIRGINIA, IRE BRANCH

Business Meeting; January 9, 1951.

YALE UNIVERSITY, IRE-AIEE BRANCH

"The Alcoholic, and Treatment of Alcoholism, by D. P. Miller, Yale University; October 25, 195

"Sound Recording and Reproduction," b L. Thompson, SoundScriber Corporation; Novem ber 27, 1950.

MEMBERSHIP

The following transfers and admission were approved and will be effective as c March 1, 1951:

Transfer to Senior Member

Carson, V. S., 215 Furches St., Raleigh, N. C.
Carter, J. M., 2510 Wetherburn Rd., Baltimore Md.
Chandler, V. H., 711 Beech St., Manchester, N. H
Chapman, F. W., 1756 Graefield Rd., Birminghan Mich.
Ellis, R. M., 3215 Washington Blvd., Indianapolis Ind.
Franklin, P. J., 3855 Rodman St., N.W., Washing ton 16, D. C.
Harris, S. J., Capehart-Fransworth Corporatio Fort Wayne, Ind.
Humphreys, T. L., 2505 Eliot Pl., Washington 2 D. C.
Ivey, H. F., 61B Brookdale Gardens, Bloomfield N. J.
Lett, R. P., 107 McClure Ave., Syracuse 5, N. Y.
Mazzola, J. R., 584 Bogert Rd., River Edge, N. J
Meisinger, H. P., Hull Rd. & Old Courthouse Rd. R. D. 3, Vienna, Va.
Nachtigall, S., 183 Ocean Pkwy., Brooklyn 18, N. Y
Neuber, R. E., 130 Willowwood Ct., Emporium, Pa
Ross, E. H., 11542 S. Hale Ave., Chicago 43, Ill.
Rubenson, J. G., 105 Bayfield Blvd., Oceanside N. Y.
Rudner, M. A., 4501 Merrydale St., Dayton 3, Ohi
Simpson, A. D., 192 Jackson St., Matawan, N. J.
Simpson, O. T., 7 Chestnut Pkwy., Garden City Chester, Pa.
Sunstein, D. E., 464 Conshohocken State Rd., Bala Cynwyd, Pa.
Szegho, C. S., 4245 N. Knox Ave., Chicago 41, Ill
Windsor, R. B., 445 Riverside Terr., Rutherford N. J.

Admission to Senior Member

Avery, R. E., Airborne Instruments Laboratory 160 Old Country Rd., Mineola, L. I., N. Y
Apstein, M., 4611 Maple Ave., Bethesda, Md.
Galella, P. F., 37-30 Warren St., Jackson Heights L. I., N. Y.
Lister, G. H., 1048 E. 176 St., Cleveland 19, Ohio
Merryman, P., 114 State, Bridgeport 3, Conn.

(Continued on page 118A)


Do you know about these
NEW TUBES for
Pulse Modulator Applications
UNITED
HIGH VOLTAGE—HIGH VACUUM DIODES
These new United Graphite Anode Diodes have been developed to fulfill the important aims of the Armed Services program for decreased size . . . increased ruggedness . . . and increased reliability of Electron Tubes. Complete technical data sent on request.
Type 577
Max. Dimen.:
Height 7-3/8"
Diameter 2-1/16"
Ratings:
Ef 5.0 volts
If 10.25 amps.
epx 25 kv
Io 300 ma
ib 1.50 amps.
Type 578
Max. Dimen.:
Height 6-1/2"
Diameter 2-5/16"
Ratings:
Ef 5.0 volts
If 6.0 amps.
epx 40 kv
Io 100 ma
ib 750 ma
Type 576
Max. Dimen.:
Height 7-1/2"
Diameter 2-5/16"
Ratings:
Ef 5.0 volts
If 14.0 amps.
epx 25 kv
Io 500 ma
ib 2.5 amps.
Type 371-B
Max. Dimen.:
Height 8-3/4"
Diameter 2-5/16"
Ratings:
Ef 5.0 volts
If 10.3 amps.
epx 25 kv
Io 300 ma
ib 1.5 amps.
Type 3B24W
Max. Dimen.:
Height 4-1/2"
Diameter 1-9/16"
Ratings:
Ef 5.0 volts
If 3.0 amps.
epx 20 kv
Io 60 ma
ib 300 ma
Type 3B29
Max. Dimen.:
Height 4-3/4"
Diameter 1-9/16"
Ratings:
Ef 2.5 volts
If 4.75 amps.
epx 16 kv
Io 65 ma
ib 250 ma
UNITED ELECTRONICS, 42 Spring Street, Newark 2, N. J.
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The following positions of interest t I.R.E. members have been reported a open. Apply in writing, addressing repl to company mentioned or to Box No. ..

The Institute reserves the right to refuse an announcement without giving a reason for th refusal.

PROCEEDINGS of the I.R.E.
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ENGINEER

Florida East Coast opportunity fc permanent positions in electronic instru mentation research and development. Tele metering, pulse circuits and compute experience desirable. Junior, Senior an Project Engineers may send resume c education, experience, references, avai ability and salary expected to Radiatio Inc., Melbourne, Florida.

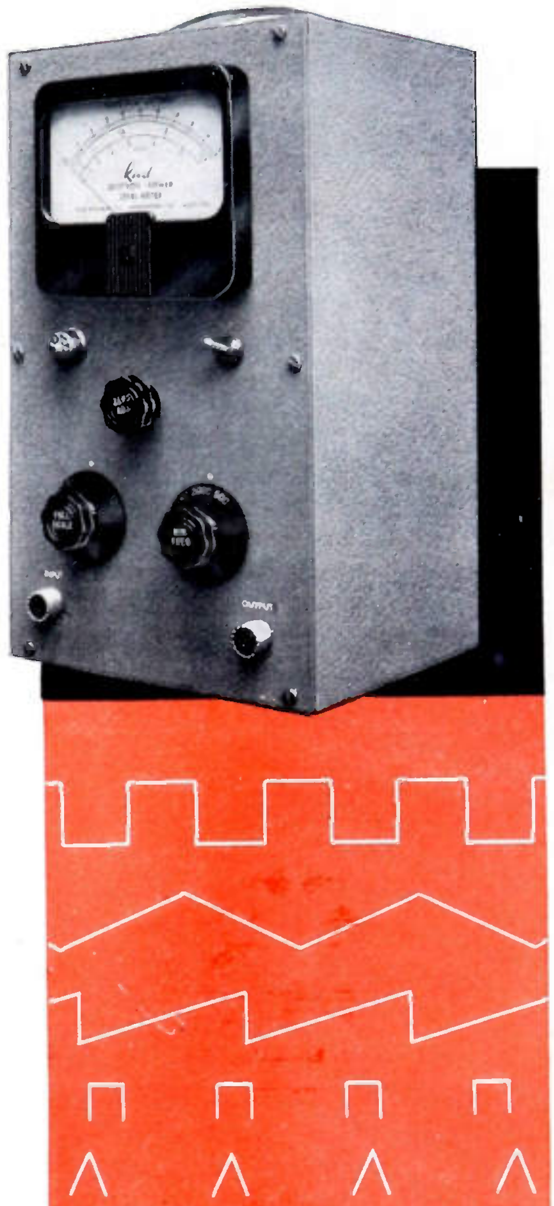
ELECTRONICS ENGINEER-WRITER

A long-established concern of hig repute in the military instruction boo field requires a technical writer of projec director calibre for permanent employ ment. A solid electronics background essential, as is direct experience in th planning and writing of instruction book to Navy, Air Force, and Signal Corp specifications. Security clearance will b required after employment. Concern located in downtown New York Cit Send detailed resume to Box 638.

(Continued on pages 92A & 94A)

marion helps Reed Research Inc.

measure true rms values of non-sinusoidal wave forms



A new aid to true RMS instrumentation is the Reed DIOTRON, developed and manufactured by Reed Research, Inc., of Washington, D. C. This amazing instrument measures true rms values of non-sinusoidal or otherwise erratic wave forms. It is a vacuum tube voltmeter whose indication depends entirely on true rms values. It is a small, compact, portable instrument used by engineers, technicians and scientists interested in the measurement and evaluation of power regardless of wave form.

Marion makes the meter upon which the Reed DIOTRON depends for much of its accuracy of indication. It provides a linear power scale and allows full scale measurements of 1 mw, 10 mw, 100 mw, 1 watt and 10 watts into 600 ohms. A corresponding true root mean square voltage scale is also included.

When you want special or standard instruments for any application that requires accurate indication — think of Marion. Marion Ruggedized Meters are the most advanced electrical indicating and measuring instruments of our time. Advanced in both construction and application, count on them for prolonged peak performance under extreme conditions of temperature, climate and actual physical violence. We invite comparison. Marion Electrical Instrument Company, 407 Canal Street, Manchester, New Hampshire.

Manufacturers of Hermetically Sealed Meters since 1944

marion meters

The leaders specify *Tensolite*

Leading engineers specify TENSOLITE Miniature Wire and Cable

because-

miniaturization programs demand less weight, less space and greater flexibility. Only TENSOLITE is devoted exclusively to this field — assuring you of faster service, lower cost, supreme quality, advanced design and know-how, and specialized facilities.

for MINIATURE FLEXIBLE INSULATED WIRE and CABLE

Stranded Copper Wires (#40 to #20) and Special Tinsel Cordage

CABLES (Multi-Conductor)

TWISTED — PARALLEL — BRAIDED

SHIELDS

BARE COPPER — TINNED COPPER SILVER PLATED

OVER-BRAIDS

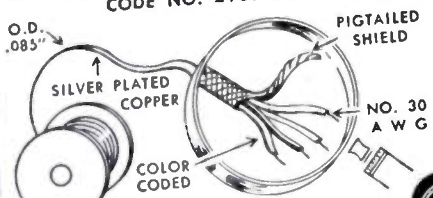
COTTON — NYLON — PLASTIC*

*TENSOLITE'S exclusive plastic film-covered Fiberglas

SUPER FLEXIBLE 4 CONDUCTOR SHIELDED CABLE

CODE NO. 2165 1-4

(Produced under Tensolite Patents)



A new construction produced by TENSOLITE to meet extremely rigid requirements of a confidential government research project. Tensolite experience and exclusive patented methods of manufacture produced the product illustrated which was tested and approved for incorporation in the design.

• TENSOLITE'S versatile patented process is uniquely suited to economical production of unlimited special constructions within its field. Wire samples and literature sent without obligation when requested by manufacturers, engineers and purchasing executives on company letterhead. Call or write today for quotations.

TENSOLITE INSULATED WIRE CO., INC.
196 MAIN STREET, TARRYTOWN, N. Y.
Tarrytown 4-2616

POSITIONS AVAILABLE WITH

VARIAN ASSOCIATES

San Carlos, California

MICROWAVE AND ELECTRONIC DEVELOPMENT

ENGINEERS, qualified for work in:
- Microwave research and development
- Klystron tube design
- Circuit design
- Traveling wave tube design
- Nuclear induction

MICROWAVE TUBE TECHNICIANS

TEST TECHNICIANS

TECHNICAL REPORT WRITERS

COMPUTERS

If you are qualified for one of these positions and are interested in a challenging opportunity with an expanding organization in an attractive environment, you are invited to send confidential details to the Personnel Director:

VARIAN associates — *99 washington st. san carlos, calif.*

POSITIONS OPEN

(Continued from page 90A)

ELECTRONIC ENGINEERS

Senior engineers or physicists, degree and experience in radar, pulse circuits, digital or analogue computers, or servomechanisms. Electronic Engineering Company, 180 S. Alvarado Street, Los Angeles 4, California.

CIRCUITS AND MICROWAVE ENGINEERS

Rapidly expanding company in the instrumentation field has openings for senior engineers with several years of experience. Men with Masters or Ph.D. degrees preferred. Excellent opportunities in field of VHF, UHF and microwave test equipment. Location Brooklyn. Send complete resume to Box 639 I.R.E.

ELECTRONIC ENGINEERS

At least three (3) years' post-college experience in development, DC amplifier, digital computers, pulse and servo design. Established company, New York City. Box 640.

ELECTRONICS ENGINEERS

Sales, design and application engineering. Positions open in sales and engineering departments of manufacturer of communications equipment. Salary commensurate with experience. Location Chicago. Box 642.

(Continued on page 96A)

Wanted...

SENIOR ELECTRONICS ENGINEERS
SENIOR MECHANICAL ENGINEERS
SENIOR PHYSICISTS

DEGREE from a top college . . . creative ability . . . real understanding of engineering principles and applications . . . record of outstanding professional accomplishment, are all essential. Salary is limited only by ability and contribution to group achievement.

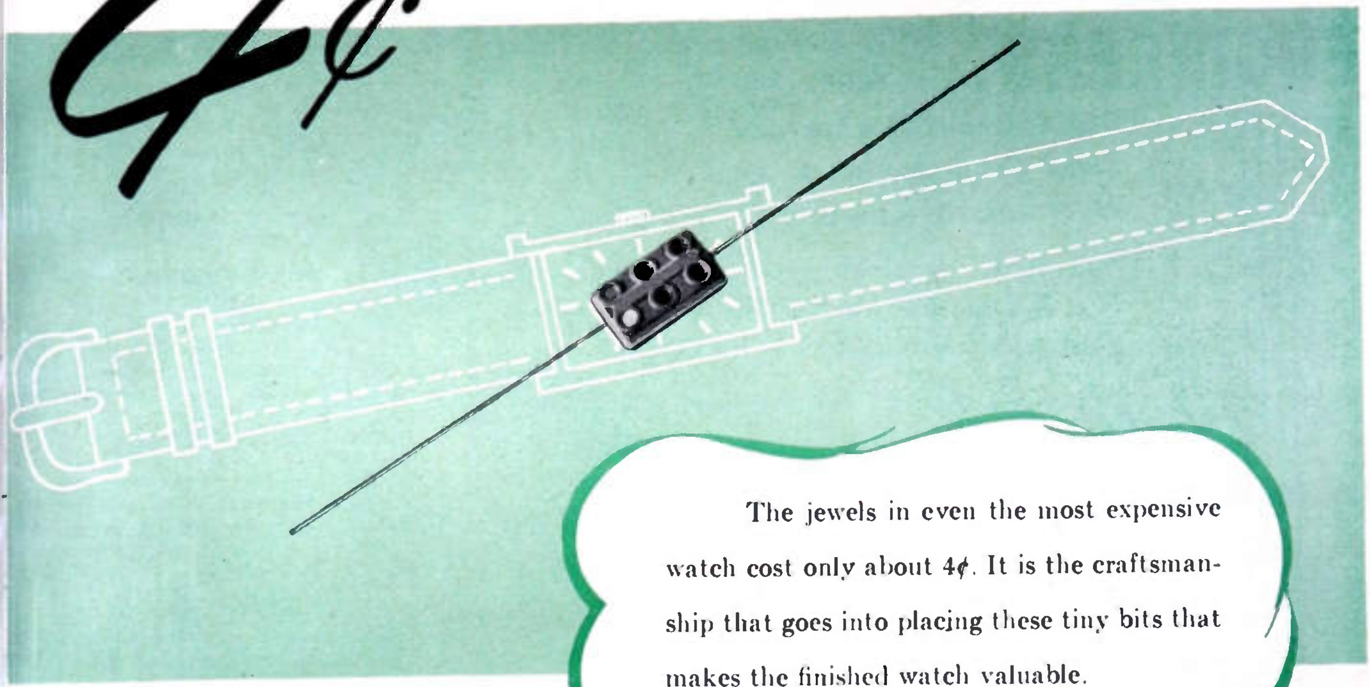
Starting in 1945, this Company has grown to a personnel of 150. Our record of successful development of servo-mechanical systems, radars, computers, test equipment, communication equipment, and instruments for guided missile programs made this growth possible. We need new qualified engineers to spearhead our further planned expansion.

If you are qualified and interested, please write giving full details on academic and professional background. Include present salary, desired salary, and date available.

See us in our Booth 98-99
RADIO ENGINEERING SHOW
New York, March 19-22

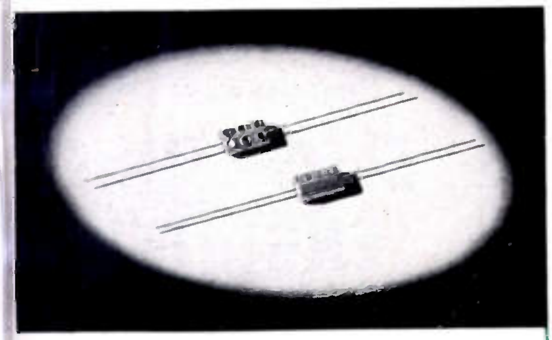
Director of Personnel
ELECTRONIC ASSOCIATES, INC.
Long Branch Avenue
Long Branch, New Jersey

4¢ WORTH OF JEWELS



The jewels in even the most expensive watch cost only about 4¢. It is the craftsmanship that goes into placing these tiny bits that makes the finished watch valuable.

The same may be said of the El-Menco CM-15 Capacitor. Tested for dielectric strength at *double* its working voltage, this mighty mite surpasses the strictest requirements of the Army and Navy. It withstands extraordinary strain under the most critical operating conditions — in any climate. Put it in your product — for peak performance.



CM-15 MINIATURE CAPACITOR

Actual Size 9/32" x 1/2" x 3/16"

For Television, Radio and other Electronic Applications.

2 mmf. to 420 mmf. cap. at 500v DCw.

2 mmf. to 525 mmf. cap. at 300v DCw.

Temp. Co-efficient ± 50 parts per million per degree C for most capacity values.

6-dot color coded.

A COMPLETE LINE OF CAPACITORS TO MEET EVERY REQUIREMENT

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

Write on your firm letterhead for Catalog and Samples.

El-Menco

MOLDED MICA MICA TRIMMER

CAPACITORS

FOREIGN RADIO AND ELECTRONIC MANUFACTURERS COMMUNICATE DIRECT WITH OUR EXPORT DEPT. AT WILLIMANTIC, CONN. FOR INFORMATION.

ARCO ELECTRONICS, INC. 103 Lafayette St., New York, N.Y.—Sole Agent for Jobbers and Distributors in U.S. and Canada

POSITIONS OPEN

(Continued from page 94A)

TELEVISION ENGINEER

For design and development of Televi sion and Radio Receivers by one of Chi cago's oldest Television and Radi manufacturers. Applicant required to hav college degree or equivalent. Experienc necessary in design and measuring tech nique. Give age, experience, referenc etc. Salary open. Apply box 643.

ENGINEERS

Four senior electronics research and de velopment engineers with a minimum o five years' experience in pulse and gen eral radar design. Assignments will in clude microwave test equipment project and guided missile development. Degre essential. Excellent opportunity for ad vancement in rapidly expanding company Modern plant of 250 workers located i Los Angeles area. Three experience junior engineers also required. Sen resume of education, experience, salar desired, to Box 644.

ELECTRICAL ENGINEER

B.S. or M.S. to work with group o circuits and miniaturization problems re lating to electronic equipment and tech nique. Must be capable of job plannin and project control. Minimum 5 years experience in both audio and TV circuit and tube component design or equipmen production. Prefer engineering physicis

(Continued on page 98A)

POSITIONS OPEN

(Continued from page 96A)

or electrical engineer with some mechanical design experience and major interest in circuits. Position is with physics laboratories. Sylvania Electric Products Inc., Bayside, Long Island. Please address replies to Personnel Manager, 40-22 Lawrence Street, Flushing, New York.

PHYSICIST

To conduct research on gaseous discharges. Prefer man with Ph.D. in physics with courses in Atomic physics, spectroscopy and chemistry, or M.S. with two years experience in nuclear research or gas discharges or thermionic emission. Position is with Long Island laboratory of nationally known electronics company. Box 645.

ELECTRONICS SALES ENGINEERS

Positions open for mature graduate sales engineers over 28 years of age, preferably with practical experience in application of dielectric heating to industrial problems. Excellent opportunities for type of individuals interested in affiliation with successful rapidly expanding organization. Locations in Chicago and other territories. Box 646.

ENGINEERS AND PHYSICISTS

Electrical engineers and physicists in university connected research institute outside continental United States. Mini-

(Continued on page 102A)

One Source of Supply—Headquarters for

E-I sealed leads and multiple headers

SEE THEM AT THE I.R.E. SHOW—BOOTH 212

Standard SEALED LEADS

Over 50 standard types to choose from. Made of hard glass, preformed with microscopic air cushioning. Absolutely free from internal strain. Tin dipped for easy soldering. Write for Bulletin 849 for complete information.

Standard MULTIPLE HEADERS

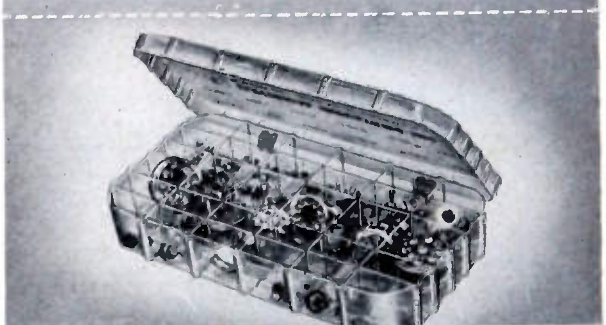
Over 100 standard types available. All headers vacuum tight, with cushioned glass preforms. Completely strain free, tin dipped, silicone treated. Many optional features including CRT closures. Full information can be obtained by writing for Bulletin 850.

CUSTOM SEALS to Specification

Practically any type of sealed terminal or multiple header can be produced to exact customer requirements. Whether your problem involves a new design or the application of a standard item, E-I engineers offer complete collaboration.

SAMPLE KIT for Designers

Contains 81 standard terminals, 11 different headers. All economy priced items—picked to solve practically any problem. Transparent case with labeled bins for easy selection. Complete kit sells for only $10.00—check or money order.

