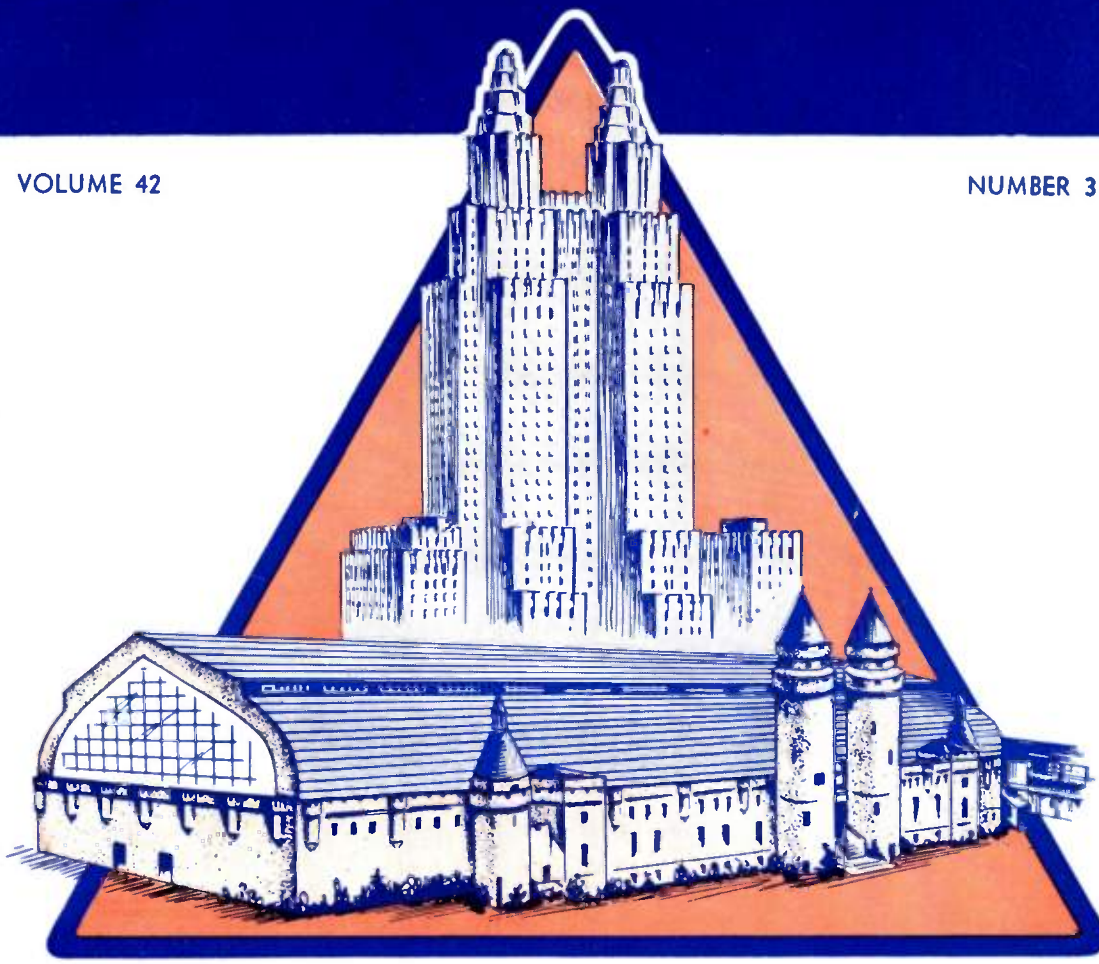
MARCH · 1954

Proceedings of the I·R·E

VOLUME 42 NUMBER 3



1954 IRE National Convention and Radio Engineering Show

March 22-25, Kingsbridge Armory and Waldorf-Astoria Hotel, New York, N.Y.

Convention technical program, page 604; What to See at the Radio Engineering Show, page 1A; table of contents follows page 128A.

The IRE Standards on Circuits and the IRE Standards on Sound Recording, appear in this issue.

The Institute of Radio Engineers

This is Your

IRE Convention Program Issue

with

What to See at the

RADIO ENGINEERING SHOW

Monday through Thursday . . . March 22-25, 1954 . . . New York City

In March Issue:

Outline of 51 Sessions

Abstracts of all Papers

Program of Social Events

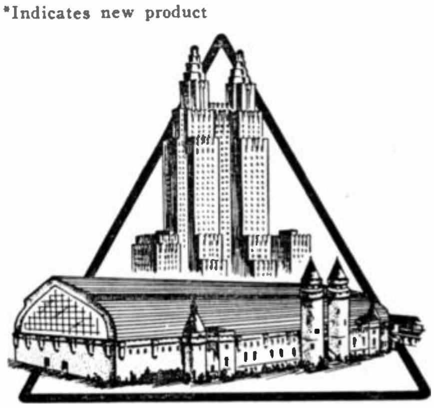
"What to See at the Radio Engineering Show" —a guide to 604 exhibits.

Starting on this page and continuing through the advertising pages is a complete outline of the Exhibits in the 1954 Radio Engineering Show held at Kingsbridge Armory. The listings for exhibitors shown in display (the larger, boxed descriptions) are amplified by advertisements of these firms right in this issue. Please consult advertising index in back pages for the pages on which these very informative ads appear.

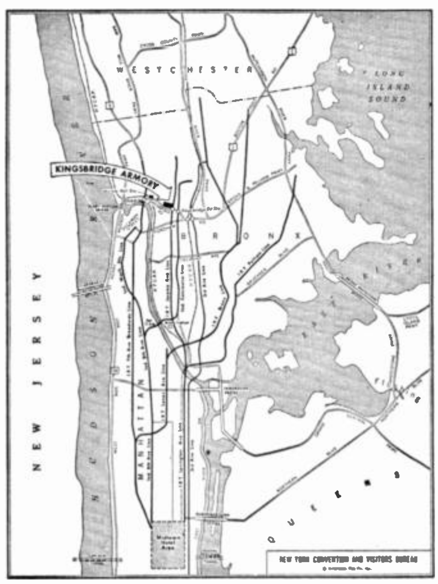
AGA Div., Elastic Stop Nut Corp. of America, 781 Airborne Ave.
Showing a complete line of Agastat time delay relays with delay period range from 0.1 second to approximately 15 minutes, including operating demonstration of typical electronic industry application.

Ace Engineering & Machine Co., Inc., 427, 431 Electronic Ave.
Exhibiting latest shielding developments. First solid shield galvanized portable enclosure; also new *copper cell-type. Featuring completely interchangeable panel construction. Free booklet "Evaluating Shielded Enclosures."

*Indicates new product



A private, FREE bus leaves for Kingsbridge Armory from the 49th St. entrance to the Waldorf-Astoria Hotel every 10 minutes.



Subway Routes to KINGSBRIDGE Armory from Midtown Area

1. Lexington Avenue IRT Express train marked "Jerome-Woodlawn Express" to Kingsbridge Road and Armory.
2. 6th Avenue IND Express train marked "D—Bronx-Concourse Express" to Kingsbridge Road. Walk three short blocks west to the Armory.
3. 7th Avenue IRT Express train marked "East 180th Street" to 149th Street, go upstairs to upper level and take the train marked "Jerome-Woodlawn Express" to Kingsbridge Road and Armory.
4. 8th Avenue IND train marked "A," "AA," or "CC" to 59th Street, and change for the train marked "D—Bronx-Concourse Express" to Kingsbridge Road. Walk three short blocks west to the Armory.

Acme Electronics Corp., 548-552 Components Ave.
See Aerovox Corp.

Acro Manufacturing Co., Acro Switch Div., 404 Electronic Ave.
Precision snap action switches for electronic and electro-mechanical systems. A new vibration resistant precision switch will be featured.

Actioncraft Products
635 Circuits Ave.
See a demonstration of
***PERMATAGS**
The plastic wire marker that
SNAPS ON

Advance Electric & Relay Co., 759 Airborne Ave.
Advance relays, exhibiting the latest miniature hermetically-sealed relays, including new 6P-DT sealed, meeting highest existing military requirements. Also miniature high voltage and 4P-DT 10 ampere industrial control relays.

Aerovox Corp.
548-552 Components Ave.
*Aerovox Printed Wiring . . . *Aerovox Ceramic Power and Transmitting Capacitors . . . *Line of Ceramic "Cartwheels" for color TV . . . *Ceramic-Cased, Deposited-Carbon, Precision Resistors.

(Continued on page 8A)

PROCEEDINGS OF THE I.R.E. March, 1954, Vol. 42, 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.

Table of Contents will be found following page 128A

Meetings with Exhibits

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

Δ

March 22, 23, 24 & 25, 1954
Radio Engineering Show and **I.R.E. National Convention,** New York City. Exhibits at Kingsbridge Armory and headquarters hotel Waldorf Astoria. Direct connections by subway and by private express busses.
Exhibits Manager: Wm. C. Copp, 1475 Broadway, New York 36, N.Y.

April 24, 1954
Eighth Spring Technical Conference, Cincinnati, Ohio
Exhibits: Mr. Alonzo M. Boothe, 1358 Grace Ave., Cincinnati 8, Ohio

Δ

May 5, 6 & 7, 1954
Technical Conference with Electronic Exhibits, I.R.E. Region Seven, Multnomah Hotel, Portland, Ore.
Exhibits: W. K. Dallas, P.O. Box 831, Portland 7, Ore.

Δ

May 7, 8, 1954
NEREM, New England Radio Engineering Meeting, Sheraton-Plaza Hotel, Boston, Mass.
Exhibits Chairman: Robert A. Waters, 4 Gordon St., Waltham 54, Mass.

Δ

May 10, 11, 12, 1954
Airborne Electronics Conference, Biltmore Hotel, Dayton, Ohio
Exhibits: R. J. McIllrath, Chairman, 410 West 1st Street, Dayton 2, Ohio

Δ

August 25, 26 & 27, 1954
Western Electronic Show & Convention, Pan-Pacific Auditorium, Los Angeles, Calif.
Business Manager: Mr. Mal Mobley, Jr., 344 North La Brea Ave., Los Angeles, Calif.

Δ

October 4, 5, 6, 1954
National Electronics Conference, Sherman Hotel, Chicago, Ill.
Exhibits: Mr. George H. Wise, c/o DeVry Technical Institute, 4141 West Belmont, Chicago 41, Ill.

Δ

Note on Professional Group Meetings: Some of the Professional Groups conduct meetings at which there are exhibits. Working committeemen on these groups are asked to send advance data to this column for publicity information. You may address these notices to the Advertising Department, and of course listings are free to IRE Professional Groups.

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HIGH VOLTAGE

molded ceramic filter CAPACITORS

Specifically engineered for reliable service in the high voltage supply filter circuits of modern television receivers and cathode ray instruments are Sprague's new molded jacket "doorknob" capacitors.

These moderately priced units incorporate an improved ceramic dielectric element encased in a thermosetting, non-flammable housing for maximum protection. Fifteen different terminal combinations are standard to meet practically every mounting requirement.

Standard capacitance rating is 500 mmf. Voltages are 30,000, 25,000, and 20,000 volts d-c to fit all applications in television receivers from 27-inch down to 17-inch screen size.

Complete engineering information on these capacitors is contained in Bulletin 606A, available on letterhead request to Sprague Electric Company, 235 Marshall Street, North Adams, Massachusetts.

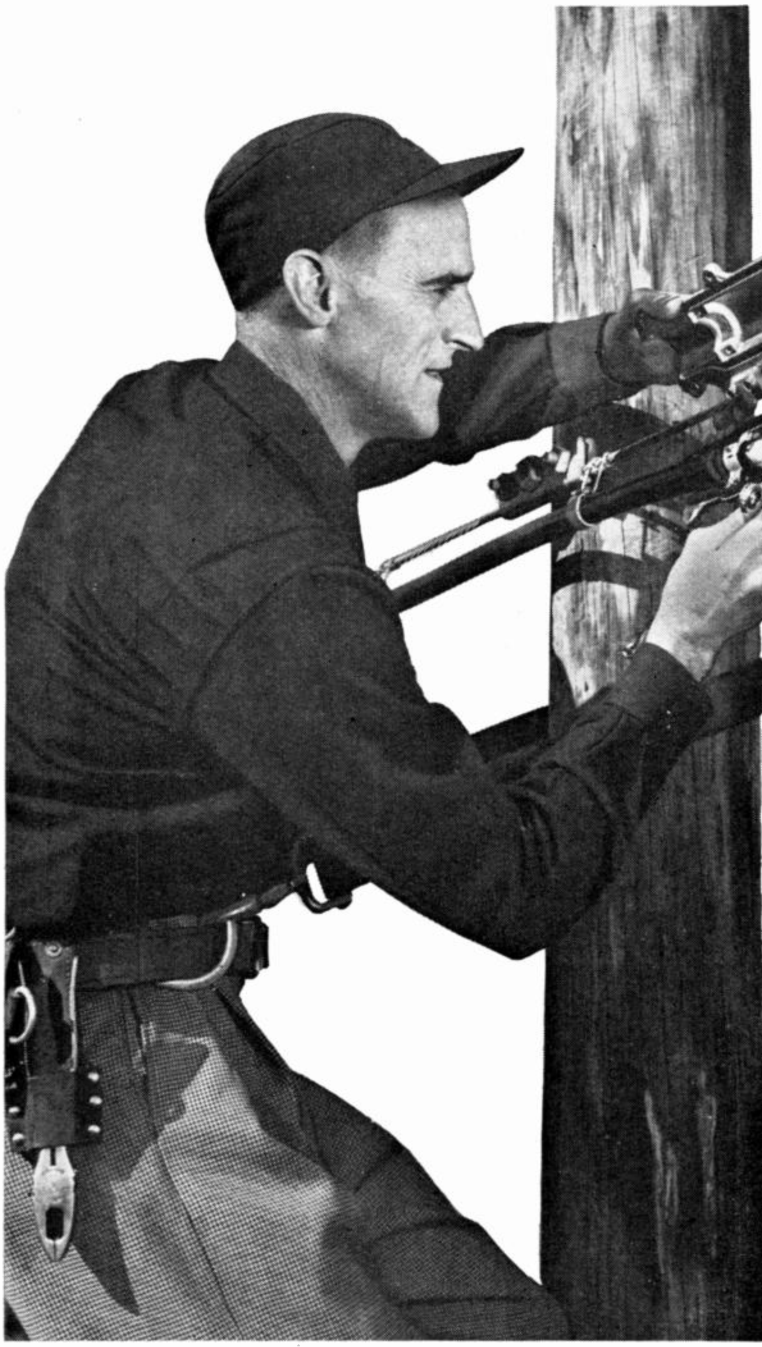
Sprague, on request, will provide you with complete application engineering service for optimum results in the use of ceramic capacitors.

SPRAGUE

WORLD'S LARGEST CAPACITOR MANUFACTURER

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

Visit our Booths at the I.R.E. Show—247-249 Instruments Ave.



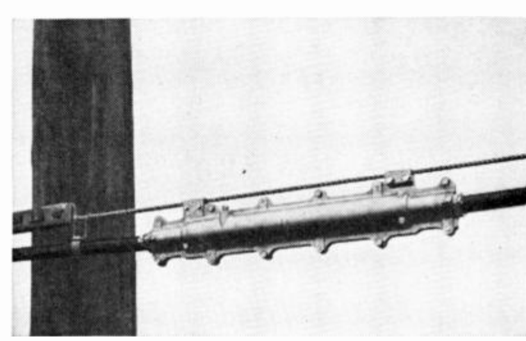
BOLTING VOICES TOGETHER

Adjusting casing over splice in polyethylene cable. Edges and ends are sealed with a new Butyl rubber compound that won't harden, dry out or lose adhesion even in extreme heat or cold.

More than ever, light, flexible polyethylene sheathed cable developed by Bell Telephone Laboratories is providing speedy answers to the demand for more telephone service.

But at thousands of splices, the sheath must be thoroughly sealed against moisture. Laboratories engineers developed a protective casing which is quickly and simply bolted in place. The edges and ends of the casing are *permanently* sealed with a new compound developed by Laboratories rubber chemists.

Now, economical polyethylene cable can be installed much faster and at lower cost. Here is another example of how Bell Laboratories continually finds ways to keep telephone service high in quality, while the cost stays low.



CLOSED CASING IN PLACE

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

Introducing FERRAMIC® "Q"

by GENERAL CERAMICS

A NEW HIGH Q, LOW LOSS, HIGH FREQUENCY CORE MATERIAL WITH STABLE CHARACTERISTICS

An ideal Core Material for Antenna Rods, Filter Inductances, Loading Coils, RF Coils and all other Applications Requiring High Performance up to 30 Megacycles.

Ferramic "Q" is an exclusive development of General Ceramics Corp. It was created to overcome the instabilities that characterized previous high performance ferrites. Exhaustive tests prove that Ferramic "Q" is completely stable in respect to age, shock, vibration, temperature. In addition this new material features higher Q and lower losses than former materials at all frequencies up to 30 Megacycles. Cost-wise, Ferramic "Q" offers extremely favorable comparison with competitive materials. For complete details, call, write or wire today.

OUTSTANDING ADVANTAGES OF FERRAMIC "Q" ARE SHOWN IN COMPARATIVE CHARACTERISTICS OF IDENTICAL COILS WITH CORES OF FERRAMICS J AND N, AND THE NEW FERRAMIC "Q" MATERIAL

Cup Core F-261

	L	C	Q
Ferramic J	154	165	50
Ferramic N	120	210	65
Ferramic Q	73	350	175

Coil consists of 20 turns #28 AWG S.F. wire random wound. Cup cores mating surfaces ground (no air gap). Inductance measured in micro-henries, capacitance measured in micro-micro-farads on Boonton Model 260-A Q-Meter. Frequency 1000 Kcs.

Ring Core F-108

	L	C	Q
Ferramic J	90	280	60
Ferramic N	60	425	100
Ferramic Q	35	725	400

Coil consists of 25 turns #20 AWG S.F. wire wound uniformly on toroid. Inductance measured in micro-henries, capacitance measured in micro-micro-farads on Boonton Model 260-A Q Meter. Frequency 1000 Kcs.

Antenna Rod F-214 — 8" Long

	L	C	Q
Ferramic J	340	75	120
Ferramic N	270	95	160
Ferramic Q	210	120	350

Coil consists of solenoid of 85 turns #26 AWG S.F. wire. Space wound along approx. 80% of rod length and centered on rod. Inductance measured in micro-henries, capacitance measured in micro-micro-farads on Boonton 260-A Q meter. Frequency 1000 Kcs.

BASIC TOROIDAL MEASUREMENTS

Initial Permeability μ_0 (1Mc)	125
Figure of Merit Q (1Mc)	400 approx.
Loss Factor $\frac{1}{\mu_0 Q}$ (1Mc)	.000020 approx.
(5Mc)	.000031
(10Mc)	.000050
(20Mc)	.000097
μ_0 vs Frequency Characteristics	Good to over 30 Mc
Q vs Frequency Characteristics	Good to over 30 Mc
Curie Temperature (°C)	250
Temp. Coeff. of μ_0 (1Mc) %/°C (25°C to 70°C)	+0.08 approx.
Temp. Coeff. of Q (Same units as above)	−0.75
Saturation Flux Density B_s (gauss) at H_{dc} = 25 oersteds	2900
Max. Permeability μ max	400
Coercive Force H_c (oersteds)	1.90
Residual Magnetism B_r	1050

At the I.R.E. Show
BOOTHS 566-568
COMPONENTS AVENUE

TYPICAL ANTENNA ROD MEASUREMENTS

FREQUENCY	Q	C=mmf.
0.6	334	344
0.8	350	189
1.0	350	120
1.2	338	83
1.4	318	60

TEMPERATURE COEFFICIENTS

Antenna Rod No. F-214 (.330 x 8"). Standard Test Coil — Space wound solenoid 85 turns #26 AWG. Formex copper, occupying approx. 80% of length of rod and centered on rod. (Resonates at 1 Mc. with 120 mmf.)

$$TC = \frac{\% \Delta \mu_0}{\mu_0} (25° \text{ to } 75°C)$$

Temp. Coeff. of Rod +1.0 to +2.0
Temp. Coeff. of Coil only ≈ 0

GENERAL CERAMICS and STEATITE CORPORATION — STEATITE INSULATORS

General CERAMICS and STEATITE CORP.
TELEPHONE: VALLEY 6-5100
General Offices and Plant: KEASBEY, NEW JERSEY

MAKERS OF STEATITE, ALUMINA, ZIRCON, PORCELAIN, SOLDERSEAL TERMINALS, LIGHT DUTY REFRACTORIES, CHEMICAL STONEWARE, IMPERVIOUS GRAPHITE, FERRAMIC MAGNETIC CORES

Flip-Flop, Type 1101C—another of the basic elements in Burroughs' integrated line of "Unitized" Pulse Control Equipment.

"Unitized" Pulse Control Equipment

saves time and money in electronic engineering

There's no longer any need to tie up engineering personnel with the time-consuming work of developing and "breadboarding" electronic test circuits. Burroughs, a leader in the office machine industry, now offers an integrated line of "Unitized" Pulse Control equipment covering all the basic functions in pulse circuit engineering. These one-basic-function units are designed with a maximum of flexibility to be used as building blocks for test systems ranging from the very simple to the most complex. Engineers need only make a block diagram of the apparatus needed, assemble the necessary Burroughs units in the plug-in rack, and interconnect them with the various standard coaxial cables and accessories. It's really that easy! It's equally easy to reassemble your units for a different project when your present tests are completed.

YOU SIMPLY "PLUG IN" BURROUGHS FLIP-FLOPS

Burroughs Flip-Flop, Type 1101C, demonstrates the one-basic-function principle that makes Burroughs "Unitized" Equipment so suitable for your needs.

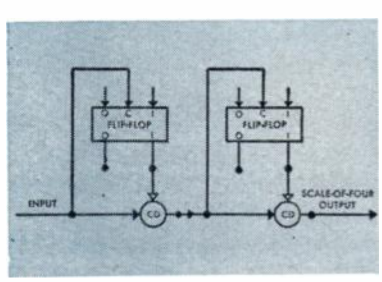
This flip-flop is a bistable circuit designed specifically to provide an output gating voltage to be used in coincidence circuits. The unit contains a pentode Eccles-Jordan circuit capable of being switched at rates up to 2.5 megacycles per second, with 0.1 microsecond pulses.

There are three inputs—Zero, One and Complement—operating from pulse amplitudes of 12 volts or more. Coaxial output jacks marked "Zero Gate" and "One Gate" supply either 0 volts or -23 volts at an impedence level of approximately 680 ohms.

Two neon lights on the front of the panel indicate the position of the flip-flop. A terminal block on the rear of the unit can be used to operate indicator lights installed at a remote point for visual monitoring.

Proved by more than two years of constant use, Burroughs "Unitized" Pulse Control equipment has been purchased by many leading electronic research organizations. Some of the users are: Massachusetts Institute of Technology, University of Michigan, Stanford Research Institute and National Union Radio Corporation.

Scale-of-Four Binary Counter Using Burroughs "Unitized" Equipment



The left flip-flop, Type 1101C, changes state with each input pulse, so that the left coincidence detector (CD) or gate, Type 1201B, is alternately opened and closed with succeeding input pulses, with the result that every other input pulse passes through the left coincidence detector, giving a count of 2. A similar flip-flop and gate combination cascaded to the first combination gives a total scale of 2 x 2 = 4. The number of flip-flop and coincidence detector combinations that can be cascaded is unlimited.

For full information on Burroughs "Unitized" Pulse Control Equipment, write or call Department 14E, Electronic Instruments Division, Burroughs Corporation, 511 N. Broad St., Philadelphia 23, Pa.

PULSE GENERATORS
COINCIDENCE DETECTORS
PULSE DELAYS
FLIP-FLOPS
PULSE GATERS
CHANNEL SELECTORS
MIXERS

ELECTRONIC INSTRUMENTS DIVISION

Burroughs

THE BEST KNOWN NAME IN OFFICE MACHINES

Visit the Burroughs Exhibit—Booths 337 and 339—At the Radio Engineering Show, March 22-25

What to See at the Radio Engineering Show

(Continued from page 1A)

SEE THE SWR INDICATOR AT **718 AIRBORNE AVE.**

AIRBORNE INSTRUMENTS LABORATORY
MINEOLA, L. I., N. Y.

AMP BOOTHS 770-2 AIRBORNE AVE.

SOLDERLESS TERMINALS & CONNECTORS FEATURING
MINIATURE TAPER PIN CONNECTOR BLOCKS*
TAPER PIN & TAPER TAB RECEPTACLES*
COMPUTER PROGRAMING BOARDS*
PULSE-FORMING NETWORKS & HIGH-VOLTAGE CAPACITORS

AIRCRAFT-MARINE PRODUCTS, INC.
HARRISBURG, PENNA.

Aircraft Transformer Corporation
507 Components Ave.

*High temperature (Type H) encapsulated transformers; *Hermetic sealed power packs, filters, pulse transformers; *Magnetic amplifiers, specialize in systems-engineered transformers, transformers and chokes to military and customer's specifications.

Aironic Accessory Co., Inc., 901 Registration Row
Miniature AN connectors, low inertia motors, precision gear trains, molded slip rings, printed circuit connectors, precision linear potentiometers, tape resistors, sub-fractional HP motors and blowers.

AIRPAX PRODUCTS COMPANY — DESIGNERS — ENGINEERS

BOOTH 825
AUDIO AVENUE

choppers — vibrators — transformers
power supplies — magamps — filters

MIDDLE RIVER BALTIMORE, MD.

Airtron inc. — TRANSISTOR WAY — MICROWAVE AVE
LINDEN, NEW JERSEY
BOOTH 373

Mixers. Duplexers. Directional Couplers. Dummy Loads. Short Slot Hybrids. A complete series of Waveguide Switches. Microwave castings to close tolerances using new economical production methods. *Equipment available in Airtron, Inc. designs or to your specifications.*

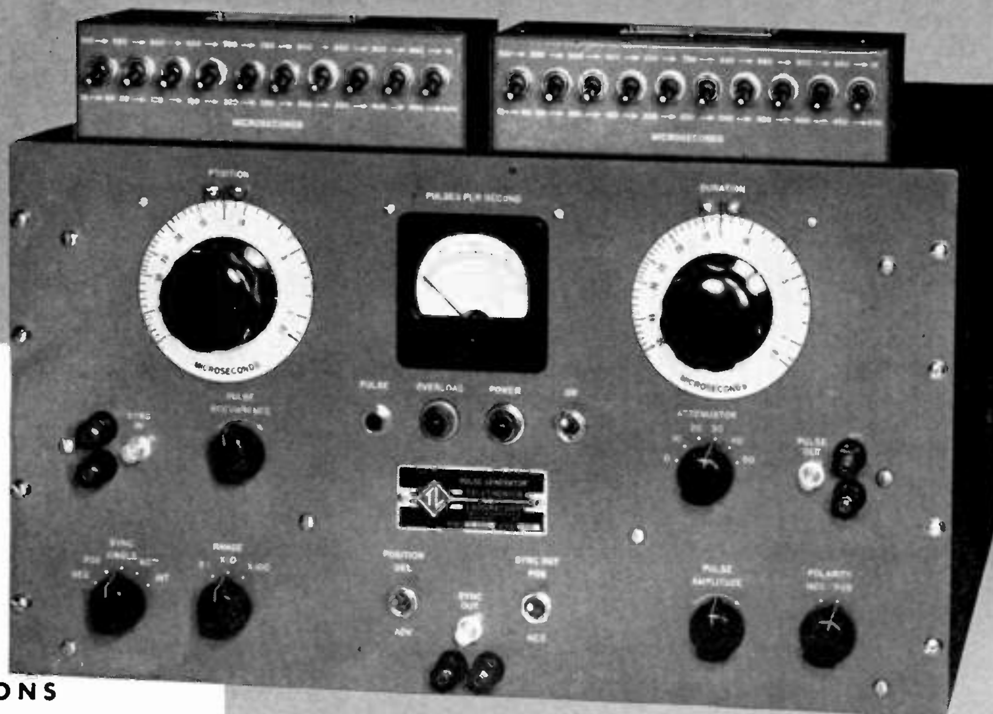
Alcar Instruments, Inc., 412 Electronic Ave.
*Ultra-Sonic soldering iron for soldering aluminum. *Ultra-Sonic control oscillator and transducers for cutting, mixing and other uses. *Fine wire coil winder.

*Indicates new product

(Continued on page 54A)

WIDE RANGE

FAST-PULSE GENERATOR



PG-200A Pulse Generator
PGA-210 Range Extenders

Visit Our Booth at the

I. R. E. Show
BOOTH No. 302

Kingsbridge Armory
Bronx, New York
March 22-25, 1954

SPECIFICATIONS

PULSE POWER

- Amplitude 100 volts open circuit
- Continuously variable over a range of -10 db
- 50 db attenuation in steps of approx. 10 db
- Driving impedance 50 ohms or less
- Max. average current (50 ohms load) 0.1 amp. for pos. pulses, 0.07 amp. for neg. pulses
- Max. recurrence rate at least 20,000 pps
- Max. duty cycle 50%, min. pulse interval (trailing edge to leading edge) approx. 40 μs

PULSE WAVEFORM

- Rise and decay times 0.03 μs or less (10% to 90% amplitude)
- Crest and base line overshoots and ripple less than 5% of average pulse amplitude
- Duration calibrated 0.1 to 50 μs, accuracy below 5000 pps within 5% or 0.1 μs whichever is greater, accuracy above 5000 pps subject to additional 0.3 μs error, min. pulse width less than 0.05 μs (50% amplitude)

PULSE POSITION

- Delay after external sync signal fixed at approx. 10 μs or adjustable from approx. 20 to 70 μs
- Advance or delay with respect to sync out trigger calibrated 0.1 to 50 μs, accuracy below 5000 pps within 5% or 0.1 μs whichever is greater, accuracy above 5000 pps subject to additional 0.3 μs error

features

- DURATION AND POSITION .05 TO 1000 μs
- RISE AND DECAY TIMES CONSTANT .03 μs
- SINGLE PULSES TO 20,000 PER SECOND
- 100 VOLTS, 50 OHMS DRIVING IMPEDANCE
- CALIBRATED WIDTH, POSITION AND RATE
- TRIGGER OR SINE WAVE SYNCHRONIZATION
- NEGLIGIBLE INTERACTION OF CONTROLS

RANGE EXTENDER

- 19 additional time increments of 50 μs each
- Continuous calibrated coverage from 0.1 to 1000 μs, accuracy within 5%
- Plugs into top of Pulse Generator directly above position or duration control

SYNCHRONIZATION

- Externally by almost any 5 volt waveform from essentially 0 to 20,000 per sec.
- Internal single pulses, power line freq. or adjustable from 20 to 20,000 pps
- Recurrence rate meter, accuracy within 5%
- Sync out trigger 50 volts, 1 μs duration

TELETRONICS LABORATORY INC.

54 KINKEL STREET, WESTBURY, LONG ISLAND, NEW YORK

glass-to-metal seals

A complete range of sizes and designs of terminals, lead-ins and stand-offs for hermetic sealing is offered by Stupakoff. Made with Kovar metal, the ideal alloy for sealing to hard glass, Stupakoff Seals are durable and dependable. These are not mechanical compression seals, but are permanently fused by chemical interaction. They may be installed by conventional assembly techniques.

Write for a copy of the new Stupakoff Catalog 453, giving details of over a thousand sizes and styles of Stupakoff Seals.

STUPAKOFF CERAMIC & MANUFACTURING COMPANY

LATROBE, PENNSYLVANIA

See Us at Booths 866, 868, Audio Avenue, Radio Engineering Show, March 22-25.

AT THE I.R.E. SHOW

new! DEVELOPMENTS IN MAGNETRONS AND KLYSTRONS

An imposing display of progress by the world leader in magnetron tube production. See the many new designs which are opening new fields of military and commercial application.

new! RAYTHEON COMPUTER COMPONENTS

Tape handling mechanisms, magnetic recording heads, binary-octal calculators, magnetic shift registers and other computer components. See the tremendous strides being made by Raytheon in this fastest-moving phase of electronics.

new! DEVELOPMENTS IN SPECTRUM ANALYSERS

Raytheon has fulfilled the profession's need for short time analysis of complex signals with a high-speed commutated filter array employing hundreds of 100, 25, or 10 cps filters with complete scanning in as short a time as 5 milliseconds. Complete technical information will be presented in our convention paper.

new! KTR-100 TV MICROWAVE RELAY

The talk of the TV industry! Complete equipment for multiplex wide band video and high quality audio transmission and reception in unbelievably light and compact form. Designed with installation, control and servicing features never before available.

new! RAYTHEON ULTRASONIC DEVICES

Here's your chance to learn what you can do with ultrasonics. New developments include sonic oscillators for medical and industrial research, ultrasonic machine tools for cutting hard or brittle materials and other products of Raytheon research in the field of sonics.

new! "RADARANGE" ELECTRONIC COOKERS

A new table model marks still further progress in this most revolutionary improvement in cooking since the invention of fire. See how meals are cooked in seconds with microwaves.

RAYTHEON®

Excellence in Electronics

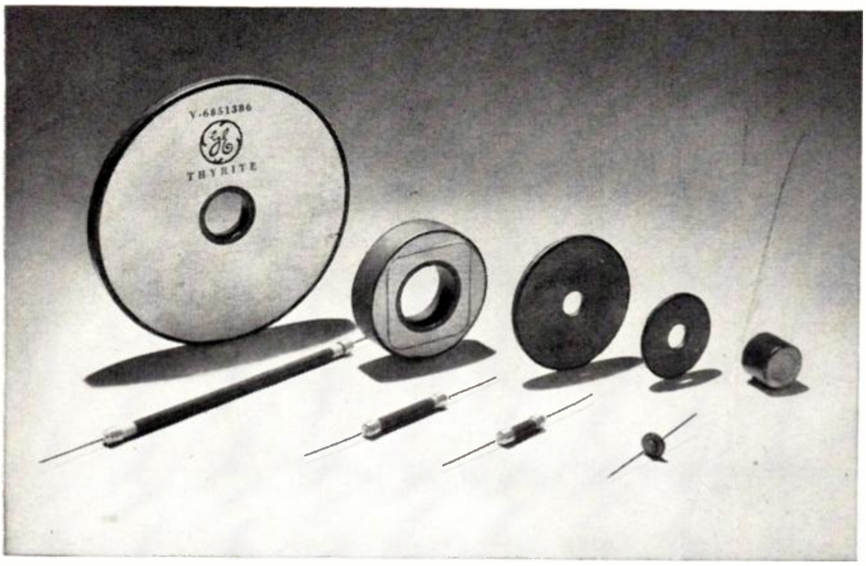
RAYTHEON MANUFACTURING COMPANY
Waltham 54, Massachusetts

EQUIPMENT DIVISION
POWER TUBE DIVISION
RECEIVING TUBE DIVISION
RESEARCH DIVISION
TELEVISION AND RADIO DIVISION

booths 145–147–149

DESIGNER'S

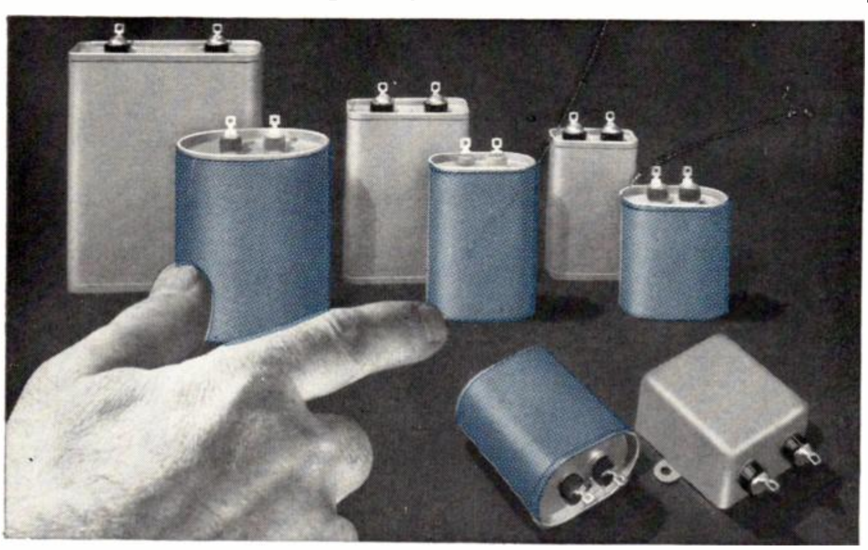
Thyrite* resistance material offers new answer to many circuit problems



Here's a silicon-carbide ceramic material, dense and mechanically strong, having non-linear resistance in which I varies as E^n—the current varies as a power of the applied voltage. General Electric Thyrite resistance characteristic is stable and substantially independent of polarity or frequency. Because of this notable electrical property, it has solved many important circuit problems in electronic applications. Available in disk-type, rod-type, or miniature resistors, Thyrite material can also be successfully molded to meet your special needs. Unaffected by pressure or vibration, it can operate in temperatures up to 150 C. Its special coating compound minimizes the effect of humidity. See Bulletin GEA-4138.

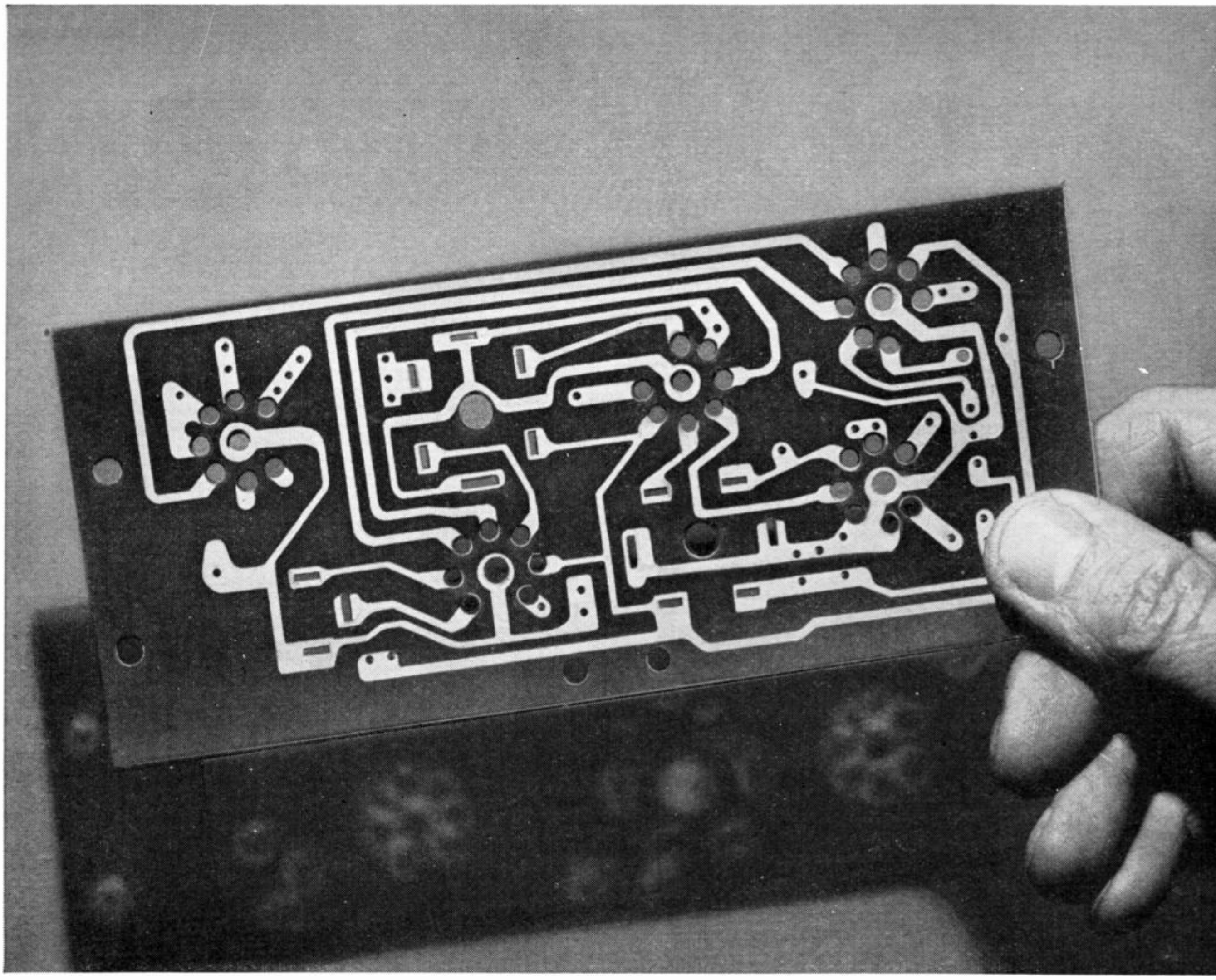
**Reg. Trade-mark of the General Electric Company.*

Drawn-oval capacitors reduce size, weight, and cost of your equipment



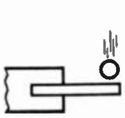
This full line of General Electric paper-dielectric capacitors features size and weight reductions up to 30 percent! They are also mechanically stronger than conventional types because of their drawn-steel containers with cover attached by double-rolled seam. You get space and cost savings plus improved reliability. Moreover, shipments arrive faster. Sturdy brackets offer versatility of mounting. Dual-rated (both a-c and d-c), these versatile capacitors are designed to replace styles CP 53 and CP 70, in ratings from 1 to 10 muf, 600 to 1500 volts d-c and 330 to 660 volts a-c. For more information check Bulletin GEA-5777.

GENERAL ELECTRIC



Pattern of things to come

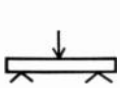
IN ADDITION TO THE PROPERTIES ALREADY MENTIONED IN THE ADVERTISEMENT, SYNTHANE HAS



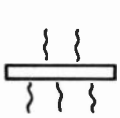
1. Impact strength. Synthane stands up in mechanical applications where jolts, jars and light shock loads are common. It does not splinter or break readily; will not delaminate.

2. Tensile strength. Synthane is strong in tension and compression.

3. Light weight. Synthane has approximately half the weight of aluminum.



4. Flexural strength. Synthane is suitable for jobs where deflexion, torsion and vibration are present. It has excellent fatigue resistance.



5. Stable Over Wide Temperature Range. Synthane is thermosetting; does not flow as temperature rises, has a low coefficient of thermal expansion.

Here is one of the brightest ideas in electronics—and one of the materials which helped make it possible. The idea is the printed circuit; the material is a laminated plastic called *Synthane.*

For years radio sets were put together by laboriously soldering a forest of wires to terminals. It was a time-consuming and expensive operation. If one connection proved faulty, the whole assembly had to be rechecked.

Then someone came up with the idea of *printing* the circuit with an acid-resisting ink on foil bonded to a base—and etching away the metal not needed. It would be quick, easy and error-proof—if the right base material could be found.

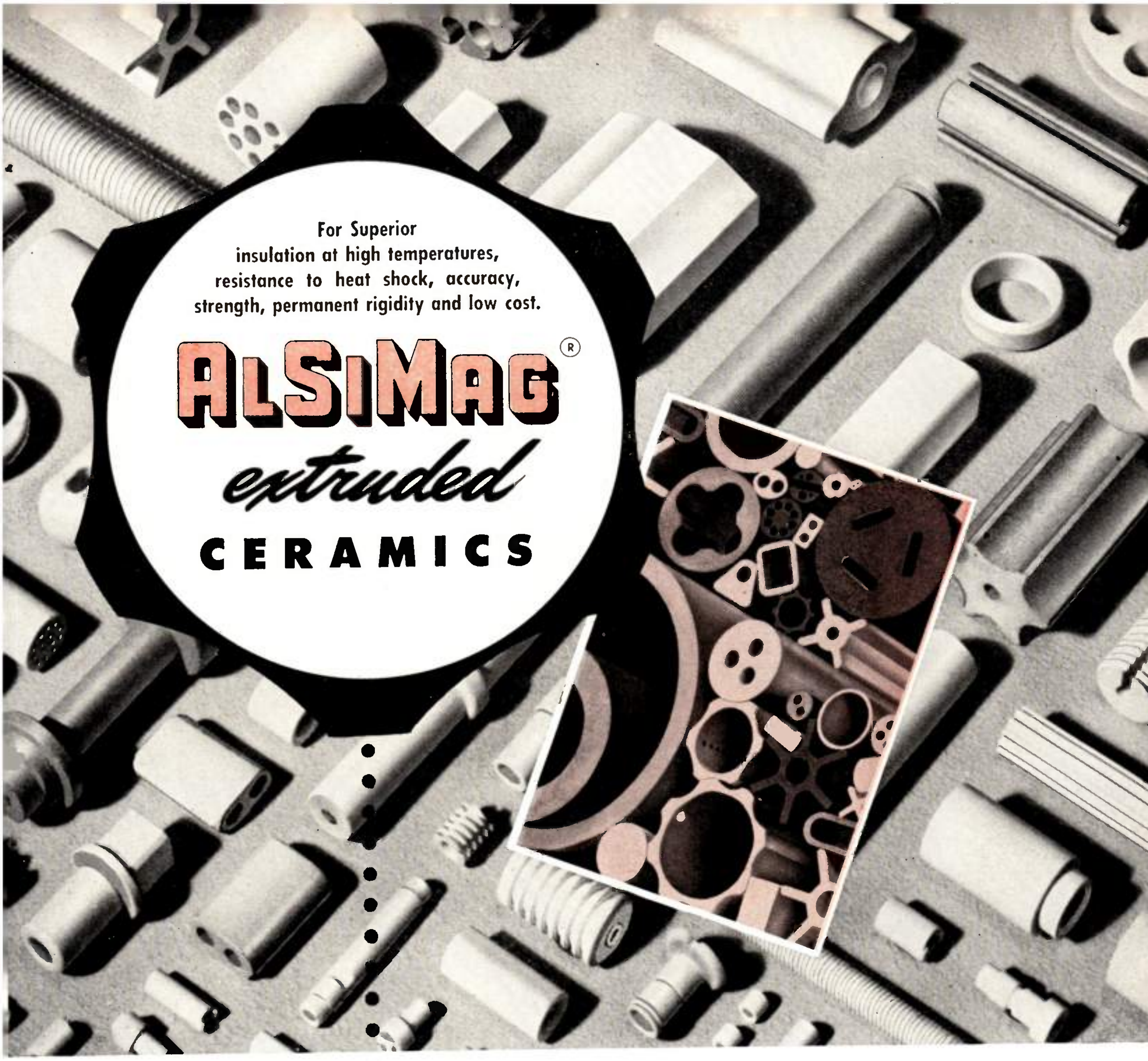
Among many tested, *Synthane* was one sheet material selected. Synthane has the necessary strength, low moisture absorption, is an excellent insulator and can be punched easily. It bonds securely to metal foil and withstands the etching acid used to remove the excess metal.

The printed circuit is still in development—but it has zoomed into favor for radio, TV, hearing aids, and many other electronic devices. There are now a dozen ways to produce what are still called "printed" circuits. And Synthane is an accepted base material for every one of them.

Synthane laminated plastics are available in a variety of grades and colors—in sheets, rods, tubes, and fabricated parts. You are invited to write for information to Synthane Corporation, 8 River Road, Oaks, Pa.

SYNTHANE CORPORATION, OAKS, PA.

SYNTHANE LAMINATED S PLASTICS



If you will give us details of your requirements our engineers will be glad to submit suggestions without cost or obligation. Try AlSiMag ceramics for best results at low cost.

AlSiMag ceramics can be extruded in uniform cross sections in almost any design. These extruded sections can then be sawed and economically machined before firing. This is the fastest and best way to produce many shapes which seem complex but which are actually quite practical and economical . . . AlSiMag ceramics are not affected by normal operating temperatures of electrical appliances and do not rust, corrode or carbonize. They are uniform physically and dimensionally, are totally and permanently rigid and do not deteriorate with time.