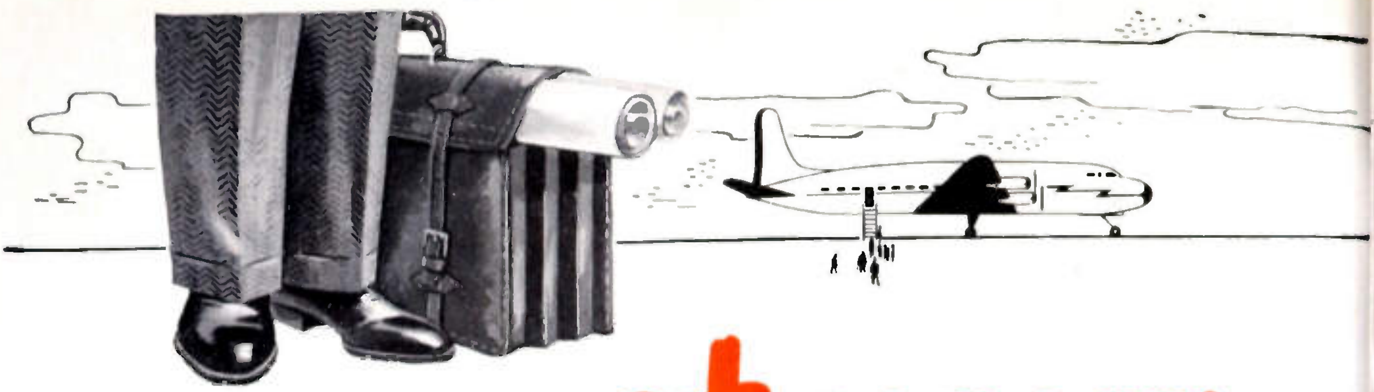


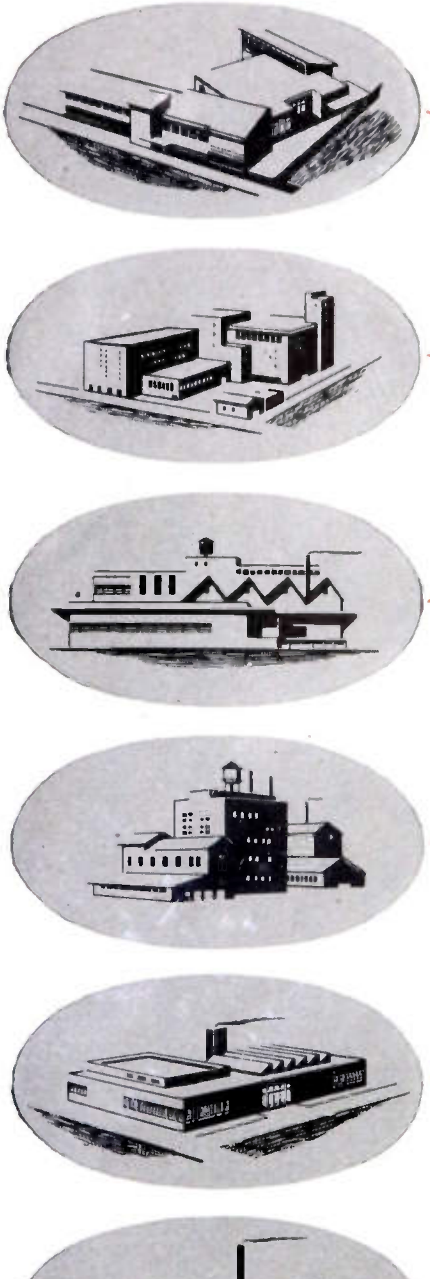
ELECTRICAL INDUSTRIES·INC

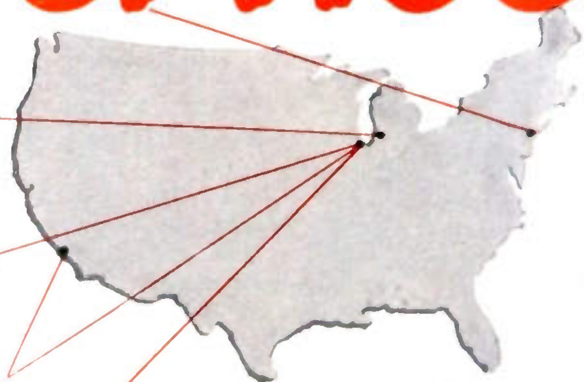
MANUFACTURERS OF SPECIALIZED ELECTRONIC EQUIPMENT

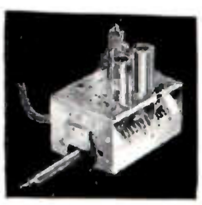
44 SUMMER AVENUE, NEWARK 4, NEW JERSEY

E I INC





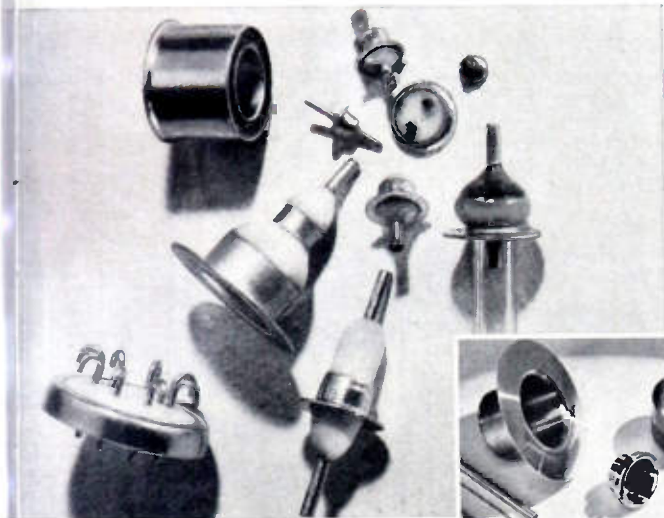




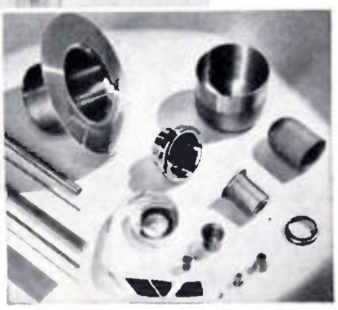
Your sealed assemblies can be kept TIGHT with

STUPAKOFF

Kovar-Glass Seals



Stupakoff Metal-to-Glass Seals are made in a variety of sizes and ratings.



Kovar Metal, the ideal alloy for glass sealing, is furnished in the form of tubes, rods, sheet, foil and fabricated shapes.

letal-to-glass seal making has been highly perfected by tupakoff. When you specify Stupakoff Seals, you get well-esigned, accurately-made products that are easy to assemble, iechanically strong, have high flashover ratings, provide igh resistance to thermal shock and are dependable. They re made in a wide variety of standard types and sizes, or in pecial designs to meet your specific needs.

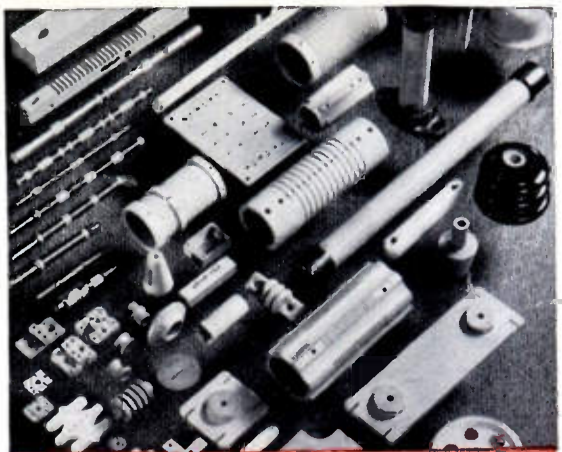
Stupakoff seals are all made with Kovar Metal, which is eadily bonded with hard glass producing no undesirable struc-ıral stresses. It has substantially the same expansitivity as ard glass from -80°C to the annealing point of glass. These aracteristics of Kovar make Stupakoff Seals dependable.

Write for samples and prices of typical Stupakoff Kovar-Glass Seals.

STUPAKOFF

CERAMIC & MANUFACTURING COMPANY

Latrobe, Pennsylvania



Representative Stupakoff Ceramic products.

STUPAKOFF

PRODUCTS

For Electrical and Electronic Applications

●

ASSEMBLIES—Stupakoff assemblies include metallized ceramic Induction COILS for radio receivers and transmitters; metallized ceramic SHAFTS for air-tuning condensers; METALLIZED PLATES for making fixed rigid assemblies; ceramic trimmer condensers.

CERAMICS—Stupakoff has long been a leading supplier of ceramic products for a wide variety of electrical and electronic applications—precision made for all voltages, frequencies and temperatures.

RESISTOR CERAMICS—Stupakoff Temperature-Sensitive Resistors are used for temperature indicating or measuring equipment such as Radiosonde, for infra-red light source and for heating elements. Supplied complete with terminals, in the form of rods, tubes, discs, bars, rings, etc.

STUPALITH—A group of ceramics having remarkable ability to withstand extreme thermal shock. STUPALITH may be made to have zero, low-positive or low-negative expansitivities. Formed by conventional methods. Safely used at temperatures up to 2200° F.

CERAMIC DIELECTRICS—Stupakoff makes general purpose Ceramic Dielectrics for by-pass, lead through blocking, stand-offs and trimmer applications. Temperature compensating Ceramic Dielectrics have coefficients from P-100 to N-2700, and high K materials up to K-6000.

Made in the form of tubes, discs and special shapes, plain or silvered. See photo below.

POSITIONS OPEN

(Continued from page 98A)

mum B.S. degree. Security clearance necessary. Send Airmail resume of training and professional experience, photograph, references, salary desired to Box 938.

TECHNICAL WRITERS

Electronics section of leading technical publisher offers permanent positions to experienced writers with engineering background; must be familiar with Government instruction book specs. Send resume and salary desired, P.O. Box 311, Yonkers, New York.

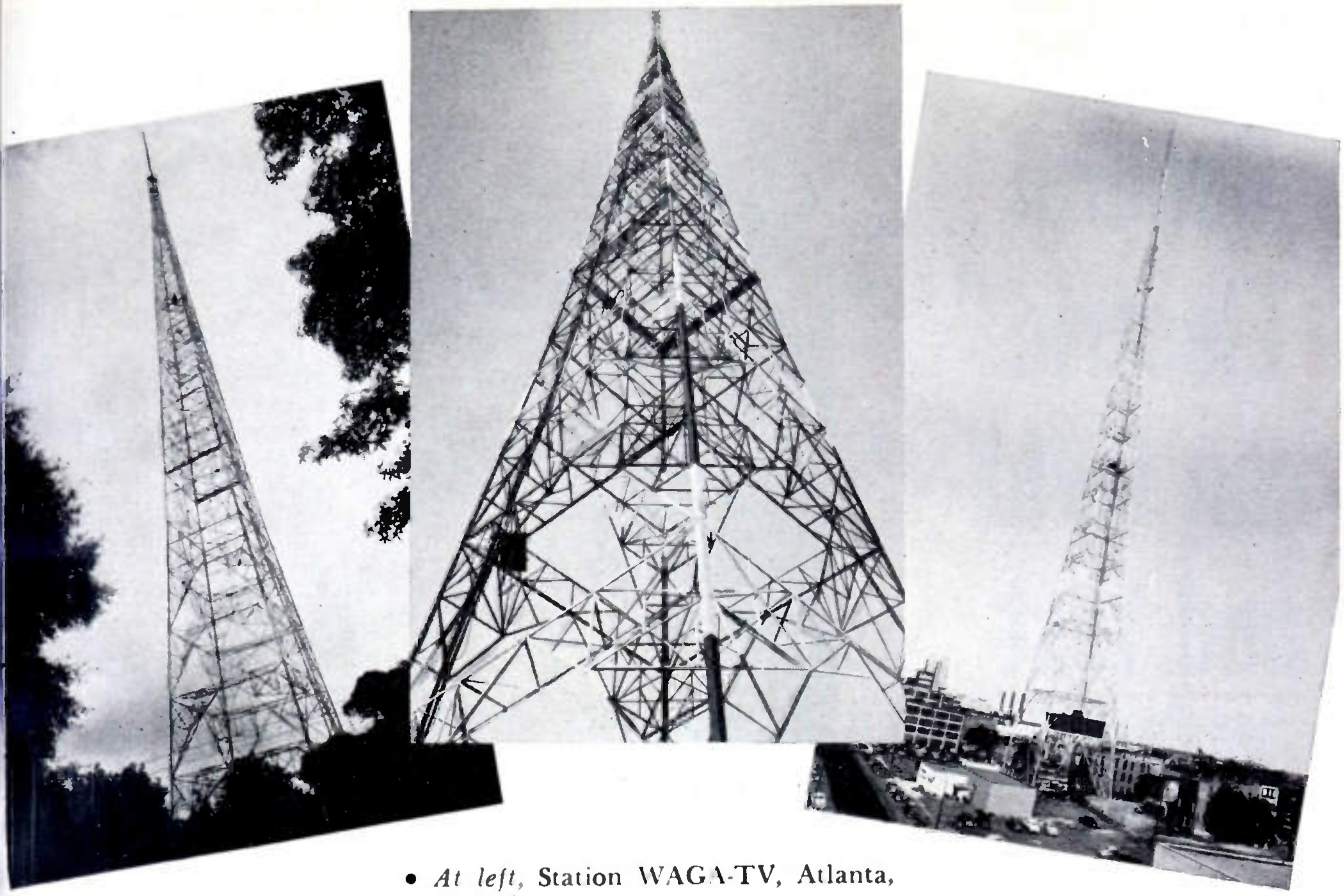
ENGINEERS AND PHYSICISTS

Several outstanding opportunities open for engineers and physicists with B.S. or advanced degrees and up to 10 years' experience in fields of electronics and physical measurements. Permanent positions in research and instrument development with independent laboratory. Send resume including type of work desired to: Physics Department, Southwest Research Institute, San Antonio 6, Texas.

ENGINEER OR PHYSICIST

For development and production. Experience: semi-conductor devices employing germanium and silicon. Very good opportunity with growing organization. Jensen Industries, Inc., 329 South Wood Street, Chicago 12, Illinois.

(Continued on page 106A)



- *At left,* Station WAGA-TV, Atlanta, Georgia
- *Above center,* Station WJBK-TV, Detroit, Michigan
- *All Blaw-*Knox H-40's! At right, WSPD-TV, Toledo, Ohio

"WE'RE PROUD OF OUR BLAW-KNOX TOWERS"*

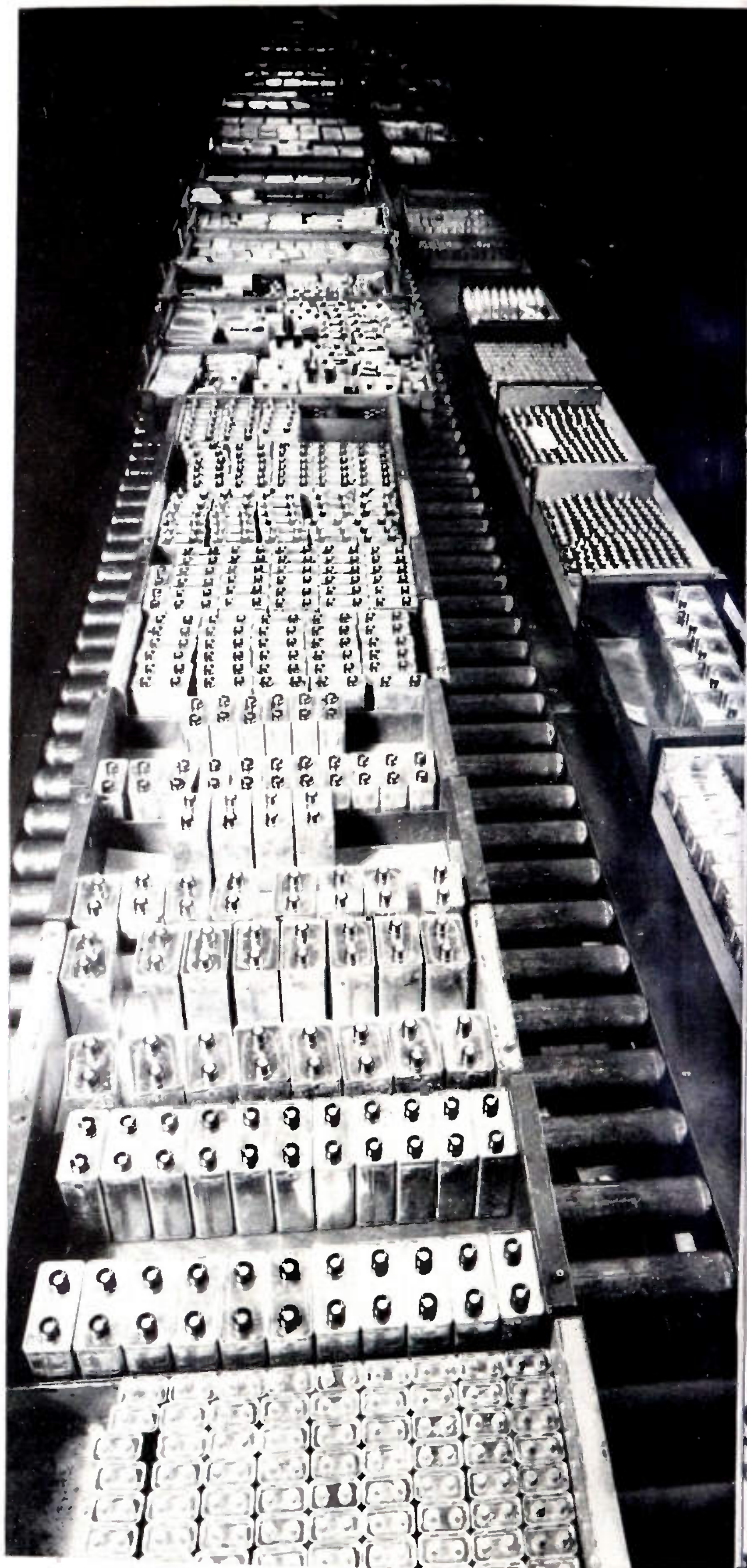
And Blaw-Knox is proud of the fact that this compliment from *The Fort Industry Company was prompted by the performance of all 13 Blaw-Knox Antenna Towers now in the service of this successful broadcasting organization.

Whether you contemplate light-weight towers for mobile communications or a sky-raking TV support, you can depend on Blaw-Knox engineered structures to get the most out of your transmitting equipment.

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2037 Farmers Bank Building, Pittsburgh 22, Pa.

BLAW-KNOX
ANTENNA TOWERS

General Electric can build and test JAN-C-25 CAPACITORS in mass production quantities



Apparatus Department,
General Electric Company,
Schenectady 5, New York

GENERAL ELECTRIC

407-301

Positions Open

(Continued from page 102A)

ELECTRONIC ENGINEER

Young electronics engineer (M.S. or Ph.D.) having initiative and imagination and an outstanding academic record wanted by a small but well-known and growing manufacturer of precision electronic measuring apparatus located in northern New Jersey about 30 miles from New York City for research and development work. Should have thorough knowledge of network theory and familiarity with electronic circuitry and VHF measurement techniques together with several years of laboratory experience. Ideal working conditions and adequate housing facilities. Salary $5,000. plus bonus. Box 648.

ENGINEERS

DESIGNER of radio receiving equipment for automobiles. Salary: $8,000 to $10,000. Age: under 40. B.S. in E.E.

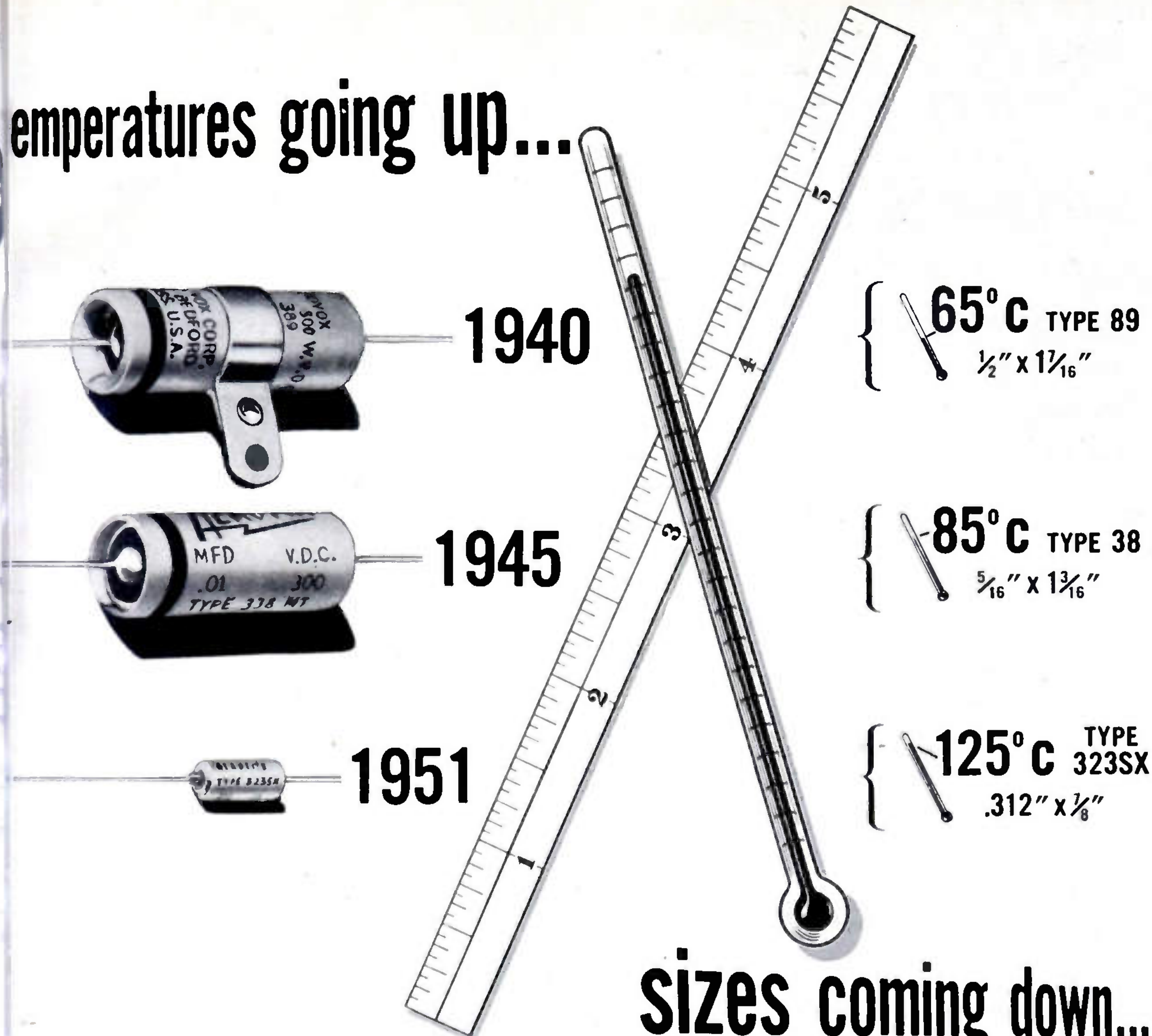
ENGINEER to design and develop small antennae for radar equipment. Salary $8,000 to $10,000. B.S. in E.E.

MANUFACTURING EXECUTIVE for plant manufacturing cathode ray and receiving tubes. E.E. degree, with experience at Superintendent level. Salary: about $10,000. Age under 45.

PROJECT ENGINEERS with E.E. degrees and experience in electronics manufacturing. Salary: $10,000 to $12,000. Age: under 40. Reply Box 649.

(Continued on page 108A)

emperatures going up...



sizes coming down...

Aerovox Capacitors

In tune with the trends of the times! That, quite aptly, describes Aerovox progress in meeting today's miniaturization and temperature requirements. Tremendous reductions in capacitor sizes and startling increases in operating temperatures (illustrated above) have resulted from such specialized engineering "know-how." And in many instances Aerovox has found it necessary to develop materials and techniques all its own.

This continuous program of "search and research" is one of the outstanding reasons why Aerovox has the ready answer to your most critical capacitor needs.

Let Aerovox collaborate on your miniaturization and temperature-rating problems. Descriptive literature may be had by writing on your company letterhead.

AEROVOX CORPORATION

THE HOME OF CAPACITOR CRAFTSMANSHIP

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

Export: 41 E. 42nd St., New York 17, N.Y. • Cable: AEROCAP, N.Y. • In Canada: AEROVOX CANADA LTD., Hamilton, Ont.

SALES OFFICES IN ALL PRINCIPAL CITIES

Positions Open

(Continued from page 106A)

CHIEF ENGINEER

Chief Engineer for manufacturer of sound recording equipment and electro-mechanical devices. Experience in electro-magnetic and audio-circuit design. Complete responsibility for engineering, from design and through production. Salary: $15,000. Reply Box 650.

TEST FACILITIES ENGINEER

Test Facilities Engineer experienced in design of test equipment for ultra-precision mechanical or electrical assemblies. Salary: $8,000 to $12,000. Reply: Box 651.

ELECTRONIC ENGINEERS—PHYSICISTS

Electronic engineers and physicists; at least one year experience in circuit work; to do design and development of electronic test equipment and geophysical instruments. Southwestern Industrial Electronics Co., P.O. Box 13058, Houston, Texas.

ELECTRONIC ENGINEERS

Research and development engineers and physicists wanted with educational background in mechanical, electrical or electronic engineering, physics or engineering physics for openings in plant and laboratory instrumentation, physical measurements, geophysics, and industrial electronics. Prefer two to four years experience in experimental research design and development of instruments, servo-mechanisms, electronic apparatus, optical equipment, intricate mechanisms of allied fields.

(Continued on page 110A)


CAUTION ON HIGH VOLTS
TRIPLETT
Model
630
There is no more useful
and dependable instrument made
FOR THE MAN WHO TAKES PRIDE IN HIS WORK
Triplett
ONLY $39.50 AT YOUR DISTRIBUTOR
TRIPLETT ELECTRICAL INSTRUMENT COMPANY · BLUFFTON, OHIO, U.S.A.

Positions Open

(Continued from page 108A)

Positions are of immediate and permanent importance to our operations. Write Personnel Director, Research and Development Department, Phillips Petroleum Company, Bartlesville, Oklahoma.

ELECTRICAL ENGINEERS

Leading manufacturer of X-ray equipment requires 3 men to train for position of sales engineers in east and middlewest. Excellent opportunity, depression proof business, stimulating field. If you can sell, like to work on your own, tangle with troublesome field service problems, don't mind occasional dirty hands or lack of a swivel chair and secretary, this is a worthwhile opportunity. Our men do well financially but work hard. If you want a soft berth, please don't reply. Previous sales helpful but not essential. State education, experience, reason for making change and past earnings. All replies held strictly confidential. Arrangements will be made to interview qualified applicants. Mr. Ed. Smith, Personnel Mgr. The Kelley-Koett Mfg. Company, 212 West Fourth Street, Covington, Kentucky.