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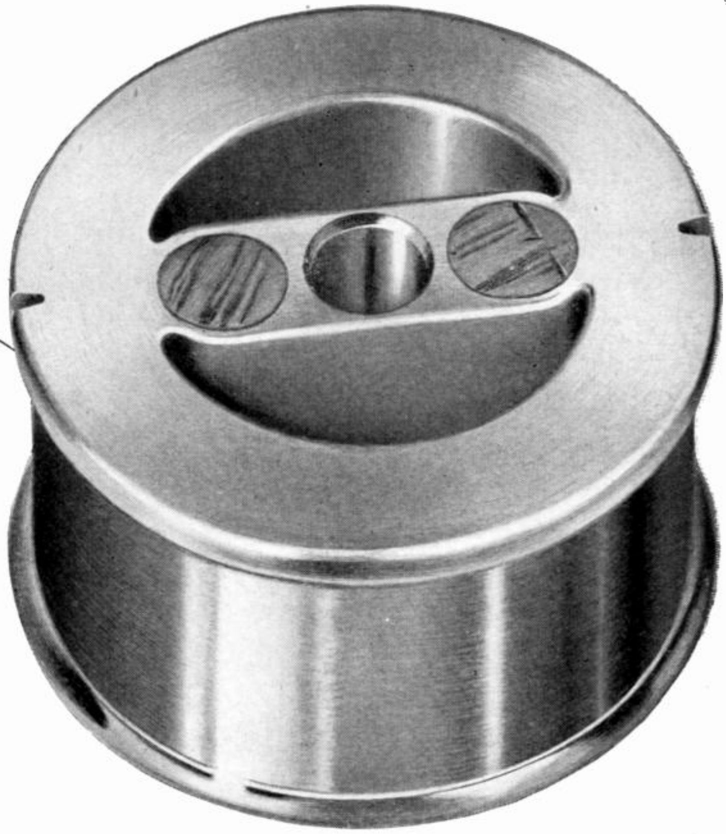
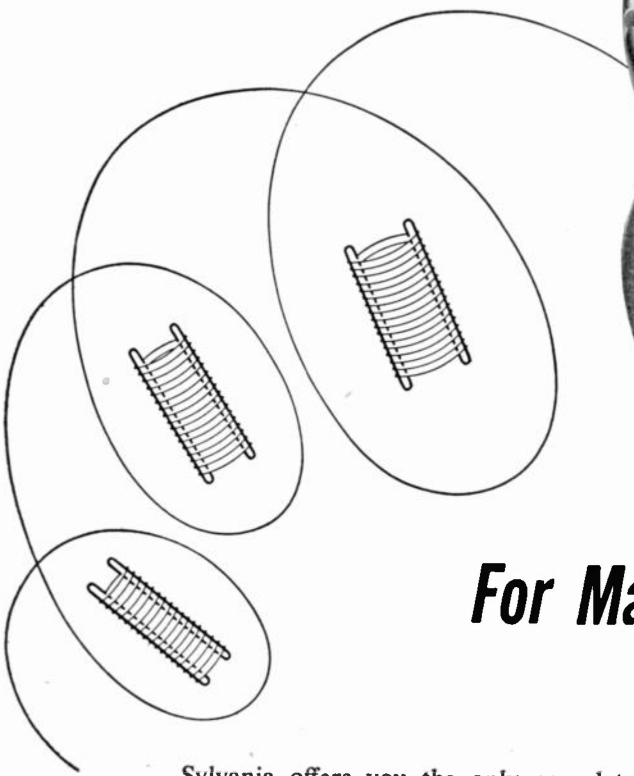
Choose Sylvania PLATED GRID WIRES...





For Maximum Performance . . . Minimum Shrinkage

Sylvania offers you the only complete line of plated grid wires . . . made to meet the most exacting requirements of tube manufacturers. Only Sylvania controls the physical properties of both the basic wire and the finished plated wire.

Here are tungsten wires, molybdenum wires, 50-50 tungsten and molybdenum, and D-nickel, in a full range of sizes plated with either gold, rhodium, silver, or nickel.

From this complete line, Sylvania can furnish tube manufacturers plated grid wire of the proper combination of materials necessary for peak performance and minimum shrinkage for any tube type.

Precision manufactured and quality controlled through drawing and plating, Sylvania wires have the characteristics known to be needed for producing the world's finest radio tubes. For full information, write to Sylvania, Dept. 4T-3103, today!

Sylvania employs the most critical test equipment to assure that physical characteristics are held within precise limits. Above is the Instron Tester which registers tensile strength, elongation and yield.

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Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

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New! A low-cost

MARKER GENERATOR

for PRD's VHF-UHF Sweep Frequency Generator

The Type 909 Marker Generator—precision engineered by PRD—provides frequency markers of crystal accuracy, which are added electronically to the response pattern. This is accomplished by connecting the Marker Generator to a special marker injection circuit in PRD's Type 907 Sweep Frequency Oscillator.

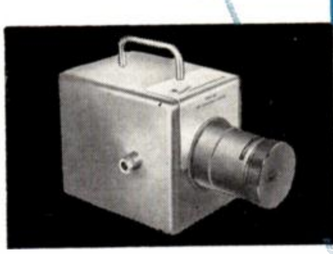
UHF Frequency Meter Type 587 provides a method of accurate absolute frequency measurement in the UHF range.

TYPE 909 CRYSTAL MARKER GENERATOR

GENERATOR: Crystal Oscillator, Harmonic Amplifiers
OUTPUT: 2, 10 or 50 mc/s (±.01%) markers up to 2000 mc/s
OUTPUT CONTROL: Marker amplitude continuously adjustable
OUTPUT IMPEDANCE: Both high and low
RADIATION: Low

TYPE 907 SWEEP FREQUENCY GENERATOR

WIDE RANGE: 40 to 900 mc/s
WIDE SWEEP: At least 40 mc/s for UHF
HIGH OUTPUT: At least 0.3 volts over entire range
OUTPUT IMPEDANCE: 50 or 75 ohms
LOW RADIATION: 10 μv or less



TYPE 587 FREQUENCY METER

CAVITY TYPE METER: May be connected as Reaction or Transmission Type
FREQUENCY RANGE: 400-1000 mc/s
ACCURACY: ±0.2%
Q FACTOR: Approx. 1000 (not less than 600)
READING: Direct

Complete data and specifications will be forwarded promptly upon request to Department R-3.

See the Complete Line at the I.R.E. Show
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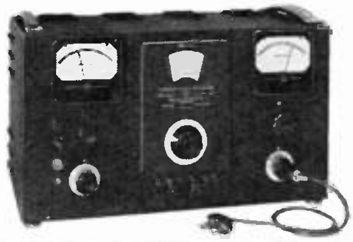
MEASUREMENTS CORPORATION

Laboratory Standards

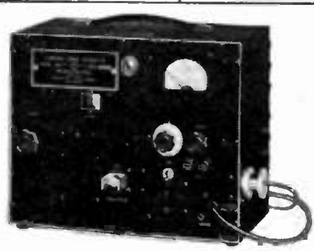
STANDARD SIGNAL GENERATOR MODEL 65-B

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
75 Kc.—30 Mc.	0.1 microvolt to 2.2 volts	AM. 0 to 100% 400 cycles or 1000 cycles External mod., 50-10,000 cycles



STANDARD SIGNAL GENERATOR MODEL 78

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
15-25 Mc.; 195-225 Mc. 15-25 Mc.; 90-125 Mc. Other ranges on order	1 to 100,000 microvolts	AM. 8200-400 cycles 625—400 cycles Fixed at approximately 30%

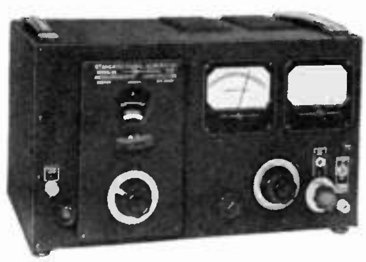


STANDARD SIGNAL GENERATOR MODEL 78-FM

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
86 Mc.—108 Mc.	1 to 100,000 microvolts	Deviation 0-300 Kc 2 ranges FM. 400-8200 cycles External mod to 15 Kc

STANDARD SIGNAL GENERATOR MODEL 80

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
2 Mc.—400 Mc.	0.1 to 100,000 microvolts	AM. 0 to 30% 400 cycles or 1000 cycles External mod., 50-10,000 cycles



STANDARD SIGNAL GENERATOR MODEL 82

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
20 cycles to 200 Kc. 80 Kc. to 50 Mc.	0-50 volts 0.1 microvolt to 1 volt	Continuously variable 0-50% from 20 cycles to 20 Kc.

STANDARD SIGNAL GENERATOR MODEL 84

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
300 Mc.—1000 Mc.	0.1 to 100,000 microvolts	AM 0 to 30%, 400, 1000, or 2500 cycles. Internal pulse modulator. External mod., 50-30,000 cycles.

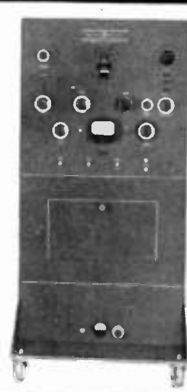
STANDARD SIGNAL GENERATOR MODEL 84-TV

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
300 Mc to 1000 Mc	Continuously variable from 0.1 microvolt to 1 0 volt	Continuously variable 0 to 30% External modulation 20 to 20,000 cycles.

STANDARD SIGNAL GENERATOR MODEL 90

FREQUENCY RANGE	OUTPUT RANGE
20 Mc.—250 Mc	0.3 microvolt to 0 1 volt

MODULATION
Continuously variable, 0 to 100% Sinusoidal modulation 30 cycles 5 mc. Composite TV modulation.



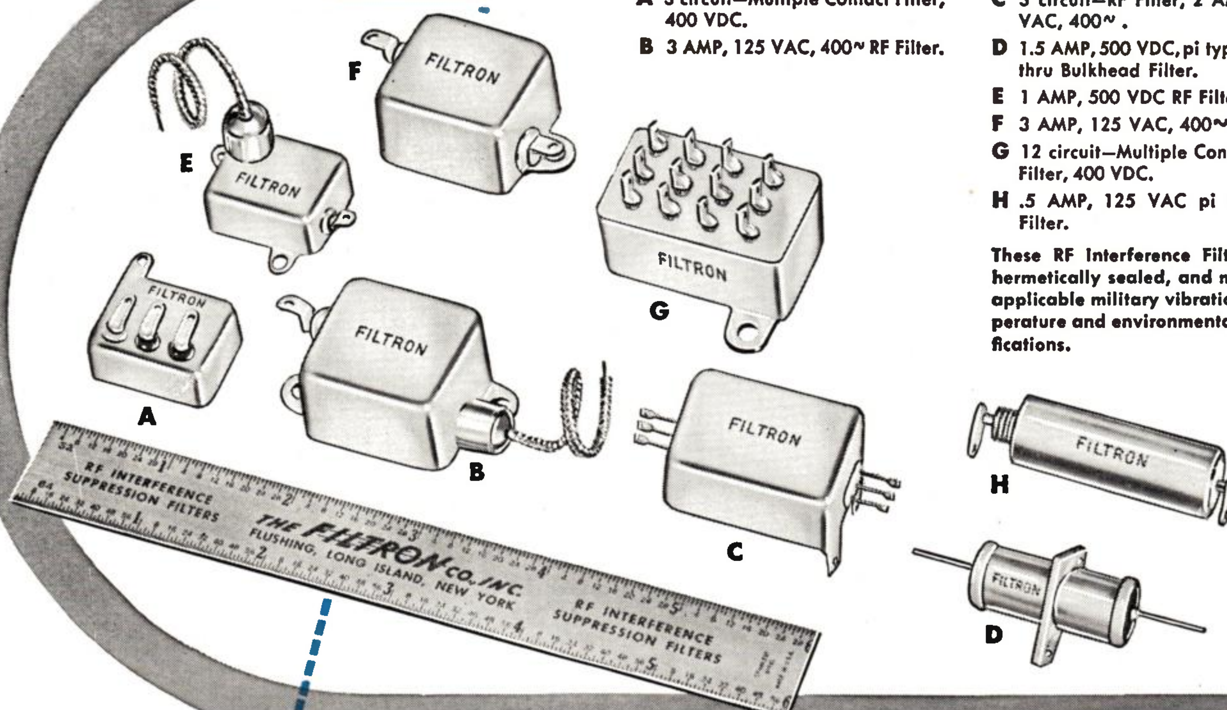
MEASUREMENTS CORPORATION BOONTON, N. J.

See Us at Booth 749, Airborne Avenue, I.R.E. Show

"INTERFERENCE FREE" means FILTERED by FILTRON

A 3 circuit—Multiple Contact Filter, 400 VDC.
B 3 AMP, 125 VAC, 400~ RF Filter.
C 3 circuit—RF Filter, 2 AMP, 125 VAC, 400~.
D 1.5 AMP, 500 VDC, pi type Feed-thru Bulkhead Filter.
E 1 AMP, 500 VDC RF Filter.
F 3 AMP, 125 VAC, 400~ Filter.
G 12 circuit—Multiple Contact Filter, 400 VDC.
H .5 AMP, 125 VAC pi type RF Filter.

These RF Interference Filters are hermetically sealed, and meet the applicable military vibration, temperature and environmental specifications.



Representative subminiature, high attenuation, hermetically sealed R.F. Interference Filters for space saving, simple installation and light weight applications.

THE newest types of Interference-Free Radar, Interference-Free Radio Transmitters, Interference-Free Receivers, Interference-Free Motor-Generator Sets, Interference-Free Inverters, Interference-Free Aircraft, Interference-Free Electronic Systems and numerous other "restricted" equipments incorporate FILTERS BY FILTRON.

Our complete engineering and manufacturing organization is devoted exclusively to the research, design and production of RF interference filters to make YOUR products noise-free.

The Filtron Company is a complete engineering and manufacturing organization that pioneered the development of special filter types: subminiatures, high attenuation, completely hermetically sealed, high altitude, high temperature and wide-band multi-section units. Today we are producing more filters than ever before.

ENGINEERING: FILTRON'S highly specialized filter engineers will discuss, test, and design RF filters to make your products "noise-free". They will meet with you at your plant, or in our own shielded laboratories.

TEST & DEVELOPMENT: FILTRON'S test and development facilities are equipped with ALL interference-measuring and test equipment, in strict accordance with all Military Specifications.

MANUFACTURING: FILTRON'S modern production facilities comprise the following departments: Capacitor Manufacturing Division • Coil Winding Division • Tool and Die Departments • Environmental Test Department • Metal Drawing, Fabricating and Stamping Departments.

WHEN YOU HAVE A RF FILTER PROBLEM, CONSULT FILTRON—THE MOST DEPENDABLE NAME IN RF INTERFERENCE FILTERS.

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An inquiry on your company letterhead will receive prompt attention.

INTERFERENCE FREE means FILTERED by

FILTRON CO., INC. • FLUSHING, LONG ISLAND, NEW YORK

LARGEST EXCLUSIVE MANUFACTURERS OF RF INTERFERENCE FILTERS

Visit Our Booth 649 Circuits Avenue at the I.R.E. Show

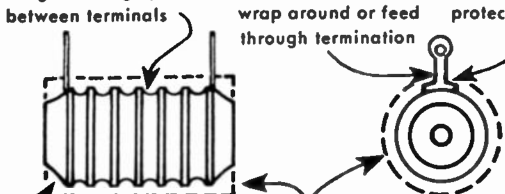
WHAT ABOUT Encapsulated PRECISION WIREWOUND RESISTORS?

Engineers, buyers, and purchasing agents during the past year have had thrust upon them something new to consider in the precision wirewound resistor field. Verbally and through the medium of advertising it has been relentlessly stated that encapsulated resistors exceed and surpass MIL-R-93A and JAN-R-93 specifications, but frequently without proof of performance. Quite to the contrary, there have been production difficulties, overnight changes in encapsulating materials, and reluctance to reveal just what these encapsulation materials were. As evidenced by previous messages in this series, Shallcross believes it better to reveal than conceal!

The bobbins and the coating in Shallcross "P" type wirewound encapsulated resistors are the same mineral filled, pigmented epoxy resin. The material is "hot" curing, which simply means that it cures at a much higher temperature than "cold" resin. Some "cold" resin resistors now on the market have one major failing, they become deformed after temperature cycling. Shallcross encapsulated resistors remain unaffected.

The efficient Shallcross encapsulation results in a sealed resistor with a physical configuration (see sketch) providing maximum winding area and leakage paths, minimum size and weight, and aesthetically, retention of the visual identity of a precision wirewound resistor. The seal of Shallcross "P" type resistors cannot be broken by flexure of the lugs. The lugs are designed so that excessive flexure will result in bending of the lug *outside* of the encapsulation.

Shallcross "P" type encapsulated resistors pass military qualification approval tests easily and are the only resistors to date to pass the more stringent qualification approval tests of a leading eastern manufacturer of electronic equipment. This test requires 24 temperature cycles from −65°C to



+100°C as compared with only 5 cycles from −55°C to +85°C required by MIL-R-93A. In qualification approval tests more rigid than MIL-R-93A, another leading eastern airborne electronic manufacturer reports that Shallcross "P" type resistors passed all tests without failure. Three other manufacturers tested had from one to nine failures in each test.

The "P" type sealed resistors are unquestionably the most outstanding development in sealed precision wirewound resistors since Shallcross patented the sealed-in steatite "1100" series in 1945. Both the old "1100" series and the new lower cost "P" types pass the immersion cycling tests of JAN-R-93, Characteristic A.

Test data, available styles and ratings for Shallcross "P" type resistors are yours for the asking.

Write for Engineering Bulletin L-30.

1929 Our twenty-fifth year 1954

SHALLCROSS MANUFACTURING COMPANY • 524 PUSEY AVENUE, COLLINGDALE, PA.

The fifth of a series to promote a better understanding of the performance characteristics of precision wire-wound resistors.

Visit our Booths at the I.R.E. Show—559-561 Components Avenue

AXIAL LEAD ENCAPSULATED RESISTORS

Ideal where space and weight are at a premium, these resistors have securely anchored leads that cannot break the seal. Available in five sizes, including several that conform to MIL-R-93A style RB52.

LUG TYPE ENCAPSULATED RESISTORS

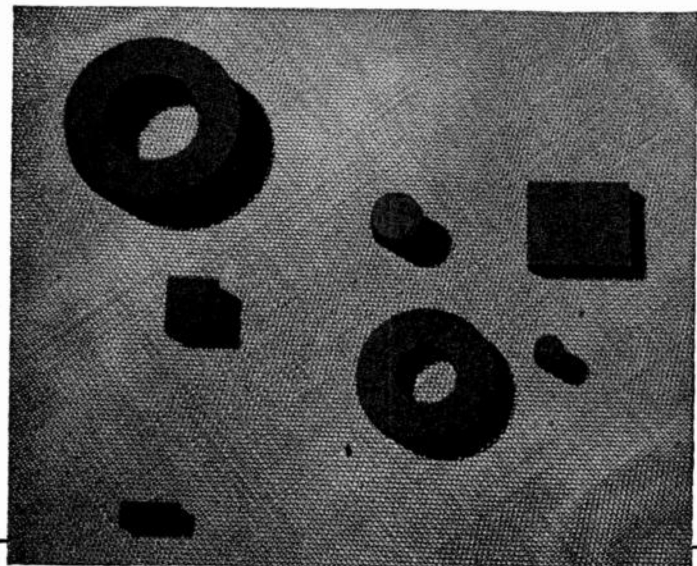
Available in all MIL-R-93A styles with commercial ratings to 3.5 watts, Shallcross "P" type resistors are suitable for 125°C operation.

Our twenty-fifth year

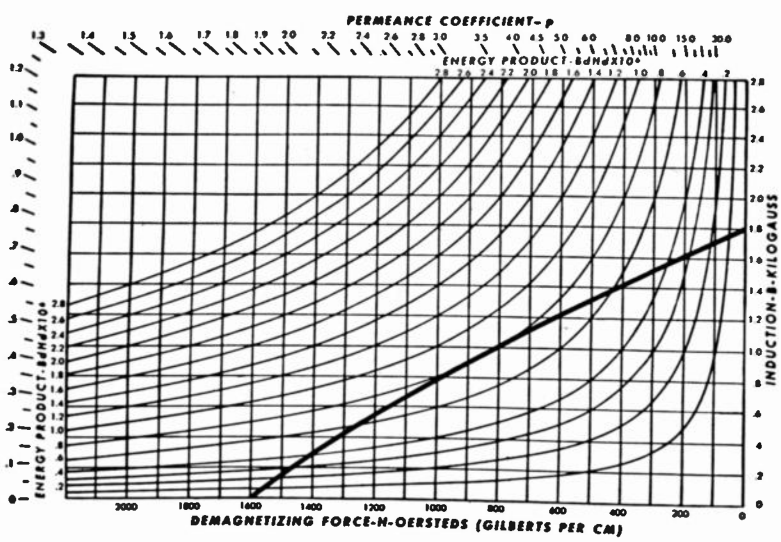
Shallcross

Presenting INDOX I . . . A

NEW CERAMIC PERMANENT MAGNET



▲ Typical INDOX I Permanent Magnets



▲ Demagnetization and Energy Product Curve for INDOX I

. . . Opens New Fields for Product Designs

INVESTIGATE THESE CHARACTERISTICS

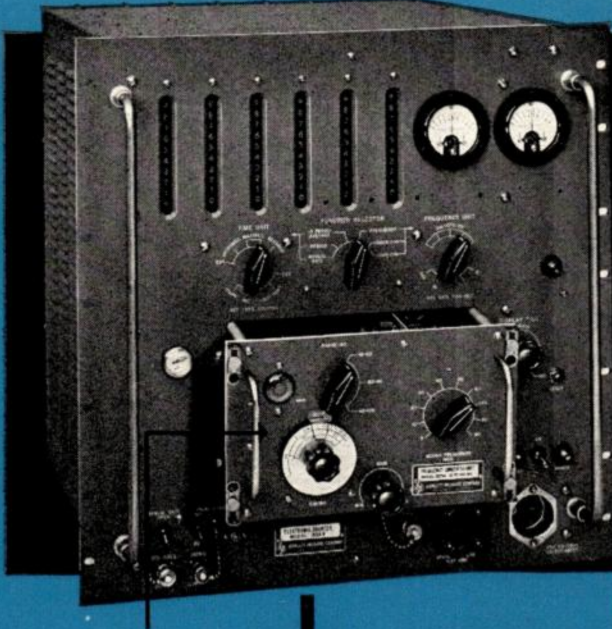
- Higher coercive force than any other commercial permanent magnet material.
- Negligible hysteresis and eddy-current losses in magnetic circuits having an alternating-current component.
- High electrical resistivity.
- No critical materials required.
- Lightweight.
- Magnetization practical prior to assembly.

Let our forty-three years of accumulated permanent magnet experience help you to utilize this new magnet in your products. Write to Dept. 3G for complete details.

INDIANA PERMANENT MAGNETS

THE INDIANA STEEL PRODUCTS COMPANY • VALPARAISO, INDIANA

WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS



Frequency 10 cps to 200 mc
Interval 1 μsec to 100 days
Period 0 cps to 10 kc

measured instantly, automatically, directly by the revolutionary new...

-hp- 525A Frequency Converter

-hp- 525B Frequency Converter

-hp- 526A Video Amplifier

-hp- 526B Time Interval Unit

-hp- 524B ELECTRONIC COUNTER

Why buy more instrumentation than you need? The new all-purpose *-hp-* 524B Electronic Counter with Plug-In Units gives you *precisely* the frequency, time interval or period measuring coverage you want now. Later, you can add other inexpensive plug-in units to double or triple the usefulness of the Counter.

Model 524B offers direct, instantaneous, automatic readings requiring no calculation, interpolation or complex instrument set-up. It has high sensitivity, high impedance, and its operation is so simple and dependable it can be used readily by non-technical personnel. Resolution is 0.1 μsec, and accuracy is 1/1,000,000 ± 1 count. Construction throughout is of highest quality components in a compact militarized design.

The new Counter with Plug-In Units gives you more range, more convenience, smaller size and lower cost than any commercial instrument combination ever offered. With this one compact equipment, you readily measure transmitter and crystal oscillator frequencies, time intervals, pulse lengths, repetition rates, frequency drift; make high accuracy ballistics time measurements or high resolution tachometry measurements, or use as a precision frequency standard giving convenience and flexibility not provided in the usual primary standard.

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

BASIC COUNTER

The basic *-hp-* 524B Counter unit measures frequency from 10 cps to 10 mc with accuracy of ± 1 count ± stability, reading direct in kc; or measures period from 0 cps to 10 kc with accuracy of ± 0.3% reading direct in seconds, milliseconds or microseconds. Eight-place registration, short term stability 1/1,000,000, display time variable 0.1 to 10 seconds. $1,890.00

COUNTER WITH PLUG-IN UNITS

***-hp-* 525A Frequency Converter** extends Counter's range to 100 mc, maintains accuracy, and increases Counter's video sensitivity to 0.1 volts through basic 10 cps to 10 mc range. $225.00

***-hp-* 525B Frequency Converter** like 525A but extends Counter's range to 200 mc at 0.25 volts sensitivity. $225.00

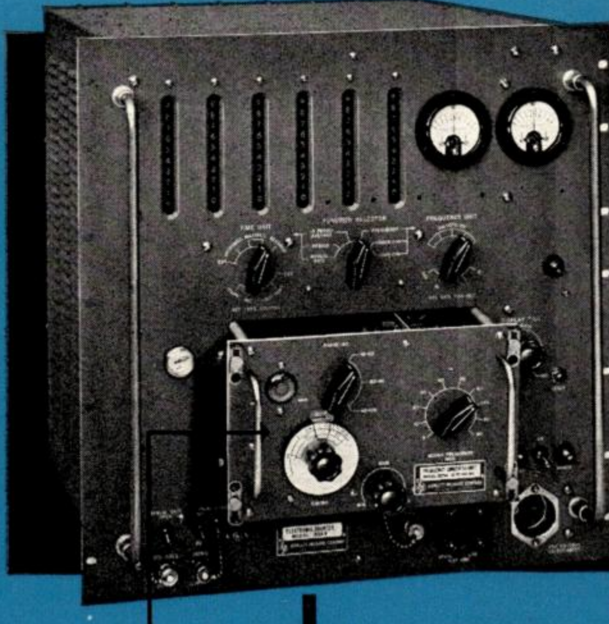
***-hp-* 526A Video Amplifier** increases Counter sensitivity between 10 cps and 10 mc to 10 millivolts for low level frequency measurement. $125.00

***-hp-* 526B Time Interval Unit** measures interval 1.0 μsec to 100 days with accuracy of 0.1 μsec ± 0.001%, reading direct in seconds, milliseconds or microseconds. Start, stop triggering in common or separate channels, through positive or negative going waves. $150.00 (Plug-in units supplied in aluminum storage case).

Request complete details today from your -hp- Field Representative, or write direct

HEWLETT-PACKARD COMPANY
2998D Page Mill Road • Palo Alto, California, U.S.A.

hp at I.R.E. Corner INSTRUMENTS AVENUE and RADIO ROAD



Frequency 10 cps to 200 mc
Interval 1 μsec to 100 days
Period 0 cps to 10 kc

measured instantly, automatically, directly by the revolutionary new...

-hp- 525A
Frequency Converter

-hp- 525B
Frequency Converter

-hp- 526A
Video Amplifier

-hp- 526B
Time Interval Unit

-hp- 524B ELECTRONIC COUNTER

Why buy more instrumentation than you need? The new all-purpose *-hp-* 524B Electronic Counter with Plug-In Units gives you *precisely* the frequency, time interval or period measuring coverage you want now. Later, you can add other inexpensive plug-in units to double or triple the usefulness of the Counter.

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Request complete details today from your -hp- Field Representative, or write direct

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2998D Page Mill Road • Palo Alto, California, U.S.A.

hp® at I.R.E. Corner INSTRUMENTS AVENUE and RADIO ROAD

STACKPOLE Ceramag® CORES
(Ferromagnetic)

for real uniformity! Wherever ferromagnetic cores are used, Stackpole Ceramag Cores have set the quality standards. But proved superiority in essential characteristics is only part of the story. Even more important is the fact that Stackpole Ceramag core characteristics are maintained with remarkable uniformity regardless of size, shape or production quantity. *The sample matches your specification "on the nose"—and each production unit is exactly like the sample!* Write for Ceramag Bulletin RC-9A including details on available grades and latest characteristic curves.

STACKPOLE Molded COIL FORMS

Cut Assembly Costs!

You can reduce coil sizes and cut assembly costs with simplified point-to-point wiring and fewer soldered connections with these Stackpole molded coil forms. Types available with iron core sections. Axial or "hairpin" leads. Write for Catalog RC-9.

STACKPOLE Slide SWITCHES

. . . the economy switches of 1001 uses!

Over 20 types of these inexpensive little Stackpole slide switches cover just about every mechanical and electrical switching requirement for radio and television equipment, small motors, appliances, electrical toys, instruments, etc. For complete details, write for Stackpole Switch Bulletin RC-9B.

Engineering Samples are proof of the pudding!

Engineering samples of standard Stackpole components are available to quantity users. Send details of your requirement for recommendation by Stackpole engineers.

ELECTRONIC COMPONENTS DIVISION

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

STACKPOLE

A NEW TERMINATION TECHNIQUE FOR . . .

- BUSINESS MACHINES
- COMPUTERS
- CONNECTOR PLUGS
- MULTI-CIRCUIT COMPONENTS
- SIGNAL APPARATUS
- PRINTED CIRCUITS

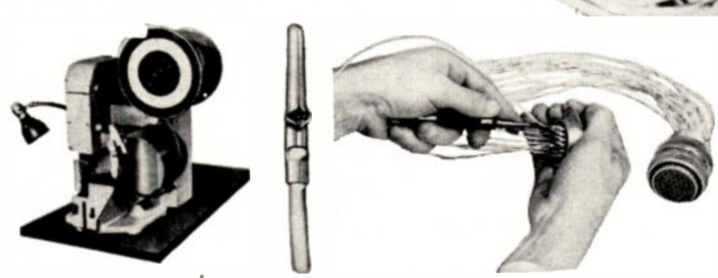
AMP ROUND TAPER PINS

At The IRE Show
AMP Booth 770-2
Airborne Ave.

Here at last is a connector which combines miniature size and self-locking action! To make electrical connections, simply press AMP Taper Pins into mating receptacles. The pins are almost as small as the wire itself, yet when securely inserted will maintain their connection even up to the point of wire failure. Salt spray and vibration tests show initial contact resistances of only 0:5 to 1.0 milliohms increasing to a maximum of 2.63 milliohms after 160 hours of cycling.

New applications are being found every day for these versatile connectors—over a billion pins are in the field in computers and associated business machines alone!

Uses include termination of printed circuits, speaker disconnects, UHF antennae filters and tuners, Germanium diodes and TV high voltage fuses etc. Extraordinary security under vibration makes them excellent for attaching wires to crowded multiple contact "AN" connectors in aircraft. Write for "TAPER TECHNIQUE" Folder.



AMP Taper pins, rolled from strip stock to very close tolerances, are wound on reels ready for use in AMP Automatic Wire Terminators. Pins can be applied as fast as operator can insert wire with speeds reported as high as 4,000 per hour! Spring type installation tool will seat pins firmly in mating receptacles.

AMP

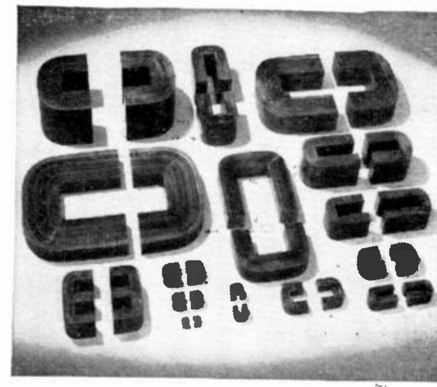
AMP Trade Mark Reg. U.S. Pat. Off. © AMP

AIRCRAFT-MARINE PRODUCTS, INC.
ELECTRONICS DIVISION
2100 Paxton Street, Harrisburg, Pa.

Aircraft-Marine Products of Canada, Ltd.
1764 Avenue Rd., Toronto 12, Ontario, Canada

ARNOLD MAGNETIC MATERIALS

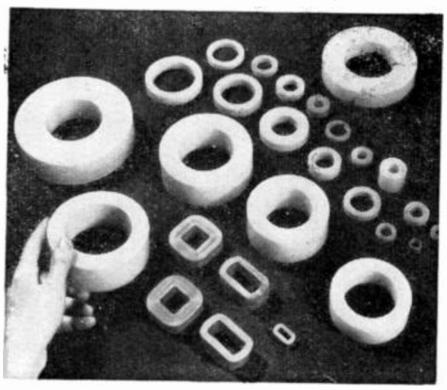
TYPES "C" AND "E" CUT CORES



Arnold "C" and "E" Cores are made from precision rolled Silectron strip (highly oriented silicon steel) in 1, 2, 4 or 12-mil thicknesses and a wide variety of window sizes and core areas, for high and low-frequency applications. Sizes range up to 10 lbs. in 12-mil strip, and from fractions of an ounce to hundreds of pounds in the thinner gauges. Cores wound from ultra-thin strip (down to ¼ mil or less) can also be supplied.

Insulated strip of the proper width is wound on a mandrel, then heat treated, bonded and cut into halves. Careful control results in accurately dimensioned and matched core halves whose effective air gap at the butt joint is very small.

In 3-phase applications, the use of "E" Cores provides weight and size reduction, as well as higher efficiency and possible cost savings. Rigid standard tests are employed for both "C" and "E" types of cores, and special tests where required.



TAPE WOUND CORES

Depending upon the specific properties required, Arnold Tape Wound Cores are available made of Deltamax, 4-79 Mo-Permalloy, Supermalloy, Mumetal, 4750 Electrical Metal, or Silectron . . . in standard tape thicknesses of 1, 2, 4 or 12-mils, and in ultra-thin gauges of ½ and ¼-mil where required.

Practically any size core can be supplied, from a fraction of a gram to hundreds of pounds. Toroidal cores are made in 22 standard sizes with protective nylon cases. Special sizes of toroidal cores, and all square or rectangular Tape Wound Cores, are manufactured to meet individual requirements.

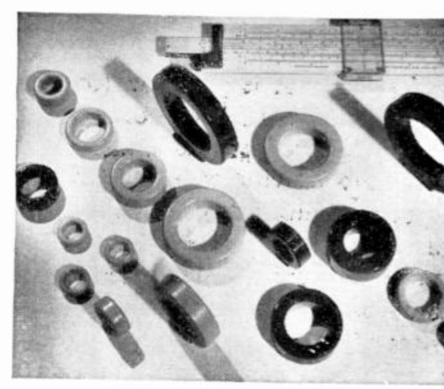
Used for magnetic amplifiers, pulse transformers, current transformers, wide-band transformers, non-linear retard coils, peaking strips, reactors, etc., this gapless type of core construction results in maximum effective working permeability with minimum flux leakage.

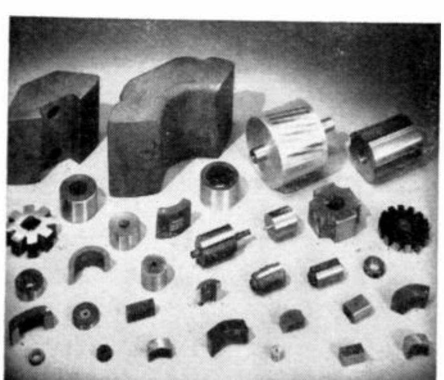
MOLY-PERMALLOY POWDER CORES

For use in loading coils, filters, broadband carrier systems and networks, for frequencies up to 200 kc, these Toroids provide high Q in a small volume, and are characterized by low eddy current and hysteresis losses.

Arnold Powder Cores are supplied in four standard permeabilities: 125, 60, 26 and 14 Mu. They provide constant permeability over a wide range of flux density. The 125 Mu cores are recommended for use up to 15 kc; the 60 Mu at 10 to 50 kc; the 26 Mu at 30 to 75 kc; and the 14 Mu at 50 to 200 kc. Many of these cores may be furnished stabilized to provide constant permeability (±0.1%) over a specific temperature range.

These Moly Permalloy Powder Toroids are available in a wide range of sizes, to obtain nominal inductances as high as 281 mh/1000 turns. They are given various types of enamel and varnish finishes, some of which permit winding with heavy Formex insulated wire without supplementary insulation over the core.





ALNICO MAGNETS

Arnold manufactures permanent magnets from all grades of Alnico, although Alnico V is usually the preferred type due to the high value of energy product of that alloy. Alnico Magnets are quite hard and somewhat brittle and may be machined only by grinding. Most sizes and shapes are manufactured as sand castings and are made to the customer's drawings and specifications. Some types and shapes of Alnico Magnets are carried as stock items.

Some small sizes of magnets may be furnished in sintered Alnico, but special shapes made in this way require rather expensive dies.

Stock sizes of all the products above are listed in Catalog GC-106. Write for your copy . . . but if you're attending the IRE show this year, see us at Booth 148.

W&D 4889

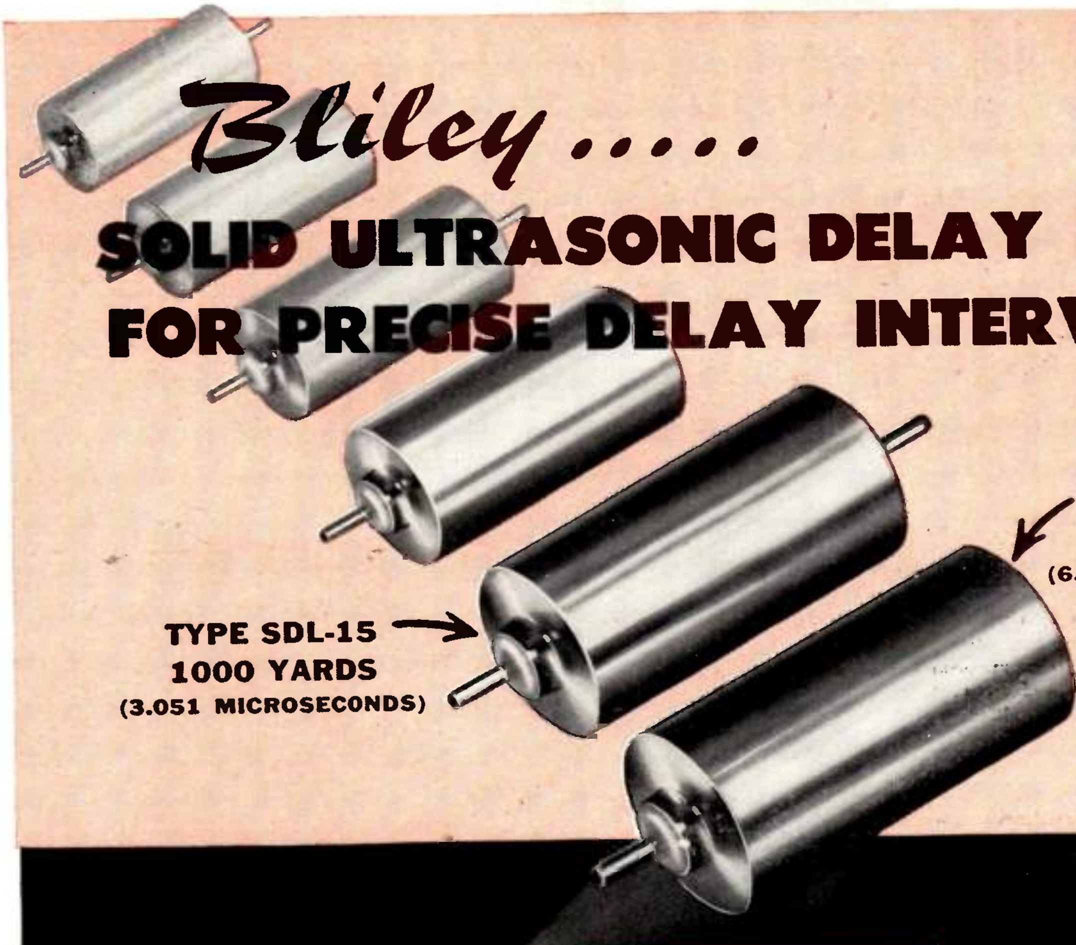
THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

General Office & Plant: Marengo, Illinois — New York: Empire State Bldg. — Boston: John Hancock Bldg. — Los Angeles: 3450 Wilshire Blvd.

Bliley .....

SOLID ULTRASONIC DELAY LINES FOR PRECISE DELAY INTERVALS



STANDARD MODELS

For

1000 or 2000 YARD MARKER USE . . . .

DESCRIPTION

Frequency 30 mc
Hermetically Sealed Case
Attenuation 26 db into 1000 ohms
Bandwidth 8 mc

Bliley Type SDL-15 (Double Ended)
Bliley Type SDL-16 (Single Ended Ringing Type)

CUSTOM BUILT

For

ANY DELAY INTERVAL IN RANGE

2-2500 MICROSECONDS

FEATURES

Frequency Range 5 - 100 mc
Low Attenuation
Low Spurious Response
Low Temperature Coefficient
Wide Bandwidth

For technical details concerning both custom built and standard models ask for Bulletin #45-A.

Bliley CRYSTALS

BLILEY ELECTRIC COMPANY
UNION STATION BLDG., ERIE, PENNSYLVANIA

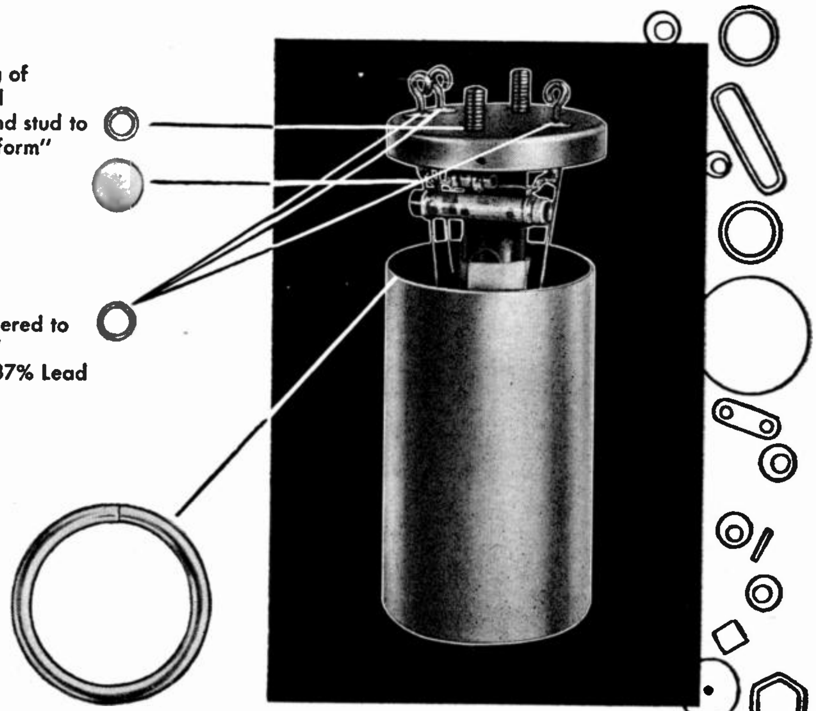
Visit us at Booth 585, Components Avenue

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

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

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

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



MAKES MANY TOUGH JOBS SIMPLE

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

KEY TO LOWERED PRODUCTION TIME

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

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

WRITE TODAY for free samples and literature

KESTER
SOLDER COMPANY

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

See "Solderforms" In Action
521 Components Ave.
IRE Show

Under pressure for

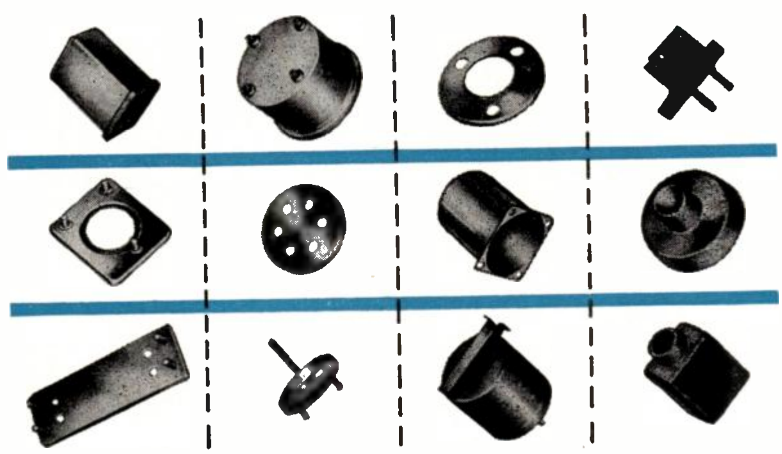
ODD SIZES and SHAPES?

HUDSON

PRECISION DRAWN
CLOSURES
AND QUALITY METAL
STAMPINGS

DEPEND ON HUDSON FOR PRECISION FORMED "SPECIALS" . . . ODD SHAPES AND SIZES AT MASS PRODUCTION PRICES. Hudson standardized production methods make it possible to solve even unusual closure problems quickly, from stock. The Hudson line includes hundreds of stock closures available with a choice of optional features. All parts are precision fabricated from selected metal stocks. Cans, covers and quality metal stampings are available in brass, copper, aluminum and steel.

CONSULT THE HUDSON CATALOG OF STANDARDIZED PARTS! Contains complete specifications on hundreds of different standard catalog items. All are available for fast delivery. Call or write for your copy, now!



HUDSON TOOL AND DIE COMPANY • INC
118-122 SO. FOURTEENTH STREET, NEWARK 7, NEW JERSEY

See Our Exhibit, 472 Electronic Ave., IRE Show

NEWS and NEW PRODUCTS

March 1954

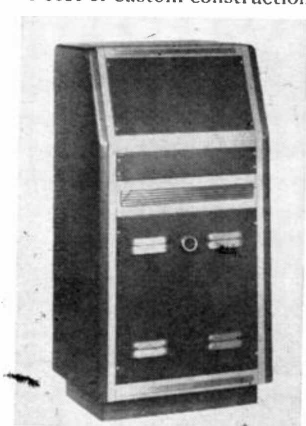
Rack-Mounted Meters

Millivac Instrument Corp., 444 Second St., Schenectady 6, N. Y., announces a new line of rack-mounted vacuum tube voltmeters and ampere meters. These instruments correspond to the older, portable type meters and can be equipped with or without terminals for connection of external indicating instruments and recorders.

The most important of these new meters are the RM-17B dc millivoltmeter lowest range 0–1 mv, 6 megohms input, the RM-18B rf meter, lowest range 0–10 mv, 1 mc to 2,500 mc; and the RM-12A ac voltmeter, lowest range 0–3 mv, 20 cps to 250 kc. In addition, ampere meters and multimeters are available in rack-mounted form. The illustration shows the RM-17B dc millivoltmeter which corresponds to Millivac's MV-17B portable meter.

Flexible Enclosures

The **Elgin Metalformers Corp.,** Liberty St., Elgin, Ill., has introduced a new standard line of flexible enclosures designed to meet custom requirements at up to one-fifth the cost of custom construction.



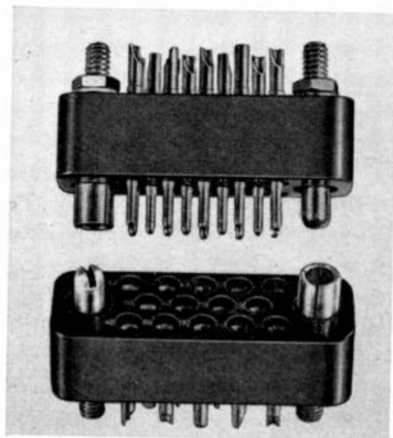
The Emcor System consists of a basic console assembly frame, 21×48×21 inches, with standard RTMA and WE mounting holes on front, top and back. Over 80 lineal inches of insert panel space is available over the frame. Provision is made for ease of wire installation via standard knockouts distributed over top shelf, base, and side of unit. Provision is also made for a key, jack and auxiliary control panel. Any number of these units may be locked together to form a console enclosure to meet the most rigid requirements.

Over 75 component units are available for tailoring a unit or group of units to meet exact requirements. Either plain or ball-cornered side dress panels are available.

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

Miniature Connectors

Announcing its improved VT Series, a line of miniature rectangular connectors, **Viking Electric,** 1061 Ingraham St., Los Angeles 17, Calif., states that the line is designed for ease of assembly and disassembly, and long service life.



VT units are available with 7, 8, 14, 18, 20, 21, 34, and 41 contacts. There is also a 25-contact unit with one high-voltage contact. Polarizing guides are optional and hoods are available for each type unit. Except for the 8-contact unit, all connectors are interchangeable with similar equipment. Socket contacts are spring types. They require no "C" rings, hence there are no rings to remove and replace during disassembly, and no undercutting is needed to seat a "C" ring on the solder-pot side. Elimination of undercutting here strengthens the pin. Pins are removed on the pin side with pliers, and replaced by a simple tool. With these connectors, it is possible to insert insulating sleeving into the insulator on the solder-pot side of both socket and pin contacts since there is no "C" ring to interfere.

Symposium on Automatic Production

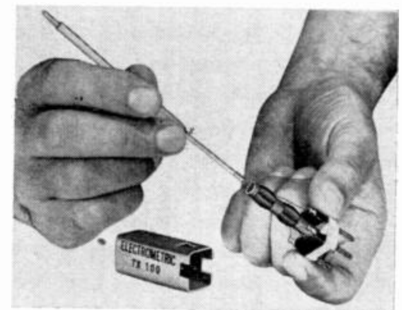
A symposium on the Automatic Production of Electronic Equipment will be held at San Francisco's Fairmont Hotel, April 19–20, 1954.

Joint sponsors are Stanford Research Institute and the United States Air Force.

General chairman of the symposium is L. K. Lee, head of the Advanced Techniques Group, Engineering Division, Stanford Research Institute, Stanford, California.

IF Transformer

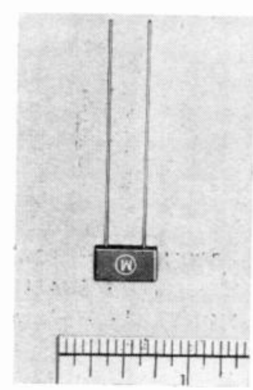
Electrometric, Inc., Woodstock, Ill., announces the type TX100 miniature IF transformer for any application requiring a $\frac{3}{4}$-inch transformer.



These are available in a wide range of inductances and Q's for AM, FM, TV and military applications. Faster set alignment can be made by tuning either from the top or from the bottom. Field trouble is minimized because all connections are soldered directly to the capacitors. Higher Q is obtained due to delay line type winding.

Subminiature Capacitor

The new "Super K" series of Subminiature ceramic capacitors which has been announced by **Mucon Corp.,** 9 St. Francis St., Newark 5, N. J., claims a new high in capacitance value for its size in subminiature capacitors.



In the "Super K" series a 0.1 μf $\pm$30 per cent capacitor, rated at 50 working volts dc, may be obtained as small as 0.300 by 0.550 by 0.110 inch thick, using multiple plate formation. A 1500 $\mu\mu$f capacitor rated at 200 wvdc measured approximately $\frac{1}{4}$ by $\frac{1}{4}$ by 0.080 inch.

"Super K" units, intended for use at or about room tempertaure are made to the shape and size required for the particular application. They are insulated with vacuum-wax, an impregnated phenolic material, with lead arrangement, either axial or radial as required.

Sample orders for the "Super K" series are filled within 2 weeks, as are sample orders for various other ceramic capacitors. Production orders can be scheduled as requirements demand.

(Continued on page 80A)

DAVEN

advanced design brings you

"PLUG-IN"

ATTENUATION NETWORKS

Combining a wide range of attenuation with a "plug-in" feature for adjusting input and output impedance.

On Daven Series 690 Attenuation Networks, the exclusive "plug-in" feature permits input or output impedance to be changed to any value by substituting "plug-in" pads of the particular impedance desired.

These networks are intended for use in general laboratory and production testing. They are extremely rugged, flexible and reliable. They are available in either "T" or "Balanced H" circuits. A range of either 110 DB in 1 DB steps can be obtained on the 2-dial series, or a range of 111 DB in 0.1 DB steps on the 3-dial series. A special card type, non-inductive winding is used, giving a frequency range of from zero to 50 KC. These units may be used above 50 KC with only a slight decrease in accuracy. Resistor units are calibrated to ±1.0% accuracy and operate at a +20 DB (0.6 watt) maximum input level.

To insure low contact resistance and uniform contact pressure Daven patented "knee-action" switch rotors are used. Silver alloy rotors, slip-rings and contacts insure finest electrical performance. Daven's exclusive "plug-in" impedance Matching Networks are available in a wide range of impedance and loss.

Write for complete catalog data.

THE DAVEN CO. 195 Central Ave., Newark 4, N. J.

Visit Us at the I.R.E. Show
Booths 543 & 545

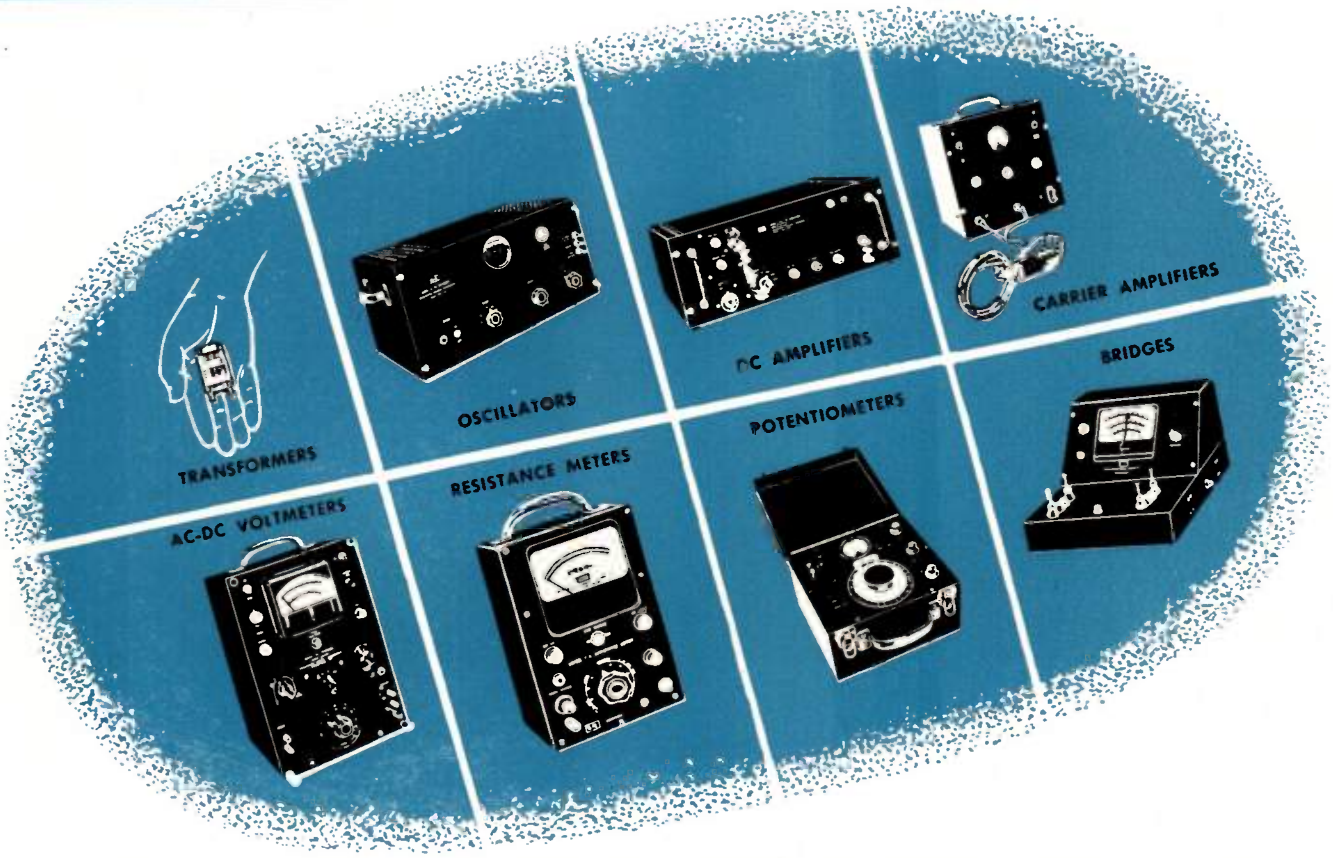
Series 690

WORLD'S LARGEST MANUFACTURER OF ATTENUATORS

IN ELECTRONIC LABORATORY TEST INSTRUMENTATION

SIE MEANS VLF*

***VERY LOW FREQUENCY**



We haven't made a transformer that works on DC yet (their range is .1 to 50,000 cycles per second) nor an oscillator that oscillates at zero cycles (.01 to 120,000 cps is their field).

But we do have direct-coupled amplifiers and carrier amplifiers that go all the way down to zero frequency. Our E-1 Comparison Bridge operates at a lower frequency than any other, and our R-1 Voltmeter will measure any potential from .0001 volts to 1000 volts in the zero-to-100 kilocycle range.

Why do we confine our laboratory-quality electronic test equipment to such a limited portion of the spectrum? True, it doesn't include radio, radar, or television, but it does include audio, geophysics, vibration analysis, servomechanisms, computers, strain-gage applications, underwater sound, chemical and medical electronics, and a host of other specialties.

In this field, S.I.E. leads the world—first with the finest in VLF instrumentation.

Write today for complete engineering details, specifications and prices on S.I.E. electronic laboratory instruments. An illustrated catalog is yours for the asking.

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.

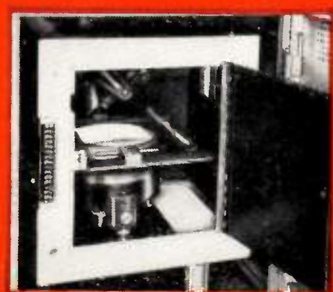
2831 POST OAK ROAD • P. O. BOX 13058 • HOUSTON 19, TEXAS

See Our Exhibit, 213, 215, Instruments Ave., IRE Show

the Du Mont

Multiplier phototubes are employed as pickups. Tube designed by Du Mont, provides extreme stability, long life and high signal-to-noise ratio. Cost of tube $55. Tube has practically infinite life, barring breakage.

Signal amplifiers are flat within 8 mc, permitting full amplification of color signals. Circuitry as simple as that encountered in audio equipment. All plug-in units, completely accessible.



Light source is a special cathode-ray tube designed and built only by Du Mont. Face plate is optically corrected, of medium density and is non-browning. Tube is operated at 45,000 volts on accelerating ring.

KFBB TV

WNAM-TV

KMMT-TV

WNOW-TV

KDSH-TV

WABD

WNEM-TV

WGEM-TV

KFBB-TV

...Surpassing all

for film pick-up

Finest reproduction of 16mm films—either new or old. Film moves through carrier silently, smoothly, minimizing chances of film breakage and wear.

opaque pick-up

Automatic carriers provide for 4" x 5" glossy or matte finish prints. Dual unit permits one carrier to be loaded while other is used in pickup.

2x2 glass slides

Automatic slide changer carries standard 2" x 2" glass slides. Dual pickup feature permits blending, or simultaneous pickup of two signals at once when operating from film, slides or opaques.

KWWL-TV

KOOL-TV

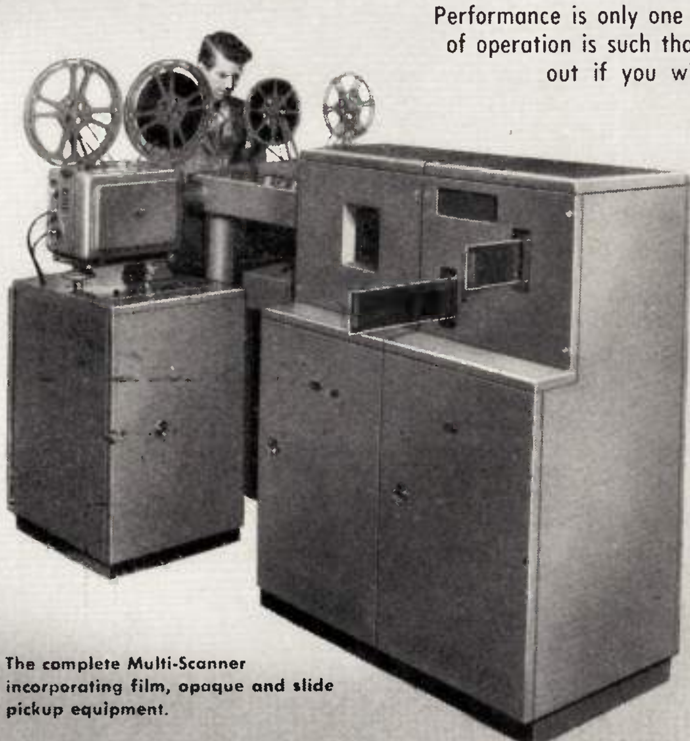
MULTI-SCANNER

The advanced method of film, opaque or slide pickup—**ready now!**—ready **for you** to use in your television broadcasting operations today!

The Du Mont Multi-Scanner offers a far more simple, more reliable and better method of electronic reproduction than ever available before. Film reproduction assumes studio pickup quality with all the original gray tones and elimination of edge flare inherent in other film pickup systems. The same true pickup is attained when the Multi-Scanner is used on slides or opaques.

Performance is only one of the many outstanding advantages of the Multi-Scanner. Simplicity of operation is such that the system is practically automatic. Thread the film in place, try it out if you wish, reverse the mechanism and you're ready to put the system in operation from a **remote** control panel.

Truly, the Du Mont Multi-Scanner has no equal —it is the modern pickup system—ready for you **today.**



The complete Multi-Scanner incorporating film, opaque and slide pickup equipment.

OPERATION: No shading adjustments necessary. Picture free from edge flare and shading. Completely automatic operation from a remote panel.

DEPENDABILITY: Simple mechanism carries film at continuous, smooth rate of travel. No tearing, wearing stop and go action.

PERFORMANCE: Gamma-corrected signals from Multi-Scanner brings out all gray tones of film, opaque or slides.

VERSATILITY: Reversing feature permits "dry runs" by operator immediately before going on air, without necessity of complete rewinding of film.

SHRINKAGE COMPENSATOR: Film shrinkage compensator permits complete control of allowances for shrinkage. Pictures frame right with the Multi-Scanner, whether new or old film.

COLOR: The Multi-Scanner is the only film system presently available that may be easily and quickly converted to color pickup.

Expectations!

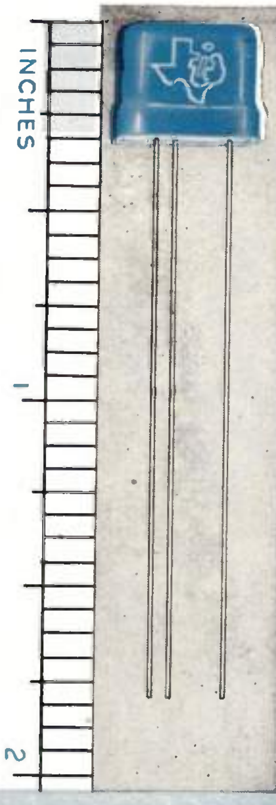
Production of Multi-Scanner units is now going ahead at full speed to meet the ever-increasing orders for this system of tomorrow, today.

DU MONT®

ALLEN B. DU MONT LABORATORIES, INC. • TELEVISION TRANSMITTER DEPARTMENT • CLIFTON, N. J.

WRH

TI transistors will FIT in Your Future!



THREE MONTHS AGO we ran this "ad" announcing a major reduction in the physical size of TI hermetically sealed junction transistors. At the Radio Engineering Show in March, TI will show transistors only one-third the size of the one illustrated at the right.

This is typical of the rapid progress being made in semiconductor device design. For first-hand information on these and other new TI semiconductor products, visit Booth 776. A real southwestern welcome awaits you there.

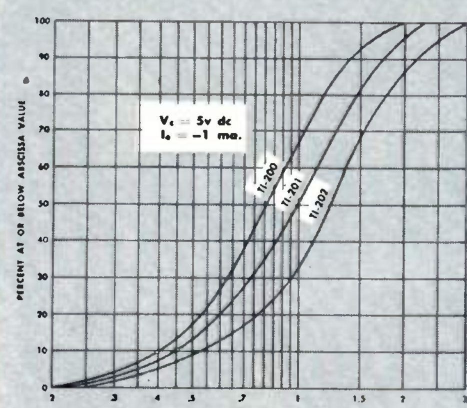
ELECTRICAL DATA: n-p-n junction transistors

	type 200	type 201	type 202	
RATINGS, RECOMMENDED MAXIMUM:				
Collector Voltage	30	30	30	volts
Collector Current	5	5	5	ma.
Collector Dissipation (at 25°C)	50	50	50	mw.
Ambient Temperature	50°C	50°C	50°C	
AVERAGE CHARACTERISTICS (AT 25° C.):				
Collector Voltage	5	5	5	volts
Emitter Current	−1	−1	−1	ma.
Collector Resistance (Minimum)	.4	.4	.4	megohms
Base Resistance	150	170	200	ohms
Emitter Resistance	22	22	35	ohms
Current Amplification Factor* (Minimum)	9	19	49	
Collector Cutoff Current (Maximum)	10	10	10	μa.
Collector Capacitance	15	17	19	μμfd.
Noise Factor** (V_C = 2.5 V., I_C = −.5 ma)	26	23	20	db
Frequency Cutoff** (α_{co})	.90	1.10	1.30	m.c.

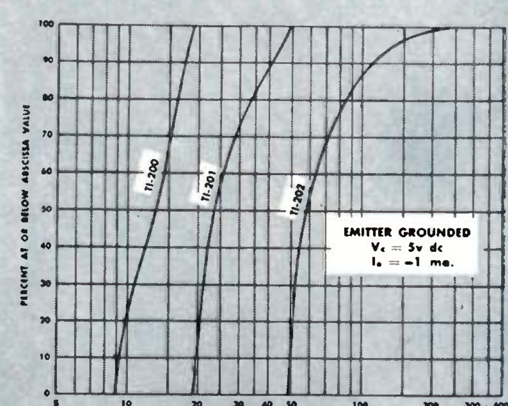
*Emitter Grounded.

**Noise Factor and Frequency Cutoff are average and individual units may vary.

STATISTICAL DISTRIBUTION CURVES
Based on 100 transistors of each type



α_{co} — Alpha Cutoff Frequency — megacycles



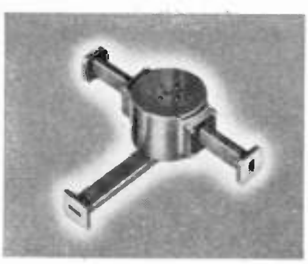
K — Current Amplification Factor

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

SNORKEL HUNTER...

with an assist by DALMO VICTOR

One typical DV Development



RADIO FREQUENCY SWITCHES

Successful high-speed rotary-scan radar antenna operation depends upon precision regulation of r-f power. This has been made possible by Dalmo Victor's development of the high-power rotary r-f switch shown. Characteristics include constant impedance at both input and output joints during rotation, capacity to transmit high power, less than 20-degree crossover angle, and complete sealing for pressurization.

Specialized radar, with antennas and other electronic instrumentation designed and produced by Dalmo Victor, makes the Navy's P2V-5 Neptune capable of locating and tracking down Snorkel submarines.

Dalmo Victor maintains the leading specialist group concentrating on design-through-production engineering of such complex lightweight electromechanical systems. This skilled organization stands ready to help you with your engineering and production problems.

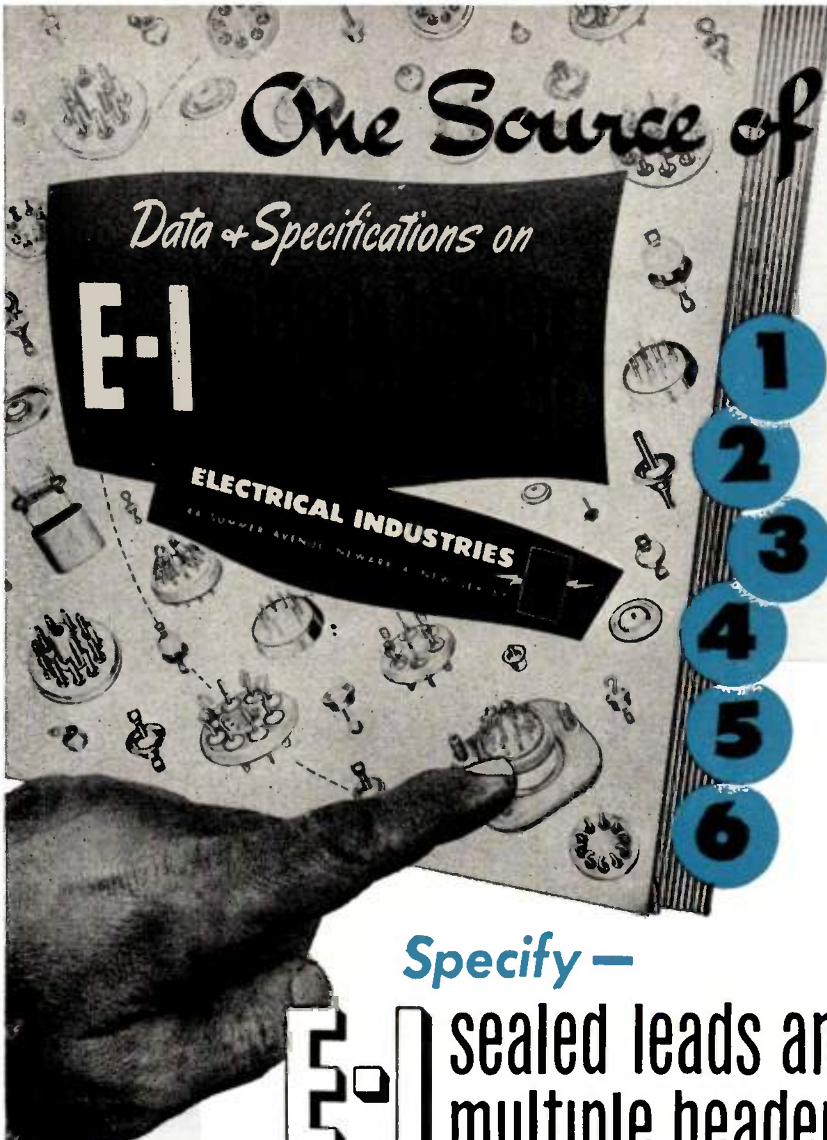
DALMO VICTOR

SAN CARLOS · CALIFORNIA

DV

DOWN-TO-EARTH ELECTROMECHANICAL ENGINEERING

One Source of Supply



by

— for every hermetically sealed termination

Specify —

E-I sealed leads and multiple headers

HUNDREDS OF STANDARD TYPES AT MASS PRODUCTION PRICES TO MEET EVERY REQUIREMENT

— at your fingertips!

Development, production and design engineers will find the complete E-I Data File a helpful addition to company files. The new brochure includes standardized terminations that economically solve all but the most unusual terminal problems. If custom types are required, E-I can supply these quickly, to exact specifications at quantity production prices.

CALL OR WRITE FOR THE NEW E-I DATA FILE NOW!

1. BULLETIN 949-A

On hermetically sealed terminals. Discusses cushioned glass construction, thermal shock resistance, preferred types and special terminals. Explains code systems and methods of installation.

2. BULLETIN 950-A

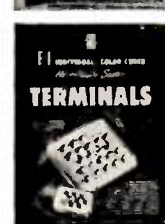
On hermetically sealed multiple headers. Explains vacuum tight feature, cushioned glass construction, strain-free qualities. Tin dipped for easy soldering and silicone treated for highest electrical resistance.

3. BULLETIN 951

With complete information on octal type plug-in and multiple headers. Feature a new principle of hermetic sealing. Solid metal blanks insure maximum mechanical strength and rigidity.

4. BULLETIN 952

Complete information on E-I end seals for hermetic sealing condensers, resistors and other tubular electronic and electrical components. Provide a permanent hermetic seal. Completely strain-free.



5. BULLETIN 953

Individual, color-coded hermetically sealed terminals. Available with glass inserts colored in standard, easily identified RMA color codes. Coloring is in the glass —no lacquers or enamels are used.

6. BULLETIN 960

Compression type multiple headers. Super rugged, absolutely rigid and practically indestructible. An exclusive E-I achievement offers vastly greater resistance to shock and vibration. Guaranteed vacuum-tight.

ELECTRICAL INDUSTRIES

44 SUMMER AVENUE, NEWARK 4, NEW JERSEY

DIVISION OF AMPEREX ELECTRONIC CORP.

E-I ®

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CIRCUITS AVENUE

EXPORT AGENTS:
PHILIPS EXPORT CORP., 100 EAST 42nd STREET, NEW YORK 17, N. Y.

*PATENT PENDING

Amphenol invites you . . .

to the corner of ELECTRONIC AVENUE AND RADIO ROAD

For the IRE Convention at Kingsbridge Armory this year AMPHENOL has prepared an extensive and interesting display of electronic components —some of them brand new developments, some selected from the over 11,000 items now in the AMPHENOL catalogs. AMPHENOL's booths are 443, 445 and 447, right on the corner of Electronic Avenue and Radio Road. We will look forward to seeing you there.

AMPHENOL

THE AMPHENOL Qwik MICROPHONE CONNECTORS

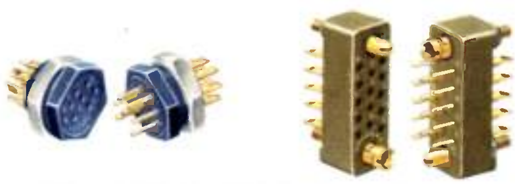
AMPHENOL proudly presents the new QWIK microphone connectors! Designed by one of America's leading industrial designers in cooperation with the skilled engineers of AMPHENOL, here at last are microphone connectors with the beauty and the efficiency to complement every microphone, in any setting!

In both mechanical and aesthetic considerations the new QWIKs are unique. They have an ingenious release device which is both extremely easy to operate and very efficient. Disconnection for either male or female connectors is made by simply sliding a button forward with a slight pressure of the thumb. For insertion, the QWIK is gently clicked in.

The finish of the new QWIKs is an attractive corrosion-resistant satin nickel—the body is a sturdy zinc alloy. They incorporate the famous 1-501 blue dielectric material, the same used on all AMPHENOL AN connectors. Contacts are gold-plated over a silver finished high conductivity bronze.

QWIKs are available, either male or female, with three or four contacts. The possibilities of their applications are such that you will want to see and study them as soon as possible.

For full information:
write to the Sales Engineering Department,
American Phenolic Corporation
1830 South 54th Avenue, Chicago 50, Illinois



small, compact Miniature Connectors for special electronic needs

hundreds of different miniature and industrial Tube Sockets

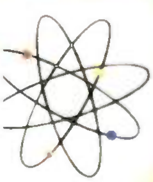
Cable quality guaranteed by strict controls, rigid inspection

versatile Plugs—unique designs, sturdy construction

new improved AN Connectors now feature gold plated contacts

fastest connect and disconnect with Blue Ribbon Connectors

PRECISION MADE COMPONENTS FOR THE ELECTRONICS INDUSTRY



AMPHENOL makes over 11,000 separate cataloged components that are used and relied upon by the electronics industry the free world over. These components include the famous AN connectors, RF connectors, cables and many special types of sockets, plugs and connectors. Their applications vary, but the distinguishing feature of all AMPHENOL components is present in each: *quality.*

The quality that is the mark of AMPHENOL components is the product of both precision engineering and precision manufacturing. Neither of these would result in quality alone. But the teamwork of the two produces the finest components available—the electronics industry has learned to rely upon AMPHENOL quality.

Not only the components on this page but thousands more are listed in the new AMPHENOL Catalog B-3. From the B-3 you will be able to fill the majority of your component needs. Where more specialized information is desired, the B-3 also lists the special AMPHENOL catalogs, A, C and D, as well as other product literature.

Rack and Panel connectors for many special applications

waterproof field serviceable Audio Connectors approved for Signal Corps

developed first for Signal Corps, waterproof Power Plugs

better design, better construction on all RF Connectors

AN Electrical and RF Connectors
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Radio and Industrial Tube Sockets
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TV, FM and Communication Antennas
Cable Assemblies
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a complete Cataloging service to the electronics industry

AMPHENOL

American Phenolic Corporation, Chicago 50, Illinois

Amform 2382—24400 Printed in U.S.A.

SEALTRON ANNOUNCES

the Royal Blue

BONDED COMPRESSION SEAL

In Sealtron Bonded Compression Seals, you get all the advantages of *both* bonding and compression — superior mechanical strength, better thermal* and electrical properties *plus extra protection* against leakage.

Our method of sealing the Bonded Compression Seal produces a bond between the glass and steel outer member. This bond, combined with the tremendous compressive force of the steel outer member, gives you the finest protection against leakage available with any glass-to-metal seal.

Sealtron's *Royal Blue* Seals come in a wide variety of shapes, sizes and terminal arrangements to suit your most specialized needs — include many shapes previously impractical with other types of seals. They're easy to solder in, will help you solve space problems in "close quarters" where miniaturization is essential.

Royal Blue Bonded Compression Seals are an important addition to Sealtron's *complete* line of glass-to-metal seals — single seals, multiple headers — also alumina (ceramic) seals. Most standard types carried in stock for quick delivery.

And take advantage of our Seal Assembly Service. We'll solder seals into your assemblies, will guarantee hermetic perfection. Our technicians build to your specifications — eliminate your specialized operations, cut down overhead, release key personnel for other work, help you meet tough production schedules.

Write today for complete information.

* Liquid Nitrogen (-320.4° F.) immediately to hot oil (500° F.) without loss of hermetic or electrical performance.

Look for us in Booth No. 827 at the IRE Show, "corner Audio Avenue and Radar Road"

SEALTRON

SEALTRON CORPORATION

READING ROAD AT AMITY, BOX 72A, CINCINNATI 15, OHIO

SEALTRON ANNOUNCES

the Royal Blue

BONDED COMPRESSION SEAL

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SEALTRON

SEALTRON CORPORATION

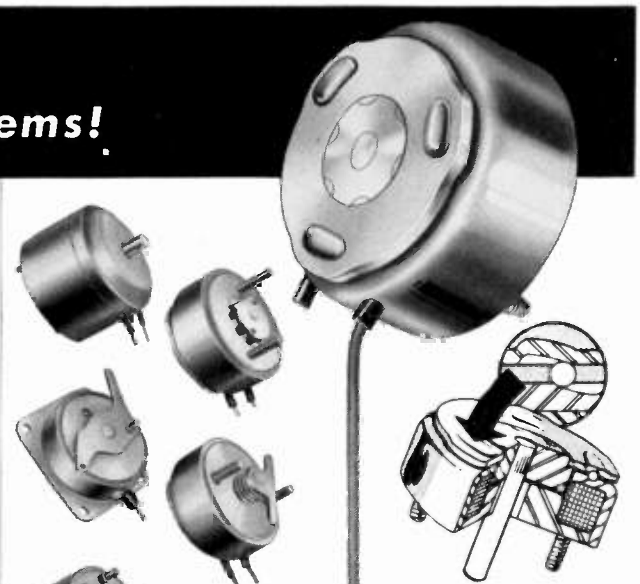
READING ROAD AT AMITY, BOX 72A, CINCINNATI 15, OHIO

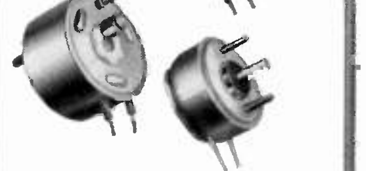
LEDEX rotary solenoids solve remote control problems!

The many production applications of Ledex *Rotary* Solenoids vary from the dependable, snap-action tripping of airborne bomb releases to the actuation of rugged, hydraulic valves in heavy duty materials handling equipment. These compact, powerful, shock resistant Solenoids are manufactured with diameters from 1⅛ to 3⅜ inches. Predetermined rotation up to 95° can be engineered to suit your product's requirements. Starting torques for 45° stroke range from ¼ pound-inches to 54 pound-inches.

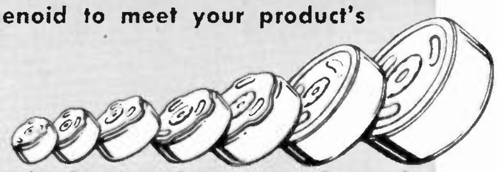
Ledex *Rotary* Solenoids operate on direct current and are adaptable for various types of power take-offs, mountings and dust covers as illustrated at the right.

We supply to quantity users and solicit the opportunity to be of assistance in engineering a Ledex *Rotary* Solenoid to meet your product's requirements.





Magnetic action moves the armature along the solenoid axis. This action is converted into a rotary motion by means of ball bearings on inclined races.

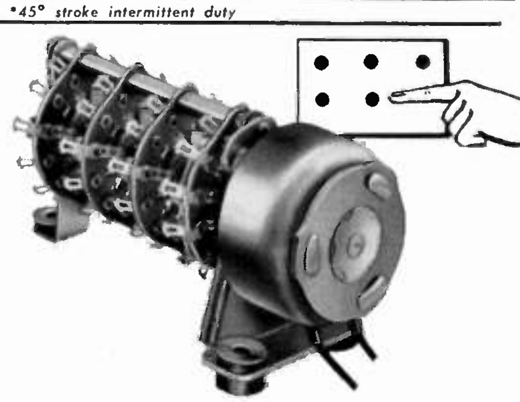


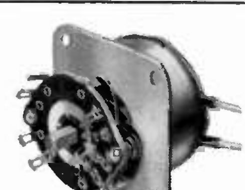
Model No.	2	3	4	5	6	7	8
Diameter Inches	1 1/8	1 5/16	1 9/16	1 7/8	2 1/4	2 3/4	3 3/8
Torque lbs.-Inches *	.4	1.0	2.0	4.0	7.5	25.0	54.0
Weight lbs.-ozs.	0-2	0-3 1/2	0-7	0-9	1-11 1/2	2-4	4-3

*45° stroke intermittent duty

LEDEX circuit selectors and stepping relays give remote control for multiple complex circuits.

Ledex Circuit Selectors and Stepping Relays can be remote controlled, are *Rotary* Solenoid operated, have positive detent action and are self-stepping or external impulsing. Many versatile designs of stepping, counting, adding and subtracting, latching, and circuit selecting relays are made possible by the combination of the Ledex *Rotary* Solenoid and wafer type rotary switches. Self-stepped or externally impulsed, the device is immediately adaptable to many remote control applications. A choice of wire sizes permits a wide range of operating voltages and power requirements. Various types of mountings further increase its adaptability. In addition to its positive control of multiple, complex circuits, a reserve of mechanical power is available for the performance of many duties other than switching operations.





VISIT US AT THE
RADIO ENGINEERING SHOW
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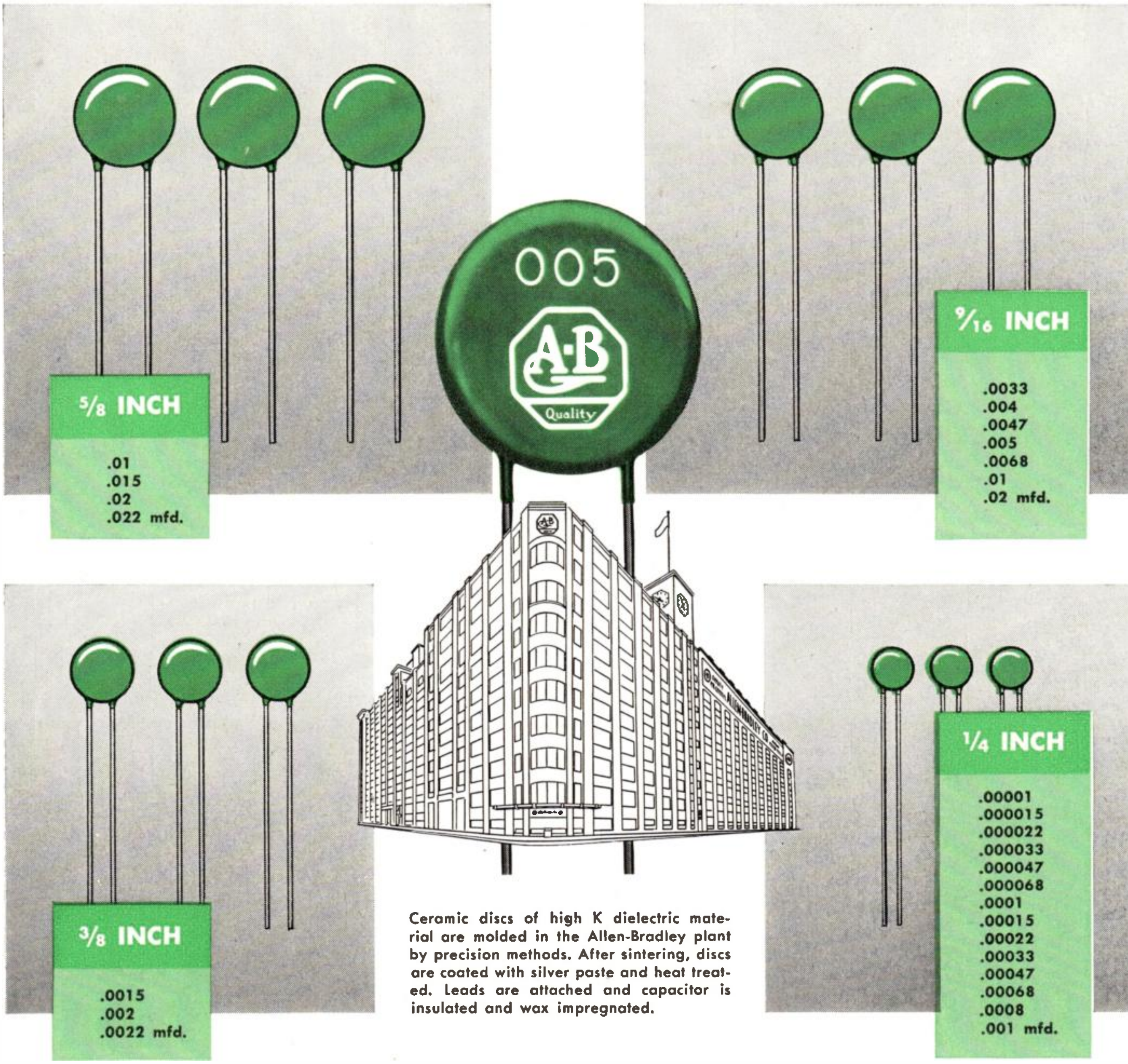
BROADCAST WAY

Write today for complete information on Ledex Rotary Solenoids and Ledex Circuit Selectors.

G. H. Leland INC. 123 WEBSTER STREET • DAYTON 2, OHIO



Ceramic discs of high K dielectric material are molded in the Allen-Bradley plant by precision methods. After sintering, discs are coated with silver paste and heat treated. Leads are attached and capacitor is insulated and wax impregnated.

NOW ALLEN-BRADLEY CERAMIC CAPACITORS from 0.00001 to 0.022 mfd.

The Allen-Bradley line of ceramic capacitors has been expanded to include new capacitors of lower values. For example, the 1/4-inch capacitors now go as low as 0.00001 mfd., making a total of 28 Allen-Bradley capacitors available from 0.00001 mfd. up to 0.022 mfd.

Every step in the manufacture of these ceramic capacitors is performed in the Allen-Bradley plant . . . from the molding and sintering of the ceramic discs to the final impregnating and testing of the finished capacitors. Allen-Bradley ceramic capacitors are approved by the engineering departments of the leading electronic, electrical, and telephone laboratories. Allen-Bradley . . . long famed for the design and production of high quality electronic components . . . is at your service as a major supplier of ceramic capacitors of superlative quality.

Samples will be submitted for your qualification tests.

Allen-Bradley Co., 114 W. Greenfield Ave., Milwaukee 4, Wis.

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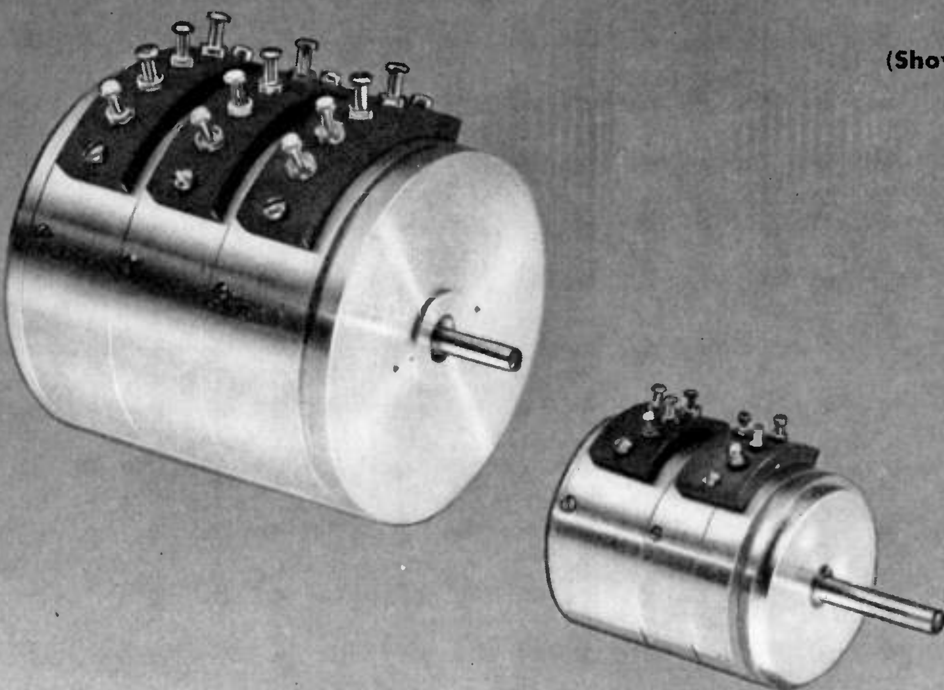
RADIO & TELEVISION COMPONENTS

QUALITY



(Shown actual size)

POTENTIOMETERS

all your precision potentiometer needs

TYPE 754 – 2" linear potentiometer – Resistance range from 800 ohms to 100,000 ohms. High linearity (±0.15% standard). Internal clamp rings permit ganging up to 8 cups on single shaft without increasing overall diameter. AIA standard 2" servo mount. Depth is 1" with .594" added for each cup section ganged. Gold-plated terminals are easier to solder and have better resistance to corrosion.

TYPE 741 – 1⅛" linear potentiometer – Internal clamp rings permit ganging up to 5 cups on a single shaft without increasing the over-all diameter. Resistance range 500 to 25,000 ohms; linearity ±0.5% standard. Electrical angle 350°. Only 1⅛" in diameter and 1⅛" long; starting torque is 0.25 oz.-in. The simplified slip ring construction and a one-piece paliney wiper give longer life and lower noise.

● ***Available immediately in sample quantities.*** Look to Fairchild for assistance in solving all your precision potentiometer problems. Fairchild has, or can make, a potentiometer to fit any requirement. For information write: *Fairchild Camera & Instrument Corp., Potentiometer Division, 225 Park Avenue, Hicksville, L. I., N. Y., Dept. 140-45H.*

FAIRCHILD

PRECISION POTENTIOMETERS

What to See at the Radio Engineering Show

(Continued from page 8A)

Alden Electronic & Impulse Recording Equip. Co., 189 Television Ave.
Direct writing recorders in the new strata of recording which differentiate from the old methods for getting related information of time and value. Showing specific, simple recorders to get on-the-spot information. The 30 channel recorder and components for building your own recorder.

Alfax Paper & Engineering Co., 191 Television Ave.
Alfax, the all purpose recording paper, using electricity as the ink. Alfax allows adjustless recording whether stylus, helix, impression, or the new methods. Alfax is direct (no processing), permanent, all-environmental, nontoxic, without arcs or fumes and needs very low current.

Andrew Alford, Consulting Engineers, 393 Microwave Ave.
R. F. Test Equipment.

Alford Mfg. Co., 393 Microwave Ave.
TV Broadcast Transmitting Antennas. Air Navigation Aids.

All Channel Antenna Corp., 800 Production Rd.
Manufacturers of the "world's most powerful patented, motorless, all direction, all channels 2-83 TV antennas." On display, Model Super 60, Ultra 150 with the new four conductor POLYMICALENE transmission line, and the new electronic orientation switch.

Barrett Div. of Allied Chemical & Dye Corp., Plastics & Resin Sales, 558 Components Ave.
Electronic devices encased in or incorporating the use of plaskon alkyd molding compound, both mineral and glass filled. Material application engineers in attendance.

Allied Control Co., Inc., 492 Electronic Ave.
Relays and coils for use in electronic control devices. *Sub-sub-miniature plug-in ¼ ampere double-pole relay. Complies with MIL-R-5757B. Suitable for high speed, low capacity, and printed circuit applications.

(Continued on page 78A)

JFD Electronics

Division of
JFD MANUFACTURING COMPANY
Brooklyn 4, N.Y.

SERVES THESE GREAT NAMES

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ANDREA
Bendix AVIATION CORPORATION
CROSLEY
DU MONT
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RCA *RADIO CORPORATION of AMERICA*
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SPERRY *GYROSCOPE COMPANY*
STEWART-WARNER ELECTRIC
STROMBERG-CARLSON

BECAUSE OF THESE FEATURES

Approximately zero temperature coefficient (with quartz and invar construction).

Approximately ±50 PPM per degree C. (with glass and INVAR construction).

One-piece spring loaded piston and screw prevent backlash.

Silver band fused to exterior of precision drawn quartz or glass tube serves as optimum stationary electrode.

"Q" as high as 7,000 at 1 mc.

Dielectric strength equals 1,000 volts DC at sea level pressure and 500 volts at 3.4 inches of mercury.

10,000 megohms insulation resistance minimum.

Operating temperatures −55 C. to +125 C. with glass dielectric. −55 C. to +200 C. with quartz dielectric.

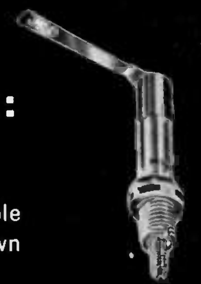
Over 100 megohms moisture resistance after 24 hours exposure to 95% humidity of room temperature.

Piston dimensional accuracy is held to close tolerance maintaining minimum air gap between piston and cylinder wall.

NEW DEVELOPMENTS

- **Capacitance ranges in miniature size units from 1.0 to 200.0 mmf.**
- **Dust-proof metal caps with extruded lead-in.**
- **Baked-in water repellent plating.**

WITH THESE:



JFD piston type variable trimmer capacitor shown actual size (one inch).

MODEL	CAP. RANGE MMF.	COEF. OF CAP.	DIELECTRIC	ROTOR
VC-1G	0.7 to 7.0	±50 PPM/°C. / ±3.5 x 10^{-4}MMF./°C. At Max. Capacity	Glass	Invar
VC-3G	0.7 to 8.0	±250 PPM/°C. / ±2 x 10^{-3}MMF./°C. At Max. Capacity	Glass	Brass
VC-4G	1.0 to 18.0	±250 PPM/°C. / ±4.5 x 10^{-3}MMF./°C. At Max. Capacity	Glass	Brass
VC-11G	0.7 to 12.0	±50 PPM/°C. / ±6 x 10^{-4}MMF./°C. At Max. Capacity	Glass	Invar
VC-11GRB	0.7 to 10.0	±250 PPM/°C. / ±2.5 x 10^{-3}MMF./°C. At Max. Capacity	Glass	Brass
VC-11GRC	0.7 to 10.0	±100 PPM/°C. / ±1.0 x 10^{-3}MMF./°C. At Max. Capacity	Glass	Brass Invar
VC-5	0.5 to 5.0	Approx. Zero/°C.	Fused Quartz	Invar
VC-5F	0.7 to 5.0	Approx. Zero/°C.	Fused Quartz	Invar
VC-11	1.0 to 10.0	Approx. Zero/°C.	Fused Quartz	Invar

(Silver plating throughout is available at slight extra cost on every model for better performance on UHF and microwave frequencies.) JFD Piston type variable trimmer capacitors.