A page from the note-book of Sylvania Research

Color Television Research Accelerated by Study of Color Phosphors in Demountable Vacuum System

ania's physicists, chemists
engineers have carried out funda-
tal research and development
olor television tubes for a con-
:able period of time.

se basic investigations into practical
r television tubes for home
industry have been conducted at
ania's Research Laboratories at
anda, Pennsylvania, and Bayside,
York. Typical of the exceptional
lities and advanced research tech-
ues used at the Sylvania labora-
es is the demountable vacuum system
wn in the photo.

elopmental samples of phosphor
ens for color television tubes may
placed in the tube for study
test. Similarly developmental
lels of three-color electron
s may be placed in the neck
he demountable evacuated en-
pe and characteristics studied.

ls continual basic research has
bled Sylvania to pioneer in
viding the television tube in-
try with a complete selection
phosphors for color picture
es. It has also paved the
toward more advanced
earch into the design and
struction of color tele-
ion tubes and circuits.
t's typical of Sylvania's
er-ceasing emphasis
productive basic research.

The operator is observing a spot of light on the phosphor screen of a developmental color television tube. By varying voltages applied to a three-color electron gun inserted in the demountable vacuum system, she can obtain data useful in improving both phosphors and gun designs for color television tubes.

SYLVANIA ELECTRIC

Don't miss
SYLVANIA'S DISPLAY
at the IRE Show,
March 19-22
Booths 104-5-6

A TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS

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.

ELECTRICAL ENGINEER

Six years experience in electromechanical and industrial electronics and measurements. Professional engineer. New York area preferred. $7,500 per year. Box 500 W.

SALES ENGINEER

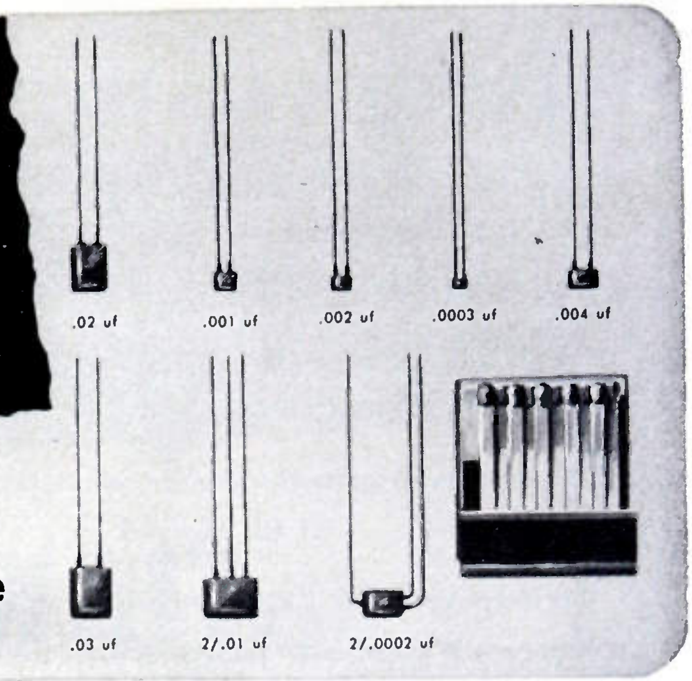
Graduate "Salesmanship for Engineers" course at C.C.N.Y., B.E.E. communications—N.Y.U. 1950. Single, age 24. Looking for job as junior or trainee that needs

(Continued on page 114A)

Specify GLENCO

MINIATURE CERAMIC PLATE CAPACITORS

...for minimum size
...maximum dependability
...convenient rectangular shape



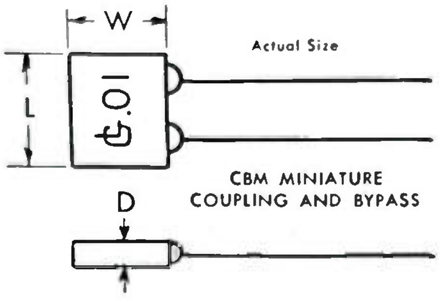
GLENCO SUBMINIATURE CAPACITORS
FOR COUPLING AND BYPASS APPLICATIONS

CBM MINIATURE 500 V. D.C. SINGLE PLATE		SMCB SUB-MINIATURE 250 V. D.C. SINGLE PLATE		CAPACITY MFD.	SMCB SUB-MINIATURE 250 V. D.C. DOUBLE LAYER		SMCB SUB-MINIATURE 250 V. D.C. MULTILAYER	
SIZES IN INCHES					SIZES IN INCHES			
L	W	L	W		L	W	L	W
.19	.14	.12	.12	.0005				
.25	.19	.18	.15	.001				
.50	.40	.28	.25	.005				
.70	.52	.50	.40	.01	.30	.19		
		.80	.60	.05	.61	.43	.48	.33
				.10	.88	.62	.65	.45
				.50			.70	.55
				1.0			1.0	.80
D=.120		D=.080			D=.120		D=.150–.800	

SPECIFICATIONS FOR CBM AND SMCB* COUPLING AND BYPASS CAPACITORS

- FLASH TESTED AT 3 TIMES RATED D.C. VOLTAGE
- POWER FACTOR LESS THAN 1%
- INSULATION RESISTANCE EXCEEDS 10,000 MEGOHMS
- MEET ALL RMA SPECIFICATIONS

*Types CBM and SMCB are shown as typical examples of the space saving possible with GLENCO capacitors. Many more standard types, including a great variety of temperature compensating ceramic capacitors, are available. Quotations on these or types to customers' specification will be supplied promptly on request.



Actual Size

CBM MINIATURE
COUPLING AND BYPASS

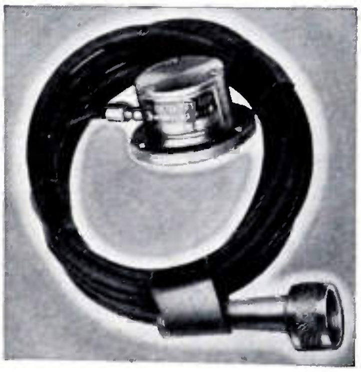
GLENCO CORPORATION
DURHAM AVENUE, METUCHEN, NEW JERSEY

***TYPE TC*—TEMPERATURE COMPENSATING CERAMIC PLATE CAPACITORS**

***TYPE CBM*—MINIATURE COUPLING AND BYPASS CAPACITORS**

***TYPE SMCB*—SUB-MINIATURE COUPLING AND BYPASS CAPACITORS**

GLENNITE ACCELEROMETER*



MODEL A403
(ILLUSTRATED)

We are currently designing a number of other types of accelerometers and strain gauges. We invite inquiries concerning units of special design. Electronic equipment can also be supplied for use in conjunction with this equipment—cathode followers, amplifiers, filters and recording equipment.

*Registered Trademark

- SENSITIVITY: 10 mv/g
- RESONANT FREQUENCY: 8 kc
- USEFUL FREQUENCY RANGE: 3 to 4000 cps
- CAPACITANCE: 1500 mmf
- SIZE: 1 7/16" diam. x ¾"
- WEIGHT: Approx. 1 ounce
- MOUNTING: 3—2 x 56 machine screws spaced 120° apart on a 1¼" diameter circle
- MAX. DIRECTIVITY: Perpendicular to mount
- TEMPERATURE RANGE: —60°C to +90°C
- ACCELERATION RANGE: 0.1 to 600g
- CABLE: 4 ft. shielded cable supplied
- CALIBRATION: Instruments individually calibrated at 2g from 20 to 1500 cps
- MOVEMENT: Compressional

GULTON MFG. CORP.
METUCHEN • NEW JERSEY

NOTE! A FEW TERRITORIES ARE STILL OPEN FOR WIDE AWAKE REPRESENTATIVES IN SELECTED AREAS—INQUIRIES INVITED.

Positions Wanted

(Continued from page 112A)

a man that has technical ability, kn how to sell, and has sincere desir sell. Box 501 W.

ELECTRONIC ENGINEER

Ph.D. in communications expected J 1951. 3 years full time university te ing. 2 years Navy electronics. Age Married. Desires academic or indus position in eastern U.S. Available Ju 1951. Box 503 W.

TELEVISION ENGINEER

B.S.T.E. American Institute of Te nology, September 1949. 5 years exp ence in radio and TV servicing. F class radio telephone license. Class amateur license. Age 23. Will reloc Resume upon request. Box 504 W.

PROFESSOR

B.S.E.E. '43, M.I.T. Radar School, C nell Ph.D. due in June. Specialist in e tromagnetic waves and propagat Teaching, research, Navy electronics, industrial experience. Teaching posi with opportunity to give graduate cou desired. Box 508 W.

ENGINEER

B.S. physics, AAF radar officer. H vard, M.I.T., completing last year ev ing law school. Extensive experie electronic research and administrat Seeks position contract negotiation, su vision or one involving dealings w government administrative agencies, N.Y. area. Box 509 W.

(Continued on page 116A)


LABSCOPE
WAIT...
If you contemplate the purchase of an OSCILLOSCOPE now, or within the near future, we sincerely urge you to wait until the convention of the Institute of Radio Engineers on March 19 to 22.
We will be in Booth No. N-20, where we will present, for the first time, our brand new oscilloscope featuring many desirable and important advancements.
Our LABSCOPE is not the result of research confined within our walls. We solicited the cooperation of a cross-section of the nation's outstanding engineers, asking them to tell us what they would like to have in a scope. Then we designed it . . . to serve the greatest number of the most discriminating and exacting engineering organizations.
We want you to see our new LABSCOPE . . . to subject it to rigid examination . . . to compare it feature for feature . . . to prove to yourself that the LABSCOPE is the instrument you want.
P.S. If you are unable to attend the convention and SEE it, drop us a line and we'll send you the data sheets on our LABSCOPE.
Brujac
BRUJAC ELECTRONIC CORPORATION
103 Lafayette Street • New York 13, N. Y.

Positions Wanted

(Continued from page 114A)

MAGNETIC AMPLIFIER DEVELOPMENT ENGINEER

B.E.E. '48. Cum Laude, Tau Beta I Eta Kappa Nu. Two years magnetic a plifier design, development, and applic tion experience with General Electr following extensive GE test progra Graduate of GE "A" advanced enginee ing program. GE servo mechanis course. Draft exempt. Desires Connectic or New York location. Box 510 W.

BROADCAST ENGINEER

B.S.T.E. American Tel. Age 27, ma ried, 2 children. First class phone licens Presently employed for two way mob radio company. Desires position in con mercial television broadcasting. Box 5 W.

TECHNICAL EDITOR, WRITER

More than two years radar and guid missle experience, honor graduate wi B.S.E.E. veteran, married, age 28. Cu rently employed. Salary requirement abo $6,000. Box 512 W.

ENGINEER

Position in management with electron laboratory and in manufacturer by ma with eleven years private industry an administrative field, 6 years as electron project engineer in administrative wor with the Government, followed by 3 yea with an electronic manufacturer in plai management as administrator coverin Government contract relations and sale organization, etc. Desires connection wit growing company. Box 513 W.

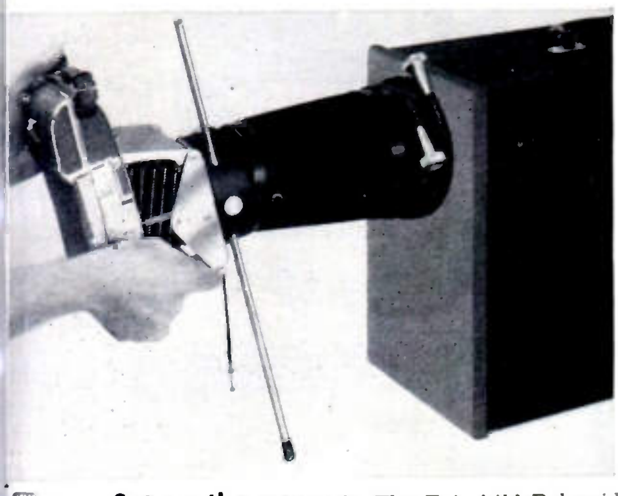
ENGINEER

B.S.E.E. Two years experience i cathode ray tubes. Desires change of po sition. 3 years radio maintenance exper ience in Signal Corps attached to Ai Corps. First class radiotelephone licens Wide range of interests in televisio radio, electronics. Age 27, married, child. Box 514 W.

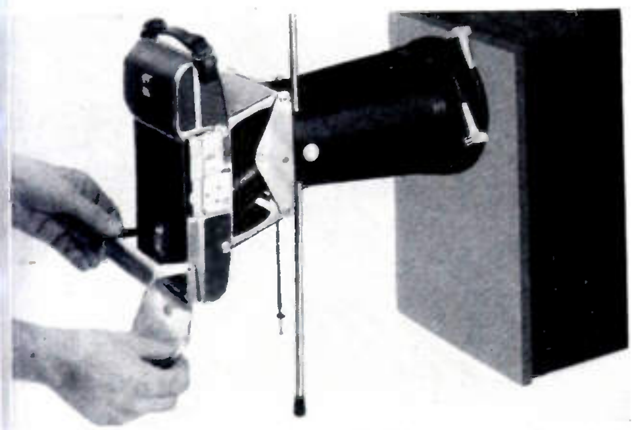
SALES ENGINEER

B.E.E. graduate sales for engineer C.C.N.Y. extensive electrical, electro mechanical and manufacturing back ground; 3 years Army radio and rada chief; studying for MBA evenings; Ne York metropolitan area; 27, married; in terview and resume upon request. Box 51 W.

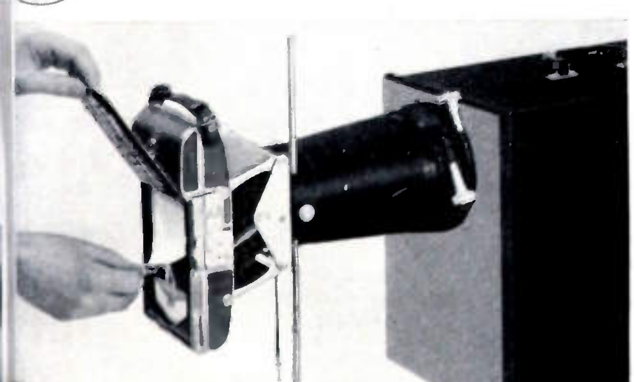
How to make Oscillograms FAST!



Set up the camera. The Fairchild-Polaroid camera consists of three units: adapter ring, hood, and camera body. To set it up, you place the handy adapter ring over the oscilloscope bezel, slip the hood into the ring, then snap the camera into the bayonet lock on the hood. That supporting rod is a safety feature that protects both camera and oscilloscope.



Pull the tab to finish exposed print. After a snap of the shutter, the exposure is made and you're ready to finish the print. If you want two exposures, it's easy to move the camera body down and make a second exposure. To finish the print, you merely pull tab at back of camera.



Remove the finished print. A minute after you've pulled the tab, the finished print is ready for evaluation. Just open the camera back and there it is. An easy job, but you have a photographically accurate record of the trace in less time than you could sketch it from memory.

—SET UP THE CAMERA
—SNAP THE SHUTTER
—SEE THE PRINT

ALL IN 3 MINUTES—or even less

with the Fairchild-Polaroid® Oscilloscope Camera

The easiest way is the fastest way when you're photographing oscilloscope images with the Fairchild-Polaroid® Oscilloscope Camera.

No more darkroom processing! With this new camera it takes only two minutes (less if you're fast) to set up and snap the picture, one minute to finish a print. Each 3¼ x 4¼ print records traces exactly one-half life size to make comparisons easy.

Write for complete data and prices on F-284 Oscilloscope Camera Kit including camera, carrying case, and film. *Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Boulevard, Jamaica 1, N. Y.* Dept. 120-14C.

SPECIFICATIONS

LENS—Special 75 mm. f/2.8 Wollensak Oscillo-anastigmat.

SHUTTER—Wollensak Alphax; speeds 1/25 sec. to 1/100 sec., "time," and "bulb."

FOCUS—Fixed (approx. 8 in.)

PICTURE SIZE—3¼ x 4¼ in. (2 or more images per print; 16 exposures per roll of film.)

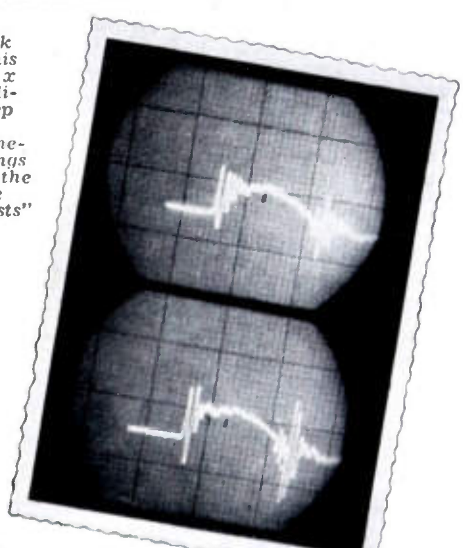
IMAGE SIZE—One-half reduction of scope image.

WRITING SPEED—to 1 in/μsec at only 3000V accelerating potential; higher speeds at higher voltages.

DIMENSIONS—Camera, 10½ x 5¼ x 6¼ in.; hood, 11 in. length, 7½ in. dia.; adapter, 2 in. width, 6⅝ in. max. dia.

WEIGHT—Complete, 7¾ lb.

Typical of the work being done with this camera is this 3¼ x 4¼ print of 35-millisecond single-sweep transient—one of a series of accelerometer-output recordings that made possible the completion of nine recorded "drop-tests" in 40 minutes.



FAIRCHILD

OSCILLOSCOPE RECORDING CAMERAS

See the Fairchild-Polaroid Oscilloscope Camera and the Fairchild Oscillo-Record Camera at the Radio Engineering Show, Booth 238-239.

MEMBERSHIP

(Continued from page 88A)

Miedema, H., 38 Kastanjelaan, Hilversum, Netherlands
Thompson, H. V., Box 187, Fort Lauderdale, Fl

Transfer to Member

Adams, R. J., 3110 Massachusetts Ave., S.E., Wa ington, D. C.
Allen, T. L., Jr., 3323 49 Loop, Sandia B Branch, Albuquerque, N. Mex.
Aucremanne, M. J., 18 Whitney Ave., Floral Pa L. I., N. Y.
Barker, R. D., 4020 Ingraham St., San Diego Calif.
Briggs, V. R., 7114-D Alvern St., Los Angeles Calif.
Brooks, W. O., 8333 Georgetown Ave., Los Ange 45, Calif.
Carterette, A. A., Jr., Hopkins Engineering Co pany, 831 Munsey Bldg., Washington D. C.
Davidoff, F., 90 Hazel St., Apt. G2, Clifton, N. J.
Dressel, H. O., 2459 Glebe Ave., New York N. Y.
Duncan, J. A., 6016 45 Ave., N.E., Seattle Wash.
Durkovic, J., 10316 Colesville Rd., Silver Spri Md.
Fishbein, S. B., Barkalow Ave., Freehold, N. J.
Fisher, L. L., 901 S. Adams St., Albuquerque, Mex.
Friedman, I., 264-61 Langston Ave., Floral Pa L. I., N. Y.
Ghose, R. N., 15 Rajballave Saha First Lane, Ho rah, India
Godsho, A. P., Bell Telephone Company of Pen sylvania, 1401 Arch St., Philadelphia Pa.
Hicks, B. A., 212 Lorraine Ave., Upper Montcla N. J.
Hutton, W. I., 310 W. Clarinda, Shenandoah, Io
Jankowski, H., 509 Vine St., Liverpool, N. Y.
Mahland, E. W., 257 Beach 134 St., Belle Harbo N. Y.
Murty, E. H., 3505 Ridgedale Ave., St. Louis 2 Mo.
Novikoff, E. B., 84-19 258 St., Floral Park, N. Y
Parenti, V. M., Calle Mandri 60, Barcelona 6, Spa
Shalloway, A. M., Georgia Institute of Technolog Box 967, Atlanta, Ga.
Shamblin, H. D., 6346 S. W. 41 St., Miami 43, Fl
Tribou, P. W., 294 Charles St., Malden, Mass.
Vincent, R. C., Box 30, State College, Pa.
Weltin, O. K., 197 Lester Rd., Park Forest, Chica Heights, Ill.
Whiffen, R. E., 8721 Loch Bend Dr., Towson 4, M

Admission to Member

Bracco, D. J., Sylvania Electric Products, Inc., Bo 6, Bayside, L. I., N. Y.
Cary, F. C., 61 Cliveden Ave., Toronto 18, Ont Canada
Clark, J. F., III, 22122 Sherman Way, Canog Park, Calif.
Clement, A. J. F., 11935 Wagner St., Culver City Calif.
Cunningham, F. B., 1702 Ross Pl., Albuquerque N. Mex.
Dean, K. W., Diddell Rd., Poughkeepsie, N. Y.
Eisenscher, E. S., School Ave., Chatham, N. J.
Falkenberg, H. R., 423 Aberdeen Ave., Dayton 9 Ohio
Fitzsimmons, R. S., 315 E. Washington, Belleville Ill.
Goldstone, L. O., 38 Cooper St., Brooklyn 7, N. Y
Halliday, J. R., Apt. D, Bldg. 3244 "A" St., Sandi Base P. O., Albuquerque, N. Mex.
Ihde, W. M., 920 S. Michigan Ave., Chicago 5, Ill
Jacobson, L. J., International Resistance Company 401 N. Broad St., Philadelphia 8, Pa.
Jones, J. D., Jr., Radio Station KTAT, Frederick Okla.

(Continued on page 120A)

VHF
UHF

IMPEDANCE MEASUREMENTS

SPEED AND CONVENIENCE

FTL-42A IMPEDOMETER

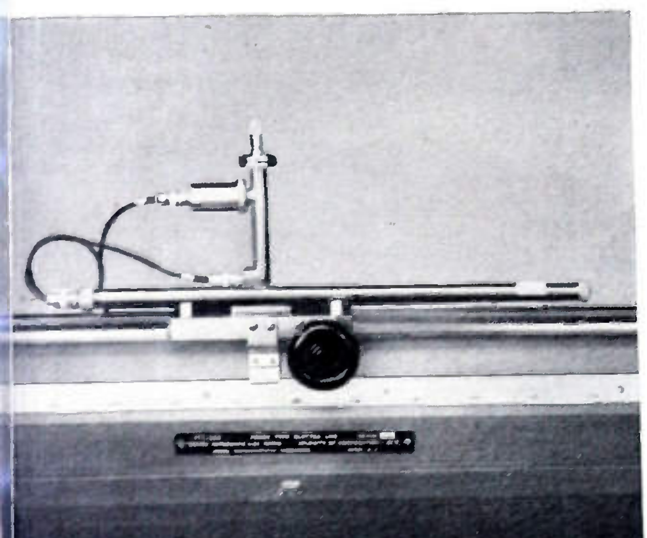
Rapid, accurate measurement of impedance, reflection coefficient and standing wave ratio. Small size, convenient for field use.

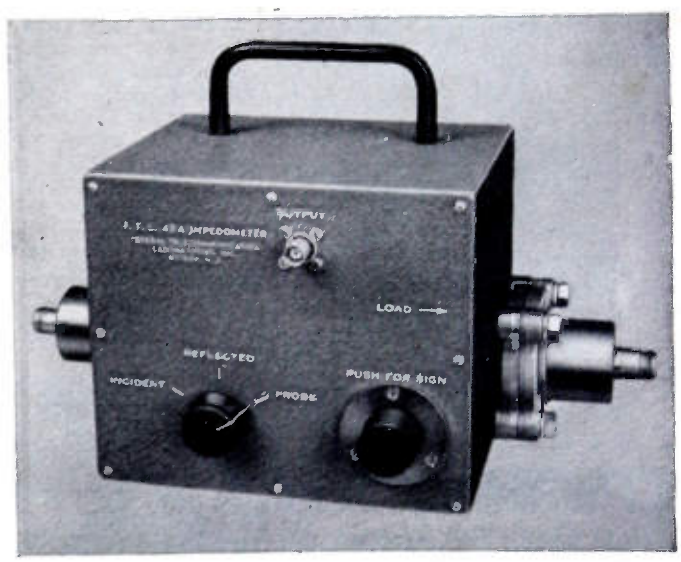
50 to 500 Mc.

Can be inserted in various sizes of solid coaxial line or flexible cables.

Make three readings, plot diagram and read off impedance to ± 5%.

$400.00.





-30A SLOTTED LINE

ise impedance measurements in the range of 60 to 1000 jacycles per second. Accuracy ± 2%.

0 to 2000 Mc range covered with slightly reduced accuracy.

xial line 250 centimeters long having a surge impedance of ohms ± 0.5 ohms.

195.00.

PRECISION

On display at booth 34,
1951 IRE Radio Engineering Show

Write for FTL-30A and FTL-42A brochures.

Federal Telecommunication Laboratories, Inc.