Call on JFD engineers for your piston capacitor requirements. Write for form 220 catalog of standard items available or send blueprints, specifications or details of application to *Piston Capacitor Department, JFD Electronics Division, JFD Manufacturing Company, Inc., Brooklyn 19, New York.*

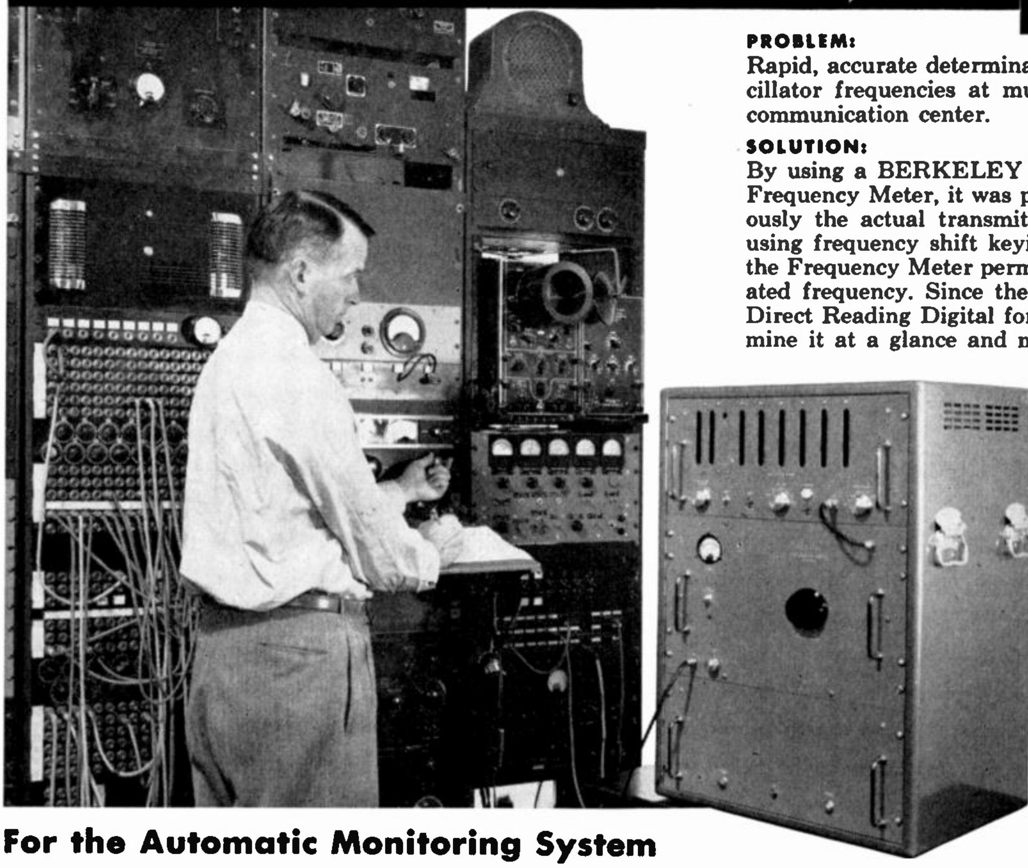
IN THEIR REQUIREMENTS FOR PISTON TYPE VARIABLE TRIMMER CAPACITORS

Visit us at the IRE Show
March 22-25, Booth 123, Military Avenue

Burton browne advertising

HOW Berkeley EQUIPMENT HELPED SOLVE A PROBLEM FOR RCA Communications, Inc.

Bolinas, California



PROBLEM:
Rapid, accurate determination of transmitter and oscillator frequencies at multiple-transmitter overseas communication center.

SOLUTION:
By using a BERKELEY Model 5570 direct reading Frequency Meter, it was possible to monitor continuously the actual transmitted frequency. Even when using frequency shift keying, the averaging effect of the Frequency Meter permitted measurement of radiated frequency. Since the frequency is presented in Direct Reading Digital form, the operator can determine it at a glance and make necessary corrections.

RESULTS:
Using the BERKELEY Model 5570, frequency determination to an accuracy of 1 part in $10^7 \pm$ 1 cycle with a new measurement every 4 seconds is now a simple routine. Previous method required 10 to 15 minutes.

For the Automatic Monitoring System

Additional equipment provides automatic recording of the last 6 digits of the measured frequency on standard adding machine tape. This is accomplished by use of the R-6 Digital Recorder in conjunction with the Frequency Meter, Model 5570.

40 to 510 Megacycles

VHF and UHF converter units are available for use with the Model 5570 (0 to 42 megacycles) Frequency Meter.

Model 5575 extends range of Model 5570 to 150 megacycles. Model 5580 covers one 30 megacycle band width from 150 to 510 megacycles when used with Model 5570. Plug-in units select the 30 megacycle band width over which the Model 5580 is to operate. Reading is made in digital form as sum of base frequency of plug-in unit and direct indication on Model 5570.

May we help solve your problem?

If it involves faster, more accurate, easier and simpler ways to measure frequency, flow, pressure, velocity, r.p.m., time intervals, viscosity, – or high speed counting and counting plus pre-set control – chances are that BERKELEY can help you solve it. Complete data sheets covering many applications in these fields are yours for the asking – check the handy coupon below and mail it NOW!

M-24

Berkeley *division*
BECKMAN INSTRUMENTS INC.
2200 WRIGHT AVE., RICHMOND, CALIF.

Dept. N-3, 2200 Wright Ave., Richmond, Calif.
Please send me application data sheets checked

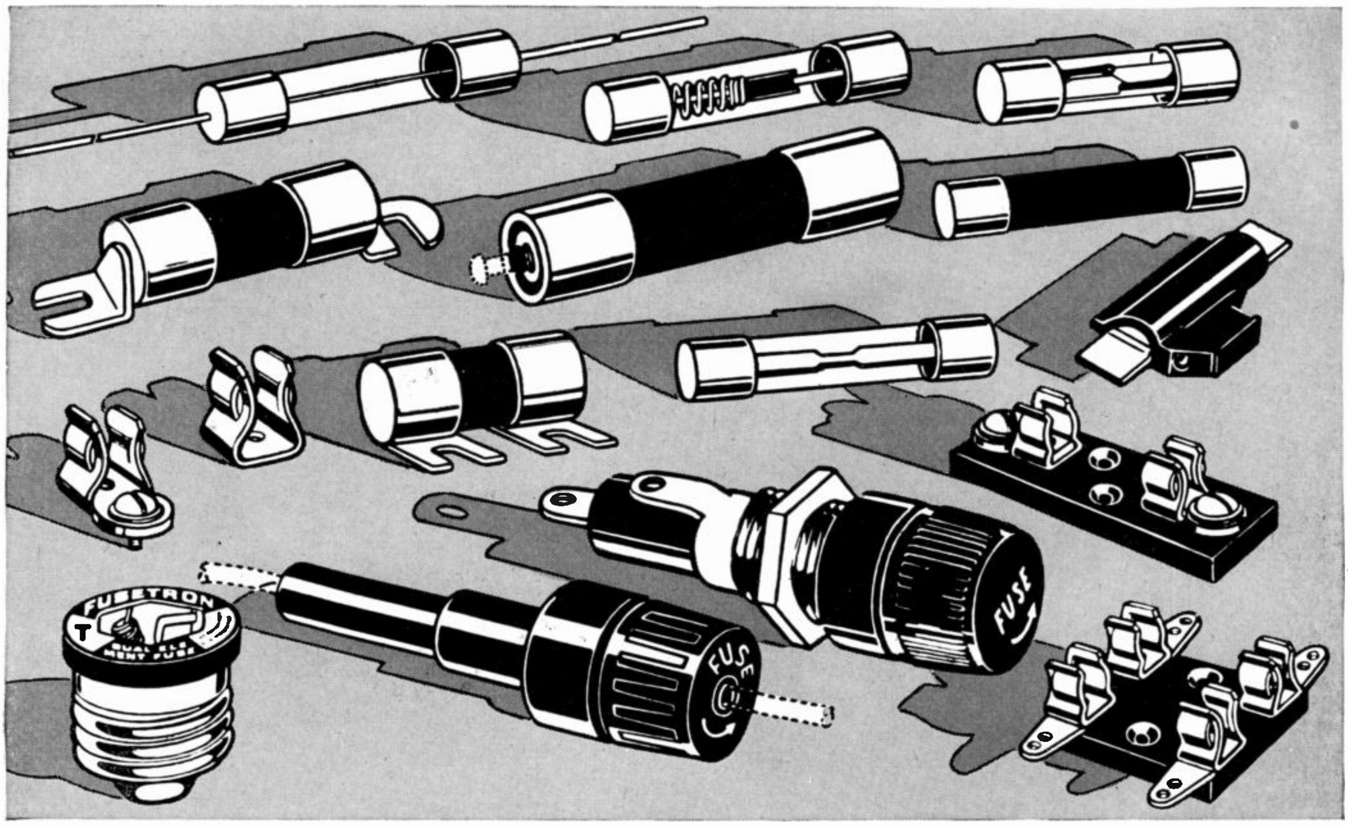
Name ______
Title ______
Address ______
City ______ State ______

MEASUREMENT OF:
☐ Flow ☐ Velocity
☐ Pressure ☐ RPM
☐ Viscosity ☐ Operating Time
☐ Frequency of ______

☐ **COUNTING OR PREDETERMINED COUNTING OF:** ______

CONTROL OF:
☐ Cutting Stock to Length
☐ Packaging and Batching

See us at Booth 752 Airborne Ave., IRE Show



WHY YOU WILL FIND IT PROFITABLE to STANDARDIZE on BUSS FUSES

BUSS OFFERS A COMPLETE LINE OF FUSES

It is easy and economical for you to choose the exact fuse for your requirements. Select from dual-element (slow blowing) renewable and one-time types . . . in sizes from 1/500 ampere up, plus a companion line of fuse clips, blocks and holders.

A fuse is a small but significant component part — for a faulty fuse that fails to protect — or a fuse that blows needlessly may reflect, in your customer's mind, on your product or service.

Dependable electrical protection is not an accident with BUSS fuses.

The makers of BUSS fuses maintain rigid quality control by testing every fuse in a sensitive electronic device that rejects any fuse not properly calibrated, properly constructed and right in all physical dimensions.

That is why you can be sure that a BUSS fuse will always operate as intended under all service conditions.

"Trouble-free" BUSS fuses can help protect your goodwill, reputation and profits.

Then be profit wise, change your buying and stock records today — to standardize on genuine BUSS fuses.

For more information mail this Coupon ▼

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

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

*Name*__________

*Title*__________

*Company*__________

*Address*__________

*City & Zone*__________ *State*______ IRE-354

Let BUSS save you engineering time.

When selecting or designing a fuse or fuse mounting let BUSS, with the world's largest fuse research laboratory and its staff of engineers, be of service. At least be sure to get the latest BUSS fuse information before final design is crystallized. It's quite possible that the fuse to meet your exact requirements is already available in local wholesaler's stocks.

Makers of a complete line of fuses for home, farm, commercial, electronic and industrial use

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

See Our Exhibit Booth 488, Electronic Ave., IRE Show

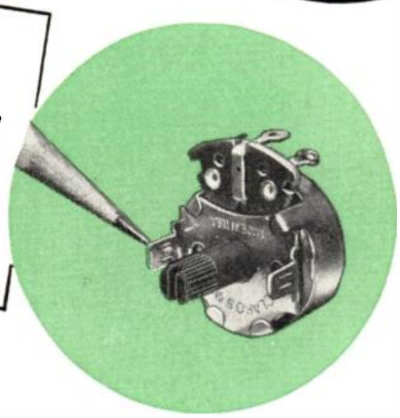
From "The House of Resistors"** come . . .

COST-REDUCING CONTROLS

So you must *get cost down* in designing that assembly? That's just the time to enlist Clarostat's cost-saving talents and facilities. The same superlative engineering and production skill that accounts for the finest quality in controls and resistors, is also available for designing and fabricating cost-reducing components. Three typical examples are presented herewith. These are *standard* items, promptly available in any quantities, at marked savings. And for any extraordinary requirements, *special* controls and resistors can be developed, tooled-up and produced.

The original "Humdinger" Series MH. Compact, rugged, wire-wound control. Virtually millions in use. Fibre base holds resistance winding. Movable arm and shaft. 1-watt. 2 to 1000 ohms.

Latest "Humdinger" Series 39. Metal-case mounted with rivets or screws. Mounting surface serves as cover. Semi-fixed setting by screwdriver slipped into rotor slot – no shaft 2-watt 4 to 5000 ohms.



Twist-Tab Mounted Series 47. Eliminates usual bushing, lockwasher, nut. Composition-element control. Metal or plastic shaft. Plastic shaft has rear slotted protrusion, therefore adjustable from front or rear.

* *It's easy* to do business with CLAROSTAT!

Agents in all principal cities. ★ Wire Western Union — we have a direct wire. ★ Telephone Dover 975 — we have added trunk lines to render service. ★ Teletype — our TWX number is Dover 275-U

STAND PAT WITH CLAROSTAT®

**Trade Mark

CONTROLS and RESISTORS

CLAROSTAT MFG. CO., INC., DOVER, NEW HAMPSHIRE

In Canada: CANADIAN MARCONI CO., Ltd., Toronto, Ont,

See Our Exhibit 725 Airborne Ave., IRE Show

POLARAD
MICROWAVE EQUIPMENT

MICROWAVE SIGNAL GENERATING EQUIPMENT

950 - 11,500 MC

Model No.	Frequency Range MCS/sec.
MSG-1	950-2400
MSG-2	2150-4600
MSG-3	4450-8000
MSG-4	6950-10,800
MSG-4A	6950-11,500

MSG 1-2

MSG 3-4

Signal Generators

Direct reading, single dial frequency control, with internal FM and pulse modulation circuits, as well as provisions for external synchronization. Delayed and undelayed sync output. Frequency accuracy ± 1%. Attenuator accuracy ± 2 db. Extremely stable. Rugged construction.

MICROWAVE SIGNAL ANALYZING EQUIPMENT

10 - 35,000 MC

LSA Laboratory Spectrum Analyzer
with 5 interchangeable R.F. heads

R.F. Head	Frequency Range in MC
LTU-1	10—1000
LTU-2	940—4500
LTU-3	4460—16,520
LTU-4	15,000—21,000
LTU-5	20,850—35,000

5 interchangeable R.F. heads provide continuous coverage from 10 MC to 35,000 MC. Single dial tuning allows for quick and simple display of any frequency spectrum. Frequency dispersion from 250 KC to 25 MC with an internal marker measuring frequency differences up to ± 12.5 MC on a 5 in. CRT display.

10 - 21,980 MC

TSA Bench Model Spectrum Analyzer
with 3 interchangeable R.F. heads

R.F. Head	Frequency Range in MC
STU-1	10—1000
STU-2	915—4560
STU-3	4370—21,980

3 interchangeable R.F. heads provide continuous coverage from 10 MC to 21,980 MC in a portable, table-top spectrum analyzer. Single dial tuning allows for quick and simple display of any frequency spectrum. Frequency dispersion from 250 KC to 25 MC with an internal marker measuring frequency differences up to ± 12.5 MC on a 5 in. CRT display.

MICROWAVE GENERAL LABORATORY EQUIPMENT

DC - 11,000 MC

Micro Power Meter—
Model P-1

Measures RMS power from DC to 11,000 MC, utilizing a single power sensitive probe. The elimination of hot wire barreters and other delicate components enables the probe to withstand overloads up to 150% without burnout or other damage. Simple operation. Rugged construction.

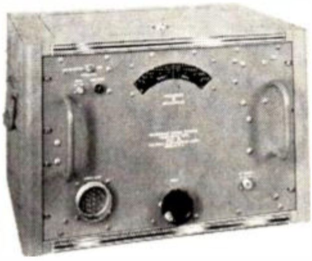
Frequency Range: DC-11,000 MC
Single Probe Operation
Power Ranges: 0-20 mw
0-100 mw

Klystron Tube Tester—
Model K-100

Compact, portable instrument designed to test performance quality of all commercially available klystron type tubes. Provides complete metering facilities, control adjustments and convenient tube data chart. Safety features.

for complete coverage of the range 10 to 50,000 MCS/SEC.

650 - 10,750 MC



Signal Sources
Microwave power output with a direct reading, single dial frequency control. Provisions for external square wave and FM modulation.
Model KX, Klystron Power Supply, especially designed for Polarad Signal Sources is available. Works with all 5 models. Has 1000 cps square wave output for modulating purposes. Stable output.

MINIMUM POWER AVAILABLE FROM POLARAD SIGNAL SOURCES IN THE RANGE OF 650 TO 10,750 MC						
FREQUENCY RANGE		MODEL SSR 650-1300MC	MODEL SSL 1050-2350MC	MODEL SSS 2200-4550MC	MODEL SSM 4350-8250MC	MODEL SSX 8000-10,750MC
MINIMUM POWER AVAILABLE (mw)	Low Range	150	80	15	10	13
	Middle Range	400	150	60	70	30
	High Range	100	100	40	15	10

12,700 - 50,000 MC

Signal Generators—12.7-39.7 KMC—A new line of signal generators covering the K and Q Bands. Internal square wave modulation and provisions for external modulation. Power meter to check internal R.F. and external source R.F. Power.

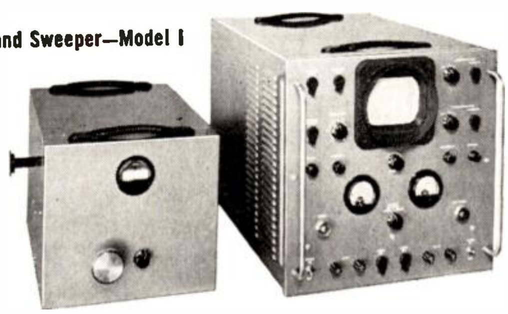
Signal Sources—12.7-50.0 KMC—A new line of signal sources providing microwave power in the K, Q and V Bands. Internal square wave modulation and provisions for external modulation.

Signal Generators Model No.	Frequency Range in KMC	Signal Sources Model No.
SG-X12	12.8 to 17.5	SS-1218
SG-6178*	15.75 to 16.25	SS-1516
SG-QK368*	16.25 to 16.75	SS-1617
SG-6253	18.0 to 22.0	SS-1822
SG-6254	22.0 to 25.0	SS-2225
SG-QK289	27.27 to 30.0	SS-2730
SG-QK140	29.7 to 33.52	SS-3033
SG-QK291	33.52 to 36.25	SS-3336
SG-QK292	35.1 to 39.7	SS-3540
	37.1 to 42.6	SS-3742
	41.7 to 50.0	SS-4150

*Provided with internal pulse and FM modulation.

8500 - 9600 MC

X Band Sweeper—Model I



A new X-Band Sweep Generator provides R.F. energy swept continuously from 8,500 to 9,600 MC. Allows the use of UHF testing techniques in the microwave region. Two independent sweep amplifiers provide a simultaneous visual display of reflection and transmission characteristics.

Output Variation: ± 1 DB max. Sweep Rate: 12 CPS.	Frequency Range: 8,500-9,600 MC Output: + 12 DBM.

12,700 - 39,700 MC

Spectrum Analyzers

Model No.	Frequency Range KMC
SA-X12	12.8 to 17.5
SA-6178	15.75 to 16.25
SA-QK368	16.25 to 16.75
SA-6253	18.0 to 22.0
SA-6254	22.0 to 25.0
SA-QK289	27.27 to 30.0
SA-QK140	29.7 to 33.52
SA-QK291	33.52 to 36.25
SA-QK292	35.1 to 39.7

A new line of portable spectrum analyzers covering the K and Q Bands, presenting the frequency distribution of R.F. energy on a 3 in. CRT display. The units are self-contained including an R.F. section, display unit and power supply.

10 CPS - 20 MC

Wide Band Video Amplifier—Model VT

An oscilloscope deflection amplifier for the measurement and viewing of pulses of short duration and rise time.

Frequency Response: flat from 10 cps to 20 mc.
Amplifier Gain: 320 (50 db.)
Phase: Linear with frequency.
Output: 120 V. pk. to pk.

Visit our booth at the I.R.E. show, 277-279

Polarad

ELECTRONICS CORPORATION
100 METROPOLITAN AVENUE
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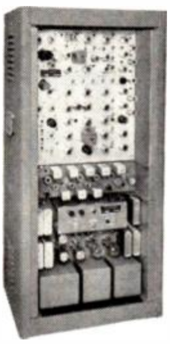
POLARAD

COLOR TV & B/W EQUIPMENT

TV PICTURE AND SIGNAL GENERATING EQUIPMENT



Color Synchronizing Generator—Model PT-201

Furnishes NTSC color TV subcarrier frequency component and contains divider network to yield 31.5 KC signal. Provides driving, blanking and synchronizing pulses, as well as vertical and horizontal dots for linearity checks. Utmost stability assured by driving all pulses from leading edge of crystal controlled oscillator.

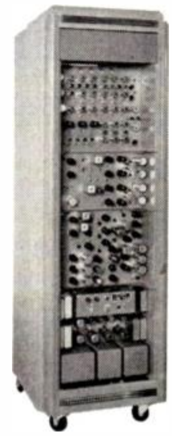
Output Signals: (4 to 6 Volts, 75 Ohms, pos. & neg. polarity):
Synchronizing Signal Camera Blanking Signal Horizontal Drive Signal Vertical Drive Signal Composite Video Output NTSC Color Subcarrier Freq. (3.579545 mc/s)

Black & White Synchronizing Generator—Model PT-104

Same as color synchronizing generator. Furnished without Subcarrier Frequency Generator.

Color Subcarrier Frequency Generator —Model PT-202

Modifies any existing standard (B/W) synchronizing generator in accordance with NTSC color TV standards by supplying NTSC color subcarrier frequency of 3.579545 mc/s ± 0.0003%. Also, contains divider network to yield 31.5 KC signal.



Color Bar Generator—Model PT-203

Provides color TV test signals, NTSC standards, for color TV equipment, networks and components. Supplies complete composite video signal in the form of seven fundamental color bars simultaneously with seven gradations of gamma bars.

Output Signals: Composite Video (2 outputs) (Sync. negative & positive)
Signal Information: 7 Bars of Color 7 Bars of Gamma Gradations White Dot Pattern (Vert. and Hor.)
Ext. Video Input for Mixing: 2 Volts neg. polarity

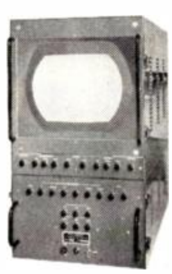
Other Equipment Available

An NTSC Color TV Flying Spot Scanner, furnished as a completely packaged unit supplying a standard color video signal. And, a **Monoscope Signal Source—** Model PT-102 used for transmitting a laboratory quality black and white test pattern.

TV MONITORING EQUIPMENT

Color Video Monitor—Model M-200

Consists of two portable units —uses 15 inch RCA tri-color Kinescope. Checks quality of NTSC color video signals in studio, on transmission, or in factory. Excellent synchronizing stability. Displays highest definition transmitted pictures with exceptionally good color rendition. All controls on front panel. Instrument may be rack mounted or employed as field test equipment.



Signal Polarity: Positive, Negative, Balanced Input Video Signal: 0.5 to 2.0 Volts, peak to peak Input Impedance: 66 mmf across 2.2 megohms Resolution: 250-300 lines (Full Utilization of NTSC Color Signal Bandwidth) Linearity: Better than 2% across raster Horizontal and Vertical

Studio Picture Monitor—Model M-105

A portable instrument used to check the picture quality of video signals in either a black/white or color television system. The unit employs a 12½" aluminized kinescope and is capable of presenting high definition transmitted pictures.

Signal Polarity: Positive, Negative, Balanced Input Video Signal: 0.25 to 2.0 Volts, peak to peak Input Impedance: 66 mmf across 470,000 ohms Retrace Time: 4 microseconds Resolution: Greater than 450 lines

Other Monitors Available:

Model M-102: High quality picture and wave form monitor.

Model 102MPS: 7" Kinescope, portable picture monitor.

Portable Wave Form Monitor—Model TO-1

Portable instrument designed for waveform analysis and amplitude measurement of NTSC color and B/W video signals in television circuits. It may be used, however, as a general purpose instrument. Means are provided for calibrating or comparing signals observed, and for selecting desired vertical amplifier bandwidth.

Deflection sensitivity: Greater than 0.1 Volts/In.
Hor. expansion: 20 tube diameters
Input Signal Level: 0.05 to 300 Volts peak to peak
Frequency Response Vertical Amplifier: I.R.E. —3.5 db at 2 mc. Normal —3.0 db at 4 mc. Line Test—3.0 db at 6 mc.

GENERAL EQUIPMENT

Power Supplies

Model No.	Output Voltage	Output Current
PT-110	400-450 V.	250-300 Ma
PT-111	250-300 V.	100-400 Ma
PT-111D*	250-300 V.	100-400 Ma
PT-112	250-300 V.	150-800 Ma

*Double Output

Polarad

Visit our booth at the I.R.E. show, 277-279

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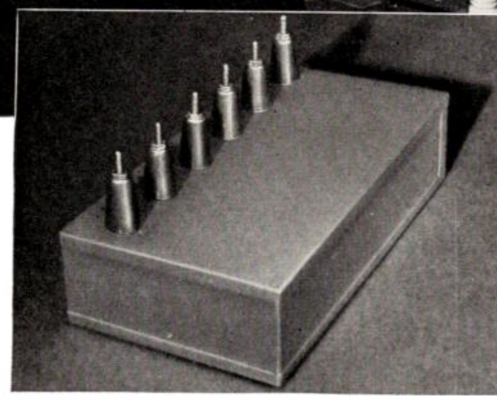


Plasticon Pulse Forming Network

New Pulse Forming Network Laboratory Highlights

200% INCREASE

in production facilities

Condenser Products offers the electronic manufacturing industry fast efficient cooperation in all phases of Pulse Forming Network design in its new completely equipped laboratory. Our enlarged engineering staff provides prompt servicing of inquiries relating to specifications analysis, research and production.

Two complete Plants are now in full operation

Strategically located in Chicago and New Haven, Conn., Condenser Products provides its customers with stepped-up service, efficient delivery scheduling, and complete quality control in volume production.

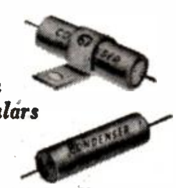
• VISIT BOOTH 423 ON ELECTRONICS AVE., RADIO ENGINEERING SHOW

Send for catalogue sheets and performance charts on any of these CP products:

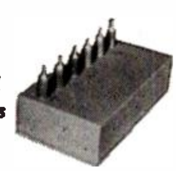
Plasticon Hi-volt Power Supplies

Plasticon Glassmikes

Plasticon Rectangulars



Plasticon Metal-clad Miniatures



Plasticon Pulse Forming Networks

CONDENSER PRODUCTS COMPANY

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Division of New Haven Clock & Watch Company

Another FIRST from -*hp*-!

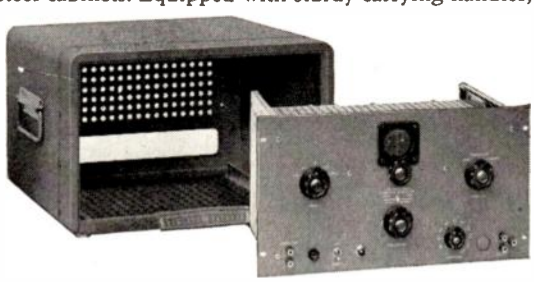
Standard test instruments mounted exactly as you want them!

• all-metal cabinets
• relay rack
• end frames

◀ **-*hp*- 100D Frequency Standard in streamlined metal cabinet now offered with -*hp*- instruments**

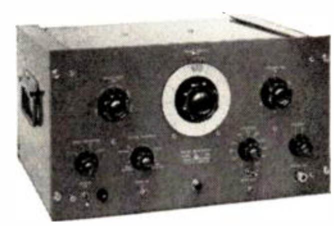
Now you can buy -*hp*- instruments mounted any of three ways, and, later on, change to any other mounting you wish. This new versatility means greater utilization of your -*hp*- instruments, and can also increase the flexibility of your entire instrument setup.

Cabinets. -*hp*- instruments having the standard 10½" x 19" panel are now available in standardized -*hp*- AC 44 aluminum-and-steel cabinets. Equipped with sturdy carrying handles, these



cabinets give your -*hp*- instruments greater protection, better ventilation, and a clean, rugged, modern appearance. Either the separate back cover or the cabinet itself can be removed quickly and easily. Cabinets are finished in wrinkle grey matching the -*hp*- grey baked enamel panel faces. -*hp*- AC44 cabinets are now available with the following instruments when factory shipment is made: -*hp*- 100C,D, 202A, 202B, 205A,AH,AG, 206A, 212A, 330B,C,D, 520A, 522A,B, 624B, 650A and 712B. Model AC44 Cabinet, with instrument, $15.00; separately, $25.00.

End frames. To increase flexibility and convenience of -*hp*- instruments for bench use, -*hp*- Model 17 End Frames are offered. These frames are of heavy gauge aluminum, equipped with sturdy carrying handles and finished in -*hp*- grey baked enamel. They fit all late model -*hp*- instruments with panel size 10½" x 19", and may be attached in moments. -*hp*- 17 End Frames, $7.50 set.



Rack mounting. Many -*hp*- instruments are basically rack mounting and can be installed directly into 19" relay racks. Many other -*hp*- instruments can be equipped for relay rack mounting at slight additional charge. A complete list of instruments available for rack mounting will be sent on request.

Smaller -*hp*- instruments, too, are now being delivered in new, streamlined cabinets. -*hp*- 512A Frequency Converter, illustrated, shows the rugged, lightweight metal cabinet now offered with such instruments as -*hp*- 200AB, 200CD, 410B and 715A.

Write today for bulletin listing all -*hp*- instruments now available with new cabinets and other mounting options

HEWLETT-PACKARD COMPANY
2999D Page Mill Road • Palo Alto, California, U.S.A.
Field representatives in all major cities

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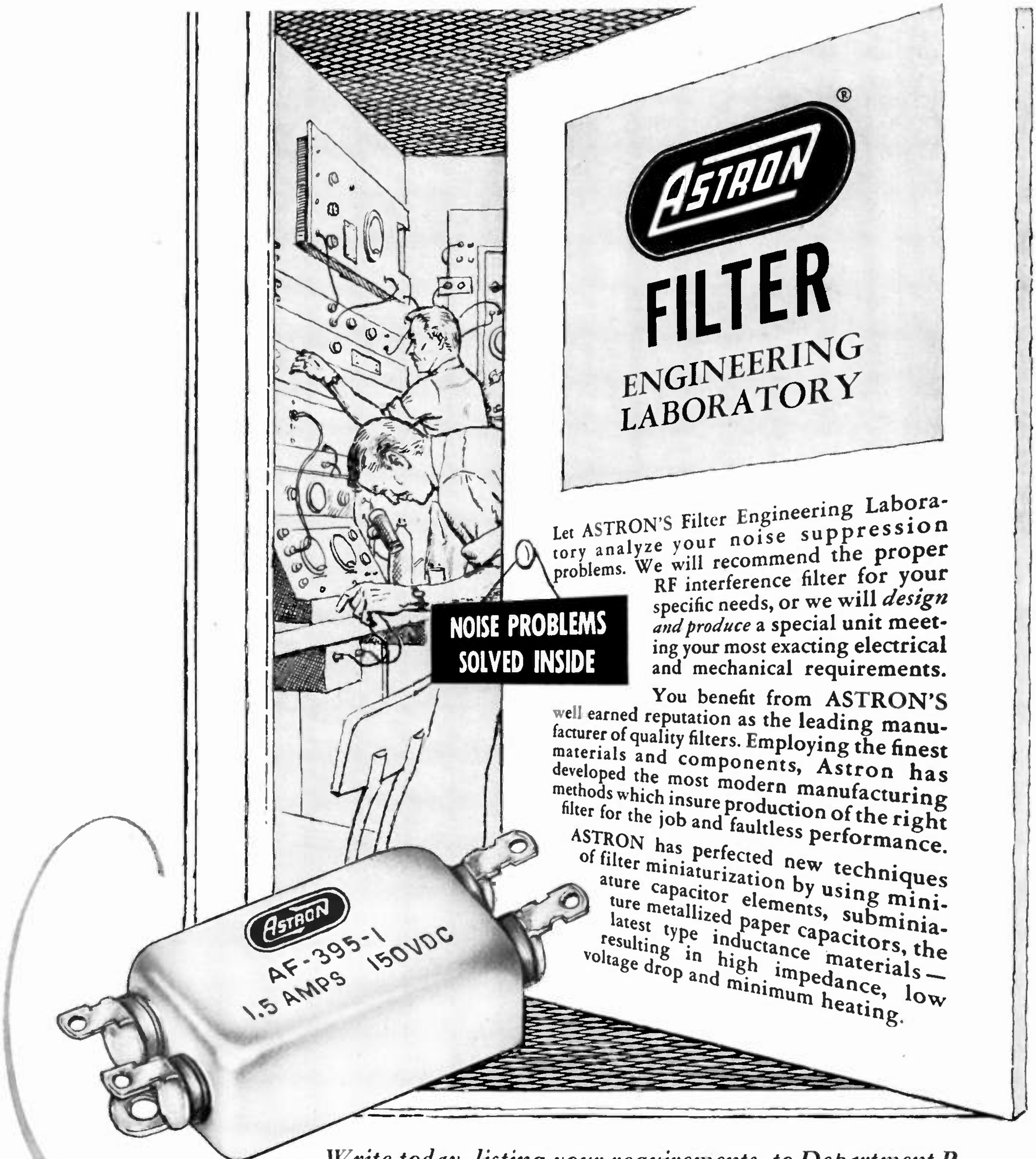
hp at I.R.E. Corner INSTRUMENTS AVENUE and RADIO ROAD



ASTRON® FILTER ENGINEERING LABORATORY

Let ASTRON'S Filter Engineering Laboratory analyze your noise suppression problems. We will recommend the proper RF interference filter for your specific needs, or we will *design and produce* a special unit meeting your most exacting electrical and mechanical requirements.

You benefit from ASTRON'S well earned reputation as the leading manufacturer of quality filters. Employing the finest materials and components, Astron has developed the most modern manufacturing methods which insure production of the right filter for the job and faultless performance.

ASTRON has perfected new techniques of filter miniaturization by using miniature capacitor elements, subminiature metallized paper capacitors, the latest type inductance materials—resulting in high impedance, low voltage drop and minimum heating.

Write today, listing your requirements, to Department P

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Radio Engineering Show
March 22-25

DEPEND ON . . . INSIST ON

ASTRON CORPORATION

255 Grant Avenue E Newark N J

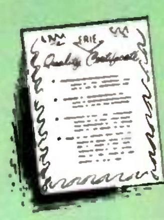
Manufacturers of a complete line of capacitors, standard and subminiature filters for every television, radio and electronic application.

Export Division: Rocke International Corp., 13 East 40 St., New York, N Y. In Canada Charles W Pointon, 6 Alcina Ave., Toronto 10, Ontario

An Insurance Policy that Saves You Manufacturing Costs
Included in every shipment of Erie Capacitors

ERIE® *Quality Certificate*

What is an ERIE Quality Certificate?



An Erie Quality Certificate is a form that lists the results of both electrical and mechanical tests for every shipment of Erie Capacitors. These tests are made by competent quality control inspectors using modern and precise measuring equipment.

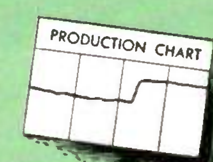
Will it Cut Costs?

YES — With the Quality Certificate you cut costs by reducing incoming inspection. You save the bother, time, and expense of returning faulty material because you are dealing with capacitors of a known quality. You also reduce the risk of putting faulty capacitors in your products.

Here's an Extra Dividend!

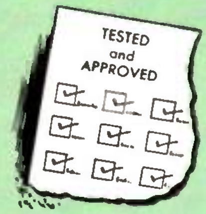
Erie Quality Certified capacitors cost you no more than other kinds. You benefit because quality products are always cheaper to use and add quality to your finished products.

Will it Speed Production?



YES — It takes less time for Quality Certified Erie capacitors to get from your receiving doors to your production lines. It eliminates costly trouble-shooting delays on your assembly line and in your inspection of the finished products.

What Does the Quality Certificate Offer?



The Quality Certificate lists the sample size and test results for each inspection sequence or series of inspection tests. The frequency distribution of capacitance values in the sample is also shown. Electrical tests include dielectric strength, insulation resistance, and dissipation factor. Other tests such as temperature coefficient, case insulation breakdown are performed and results listed where applicable. The certificate also contains a complete inspection check list for mechanical and visual items. The sampling tables used are MILITARY STANDARD 105 with AQL's (Acceptable Quality Level) ranging from 0.4% for performance items to 1.5% for non-functional deviations.

Again the Pioneer

As in so many other important developments in electronic components, Erie again leads the field. Erie is the first ceramic capacitor manufacturer to give customers this complete quality information with each shipment.

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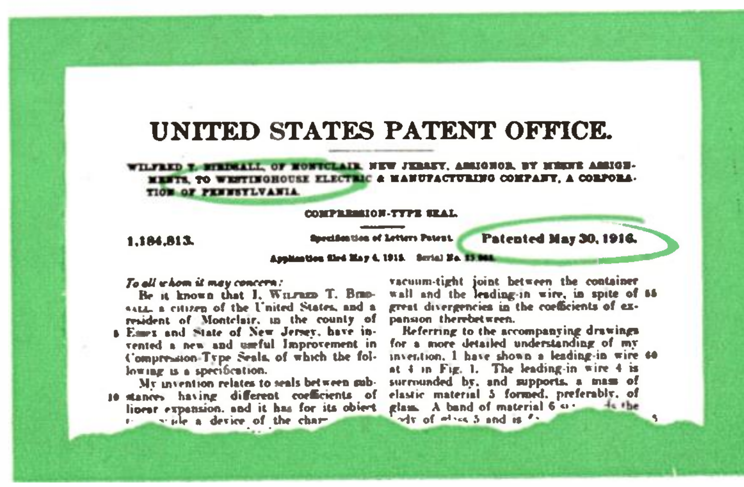
Visit Our Booth 538, Components Ave., IRE Show

The Invention of Compression-Type Seals is about as Old as Grandma's Phonograph—

but Constantin's Production Facilities and Methods are as New as Tomorrow



UNITED STATES PATENT OFFICE.

WILFRED T. BIRDSALL, OF MONTCLAIR, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

COMPRESSION-TYPE SEAL.

1,184,813. Specification of Letters Patent. Patented May 30, 1916.

To all whom it may concern:

Be it known that I, WILFRED T. BIRDSALL, a citizen of the United States, and a resident of Montclair, in the county of Essex and State of New Jersey, have invented a new and useful Improvement in Compression-Type Seals, of which the following is a specification.

My invention relates to seals between substances having different coefficients of linear expansion, and it has for its object ... a device of the char...

vacuum-tight joint between the container wall and the leading-in wire, in spite of great divergencies in the coefficients of expansion therebetween.

Referring to the accompanying drawings for a more detailed understanding of my invention, I have shown a leading-in wire at 4 in Fig. 1. The leading-in wire 4 is surrounded by, and supports, a mass of elastic material 5 formed, preferably, of glass. A band of material 6 ... the ... of glass 5 and is ...

The invention of compression-type seals in general is quite old as evidenced by U. S. Letters Patent No. 1,184,813, issued to Wilfred T. Birdsall and assigned to the Westinghouse Electric and Manufacturing Co. on May 30, 1916, for the original compression-type seals, expired in 1933. It is now public domain.

Yes, the idea of high compression glass to metal seals is thirty-seven years old and public domain. The compression principle can be employed by anyone, but Constantin makes the *quality* seal.

The wise buyer now is concentrating on quality of manufacture and materials. For over eight years L. L. Constantin & Company has been operating the most modern machine shop facilities for die construction, stampings, and bending—a glass department capable of compounding, tableting and sintering—latest ovens for fusing—multi-slide machines for pin fabrication. In this way, our completely self-contained plant operating all under one roof, can produce true compression seals of highest quality, in addition to our regular line of hard glass to KOVAR and RODAR alloy seals.

We at Constantin realize that adding color to the already pure white glass does not add to the strength, and for identification purposes, whether you buy green, gray, blue, brown or other colors, you will find Constantin seals to be consistently uniform and superior in strength.

Constantin can proudly say that it is not selling an idea. Constantin is selling precision engineered high compression glass-to-metal vacuum seals. See them, test them, and compare.

Seals also available in KOVAR and RODAR alloys to hard glass types.

Also manufacturers of—

- **MULTI-PIN HEADERS**
- **TERMINALS**
- **TRANSISTOR MOUNTS**
- **MULTI-PIN CON PLUGS**
- **END SEALS**
- **CRYSTAL HOLDERS**
- **VACUUM COATING EQUIPMENT**

L. L. Constantin & Co.

MANUFACTURING ENGINEERS

Rt. 46 and Franklin Ave., Lodi, N. J.

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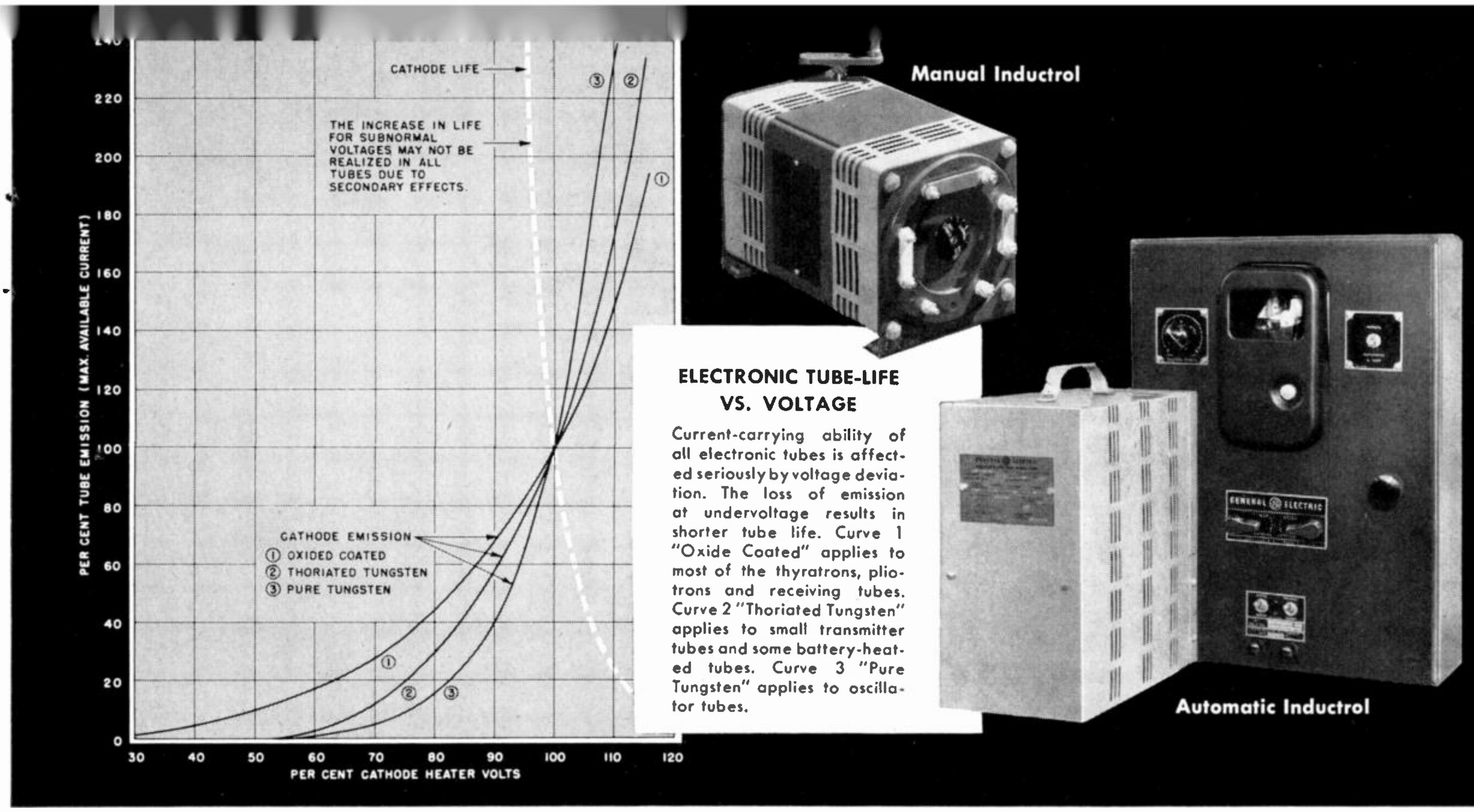

ELECTRONIC TUBE-LIFE VS. VOLTAGE

Current-carrying ability of all electronic tubes is affected seriously by voltage deviation. The loss of emission at undervoltage results in shorter tube life. Curve 1 "Oxide Coated" applies to most of the thyratrons, pliotrons and receiving tubes. Curve 2 "Thoriated Tungsten" applies to small transmitter tubes and some battery-heated tubes. Curve 3 "Pure Tungsten" applies to oscillator tubes.

For maximum tube life and performance, include G-E Inductrols as "original equipment"

Automatic voltage regulation provides an effective and economical means of avoiding losses in power capacity

The life and efficiency of the electronic equipment you manufacture depends, to a large extent, on the performance of the electronic tubes. Tube life is adversely affected by over- or under-voltage conditions *that can easily be prevented.*

G-E dry-type induction voltage regulators, called Inductrols, offer you an effective and economical means of maintaining correct operating voltage. Two types are available for indoor service on circuits 600 volts and below, single-phase 3 to 240 kva; three-phase 9 to 520 kva.

1. **Automatic** Inductrols maintain a closely regulated output voltage from a varying supply voltage with a bandwidth of ±1%. The standard range of regulation is plus and minus 10%.
2. **Hand-operated or manually controlled motor-operated** Inductrols provide a variable output voltage from a relatively constant supply voltage. They supply 100% raise and 100% lower regulation.

You can put your confidence in—

GENERAL ELECTRIC

Typical applications for G-E Inductrols that have proved highly effective include: radar equipment, induction heating equipment, medical and industrial x-ray equipment, TV and radio transmitters.

For further information, contact your nearest G-E sales office, agent or distributor...or return the attached coupon.

HERE'S HELPFUL G-E DATA ON INDUCTROLS

For full details on dry-type induction voltage regulators, return this coupon . . . today!

Single-phase INDUCTROLS, indoor service
600 volts and below on circuits 3 to 240 kva—GEC-795A ☐

Three-phase INDUCTROLS, indoor service
600 volts and below on circuits 9 to 520 kva—GEA-5824 ☐

Application bulletin,
Inductrols and electronic equipment—GEA-5936 ☐

General Electric Company
Section D 423-201, Schenectady 5, N.Y.

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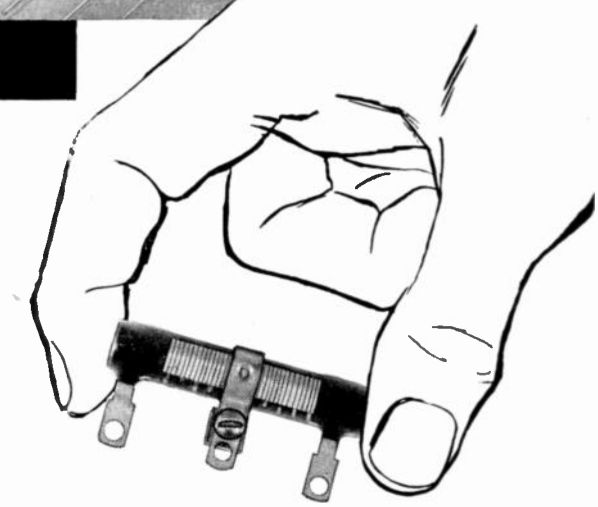
Company ____________________

Address ____________________

City ____________ Zone ______ State ____________

OHMITE® *Resistors...*



THE MOST COMPLETE LINE OF WIRE-WOUND RESISTORS ON THE MARKET

Whatever your resistor needs . . . chances are there's an Ohmite resistor "tailored" exactly to the job. For the Ohmite line includes literally hundreds of units covering a wide range of types and sizes. There are fixed, tapped, adjustable, precision, and non-inductive resistors, with many types of terminals and mountings in a variety of ratings. Regardless of the particular unit *you* need, you are assured of the special design and construction features that have earned Ohmite's reputation for unsurpassed dependability.