500 Washington Avenue
Nutley 10, New Jersey

MEMBERSHIP

(Continued from page 118A)

Knarr, C. E., 13 Linden Terr., Towson 4, Md.
Lenson, S., 14A Bloomfield St., Dorchester, Ma
Maddox, R. D., 437 S. W. 16 St., Richmond, Ind
McCormack, J. E., Radio Station WHUM, Be shire Hotel, Reading, Pa.
Reed, R. C., 75 Turner St., Dedham, Mass.
Schweiss, W. W., 1104 Fanshawe St., Philadelpl Pa.
Smith, H. W., 1305 W. 40, Austin, Tex.
Stevens, L. G., Radio Station WLAV, Grand Ra ids 2, Mich.
Wiener, A., Box 721, Melbourne, Fla.
Winston, G. R., 3724 Binkley Ave., Dallas 5, T
Zapotocky, A. C., 27 Winthrop Rd., Washingt Park, Nixon, N. J.

The following elections to Associate we approved and are effective as of Februa 1, 1951:

Abrams, I., Wheeler Laboratory, 122 Cutter M Rd., Great Neck, L. I., N. Y.
Agree, I., 60 Cooper St., New York 34, N. Y.
Antosy, S. J., AFN Bayreuth, APO 696-6, c/o Po master, New York, N. Y.
Axeling, G. S., 107 Moore St., Princeton, N. J.
Bardfield, M. L., 4 Brinsley St., Boston 21, Ma
Beardslee, D. A., Valparaiso Technical Institu Valparaiso, Ind.
Belderok, H. C., 139 N. Columbus Ave., Freepo N. Y.
Beckerle, F., Jr., 47 Vermont, Buffalo, N. Y.
Berger, M., 99 Ocean Ave., Brooklyn 25, N. Y.
Bialkowski, M., 906 Myrtle Ave., Brooklyn, N.
Bishop, E. F., 4755 N. Malden, Chicago, Ill.
Bradish, W. M., 1523 N. McCadden Pl., Hollywoo Calif.
Britton, R. C., Radio Company, 66 Signal Opr. B Camp Gordan, Ga.
Browne, W. A., West Crook Rd., Emporium, Pa
Brumm, G., 18 Ackermann St., Zurich 44, Swit land
Busby, E. S., Jr., 25 Lawrence Cir., Portsmouth, V
Buschmann, W. T., 4 E. Sixth St., Emporium, Pa
Cain, G. H., Jr., 1015 Second St., Santa Monic Calif.
Campbell, W. O., Box 183, Morrill, Neb.
Cervenak, E. D., 2154 W. 20 St., Cleveland, Oh
Chandler, A. H., 846 Howe St., Vancouver, B. C Canada
Chenoweth, W. G., 3304 Hamilton Ave., Baltimo 14, Md.
Clark, J. E., 3325 Edgeworth, Ferndale, Mich.
Cohn, E., Secon Metals Corporation, 228 E. 45 S New York, N. Y.
Conway, J. G. C., 128 Torbay Rd., Harrow, Ra ners Lane, Middx., England
Cowan, S. R., 342 Madison Ave., New York, N. Y
Cumeralto, Q. C., R. D. 3, Hanover, Pa.
Davis, V. E., 2380 Wilson St., Beaumont, Tex.
Demeree, K. W., 60 Rotary Ave., Binghamto N. Y.
Dutton, C. G. O., Sun Oil Company, Box 283 Beaumont, Tex.
Earnest, H. N., Hedron Macg.-1, Cherry Poin N. C.
Elices, F. J., 3728 Chesapeake St., Washingto D. C.
Fagerhaugh, K. H., 86 E. Randolph St., Chicag Ill.
Ferguson, D. R., 20404 Spencer, Detroit, Mich.
Francis, E. P., 4409 Monroe, Wayne, Mich.
Freed, L. E., 1481 E. Fifth St., Brooklyn, N. Y.
Garber, J. F., Jr., Air Materiel Command, Box 24 Wright Field, Dayton, Ohio
Geiger, D. L., 4900 Euclid, Cleveland 3, Ohio
George, J. N. S., 9 Florence Crescent, Toronto, Ont Canada
Giger, A. J., Florastrasse 23, Solothurn, Switzerlan
Hackett, F. J., Box 399, Kenora, Ont., Canada
Hagger, H. J., 155 Thierstenerrain, Basle, Switze land

(Continued on page 121A)

MEMBERSHIP

(Continued from page 120A)

- sen, W. N., R. D. 6, Muscatine, Iowa
- der, J. F., 60-58 71 Ave., Brooklyn, N. Y.
- du, G. K., Box 1226, Plainfield, N. J.
- in, W. H., 1965 Greenwood Ave., San Carlos, Calif.
- berg, E. N., 56 Herzl St., Haifa, Israel
- gins, L. A., 32 Charles St., Jersey City, N. J.
- chberg, J. K., 7306 Kenwell St., Dallas, Tex.
- ni, G. Y., 513 Kalanikoa Ave., Hilo, Hawaii, T. H.
- bowitz, A., 494 Hegeman Ave., Brooklyn, N. Y.
- k, J. J., 87 Sanford Ave., Amsterdam, N. Y.
- son, H. A., The Electrodyne Company, 32 Oliver St., Boston 10, Mass.
- es, E. D., Mezes Hall, Apt. 106, North Brothers Island, New York, N. Y.
- os, F., Armour Research Foundation, Technical Center, Chicago 16, Ill.
- chik, W. E., 1442 Ridge Ave., North Braddock, Pa.
- hn, W. R., R. D. 3, Hanover, Pa.
- I. H., R. D. 2, Hobson Rd., Fort Wayne, Ind.
- eja, C., R. F. D. Hendrick St., Easthampton, Mass.
- rence, A. H., 11227 92 St., Edmonton, Alta., Canada
- R. J., 6126 S. Dorchester St., Chicago, Ill.
- cDonald, D. A., 77 Atkinson St., Bellow Falls, Vt.
- rgna, C. R., Hadlaubstr. 47, Zurich 6, Switzerland
- Innes, H. W., 6560 E. Hastings St., North Burnaby, B. C., Canada
- Manus, J. E., 35 W. 33 St., Chicago, Ill.
- rrihew, H. W., 740 New St., Allentown, Pa.
- ler, C. V., 1020 N. Broadway, Milwaukee 3, Wis.
- ller, J. C., Jr., 6507 Starling Cir., Dallas, Tex.
- rgan, D. E., Wilson-Hazel, 4544 N. Hazel Ave., Chicago, Ill.
- rris, A. A., 527 Bushwick Ave., Brooklyn 6, N. Y.
- rton, D. E., 2012 N. 23 Pl., Phoenix, Ariz.
- rray, J. M., 308 Myrtle Ct. Apts., Augusta, Ga.
- umeyer, B. W., C. I. T., Nuclear Research Center, Saxonburg, Pa.
- wdorf, A. S., 1059 53 St., Brooklyn, N. Y.
- ner, J. A., Swedish Electrical Commission, Stockholm 16, Sweden
- on, C. F., 6214 N. Winthrop Ave., Chicago, Ill.
- pchuk, J. M., 44 Ahorn St., Peabody, Mass.
- ford, C. J., Jr., 1587 Penistone Rd., Birmingham, Mich.
- illips, J., 118 Villa Ave., Buffalo, N. Y.
- ellnitz, F. D., USN Air Development Center, Johnsville, Pa.
- lito, V. J., 27 Ellington St., Dorchester 21, Mass.
- ice, R. L., 2144 N. Quebec St., Arlington, Va.
- abe, H. P., 202 Park Dr., Dayton 10, Ohio
- tko, E., 7177 Nagle, Detroit 13, Mich.
- berts, J. O., Rock Island Broadcasting Company, WHBF-TV, Rock Island, Ill.
- ssell, R. S., 1217 George St., Lansing, Mich.
- ffro, Y. L., 800 N. Clark St., Chicago, Ill.
- ks, H. L., 166 Hicks St., Brooklyn 2, N. Y.
- xena, A. P., Comm. Centre Police W-T Sec., Asst. Wireless Officer Tech., Dilkusha, Lucknow, India
- hofield, C. R., 350 Arch St., Sunbury, Pa.
- honsleben, M. W., 658 Birchstrasse, Zurich 52, Switzerland
- hreiber, O. P., 424 Howard Ave., Middlesex, N. J.
- irer, H. W., Hixon Laboratory, University of Kansas, Medical Center, Kansas City, Kans.
- ivastava, G. P., Communication Center, Dilkusha Rd., Lucknow, India
- eele, E. E., 1129 Alameda Ave., Glendale 1, Calif.
- llenger, J. E., Jr., Box 176, Pahokee, Fla.
- resher, W. E., 1608 Karwin Dr., Dayton, Ohio
- rban, C., Urban Associates, Cornell Bldg., Pleasantville, N. Y.

(Continued on page 122A)

Membership

(*Continued from page 121A*)

Van Davelaar, F. S., Wheeler Laboratories, 1 Cutter Mill Rd., Great Neck, L. I., N.
Van De Velde, F. J., 52 Ave. De Beco, Brussels, Belgium
Vedo, J. B., 4100 Polk, Gary, Ind.
Warshaw, M., 2136 LeMoyne St., Los Angeles Calif.
Wehrung, N. J., Box 318, Dodge Rd., Tonawan N. Y.
Weiner, G., 26 Hershey St., Dayton 5, Ohio
Weiss, E. J., 627 Belmonte Park, N., Dayton 5, O
Woodbeck, R. J., 608 Washington St., Valparai Ind.
Wulliman, J. C., Stations WCNB & WCNB-F Connersville, Ind.

News—New Product

A Survey of Advertising Pref erences of Members of The Institute of Radio Engineers

In December, 1950, the Advertisi Department of the Institute initiated survey to determine what advertisemen were most acceptable and helpful to t membership—and why.

To obtain the information a Post Ca (see illustration) was mailed to a portion the membership representing a good cros section of the country. This will be do each month, until the entire roster has bee polled. Replies were received from 2 states, Washington, D. C., Alaska, Car ada, and the Army overseas.

The reason why a member liked an ac vertisement fell into the following "pa tern" (not necessarily in order of prefe ence).

1. Specifications or Data.
2. Prices Quoted.
3. Application Data.
4. Engineering Drawing, Charts, Graph or Wiring Plan.
5. Good Visual Display—Attracts At tention.
6. Brief Yet Complete.
7. Dignified Presentation.
8. Generally Informative or Instructive
9. Performance Characteristics.
10. No Ballyhoo or Advertising Blurbs.
11. No Answer.
12. Definitely Negative.

Other Reasons Infrequently Given—
A. New Techniques.
B. Order Blank in Ad.
C. Physical Dimensions.
D. New Product.
E. Cut Away Drawing or Explode View.
F. Invites Correspondence.

The recipient of the card is requeste to make a choice for the specific month and then to state the reason for selection Next, to choose an advertisement from th IRE Directory. Thirdly to state his typ of business; and last to tell us if (A) h makes purchases, (B) sets specifications (C) can influence buying, (D) has no inter est in buying. Each of the last group i given a numerical value which is totaled t obtain a "point evaluation" of the me who prefer the ad.

(*Continued on page 124A*)

News—New Products

(Continued from page 122A)

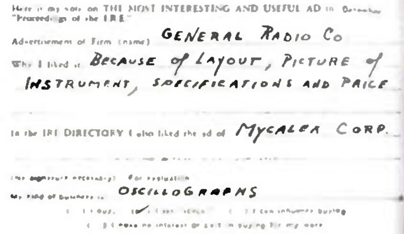
This is the result of the December study

Firm & Page	Vote	Ans.	Value
General Radio Co. Back Cover	15	5, 10	40
Hewlett-Packard Pgs. 26A & 27A	14	1, 5	28
A. B. DuMont Labs. Page 22A	13	6	31
Int'l. Resistance Pgs. 12A & 13A	8	5	21
Radio Corp. of Am. Pgs. 56A & 57A	7	5	18
Centralab Pgs. 33A, 34A, 35A, 36A	6	1, 5	15
Cannon Elec. Dev. Page 78A	4	6	7

Only the top group of votes are being reported in this preliminary study.

Mycalex Corp. Insert	10	Directory
Communication Prods. Insert	6	Directory
Automatic Elec. Insert	5	Directory

NOTE: *Vote* indicates total votes.
Ans. indicates the answer most frequently given, or in a tie, both.
Value indicates point evaluation total of voters.
Directory refers to the IRE Directory.


Here is my vote on THE MOST INTERESTING AND USEFUL AD in December "Proceedings of the I.R.E."

Advertisement of Firm (name) GENERAL RADIO CO

Why I liked it BECAUSE OF LAYOUT, PICTURE OF INSTRUMENT, SPECIFICATIONS AND PRICE

In the IRE DIRECTORY I also liked the ad of MYCALEX CORP.

My field of business is OSCILLOGRAPHS

More than one reason was given by most men as the basis for selecting an ad. To avoid making a prejudiced selection the researcher took the first reason in 90 per cent of the answers, on the basis that the most important factor would be stated first. This may be a fallacy, however, interpretation was avoided, in an attempt to be factual.

Most secondary reasons given were answers #1 and #2. And this may be considered in next month's report. This will be a "continuing study."

Recent Catalogs

• • • Two Laboratory Reports, #1 & #2, have been released by **Technology Instrument Corp., 1058** Main St., Waltham, Mass.

Report #1 concerns itself with "Low-Frequency Characteristics of the Type 320-A Phase Meter." This is an instrument which utilizes a pulse position comparison method for measuring the phase angle difference between two electrical signals.

Report #2 is devoted to "Determination of The *Q* of Coils By Means of A Z-Angle Meter And The Series Resonance Method," "Type 500—A Wide-Band Decade Amplifier," and "Network Calculators."

• • • **Instrument Specialties Co., Inc.,** Little Falls, N. J., has printed Catalog #6, which deals with the complete line of microprocessed springs of beryllium copper for many applications. Also given is information on engineering, toolmaking, and the sample service offered by the firm.

The MOST VERSATILE AND SENSITIVE Oscilloscope EVER Built!

OMPACT-SIMPLE
EASY MOBILITY

ome of the outstanding advantages of the...
NEW LAVOIE LA-239A OSCILLOSCOPE

- Takes the guesswork out of pulse techniques.
- Accurately measures amplitude, width, separation, repetition rate and rise time without the need of additional equipment.
- Accurate timing markers provide means of calibrating the linear time base.
- Internal trigger generator permits pulse generator and oscilloscope to be triggered simultaneously, while sweep delay circuit allows a small portion of image to be expanded TEN TIMES normal size.

INCREASED PRODUCTION NOW PERMITS ***A REDUCTION*** OVER FORMER LIST PRICE
WITH SPECIAL REDUCTIONS TO TECHNICAL SCHOOLS AND NON-PROFIT ORGANIZATIONS

'rite for Technical Bulletin LA-239A
ving complete detailed information.

Lavoie Laboratories
RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists **in the Development and Manufacture of UHF Equipment**

VISIT US AT BOOTH 87, 88 RADIO ENGINEERING SHOW

What to see at the Radio Engineering Show

(Continued from page 60A)

Firm — **Booth**

Federated Metals Division, American Smelting & Refining Co., Whiting, Ind. — 33
Federated and Federated Gardiner brand rosin core solder, an alloy of tin and lead in wire form with a turpentine distillate flux incorporated in the center. Federated and Federated Gardiner brand RTS solder (a tin-lead solder). Copper anodes, cast, electrodeposited and rolled for all copper plating operations.

Federated Purchaser, Inc., New York, N.Y. — 32
Distributors of industrial electronic equipment and components. Audio broadcasting and receiving equipment. Audio systems, instruments, and test equipment. TV components. "Radio's Master," a reference manual and buying guide.

Ferris Instrument Co., Boonton, N.J. — 1, 2,
Radio receiver testing equipment.

Filtron Co., Inc., Flushing, L.I., N.Y. — 4
Radio frequency interference suppression filters.

Fisher Radio Corporation, New York, N.Y. Theatre — 31
High quality FM and AM receivers. High quality audio amplifiers.

Ford Instrument Co., Div. of The Sperry Corp., Long Island City, N.Y. — 21
Synchro motors, servo motors, resolvers, differentials (mechanical). Integrators.

Freed Transformer Co. Inc., Brooklyn, N.Y. — 10
Transformers, reactors, wave filters, High "Q" toroid inductors, precision laboratory measuring instruments.

Furst Electronics, Chicago, Ill. — 363
Wide-band DC amplifiers, wow meter, regulated power supplies of various capacities and sizes.

Gates Radio Co., Quincy, Ill. — 214
A new model 10KW high frequency communications and broadcast transmitter, a display of radio frequency control and transmission line items in the higher powered ranges and broadcast station accessory equipment.

General Ceramics and Steatite Corp., Keasbey, N.J. — 47
Steatite low loss insulators, ferramics, hermetically sealed terminals, porcelain (dry process and wet process) high dielectric constant titanate materials, magnetic amplifiers.

General Electric Co., Schenectady, N.Y. — 113 to 119
Electronics equipment and components.

General Electric Co., Electronics Dept., Syracuse, N.Y. — 113 to 119
Cathode ray, transmitting, and receiving tubes; TV and industrial tubes; Germanium diodes; loudspeakers; tone arms, phonograph cartridges; TV components, preamplifiers.

General Precision Laboratory, Inc., Pleasantville, N.Y. — S-9 to S-11
New Design TV camera chains for field and studio, new sensitive film chain for better picture quality; precision projectors for standard film chains and for portable machines for use with image orthican cameras. Projectors are finest professional machines designed for TV. Camera chains features remote control of iris, lens change, and focus (pan and tilt also available).

General Radio Co., Cambridge, Mass. — 92, 93
Coaxial elements, slotted line, UHF admittance meter, bolometer bridge, VHF and UHF oscillators, two-signal audio generator, standard-signal generators, variacs, random noise generator, octave-band filter, resistance limit bridge, dielectric measuring equipment, vacuum-tube voltmeters, megohmmeter, power amplifier, resistors, capacitors, inductors.

John Gombos Co., Inc., Irvington, N.J. — 262
Custom built electronic components, precision machined parts, radar filters, cross bar switches, crystal holders, crystal converters, jacks and connectors, beryllium copper connectors.

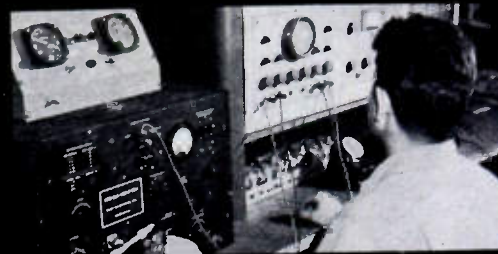
(Continued on page 128A)

It's JFD for

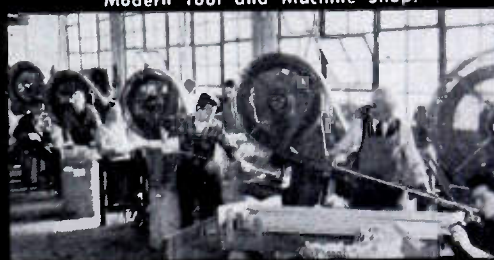
FFD

acilities For Defense

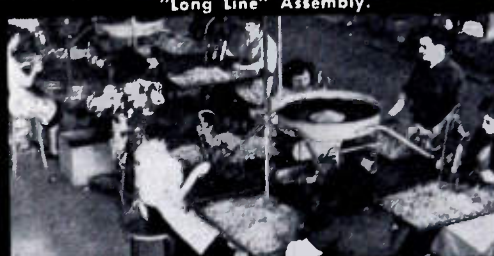
D . . . one of the world's largest producers of television ıtennas and accessories . . . invites orders for prime ıd sub-contract work. Our **Facilities For Defense** ıve been used, in the past, by such industry leaders ; **RCA, PHILCO, ADMIRAL, PILOT, MOTOROLA, BENDIX, 'ROMBERG-CARLSON** and many others. Personnel and roduction machinery are geared to the standard of uality and mass production that meets your "dead-ıes" and lowers your costs.


Section of Engineering Dept.


Modern Tool and Machine Shop.


High Speed Production.


"Long Line" Assembly.


Manufacturing "Elbow Room."


Extensive Warehousing.

Can we serve YOU?

We will be exhibiting at the I.R.E. Show. See us in Booth No. 215.

or experience, know-how, dependability ınd financial responsibility—you can count ın **JFD's Facilities For Defense.** Phone, vire or write direct to Mr. Albert Finkel, /ice-President.

DIVISION OF CONTRACT OPERATIONS

JFD **MANUFACTURING CO., Inc.**
6137C 16th AVENUE, BROOKLYN 4, N. Y.
FIRST in Television Antennas and Accessories

Proving Ground for *DEPENDABILITY*

This part of our equipment for testing airborne radar antennas may give you some idea of the job that Dalmo Victor is prepared to do. Prepared by years of experience in a specialized field of the engineered design, development and production of complex electro-mechanical equipment. During these years a skilled staff of engineering specialists has been organized and integrated with a team of production experts.

As a result, Dalmo Victor offers you a service unique in the electro-mechanical field. Our mechanical and electronic engineers offer a proven record of ingenuity and sound design supplemented by the services of staff specialists in micro-waves, servos, metallurgy, stress and vibration. Our production staff offers years of experience in the manufacture and fabrication of complex parts, in a variety of materials and by a variety of processes. *(As an example, Dalmo Victor has been continuously fabricating in magnesium since 1943, and introduced magnesium wave guide in 1944.)* To this is added the best in equipment and a corps of craftsmen especially selected for their individual skills. Top this off with a testing laboratory that is completely equipped for mechanical and electronic testing under sea level, altitude and extreme temperature conditions, for both components and complete equipment.

The result is a competent, resourceful, reliable and integrated team capable of assuming the complete responsibility for designing, producing and testing unusual electro-mechanical equipments from development through production.

If this is your need,
Dalmo Victor is at your service.

DALMO VICTOR
SAN CARLOS
CALIFORNIA

What to see at the Radio Engineering Show

(Continued from page 126A)

Firm — **Booth**

Gray Research & Development Co., Inc., Hartford, Conn., and New York City — 23, 2
Dual-audograph monitoring recorder, Telop, sound effects console, 108B Arm, 106SP Arm, 103S Arm, 602 Equalizer, 603 Equalizer, TV color monitor, airplane electronic control boxes.

Grayhill, Chicago, Ill. — 2
Represented by Wally Swank.

Green Instrument Co., Inc., Cambridge, Mass. — 2
Pantograph engraver for name plates, dials and scales. Instrument panels up to 19" in height. Rotary tables, self-centering vises, clamping fixtures, cutter grinder. Radial attachment with automatic spacing, designed to engrave from straight line of type. Special machinery for production engraving.

Guardian Electric Mfg. Co., Chicago, Ill. — 365 to 36
Relays, hermetically sealed.

A. W. Haydon Co., Waterbury, Conn. — 54
Timing motors, time delay relays, report cycle timer.

Haydu Bros., Plainfield, N.J. — 82
Induction generators, induction welders, test equipment, television, radio, and power tubes, electron guns, electron gun components, radio tube components, special burners for heating and forming glass.

Heiland Research Corp., Denver, Colo. — 336
Multi-channel oscillograph recorders, galvanometers and associate equipment for use in testing aircraft, guided missiles, and for general laboratory and industrial instrumentation applications.

Heldor Metal Products Corp., Belleville, N.J. — S-3
Transformer cases, hermetic seal terminals.

Helipot Corp., S. Pasadena, Calif. — 83, 84
Precision wire wound rheostats, potentiometers, both helical and single turn. Introducing the new Model J, a 2-inch diameter, continuous rotation single turn potentiometer, developed for servo mechanism application, and equipped with ball bearings as a standard feature.

Hermetic Seal Products Co., Newark, N.J. — 129
Glass-metal terminals, bushings, headers, plugs, and bases, in single or multi-headers for the electronic industry.

Hewlett-Packard Co., Palo Alto, Calif. — 40, 41
Audio oscillators, vacuum tube voltmeters, audio signal generators, pulse generators, distortion analyzers, square wave generators, signal generators, microwave equipment, frequency measuring equipment, power supplies, attenuators, wide band amplifiers, decade scalers, frequency counters, waveguide test equipment, frequency range, 2,600 to 18,000 Mc.

Hickok Electrical Instrument Co., Cleveland, Ohio — N-11
Testing equipment: tube testers, signal generators, sweep generators, vacuum tube voltmeters. Volt-ohm milliammeters, oscilloscopes, kilovoltmeters. Indicating instruments: voltmeters, ammeters, milliammeters, microammeters, wattmeters, and meters for special purposes.

Hi-Q, Franklinville, N.Y. — 63
Hi-Q ceramic capacitors, trimmers, choke coils, wire wound resistors.

Howard Industries, Inc., Racine, Wis. — 221
Represented by Wally Swank

Hytron Radio & Electronics Corp., Salem, Mass. — 253
Radio and television picture tubes, transmitting, receiving and cathode-ray tubes.