OHMITE®

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for Catalog No. 40
Ohmite Manufacturing Co.
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Skokie, Illinois
(Suburb of Chicago)

FIRST IN WIRE-WOUND RHEOSTATS AND RESISTORS

See Our Exhibit 554 Components Ave., IRE Show

WAVELINE

precision instruments

measurement standard of industry

Man's progress has always depended upon the accuracy of scientific measurement.

Waveline, industry leader in production of precision microwave instruments and accessories . . . parallels the needs of progress . . . increases numbers of more exact measuring devices.

Improvements in engineering, laboratory and production facilities make possible even greater development, scheduling and delivery service for all clients.

In the field, Waveline's staff of trained engineers are ready to give immediate and personal attention to all technical problems.

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Everette Associates, Inc.
Box 6236
Speedway City

KANSAS CITY 3, MO.
Everette Associates, Inc.
1629 East 31st

LOS ANGELES 6, CALIF.
John B. Tubergen Co.
2232 West 11th Street

NEWARK, N. J. AREA
Gawler-Knoop Co.
178 Eagle Rock Ave.
Roseland, New Jersey

NEW HAVEN 15, CONN.
Robert A. Waters. Inc.
1150 Whalley Avenue

NEW YORK CITY AREA
Gawler-Knoop Co.
178 Eagle Rock Ave.
Roseland, New Jersey

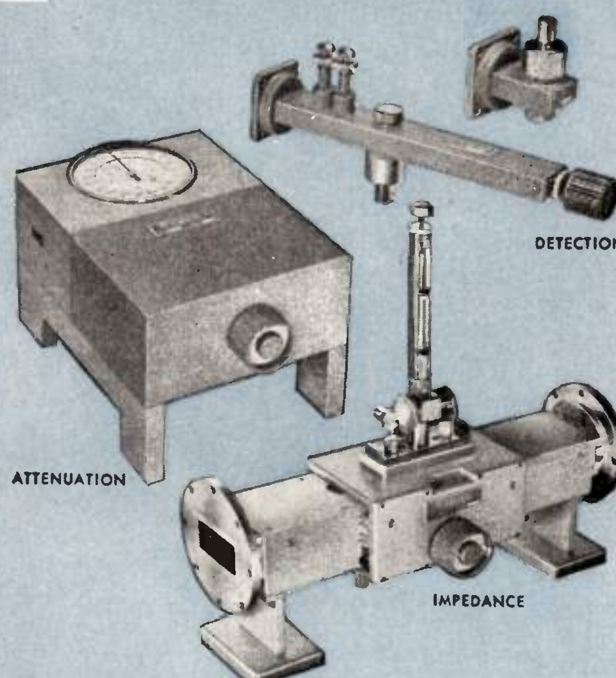
PHILADELPHIA, PA. AREA
Gawler-Knoop Co.
835 Glenside Avenue
Wyncote, Pa.

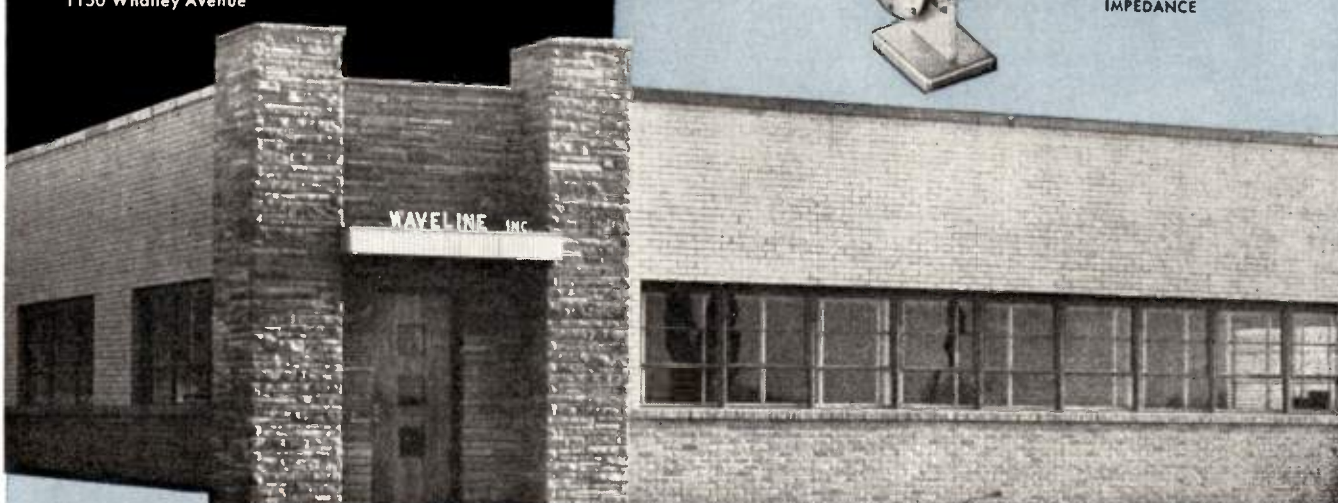
ROCHESTER 10, NEW YORK
Edward A. Ossmann & Associates, Inc.
3 Juniper Street

SYRACUSE, NEW YORK
Edward A. Ossmann & Associates, Inc.
308 Merritt Avenue

WASHINGTON, D. C. AREA
Gawler-Knoop Co.
901 Pershing Drive
Silver Spring, Maryland

TORONTO 12, CANADA
R-O-R Associates, Ltd.
290 Lawrence Ave., W.





Write today for Technical Data on microwave instruments

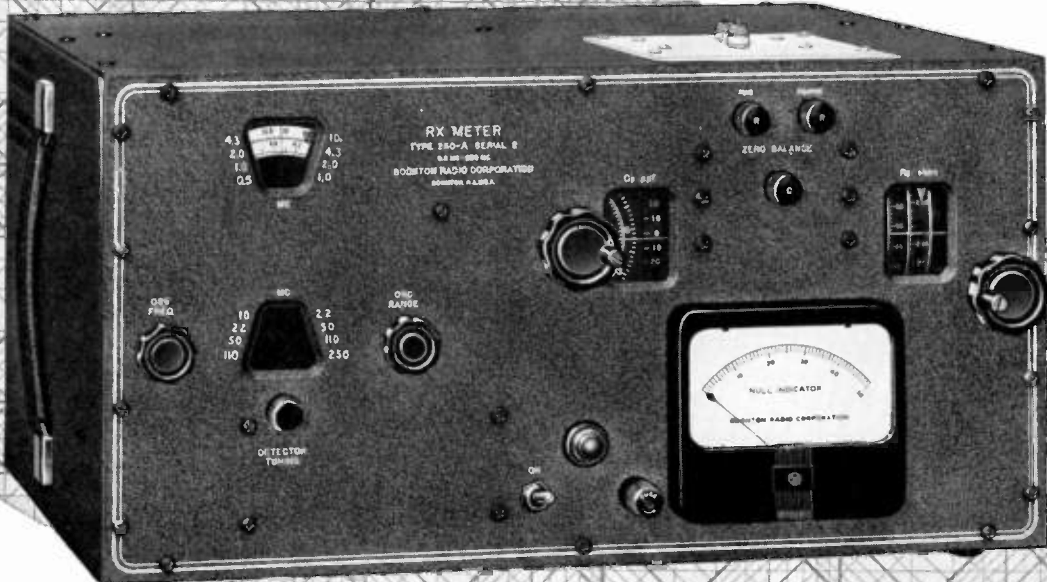
BE SURE TO SEE US AT BOOTH 376 IRE SHOW.

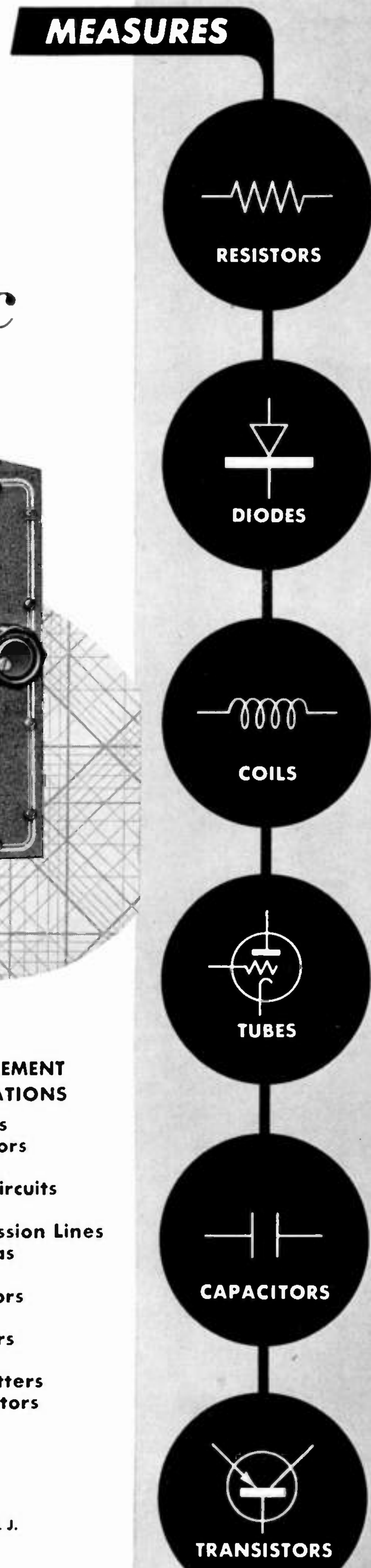
WAVELINE INC
CALDWELL NEW JERSEY

A Completely Self-Contained

RF BRIDGE

500 kc to 250 mc





RX METER TYPE 250-A

- **SAVES** valuable engineering labor: makes RF bridge measurements a "means to an end" rather than an end in themselves.
- **INCLUDES** self-contained test oscillator, local oscillator, Schering bridge, detector, and null indicator.
- **INDICATES** directly equivalent parallel resistance and capacitance (or inductance) of any two-terminal network.
- **MEASURES** dynamic and static systems under actual operating conditions.
- **CONNECTS** to unknown from convenient binding posts or Type N coaxial (with use of accessory adapter).

SPECIFICATIONS

FREQUENCY RANGE: 500 KC to 250 MC in eight ranges.

FREQUENCY ACCURACY: $\pm 1\%$.

RESISTANCE RANGE (Rp): 15 to 100,000 ohms.

RESISTANCE ACCURACY (Rp): $\pm \left\{ 2 + \frac{F_{mc}}{200} + \frac{R_p}{5000} + \frac{Q}{20} \right\} \% \pm 0.2$ ohms.

CAPACITANCE RANGE (Cp): -100 mmf to $+20$ mmf.

CAPACITANCE ACCURACY (Cp): $\pm \left\{ 0.5 + 0.0002\, F^2_{mc} \right\} \% \pm 0.15$ mmf.

TEST VOLTAGE: 0 volts D. C. (Up to 50 ma. may be passed through unknown terminals).
0.1—0.5 volts R. F. (may be conveniently reduced to 20 mv.).

POWER REQUIREMENTS: 105—125 volts, 50/60 cps, 60 watts (internally regulated).

MEASUREMENT APPLICATIONS

Resistors
Transistors
Tubes
Tuned Circuits
Diodes
Transmission Lines
Antennas
Coils
Capacitors
Chokes
Receivers
Filters
Transmitters
Attenuators
Pads

Price: $1250.00 F.O.B. Boonton, N. J.

BOONTON RADIO *Corporation*
BOONTON·N·J·U·S·A·


STANDING WAVE AMPLIFIER

What to See at the Radio Engineering Show

(Continued from page 54A)

Alpha Wire Corp., 454 Electronic Ave.
Electronic wire and cable. Government specification and commercial types for radio-sound-aircraft-radar-television.

Altec Lansing Corp., 882, 884 Audio Ave.
*21C "Lipstick," a small condenser microphone for lapel as well as hand and stand mounting. *One specially developed for medical applications (heart and circulatory).

American Silver Company, Inc., 350 Mobile Ave.
Wide variety ferrous, non-ferrous, precious metal strip. Thin gauges, very close tolerances. For electronic, communications, instrumentation and allied industries. Clad metals. *Thermostat metals.

*Indicates new product

(Continued on page 87A)

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 36A)

RF and Microwave Insulation

Stycast 0005, a newly developed plastic material featuring, low dissipation factor, excellent high and low temperature stability and machining ease was developed by **Emerson & Cuming, Inc.**, 869 Washington St., Canton, Mass.

This new material has tensile strength of 11,000 psi, and a Rockwell M Scale hardness of 105. At frequencies of 60 to 10^{10} cps the dielectric constant is 2.53 to 2.56; dissipation factor is below 0.0005.

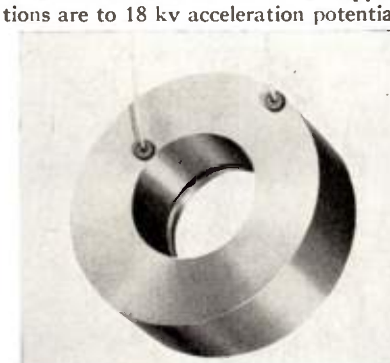
Stycast 0005 will withstand temperatures as low as −70°C(94°F) without adverse electrical or physical effects. It is a thermosetting plastic and will not flow even when subjected to temperatures as high as 200°C (392°F) though it is recommended that prolonged heating under stress should be limited to 125°C.

Stycast 0005 rods are available in diameters from ¼ inch to 3 inches; in sheets from ¼ to 1 inch in thickness.

For detailed specification and prices write for Bulletin 9-6-3.

Focus Coil

Designed for use as a precision standard for checking the distortions in production focus coils and as a component in units or applications requiring sharpest focus, a new electromagnetic focus coil has been announced by **Syntronic Instruments, Inc.**, 100 Industrial Rd., Addison, Ill. Type F10 fits cathode-ray tubes having a 1½ inch maximum neck diameter. Applications are to 18 kv acceleration potential.



The manufacturers claim that spot distortion is eliminated by a 1/10 inch wall machined case. This case is soft magnetic iron machined to close dimensional accuracy.

External magnetic fields are eliminated by the nature of the design. As a result, there is no distortion or beam bending in the magnetic gun. There is no beam shadowing. The unit may be used for centering the beam if desired.

F10 is obtainable over a wide range of coil resistance. The following data is typical for this coil.

Electrical data (this data covers Type F10A 12,000 ohm coil which is carried in stock and meets many laboratory requirements); R-12,000 ohms; I-25 ma at 18 kv (for focal length of 2.5 inches; E-300 v. Catalog available on request.

(Continued, See Index)

PICTURE TUBES

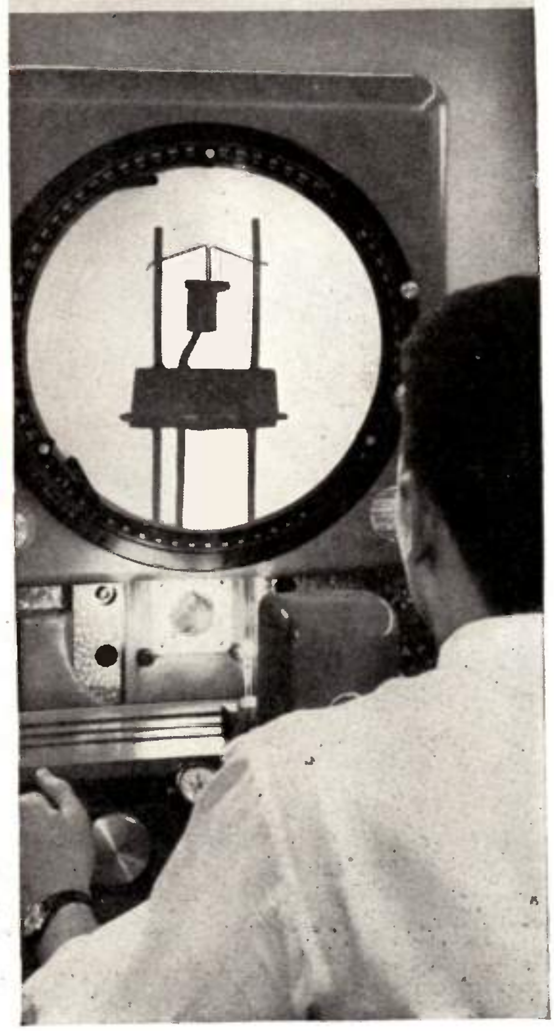
RADIO TUBES

TV TUBES

SPECIAL-PURPOSE ELECTRON TUBES

CRYSTAL PRODUCTS

PLUS—ALL THE TECHNICAL SERVICE THAT GOES WITH THEM



TUNG-SOL ALSO MAKES ALL-GLASS SEALED BEAM LAMPS, MINIATURE LAMPS AND SIGNAL FLASHERS.

TUNG-SOL 50 YEARS ACHIEVEMENT

TUNG-SOL

Visit us at The Radio Engineering Show
Booths 687, 689, Circuits Avenue

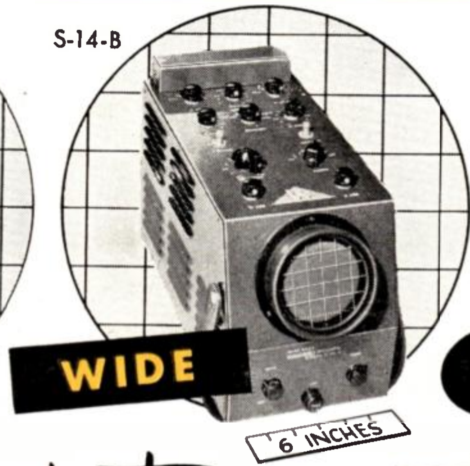
TUNG-SOL ELECTRIC INC., Newark 4, New Jersey
Sales Offices: Atlanta, Chicago, Columbus, Culver City (Los Angeles), Dallas, Denver, Detroit, Newark, Seattle.

Waterman POCKETSCOPE

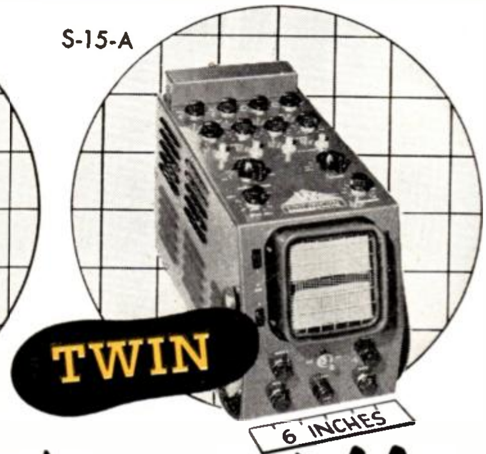
The Pocket-Size Oscilloscope

S-14-A

S-14-B



S-15-A



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

Featuring small size, light weight and outstanding performance the HIGH, WIDE and TWIN POCKETSCOPES have become the "triple threat" of the oscilloscope field. Their incomparable versatility, reliability and accuracy have skyrocketed this team of truly portable instruments into unparalleled demand. Each oscilloscope features DC coupled amplifiers in both vertical and horizontal channels.

HIGH

The S-14-A HI-GAIN POCKETSCOPE provides the optimum in oscilloscope flexibility for analysis of low-level electrical impulses. Extremely light weight (12¾ lbs.), compact in size (12 x 5¾ x 7 in.), dependable and accurate in performance. Vertical and horizontal channels: 10mv rms/inch with response within 2DB from DC to 200 KC and pulse rise of 1.8 µs . . . non-frequency discriminating attenuators and gain controls with internal calibration of trace amplitude . . . repetitive or trigger time base with linearization from ½ cycle to 50 KC with ± sync or trigger.

WIDE

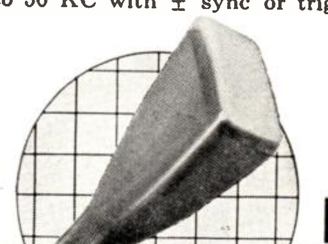
The S-14-B WIDE BAND POCKETSCOPE is ideal for investigations of transient signals, DC signals, aperiodic pulses or recurrent waveforms. Vertical channel: 50 mv rms/in. within —2DB from DC to 700 KC . . . pulse rise time of 0.35 µs. Horizontal channel: 0.15v rms/in. within —2DB from DC to 200 KC . . . pulse rise of 1.8 µs. Attenuators and gain controls are non-frequency discriminating . . . trace amplitude calibration . . . repetitive or triggered time base from ½ cycle to 50 KC . . . ± sync or trigger . . . trace expansion, filter graph screen and many other features . . . 14 lbs. . . . 12 x 6 x 7 inches.

TWIN

The S-15-A POCKETSCOPE is a portable, twin tube, high sensitivity oscilloscope with two independent vertical as well as horizontal channels. It is indispensable for investigation of electronic circuits in industry, school and laboratory. Vertical channels 10 mv rms/in. with response within—2DB from DC to 200 KC and pulse rise time of 1.8 µs . . . horizontal channels 1v rms/in. within —2DB from DC to 150 KC . . . non-frequency discriminating controls . . . internal signal amplitude calibration . . . linear time base from ½ cycle to 50 KC, triggered or repetitive, for both horizontal channels.

S-11-A

The S-11-A INDUSTRIAL POCKETSCOPE is a small, compact (5x7x11 inches), and lightweight (8¾ lbs.) instrument for observing electrical circuit phenomena. The flexibility of the POCKETSCOPE permits its use for AC measurements as well as for DC. The vertical and horizontal amplifiers are capable of reproducing within —2DB from DC to 200 KC with a sensitivity of 0.1v rms/in. . . . repetitive time base from 3 cycles to 50 KC continuously variable throughout its range . . . variations of input impedance, line voltage or controls do not "bounce" the signal—the scope stabilizes immediately.



RAYONIC CATHODE RAY TUBES BY WATERMAN

TUBE	PHYSICAL DATA		STATIC VOLTAGE		DEFLECTION*		LIGHT OUTPUT**
	FACE	LENGTH	A3	A2	VERT	HOR	
3JP1	3"	10"	3000	1500	111	150	352
3MP1	3"	8"		750	99	104	33
3RP1	3"	9.12"		1000	61	86	44
3SP1	1.5x3"	9.12"		1000	61	86	44
3XP1	1.5x3"	8.875"		2000	33	80	218

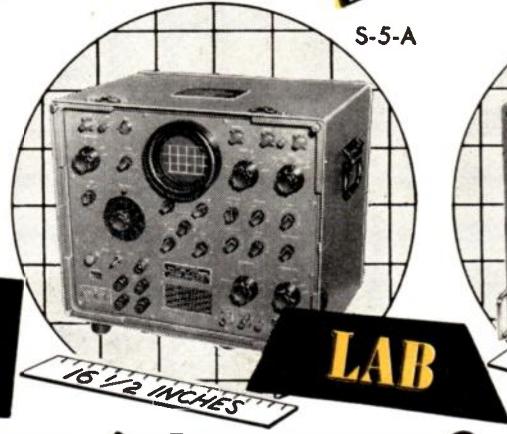
*Deflection in volts per inch.
**Light output of an element of a raster line (one mm long and not exceeding .65 mm in width) in microlumens.

The basic properties of the cathode ray tube that concern the designer or the user are: deflection sensitivity, unit line brightness, line width, static voltage requirements and physical size. A comparison between cathode ray tubes manufactured by Waterman Products Company is shown in the table adjoining. These tubes are available in P1, P2, P7 and P11 phosphors. 3JP1, 3JP7, 3SP1 and 3XP1 are available as JAN tubes.

Visit our Booths (158 and 160) at the IRE Show March 22 to 25.

PULSESCOPE by Waterman

The Oscilloscope that Portrays the Pulse



Classic Examples of Precision Engineering...

The PULSESCOPES are cathode ray tube oscilloscopes that portray the attributes of the pulse: shape, amplitude, duration and time displacement. All PULSESCOPES have internally generated markers with the basic difference that in the SAR PULSESCOPE the markers initiate the sweep while in the others the sweep starts the markers.

BROAD

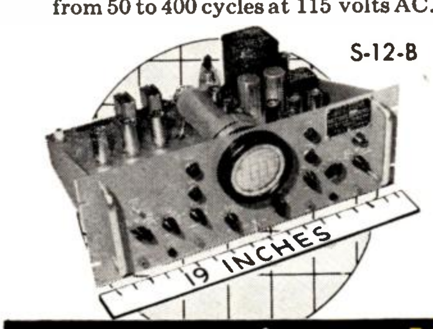
The S-6-A BROAD BAND Scope is a PULSESCOPE in performance, POCKETSCOPE in size. The instrument measures DC as well as AC signals. Unique DC calibration methods permit rapid measurements of either positive or negative, AC or DC signals. Vertical amplifier sensitivity of 0.2v rms/inch, and response to 5 mc within 3DB . . . pulse rise time of 0.1 μs . . . internal markers from 1 to 1000 μs . . . repetitive or trigger sweep from 5 cycles to 500 KC with 5X sweep expansion . . . sweep, marker and DC calibrating voltage available externally. Size 8½ x 6¾ x 13¾ in. Weight 22 lbs. Operates from 50 to 400 cycles at 115 volts AC.

LAB

The S-5-A LAB PULSESCOPE is a JANized (Gov't Model No. OS-26) portable, AC, wide band-pass, laboratory oscilloscope ideal for pulse as well as general purpose measurements. Internal delay of 0.55 μs permits observation of pulse leading edge. Includes precision amplitude calibration, 10X sweep expansion, internal trace intensity time markers, internal trigger generators and many other features. Video amplifier 0.1v p to p/inch . . . pulse rise time of .035 μs or response to 11 mc. 1.25 to 125,000 μs triggered or repetitive sweep . . . internally generated markers from 0.2 to 500 μs . . . trigger generator from 50 to 5000 pps. for internal and external triggering. Operates from 50 to 400 cycles at 115 volts AC.

SAR

The S-4-C SAR PULSESCOPE is a JANized (Gov't Model No. OS-4) portable instrument (31.5 lbs.) for precision pulse measurements for radar, TV and all electronic measurements. Portrays all attributes of the pulse . . . internal crystal controlled markers of 10 and 50 μs available for self-calibration . . . in R operation a small segment of the A sweep is expandable for detailed observation with a direct-reading calibrated dial accurate to 0.1%. Video amplifier band-pass up to 11 mc . . . optional video delay 0.55 μs . . . pulse rise and fall time better than 0.07 μs . . . R pedestal (sweep) 2.4 to 24 μs . . . video sensitivity of 0.5v. p to p/inch. Easily convertible from μs to yards. Operates from 50 to 400 cycles at 115 volts AC.



RAKSCOPE

Because the panel is only 7" high and fits any standard rack, the S-12-B RAKSCOPE admirably fills the need for a small oscilloscope of wide versatility. With all the features of the S-11-A POCKETSCOPE, the RAKSCOPE is JANized (Gov't Model No. OS-11), and has many additional advantages; the sweep, from 5 cycles to 50 KC, is either repetitive or triggered . . . vertical and horizontal amplifiers are 50 mv rms/inch with band-pass from 0 to 200 KC . . . special phasing circuitry for frequency comparison.

WATERMAN PRODUCTS CO., INC.

WATERMAN PRODUCTS

PHILADELPHIA 25, PENNA., U.S.A.

CABLE ADDRESS, POKETSCOPE, PHILA.

Manufacturers of POCKETSCOPES® • RAKSCOPES® • PULSESCOPES® and RAYONIC® TUBES

I·R·E NATIONAL CONVENTION and RADIO ENGINEERING SHOW

New York City
March
22-23-24-25

See latest developments in Fusion Sealed semiconductor devices at the

Hughes Exhibit

Booths
753-755-757
Kingsbridge Armory

Inspect the new Hughes Silicon Junction Diode shown for the first time. Standard Hughes point-contact germanium diodes in RETMA and special types will also be on display.

HUGHES DIODES

A New Standard of Reliability

Reliability in semiconductor devices is determined principally by permanent freedom from the two major causes of failure—moisture penetration of the envelope, and electrical instability under extreme operating conditions.

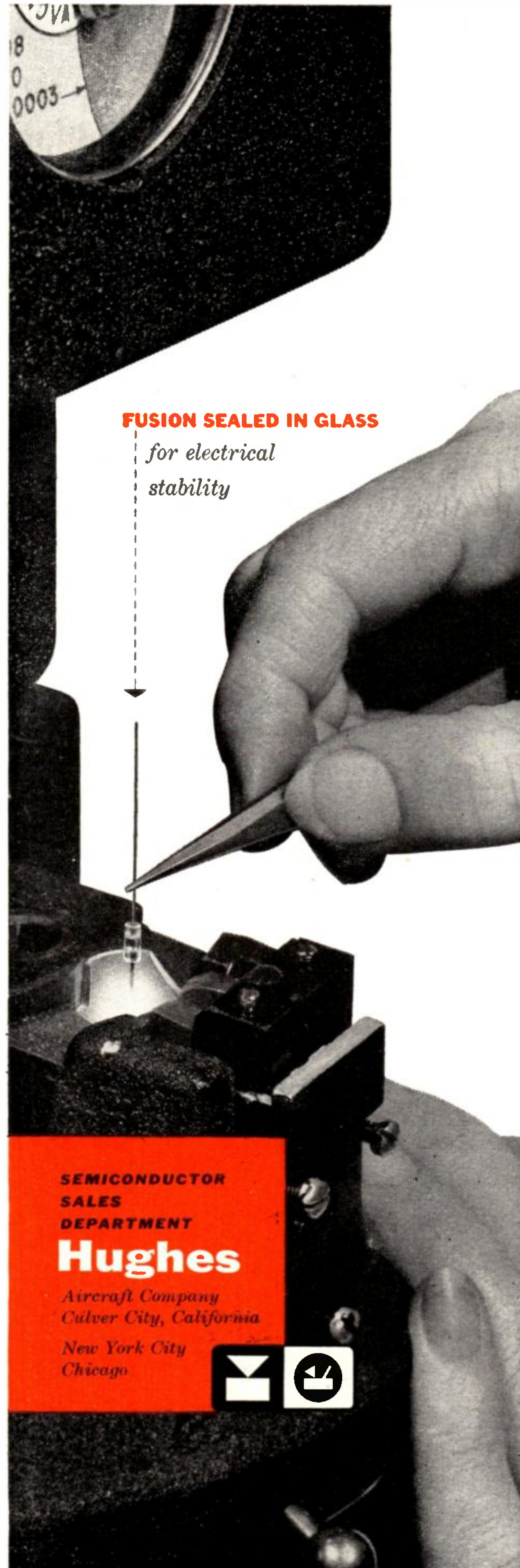
HUGHES SEMICONDUCTOR DEVICES are designed to prevent such failures through two exclusive features:

1. **Fusion Sealing**—The glass-to-metal seal, proved in billions of vacuum tubes, is incorporated to full advantage in semiconductor devices by the Hughes-developed process of fusion sealing at high temperature. The result is a rigid *one-piece* glass envelope impervious to moisture.

2. **100% Testing**—Hughes 100% testing procedures *invite* instabilities to occur prior to shipment, assuring rejection of defective units. *Each* standard **HUGHES DIODE** is temperature-cycled in saturated water vapor, JAN shock-tested, and electrically tested under vibration. This testing procedure insures operation of **HUGHES DIODES** under adverse conditions of moisture, temperature, vibration and severe shock.

Reliability of **HUGHES DIODES** has been proved in advanced airborne military radar and fire control systems, and for guided missiles. All Hughes semiconductor devices are designed to the same high standards of reliability.

Dimensions of actual diode envelope: 0.130" X .265"



What to See at the Radio Engineering Show

(Continued from page 78A)

Amperex
ELECTRONIC CORP.
Hicksville, Long Island, N. Y.
273-275 INSTRUMENTS AVE.
(Corner of Transistor Way)
Transmitting and Power Tubes, Rectifiers, Magnetrons, Thyratrons, Geiger Tubes, X-Ray Tubes, Fixed Vacuum Condensers, Germanium Diodes, Transistors, Special Purpose Tubes.

Ampex Corporation
Theatre #1
857 Audio Ave.
Data Recording 3D Stereophonic Sound demonstration
Latest professional audio recorders, reproducers. Magnetic recorders for all types of data. High speed tape duplicator, making pre-recorded tapes economically possible.

Andersen Laboratories, Inc.
422 Electronic Ave.
Solid ultrasonic delay lines. *Low attenuation lines precisely calibrated, operating over wide temperature range. Integrators and electronic circuit designs associated with delay line use.

Andrew Corporation
352 Mobile Ave.
Will feature HELIAX, a flexible air dielectric transmission line in 7/8" and 1 5/8" sizes, a new addition to a broad product line of radio antenna equipment.

ASCOP ®
Radio Telemetering
Time Division Data Systems
R-F Preamplifiers and Multicouplers
High Speed Sampling Switches
206-208 INSTRUMENTS AVE.
APPLIED SCIENCE CORP. OF PRINCETON
PRINCETON, N. J. · LOS ANGELES, CAL.

*Indicates new product

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

(Continued on page 106A)

New—at the show. Be sure to see them...

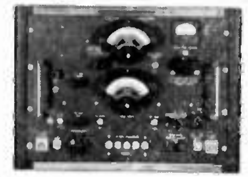
KAY ELECTRIC COMPANY BOOTH NOS. 242 244 246

MEGA-PIX SR. A crystal controlled TV picture and sound RF signal source for color, black and white. Built-in sound carrier modulating frequency. Standard video input signal required. Price: $990.00

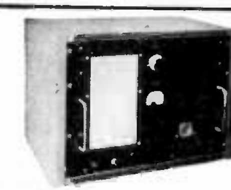
RADA-PULSER SR. A versatile pulsed-carrier generator with continuously variable calibrated frequency range from 12 mc to 80 mc. Calibrated variable pulse widths from 0.2 to 20 microseconds.

ULTRA-MARKER. Provides very narrow "pip" type crystal positioned marks at UHF TV picture and sound carrier frequencies on every channel or every fourth channel. Price: $395.00

MODEL UHF MARKA-SWEEP. Combines ULTRA-SWEEP and ULTRA-MARKER in single cabinet. Channels marked on dial, permitting rapid selection of any UHF TV channel with crystal positioned markers. Price: $945.00



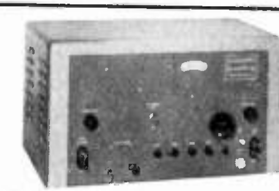
RADA-NODE. Complete radar noise figure measuring equipment, including IF and microwave noise sources, 30 and 60 mc amplifiers, accurately calibrated attenuator and indicating meter. Accuracy to fraction of a db.



MICROLATOR. Precisely controlled continuously tunable CW signal source. Range 8500-9600 mc. Frequency maintained through use of intermediate frequency loop system coupled to dial type micrometer tuning control.

TRANSALYZER. A transistor curve plotter designed to provide permanent record of input, transfer and output static characteristics in any of the standard grounded base, emitter and collector connections.

RADALYZER. A radar type receiver with a 30 mc IF for low level microwave measurements. Insertion loss measurements of over 60 db or losses of only 0.2 db are possible.



ULTRA-SWEEP. Precision UHF sweeping oscillator (450-900 mc) with 3 volt output, very flat amplitude response and frequency dial accurate to approx. ±1 mc. Sweep width variable to 50 mc. Price: $650.00

RADALIGNER. Wide band sweeping oscillator providing two radar swept IF frequencies, CW center frequencies and narrow crystal positioned markers. Metered output of 0.5 volts into 72 ohms. Price: $750.00

ULTRA-PIX. UHF TV crystal controlled picture and sound RF signal source. Covers three UHF channels. Other specifications same as MEGA-PIX SR. Price: $795.00

MODEL VIDEO TTV MARKA-SWEEP. Combines 8 mc wide video sweeping oscillator with 5 crystal positioned markers and a continuously variable marker. Metered output of 1.5 volts into 72 ohms. Price: $695.00

XTALATOR. Crystal controlled decade switched oscillator covering 100-500 mc with accuracy better than 0.005%. Decade switching for convenience and perfect resetability plus continuously variable tuning.

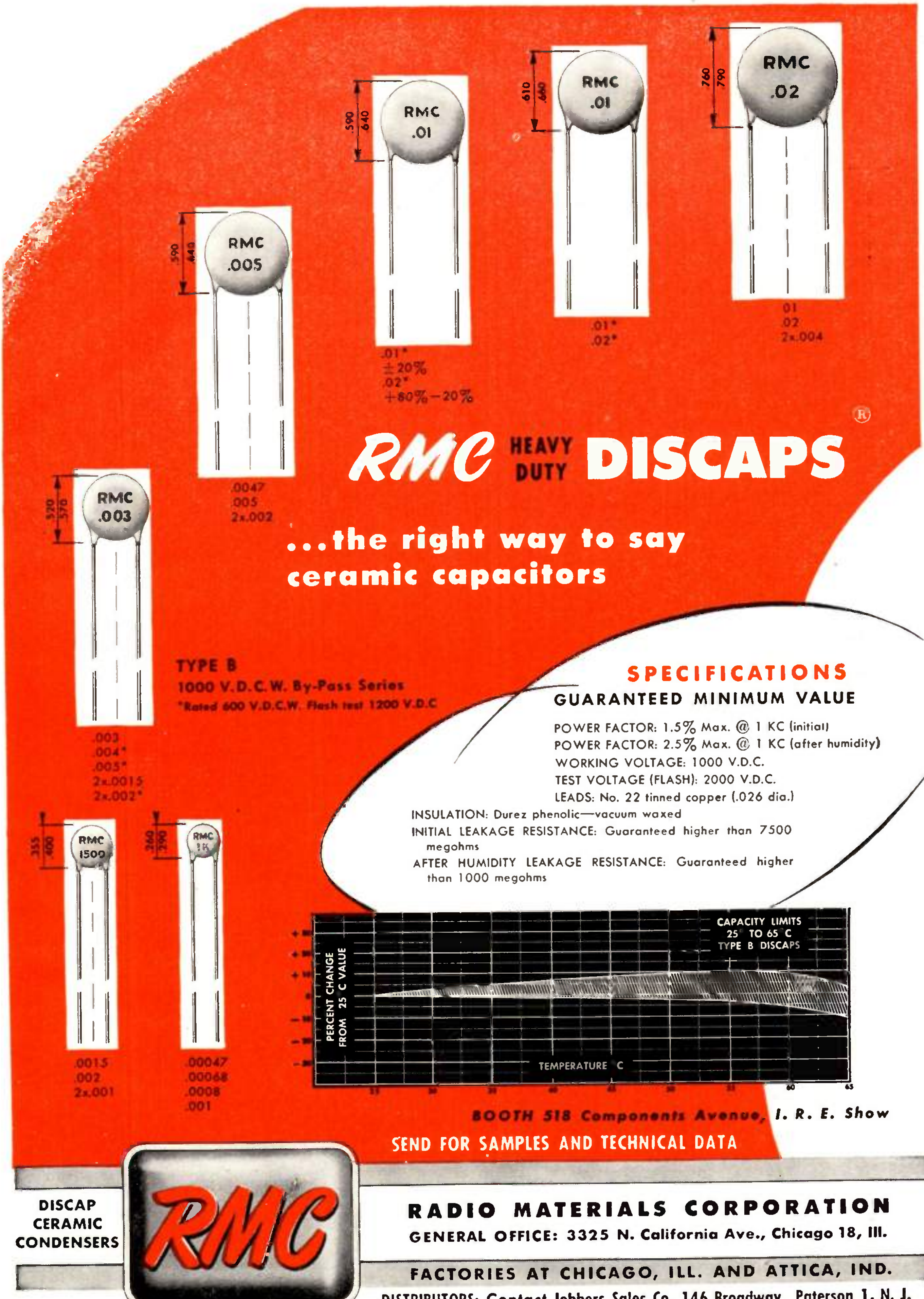
NEW MICROWAVE MEGA-NODES. Calibrated random noise sources with new gas tubes that have approx. zero temperature coefficient. RG-91/U waveguide for 12.4-18.0 kmc and RG-53/U for 18.0-26.5 kmc. Price: Waveguide $295.00, Power Supply $150.00

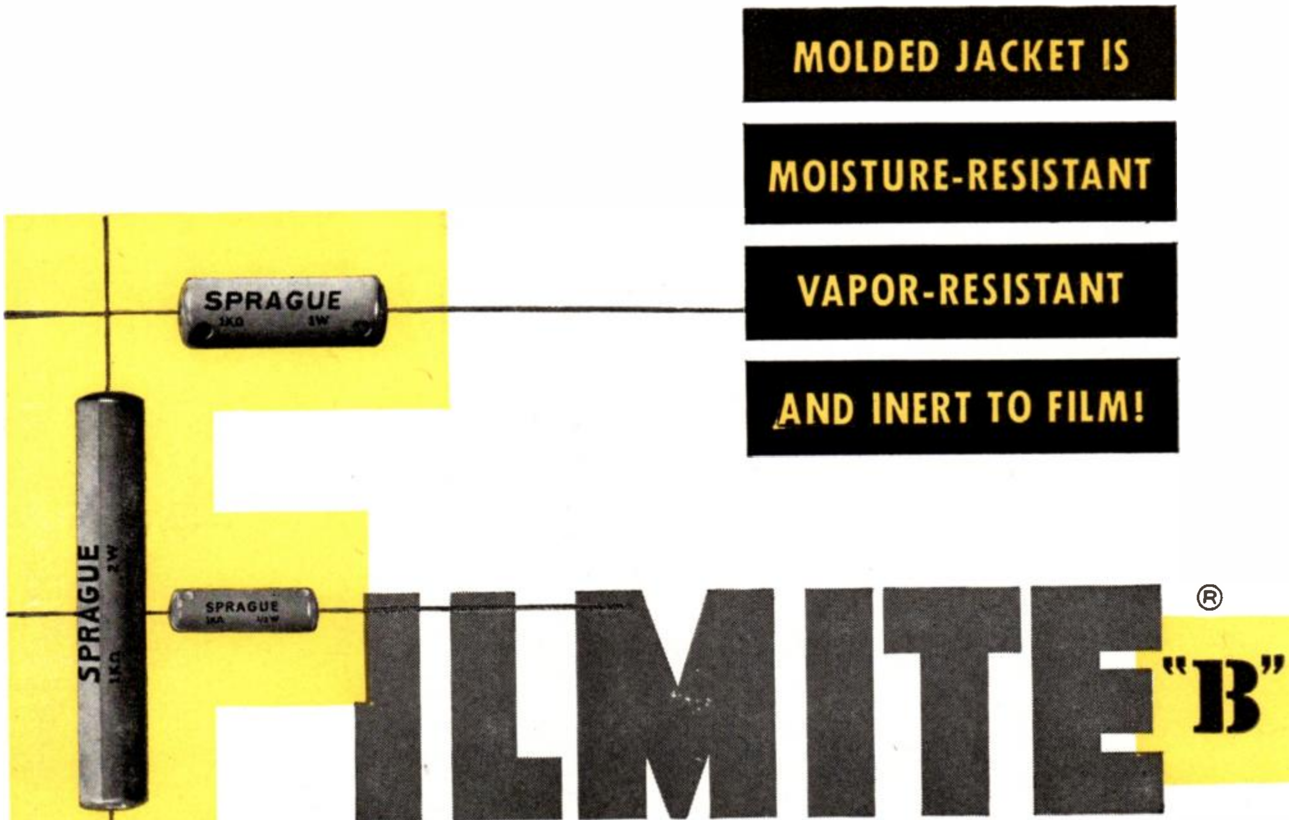
All Prices f.o.b. Pine Brook, New Jersey

IF YOU CAN'T ATTEND THE SHOW — WRITE

KAY ELECTRIC COMPANY

14 MAPLE AVENUE PINE BROOK, N. J.


RMC .02
.01
.02
2x.004
RMC .01
.01*
.02*
RMC .01
.01*
±20%
.02*
+80%—20%
RMC .005
.0047
.005
2x.002
RMC .003
.003
.004*
.005*
2x.0015
2x.002*
RMC 1500
.0015
.002
2x.001
RMC
.00047
.00068
.0008
.001
RMC HEAVY DUTY DISCAPS ®
...the right way to say ceramic capacitors
TYPE B
1000 V.D.C.W. By-Pass Series
*Rated 600 V.D.C.W. Flash test 1200 V.D.C
SPECIFICATIONS
GUARANTEED MINIMUM VALUE
POWER FACTOR: 1.5% Max. @ 1 KC (initial)
POWER FACTOR: 2.5% Max. @ 1 KC (after humidity)
WORKING VOLTAGE: 1000 V.D.C.
TEST VOLTAGE (FLASH): 2000 V.D.C.
LEADS: No. 22 tinned copper (.026 dia.)
INSULATION: Durez phenolic—vacuum waxed
INITIAL LEAKAGE RESISTANCE: Guaranteed higher than 7500 megohms
AFTER HUMIDITY LEAKAGE RESISTANCE: Guaranteed higher than 1000 megohms
CAPACITY LIMITS 25° TO 65° C TYPE B DISCAPS
PERCENT CHANGE FROM 25° C VALUE
TEMPERATURE °C
BOOTH 518 Components Avenue, I. R. E. Show
SEND FOR SAMPLES AND TECHNICAL DATA
DISCAP CERAMIC CONDENSERS
RMC
RADIO MATERIALS CORPORATION
GENERAL OFFICE: 3325 N. California Ave., Chicago 18, Ill.
FACTORIES AT CHICAGO, ILL. AND ATTICA, IND.
DISTRIBUTORS: Contact Jobbers Sales Co., 146 Broadway, Paterson 1, N. J.



DEPENDABLE BORO-CARBON RESISTORS ...IN ½, 1, AND 2 WATT RATINGS

Now for the first time you can obtain a superior yet relatively low cost film-type resistor for military electronic gear—resistors that not only meet the severe performance requirements of Military Specification MIL-R-10509A, but are capable of full wattage dissipation at 70°C ambient!

Sprague Type 4E, 5E, and 6E Filmite B resistors are housed in a dense molded jacket which not only provides unexcelled physical protection for the film resistance element but serves as a barrier to moisture and vapor, the twin enemies of all film-type resistors.

Boro-carbon films are unusually sensitive to moisture. Protection against moisture in any form is a primary requirement for successful long term stability of resistance. The low-loss phenolic housings on molded Filmite resistors not only shed water but are vapor resistant and inert to the film material. There is minimum possibility of field failure through electrolytic action and penetration of moisture or vapor through the dense molded jacket.

Other features of molded Filmite B resistors are special low-contact-resistance, low noise end terminations held rigidly in place on special ceramic cores, extremely low temperature and voltage coefficients of resistance, and excellent load-life and high frequency characteristics.

For complete engineering data, write for Engineering Bulletin No. 130 to:

SPRAGUE ELECTRIC COMPANY
235 Marshall Street, North Adams, Mass.

SPRAGUE TYPE NO.	WATTAGE RATING	DIMENSIONS (INCHES) L	D	RESISTANCE (OHMS) Min.	Max.	VOLTAGE (Max.)
4E	½	¾	¼	100	1 Meg.	350
5E	1	1¹⁄₁₆	⅜	100	2 Meg.	500
6E	2	2³⁄₁₆	⅜	200	10 Meg.	750

Standard Resistance Tolerances: 1 2 and 5%

SPRAGUE

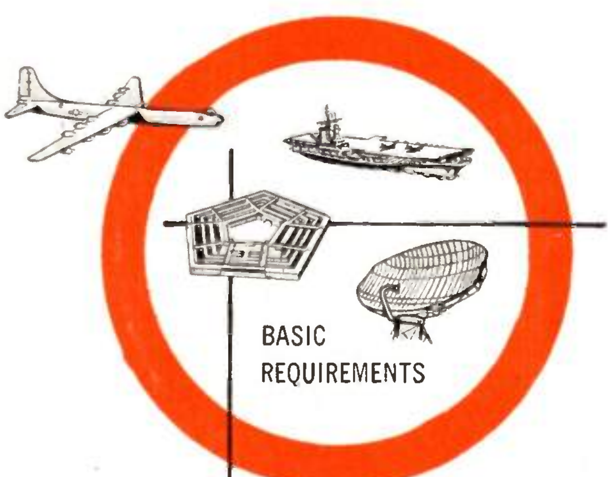
PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT

NORTH ADAMS, MASSACHUSETTS

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

Automatic testing and recording permits accurate evaluation of greater numbers of resistors.

ONLY IRC MAKES SO MANY JAN AND



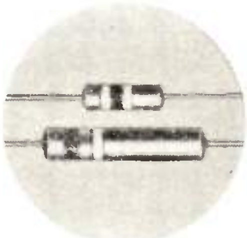
JAN and MIL Specifications are basic guideposts for electronic advancement, whether used as engineering reference points or as procurement standards. IRC's dual emphasis on mass production and frequent, accurate performance testing assures you of the highest performance standards at the lowest possible cost.

56 different IRC resistors is today's figure—all equivalent to JAN or MIL specifications. And all are standard units, available on excellent delivery cycle! If you manufacture end-equipment for the armed forces and must meet these specifications, or if you apply them as standards to your own requirements, depend on IRC for everything you need. For, manufacturing the widest line of resistors in the industry—127 different types in all—IRC is logically your best source of JAN and MIL type units.

SEE IRC's NEWEST RESISTORS
553 & 555 COMPONENTS AVE.
Radio Engineering Show, Kingsbridge Armory, N.Y.C., March 22-25

JAN-R-29 *specification*

For all requirements of JAN-R-29 Specification, Amendment 4, IRC sealed precision Voltmeter Multipliers function efficiently even when exposed to the most severe humidity. Used with 1-milliampere DC instruments, they enable voltage measurements to be made up to 6000 volts. Send for Bulletin.



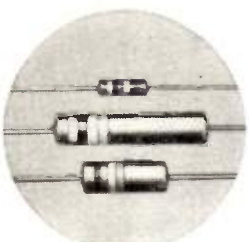
JAN-R-184 *specification*

Unusually stable and inexpensive, IRC BW Wire Wounds meet JAN-R-184 Specification, Amendment 5, at ½ and 1 watt. Resistance element is uniformly and tightly wound on insulated core. Molded housing provides full insulation. Widely used in meters, analyzers, high stability attenuators, low-power ignition circuits, etc. Send for Bulletin.

MIL-R-26B *specification*

For high power dissipation, IRC Power Wire Wounds meet every commercial requirement of MIL-R-26B Specification. Characteristic G. Tubular, flat, fixed, adjustable, inductive, non-inductive, lead, lug and ferrule types provide resistors for virtually any circuit. From 5 to 225 watts. Send for Bulletin.

MIL TYPE RESISTORS



MIL-R-11A *specification*

IRC Advanced BT Resistors meet and beat MIL-R-11A Specification, Amendment 2. Filament-type resistance element and other exclusive features afford extremely low operating temperature and superior power dissipation in a compact, light, fully insulated unit. Available at ¼, ½ and 1 watt to MIL specification and 2 watts to commercial specification. Send for Bulletin.

NEW *product*

HERMETIC *sealing terminal*

Overcomes limitations of other types of hermetic sealing terminals.

Molded KEL-F* body—chemically inert to organic solvents, acids, oils, fumes.

Rugged construction—tough and resilient; withstands constant vibration.

Type HS-1 Feed-Thru Terminals, provide assured hermetic sealing for electrical and electronic components. Exclusive IRC molding Technique bonds Kel-F* to metal in a superior seal. Designed to the sealing requirements of MIL-T-27. Send coupon for full data

*Trademark—M. W. KELLOGG CO.

Boron & Deposited Carbon Precistors • Power Resistors • Voltmeter Multipliers • Low Wattage Wire Wounds • Insulated Composition Resistors • Volume Controls •

Wherever the Circuit Says IRC

Precision Wire Wounds • Ultra HF and Hi-Voltage Resistors • Selenium Rectifers • Insulated Chokes • Hermetic Sealing Terminals •

INTERNATIONAL RESISTANCE CO.

405 N. Broad St., Philadelphia 8, Pa.

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

Send me data on ☐ MF Voltmeter Multipliers, ☐ BW Resistors, ☐ Power Wire Wounds, ☐ Advanced BT Resistors, ☐ HS-1 Terminals.

Name__________

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Company__________

Address__________

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FILL ALL YOUR COLOR-TV TUBE NEEDS!

New G-E Receiving Tubes for Color!

Your first aim in designing your new color-TV chassis is quality reception. Your second aim is economy, so that the selling price may be—and remain—competitive.

General Electric helps you reach both objectives by bringing you five new receiving tubes specially designed for color. Each of them does a particular job in a color receiver *better* . . . or, it replaces two or more standard tubes, saving you money.

G-E tube engineers at the I.R.E. Show will be glad to explain fully the circuit functions of the five new tubes. Still other types are on their way. Keep constantly in touch with General Electric for new, advanced tubes for color TV!

G-E TUBE SERVICE includes (1) special design and application help with your tube problems, (2) coast-to-coast tube warehousing for fast deliveries to your plant, (3) same-day processing of your tube orders, (4) local-laboratory help in checking your circuit performance. Top service to manufacturer-users is an important chapter of the General Electric tube story!

2V2
High-voltage rectifier

5AU4
High-output full-wave rectifier

6AR8
Sheet-beam synchronous detector

6BJ7
Triple diode for d-c restoration

6BU5
High-voltage pentode for shunt regulation.

OTHER NEW G-E TYPES
specially developed for color television will be ready shortly.

SEE G.E.'s COMPLETE LINE AT THE SHOW!

Booths 186 to 190, Television Avenue

G-E Tri-color Picture Tubes!

In production at an expanding rate, G-E tri-color picture tubes are available now. See the 15" type on display, also the 19" tube that will be ready shortly. Both are aluminized, glass, using three electron guns, with a planar shadow mask for color selection.

Development is proceeding on larger tubes, on improved types. You may expect G-E tubes that will give steadily bigger—brighter—clearer pictures. You may expect an ever-truer palette of colors.

For your needs now . . . today . . . G. E. has picture tubes for color TV ready. For tomorrow's more advanced types, come to G.E also! *Tube Department, General Electric Co., Schenectady 5, N. Y.*

TYPE 15GP22

19-INCH TYPE

GENERAL ELECTRIC

162-1A2

AC LINE REGULATORS

regulated DC SOURCES

regulated B SUPPLIES

Since it pioneered the field years ago, Sorensen has been the acknowledged leader in electronic power control. Its standard line includes a wide variety of instruments in a broad range of capacities to meet practically any needs; all are notable for sound design, conservative rating, and fine workmanship. Most items can be delivered quickly in reasonable quantities. Sorensen invites your inquiries concerning special instruments to meet unusual requirements.


Model 1000S AC Regulator

AC REGULATORS

Utilizing the original Sorensen circuit and incorporating the SAFETY DIODE, these regulators are noted for economical operation, accuracy, and easy maintenance.

ELECTRICAL CHARACTERISTICS

Models available (Numbers denote VA capacities): 150S, 250S, 500S, 1000S (—2S also), 2000S, 3000S (—2S also), 5000S (—2S also), 10000S (—2S also), 15000S (—2S also)

Input	95-130 VAC, 1ø 50-60~,190-260 VAC in "—2S" models
Output	115 VAC ADJ. 110-120; 230 VAC with "—2S" models
Reg. accuracy	±0.1% against line or load
Distortion	3% max.
P.F. range	Down to 0.7
Load range	0 to full load
Miscellaneous	Models 150S, 250S, 500S, 1000S, 5000S, 10000S, and 15000—2S are self-contained. Cabinets available for others.


Nobatron Model E-6-15A

NOBATRONS* (low-voltage, high current, *regulated* DC sources)

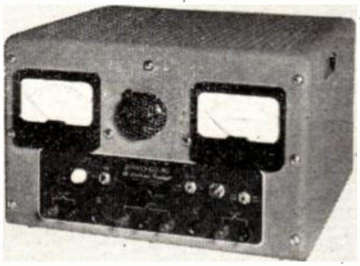
Provide stability comparable to batteries and eliminate recharging interruptions, fume and acid hazards, installation difficulties.

*Reg. U.S. Pat. Off.

ELECTRICAL CHARACTERISTICS

Models available (numbers indicate voltage & current): E-6-5A, E-6-15A, E-6-40A, E-6-100A, E-12-5, E-12-15, E-12-50, E-28-5, E-28-10, E-28-30, E-28-70, E-28-150, E-48-15, E-125-10, E-200-5 (Also Model SWR-5 with output either 6VDC @ 10 amp or 12VDC @ 5 amp)

Input	95-130 VAC, 1ø, 50-60 cycles. 120/208 3ø, 4-wire wye for the E-28-150. The E-28-70 requires 190-260, 1ø power.
Reg. accuracy	±0.2% against line or load changes
Ripple	1% RMS max.
Load range	1/10 to full load
Output range	Adjustable ±10%; down to 20% at lesser accuracy
Recovery time	0.2 seconds on all models up to 1 KW rating, increasing to 0.5 seconds at 10KW
Miscellaneous	Normally for rack mounting — cabinets available. Normal finish — gray wrinkle. Meters standard in some models; available in all.
Note	"A" model output either 6 or 7 volts


B-Nobatron Model 600BB

B-NOBATRONS (high-voltage, low current, *regulated* DC supplies)

These B-Supplies have been designed to meet the broadest technical and economical requirements. The internal impedance figures given are from measurements in accordance with IRE specifications for measurement of power supply internal impedance.

ELECTRICAL CHARACTERISTICS

UNIT	325BB	350B (dual supply)	560BB	500BB	600BB	1000BB
Output voltage (VDC)	0-325	*	0-500	0-500	0-600	200-1000
Output current (Ma)	0-125	*	0-200	0-300	0-500	0-500
Regulation accuracy	±0.5%	±0.5%	±0.5%	±0.5%	±0.25% 0.5% at 0-100VDC	±0.5%
Ripple (MV-RMS)	5 max.	10 max.	5 max.	5 max.	3 max.	20 max.
Bias supply (VDC at 0-5 Ma)	0-150	none	0-150	0-150	0-150	none
Max. bias circuit impedance	25000 ohms	. . .	25000 ohms	25000 ohms	50000 ohms	. . .
Internal impedance (max.)	2.0 ohms	2.0 ohms	2.0 ohms	2.0 ohms	2.0 ohms	2.0 ohms
AC input range (50-60 , 10)	105-125	105-125	105-125	105-125	105-125	105-125
AC voltage (C.T., unregulated)	6.3 @ 10 amp.	. . .	6.3 @ 10 amp.	6.3 @ 10 amp.	6.3 @ 15 amp.	. . .

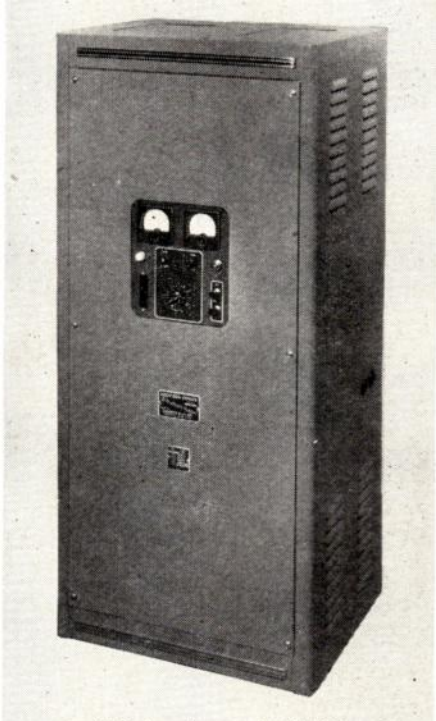
*(1). 175-350 VDC at 0-60 Ma in each of two supplies simultaneously. Each adjusted independently, but with a common negative. (2). 175-350 VDC at 120 Ma in a single supply. (3) 0-175 VDC at 0-60 Ma in a single supply. For condition (3) maximum regulation is 1.5 volt.

NOBATRON-RANGERS (Wide-range variable *regulated* DC sources)

ELECTRICAL CHARACTERISTICS

Input range	95-130 VAC, 1ø, 50-60 cycles for SR30 and SR100. 190-260 VAC, 1ø, 50-60 cycles for the SR2.			
Reg. accuracy	±0.25% at any voltage setting.			
Ripple	1% RMS max.			
Output	Model	SR-100	SR-30	SR-2
	VDC	5-135	5-30	100-300
	Amps	1-10	3-30	1-10

These versatile and popular instruments have electrical characteristics similar to the standard Nobatrons, except that output voltage is continuously adjustable. Circuitwise, they incorporate adaptations of the Nobatron circuit.


Nobatron-Ranger Model SR2

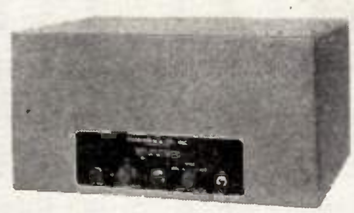
AT THE IRE SHOW — SEE THE SORENSEN LINE AT BOOTH 646, CIRCUITS AVE.

regulated FREQUENCY CHANGERS

regulated wide-range-variable DC SOURCES

regulated TUBELESS DC SOURCES

Tubeless DC Source Model MA6/15



± 0.01% Accuracy AC Regulator Model 1001

Frequency Changer Model FCD1000

NEW!

See these at the IRE Show!

FREQUENCY CHANGERS

Electronically controlled, these instruments give accurate control of voltage and frequency, with good wave shape. They may be placed next to the load, eliminating the need for costly installation.

ELECTRICAL CHARACTERISTICS

Input voltage range	95-130 VAC, 1Ø, 50-60 cycles for the FCD250. 208 or 230 VAC ±10%, 1Ø, 50-60 cycles for the FCD1000 and FC1000.
Output voltage	115 VAC, 1Ø, adjustable between 110-120 volts
Output frequency	FCD250 & FCD1000 — 400 cycles, adjustable ±10%. FC1000 — 60 cycles, adjustable between 45-65 cycles.
Output voltage reg.	±1%
Output frequency reg.	±1% in standard model ±0.01% with auxiliary frequency standard (fixed output)
Load range	0-250 VA in the FCD250 0-1000VA in the FCD1000 and FC1000
Distortion	5% maximum

±0.01% REGULATION MODELS

Extremely precise, these are nonetheless rugged, serviceable instruments. The AC regulator is used primarily in calibration applications; the DC source is designed to power the Beckman Model DU Spectrophotometer.

ELECTRICAL CHARACTERISTICS

Super-accurate AC Line Regulator Model 1001	Load range	0-1000 VA
	Input volt. range	95-130 VAC, 1Ø, 55-65~
	Load P.F. range	0.7 lagging to 0.95 leading
	Output voltage	115 VAC 1Ø (adjustable from 110-120 volts)
	Distortion	3% max.
	Time constant	0.1 seconds
	Reg. accuracy	±0.01%
DC Power Source for Spectrophotometers Model E-6/2-5 Nobatron	Input volt. range	95-130 VAC 1Ø, 50-60 cycles
	Output #1 for lamp	6VDC adjustable ±5% at 5 amperes
	#2 for filament	6VDC at 100 Ma.
	#3 for bias	2VDC adjustable ±10% at 100 Ma.
	Filtering #1	1% max.
	#2 & 3	0.05% max.
	Reg. accuracy	±0.01% against line changes
	Time constant	Output voltage is insensitive to fluctuations in input line

TUBELESS REGULATED DC SOURCES

These units have been designed for heavy-duty industrial applications. Tubeless, and utilizing magnetic amplifier principles, they offer the utmost in reliability.

ELECTRICAL CHARACTERISTICS

MODEL	MA6/15	MA2850
Input	190-230 on 208 line, 1Ø, 60~ 210-250 on 230 line, 1Ø, 60~	190-230, 3Ø, 4-wire, wye, 60~
Output	4.5-7.7 VDC at 0-100 amperes 8.5-15.4 VDC at 0-75 amperes	23-32 VDC at 0-50 amperes
Ripple	1% max. RMS	3% max. RMS
Reg. Accuracy	±1% against line and load combined	±1% against line and load combined
Time constant	0.2 seconds	0.5 seconds

400-CYCLE EQUIPMENT

AC REGULATORS — The characteristics are similar to 60-cycle equipment, except that regulation accuracy is ±0.5%, distortion is 5% max., and capacities are 250, 500, 1200, and 2500 VA. *NOBATRONS* — With the same general specifications as 60-cycle Nobatrons, instruments are available with outputs of 6 VDC at 40 amperes, 12 VDC at 10 amperes, and 28 VDC at 10 amperes.

HERMETICALLY SEALED & MILITARIZED REGULATORS

Wound components of many Sorensen instruments can be hermetically sealed by the Fosterite process (Sorensen does this under Westinghouse license) or by standard potting. Sorensen also builds equipment to meet MIL-T-27 and JAN specifications on resistance to shock, vibration, humidity, etc.

GENERAL CATALOG

Expanded information on all the instruments in the Sorensen line will be found in the new general catalog. For your free copy, write on your letterhead to Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. In Europe, correspond directly with Sorensen A. G., Gartenstrasse 26, Zurich 2, Switzerland.

NATION-WIDE SERVICE

Authorized Sorensen representatives are listed below. Look up the one located nearest you — don't hesitate to call on him for consultation and advice.

CALIFORNIA — LOS ANGELES
Gerald B. Miller Co., 1550 No. Highland Ave., Hollywod 28. Phone Hollywood 9-6305

CALIFORNIA — SAN FRANCISCO
Gerald B. Miller Co., 1334 Old Country Road, Belmont. Phone: Lytell 3-3438

COLORADO — DENVER
Ronald G. Bowen Co., 446 Broadway. Phone: Sherman 2501

CONNECTICUT — BRIDGEPORT
Yewell Associates, 1101 E. Main St. Phone: 66-0000

DC — WASHINGTON
Horman Associates, 2017 S. St., N.W. Phone: Decatur 2-8000

FLORIDA — FORT MYERS
Arthur H. Lynch & Associates, P.O. Box 466. Phone 5-6762

GEORGIA — ATLANTA
Floyd Fausett & Son, 777 Pinehurst Terr., S.W. Phone: Raymond 3104

ILLINOIS — CHICAGO
Loren F. Green & Associates, 4949 W. Diversey Ave. Phone: National 2-2370

KENTUCKY
H. A. Watson, Jr., 817 Citizens Bldg., Cleveland, Ohio. Phone: Tower 1-1947

MASSACHUSETTS — BOSTON
Yewell Associates, 751 Main St., Waltham, Mass. Phone: 5-7420

MICHIGAN — DETROIT
S. Sterling Company, 15310 W. McNichols Rd. Phone: B'way 3-2900

MISSOURI — KANSAS CITY
Harris-Hanson Company, 7916 Paseo Ave. Phone: Highland 5644

MISSOURI — ST. LOUIS
Harris-Hanson Company, 5506 S. Kingshighway. Phone: Sweetbriar 5584

NEW JERSEY — NORTHERN
RMC Associates, 114 E. Main St., Bogota, N.J. Phone: Diamond 2-5343

NEW JERSEY — SOUTHERN
I. E. Robinson Co., 702 Maltison Ave., Asbury Park, N.J. Phone: Allenhurst 3-2404

NEW MEXICO — ALBUQUERQUE
Gerald B. Miller Co., 327 Wyoming, S.E. Phone: 5-6466

NEW YORK — NEW YORK
RMC Associates, 170 E. 80th St. Phone: TR. 9-2023

NEW YORK — SYRACUSE
J. D. Ryerson Co., 412 E. Genesee St. Phone: 76-8344

NORTH CAROLINA — CHARLOTTE
James L. Highsmith, P.O. Box 1011. Phone: 5-6436

OREGON — PORTLAND
James L. Kearns Co., P.O. Box 5108. Phone: Lincoln 4747

PENNSYLVANIA — EASTERN
I. E. Robinson Co., 7217 Marshall Rd., Upper Darby, Pa. Phone: Flanders 2-5911

PENNSYLVANIA — WESTERN
H. E. Ransford Co., Grant Bldg., Pittsburgh, Pa. Phone: Grant 1-1880

TENNESSEE — KNOXVILLE
A. R. Hough, P.O. Box 1452. Phone: 7-6660

TEXAS — DALLAS
Earl W. Lipscomb & Associates, P.O. Box 8042. Phone: Elmhurst 5345

CANADA — VANCOUVER, B.C.
Frederick Goertz, Ltd., 1170 Robson St.

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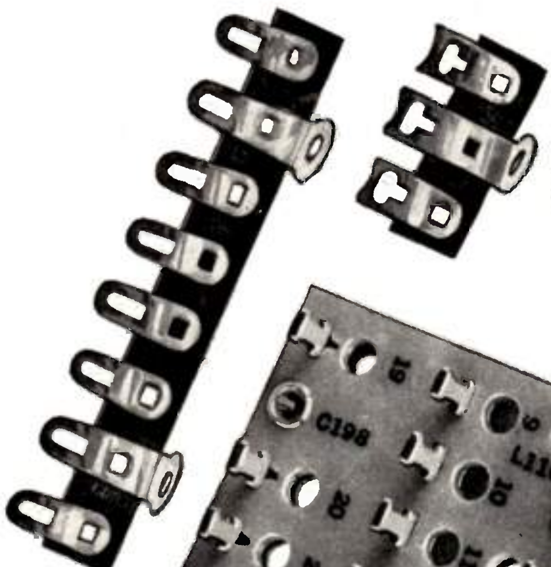
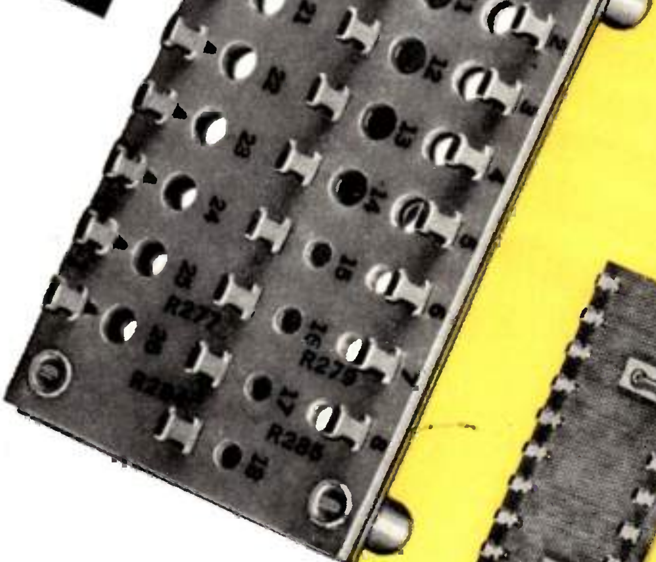
Charles W. Pointon, 6 Alcina Ave. Phone: Oliver 7984

SORENSEN 375 FAIRFIELD AVENUE STAMFORD, CONNECTICUT

Special "miniaturized" strips available, actual size shown.

TERMINAL STRIPS ...BOARDS



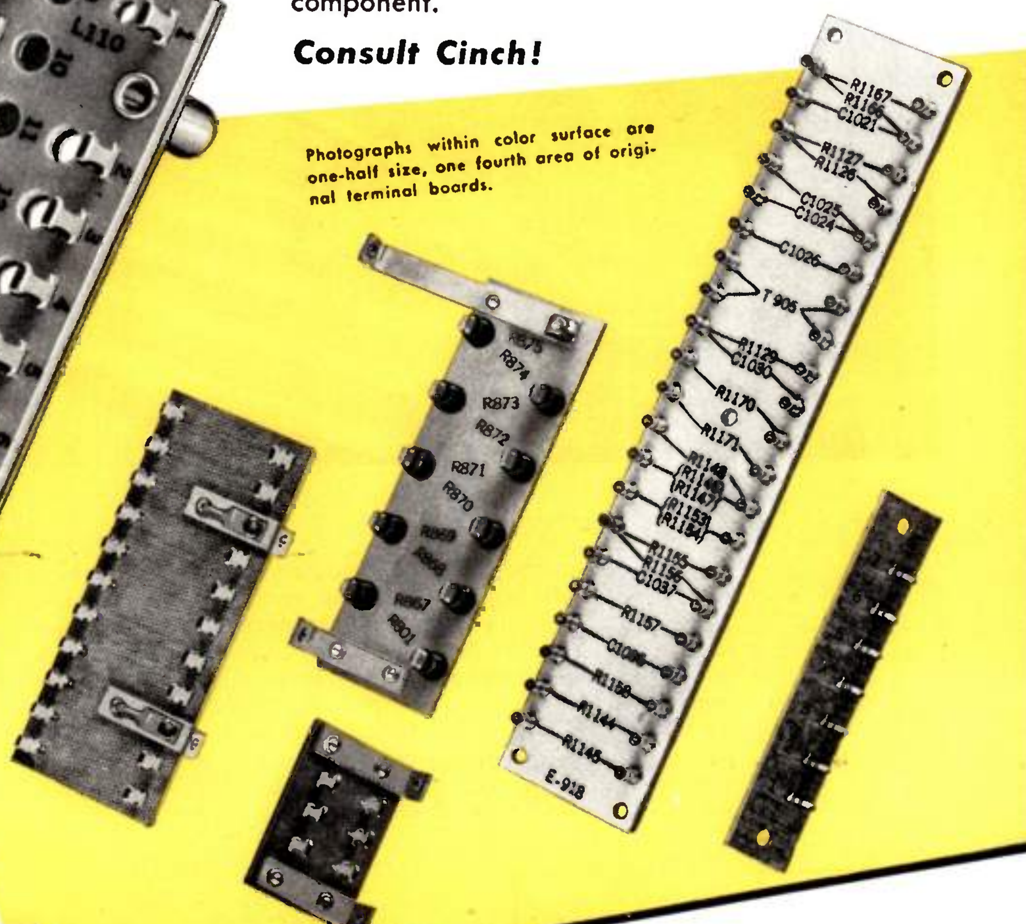


The terminal strip, a CINCH engineering "first", is today a *Standard* electronic component. Something of the scope of the CINCH operation in the design and production of metal plastic assemblies is indicated by the terminal boards fabricated to meet exacting armed forces requirements.

CINCH facilities and engineering experience and ability assure the satisfactory fulfillment of any assignment for a terminal strip, board or electronic component.

Consult Cinch!

Photographs within color surface are one-half size, one fourth area of original terminal boards.



Cinch components are available at leading electronic jobbers — <u>*everywhere*</u>.

At the IRE Convention Show, Booth Nos. 394 and 396.

Cinch ELECTRONIC COMPONENTS

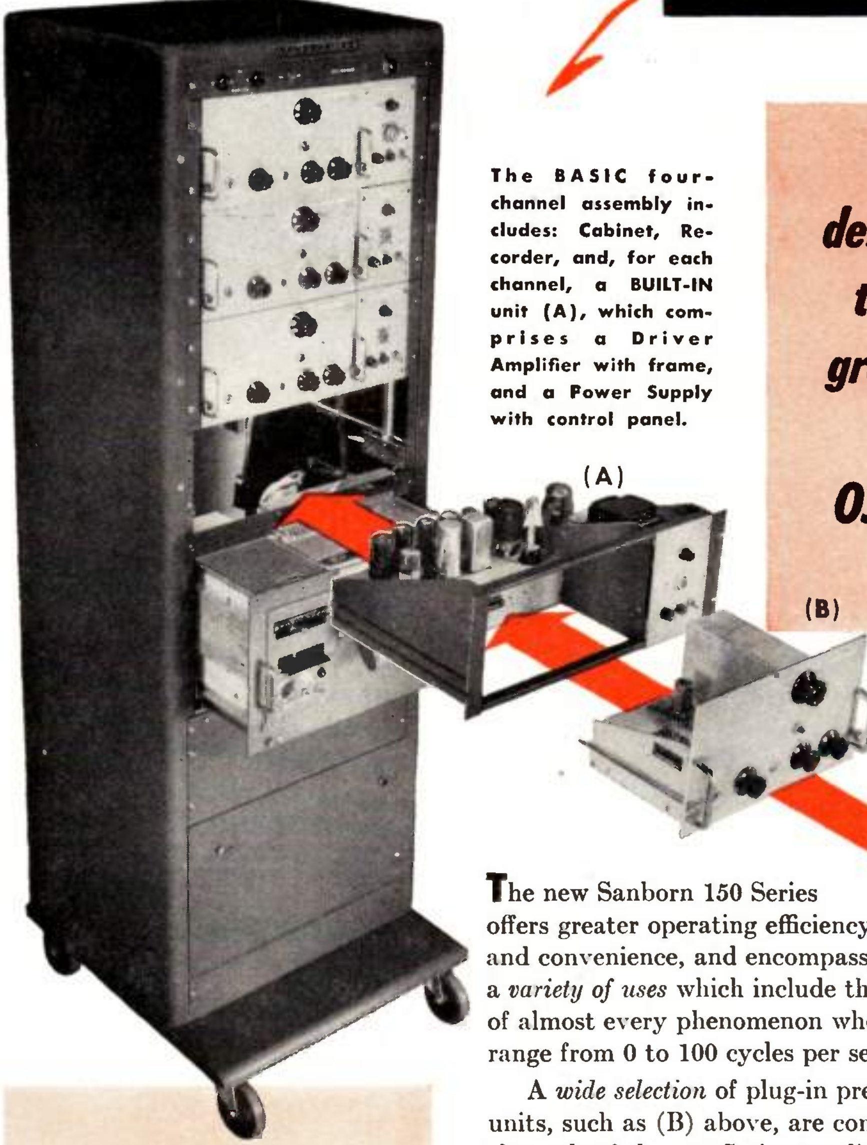
CINCH MANUFACTURING CORPORATION

1026 South Homan Ave., Chicago 24, Illinois

Subsidiary of United-Carr Fastener Corporation, Cambridge, Mass

SANBORN 150 SERIES
OSCILLOGRAPHIC RECORDERS

A NEW design concept that brings even greater versatility to industrial OSCILLOGRAPHIC RECORDING



The BASIC four-channel assembly includes: Cabinet, Recorder, and, for each channel, a BUILT-IN unit (A), which comprises a Driver Amplifier with frame, and a Power Supply with control panel.

You have a CHOICE of readily interchangeable, plug-in Preamplifiers (B) for EACH channel, as described below.

The new Sanborn 150 Series offers greater operating efficiency and convenience, and encompasses a *variety of uses* which include the accurate recording of almost every phenomenon whose frequency spectrum lies in the range from 0 to 100 cycles per second.

A *wide selection* of plug-in preamplifiers, or "front end" units, such as (B) above, are completely interchangeable in any or all channels of the 150 Series amplifier section, where they simply plug in to the driver amplifier and power supply, (A) above, which are already in place.

Available plug-in Preamplifiers include: AC-DC, CARRIER, SERVO-MONITOR, DC COUPLING, LOG-AUDIO, and LOW LEVEL. Blank plug-in assemblies are also available for users to make input circuits for special measurement problems.

And, there are the popular Sanborn advantages: a high torque movement (200,000 dyne cms per cm deflection), direct *inkless* recording in *true rectangular coordinates*, and provision for code and time markings.

A new catalog on Sanborn Oscillographic Recording Systems and their components will be sent gladly on request.

OTHER SANBORN IMPROVEMENTS

- Extended frequency response.
- Improved regulated power supply.
- Individual stylus temperature control for EACH channel.
- Improved, single control, paper speed selector. Nine speeds — 0.25 to 100 mm/sec.
- Recorder slides out, if desired, for better view of recorded events, or for notations on record (illustrated at right).
- Improved control of input signals by use of 1, 2, 5 ratios on attenuator.

Be sure to see the 150 Series at BOOTHS 455–457, I.R.E. Convention, Kingsbridge Armory, Bronx, N. Y. March 22–25, 1954.

SANBORN COMPANY
INDUSTRIAL DIVISION

195 MASSACHUSETTS AVENUE
CAMBRIDGE 39, MASS.

The 21 IRE Professional Groups show the expansion pattern of a modern engineering society in meeting the diversified needs of its members in the ever widening science of radio-electronics.

Membership in a Professional Group is open to any paid-up member of the I.R.E. The cost is only an annual extra publications fee, usually $2. This fee is shown in the descriptions that follow.

An IRE Member may join as many Professional Groups as serve his interest and wishes. Such membership serves to associate him with other engineers of the same specialized interests within the radio-electronic field.

The 21 Professional Groups are listed below, together with a brief definition of each, the name of the Group Chairman, and publications to date. * Means still available.

Aeronautical and Navigational Electronics

The application of electronics to operation and traffic control of aircraft and to navigation of all craft.

Dr. K. Charlton Black, Chairman, Polytechnic Research & Development Co., 55 Johnson Street, Brooklyn 1, N.Y.

Fee $2. 8 Transactions. 4 Newsletters. *4, *5, *6, *8, & *9, and Newsletters.

Broadcast & Television Receivers

The design and manufacture of broadcast and television receivers and components and activities related thereto.

Mr. Earl I. Anderson, Chairman, Assistant Manager, Industry Service Lab., RCA Laboratory Div., 711-5th Ave., New York, N.Y.

Fee $2. Transactions *1, *2, *3, *5

Antennas and Propagation

Technical advances in antennas and wave propagation theory and the utilization of techniques or products of this field.

Mr. P. S. Carter, Chairman, c/o RCA Laboratories, Rocky Point, L.I., N.Y.

Fee $4. Four transactions published. *4 Vol. 1, No. 1; Vol. 1, No. 2.

Broadcast Transmission Systems

Broadcast transmission systems engineering, including the design and utilization of broadcast equipment.

Mr. Lewis Winner, Chairman, Editor, Television Engineering, 52 Vanderbilt Avenue, New York 17, N.Y.

Fee $2. Convention Report. *1, *2, *3, *5

Audio

Technology of communication at audio frequencies and of the audio portion of radio frequency systems, including acoustic terminations, recording and reproduction.

Mr. Marvin Camras, Chairman, Armour Research Foundation, Chicago, Ill.

Fee $2. Published 14 Transactions, 4 Newsletters. *5, *7, *9, *10.

Circuit Theory

Design and theory of operation of circuits for use in radio and electronic equipment.

Dr. Chester H. Page, Chairman, National Bureau of Standards, Connecticut Ave., Washington 25, D.C.

Fee $2. *PGTC-1, *PGCT-2, Transactions.

THE INSTITUTE OF RADIO

Communications Systems

Radio and wire telephone, telegraph and facsimile in marine, aeronautical, radio-relay, coaxial cable and fixed station services.

Col. John Hessel, Chairman, Signal Corps Engineering Laboratories, Fort Monmouth, N.J.

Fee $2. *Vol. CS-1, No. 1, *Vol. CS-2, No. 1.

Electronic Component Parts

The characteristics, limitations, applications, development, performance and reliability of component parts.

Mr. Floyd A. Paul, Chairman, Supervisor, Electronic Reliability Sec., Dept. 3230, Northrop Aircraft, Inc., Hawthorne, Calif.

Fee not yet established.

Electron Devices

Electron devices, including particularly electron tubes and solid state devices.

Dr. Leon S. Nergaard, Chairman, RCA Laboratories, Princeton, N.J.

Fee $2. Transactions *1, *2, *3, *4.

Electronic Computers

Design and operation of electronic computers.

Mr. John H. Howard, Chairman, Burroughs Corp., 511 North Broad Street, Philadelphia 23, Pa.

Fee $2 Transactions 1, 2, and *Vol. EC-2, No. 2, *Vol. EC-2, No. 3, *Vol. EC-2, No. 4.

Engineering Management

Engineering management and administration as applied to technical, industrial and educational activities in the field of electronics.

Gen. Tom C. Rives, U.S.A. (Ret'd.), Chairman, General Electric Company, Electronics Park, Syracuse, N.Y.

Fee $1. Convention Report.

Industrial Electronics

Electronics pertaining to control, treatment and measurement, specifically in industrial processes.

Dr. Eugene Mittelmann, Chairman, Consulting Engineer, 549 W. Washington Blvd., Chicago 6, Ill.

Fee $2. Convention Report, *PGIE-1.

Information Theory

Information theory and its application in radio circuitry and systems.

Dr. William G. Tuller, Chairman, Melpar, Inc., 452 Swann Ave., Alexandria, Va.

Fee $2. Transaction 1. *PGIT-2.

Instrumentation

Measurements and instrumentation utilizing electronic techniques.

Mr. Ivan G. Easton, Chairman, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Fee $1. Transactions 1. *2. Convention Report

Medical Electronics

The application of electronics engineering to the problems of the medical profession.

Mr. L. H. Montgomery, Jr., Chairman, 612 Craighead Street, Nashville, Tenn.

Fee $1. *Convention Report, *PGME-1.

Microwave Theory and Techniques

Microwave theory, microwave circuitry and techniques, microwave measurements and the generation and amplification of microwaves.

Mr. Andre G. Clavier, Chairman, Federal Telecommunication Laboratories, 500 Washington Ave., Nutley, N.J.

Fee $2. *Vol. MTT-1, No. 2.

Nuclear Science

Application of electronic techniques and devices to the nuclear field.

Dr. Lloyd V. Berkner, Assoc. Universities, Inc., 350 5th Ave., New York 1, N.Y.

No fee established yet.

Quality Control

Techniques of determining and controlling the quality of electronic parts and equipment during their manufacture.

Mr. Leon Bass, Chairman, General Electric Co., Electronics Div., Syracuse, N.Y.

Fee $2. Transactions, *PGQC-1, *PGQC-2.

Radio Telemetry and Remote Control

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Mr. Martin V. Kiebert, Jr., Chairman, 463 Boulevard, Hasbrouck Heights, N.J.

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Vehicular Communications

Communications problems in the field of land and mobile radio services, such as public safety, public utilities, railroads, commercial land transportation, etc.

Mr. W. A. Shipman, Chairman, Columbia Gas Sys. Ser. Corp., 120 East 41 Street, New York 17, N.Y.

*2, *3.

Ultrasonics Engineering

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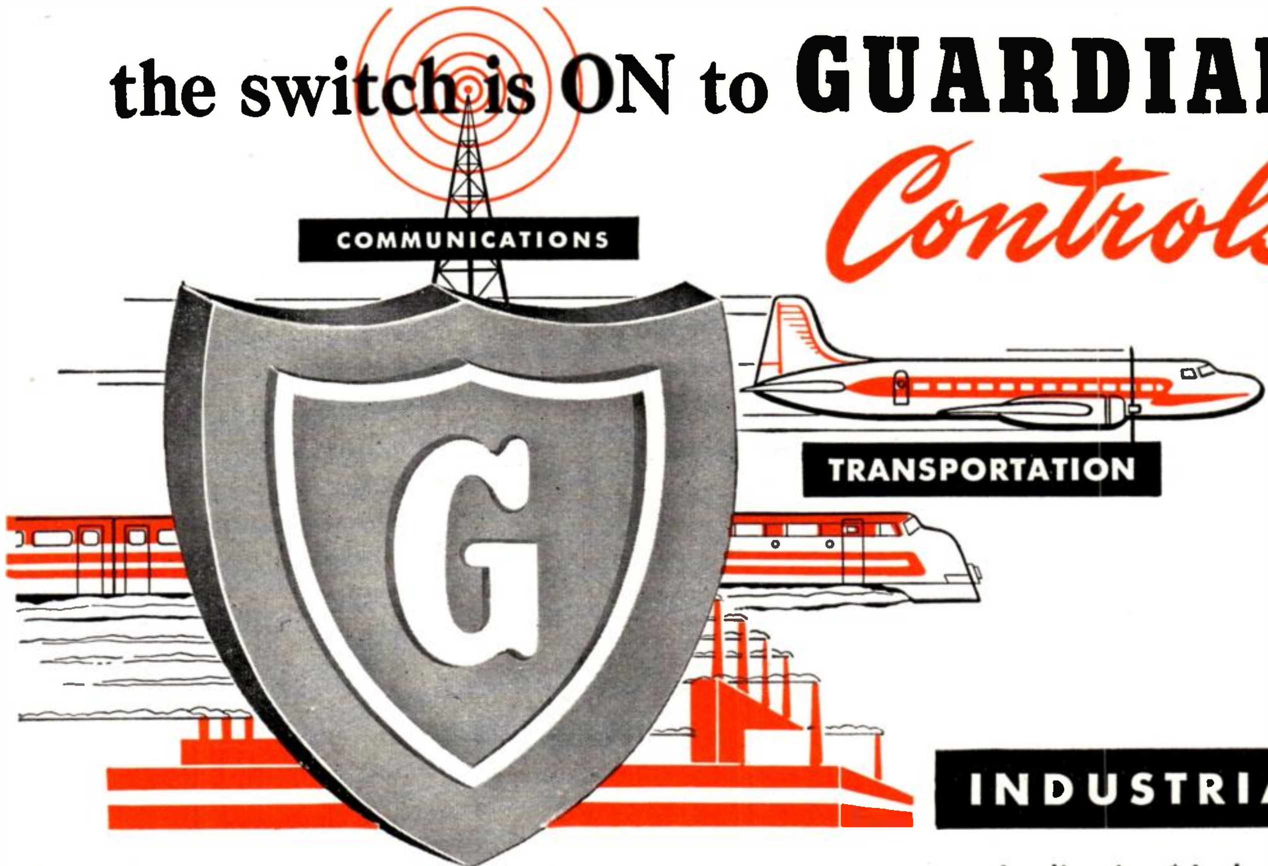

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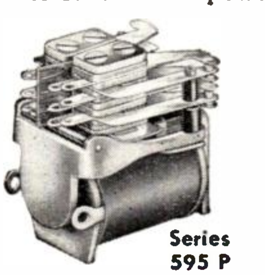

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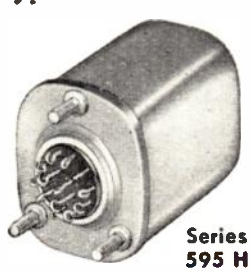

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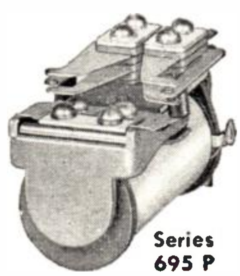

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(Continued from page 87A)

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ELECTRO-MOTIVE MFG. CO.

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Arnold Engineering Co.
148, 150 Military Ave.

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*Indicates new product

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(Continued on page 112A)

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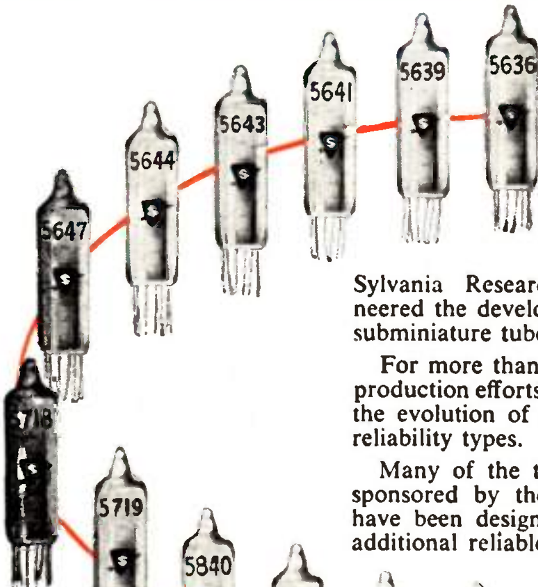

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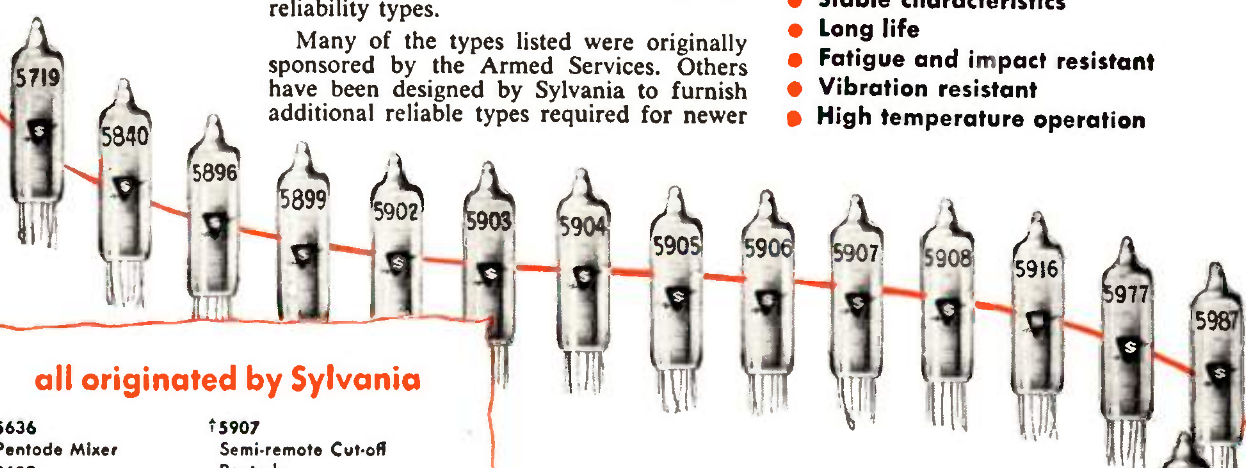
Outstanding Design Features

- Low inoperative failure rate
- Stable characteristics
- Long life
- Fatigue and impact resistant
- Vibration resistant
- High temperature operation



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5636 Pentode Mixer
5639 Video Output Pentode
5641 Rectifier
5643 Thyratron
5644 Voltage Regulator
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5718 Medium Mu Triode
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5840 Sharp Cut-off Pentode
5896 Double Diode Detector
5899 Semi-remote Cut-off Pentode
5902 Audio Power Pentode
***5903** Double Diode Detector
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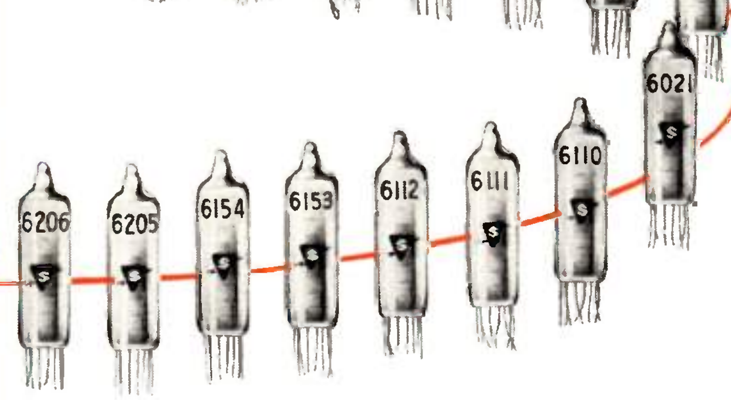
†5905 Sharp Cut-off Pentode
†5906 Sharp Cut-off Pentode
†5907 Semi-remote Cut-off Pentode
†5908 Pentode Mixer
***5916** Pentode Mixer
5977 Low Mu Triode
5987 Power Control Triode
6021 Medium Mu Double Triode
6110 Double Diode Detector
6111 Low Mu Double Triode
6112 High Mu Double Triode
6153 Sharp Cut-off Pentode Low Cgp (Separate suppressor)
6154 Remote Cut-off Pentode Low Cgp (Separate suppressor)
6205 Sharp Cut-off Pentode (Separate suppressor)
6206 Semi-remote Cut-off Pentode (Separate suppressor)

‡6308 Voltage Reference Tube.

**26-volt heater †26 volts all elements ‡Cold Cathode Type*
All other types are 6.3 volt heaters.



For complete data sheets and specifications concerning any of the above tube types and for application information, see your Sylvania Sales Engineer or write to: Sylvania Electric Products Inc., Dept. 4R-3103, 1740 Broadway, New York 19, N. Y.