Indiana Steel Products Co., Valparaiso, Ind. — 278
Permanent magnets, magnetron assemblies, loudspeaker magnets, ion trap magnets, focusing magnets.

Industrial Hardware Mfg. Co. Inc., New York, N.Y. — 346
A complete line of laminated sockets, terminal strips, and representative metal and phenolic stampings produced to specifications.

(Continued on page 130A)

What to see at the Radio Engineering Show

(Continued from page 128A)

Firm — **Booth**

Industrial Products Co., Danbury, Conn. 225
Coaxial connectors, panel connectors, coaxial and wave guide components, cable assemblies.

Industrial Timer Corp., Newark, N.J. 221
Represented by Wally Swank

Instrument Specialties Co. Inc., Little Falls, N.J. 26
Standard high frequency items, beryllium copper custom-made springs.

Instruments Publishing Co. Inc., Pittsburgh, Pa. 34
"The Handbook of Measurement and Control," "Instruments," "The Instrument Maker," "The Instrument Index," "The Instrument Maker Guide," and numerous other technical books on various phases of instrumentation, design, theory, and application.

International Nickel Co. Inc., New York, N.Y. 35
Application of nickel and nickel alloys in electronic industries.

International Resistance Co., Philadelphia, Pa. 107
Resistors.

J-B-T Instruments, Inc., New Haven, Conn. S-19
Vibrating reed frequency meters, panel and portable types, including new 1½ inch and 3½ inch sealed types for audio oscillators. Elapsed time meters; selector switches, 14 and 20 positions, new molded type, also laminated type. Lever switches, 3 and 4 position. Electronic temperature controller. Two inch inexpensive milliammeters, voltmeters.

JFD Manufacturing Co. Inc., Brooklyn, N.Y. 215
TV and FM antennas, lightning arresters, TV voltage regulators, brackets, accessories, and screw eyes. Radio battery plugs, resistance line cords, dial belts kits, dial pointers, test leads, auto and home antennas, auto radio fittings, auto replacement cables, auto body plugs, radio chemicals, phonograph needles, tube shields, test tools, radio hardware, microphone connectors, ac-dc ballast tubes, step-down transformers, step-down resistance cords, battery harness.

Jensen Mfg. Co., Chicago, Ill. 317
Loudspeakers, headphones, and transformers.

E. F. Johnson Co., Waseca, Minn. 221
Represented by Wally Swank.

Howard B. Jones Division, Cinch Mfg. Corp., Chicago, Ill. 255, 256
Plugs and sockets, barrier terminal strips, fanning strips, terminal panels, fuse mounts.

Kalbfell Laboratories, Inc., San Diego, Calif. 265
Ratio voltmeter, dynamic Micro-Miker, plug-in amplifiers, logarithmic attenuators, bridged-T filters, and decade amplifier.

Karp Metal Products Co. Inc., Brooklyn, N.Y. 49, 50
Custom fabricated sheet metal housings, consoles, and cabinets.

Kay Electric Co., Pine Brook, N.J. 22
Electronic instruments—THE MEGA-LINE: Mega-Sweep; Marka-Sweep (Models RF-P, IF, Video); Rada-Sweep; Mega-Pulser; Mega-Match; Mega-Node; Microwave Mega-Nodes. SONALINE: Vibralyzer; Sonaligner; Sona-Graph.

Kelley-Koett Instrument Co., Cincinnati, Ohio 386
A line of instruments and accessories for the detection and measurement of nuclear radiations. Applications include area monitoring, personnel protection, civil defense against atomic warfare, and laboratory work in hospitals and industry. Original designer and manufacturer of an instrument approved for civil defense use: the AN/PDR-T-1.

Kenyon Transformer Co. Inc., New York, N.Y. 56
Transformers, reactors, electric wave filters. Both commercial and military types.

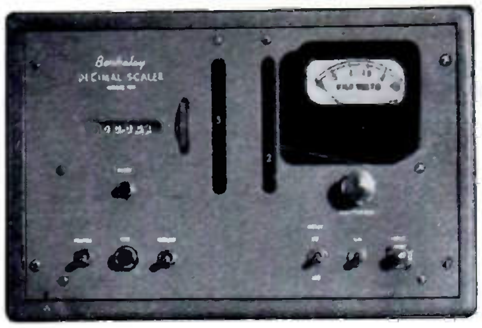
(Continued on page 132A)

2 NEW *Berkeley* SCALERS!

SINGLE "H. V." CONTROL

POSITIVE OR NEGATIVE "H. V." SUPPLY*

GM OR SCINTILLATION COUNTING*



SMALL—LIGHTWEIGHT

SCALE OF 100

PLUG-IN CONSTRUCTION

PREDETERMINED COUNT*

MODEL 100

Berkeley Basic Scaler

SINGLE HI-VOLTAGE CONTROL simplifies operation, prevents inadvertent over voltaging of GM tubes. Single continuous control from 0 to 2,500 volts.

TRUE DECIMAL PRESENTATION for easy reading. No interpolation, no lights to add. Results are presented in direct reading form on illuminated panels of the two electronic counting units. A 6-place mechanical register extends total capacity to 99,999,999. Selectable electronic scale of 10 or 100.

SMALL, LIGHTWEIGHT for easy portability. Weighs only 18 lbs.; measures 9¾" x 10¾" x 14½". Baked enamel finish permits easy decontamination.

ACCESSORY OUTLETS are provided for external clock, timer, loudspeaker, or output pulse per count to drive count rate meter or counting rate computer and recorder.

LOW COST—The Berkeley Model 100, produced in quantity, provides a basic Geiger-Muller scaler at minimum cost.

PRICE . . . $330.00

***MODEL 110**

Berkeley Universal Scaler

This versatile scaler has all the features of the Model 100, plus:

POSITIVE OR NEGATIVE HI-VOLTAGE SUPPLY, selectable by simple internal switch, permits use with either GM or scintillation detectors.

BUILT-IN PREDETERMINED COUNTER provides presettable scaling factors of 100, 200, 400, 1,000, 2,000, 4,000, 10,000 and 20,000.

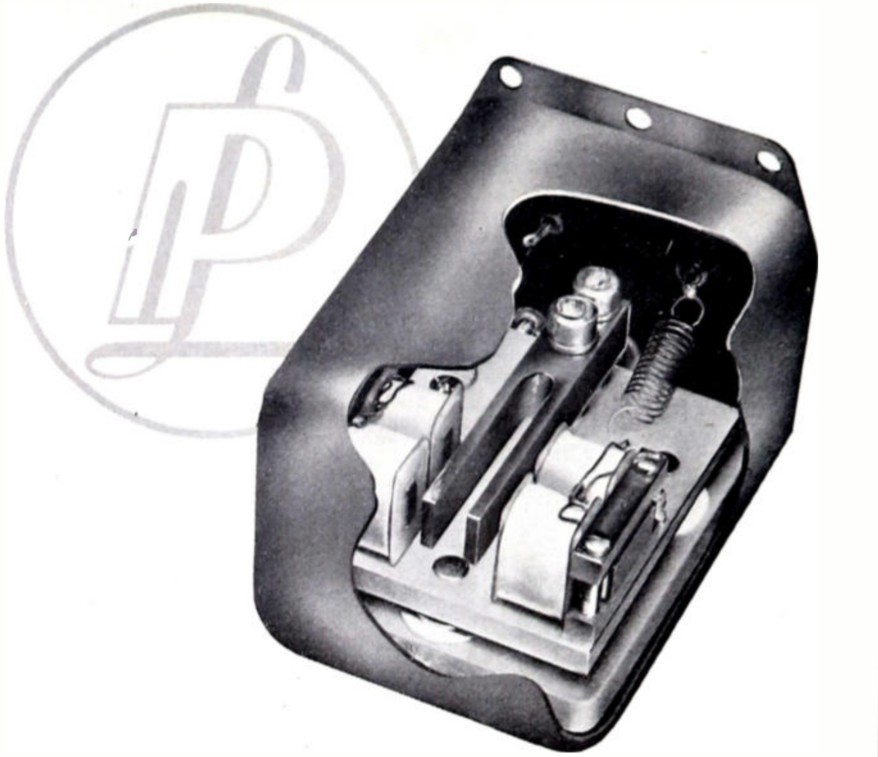
PRICE . . . $395.00

For complete information, write for Bulletin IRE-100

SEE OUR DISPLAY AT **BOOTH 378**
IRE SHOW NEW YORK, MAR. 19-22

Berkeley Scientific Corporation
2200 WRIGHT AVE. • RICHMOND, CALIF.

erkeley Scientific Representatives: DALLAS, TEX. — John A. Green Co. • VANCOUVER, B. C. — Hugh M. Birch-Jones Co. EVELAND — J. R. Donnemiller • MONTREAL, QUEBEC — Electrodesign • CHICAGO - KANSAS CITY — Everett Associates • NEW YORK CITY (Export) Frathom Co. • NEWARK - WASHINGTON, D. C. - PHILADELPHIA — Gawler-Knoop Co. • MINNEAPOLIS, MINN. — Graybar Electric • PORTLAND, REGON — Hawthorne Electronics • DENVER - SALT LAKE CITY — Mine & Smelter Supply • ATLANTA — Murphy & Cota • ROCHESTER, N. Y. — E. A. Ossman • LOS ANGELES — V. T. Rupp Co. • DETROIT — S. Sterling Co.



What to see at the Radio Engineering Show

(Continued from page 130A)

Firm — **Booth**

Kester Solder Co., Chicago, Ill. — 25
"Resin-five" core solder, plastic rosin-core solder, "Specialized" flux-core solders, industrial external soldering fluxes, soldering paste and salts, soldering accessories.

Ketay Manufacturing Corp., New York, N.Y. — 3
Small high precision synchros, servo amplifiers, resolvers, servo motors, specialty transformers, rotary switches and Navy audible signal equipment.

Kings Electronics Co., Brooklyn, N.Y. — 29
Kings Microwave Co., Tuckahoe, N.Y.
Coaxial connectors, rf fittings, microwave components and equipment.

James Knights Co., Sandwich, Ill. — S-1
Quartz crystals, mounted and unmounted, supersonic crystals, frequency standards, quartz crystal ovens.

Kulka Electric Mfg. Co. Inc., Mt. Vernon, N.Y. — S-2
Barrier type terminal blocks, jumpers, solder lugs, electrical wiring devices, junction boxes, aircraft thimbles, identification tags, switches, wiring assemblies made to specification.

Kupfrian Manufacturing Co., Binghamton, N.Y. — 37
Flexible shaft couplings and flexible shaft assemblies for remote control of potentiometers, tuners, switches, repeaters, revolution counters and other instruments and components. Electrostatic wire shielding and push-pull controls.

Lambda Electronics Corp., Corona, L.I., N.Y. — 34
Laboratory power supplies.

La Pointe-Plascomold Corp., Windsor Locks, Conn. — 39,
Television, FM, UHF, VHF, antennas; TV, microwave, UHF, VHF, towers; TV accessories; lightning arresters.

Lavoie Laboratories, Morganville, N.J. — 87, 8
UHF equipment, meters, receivers, transmitters, test equipment.

Leach Relay Co., Los Angeles, Calif. — 33
Relays, electronic and hermetic sealed.

Linde Air Products Co., New York, N.Y. — 5
MSC (Mass Spectrometer Checked) RARE GASES: helium, neon, argon, krypton, Xenon. SYNTHETIC CRYSTALS: calcium tungstate and cadmium tungstate rods, as-grown or polished (⅛ inch cross section). Sapphire and ruby boules and rods, titania (Rutile) boules. Fine alumina polishing powders.

Littelfuse, Inc., Chicago, Ill. — 13
Fuses and fuse mountings.

Lord Manufacturing Co., Erie, Pa. — 21
Latest developments in vibration-control mountings and equipment bases. Temproof mountings which maintain efficiency from −80° to +250° F. Radiofocal mounting bases for airborne electronic equipment under actual flight conditions.

M B Manufacturing Co., New Haven, Conn. — S-1
Industrial electronic vibration fatigue equipment for vibration testing of structures and materials to MILS 272, vibration measuring equipment, vibration isolators, engineering consultation for improvement of design and vibration testing laboratory service.

Machlett Laboratories, Inc., Springdale, Conn. — 96, 97
Electron tubes for broadcast and industrial application.

Magnecord, Inc., Chicago, Ill. Theatres — 308, 31
Audio amplifiers and loud speakers, magnetic recording equipment.

P. R. Mallory & Co., Inc., Indianapolis, Ind. — 37, 38
Mercury batteries, rectifiers, capacitors, noise filters, high frequency tuners, switches, jacks, plugs, vibrators, resistors, fixed and variable.

(Continued on page 134A)

specify Sorensen RANGERS

(FULL-RANGE-VARIABLE DC SUPPLYS)

This versatile supply is a combination of the widely used Sorensen NOBATRON and a filter-variable output circuit. The result gives a continuously variable output voltage regulated against line and load changes through the full range of the instrument. Look at the specifications tabulated below — check them against your requirements. Where range of output, adaptability to diverse applications is essential, the Sorensen RANGER may well be your instrument of choice.

ELECTRICAL SPECIFICATIONS

Model No.	SR-10	SR-30	SR-50
Output range	0 - 135 VDC	0 - 30 VDC	0 - 13 VDC
Current range	1 - 10 amps	3 - 30 amps	5 - 50 amps
Input voltage	95 - 130 VAC, 50 - 60 cycles, single phase		
Regulation accuracy	± 0.25 percent at any voltage setting from 3 VDC to top rating		
Ripple	RMS max. 1% of output setting		

Meters — standard. Coarse and fine adjustment available.

Write for complete information

For other regulated DC supplys, investigate Sorensen's line of NOBATRONS (low - voltage) and B-NOBATRONS (high voltage).

POWER controlled converted

Sorensen *and company, inc.*
375 FAIRFIELD AVE. • STAMFORD, CONN.

What to see at the Radio Engineering Show

(Continued from page 132A)

Firm — Booth

Manufacturers Thread Grinding, Inc., Eatontown, N.J. 217
Wavemeters and special micrometers, and component parts for the electronics trade. These wavemeters and special micrometers feature high accuracy and resetability, achieved by use of special screw threads and invar materials.

Marconi Instruments, Ltd., New York, N.Y. 1
Industrial, electro-medical, nucleonic and laboratory electronic measuring equipment. Particular emphasis on frequency measuring and generating devices from 50 kc to 9,600 Mc. Universal and admittance bridges, Q meters, dielectric test sets and power measuring devices.

Marion Electrical Instrument Co., Manchester, N.H. 2
"Ruggedized," hermetically sealed electrical indicating instruments which comply with all latest government specifications; special scale-changing instruments for use in ray detection, etc., bakelite cased meters, low powered induction heating equipment and meters designed to meet special requirements.

W. L. Maxson Corp., New York, N.Y. 2
A precision phasemeter, designed to measure the phase difference betwen two audio signals with an accuracy of one tenth (0.1) degree, frequency range 30-20,000 cps. Included are exhibits of Unimax snap acting switches, and Langevin Mfg. Corp. transformers, audio amplifiers, etc.

McGraw-Hill Companies, New York, N.Y. 2
Books and publications of interest to electronic and nucleonic engineers.

Measurements Corp., Boonton, N.J. 226, 22
Standard signal, FM signal, square wave, and pulse generators. UHF radio noise and field strength meters, megacycle meters, crystal calibrators, intermodulation meters, vacuum tube voltmeters, peak voltmeters, L-C-R bridges, megohm meters, rf attenuators, oscillators, special test instruments.

Mepco, Inc., Morristown, N.J. N-
Precision resistors Jan-R-93; precision resistors standard; meter multiplier resistors Jan-R-29; resistor assemblies, special resistors.

Microwave Equipment Co., No. Caldwell, N.J. S-11
Microwave test equipment, waveguide components, radar assemblies, microwave antennas, laboratory test instruments, waveguide test instruments.

James Millen Mfg. Co., Inc., Malden, Mass. 41
Meters and test equipment, filters, power supplies, transformers, capacitors.

Milivac Instruments Corp., Schenectady, N.Y. 24
DC microvoltmeters, rf millivoltmeters, dc and low frequency millivolt-recorders.

Motorola, Inc., Chicago, Ill. 28
Mobile and portable radio equipment.

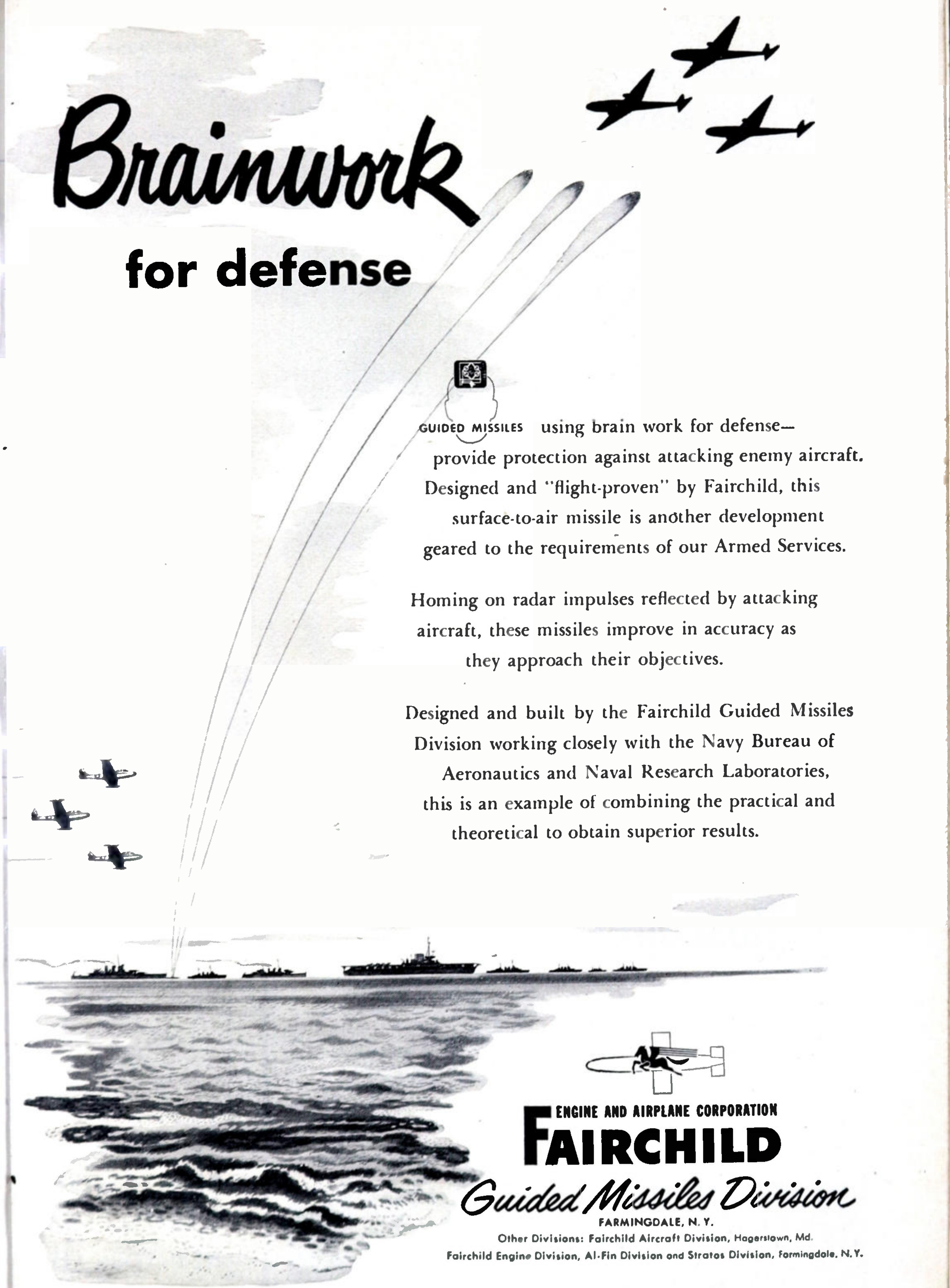
Mucon Corporation, Newark, N.J. 33
Capacitors: Ceramic, miniature Hi-K ceramic, temperature compensating, and miniature stand-off. Capacitors of special design, printed circuit assemblies, miniature noise filters. Miniature components—high stability rf coils, high temperature composition resistors.

Muter Company, (The Rola Co. Inc., Jensen Mfg. Co.) Chicago, Ill. 31
Ceramic capacitors, wire-wound resistors, potentiometers, rf and if coils, switches, loud speakers, and transformers.

Mycalex Corp. of America, Clifton, N.J., N.Y. Theatre 30
Mycalex (glass-bonded mica) insulating materials: sheets, rods and fabricated parts, capacitor dielectrics. Injection molded components and end products such as "Mycalex 410" and "410X" tube sockets, trimmer capacitors, miniature tie-in terminals, telemetering switching devices.

N. R. K. Mfg. & Engineering Co., Chicago, Ill. N-19
Waveguide assemblies, radar components, precision instruments manufactured to your blue-prints and specifications.

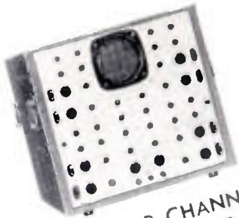
(Continued on page 136A)


Brainwork
for defense
GUIDED MISSILES using brain work for defense—
provide protection against attacking enemy aircraft.
Designed and "flight-proven" by Fairchild, this
surface-to-air missile is another development
geared to the requirements of our Armed Services.
Homing on radar impulses reflected by attacking
aircraft, these missiles improve in accuracy as
they approach their objectives.
Designed and built by the Fairchild Guided Missiles
Division working closely with the Navy Bureau of
Aeronautics and Naval Research Laboratories,
this is an example of combining the practical and
theoretical to obtain superior results.
ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Guided Missiles Division
FARMINGDALE, N. Y.
Other Divisions: Fairchild Aircraft Division, Hagerstown, Md.
Fairchild Engine Division, Al-Fin Division and Stratos Division, Farmingdale, N.Y.

See us at Booths 274-275, I.R.E. Show

...FOR CRITICAL ANALYSES

H-21 DUAL CHANNEL OSCILLOSCOPE
Indicates 2 independent signals simultaneously. Sensitivity better than 0.085 Vdc/in. (30 MV rms/in.)



H-45 FOUR CHANNEL OSCILLOSCOPE
Offers choice of any combination of high sensitivity dc amplifiers or wide band ac amplifiers.

H-43 FOUR CHANNEL OSCILLOSCOPE
Designed for strip-film recording of up to 4 variables on a single 5" tube. Readily portable.

H-22 UNIVERSAL DUAL CHANNEL OSCILLOSCOPE
Plug-in ac or dc amplifiers. Two independent channels on a single tube register phenomena from dc to 1 megacycle.

H-81 EIGHT CHANNEL OSCILLOSCOPE
A unique design originally developed for film strip recording of seismographic phenomena. Frequency response 20 to 150,000 cps. A DC model with sensitivity of 2 MV dc/in. also available.

ETC

Multi-Channel Oscilloscopes

As specialists in multi-channel 'scopes, ETC offers a broad line for critical testing, production and research needs. In addition to standard types incorporating 2, 4, and 5 wave forms on a single tube, many special designs and adaptations are regularly produced for specific uses. Full details on any type will gladly be sent on request.

MULTI-GUN CATHODE TUBES
The answer to problems involving registration of a multiplicity of transients on a single screen. 2-, 4-, 6-, 8- and 10-gun types. Also a complete line of standard 5" cathode ray tubes.

electronic tube corporation
PHILADELPHIA 18, PENNSYLVANIA

What to see at the Radio Engineering Show

(Continued from page 134A)

Firm — **Booth**

National Carbon Division, New York, N.Y. 52,
(Union Carbide & Carbon Corp.)
Radio batteries, hearing aid batteries, batteries for radiation detectors, photo-flash and miscellaneous laboratory equipment.

National Company, Inc., Malden, Mass. S
Electronic components, communications receivers, television.

National Research Corp., Cambridge, Mass. 1
High vacuum equipment including diffusion pumps, booster pumps, gauges, vacuum furnaces and gas free high purity metals. Featuring: a miniature B-1 booster pump for use on rotary exhaust equipment; and accurate and automatic equipment for gas filling of tubes.

J. M. Ney Co., Hartford, Conn. 2
Precious metal contacts for sliding and other uses in instruments.

Northern Radio Co., Inc., New York, N.Y. 30
Multiplex teletype system using tone frequencies. Teletype dual diversity receiving and transmitting system. Multichannel tone carrier system.

Nuclear Instrument & Chemical Corp., Chicago, Ill. 3
The latest equipment for measurement and application of radioactivity in industry, research and military use. Also civilian defense instruments.

Nucleonics see McGraw-Hill 20

Ohmite Manufacturing Co., Chicago, Ill. 2
Resistors, rheostats, power tap switches, rf chokes.

(Continued on page 145A)

·ws—New Products

manufacturers have invited PROCEEDINGS
rs to write for literature and further technical
nation. Please mention your I.R.E. affiliation.

DC Microvolt Meter

'he new MV-15A dc microvolt meter
a full scale sensitivity of 10 μv and an
t impedance of 1,000 ohms is available
Millivac Instrument Corp., P.O. Box
, New Haven, Conn.

'his improvement of dc vacuum tube
neter sensitivity was made possible
ugh the development of a new contact
dc modulator which basically varies
the conventional chopper circuit. In-
d of periodically opening and inter-
ing the incoming dc voltage to be
sured and then discharged through a
of contacts and a tuned transformer.
scillatory pulse is set off in this manner
h is then amplified, rectified and
red. The new modulator not only in-
ses the sensitivity of dc carrier—type
lifiers, but, in addition, eliminates to
onsiderable extent contact hazards
monly found in ordinary chopper cir-
s.

Literature

A new tube substitution manual ar-
ed in nine parts providing text and
ts on general tube classifications; cir-
modifications in which additional re-
ors are needed; substitute battery
s; substitute 150-ma types, substitute
ma types; substitute transformer and
types; TV receiver types; TV picture
s; and change-over diagrams may be
ined from the **Advertising Dept.,
ania Electric Products Inc.**, Emporium

·A new folder describing paper-thin
less steel has been published by
co **Steel Corp.**, Middletown, Ohio.
plete information is given on how the
al is supplied, along with typical me-
ical properties. Of special importance
e description of Armco 17-7PH thin-
e strip, which (according to the manu-
urer) has a tensile strength, compara-
to the best high carbon spring steel.

(Continued on page 138A)

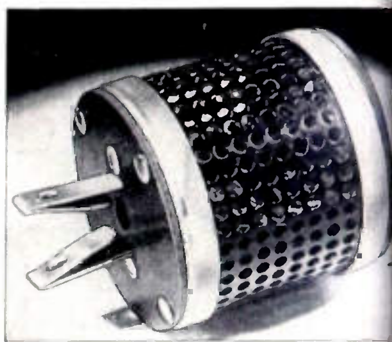
News—New Product

These manufacturers have invited PROCEEDIN readers to write for literature and further techn information. Please mention your I.R.E. affiliat

(Continued from page 137A)

Plug-in Line-Voltage Regulator

For steadier TV pictures despite li voltage fluctuations, **Clarostat Mfg. C Inc.**, Washington St., Dover, N. H., n offers an automatic line-voltage regula



The amplifiers have separate inp and individual outputs and are specifica designed to be used in the video circu of television transmission and test setu Each amplifier has unity gain within per cent and the frequency response is su that at low frequencies a 60-cps squ wave will not be deteriorated and at hi frequencies, the response is down not m than 3 db at 11 Mc and 6 db at 13 M The inputs of this unit are of the "br ing" type and have a relatively high inp impedance so that all of the amplifiers m be paralleled across a video line wi minimum disturbance to the drivi source. Each amplifier delivers, to a ohm output line, either the same or t opposite polarity of the signal it receiv by the operation of a toggle switch. T low-frequency compensation is of an a vanced type and uses only highly stal components.

100-A Dynamic Analyzer

The 100-A, dynamic analyzer, man factured by **Industrial Control Co.**, 14 Undercliff Ave., New York 52, N. Y., is instrument that facilitates the measu ment of frequency and transient respon

of low-frequency systems by electri methods. It is particularly applicable the servomechanism, either as a clos loop, or in its individual components.

(Continued on page 139A)

(Continued from page 138A)

)f chief interest is the flexibility of the ce. The generating mechanics are nted on a separate shock-mounted zontal chassis, which is easily acces- thru panel cutouts in the case. The ents themselves are mounted with dboard apparatus. A vertically nted electronic chassis furnishes the er for the speed drive, the excitation ges, etc. This construction allows the to quickly modify the unit for some ial test, by changing gear ratios, add- ignal generating components, etc.

he range of modulating frequencies is 0.1 to 50 cps for transfer function . Phase measurements can be made accuracies of ±2°. For the transient , the damped natural frequency and height of the first overshoot can be sured.

This aid to better TV reception, par- arly in rural districts or areas ex- encing line-voltage fluctuations, is a ly accessory. With male and female on connections at either end, it plugs etween the TV set's attachment plug the outlet. Two models are available: A rated at 300 watts, for sets con- ing 200 to 300 watts, and TV-B rated 75 watts, for sets consuming 300 to watts

Externally Coated G-M Counters

The Raytheon Manufacturing Co., 55 pel St., Newton, Mass., is now using a

oidal graphite dispersion as a coating on outside of their CK1026 radiation nter tubes.

The coating is manufactured by the eson Colloids Corp., Port Huron, h.

Raytheon claims to have selected this oidal graphite coating, known as "dag" persion #154, because it is chemically rt, electrically conductive, opaque, and eres well to any glass surface despite face scratching.

The unusual factor about this use of g" dispersion #154 is that it is applied produce a durable coating on the outside the tube. A coating applied in this man- performs the function of a mechanical tact, permitting a clip to be snapped the tube without danger of scratching surface when forced on or off.

Other features which the tube possesses : all glass construction, self-quench- lity, 800 to 950-volt operation, long life logen atmosphere, and the ability to erate in a wide temperature range.

(Continued on page 140A)

News—New Product

These manufacturers have invited PROCEEDIN readers to write for literature and further techni information. Please mention your I.R.E. affiliati

(Continued from page 139A)

New Miniature "T" Netwo Attenuator

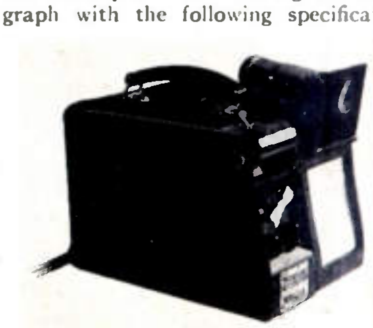
The Daven Co., 191 Central A Newark 4, N. J. has developed a new " network attenuator, series 730, which h 30 steps of attenuation in only 2½-in diameter.

The 730 has zero insertion loss, constant input and output impedance, a is suited for use where space is of imp tance. It is available in steps of 0.5, 1 1.5, or 2.0 db. It has a flat frequency ch acteristic to 30 kc. On special order, frequency range can be extended to 200

Its standard resistance accuracy is per cent. When requested, accuracies low as ±0.1 per cent are available.

Fast Writing Ink Oscillogra

Sound Apparatus Co., Stirling, N. has developed a fast writing ink oscil graph with the following specificati



frequency range from 0 to 600 cps meas ing range between 5 and 160 volts, or b tween 2 and 60 ma; sensitivity appro mately 0.1 mm/volt; impedance 2,7 ohms.

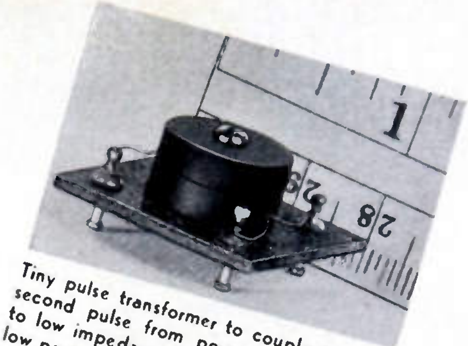
There are 10 selectable paper spee Featuring a new writing mechanism, t pen is automatically closed when the i strument is not in use, thus preventi drying of ink or necessity to clean pen. T record is made on transparent chart pap which can be projected and reproduced any desired form. The record is in straigh line, rectangular co-ordinates. Maximu amplitude is 2×30 = 60 mm.

Recorder & Tape Testing Service

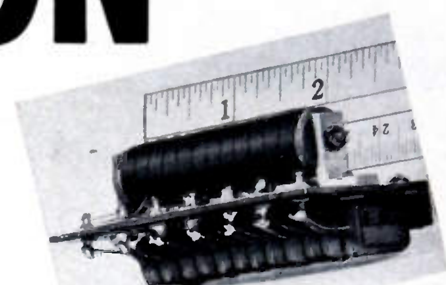
Laboratory equipment that can test t performance characteristics of sound r cording tape, recorders, and playback uni "in a matter of minutes" has been set in St., Paul, Minn., for use by the indust (at no charge) it was announced th month.

(Continued on page 142A)

DESIGN AND PRODUCTION FACILITIES ...NOW AVAILABLE



Tiny pulse transformer to couple 2 microsecond pulse from power amplifier tube to low impedance load. We can produce low power pulse transformers to reproduce pulses of widths ranging from a fraction of a microsecond to several milliseconds.



Lumped delay line with phase correction: 1750 ohm; 20 microsecond delay; cut-off frequency of 200 kc; 1/2 db power loss. We are prepared to make delay lines covering the audio and radio frequency spectrums.

Low-loss inductor: inductance = 1 henry; Q = 400 at 30 kc. Extmerely low-loss inductors and high-fidelity transformers are obtainable over a wide range of values and frequencies, using similar structures in various physical sizes.

In the course of a current assignment, these components were developed. We invite inquiries regarding similar requirements where an unusual approach and exceptional engineering ability and material know-how are requisites.

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News New—Products

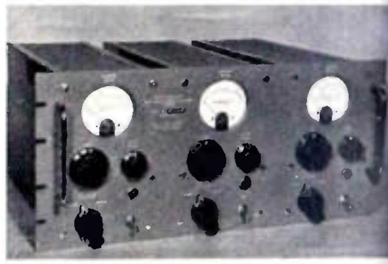
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 140A)

Signal Splitter Eliminates Adjacent Channel Interference

J. L. A. **McLaughlin**, 5729 LaJolla Blvd., LaJolla, Calif., specializing in the field of heterodyne elimination, announces the new Series 10 Signal Splitter, a selectable single-sideband converter for eliminating adjacent channel and heterodyne interference. Either sideband can be rejected with high attenuation.

The Series 10 signal splitters are in single, dual, and triple units. The latter are suitable for frequency or space diversity reception. Single and dual units are mounted on a standard rack panel 5¼ inches high, and triple on 8¾ inches high.



Models are available with information bandwidths of 200, 2,500 and 5,000 cps within ±1 db suitable for the reception of high speed telegraphy, voice, and transoceanic broadcast reception.

Series 10 signal splitters can be employed with standard single or diversity communication receivers.

Closed Circuit TV Transmitter

The Dumitter, just announced by the **Television Transmitter Div., Allen B. DuMont Laboratories, Inc.**, Clifton, N. J., permits TV camera signals to be distributed to a large number of standard TV receivers, over connecting cables.

The Dumitter is a compact, completely portable unit. It takes the composite video signal from any standard TV camera chain, and feeds it via a single coaxial cable to the antenna terminals. A carrier signal of the frequency of either Channel 2 or 3 (optional on the Dumitter controls) is used. Up to 125 receivers can be driven simultaneously, with transmission of over several thousand feet.

(Continued on page 143A)

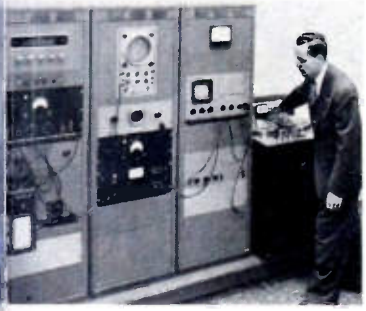
manufacturers have invited PROCEEDINGS s to write for literature and further technical ation. Please mention your I.R.E. affiliation.

(Continued from page 142A)

'he antenna lead-in is disconnected the receiver, while the Dumitter sigls being received, by switching from nitter line to antenna lead-in, perng the receiver to function on either d-circuit or standard telecasting at No circuit alterations or component ges are required.

ince the signals travel through coaxial s, reception is free from outside interce. No license is required, since the mitter does not radiate.

'he equipment and a staff to operate it provided by **Minnesota Mining and ufacturing Co.**, 900 Fauquier St., St. 6, Minn., maker of **Scotch** sound reng tape, as a consultant service for the strv.



'he three racks of laboratory equipt, plus recorders, and speakers, permit suring such performance characterts as output at any frequency, uniity of output at any frequency, signaloise ratios, dynamic range, wow, ter, harmonic distortion, intermodula- and modulation noise.

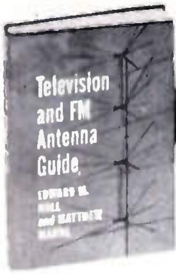
ncluded in the equipment are an FM tuner, oscilloscope, wow meter, antine volt meters, dual-channel oscilgph with associated dc amplifiers, two fidelity audio amplifiers, two profesal quality recorders that operate at any d from 3¾ to 15 inches per second, a sonic analyzer for measuring distor- and frequency response and for show- noise spectra.

special bias circuit was built into the rders to permit introducing wide varias in bias.

Double Triode For Wide Angle TV Vertical Deflection

A newly developed double triode reng type tube designed for wide angle cal deflection in large TV picture s which will handle the entire vertical ction system, has been announced by **Radio Tube Div., Sylvania Electric lucts Inc.**, Emporium, Pa.

(Continued on page 151A)



Just published

TELEVISION & FM ANTENNA GUIDE

How to get the most out of the antenna system at any location.

by E. M. Noll and Matthew Mandl

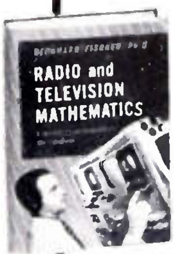
This excellent handbook will save you much testing and readjusting and insure the best reception from any antenna system. It gives you the characteristics, dimensions, advantages and disadvantages of all VHF and UHF antennas and allied equipment, including heretofore unpublished information on new types recently tested by the authors. It tells how to determine the right type of antenna for a specific location, locate space loops, determine signal strength, etc.; how to mount various types of antennas on different kinds of roofs or window sills; how to minimize noise and avoid standing waves in transmission lines, and all other installation procedures. Handy tables give comparative data, and there is full, clear instruction in all fundmental antenna principles. $5.50

MOVIES FOR TV

A practical how-to-do-it guide for technician and program director

by J. H. Battison

This complete, practical book gives you all the information you need to choose the best equipment, operate it most efficiently, and make the most effective use of movies on TV programs. It explains the operation of all leading makes of cameras, projectors, sound and kinescope recording equipment, different types of lenses, etc., giving the advantages, disadvantages, and relative costs of each. It shows what may go wrong and how to avoid trouble, what type of picture is good on television and what is not, how to light movies for best TV reception, how to insure good shots on location, combine live scenes with movies, produce special effects, titles, newsreels, different types of commercials, and much else that will be of utmost practical aid to station personnel and program planners. $4.25



RADIO & TELEVISION MATHEMATICS

by Bernhard Fischer

This unique book of 721 problems and solutions shows what formulas to use, what numerical values to substitute, and each step in solving all problems commonly encountered in radio, television, and industrial electronics. The problems are conveniently arranged under radio and electronic topics so that you can quickly find the solution you want. Formulas listed according to use, complete tables, and a review of the use of powers of 10, the j-operator, polar vectors, etc. are given at the end of the book. $6.00

TELEVISION FOR RADIOMEN

by E. M. Noll

An outstanding basic reference on the operating principles and function of every part and circuit in today's television receivers and on the chief principles of transmission, together with practical instruction in installation and alignment procedures, testing equipment and how to use it, adjustment and trouble-shooting. The many illustrations include 3 large, complete diagrams of RCA, GE, and Philco projection receivers folded into the book. $7.00

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March 19-22 1951

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Acme Electric has been identified with the electronic industry since the crystal set days. The vast store of experience that Acme engineers have accumulated over these many years can be of considerable value in helping you solve your electronic transformer problems. We offer transformer engineering co-operation and facilities to build quality transformers in quantity production.

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TRANSFORMERS

What to see at the Radio Engineering Show

(Continued from page 136A)

n	Booth
ramic Radio Products, Inc., Mt. rnon, N.Y. c analyzer, AP-1, for high speed visual ysis of harmonics, vibrations, noise, modulation and acoustics. Ultrasonic yzer, SB-7, for analysis of spectrum een 2 kc and 300 kc. Sonic response ator, G-2, a visual curve tracer for o responses. Panalyzor and Panadap-or simple high speed rf spectrum stud-nd monitoring.	N-6
Metal Products Corp., Long Island y, N.Y. y racks, cabinets, panels, chassis, l parts.	N-10
ridge Transformers, Ltd., Tolworth, rrey, England o and power transformers. The CBF ut transformer with a "C" type core a 15 octave band width.	263
co Corp., Philadelphia, Pa. ributions in the microwave industry. tiplex equipment, microwave communi-ons relay, television relays, and Loran g advance design techniques and ap-tions. Cathode-ray tubes and details iniature and sub-miniature tubes.	43, 44
rad Electronics Corp., Brooklyn, N.Y. vision broadcast studio equipment, television equipment, microwave and ratory test equipment including all-l spectrum analyzer, signal generators, al sources, radio cue system.	S-7
technic Research & Development Co., c., Brooklyn, N.Y. ision waveguide and coaxial compo-s and electronic test equipment for the F and microwave ranges. Attenuators, ted sections, frequency meters, signal erators, spectrum analyzers, power ers, and bolometers.	268, 269
ter & Brumfield, Princeton, Ind. ays	N-5
ter Instrument Co., Inc., Great Neck, I., N.Y. h speed electronic counters, counter nographs, megacycle frequency meas-ment equipment, electronic computor ponents.	135
cision Apparatus Co., Inc., Elmhurst, I., N.Y. ctronic test and measuring instruments accessories, rf signal generators, FM-sweep signal generators, vacuum tube meters, cathode-ray oscillographs, hode-ray tube testers, vacuum tube ers, multi-range volt-ohm-db-milliam-ers, circuit analyzers, high potential probes, rf test probes, etc.	205
sto Recording Corp., Paramus, N.J. heatre k and tape recorders, associated ampli-s, blank recording disks. Special atten-e recording equipment and to newly eloped tape transport mechanism which aches to any 16 inch transcription turn le. The output of this device feeds ectly into ordinary speech input equip-nt	305
ce Electric Corp., Frederick, Md. ctrical relays.	394
duct Development Co., Inc., Arlington, J. e series of coaxial transmission lines id), cover all applications through the rowave frequencies. Special "Broad-bd" series for continuous frequency vice. Microwave antennas and reflec-ts, relay towers, hangers, pressurization ipment, adapters to cable, and solid lectric cable assemblies.	222
blishers' Authorized Binding Service Book Shop Bindery) Chicago, Ill. ding of scientific periodicals.	361
ramid Electric Co., North Bergen, N.J. ectrolytic and paper, and oil impreg-ted paper capacitors (low and high-tage) for transmitting and receiving ilitary usage). "Glasseal" hermetically led miniature paper capacitors in metal es, featuring a glass-metal end seal.	208

(Continued on page 147A)

Standard RADIO INTERFERENCE and FIELD INTENSITY Measuring Equipment

Complete Frequency Coverage - 14kc to 1000mc!

VLF!

NM - 10A

14kc to 250kc

Commercial Equivalent of AN/URM-6.
Very low frequencies.

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Frequency range includes FM and TV Bands.

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Commercial Equivalent of AN/URM-17.
Frequency range includes Citizens Band and UHF color TV Band.

These instruments comply with test equipment requirements of such radio interference specifications as JAN-I-225, ASA C63.2, 16E4(SHIPS), AN-I-24a, AN-I-42, AN-I-27a, AN-I-40 and others.

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What to see at the Radio Engineering Show

(Continued from page 145A)

in — Booth

n Electric Co., Inc., New York, N.Y. 314
l speakers for all industrial, commer-
and military applications.

lio Corporation of America 4 to 9
. Victor Div., Camden and Harrison,

s, tube parts and machinery, bat-
s, test and measuring equipment,
ronic components.

Laboratories Div., Princeton, N.J.
tronic research and development proj-

io-Electronics, New York, N.Y. S-2
o-Electronics magazine, a technical
zine in the field of radio-television-
), also exhibiting the Gernsback Li-
y books, 15 low priced technical books
ring radio, audio, and servicing.

lio Magazines, Inc., New York, N.Y. 94A
lio Engineering," the journal for the
d engineer, official publication of the
o Engineering Society. "Audio An-
gy," a collection of reprints of articles
ome reproduction systems.

lio Materials Corp., Chicago, Ill. 338
icaps"; ceramic capacitors guaranteed
imum value types, temperature com-
ating types, general purpose types.

lo Receptor Co., Inc., New York, N.Y. N-16
nium rectifiers and customers' equip-
t showing application of rectifiers.
ial stress is being placed on small
-wave rectifiers at 20 ma for bias ap-
ation, and bridge rectifiers at 40 ma.
lications running to many kilowatts,
a dielectric heating machine with
ucts manufactured thereon.

ldio & Television News," 395
ldio-Electronic Engineering"
-Davis Publishing. Chicago & New
rk

m Instruments, Inc., New York, N.Y. 271
ect recording oscillographs, and ac-dc
lifiers. A new circuit element that may
sed as a transducer, filter or oscillator
very high sensitivity and stability.

gertone, Inc. Newark, N.J. Theatre 312A
gnetic tape recorders.

land Corp., Chicago, Ill. 344
television tubes.

theon Manufacturing Co., 13
altham, Mass.
ctronic tubes, radar components, stored
rgy welding equipment, magnetic tape
dling mechanism for automatic digital
puter and precision sonar depth sound-

ves Instrument Corp., New York, N.Y. 134
REAC differential analyser which has
le the mathematical approach to re-
rch and engineering problems economi-
y feasible. Precision induction type
lves for 60, 400 and 1,000 cps operation.
ndard instrumentation parts and servo-
hanism components, constituting a
hod of producing experimental com-
er and control devices.

ves Soundcraft Corp., New York, N.Y.
heatre 312B
nk transcription and recording disks,
gnetic sound recording film, magna-
pe film, television picture tubes, mag-
ic recording tape.

F Manufacturing Corp., 364
ineola, L.I., N.Y.
et metal fabrication of exacting stand-
s, engineering and design.

n F. Rider Publisher, Inc., New York
.Y. 243
ler Service Manuals (AM-FM-TV-PA),
electronic textbooks, one of the most
ent being the "Encyclopedia on Cath-
-Ray Oscilloscopes and Their Uses."
pecial service of the organization is the
paration of technical literature.

binson Aviation, Inc., Teterboro, N.J. S-4
ration control engineers demonstrating
ne of vibration and shock control units,
ices and systems. Met-L-Flex, the all-
tal, all-weather resilient mounting sys-
. Special and engineered mounting
tems.