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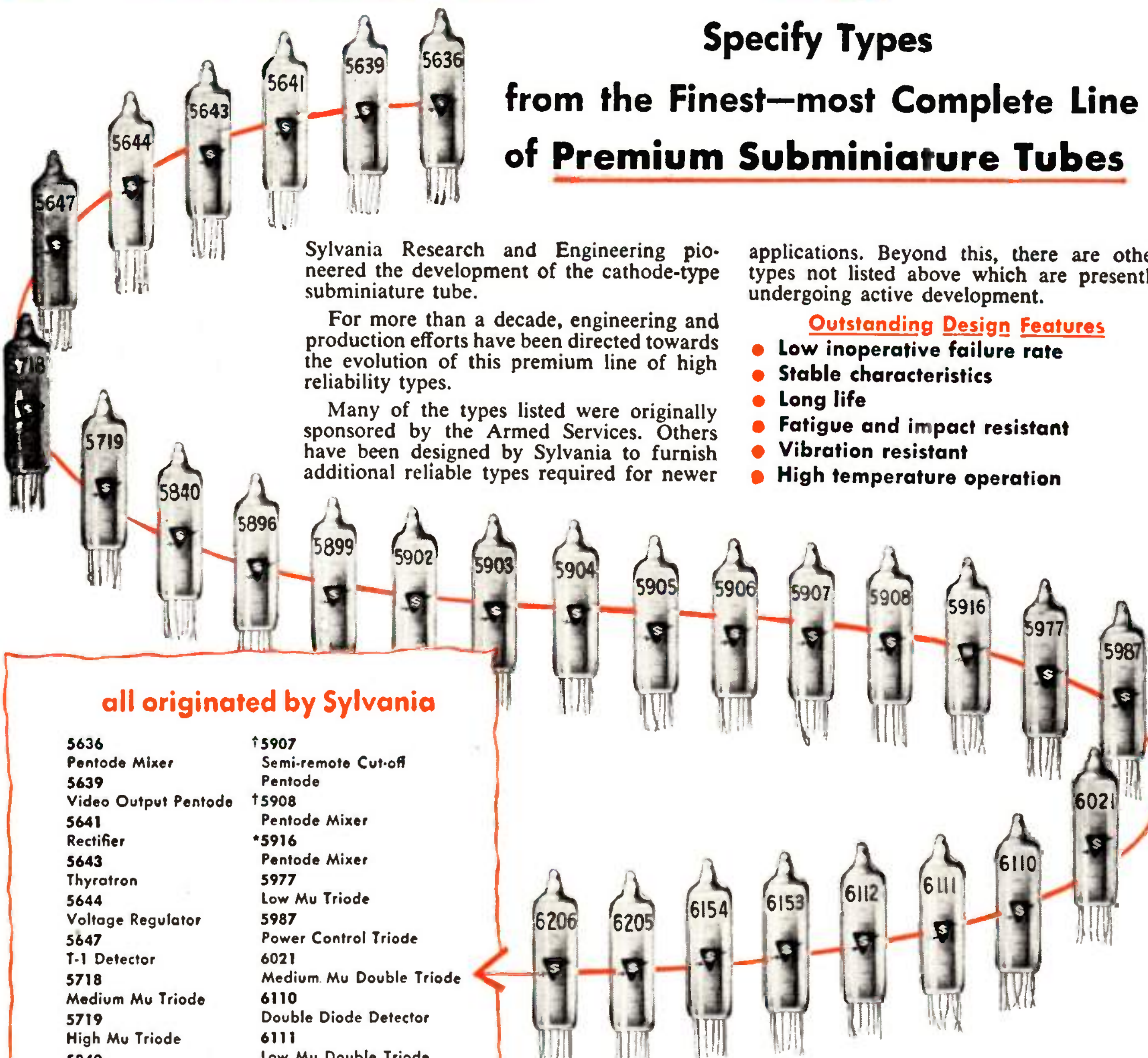

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Outstanding Design Features

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- **Stable characteristics**
- **Long life**
- **Fatigue and impact resistant**
- **Vibration resistant**
- **High temperature operation**

all originated by Sylvania

5636
Pentode Mixer
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Medium Mu Triode
5719
High Mu Triode
5840
Sharp Cut-off Pentode
5896
Double Diode Detector
5899
Semi-remote Cut-off Pentode
5902
Audio Power Pentode
***5903**
Double Diode Detector
†5904
Medium Mu Triode
†5905
Sharp Cut-off Pentode
†5906
Sharp Cut-off Pentode
†5907
Semi-remote Cut-off Pentode
†5908
Pentode Mixer
***5916**
Pentode Mixer
5977
Low Mu Triode
5987
Power Control Triode
6021
Medium Mu Double Triode
6110
Double Diode Detector
6111
Low Mu Double Triode
6112
High Mu Double Triode
6153
Sharp Cut-off Pentode Low Cgp (Separate suppressor)
6154
Remote Cut-off Pentode Low Cgp (Separate suppressor)
6205
Sharp Cut-off Pentode (Separate suppressor)
6206
Semi-remote Cut-off Pentode (Separate suppressor)

‡6308 Voltage Reference Tube.

*26-volt heater †26 volts all elements ‡Cold Cathode Type
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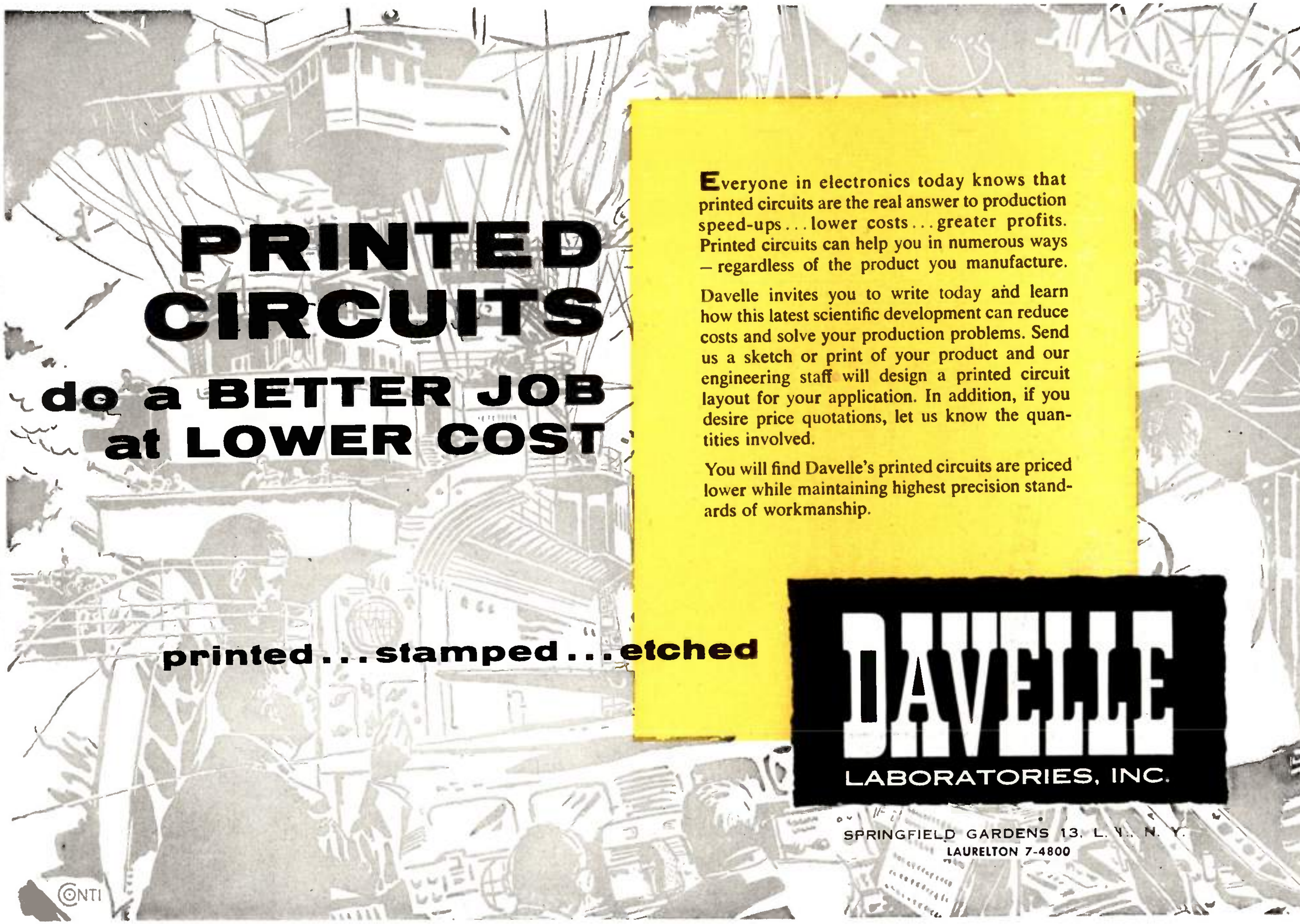

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What to See at the Radio Engineering Show

(Continued from page 107A)

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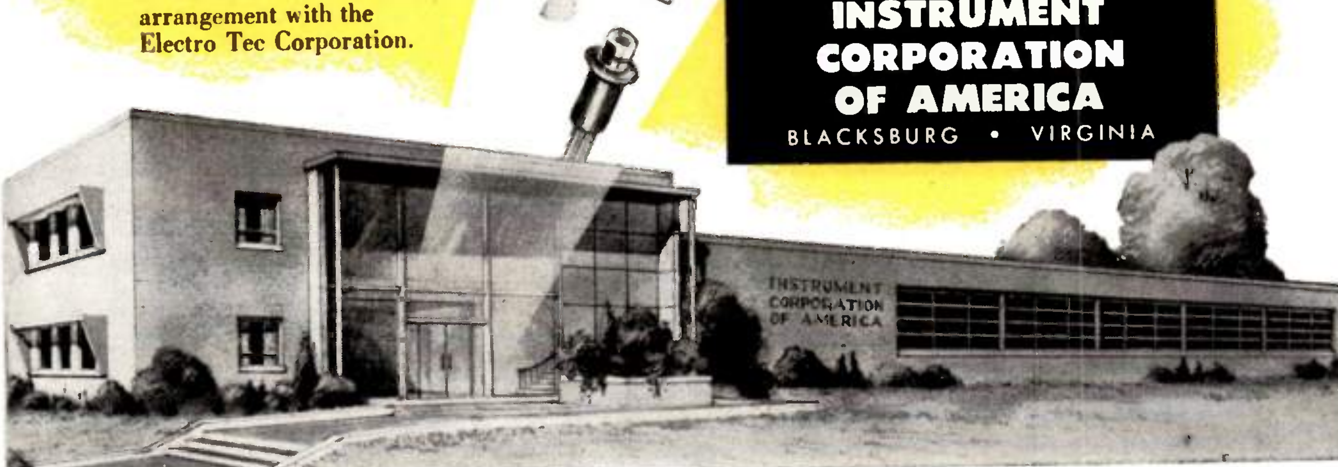

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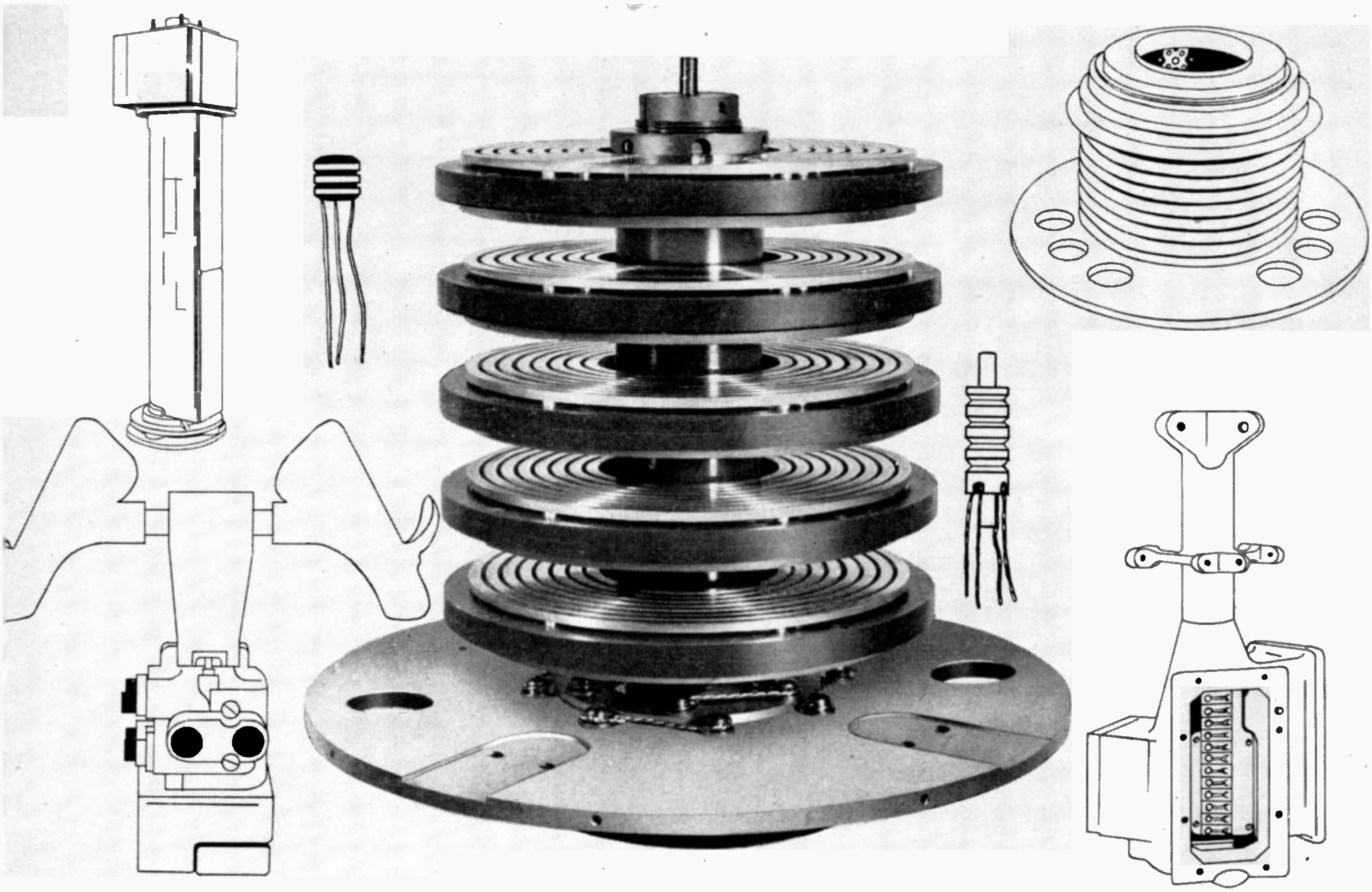

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Models 7010—1, 2, 3	7000 to 10000 MC	RG-51/U
Models 5882—1, 2, 3	5800 to 8200 MC	RG-50/U
Models 4458—1, 2, 3	4400 to 5800 MC	RG-49/U

Frequency Standards

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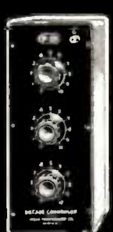

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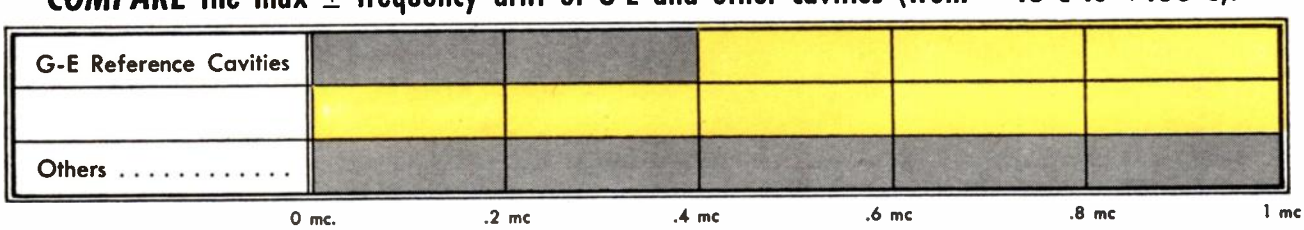

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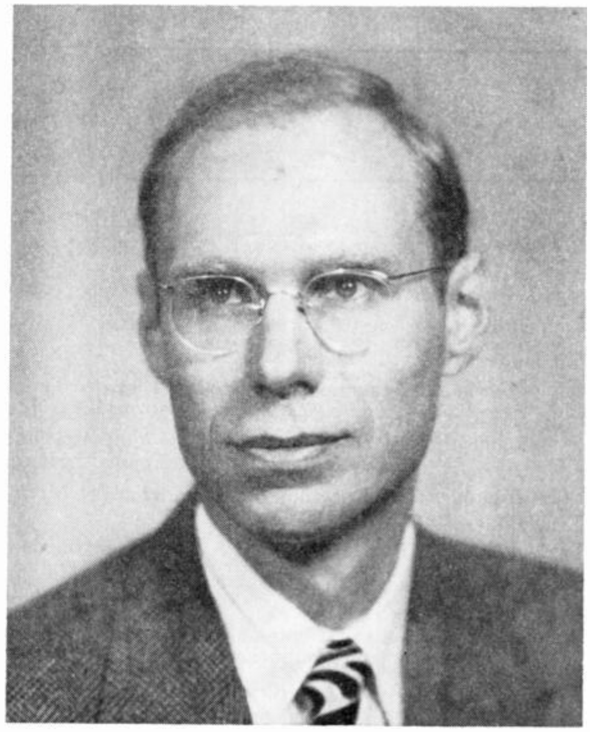


John R. Pierce

EDITOR—1954

John R. Pierce was born in Des Moines, Iowa, on March 27, 1910. He received his Bachelor's and Master's Degrees in Electrical Engineering from the California Institute of Technology in 1933 and 1934 respectively. In 1936 he received his Ph.D. degree from the same institution.

Since 1936 he has been a member of the technical staff of the Bell Telephone Laboratories, Inc., where he has been concerned with various vacuum-tube problems. In January, 1952, he became Director of Electronics Research at Bell Laboratories.

Dr. Pierce became a Senior Member of the IRE in 1946, after being associated with the Institute since 1935, first as a Student and then as an Associate Member. In 1948 Dr. Pierce received the IRE Fellow Award for his "many contributions to the theory and design of vacuum tubes." He is the recipient of the Eta Kappa Nu "Outstanding Young Electrical Engineer" award for 1942, and the IRE Morris Liebmann Memorial Prize for 1947. He has been a member of the IRE Papers Procurement Committee and served as second vice-president of that committee in 1943. Since 1936, Dr. Pierce has written many papers for the PROCEEDINGS OF THE I.R.E., on such subjects as thermal velocity, electron guns, electron multipliers, traveling wave tubes, noise, pulse code modulation, filters and double-stream amplifiers.

Dr. Pierce is the author of two widely known books in his field, *Theory and Design of Electron Beams*, and *Traveling Wave Tubes*, and in addition has written many popular science articles for various magazines. He is a Fellow of the American Physical Society, and a member of the American Institute of Electrical Engineers, the British Interplanetary Society, Tau Beta Pi and Sigma Xi.

What Is Wrong with Engineering Education?

H. G. Booker

For evidence of the high value which the engineering profession places on originality of thought, one has only to look at the vast amount of research activity now being supported by private industry and government. With the creative mind, then, such a valuable commodity, it behooves us to insure that the source of this commodity, namely, our college education system, is functioning effectively.

A stimulating analysis and critique of the quality of instruction which today's undergraduate and graduate student receives in most engineering colleges is capably set forth in the following guest editorial by a Fellow of the I.R.E. who, as Professor in the Department of Engineering Physics and School of Electrical Engineering at Cornell University, Ithaca, N. Y., has contributed substantially to the fields of engineering, science, and education.—*The Managing Editor.*

The achievements of American engineering are great beyond question, but can the same be said with equal conviction of American engineering education? Perhaps so, in terms of the number of undergraduates who are being professionally trained. But what of the quality of the education they are receiving? Can it even be called "education"?

Doubts on this matter reside in the minds of many faculty members in engineering schools, whatever front they may present to the rest of society. Evidence for this uneasiness can be seen in the number and variety of the curricula changes that have taken place in recent years in some engineering schools. Several schools have changed from a four-year to a five-year undergraduate program. Others have completed the conversion of their master's degree from graduate to undergraduate in character by eliminating the last vestige of a requirement for original thought.

In analyzing what is wrong with engineering education most engineering educators appear to start with the prejudice that there can be nothing seriously wrong with the technical courses for which they are responsible. The trouble must, they feel, lie eslewhere. Engineering educators consequently have found it easy to agree with each other that engineering education is too specialized. By agreeing that students need a "broader" education, engineering faculties have been able to share their worries with nonengineers and avoid facing the possibility that the main trouble may lie in their own engineering departments.

The principal function of undergraduate education should be to develop the mind of a student by having him think through things that other people have frequently thought through before. It should be the object of undergraduate education to pursue this process to the point where it is no longer worth the student's while to think through well-known thoughts merely in order to develop his mind. Graduation should signify that the student's mind is about as developed as it can be merely by studying what is well known. By contrast, it should be the object of graduate education to develop the student's mind by having him think through things that have not been completely thought through before so far as the student is aware. Research should thus be the principal tool of graduate education.

There are a number of universities in the world where graduate education is distinguished from undergraduate education by quite a clean-cut change of emphasis from study based on well-known thoughts to study based on novel thinking. But in most American universities this distinction has not been maintained. It has not been possible for the Public Educational System to provide early education suitable for the kind of individual who ultimately enters graduate school, and the universities, in their turn, have been unable to fulfill in four years the objectives of undergraduate education defined above. Graduate students usually spend half of their period at graduate school completing an education which in reality is undergraduate in type before they can devote their minds to novel thinking. Most engineering students, when they enroll in a graduate school, do not even realize that they are supposed to be entering on an educational program based on novel thinking. Their idea is that graduate education is merely a more thorough but more specialized version of undergraduate education.

The graduate student in engineering can hardly be blamed for not knowing the true philosophy underlying graduate education if his professors are almost equally ignorant. How many engineering schools have no research program deliberately planned to provide the thesis work of graduate students? Of course, most universities could not afford to do this out of their regular budget. But how many engineering schools are carrying out sponsored research that has not been primarily organized so as to provide the thesis work of graduate students? How many engineering schools use sponsored research for haphazard employment of anyone they can engage instead of as a form of scholarship support for graduate students engaged in their thesis research? How many graduate schools operate regulations that penalize a student for working on his thesis research through the medium of sponsored research even when this is the only form of research education and scholarship support provided for him? How many engineering schools permit, and even encourage, their staff to fritter their research effort away as consultants to industry while the direction of graduate thesis research is partially neglected?

The plain fact is that there is nothing wrong, or even unduly specialized, about engineering as a basis of education, undergraduate or graduate. Engineering provides a wealth of material for developing the minds of students on the basis of both well-known and novel ideas. What is wrong with engineering educators is that they obstinately refuse to use engineering as a basis of education. An interesting test of good education in engineering is this: If an engineering professor engaged in teaching an intelligent group of engineering students suddenly became aware to his surprise that not a single student intended to become a professional engineer and that their presence before him was primarily to develop their minds and sharpen their wits, would the professor maintain a calm conviction that he was doing his best for them? There must be a good deal of activity in engineering schools that would not meet this test. This activity may perhaps be acceptable professional training, but it is indifferent education.

Developments in Sintered Magnetic Materials*

J. L. SALPETER†

The following paper was recommended for publication by the Tutorial Papers Subcommittee of the IRE Committee on Education.—*The Editor.*

Summary—**The fundamentals of ferromagnetism are recalled before discussing the principles which guided the development of modern, nonmetallic, magnetic materials. Basic reasons for the properties of "Ferrox-cube" and "Magnadur" are explained in detail.**

Introduction

Sintering methods have been used for some time with success in preparing metallic magnetic materials, but recently a new class of sintered magnetic materials came into prominence, i.e. nonmetallic materials, for the preparation of which ceramic methods are particularly suitable. Those materials include both magnetically soft and magnetically hard materials and they all have in common a high electric resistivity which greatly reduces the skin effect and makes their use at high frequencies possible. Another common characteristic of the new materials is the fact that they can mostly be made without the use of costly and not readily available metals. Of the three ferromagnetic elements, iron, nickel and cobalt, only iron is abundant (yearly world production about 100 million tons, of which perhaps 1 per cent is used for magnetic purposes). The yearly world production of nickel is about 150,000 tons, of which some 5 per cent are used in magnetic alloys, the rest being needed for structural and corrosion resistant steels, for electroplating and for chemical purposes. Cobalt is even more scarce, its yearly world production being of the order of 6,000 tons, of which one-third is used in the manufacture of permanent magnets. It seems therefore of great importance to be able to substitute, as far as possible, other metals for cobalt and nickel. This is largely the case with the new nonmetallic materials.

Actually, the first known magnetic material, magnetite or lodestone, Fe_3O_4, was nonmetallic, but its electric resistivity was not very high and so the skin effect and eddy current loss were still appreciable. For that reason few engineering uses have been found for magnetite. If we replace one iron atom in Fe_3O_4 by another metal such as copper, manganese, or nickel, we obtain a ferrite, copper ferrite, $CuFe_2O_4$, manganese ferrite, $MnFe_2O_4$, and so on. These ferrites have a very high electrical resistance (without losing their magnetism) and it is with them that we shall be concerned, as far as soft magnetic materials are concerned. The electric and magnetic properties of ferrites were studied as long ago as 1909 by Hilpert but their magnetic performance was then very poor. Although the skin effect was really negligible, the permeability was low and the total losses high, so that this class of materials has been abandoned. In 1933 the study of ferrites was resumed in the Philips Laboratories in Eindhoven, and after many years of research, materials have been developed with some excellent magnetic properties, which are now marketed under the brand "Ferroxcube." These soft materials have not only proved valuable for cores of inductors in telephony, wave filters, radio receivers, and transmitters and so on, but they are also of great interest to physicists, because the practical elimination of the skin effect makes possible the study of magnetic phenomena within the body at high frequencies. As is well known, the skin effect in metals not only increases the losses, but screens the interior of the metal from the magnetic field. Thanks to the absence of the skin effect, the ferrites proved to be suitable materials for the study of such phenomena as "ferro-magnetic resonance" at high frequencies.

The other class of new nonmetallic materials is known as "Magnadur" and is magnetically hard. Just as the Ferroxcubes were derived from the mineral magnetite, the Magnadurs are derived from the mineral magnetoplumbite, $PbO \cdot 6Fe_2O_3$. While the ferrites crystallize in a cubic lattice, magnetoplumbite has a hexagonal structure. The first Magnadur material that has appeared on the market is derived from magnetoplumbite by substituting barium for lead and has the formula $BaFe_{12}O_{19}$. This material, although of a comparatively low retentivity, has an exceedingly high coercive force which, strangely enough, increases with increasing temperature. Due to its high coercive force the material can be used in the form of discs, without the danger of demagnetization, and is being applied already in loudspeaker circuits.

Ferromagnetism

The team of physicists and chemists who started investigations on ferrites in the Philips Laboratories was headed by Dr. Snoek, who has explained in the literature the principles which served as a guide in the development work.[1] However, before we discuss those principles it will be well to recall the fundamentals of ferromagnetism.

* Decimal classification: R282.3. Reprinted from Proc. I.R.E. (Australia), May, 1953 issue, by permission of the Institution of Radio Engineers, Australia.

† Research Physicist, Philips Electrical Industries Pty. Ltd., South Australia.

[1] J. L. Snoek, "New Developments in Magnetic Materials," Elsevier Publ. Co., New York, N. Y.; 1947.

A ferromagnetic body could be defined as a body whose permeability is greater than 1.01. All bodies are magnetic and have magnetic permeabilities. Those with permeabilities less than unity are referred to as diamagnetic, those with permeabilities greater than unity are paramagnetic, and ferromagnetics are a special class of paramagnetics. There are only three ferromagnetic elements: iron, nickel, and cobalt, and alloys and compounds containing one or more of those three elements can be ferromagnetic. (Heusler alloys are an exception, they are ferromagnetic without containing any of the three elements mentioned.) The magnetic properties of a body can be attributed to elementary magnets embodied in each atom of the substance and to the mutual interaction between these elementary magnets. The strength of such an atomic magnet is called atomic moment and is usually expressed in magnetons ("Bohr magnetons"). The number of magnetons per atom in Fe, Co, Ni are 2.22, 1.71 and 0.60, respectively. The number of magnetons per atom in paramagnetics is about of the same order as in ferromagnetics, and yet the permeabilities of paramagnetics are of the order of 1.001 or less, while the permeabilities of ferromagnetics are of the order of 1,000 and more. The particular behavior of the ferromagnetics cannot then be ascribed to particularly high magnetic moments. Pierre Weiss, the famous pioneer in the field of ferromagnetism, put forward the theory that in ferromagnetics special "molecular fields" align the elementary magnets. A (soft) ferromagnetic can be magnetized to saturation by a field of one oersted, while a paramagnetic would require a field of millions of oersteds for magnetization to anything like the same strength. Now the molecular fields suggested by Weiss should have an intensity of millions of oersteds in order to align the elementary magnets, as we find them aligned in ferromagnets. For

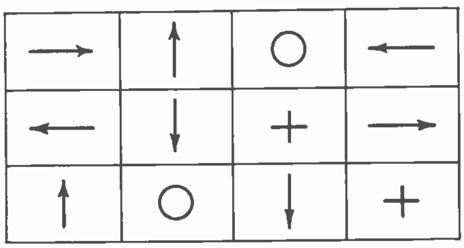


Fig. 1—A pattern of domains with six different magnetic vectors and bulk magnetization zero. Circles and crosses denote vectors perpendicular to the plane of the drawing (out and into the paper).

a long time the origin of these forces in the Weiss molecular fields was a puzzle to the physicists, although their existence had been established beyond any reasonable doubt. Quantum mechanics has supplied an answer to the puzzle and has shown that the forces are primarily of electrostatic origin, modified by the peculiar concepts of matter and electricity due to the wave character of the electron. The forces are referred to as "exchange forces" but we shall not deal with them in detail but only state the result which is, that under certain exceptional circumstances, the exchange forces align the atoms in such a way that the north poles of the elementary magnets all point in the same direction. This statement has to be qualified in one important respect. If all the elementary magnets were aligned as we have just said, any piece of iron would be always magnetized to saturation without the application of any magnetizing force. Weiss himself reconciled his hypothesis of the molecular fields with the conclusion just drawn in the following way: The spontaneous magnetization achieved by molecular fields is restricted to small regions, so-called "domains," and although each domain is magnetized to saturation, the directions in the individual domains vary in such a way as to make the over-all magnetization of the piece of iron in bulk equal to zero (see Fig. 1).

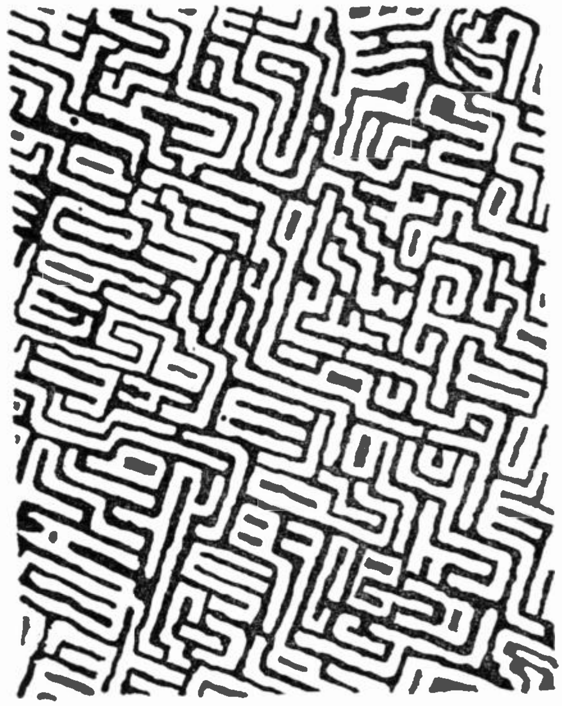


Fig. 2—"Bitter" pattern on the face of a polished single crystal of iron-silicon.

The advance of the concept of "domain" from a mere hypothesis to a well established physical feature was particularly due to the Bitter powder pattern technique. It is known that iron filings can be used to portray the directions of lines of magnetic force around a magnet. If we replace the filings by a suspension of small size iron-oxide particles and pour this suspension over the polished surface of a magnetic body, we observe under the microscope peculiar patterns (Fig. 2) due to the boundaries between individual domains representing lines of greater magnetic intensity than the rest of the surface. Thus the powder accumulates on these lines and so forms patterns of domain boundaries, peculiar to the particular substance and its particular magnetic condition. We can observe the patterns, both when the substance is magnetized and not magnetized and watch, for instance, how the pattern changes when the body is subjected to tension. In Fig. 2 we see the pattern on the polished surface of an iron-silicon crystal.

Crystal Anisotropy

Iron crystallizes in a cubic system, the iron atoms occupying the corners and the center of a cube (Fig. 3). In a single unstrained iron crystal, the domains are magnetized along one of the cubic axes (one of the six arrows in Fig. 3). These directions are called directions of "easy" magnetization and can be regarded as the "natural" ones for iron. The directions of face diagonals are directions of "medium" and those of cube diagonals directions of "hard" magnetization. To have the arrows of a domain in an iron crystal pointed in a direction other than an "easy" one, a magnetizing force has to be applied and this magnetizing force will have to be larger the nearer the desired direction is to the "hard" one. To saturate the crystal in an easy direction requires a fraction of one oersted, but to saturate it in a hard direction it requires about 500 oersteds. This means, the crystal is "anisotropic," i.e. its (magnetic) properties depend on the direction. In hexagonal cobalt the magnetic anisotropy is still more pronounced: 10,000 oersteds are not sufficient to magnetize a cobalt crystal in its hard direction.

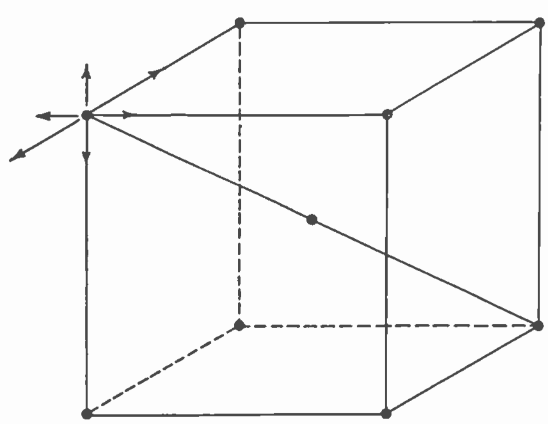


Fig. 3—Unit of an iron crystal lattice. The lattice is cubic and body-centered. The six arrows indicate the six directions of easy magnetization, the cube diagonals are the directions of hard magnetization (one of them drawn in the figure). The face diagonals (not drawn in the figure) are directions of medium magnetization.

In a polycrystalline specimen the crystallographic axes of the individual grains are distributed haphazardly and if we want to magnetize the specimen in any particular direction, that direction will in some grains coincide with an easy direction, in others with a hard one. As a result the specimen will be the harder to magnetize the more pronounced the crystalline anisotropy of the crystals composing the specimen. Thus we can understand that the larger the crystal anisotropy, the lower will be the permeability and vice versa. As a rule cubic crystals have a lower anisotropy than for instance hexagonal ones and it is understandable that Ferroxcube materials are made of cubic, while Magnadur ones are of hexagonal crystals.

Magnetostriction

When we magnetize a nickel rod along its axis, it contracts. Although the contraction is very small, say 15 parts in a million for the application of a magnetizing field of four oersteds, the importance of the phenomenon will be seen if we consider the converse case, i.e. the decrease of magnetization of the nickel rod on stretching. The magnetostriction of nickel is negative, i.e. the length decreases with magnetization while the magnetostriction of magnetite say, is positive.

Due to magnetostriction an applied tension or compression will alter the permeability of a magnetic body. The same applies to internal stresses. It is understandable that a system of internal stresses will generate a system of easy and difficult directions of magnetization, which system will be superposed on the system of crystalline easy and difficult directions. In the case of very heavy internal stresses it can even happen that the system imposed by the stresses will be more pronounced than the crystalline one. Heavy internal stresses make the material harder to magnetize and in hard magnetic materials internal stresses are introduced on purpose, while in soft magnetic materials internal stresses are carefully avoided. However, it is never possible to avoid internal stresses altogether, and the only way to make the small internal stresses harmless is to reduce magnetostriction, if this be possible. With mixed ferrites it is indeed possible to reduce magnetostriction in the following way. All ferrites have a negative magnetostriction, except magnetite itself that has a positive magnetostriction. By preparing a mixed ferrite with a small quantity of Fe_3O_4 we can reduce magnetostriction to a negligible value. The ferrites denoted by Ferroxcube III are all manganese zinc ferrites with practically zero magnetostriction. They all have high initial permeabilities (more than 600), but due to the admixture of Fe_3O_4 their resistivity is comparatively low (20–80 ohm-cm.).

Cube Temperature

We have seen that we can increase permeability by decreasing the crystal anisotropy, internal stresses, and magnetostriction, but more important still is the saturation magnetization (permeability increases with the square of the saturation magnetization). On what does the saturation magnetization now depend? We have seen that in ferromagnetics the exchange forces tend to align the atoms in such a way as to have all the elementary atomic magnets pointing in one direction. The aligning tendency is counteracted by the thermal motion of the atoms. At the absolute zero of temperature where there is no thermal motion, the alignment is perfect and the saturation magnetization is given by the sum of all the atomic magnetic moments. With rising temperature the thermal motion increases and increasingly disturbs the alignment achieved by the exchange forces. As a result the saturation magnetization decreases with the temperature, at first very slowly, almost imperceptibly, but then more rapidly, until at some definite temperature, the magnetization collapses entirely. The temperature at which this happens is referred to as Curie temperature or Curie point. In Fig. 4 the saturation magnetization of iron is depicted as a function of the temperature: it can be seen that at 770 degrees C. the magnetization drops quite rapidly to zero. The Curie points of cobalt and nickel are 1,130 degrees and 360 degrees C. respectively.

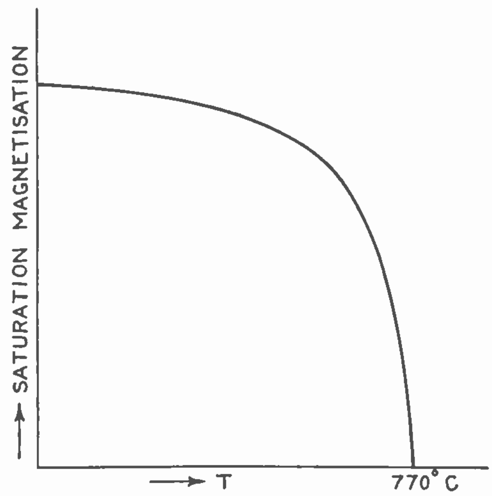


Fig. 4—Saturation magnetization of iron versus temperature. At 770 degrees C. the magnetization drops to zero (Curie point).

An interesting feature of the magnetic behavior near the Curie point is the fact that the permeabilities of most (soft) ferromagnetics increase with increasing temperature and reach a maximum just below the Curie point. In Fig. 5 the initial and maximum permeabilities of iron are shown as functions of temperature. The explanation of this curious phenomenon is seen in the decrease of the magnetic crystalline anistropy with the temperature. Due to the thermal motion the atoms deviate from their equilibrium positions and at the same time the magnetic vectors of the elementary atomic magnets deviate from their directions of easy magnetization, i.e. the thermal motion helps us to turn the vectors towards the directions of hard magnetization. Although this may not be the whole explanation, the fact is that the magnetic anisotropy decreases with rising temperature much faster than the saturation magnetization and as a result the permeability increases.

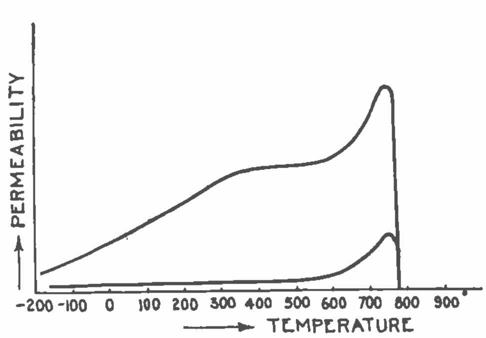


Fig. 5—Both the initial and the maximum permeabilities of iron have a sharp maximum just below the Curie point.

To achieve high permeabilities would then be in principle possible either by using known ferromagnetics just below their Curie points, e.g. iron at some 750 degrees C., or to synthesize new ferromagnetics with Curie points not very much higher than room temperature. This latter alternative has been employed in the preparation of Ferroxcubes with a deliberately low Curie point. Of all the ferrites investigated, zinc ferrite is nonmagnetic and an admixture of zinc ferrite to another ferrite lowers the Curie point of the mixed ferrite. Thus Ferroxcubes III are manganese-zinc ferrites with Curie points ranging from 130 degrees to 235 degrees C. and permeabilities in the range 806–1,750. We see that the permeabilities obtainable with Ferroxcubes III are about 10–20 times higher than those of iron dust cores.

Temperature Coefficient of Permeability

The drawback of a low Curie point is the temperature dependence of the permeability. Fortunately, Ferroxcube cores are mostly made with air gaps, and the air gap reduces considerably the temperature dependence of the permeability. In a core with an air gap it is the effective permeability that matters, not the actual permeability of the core material, and, accordingly, the temperature coefficient of the effective permeability only is important. We shall see that the effective temperature coefficient c' is reduced in relation to the actual material coefficient c in the same ratio as the permeabilities themselves, i.e.

$$c'/c = \mu'/\mu \qquad (1)$$

where μ and μ' stand for the core permeability (without air gap) and the effective permeability (with air gap) respectively. To prove this we shall use the well-known formula for the effective permeability of a core of uniform cross section with an air gap:

$$\mu' = \frac{\mu}{1 + \beta\mu} \qquad (2)$$

where β denotes the ratio of the air gap length to the core length. If we write (2) in the reciprocal form:

$$1/\mu' = 1/\mu + \beta \qquad (3)$$

we can simply interpret it by saying that the reluctance of the total magnetic path (which is inversely proportional to μ') is equal to the sum of the reluctances of the core and the air gap. By differentiating both sides of (3) with respect to the temperature T, we obtain:

$$\frac{1}{\mu'^2}\cdot\frac{d\mu'}{dT} = \frac{1}{\mu^2}\cdot\frac{d\mu}{dT} \qquad (4)$$

or

$$c'/\mu' = c/\mu \qquad (1)$$

since by definition

$$c' = \frac{1}{\mu'} \cdot \frac{d\mu'}{dT} \cdot$$

The quotient c'/μ' is independent of the value of the air gap and for this reason we shall find the values of c'/μ' quoted in catalogues rather than of c itself. To obtain the effective temperature coefficient from the number given in the catalogue it is only necessary to multiply that number by the effective permeability of the particular circuit.

Saturation Magnetization

Another drawback of a low Curie point is a low saturation magnetization. While the saturation magnetization of iron at room temperature is only a few per cent lower than at the absolute zero, magnetization at room temperature of ferrites with a low Curie point may be as low as 50 per cent of the value measured at (−200 degrees C.). For Ferroxcubes III the saturation magnetization at room temperature is between 3,000 and 4,000 gauss as compared with some 21,000 for iron, i.e. about six times lower. The one factor responsible for that low value is the low Curie point, but on the other hand the magnetic moment of an iron or nickel ion in a compound is larger than in the metallic state (as has been found by measurements on paramagnetic salts). The actual saturation magnetization of the ferrites is much lower than could have been expected from these considerations. To explain this defect of magnetization, a theory has been put forward that in some substances the exchange forces do not align the neighboring atoms parallel but antiparallel, as indicated in Fig. 6. This phenomenon is referred to as antiferromagnetism and can occur in crystals like those of a spinel structure where the sites occupied by the magnetic ions in the lattice are not all of the same value as far as the number of immediate neighbors is concerned. It can then happen that the atoms occupying sites A, say, are all aligned parallel in one direction, and the atoms occupying sites B, say, are aligned parallel also but in the opposite direction and the resulting magnetic moment per unit cell of the lattice corresponds with the difference of the atoms A and atoms B. It appears that this theory enables us to predict the saturation magnetization if composition and crystal structure are known in detail.

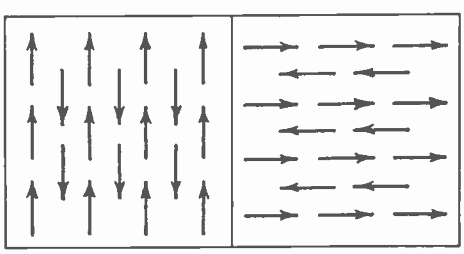


Fig. 6—Two domains of an antiferromagnetic substance.

The comparatively low saturation precludes the use of ferrites for power transformers at 50 cps but ferrite power transformers are quite practicable in a range somewhere between 10 and 100 kc. This is due to the fact that the ferrites are practically free from eddy currents and the hysteresis losses increase with frequency at a slower rate than eddy current losses.

Dimensional Resonance

Despite the absence of eddy currents there are some dimensional effects to consider. This is due to the fact that ferrites apart from being ferromagnetics (or rather antiferromagnetics) are also dielectrics with some considerable permittivities. Since the propagation velocity of electromagnetic waves in a medium of a permittivity k and permeability μ is $c/\sqrt{k\mu}$, where c is the velocity of light, it can happen that at some frequency the wavelength within the ferrite becomes equal to the smallest dimension of the specimen, in which case the field intensity within the specimen will become excessively high and high losses will be the result. In the case of a particular manganese-zinc ferrite with a permittivity of 100,000 this frequency was somewhat below 1 mc for a core of 1 cm×1 cm cross section. However, a permittivity of 100,000 is quite exceptional and with other types of ferrites the dimensional effect for a 1 cm×1 cm cross section does not occur below about 40 mc.

Core Losses

So far we have been dealing mainly with the drawbacks of mixed ferrites, or rather with the price that had to be paid for high values of permeability in the absence of eddy currents. We have said that to obtain high permeabilities in ferrites, low magnetostriction and low Curie points are essential. But low magnetostriction, if achieved with the admixture of Fe_3O_4, means lower resistivity, and a low Curie point entails temperature dependence of permeability and low saturation at room temperature. Generally speaking, it is not yet possible to prepare a mixed ferrite which incorporates all the good properties with the exclusion of all the undesirable ones. It is only possible to achieve in any particular grade a balance of favorable and unfavorable properties, a balance that makes that particular grade suitable for a particular range of applications.

The main advantage of Ferroxcubes is the possibility of achieving a high-quality factor Q in a circuit employing Ferroxcube cores, combined with small size and good shielding properties. With metallic ferromagnetics it is necessary to laminate the material at low frequencies, in order to avoid excessive eddy current losses and to use it in the form of powders at higher frequencies. But pulverizing not only reduces the effective permeability; the "intrinsic" permeability itself starts to decline with very small particle sizes. With ferrites it is true that it is also necessary to reduce the effective permeability by inserting an air gap, but the over-all result is that in many cases it is possible to achieve a much higher Q and a smaller size than with dust cores.

It is usual to characterize a material by the quotient $\tan \delta/\mu$, where δ stands for the loss angle and μ for the (effective) permeability. The quality $\tan \delta/\mu$ is a suitable criterion, because it is largely independent of the air gap. To see this, let us recall the definition of $\tan \delta$. Let L be the self-inductance of a cored coil, ω the number of cycles in 2π seconds, and R the equivalent series resistance representing the losses of the coil. Then $Q=\omega L/R$ and $\tan \delta = 1/Q = R/\omega L$, where δ is the phase angle between the terminal voltage of the coil and the voltage across L (imagined resistanceless). Suppose the coil consists of N turns through which an ac current I flows, generating a flux density B in the core. If we cut a gap in the core, we shall have to increase the number of turns from N to N' in order to maintain the same B in the core with the same I in the coil. The ratio N'/N indicates by how much the permeability has been effectively decreased:

$$\frac{\mu'}{\mu} = \frac{N'}{N} \tag{5}$$

where μ and μ' stand for the permeabilities before and after cutting the air gap. If we now remember that L is proportional to the product of the square of N and the effective permeability we can write:

$$\left.\begin{aligned} L &= \text{const.} \times N^2\mu \\ L' &= \text{const.} \times N'^2\mu' \end{aligned}\right\} \tag{6}$$

where L' denotes the self-inductance with the air gap. From (5) and (6)

$$L\mu = L'\mu'. \tag{7}$$

Since we maintain the same B in the core after cutting the gap as before, core loss R' will be practically the same as R (the only difference being that the volume of the core has been diminished by the small volume of the gap) and so we can write:

$$\frac{R'}{\mu'\omega L'} = \frac{R}{\mu\omega L} \tag{8}$$

or

$$\frac{\tan \delta'}{\mu'} = \frac{\tan \delta}{\mu}. \tag{9}$$

The quantity $\tan \delta$ is not very much different for the various grades of Ferroxcube at low frequencies and is of the order of 0.01; however, it increases with the frequency. Fig. 7 shows how $\tan \delta/\mu$ varies with the frequency for various grades of Ferroxcube. We see that $\tan \delta/\mu$ stays mostly constant up to some frequency, when it suddenly rises. The frequency at which that happens limits the range in which the particular grade can be usefully employed and we can see the lower $\tan \delta/\mu$, the lower is the limiting frequency. Fig. 7 explains why a comparatively large number of grades of Ferroxcube is necessary: materials suited for high frequencies have higher losses and lower permeabilities, but if a material is required for only low frequencies, then we can use one with a small $\tan \delta/\mu$.