(Continued on page 149A)

What to see at the Radio Engineering Show

(Continued from page 147A)

℩rm	Booth
℩a Co., Inc., Chicago, Ill. ℩idspeakers, headphones, and transform-	317
℩tron Manufacturing Co., Inc., Woodstock, N.Y. ℩wers, fans, interlocks, tube-supports electronic cooling applications. Range n 2,000-CFM to 6-CFM capacity, cover line voltages and frequencies including many special designs for military applications.	302
℩iborn Company, Cambridge, Mass. ℩gle and multichannel direct-writing re-℩lers, featuring permanent records, made ℩hout ink, and having true rectangular ℩rdinates. Interchangeable ac and dc amplifiers, and interchangeable driver ℩plifiers of dc, strain gage and other ℩es.	N-13
℩l W. Schutter, Lindenhurst, L.I., N.Y. ℩dar and electronic component parts.	260
Sentific Electric, Garfield, N.J. ℩luction heating equipment, projection ℩evision, life test racks for cathode-ray ℩es, cathode-ray tube testers.	60
℩rman Hosmer Scott, Inc., Cambridge, ℩ass. ℩und-level meters, vibration meters, ℩naural noise suppressors, dynaural high ℩elity amplifiers, electronic and labora℩y apparatus.	219
℩vo Corporation of America, New Hyde Park, L.I., N.Y. ℩dio equipment: electronic goniometer ℩ection finder, crystal controlled signal ℩nerator, broadband spectrum generator. ℩vo equipment: servo synthesis equip℩nt, the servoboard, reluctance servo ℩plifiers, electronic controllers, and the ℩voscope analyzer. Thermal radiation de℩tion: Thermistor bolometers, preampli℩rs and power units.	348
℩allcross Mfg. Co., Collingdale, Pa. ℩kra-Ohm" precision wire-wound re℩tors; wire-wound surge resistors; high℩tage corona-protected resistors; Ayrton ℩iversal shunts; ratio arm boxes; second℩ resistance standards, etc.	280, 281
℩eldon Electric Co., Irvington, N.J. ℩levision tubes, electrical cords and ℩gs, and high powered flood lights.	390 to 392
℩ma Instruments, Inc., Boston, Mass. ℩lays, sensitive, polarized, keying, dif℩ential, miniature, hermetically sealed.	209
℩npson Electric Co., Chicago, Ill. ℩nel instruments and radio and TV test ℩uipment.	86
℩ark Simpson Mfg. Co., Inc., Long Island City, N.Y. ℩gnetic tape recorders, high fidelity am℩fiers, transcription players, sound equip℩nt.	206
℩la Electric Co., Chicago, Ill. ℩nstant voltage transformers for indus℩al, scientific, and military applications.	21
℩rensen & Co., Inc., Stamford, Conn. ℩ voltage regulators, regulated dc sup℩es, nobatrons, rangers, voltage reference ℩ndards, fosteriting process.	236, 237
℩ecialties, Inc., Syosset, L.I., N.Y. ℩levision camera iris control, automatic ℩rent balance (continuous computation), ℩nsformers, angle of attack indicator, ℩ctrostatic locator.	332
℩encer-Kennedy Laboratories Inc., Cambridge, Mass. ℩ Mc amplifiers, wide band chain ampli℩rs, 100 Mc amplifier, chain pulse ampli℩r, TV amplifier, variable electronic fil℩, single section and dual section acces℩ies.	S-1
℩erry Gyroscope Co., Div. Sperry Corp., Great Neck, N.Y. ℩ystron tubes for microwave generation ℩d microline instruments for microwave ℩asurement. A display on frequency ℩ltiplication and high power amplifica℩n at microwave frequencies.	57, 58, 59

(Continued on page 153A)

ℐews—New Products

ɪse manufacturers have invited PROCEEDINGS ɪders to write for literature and further technical ɪrmation. Please mention your I.R.E. affiliation.

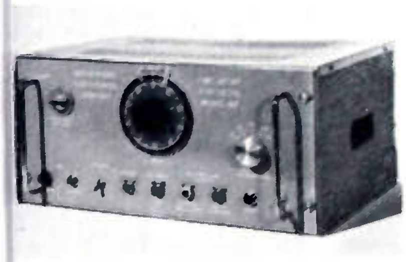
(Continued fom page 143A)

The tube was designed to meet specific ɪɔe characteristics with ample outputs for ɪtical deflection in the largest TV picture ɔes now available. The tube, type

ɪL7GT, also permits simplification and ɪtter performance when applied to TV ɛcuits requiring two tubes for vertical de-ɪtion.

Time Delay Generator

The Model A2 time delay generator de-ʒned by the **Rutherford Electronics Co.,** 24½ S. Robertson Blvd., Culver City, ɪlif., produces variable time delays rang-ɪ from 0.4 microsecond to 100,000 micro-ɪonds. Five delay ranges are provided, ɪving a full scale reading of 10 micro-ɪonds on the lowest range and progress-ɪ by decade steps to the highest range of 0,000 microseconds. Blocking oscillator ɪd single shot multivibrator output wave-ɪrms are provided.



The unit is useful in the radar and pulse ɛchnique fields for measuring unknown ɪlays or generating a fixed delay.

The instrument features high linearity, ɛcuracy, and freedom from jitter. The ɪrge clear dial facilitates setting and the ɪe decade ranges prevent crowding of the ɪales.

The blocking oscillator pulse is 0.5 ɪicrosecond wide while the multivibrator ɪulse width is designed to permit easy ɪiewing on a synchroscope and is a func-ɪon of the delay range in use.

(Continued on page 163A)

What to see at the Radio Engineering Show

(Continued from page 149A)

Firm	Booth
Sprague Electric Co., North Adams, Mass. Capacitors, resistors, radio noise filters, magnetic wire, hearing aid batteries.	27, 28
Square Root Mfg. Co., Yonkers, N.Y. Antennas, coronaseal horizontal deflection transformers, tubular capacitors, high voltage capacitors, ceramic disk capacitors, toroidal coils.	231
Standard Electric Time Co., Springfield, Mass. Timers, chronotachometers, custom-built voltage distribution and test panels, clock systems, hydraulic network analyzers.	370
Standard Piezo Co., Carlisle, Pa. Quartz crystal units for frequency control.	203
Standard Transformer Corp., Chicago, Ill. Transformers, reactors, power supplies.	360
Stevens Manufacturing Co., Inc., Bimetal thermostats and devices. The exhibit will show samples of complete and cut-away thermostats of the positive acting type as well as snap acting type.	S-3
Stupakoff Ceramic & Mfg. Co., Labrobe, Pa. Assemblies, metal to ceramics, metal to glass, ceramic to glass. Capacitor ceramics, rods, tubes, disks, complete range. Ceramics, plain metallized or assembled, alumina, cordierite, magnesia, porcelain, steatite STUPALITH, thoria, titanates and zircon. Kovar; sheet rod, tubing, eyelets, leads, fabricated shapes. Resistors, ceramic temperature sensitive, infra-red source. Seals; kovar-glass, terminals, lead-ins, stand-offs, etc.	376
Sun Radio & Electronics Co., New York, N.Y. Distributor for electronic component manufacturers and exclusive distributor for Peerless Transformers in the New York area. Offering a 132 page radio-electronic parts catalogue, also 100 page catalogue of high fidelity audio equipment.	319

(Continued on page 155A)

WIRES -- Measured,

Cut and Stripped Automatically

Fast at Low Cost

1. CUT WIRES FROM 1" TO 60' IN LENGTH
2. STRIP UP TO FIVE INCHES
3. HANDLES WIRES FROM 26 GAUGE TO 000 GAUGE

Applications of Artos Machines throughout the automotive, radio, telephone, and electrical appliance industries have the economy-improving efficiency-increasing values of fully automatic cutting, measuring, and stripping of wires.

Artos machines are available in a variety of models. There is probably one to meet your exact requirements, in either bench or floor models.

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the

AUDIO TRANSFORMERS

that pass all tests!

•

The test of time, no less than test by leading technicians, has proved the range of Partridge Audio Transformers to be the most efficient and reliable in the world. For example the famous

*WILLIAMSON Output TRANSFORMER, of which there is no U.S. equivalent (vide "Audio Engineering" Nov. 1949) is produced to the original specification and comes to you for $21.00, mail and insurance paid. Then there is the

*PARTRIDGE CFB 20 Watt output type, universally accepted as without rival anywhere. Here are some brief figures: Series leakage induct. 10 m.H; primary shunt induct. 130 H, with 'C' core construction and hermetically sealed—to you for $30.00, mail and insurance paid.

•

Send for fullest data, including square wave tests, distortion curves etc. We'll rush this Air Mail together with list of U.S. stockists.

★

YOU CAN
JUDGE FOR YOURSELF
at the
RADIO
ENGINEERING SHOW, N.Y.

(STAND 263) March 19th-23rd 1951 where the range of Partridge Audio transformers is being exhibited.

NOTE. We despatch by insured mail per return upon receipt of your ordinary dollar check.

Jobbers are invited to handle the transformer that the States is eager to buy—remember, immediate delivery from large stocks in New York!

PARTRIDGE TRANSFORMERS LTD.

ROEBUCK ROAD TOLWORTH
SURREY ENGLAND

What to see at the Radio Engineering Show

(Continued from page 153A)

Firm	Booth
Superior Electric Co., Bristol, Conn. Powerstat variable transformers, stabiline automatic voltage regulators, type EM (electro mechanical), automatic voltage regulators type IE (instantaneous electronic), dc power supplies, ac power supplies, 5-way binding posts.	108, 109, 110
Surprenant Mfg. Co., Boston, Mass. New high temperature wire insulators, hook-up wires, hook-up aircraft thermocouple telemetering wire.	72
Wally Swank, Syracuse, N.Y. Products of: Advance Electric & Relay Co., Curtis Development & Mfg. Co., Electric Motor Corp. & Cyclobm Motor Corp. (Divisions of Howard Industries, Inc.), Grayhill, Industrial Timer Corp., E. F. Johnson Co.	221
Switchcraft, Inc., Chicago, Ill. Phone jacks, phone plugs, microphone jacks and plugs, telephone and military type jacks, push button switches, rotary switches and lever-action switches, and associated products.	337
Sylvania Electric Products Inc., New York, N.Y. and Emporium, Pa. Radio receiving tubes, subminiature tubes, ruggedized tubes, television picture tubes, germanium diodes, strobotrons, glow modulator tubes, testing devices, parts and chemicals.	104 to 106
Synthane Corporation, Oaks, Pa. Laminated plastics products; sheets, rods, tubes, fabricated parts, molded laminated and molded macerated products.	N-1

(Continued on page 157A)

What to see at the Radio Engineering Show

(Continued from page 155A)

Firm	Booth
Tech Laboratories, Inc., Palisades Park, N.J. Reverberation generator, attenuators, potentiometers, switches.	211
Tech-Master Products Co., New York, N.Y. Improved custom quality 630 type TV chassis and kit, TV conversion kits, booster kits, automatic gain control kits, quality TV components, adjustable kine tube mounting brackets. New Lo-Cost "Universal" TV Kit.	267
Technical Materiel Corp., Mamaroneck, N.Y. Communications terminal equipment including rhombic antenna couplers, frequency shift keyers and converters, high speed voice frequency tone systems, dual diversity receivers, a newly conceived fixed frequency receiver and a crash position beacon for airplanes.	131, 132
Technology Instrument Corp., Acton, Mass. Precision potentiometers, decade amplifiers, Z angle meter, audio and rf; phase meter; rf oscillator; slide wire resistance boxes. Torque meter.	101
Tektronix, Inc., Portland, Ore. Wide band cathode-ray oscilloscopes, wide band amplifiers (conventional and dc coupled) square wave generators, electronic instruments for medical research.	234, 235
Telechrome, Inc., Amityville, L.I., N.Y. New video generating equipment, monochrome flying spot picture generator, monochrome monitor, monochrome RMA composite sync. generators, FCC color standard composite sync. generator, field sequential color mixer.	266
Telechron Inc., Ashland, Mass. Meters and timers.	84, 85

(Continued on page 159A)

MANUFACTURERS AND DESIGNERS OF

CONTINUOUSLY VARIABLE REGULATED DC SUPPLIES

MODEL D6-DUAL, HEAVY DUTY

- ✓ DUAL regulated outputs, continuously variable, 0 to 600 volts.
- ✓ Maximum current 200 milliamperes each, or 400 combined.
- ✓ Regulation better than .5%.
- ✓ 6.3 volts AC at 10 amperes center-tapped.
- ✓ Ripple voltage less than 10 millivolts.
- ✓ Stabilized bias supply.
- ✓ Request Bulletin 53 for Detailed Information.

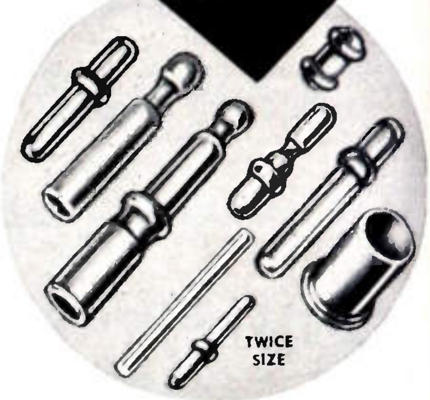
MODELS A3 AND A3A

- ✓ Continuously variable, 0 to 350 volts.
- ✓ Ripple voltages less than 10 millivolts.
- ✓ Regulation better than .5%.
- ✓ Maximum current 200 milliamperes.
- ✓ Stabilized variable bias supply.
- ✓ 6.3 volts AC at 5 amperes.
- ✓ Request Bulletin 52 for Detailed Information.

Oregon ELECTRONICS MFG. CO.

206 S.W. WASHINGTON ST., PORTLAND 4, ORE., U.S.A.

Need VOLUME on Small Parts Like These?



Investigate

MULTI-SWAGE

Economy Way to Get Volume!

If it's VOLUME you need on small tubular metal parts similar to these, be sure to look into Bead Chain's MULTI-SWAGE Process. Send the part (up to ¼" dia. and to 1½" length) and your specs for a quotation. Chances are you'll find a new way to effect important savings.

Much Cheaper Than Solid Pins

Many prominent users of solid pins for electronic and mechanical purposes have cut costs by switching to Multi-Swaged *tubular* pins . . . without sacrificing strength or accuracy. Often this is possible to accomplish.

Typical Applications —

As terminals, contacts, bearing pins, stop pins, male-female connections, etc., in a wide variety of electronic and mechanical products:—Toys . . . Business Machines . . . Ventilator louvres . . . Radio and Television apparatus . . . Terminal-boards . . . Electric Shavers . . . Phono Pick-ups, etc. *For DATA BULLETIN*, write to

TRADE B MARK

The **BEAD CHAIN** Mfg. Co.

11 Mountain Grove St., Bridgeport 5, Conn.

Manufacturers of BEAD CHAIN — the kinkless chain of a thousand uses, for fishing tackle, novelty, plumbing, electrical, jewelry and industrial products.

What to see at the Radio Engineering Show

(Continued from page 157A)

irm	Booth
elevision Equipment Corp., New York, N.Y. V camera, oscilloscopes, TV accessories.	S-21
el-Instrument Co., Inc., East Rutherford, N.J. ype 1000 Teledaptor, Type 1210 12 chanel rf wobbulator, type 1500 B if wobbulaır, type 1900 multifrequency crystal gen·ator, type 2111 12 channel television ansmitter, type 2120 single channel TV ansmitter, type 2200 TV sync signal gen·ator, type 2300, monoscope camera, type 11 video distribution amplifier.	N-14, N-15
erminal Radio Corp., New York, N.Y. ew products and various electronic equipent distributed by Terminal Radio Cor·oration. Nucleonic components of Vicreen Instrument Co., and magnetic re·orders by Concertone and Ampex will be isplayed.	286
. H. Terpening Co., New York, N.Y. icrowave transmission lines and asso·ated components.	373
homas Electronics Inc., Passaic, N.J. elevision pictures tubes and precision ectronic equipment.	S-14
innerman Products, Inc., Cleveland. Ohio peed nuts, speed clips, speed clamps, coil ırm fasteners and special engineered isteners for radio and television.	351, 353
ransicoil Corp., New York, N.Y. ontrol motors, precision gear trains, in·action generators, servo amplifiers.	229
riplett Electrical Instruments, Bluffton, Ohio lectrical measuring instruments and test juipment.	257

(Continued on page 161A)

VEECO STOPS LEAK WORRIES!

Whether it's TUBES or HERMETICS you can be sure of POSITIVE LEAK TESTS by using the

VEECO MASS SPECTROMETER LEAK DETECTOR

This instrument is a simplified, portable Mass Spectrometer, specifically designed to be extremely sensitive to Helium.

In operation, a jet of Helium is directed at points of suspected leakage. When a leak is encountered, the Helium serves as a "tracer," and flows to the Leak Detector where it immediately produces a visual or audible signal. It's that simple. Even unskilled personnel can operate it.

The Veeco Leak Detector is being used by leading manufacturers of electronic tubes and hermetically sealed devices. It has been proved to be the fastest, most sensitive device for precisely locating very small leaks. One manufacturers reports that the Veeco paid for itself in 36 hours!

AS EXHIBITED AT THE

Radio Engineering Show
Grand Central Palace
R I E
New York City

You are invited to visit us at Booth 381 at the IRE Show

March 19-22 1951

Stop in for a demonstration or send your sample for test.

Write for Literature LD-3.

VACUUM ELECTRONIC ENGINEERING CO.

756 THIRD AVENUE
BROOKLYN 32, N.Y.

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for your

Raytheon Tube Requirements

in the

Metropolitan New York Area

It's

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Serving the trade for over a quarter century

H. L. DALIS INC.

Wholesale Distributors Electronic Parts

175 VARICK ST.,
NEW YORK 14, N.Y.

Wire or Write Dept. IND

What to see at the Radio Engineering Show

(Continued from page 159A)

irm	Booth
uscon Steel Co., Youngstown, Ohio lf-supporting radio towers, uniform cross ction guyed towers, towers for micro- ive systems.	230
. S. Armed Forces Exhibition U. S. Navy— ectronics in medicine, ultra-high fre- ency communication system, model an- nna range, milli-micro second oscillo- ope, Marine Corps close air support com- inication system, Ionsphere Model, high eed stroboscope, ballistic flashlight and dar tracing, image converter, diversity ceiver, ordnance electronic standard rts, and infrared display.	322, 324, 325
S. Army Signal Corps— ghlight items are: video-phone two way ral and visual communication system; omic radiation dosimeter; surface wave insmission demonstration; delayed eech feedback equipment, for speech oblems 451b portable teletype equip- nt; miniaturization advances and inted circuit equipment; electronic mem- y and scanner; meteorological instru- entation; electrophotographic camera.	
S. Air Force.	
unitions Procurement Bureau	
med Services Electro Standards Agency SESA	

(Continued on page 165A)

Procurement Feature

Four desks to help manufacturers get orders, will be staffed by procurement personnel from Munitions, Air Force, Navy and Signal Corps on the third floor, Radio Engineering Show.

U. S. Armed Forces Exhibit

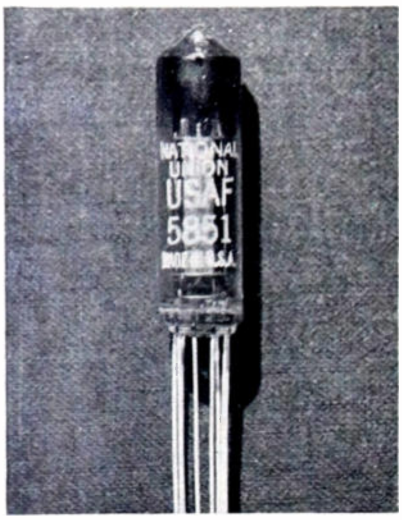
News—New Products

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

(Continued from page 151A)

Filamentary Type Beam Power Output Pentode

A new Type 5851, ruggedized subminiature tube, has been announced by the **National Union Radio Corp.**, 350 Scotland Rd., Orange, N. J.



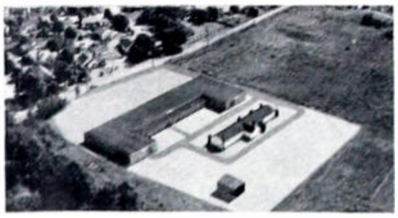
Designed for use in military and other applications where the tube is subjected to excessive shock and vibration, this tube is suitable for frequency doubler operation up to 400 Mc producing 120 milliwatts. The 5851 filament requires only 55 ma current at $2\frac{1}{2}$ volts; it also may be operated at $1\frac{1}{4}$ volts at 110 ma.

This tube in T-3 envelope has a plate dissipation rating of $1\frac{1}{2}$ watts. As a class-A amplifier, it will deliver 650 milliwatts audio output at 10 per cent total harmonic distortion.

The 5851 is designed and tested for shock at 500 g. It may be soldered into the circuit or used with a standard subminiature socket.

Ratings and mechanical data can be obtained by requesting 5851 data sheet.

Plant Expansion



Measurements Corporation is now located in a new air-conditioned plant on Intervale Rd., Boonton, N. J. They have 25,000 feet of floor space for manufacturing and research of their line of laboratory standards.

(Continued on page 169A)


STANDARD SIGNAL GENERATOR
MEASUREMENTS CORPORATION

What to see at the Radio Engineering Show

(Continued from page 161A)

m	Booth
ted Transformer Co., New York, N.Y. nsformers, reactors, chokes, voltage ilators, filters (audio, carrier, super- c) high Q coils, filter coils, step-down nsformers, equalizers, hermetically ed components, and amplifier kits.	81
versal Winding Co., Providence, R.I. ılated multiple coil winder both auto- ic and manual feed. Machines for un- lated coils on spools or forms both e and small. Winder for universal type s in multiple. Automatic wrapping ma- ie for covering asbestos cords.	S-5, S6
versity Loudspeakers, Inc., White ains, N.Y. nmercial, industrial, military and high lity loudspeakers.	323
uum-Electronic Engineering Co., rooklyn, N.Y. h vacuum and leak detector equipment. ss spectrometer leak detector for check- vacuum tubes, hermetically sealed ipment, and large high vacuum sys- s, and high vacuum valves.	381
ian Associates, San Carlos, Calif. stron tubes from 1,000 to 10,000 Mc and n 0.01 watts to 4,000 watts; reflex oscil- rs, two-cavity oscillators and ampli- s; are useful as signal generators, local llators and transmitters. Traveling ve amplifiers with 600 Mc bandwidth 3,000 Mc. Type F-6 nuclear induction meter; specialized microwave measur- equipment.	55
tor Electronic Co., Los Angeles, Calif. e sockets, plug-in units, circuit units.	331

(Continued from page 167A)

What to see at the Radio Engineering Show

(Continue from page 165A)

'irm	Booth
ictoreen Instrument Co., Cleveland, Ohio nstruments for X-ray and radioactivity ıeasurement, dosage control, personnel rotection, health survey, decontamination uality control, prospecting and civil de- :nse. Components for radiation measur- ıg instruments, including Hi-Meg Resist- rs, Geiger-Counter tubes, electrometer ıbes, high voltage regulators and other ub-miniature electron tubes. The Model 39 Portable Survey Meter, Model 517 Vi- rator Power Supply, Model 510 Roentgen :atemeter, Model E523 Detector-Meter and Iodel 521 Accelerometer.	382
'itramon Inc., Stepney, Conn. apacitors, groups of capacitors and ca- acitors with circuitry contained within npervious, glass-like ceramic bodies.	216
Valdes Kobinoor, Inc., Long Island City, N.Y. 'ruarc retaining rings will be exhibited nd demonstrated. Actual application of he rings in a diverse number of electronic roducts will be made available.	358
Vard Leonard Electric Co., Mt. Vernon, N.Y. :lectric control devices, vitrohm resistors nd rheostats, magnetic relays and con- ıctors, power resistor handbooks, an au- hentic treatise on power resistors.	347

(Continued on page 171A)

Procurement Feature

Four desks to help manufacturers get orders, will be staffed by procurement personnel from Munitions, Air Force, Navy and Signal Corps on the third floor, Radio Engineering Show.

U. S. Armed Forces Exhibit

S·S·White MOLDED RESISTORS

The "All-Weather" Resistors

Of particular interest to all who need resistors with inherent low noise level and good stability in all climates

TYPE 65X
Actual Size

STANDARD RANGE
1000 OHMS TO 9 MEGOHMS

Used extensively in commercial equipment including radio, telephone, telegraph, sound pictures, television, etc. Also in a variety of U. S. Navy equipment.

HIGH VALUE RANGE
10 to 10,000,000 MEGOHMS

This unusual range of high value resistors was developed to meet the needs of scientific and industrial control, measuring and laboratory equipment—and of high voltage applications.

SEND FOR BULLETIN 4906

It gives details of both the Standard and High Value Resistors, including construction, characteristics, dimensions, etc. Copy with Price List mailed on request.

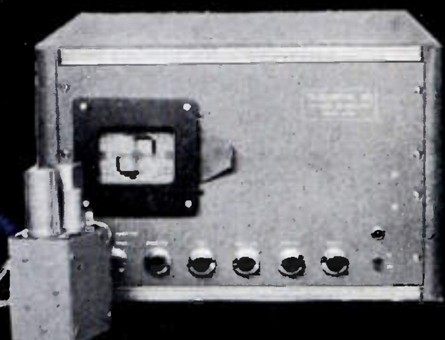
THE S.S.White DENTAL MFG. CO. INDUSTRIAL DIVISION
Dept. G-R, 10 E. 40th St.
NEW YORK 16, N.Y.

NEW!

TELECHROME

FLYING SPOT PICTURE GENERATOR
Model 300-A

Used in TV stations, development laboratories, schools, factories, service organizations and wherever a reliable, easily changed video picture source is required



Supplied with driven sweep 10" monitor
$965.00
Complete

LIMITED PRODUCTION ON ABOVE MODELS
Write today for catalog of our color equipment line.

TELECHROME
INCORPORATED
88 Merrick Rd, Amityville, L.I., N.Y.

- Resolution greater than 500 lines
- Supplied with standard RMA 3x4" test pattern
- Slide Holder for positive or negative transparencies
- Excellent picture tonal rendition
- Supplies pictures without driving pulses from a sync. generator
- Low and high impedance outputs, black positive or negative polarities

Complete with all tubes, self-contained high and low voltage regulated power supplies, sweep and video circuits, in rack width metal cabinet.

EMPIRE DEVICES

UHF IMPULSE GENERATOR
Model IG-102

Pulse width less than 0.001 microseconds, spectrum flat within 0.5 DB from 0.01 MC to 1000 MC; Pulse repetition rate 2 to 2500 CPS; Output level continuously adjustable from 7 to 70,000 microvolts per megacycle bandwidth; Impedance 50 ohms; Permanent accuracy and stability.

Application: Standard signal source for study and measurement of RF interference. Calibrating standard for noise meters. Bandwidth measurements. Transient response and receiver alignment.

STEP ATTENUATOR
Model AT-100

50 ohm resistive networks; VSWR-1.2 from DC to 1000 MC; Six positions; Up to 80 DB attenuation.

UHF ATTENUATOR
Model AT-50

50 ohm precision pad; VSWR-1.1 from DC to 4000 MC; Attenuation from 1 DB to 80 DB; Accuracy—3%.

NOISE AND FIELD INTENSITY METER
Model NF-105

Frequency range 20 to 400 MC; Built-in standard impulse noise and sine wave calibrators; Regulated "A" and "B" supply; Slide back and meter indication; True peak reading meter; Sensitivity 2 to 100,000 microvolts.

Accessories: Broad band antenna, Dipoles, Magnetic and electric field probes, Line probes, Inverter for battery operation and Remote Indicator.

Visit our booth No. 349 at the IRE show

EMPIRE DEVICES, INC.
38-25 BELL BOULEVARD
BAYSIDE, N. Y.

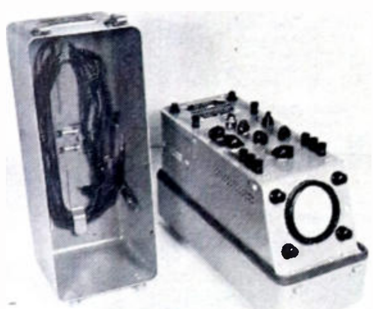
ese manufacturers have invited PROCEEDINGS
iders to write for literature and further technical
ormation. Please mention your I.R.E. affiliation.

(Continued fom page 163A)

New Miniaturized Oscilloscope

Features typical of large precision boratory oscilloscopes are characteristic the new miniaturized oscilloscope an- ›unced by the **Hycon Mfg. Co.** In an in- rument of this small size its adequacy th regard to testing of high-frequency uipment and portrayal of pulse type ive forms is unique.

Now being produced by **Hycon Mfg.**)., 2961 E. Colorado St., Pasadena 8, ılif., for the Air Forces and the Navy in rge quantities, this miniaturized oscillo- ope, 9×6×14½ inches, is particularly signed to endure rough handling. The ter case is water tight. Its easy port- ility makes it especially useful for serv- ng television, radar, and all uhf equip- ent in the field.



The wide-band and linearity features the instrument have heretofore been und only in laboratory-type equipment. ie sweep frequency range is from 3 to yond 50,000-cps. Vertical amplifier re- onse is flat within 3 db from dc to 2 Mc, iile horizontal response is flat within 2 db om dc to 100 kc. Faithful reproduction of ive forms with 3 microsecond rise time d 100 kc square waves is an unusual ıture.

Other features are the incorporation of blanking amplifier and a synchronizing ıplifier, and a circuit design which main- ins a sweep return time ratio of not less an 5 to 1 at all frequencies. Deflection ısitivity exceeds 0.5 volt per inch at all e voltages from 105 to 125 volts and at line frequencies from 50 to 1,000 cps. iked radar pulses up to several hundred c in frequency may be portrayed faith- lly by making direct connections to the flection plates.

• **Andrew Corp.**, 363 E. 75th St., Chi- go 19, Ill., has released Bulletin 10-D, a neral price list, on coaxial cable, rigid axial transmission lines antennas, an- nna tuning equipment and components, d tower lighting equipment.

(Continued on page 173A)

What to see at the Radio Engineering Show

(Continued from page 167A)

Firm	Booth
Ward Productors Corp., Div. of The Gabriel Co., Cleveland, Ohio Antennas for communication services in portable, mobile and fixed station designs.	218
Waterman Products Co. Inc., Philadelphia, Pa. POCKETSCOPES, PULSESCOPES, RACKSCOPES and RAYONIC TUBES. POCKETSCOPES are miniaturized cathode ray oscilloscopes, exceedingly small in size but complete in performance. Two new PULSESCOPES will be shown for accurate pulse determination, in amplitude, shape, duration and time displacement. Miniaturized cathode ray tubes both round and rectangular will be exhibited.	29
Webster-Chicago Corp., Chicago Ill. Diskchangers, fonografs, and "Electronic Memory" wire recorders, dictation machines and WEB-COR tape recorder.	313 & 315
Western Lithograph Co., Los Angeles Calif. E-Z code wire markers, business systems, cable, conduit and pipe markers, high production identification methods. Aircraft hydraulic markers, pressure sensitive contact labels.	107
Westinghouse Electric Corp., Pittsburgh, Pa. Hipersil cores, rectox and selenium rectifiers, tubes, AB "DE-ION" circuit breakers, electrical instruments, hipernik V toroids and other magnetic alloys, linestarters and pushbuttons.	65 to 69
Wind Turbine Co., West-Chester Pa. Sections of TRYLON Towers.	48
The Workshop Associates, Inc., Needham, Mass. Parabolic antennas for microwave relay systems various other special duty antennas.	39

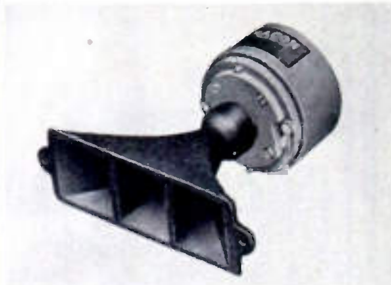
News—New Products

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

(Continued from page 169A)

New Tweeter

Designed for the wide range audio systems in use at present is the new Model CHU-5 tweeter, just announced by Racon Electric Co., Inc., 52 E. 19 St., New York, N. Y.



Model CHU-5 provides uniform response to 12,000 cps with usable output to beyond 15,000 cps. When used with a 12- to 15-inch cone speaker and proper network, it handles 25 to 30 watts of program material. Its impedance is 15 ohms.

The horn is built of cast aluminum, and is flared for widest distribution pattern. Packed with each Model CHU-5 is a four-page pamphlet (including wiring diagram) to cover network. Complete data are supplied for the necessary chokes and capacitors and constants take into consideration cone speakers of 4, 8, or 15 ohm impedances.

(Continued on page 175A)

200 MC BAND WIDTH AMPLIFIERS

Model 202P Wide-Band Chain Amplifier with Regulated Power Supply.

Band Width: 100 KC to 200 MC. Gain: 20 db.
Impedance: 200 ohms. Rise Time: Less than .003 usec.

With the Model 202P: very fast pulses, transients and other high frequency voltages can now be amplified.

With the Model 202P: vacuum tube voltmeters and oscilloscopes are ten times more sensitive.

With the Model 202P: the output voltage of signal, sweep and pulse generators is ten times greater.

Other Wide-Band Chain Amplifiers available:
Model 200A — 10 db Gain. Model 204 — 40 db Gain.

Makers of chain amplifiers, temperature controls, variable electronic filters and power supplies.
Write for Bulletin 202P-1-E

SKL SPENCER-KENNEDY LABORATORIES, INC.
186 MASSACHUSETTS AVE., CAMBRIDGE 39, MASS.

MAGNETIC AMPLIFIERS · INC

Affiliate of GENERAL CERAMICS & STEATITE CORP.
11-54 44th DRIVE, LONG ISLAND CITY, N.Y.—TEL. STILLWELL 6-2191

A N N O U N C E S

PACKAGED MAGNETIC AMPLIFIERS

- Standard Units
- Push-Pull or Single
- Completely Self-contained
- As Easy to Install as a Transformer

See us at the IRE SHOW
BOOTH 136

Other Standard or Specially Engineered Units:
SATURABLE REACTORS, SATURABLE TRANSFORMERS, PRE-AMPLIFIERS, PHASE SENSITIVE DEMODULATORS, HIGH FREQUENCY MAGNETIC AMPLIFIERS

Where the Requirements are Extreme ...

Use SILVER GRAPHALLOY

For extraordinary electrical performance

GRAPHALLOY
TRADE MARK REG. U. S. PAT. OFF.

THE SUPREME BRUSH AND CONTACT MATERIAL

IN BRUSHES

- for high current density
- minimum wear
- low contact drop
- low electrical noise
- self-lubrication

IN CONTACTS

- for low resistance
- non-welding character

Graphalloy is a special silver-impregnated graphite

Accumulated design experience counts — call on us!

GRAPHITE METALLIZING CORPORATION
1001 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

News—New Products

hese manufacturers have invited PROCEEDINGS :aders to write for literature and further technical ıformation. Please mention your I.R.E. affiliation.

(Continued from page 173A)

New Meters

Production of a new 1½-inch vu and ½-inch db meter has been announced by nternational Instruments, Inc., 331 East ›t., New Haven 11, Conn. These instru- nents are designed to measure the strength ıf audio signals as applied to communica-

tions equipment, and are claimed to be the smallest and lightest made. Both types of instruments are completely self-contained, ready for installation.

(Continued on page 177A)

Laboratory Standards

PULSE GENERATOR

MODEL 79-B

SPECIFICATIONS:

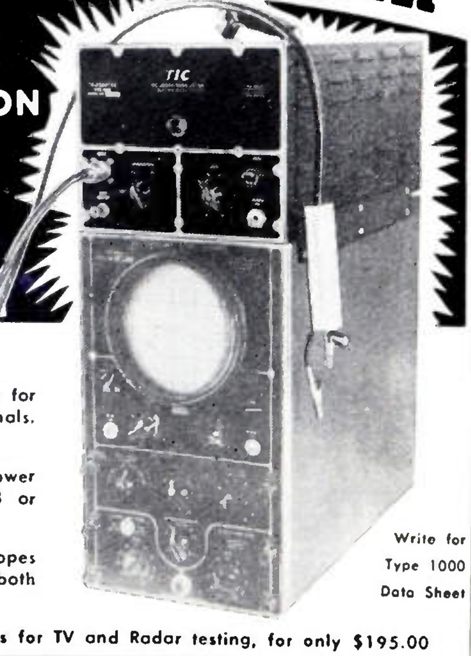
FREQUENCY: continuously variable 60 to 100,000 cycles.
PULSE WIDTH: continuously variable 0.5 to 40 microseconds.
OUTPUT VOLTAGE: Approximately 150 volts positive.
OUTPUT IMPEDANCE: 6Y6G cathode follower with 1000 ohm load.
R. F. MODULATOR: Built-in carrier modulator applies pulse modulation to any r.f. carrier below 100 mc.
MISCELLANEOUS: Displaced sync output, individually calibrated frequency and pulse width dials, 117 volt, 40-60 cycles operation, size 14"x10"x10", wt. 31 lbs.

MEASUREMENTS CORPORATION
BOONTON • NEW JERSEY

2 PURPOSE TELEDAPTER

- **TELEVISION WAVE FORM OBSERVATION**
- **RADAR PULSE**

LOW PRICED AT $195 F.O.B. PLANT



- Converts a DuMont 208 or 304 Scope for use with TV and Radar pulse type signals. Response 3 db down at 5 M.C.
- Completely self-contained including power supply. No modifications to the 208 or 304 Scope required.
- Size matches both Type 208 and 304 scopes and tie plates are furnished to fasten both instruments together.

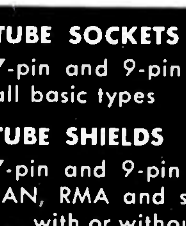
Write for Type 1000 Data Sheet

Convert your Type 208 and 304 Scopes for TV and Radar testing, for only $195.00

Manufacturers of a complete line of TV and Radar Test Equipment
TIC Tel-Instrument Co. Inc.
50 PATERSON AVENUE • EAST RUTHERFORD, N. J.

greater precision in components... facilitates and improves assembly

E L C O



TUBE SOCKETS
7-pin and 9-pin miniatures in all basic types

TUBE SHIELDS
7-pin and 9-pin miniatures in JAN, RMA and snap-on types . . . with or without lead shields

Write for Catalog C-1

COMING SOON . . . the most revolutionary new connector ever furnished the electrical and electronic field. WATCH FOR IT from . . .

ELCO CORPORATION
190 W. Glenwood Ave., Phila. 40, Pa.

News—New Products

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

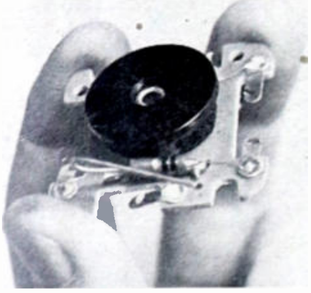
(Continued from page 175A)

These instruments are available in three case styles: 1½-inch square waterproof case (as illustrated) 1½-inch round waterproof case complete with "O" ring for making a waterproof seal to the panel, and 1½-inch round flange mounting case with commercial type of seal.

These meters contain a *D'Arsonval* type subminiature meter movement developed by International Instruments to reduce the size and weight of electrical and electronic instruments

Static Magnetic Memory Device

Developed by Harvard Computation Laboratory and manufactured by **Alden Products Co.**, 117 N. Main St., Brockton, Mass., the *Static Magnetic Memory*, an entirely new device for recording and storing information in digital calculating machinery, could constitute one of the most important developments of recent years. It is predicted that within 5 years the SMM delay line will replace 90 per cent of the vacuum tubes in many applications.



Based upon the discovery of a ferromagnetic alloy having a fairly rectangular hysteresis loop of low coercive force, the Static Magnetic Memory operates essentially as a magnetic trigger pair which require no vacuum tubes to maintain position. The unique characteristics of the SMM storage device mean permanent information storage comparable to magnetic drum storage but independent of mechanical movement, a variable information handling rate ranging from zero to 30,000 cps with probable increases in the future limit, and pulse information storage without power.

Application in scientific and technological fields of this new information storage device can be made wherever pulse storage and control in the field of computer operation is involved.

(Continued on page 179A)

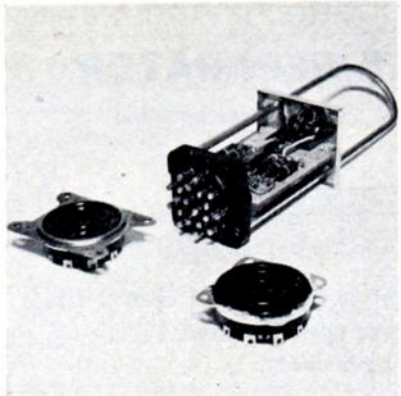
News—New Products

iese manufacturers have invited PROCEEDINGS aders to write for literature and further technical formation. Please mention your I.R.E. affiliation.

(Continued from page 179A)

Plug-In Noninterchangeable Base and Sockets

Alden Products Co., 17 N. Main St., 'rockton, Mass. announces the addition of ıe Alden "20" noninterchangeable base nd sockets to its line of plug-in components.



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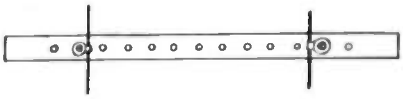
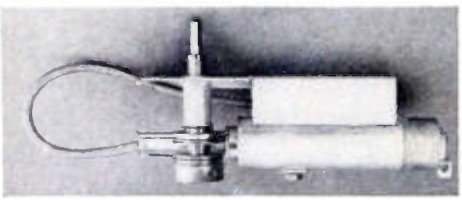




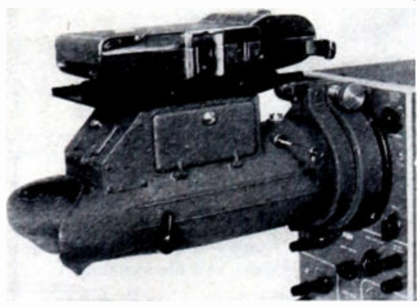
News—New Products

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

(Continued from page 179A)

Oscillo-Record Camera Delivers Finished-Prints

A new oscillograph-record camera recently announced by the **Instrument Div., Allen B. DuMont Laboratories, Inc.,** Clifton, N. J., provides, in one minute, a complete record of an oscillograph image. No darkroom facilities are required. Waveform comparison is immediate. The camera is designed specifically for application with any standard, 5-inch, cathode-ray oscillograph.

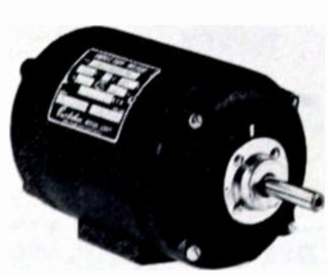


The camera employs the *Polaroid-Land* process for delivering a finished print at the termination of each completed exposure or set of exposures. By means of a sliding mount, the camera may be positioned so that several traces can be recorded on a single print, for side-by-side comparisons. There is also a built-in detent which divides a single print into one, two, or three separate exposure areas.

The lens aperture is f/2.8; and the lens is coated to minimize halation. Shutter settings are 1/100, 1/50, 1/25, time, and bulb.

Fractional HP Motors

The **Cyclohm Motor Corp.,** Div. of **Howard Industries Inc.,** Racine, Wis., announces their new fractional HP motor model 2900, now being manufactured as a 2-speed hysteresis motor for use in tape recording applications. Model 2900 is also available as nonsynchronous capacitor motor and torque motor with high resistance rotors.



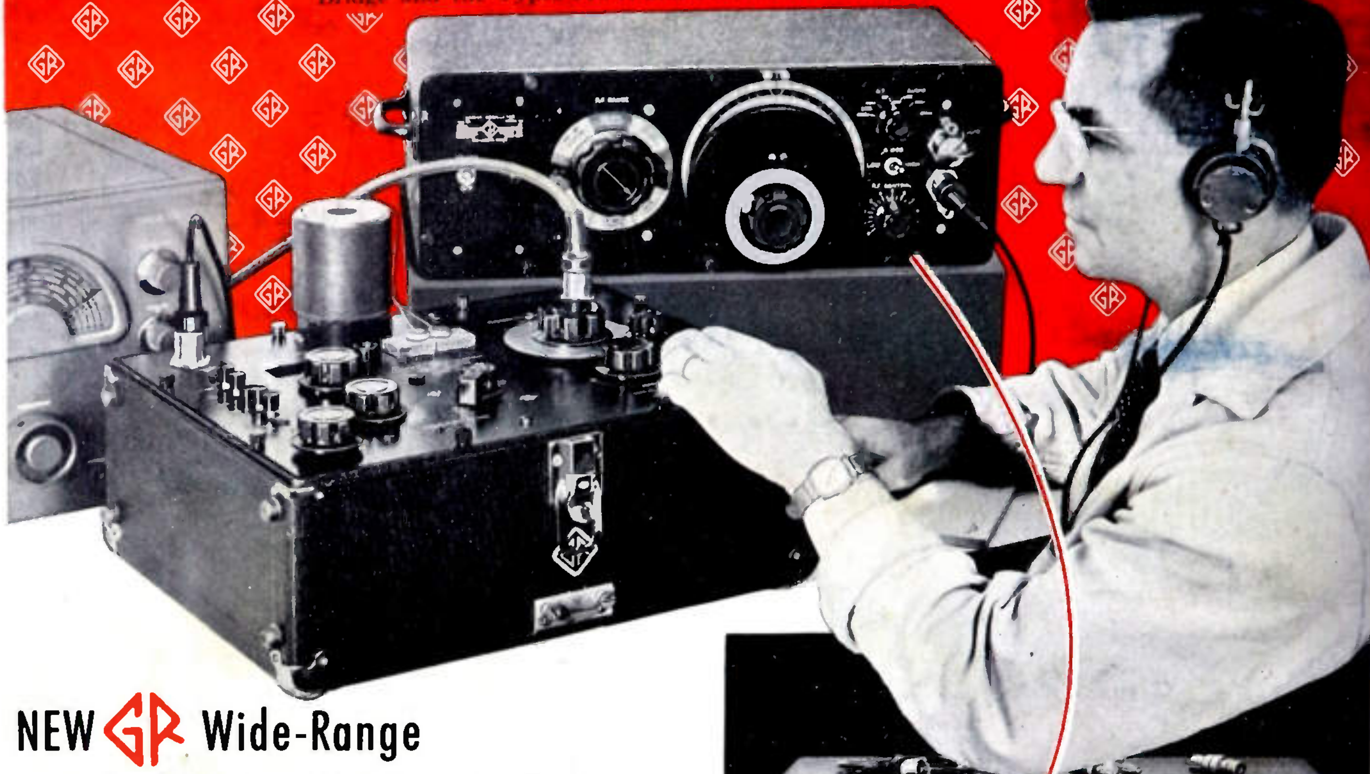
Model 2900 is rated 1/100 to 1/15 hp. It is used in powering blowers for electronic equipment, telegraph switching equipment, tape pullers for automatic code equipment, etc.

PROFESSIONAL CARDS

INDEX AND DISPLAY ADVERTISERS

DISPLAY ADVERTISERS

Typical set-up for measuring characteristics of r-f coil. Types 1330-A Bridge Oscillator, 821-A Twin T Impedance Measuring Circuit and a communications-type receiver. The oscillator is equally suited to use with other bridges such as the Type 716-C Capacitance Bridge and the Types 916-A and 916-AL R-F Bridges.

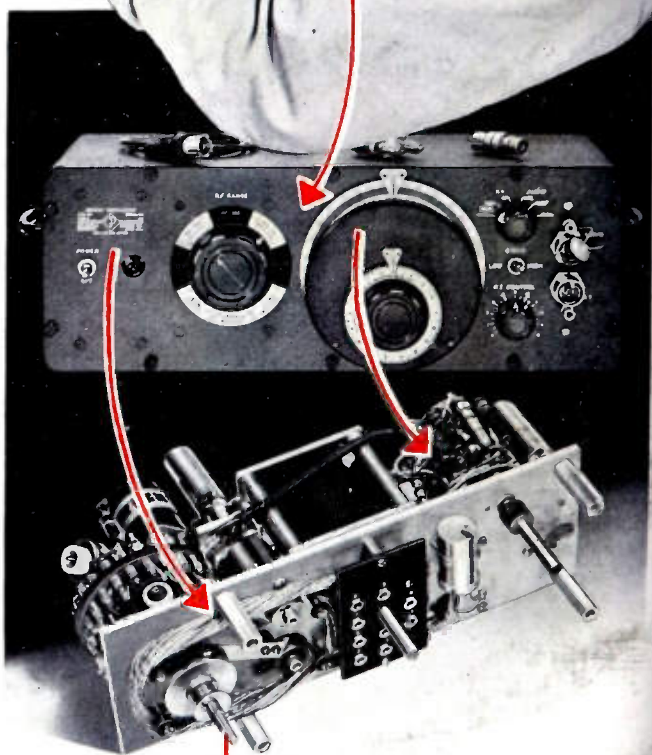


NEW GR Wide-Range BRIDGE OSCILLATOR

5 kc to 50 Mc — 12 Volts Output

The new G-R Type 1330-A Bridge Oscillator is designed especially as a power source for bridge, antenna and general laboratory measurements. It is relatively inexpensive, has high output, excellent shielding and many operating conveniences. Among its features are:

- **WIDE FREQUENCY RANGE:** *5 kc to 50 Mc, carrier*
- **THREE MODULATION FREQUENCIES:** *internal a-m at line and at 400 c and 1,000 c, at two levels of approximately 30% and 60%*
- **GOOD OUTPUT:** *12 volts, open circuit; ¾ watt into 50-ohm load*
- **FREQUENCY ACCURACY:** *Carrier — ±2% above 150 kc, ±3% below, no load. Audio — ±5% for 400- and 1,000-cycles*
- **LOW LEAKAGE:** *about 50 μv per meter at 1 Mc, two feet from oscillator*
- **COAXIAL OUTPUT** *jacks, cable and adaptors permit complete shielding from oscillator to measuring instrument*
- **LOGARITHMIC DIAL:** *calibration logarithmic from 5 kc to 15 Mc*
- **INCREMENTAL-FREQUENCY DIAL:** *indicates increments of 0.1% per division from 5 kc to 15 Mc*
- **LOW DISTORTION:** *between 1% and 6% at 60% modulation level; r-f distortion 3% over most of range*
- **VERY COMPACT CONSTRUCTION:** *panel relay-rack width, only 7 inches high; cabinet 9 inches deep*
- **EASY SERVICING:** *oscillator plugs out of shielding box and has servicing cable to test instrument*



Excellent mechanical construction throughout. Oscillator assembly plugs into deep brass box; double cover completes shielding. Note servicing cable permitting instrument to be tested on bench.

Type 1330-A Bridge Oscillator . . . $525.00

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 1000 N. Seward St., Los Angeles 38