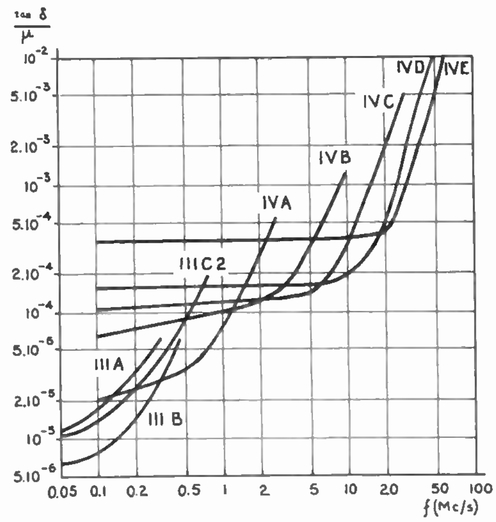


Fig. 7—Tan δ/μ versus frequency.

Rayleigh's Law

We shall now discuss how the losses indicated by $\tan \delta$ come about in Ferroxcubes. Although eddy current losses are almost negligible, other losses comprising hysteresis losses and so-called "residual" losses are not so. We shall first discuss hysteresis losses and this will be best done by contemplating the magnetization curve and the hysteresis loops. Since we are dealing mostly with small amplitudes and low values of induction, it will be possible to base our discussion on Rayleigh's law, valid in fields small compared with the coercive force.

Rayleigh's law consists of two parts, the first one pertaining to the magnetization curve proper, the other to the hysteresis loop. Suppose our specimen is completely demagnetized and we start from the zero point $H=0$, $B=0$ (Fig. 8). On continuously increasing the field H, the induction B increases continuously according to a parabolic law:

$$B = \mu_0 H + \alpha H^2. \tag{10}$$

The first term in (10) is linear in H, and μ_0 is referred to as the "initial permeability." The second, quadratic term causes the B–H line to curve upwards. Let us now stop at $H=H_1$ and reverse the field. The induction B which at $H=H_1$ had the value B_1 starts to decline and the decrease $B-B_1$ will be a parabolic function of the decrease $H-H_1$. However, the coefficient of the quadratic term will be only half the value of the coefficient in (10) and this is the second part of Rayleigh's law:

$$B - B_1 = \mu_0(H - H_1) - \frac{\alpha}{2}(H - H_1)^2, \tag{11}$$

(11) representing the upper branch of the hysteresis loop (Fig. 8). (If the coefficient of the quadratic term in (11) were the same as in (10), the upper branch of the

loop would return to the zero point, which, as we know, never happens.) We continue now downwards until we arrive at $H=-H_1$, $B=-B_1$ and then we return traversing the lower branch of the loop (represented again by (11) but with a positive sign before $\alpha/2$. The surface

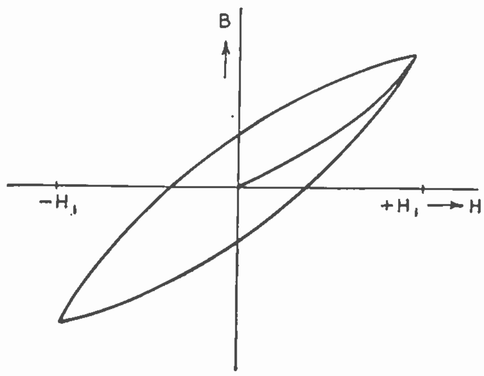


Fig. 8—Rayleigh's law.

area of the loop is equal to the heat dissipated in a unit volume of the core during one cycle. The residual induction B_r, i.e. the induction for $H=0$ on the loop is:

$$B_r = \frac{\alpha}{2} H_1^2 \tag{12}$$

(which follows easily from (10) and (11), if we calculate B_1 from (10), substitute the value in (11) and put $H=0$). With increasing H_1 the length of the loop increases linearly with H_1, but its thickness increases linearly with B_r or H_1^2 and consequently the surface area increases with H_1^3. A simple integration gives us for the hysteresis loss W_h per cubic cm and per cycle

$$W_h = 1/3\pi \cdot \alpha H_1^3. \tag{13}$$

Equation (13) can also be written as

$$W_h = \alpha/3\pi \cdot B_1^3/\mu^3 \tag{14}$$

but in this case μ stands for B_1/H_1 and not for the initial permeability. Still, for materials with a not too large α the permeability μ will not differ much from the initial permeability, which justifies saying that the hysteresis loss increases with the third power of the flux density B_1, i.e.

$$W_h = \text{const. } B^3. \tag{15}$$

It is useful to express the hysteresis loss in terms of an equivalent hysteresis resistance R_h as follows:

$$R_h I^2 = W_h f v \tag{16}$$

where I stands for the rms value of the current, f for the frequency, and v for the volume of the core. In order to eliminate I from (16) let us recall the relation

$$LI^2 = \frac{v}{8\pi} \cdot BH \tag{17}$$

where the left-hand side expresses the magnetic energy of the core in terms of L and I, the right-hand side in terms of the BH product and the volume. Let us now rewrite (16) and (17) as follows:

$$R_h I^2 = \text{const.} \times B^3 f v \tag{18}$$

$$LI^2 = \frac{v}{8\pi} \cdot \frac{B^2}{\mu} \cdot \tag{19}$$

By dividing (18) by (19) we obtain:

$$\frac{R_h}{\mu f L} = C_h \cdot B \tag{20}$$

where C_h is a material constant and is referred to as the "hysteresis coefficient." Sometimes it is preferable to eliminate from (18) and (19) not the current I but the induction B (because it is easier to measure I than B). To do this we square both sides of (18) and cube both sides of (19) and then divide (18) by (19). Then

$$R_h = \text{const.} \times \frac{(L\mu)^{3/2}}{\sqrt{v}} \cdot fI. \tag{21}$$

In telephone engineering it is customary to make measurements at a frequency of 800 cps, and, with regard to this, (21) is written in the form

$$\frac{R_h}{L} = q_2 \cdot \sqrt{L} \cdot \frac{f}{800} \cdot I \tag{22}$$

where q_2 is no longer a material constant but depends on the volume v of the core. The symbol q_2 has been adopted by the CCIF. If we take a core of a volume of 24 cubic cm with a uniform cross section and an effective permeability of 100 (typical approximate figures for loading coils) and denote the q_2 of that core by q_2 (24–100), then we can deduce from (21) and (22) that q_2 for any other volume v and effective permeability μ' will be

$$q_2 = q_2(24\text{–}100) \left(\frac{\mu'}{100}\right)^{3/2} \cdot \sqrt{\frac{24}{v}} \cdot \tag{23}$$

The constant q_2 (24–100) is referred to as the "hysteresis factor" and is quoted in the Ferroxcube catalog for various grades. We have based our discussion on Rayleigh's law although ferrites do not fully comply with that law. For that reason q_2 is not quite independent of H_{max} and the values quoted in the catalog are valid only for inductions not exceeding about 30 gauss.

If the core cross section is not uniform, then we split the circuit into pieces each with a uniform cross section $A_1, A_2, A_3, \cdots$, and with lengths $l_1, l_2, l_3 \cdots$. The flux density will now be different in the individual pieces: it will be $B_1=F/A_1$, $B_2=F/A_2$, $B_3=F/A_3, \cdots$, where F stands for the total flux. The volumes of the individual pieces are $v_1=A_1l_1$, $v_2=A_2l_2$, $v_3=A_3l_3, \cdots$. Taking that into account after rewriting (18) and (19) in the form:

$$R_h I^2 = \text{const.} \sum B_i^3 f v_i \tag{24}$$

$$LI^2 = \frac{1}{8\pi} \cdot \frac{1}{\mu} \cdot \sum B_i^2 v_i \tag{25}$$

we obtain easily for equivalent volume v of the circuit

$$v = \frac{(\sum l_i/A_i)^3}{(\sum l_i/A_i^2)^2}. \qquad (26)$$

The volume so computed inserted in (23) gives us the q_2 for the core with nonuniform cross section.

"Residual" Losses

Were the hysteresis losses the only magnetic losses occurring in a semiconductor core, the loss resistance would approach zero with B_{max} approaching zero (see [20] of the previous section). Yet, it turned out that with vanishing B_{max} the loss resistance does not approach zero. Let us denote the total loss resistance by R_{tot}, then in the general case we have

$$\frac{R_{tot}}{\mu f L} = C_e \cdot f + C_h \cdot B_{max} + C_r. \qquad (27)$$

The right-hand side of (27) consists of three terms: the first term, the eddy current term, is proportional to the frequency; the second term, the hysteresis term, is proportional to the B_{max} while the third term that is responsible for the residual losses, is independent of f and B_{max}. In our case we can neglect C_e, C_h has already been dealt with, and only the term C_r remains to be discussed. At low values of induction the product $C_h \cdot B_{max}$ is usually small compared with C_r and so at low inductions residual losses are prevalent at all frequencies.

It is customary to express the residual losses in terms of complex permeabilities. Any magnetic loss causes a phase shift between H and B. Let us consider again the hysteresis loop according to Rayleigh's law. Rayleigh's loop can be approximated by an ellipse, as indicated in

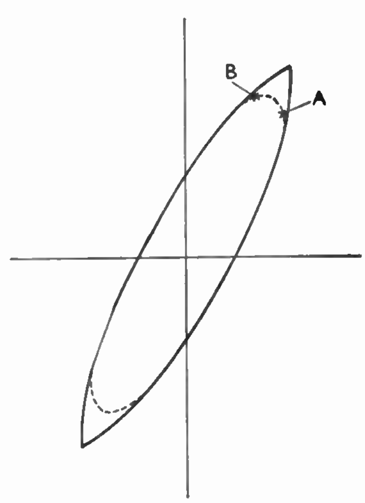


Fig. 9—Rayleigh's loop approximated by an ellipse.

Fig. 9, in which case we can imagine both H and B as sine functions of time with a phase difference δ. When $\delta = 0$ the ellipse degenerates into a straight line; the larger the phase angle δ, the fatter becomes the ellipse. It is the deviation of the Rayleigh loop from the ellipse that causes distortion (third harmonic). There is an interesting feature distinguishing between the hysteresis loop and an ellipse: if we travel along the ellipse from A to B (Fig. 9), B increases while H decreases. Physically, this would indicate a kind of inertia in B in the case of the ellipse, which inertia is however totally absent in the case of the hysteresis loop. We shall see later that in the case of "residual" losses we indeed have reason to suspect an inertia in B, or rather in the physical process responsible for B.

Let us then write

$$\mu = \mu' - j\mu''$$

where μ' stands for the real part and μ'' for the imaginary part of the permeability. The meaning of the terms will be clear if we substitute the above expression for μ in the equation $B = \mu H$. We then obtain

$$B = \mu' H - j\mu'' H.$$

The first term on the right-hand side corresponds with the inductive part, the second term with the resistive part of the impedance, and the factor $(-j)$ indicates that the resistive part lags behind the inductive part by 90 degrees. It follows that

$$\tan \delta = \mu''/\mu'$$

and accordingly by specifying both μ' and μ'' we convey information about the permeability and losses.

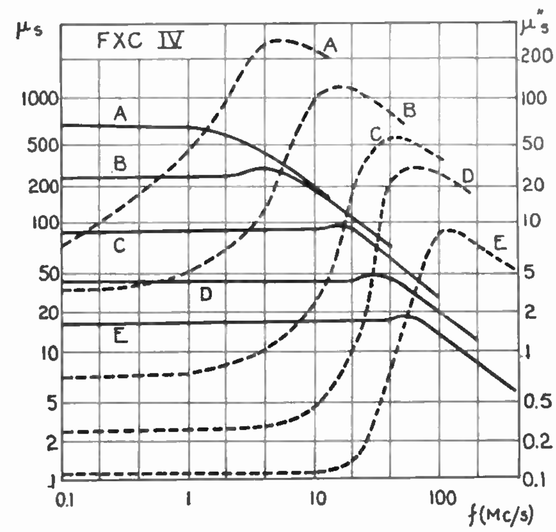


Fig. 10—Complex permeability versus frequency.

In Fig. 10 the full curves represent μ' and the dotted ones μ'' as functions of frequency for various grades of Ferroxcube. We see that μ' stays constant up to some critical frequency and then suddenly decreases, while the μ'' curves have a steeply rising part around the same critical frequency. The higher the value of the permeability, the lower the frequency at which this happens, which is essentially the same statement as that conveyed by Fig. 7.

Gyromagnetic Phenomena

Although a complete theory of residual losses is not yet available, it is believed that the background of these losses is connected with the damping accompanying gyromagnetic processes within the magnetic atoms. We had started explaining ferromagnetism by assuming magnetic dipoles incorporated in the magnetic atoms but we have said nothing about the nature of those dipoles. As we know, no elementary magnetic poles exist in nature and accordingly no real magnetic dipoles; magnetic behavior is caused only by "electricity in motion." An atom consists of a nucleus and a number of electrons circling around the nucleus, like planets around the sun. Each circling electron represents a magnetic moment, but somehow those "orbit moments" largely cancel each other and we can disregard them (as a first approximation). The magnetic moment of the atom is due to the motion of the electron around its own axis, the electron "spin." Each electron is assumed to have an intrinsic spin with which exactly one Bohr magneton of magnetic moment is associated. The hypothesis of the spinning electron was originally evolved to explain some facts of the optical spectra, but at the same time it is useful to explain the magnetic behavior of atoms. The spin can be positive or negative (depending on the sense of rotation) and one positive and one negative spin cancel each other. An atom of iron contains 52 spinning electrons, but their spins largely cancel each other and in the balance there remain only 2.2 magnetons per atom.

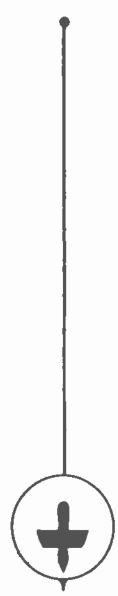
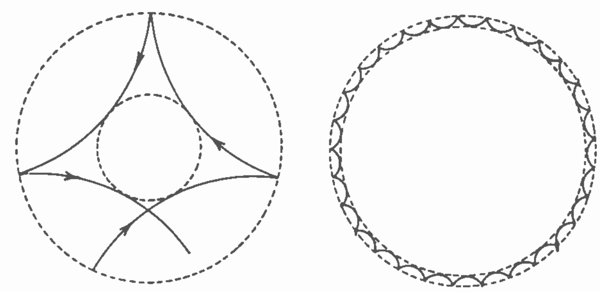


Fig. 11—A pendulum whose body contains a spinning top.

A spinning electron is magnetostatically equivalent to a magnetic dipole, but there is one important difference. Since an electron is endowed with mass a spinning electron represents mechanically a spinning top. If by applying a magnetic field we try to turn the axis of the spinning electron, we have to keep in mind that our magnetic dipole is inseparably coupled with a spinning top and we know how strangely a spinning top behaves if we try to incline its axis.

Let us imagine a pendulum whose body contains a spinning top. In Fig. 11 the pendulum is represented as in equilibrium with the force of gravity. Now let us move the pendulum arm away from the vertical and then release it. An ordinary pendulum would begin to oscillate around the equilibrium in a vertical plane. Instead of that, our pendulum will describe an orbit like the one depicted in Fig. 12(a), where we see two dotted circles between which the orbit of the pendulum point is contained. The higher the number of revolutions of the top per second, the larger will the diameter of the inner circle become, until eventually the orbit of the pendulum will be hardly distinguishable from a circle (Fig. 12(b)). The movement of the pendulum along the circle



(a) (b)

Fig. 12—Precession orbit for (a) low J; (b) high J.

is referred to as "precessional" movement and apart from the angular velocity (frequency) of the spin, we have now to consider the angular velocity (frequency) of the precession as well. The precession frequency is equal to the quotient M/J where M stands for the product of the weight and length of the arm of the pendulum, while J stands for the angular momentum of the spinning top.

If we replace the spinning top by a spinning electron whose axis we want to turn by a magnetic force, we can try to apply our knowledge about spinning tops to the magnetic behavior of atoms. To make the analogy complete, we still have to provide the "suspension" for the spinning electron. We have mentioned previously that the crystalline anisotropy forces provide the atoms with an equilibrium position, characterized by the direction of "easy" magnetization, and so the lattice plays the part of the suspension, while the anisotropy forces replace the force of gravity. If now an applied magnetic field tries to turn the spin axis from the equilibrium position, the spinning electron will evade the invitation of the magnetic field to align itself in its direction by a precession movement. In the absence of damping, the axis of the spin would continue indefinitely to move in a cone and would never settle, which would mean that we could not magnetize anything. Obviously, there must be some damping due to which the precessional movement dies out and the spin axis becomes aligned by the applied magnetic field. If the applied field is alternating, damping (and losses) will occur at each reversal and the losses associated with the precessional movement are believed to be identical with the "residual" losses. These losses can be expected to become particularly heavy when the frequency of the alternating magnetic field approaches the precession frequency. We have said that the precession frequency is given by the quotient M/J, where J is proportional to the force of gravity (weight of the pendulum). The force of gravity is the agency responsible for the equilibrium position of the pendulum, just as the anisotropy forces hold the atom and with it the spin axis in the "easy" direction. The larger the anisotropy the higher will be the precession frequency and accordingly the higher the frequency of the magnetizing force for which the residual losses will approach a maximum. At the same time a large anisotropy firmly binds the electron spin axis to the "easy" direction and for that reason the permeability becomes smaller. Hence, a large frequency range in which a particular grade of Ferroxcube is useful goes with a lower value of permeability and a low-frequency range with a higher value of permeability.

In Fig. 7 we have seen that for every Ferroxcube grade there is a frequency at which the imaginary permeability goes steeply up and the real permeability as steeply down. This behavior is in accordance with the picture of gyromagnetic resonance although theoretically we could have also expected a peak of the real permeability before it decreased. Somehow this peak is damped out and instead the permeability stays constant up to the resonance frequency.

One consequence of the idea of the spinning electron that obtrudes itself is this. Since angular mass momentum is inseparably coupled with magnetic moment in the spinning electron, it should be possible to magnetize a body by rapid mechanical rotation. This inference proved correct and this was the oldest gyromagnetic experiment whose results indicated that it is the electron spin and not the orbital motion that is responsible for the atomic moment.

Another series of gyromagnetic experiments is of more recent date and is centered on the resonance between the alternating magnetizing force and the precession movement of the spinning electron. We have seen before, that the immediate response of the spin to the applied field is a precession movement which implies a small magnetic vector rotating in a plane perpendicular to the axis of equilibrium. The axis of equilibrium will be different in different domains and so if we want to make the phenomenon observable, it is necessary to turn the whole body into one domain which is best achieved by magnetizing the body in any one direction to saturation. The spin axes will then be everywhere orientated in one direction which will be their direction of equilibrium. If we now apply a high-frequency alternating magnetizing field perpendicular to the direction of the saturating field, the result will be a magnetic vector rotating in a plane perpendicular to the direction of saturation, i.e. we shall have magnetization in a direction perpendicular to the magnetizing force as well as in the direction of the force itself. Instead of magnetizing the body to saturation, we can use a permanent magnet and wind around it two coils in which the planes of the turns are perpendicular to each other while both contain the direction of permanent magnetization. The coupling of the two coils in the ordinary sense is zero, but as far as the precessional magnetization is concerned, they are effectively coupled. This is one of the models of a "gyrator," which was invented by Professor Tellegen.

The Magnetization Process

So far we have been dealing with ferrite materials exposed to weak fields. The weak fields are the more important ones in communication engineering applications and in those fields the behavior of the material is best characterized by the initial permeability. We know that with iron the initial permeability is of the order of 200, but with increasing fields the permeability goes up and reaches values of the order of 5,000. How do the ferrites behave in this respect? The answer is that in some cases the permeability grows with increasing field strength, but then the higher permeability is frequency dependent (decreases with increasing frequency). In other cases the permeability is independent of frequency, but then it is also independent of the field strength. Whether the first or the second case is obtained depends on composition of the ferrite and on the sintering process by which it was produced. In Fig. 13 we have two sets of magnetization curves (B versus H), in both of which the ferrites have the same composition and differ only as far as their firing temperature is concerned. The curves in Fig. 13(a) refer to a ferrite that has been fired at 1,200 degrees C., those in Fig. 13(b) to the same ferrite but fired at 1,450 degrees C. In order to be able to interpret those differences of the magnetization curves, we shall recall a few features of the magnetization process of ferromagnetics.

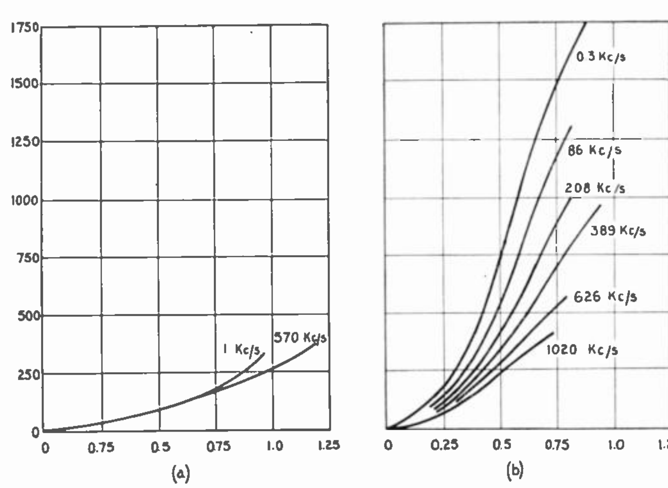


Fig. 13—*B-H* curves for various frequencies for a ferrite with (a) a low sintering temperature; and (b) a high sintering temperature.

We have dealt briefly already with the magnetization process of a single atom and have seen how the settling of the spin axis in a new direction is associated with a precession movement (and damping and losses). Yet we have to take into account the fact that magnetic matter is organized in domains in each of which all spins are orientated in the same direction. The domain directions are distributed in such a way that in absence of an external, magnetic field the over-all magnetization of the body in bulk is equal to zero. If we expose the body to a magnetic field two things can happen. Either all spins in all domains turn towards the direction of the magnetizing force, or the spin axes remain essentially as before but some domains grow at the expense of others. Of course the growing domains are those whose directions more or less coincide with the direction of the magnetizing field, while those domains whose directions oppose the magnetizing field are the victims. The first mode of magnetization is referred to as "rotational" while the second mode is denoted by the term "wall displacements" (meaning domain walls). Only in rotational processes can we observe gyromagnetic phenomena because in those processes all spins turn simultaneously. There are of course spin rotations during a wall displacement too but only comparatively few at a time and the effect is too small to be observed directly.

In iron, wall displacements prevail at low and medium fields while rotations occur at very strong fields. In ferrites, however, rotations prevail at low fields, but with stronger fields both wall displacements and rotations can occur. Before we discuss this aspect more closely, we had better become more acquainted with the notion of "domain wall."

Bloch Walls

The domain walls are usually referred to as Bloch walls, because Bloch was the first to point out that a domain wall contains a considerable amount of energy and he computed that energy. A domain wall is not simply a geometrical boundary between two domains with different spin orientations, it is rather a transition zone in which the spin direction changes gradually from one direction to the other as indicated in Fig. 14, which

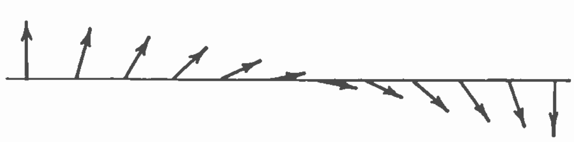


Fig. 14—The Bloch wall is a zone of transition from one spin direction to another.

depicts a 180-degree transition. Why has the transition to be a gradual one? An abrupt change of spin directions would make it necessary to overcome a tremendous resistance put up by the exchange forces. The exchange forces try to align all spins parallel and if two neighboring spins include an angle larger than zero that implies an accumulation of some exchange energy in the exchange field surrounding the two electrons. Why then domains at all, we may ask? We shall return to this question later, and for the time being we take the existence of domains for granted. Given now two neighboring domains with different spin directions, what shall be the thickness of the domain wall? The exchange forces will tend to make the wall as thick as possible, because the more gradual the transition, the smaller the total exchange energy accumulated in the wall. (The exchange energy goes up with the square of the angle between two neighboring spins.) Yet, there is another agency that tends to make the wall thin. The spin directions on both sides of the wall are directions of "easy" magnetization and an orientation along any intermediate direction requires more energy. The thicker the wall, the more energy has to be stored in it due to the "hard" directions, no matter whether the origin of the hardness is crystal anisotropy or internal stresses. There will then be a compromise between the two trends and the wall thickness will settle at a value that makes the sum of the two energies, one due to exchange forces, and the other due to anisotropy (crystalline or stress anisotropy) a minimum.

Let us now contemplate a wall displacement: a wall moves from position "1" to position "2." In position "2" the wall will require a different amount of energy from the one required at "1." Let us assume that the wall energy in position "2" is much larger than in position "1," then a large magnetic force is required to shift the wall from "1" to "2," and then a rotational process may be easier. If the energy at "2" is only a little larger than at "1," then wall displacement may be preferable. But if the energy at "2" is smaller than at "1," then the wall would have shifted spontaneously from "1" to "2" before we applied any magnetic force, and the displacement would have been irreversible. Let us formulate this result more precisely. The wall energy is a function of the position of the wall within the body. Although the exchange forces are everywhere the same, the anisotropy and internal stresses vary from point to point and accordingly the (virtual) wall thickness and wall energy vary too (that is thickness and energy of a wall *if* we would place it in a particular position). Let us now trace any (virtual) line along which we would like the wall to travel (the wall being always perpendicular to that line). As long as the wall energy goes up along this line, the wall displacement is reversible because on removing the external field, the wall will return to its initial position. As soon, however, as we reach an energy maximum, the wall will slide down the other side—irreversibly. We can shift the wall back not simply by removing the external field applied, but by applying a field of opposite direction and sufficient strength (coercive force). On the other hand, positions where the wall energy is a minimum will be positions of rest, and the deeper the minimum the more difficult it will be to dislodge the wall from that position.

It is now important to note that such a position of a deep minimum can be created by means other than minimum anisotropy. If we have in the body small nonmagnetic inclusions, such as tiny air bubbles (voids), the domain walls seem to favor those inclusions. They stretch preferably in such a way as to include as many as possible of those holes.[2] Now a sintered body like a ferrite is as a rule less dense than the density computed from the lattice constants (X-ray density) and contains therefore a number of small voids. Those voids are anchorage points for the Bloch walls and the walls are hard to dislodge. This seems to be the reason why in ferrites the magnetization process at low levels is mainly rotational. If we sinter the body at a higher temperature, we close the voids and wall displacements become possible. This creates then additional magnetization at higher levels in dense ferrites. But this additional permeability is frequency dependent, because irreversible wall movements require some time and cannot follow hf magnetizing fields. In a rotational process all spins turn simultaneously and this is a comparatively quick process. But in a wall displacement (particularly in an irreversible one) the spins turn one thin layer after another and that naturally takes longer. In a ferrite with voids the walls are firmly attached to the voids and only spin rotations are possible, which creates a frequency independent permeability (up to the point of gyromagnetic resonance).

Particle Size and Bloch Walls

We can now take up the question: Why domains at all? If the exchange forces tend to align all spins in one direction, what stops them from doing so? The answer is, that in this case not only small regions, but the whole body would be magnetized in bulk and there would be in the space surrounding the body a magnetic field and some amount of energy stored in that field. Yet nature arranges things in such a way as to commit the least amount of energy in a given closed system. If instead of a single domain we split the body in two domains with opposing magnetic vectors, the field energy in the space around the body would be roughly only half of what it was before. Splitting it in four domains would reduce the energy to $\frac{1}{4}$ and so on. Why then does not this splitting of the body into domains go on indefinitely? Because each new domain requires a new Bloch wall and the energy density within a wall is much larger than in the interior of a domain. Again, we shall make a compromise and settle at a number of domains, which makes the sum of the energies (field energy and surplus energy in a Bloch wall) a minimum. This argument makes it in principle possible to estimate the size of domains in the absence of a magnetizing field.

To begin with, we realize that if a particle is sufficiently small, the particle will not be able to afford a wall. The thickness of a Bloch wall does not depend on the particle size, of course, and if we choose, say, a sphere of a diameter about equal to the wall thickness, the total energy of the particle would be much larger with the wall than without. Let us now increase the size of the particle gradually and investigate at what diameter it would pay to insert a wall into the sphere. The field energy of the particle of diameter d and saturation magnetization I_s is proportional to the product $I_s^2 \cdot d^3$, while the wall energy is proportional to the product $\sigma \cdot d^2$, where σ stands for the surface energy density of the wall. Since the first product increases with the cube, the other with the square of d, there will be a value of d, for which the two energies will become comparable. It is easy to see that the critical diameter d_0 for which a Bloch wall becomes possible will be proportional to σ/I_s^2, or

$$d_0 = \text{const. } \sigma/I_s^2. \tag{28}$$

If the particle size is smaller than d_0, then no wall formation will be possible and any magnetization of the particle will have to be achieved by rotation. For Ferroxcubes that would not matter, because in Ferroxcubes the magnetization takes place mainly by rotations anyway. It is different with those materials like iron, where in low and medium fields the magnetization takes place by wall movements. In such materials wall movements would have to be replaced by rotations, if the particle diameter becomes smaller than d_0 and as a result the magnetization would become more difficult and the permeability lower. That is one reason why with iron dust cores we cannot decrease the particle size indefinitely. In fact, when we reach the size 150 Å (Angstrom units), the iron particle becomes magnetically hard and the idea of making permanent magnets of iron powders of particle sizes around 150 Å appears very attractive. That brings us to our second subject, namely: sintered hard magnetic materials. Recently, many experiments and even trial runs on a commercial scale were made to produce permanent iron powder magnets, but unfortunately the difficulties were too great. The difficulties are to avoid oxidization during and after manufacture and to obtain some degree of mechanical strength. It appears that further experiments on this line have been abandoned (for the time being, at least). However, if we take oxides instead of metals there is no danger of oxidization and we can use sintering methods to achieve mechanical strength. It is true, any nonmetallic material will have a smaller saturation I_s, but this very fact makes the critical diameter d_0, according to (28), consequently larger and the pulverization process easier.

Ferroxdure

The new hard magnetic material that has been developed in the Philips Eindhoven Laboratories and is being marketed under the brand "Magnadur" is based on the mineral magnetoplumbite of the composition $Pb \cdot 6Fe_2O_3$. This mineral in its natural condition is

[2] A simple explanation was offered by M. Kersten, who said that a nonmagnetic hole does not require any magnetic energy. This view has been seriously criticized by L. Neél on the ground that holes mean poles, but his theory is too involved to be discussed here.

weakly magnetic, but it can be made magnetically hard, if prepared by sintering in such a way as to consist of small grains. Lead can be replaced by barium, strontium, or calcium and the material now on the market is the barium compound $BaFe_{12}O_{19}$. This compound has a hexagonal crystal structure with one axis of easy magnetization (parallel to the hexagonal axis). The properties of the material are not sensitive to impurities or exact ratios of the constituents, but they are dependent on the sintering temperature and time.

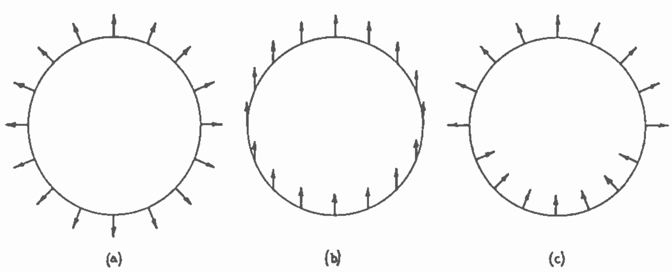


Fig. 15—Distribution of domain vectors for (a) zero magnetization, (b) saturation magnetization, (c) remanent magnetization.

The saturation magnetization of Magnadur is low (due to antiferromagnetism of the magnetoplumbite structure); it is only 4,200 gauss (as compared with 14,000 gauss for Ticonal G). The coercive force however is very high. Let us see how this high coercive force comes about. Let us assume that the grains are small enough (i.e. of the order of 1 micron) to form single domains, without walls. In the demagnetized condition the domain vectors, of which every one occupies an easy direction, are distributed at random so that the over-all vector sum is zero (Fig. 15(a)). After we have magnetized the body to saturation, all the vectors point in one direction, as indicated in Fig. 15(b). If we now remove the magnetizing field, the magnetic vectors will return each to its nearest, but not necessarily the original, easy direction (Fig. 15(c)). Half of the vectors will occupy their original positions (and arrows), the other half will be reversed by 180°. As a result there will be a remanent magnetization, about half of the saturation magnetization, i.e. about 2,000 gauss. Now let us try to demagnetize the body. In order to do so we shall apply a field in reverse and try to turn the vectors from their easy directions. The larger the anisotropy constant, the larger will be the force required to turn some of the vectors away from their easy directions so that the vector sum be again zero. That force is for Magnadur within the range 2,000–3,200 oersteds (coercive force $({}_IH_c)$. The coercive force ${}_IH_c$ meant here is the force required to reduce the magnetization of the body to zero, while usually by coercive force is meant the force required to reduce the induction B to zero $({}_BH_c)$. Since

$$B = H + 4\pi I$$

it is seen that ${}_IH_c$ is always larger than ${}_BH_c$. Let us take the extreme case where the magnet is not only permanent but eternal, that is, no finite force would be able to destroy its magnetization I_r. In that case ${}_IH_c$ would be infinite, but ${}_BH_c$ would be equal to $4\pi I_r$.

Owing to the high coercive force and low remanent induction, the Magnadur magnets have to be disc shaped, which, however, for many circuits, like loudspeaker circuits, is not a disadvantage.

A peculiarity of Magnadur is the strange fact that its coercive force rises with the temperature. At 250 degrees C. its value is 50 per cent higher than at room temperature, and it is permissible to heat the magnet up to 400 degrees C. without destroying in the least its permanent magnetization. After cooling down, the magnet shows again the same remanent magnetization as before.

The nonmetallic character and high resistivity makes the material suitable for hf applications. We shall mention only one such application, i.e. for adjusting the temperature coefficient of the permeability of Ferroxcubes. We remember that this temperature coefficient is positive and in some cases it may be important either to make the permeability strictly temperature-independent or even to have that temperature coefficient negative instead of positive. This can be done by a dc premagnetization (polarization) of the Ferroxcube. We know that the saturation magnetization of Ferroxcube decreases with rising temperature, hence the magnetization curves for two temperatures T_1, T_2 (where $T_2 > T_1$) look like those depicted in Fig. 16. The initial perme-

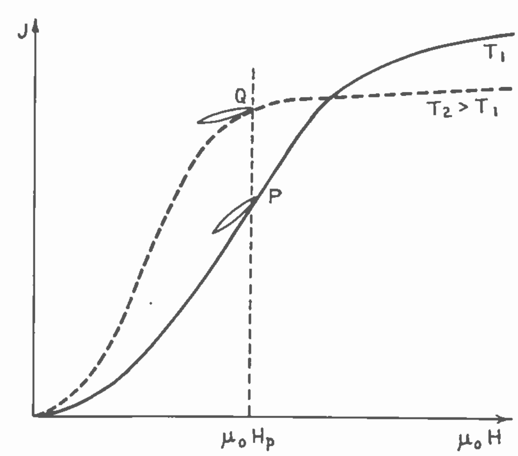


Fig. 16—The solid curve depicts the I-H relation for the temperature T_1, the dotted one for the higher temperature T_2. The initial slope is higher for T_2 than for T_1, but the slope of the minor loop at Q is lower than the slope of the minor loop at P.

ability at T_2 is lower than the one at T_1 (see slope of the two curves at the origin) but with a polarizing H_p the slope of the minor loop at Q is smaller than the slope of the loop at P. The polarizing force H_p can be chosen so as to exactly compensate the positive temperature coefficient.

Behavior of Germanium-Junction Transistors at Elevated Temperatures and Power-Transistor Design*

L. D. ARMSTRONG†, MEMBER, IRE, AND D. A. JENNY†, ASSOCIATE, IRE

Summary—**This paper discusses the limitations of germanium-junction transistors at elevated operating temperatures. The limiting factors are a consequence of increased thermal hole-electron pair generation at higher temperatures. This causes an increase in collector "leakage" current, which affects the base current. Thus, due to the base-lead resistance, the emitter to base-bias conditions are changed.**

The problems associated with power transistors are discussed, including cooling of the unit, current and voltage limitations, and reduction in base-lead resistance. It is pointed out that, in addition to bias changes, base lead resistance also causes a power loss which becomes important at the high currents used in power units.

Examples of liquid convection cooled and metallic conduction cooled *n-p-n* and *p-n-p* power transistors are described. Satisfactory "alpha" values are maintained to collector currents of over one hundred milliamperes. In class A operation power gains exceeding 30 db and efficiencies close to the theoretical limit of 50 per cent are obtained at 1 watt dissipation levels.

Introduction

THE DESIGN of alloy-junction transistors for applications at increased power levels involves the effects of increased operating temperature and attempts to minimize this temperature increase. Power transistors must also be capable of handling large currents while such operating parameters as the current gain should be relatively constant over the operating range. Other power applications make it desirable that the transistor operate at a relatively high voltage. These and other aspects will be considered in connection with the design of alloy-junction transistors of both *n-p-n* and *p-n-p* types, capable of about one-watt dissipation.

Temperature Effects

It is well known that transistors made from germanium cannot be used in applications involving an excessive operating temperature, either ambient or due to internal heat generation. This is an inherent property of germanium, as of all semi-conductors, due to the creation of hole-electron pairs by thermal energy. Power transistors are in the class of heat-generating devices and one of the chief limitations in their design is due to temperature effects. For optimum performance it is thus essential to know how transistor properties are affected by temperature increases, and what modifications can be introduced into the design and fabrication to minimize the changes.

Initial experiments on low-power, alloy-junction *n-p-n*[1] and *p-n-p*[2] transistors showed these units would operate, at least for short intervals, with satisfactory power gain and current gain at temperatures up to approximately 110 degrees C., but that changes in characteristics become more and more evident as the temperature rose. The most obvious and also the most important of these is the increased reverse or back current to the collector due to the increased thermal generation of carriers at higher temperatures.

Consider the structure of an alloy-junction transistor (Fig. 1). It consists of a slab of germanium, with two alloyed junctions on opposite sides, and a base connection to the germanium at a region somewhat remote from the junctions. $r_{bb'}$ is the resistance of the germanium between the base connection and the junction region and is a few hundred ohms in typical low-power transistors.[3] It decreases somewhat as the operating temperature increases, due to the decrease in the resistivity of the germanium. However, this change is not large enough to modify the present discussion.

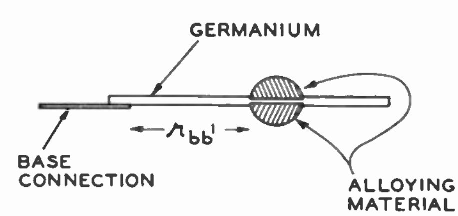


Fig. 1—Sectional view of an alloyed-junction transistor.

That part of the collector current which does not come from the emitter must come from the base. A major part of this current at high temperatures is the reverse current due to thermal generation. This current to the base passes through $r_{bb'}$ and causes a voltage drop which obviously will appear across the emitter and affect the emitter current. This voltage is in the direction to increase emitter current. If the transistor is hot because of heat generated within it, the effect may be such as to cause it to "run away" and destroy itself.[4] The effect is analogous to grid-emission in electron tubes

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† RCA Laboratories Div., RCA, Princeton, N. J.

[1] D. A. Jenny, "A germanium *n-p-n* alloy-junction transistor," Proc. I.R.E., vol. 41, pp. 1728–1734; December, 1953.

[2] R. R. Law, C. W. Mueller, J. I. Pankove, and L. D. Armstrong, "A developmental *p-n-p* junction transistor," Proc. I.R.E., vol. 40, p. 1352–1357; November, 1952.

[3] L. J. Giacoletto, "Equipments for measuring junction transistor admittance parameters for a wide range of frequencies," *RCA Review*, vol. 14, no. 2, p. 269; 1953.

[4] R. F. Shea, "Transistor operation: stabilization of operating points," Proc. I.R.E., vol. 40, pp. 1435–1437; November, 1952.

except that, in the transistor case, part of the dc resistance is inherent in the unit. The reverse currents due to thermal generation at an internal temperature of 100 degrees C. were larger in *n-p-n* units than in the corresponding *p-n-p* transistors. The dc current added to the collector circuit by thermal generation is not serious in most power applications, where it will be small in comparison with the average current being used. However, the effect on the emitter-base control bias points out the necessity of maintaining the transistor element at a temperature below 100 degrees C., unless special circuit arrangements are made.

The base-lead resistance $r_{bb'}$ also influences the operation of power transistors in another way. The transistor output is proportional only to that portion of the input voltage that is developed across the internal elements of the unit. In other words, $r_{bb'}$ acts like an attenuator, and a higher driving power must be impressed at the input of the transistor for a given output. This is equivalent to a reduction in power gain.

Design of Power Transistors

The base-lead resistance may be decreased by increasing the thickness of the wafer, decreasing the resistivity of the germanium, and by plating the germanium wafer with a low resistivity metallic layer, thus bypassing some of the wafer resistance. The germanium thickness is, however, controlled by the amount of alloying penetration that may be obtained under practical conditions. Reducing the germanium resistivity is limited by factors which result in an increasing percentage of poor junctions. In addition, the maximum collector voltage decreases rapidly with decreasing germanium resistivity and current-gain values become generally lower. Plating can reduce $r_{bb'}$ by a factor of 2. In the design of practical transistors all factors are combined for most effective reduction of the base-lead resistance under given operating conditions. Typical values of $r_{bb'}$ range from 15 to 250 ohms for the power transistors we are discussing.

Another aspect of power-transistor design that must be considered is the current and voltage limitations of the units. The collector-to-emitter current-gain factor, α_{ce}, or the related collector-to-base current-gain factor, α_{cb}, decreases at large emitter-current densities. If transistors are to be operated as large-signal devices, it is desirable that variations in current-gain factor be reduced to a minimum over the entire range of currents to be used. This necessitates the use of large enough junctions to reduce the current density.

In the case of early general-purpose, low-power alloy-junction transistors, the α fall-off with increasing emitter current was less for *n-p-n* than *p-n-p* type units for the same junction areas. In the practical units described herein a combination of a larger emitter area for the power *p-n-p* transistor and appropriate processing gave equivalent and satisfactory α fall-off characteristics for the two types.

The voltage that may be applied to the collector depends upon the resistivity of the germanium, the firing schedules, and the type of unit. The *p-n-p* alloy units withstand higher voltages than *n-p-n* alloy units made from similar resistivity germanium, and the maximum voltage increases with the resistivity of the base germanium. However, the aforementioned base-lead resistance $r_{bb'}$ also increases with germanium resistivity. A proper balance must therefore be sought, based on the desired operation characteristics.

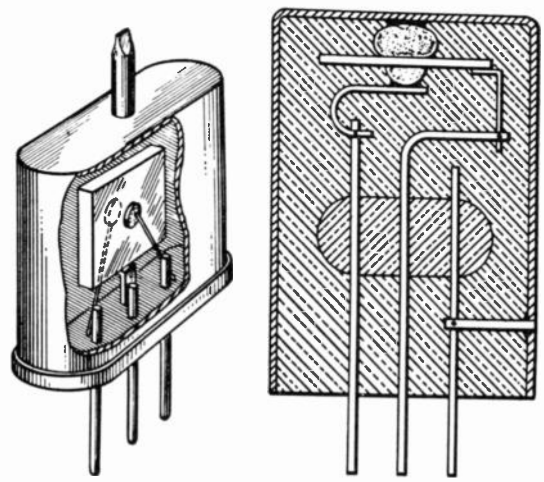

Fig. 2—Assembly details of liquid-cooled (left) and metallic-conduction-cooled (right) power transistors.

Methods of Cooling

The effects of increased operating temperature on transistors emphasize the need for cooling the elements if higher power dissipation is to be obtained. Experience indicates that the temperature of the transistor wafer should in general not exceed about 80 degrees C. In the present work the heat dissipation of transistors has been increased by immersion in a cooling liquid, soldering a cooling fin to the wafer, and by soldering a cooling fin to the collector contact. A liquid-cooled unit and one using a cylindrical cooling surface attached to the collector are shown in Fig. 2. In the liquid-cooled unit the basic transistor unit is immersed in a cooling liquid contained in a metal shell. The heat generated in the transistor is transferred to the metal shell by liquid convection, and from the shell by air convection. The requirements for the liquid coolant are: (*a*) low viscosity to allow rapid circulation, (*b*) high heat capacity for efficient heat transfer, (*c*) boiling point well above the operating temperature, and (*d*) excellent electrical insulation properties, since the liquid is in direct contact with the junction surfaces. Benzene, toluene, and xylene are suitable coolants. Toluene has proved the most successful because of its low viscosity and relatively high boiling point. Although the liquid-cooled version is not rugged mechanically and, in addition, uses an inflammable liquid, the junctions suffer little deterioration during mounting. Consequently this type of mounting has been used for power units with very low collector reverse-saturation-current requirements.

The other cooling methods, which use a metallic conduction path to transfer the heat, are rugged and contain no inflammable liquid. Since most of the heat is generated at the collector junction, it is advantageous to attach the cooling metal to the collector directly. A successful version, shown in Fig. 2, consists of a copper cup to the inside of which the transistor is attached by a solder, which is initially a liquid, between the collector and the bottom of the cup. The liquid solder, a saturated solution of indium in mercury, forms a good electrical and thermal contact between the collector and metal cup. The cup is then filled with a molding resin to mechanically protect the unit. In subsequent operation of the device at a higher operating temperature, enough of the impurity material is dissolved in the liquid solder to finally form a solid metallic bond. When operated at 1-watt dissipation the envelope temperature in both types described was about 50 degrees C. above ambient, and the junction temperatures 10 to 15 degrees C. above that of the envelope.

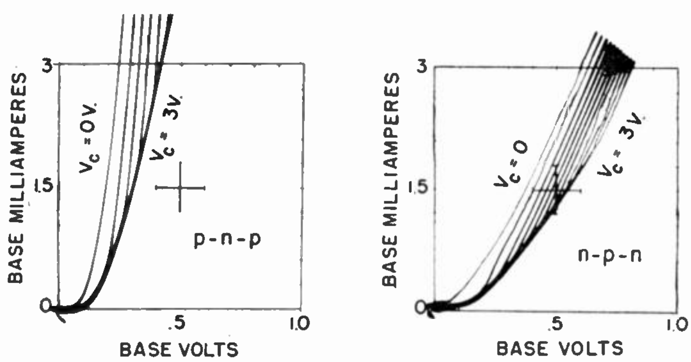

Fig. 3—Input characteristics for $V_C=0$ to $V_C=3$ volts in ten equal steps.

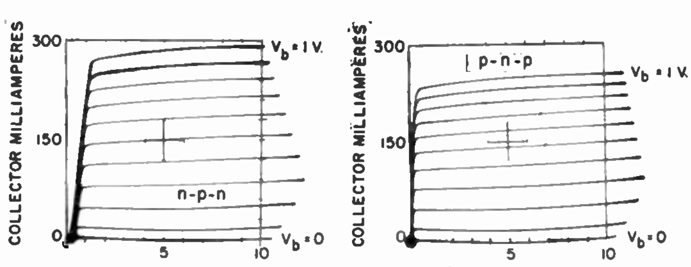

Fig. 4—Output characteristics for $V_B=0$ to $V_B=1$ volt in ten equal steps.

Electrical Characteristics

These laboratory-type power transistors can operate at about 1-watt dissipation. Experimentally, they have been operated at 3 watts with additional forced-air or water cooling. It is felt that the present limit is due chiefly to the limited cooling area. From a purely dissipation point of view, it is irrelevant whether high voltage and low current are used, or vice versa. However, junction transistors, in contrast to electron tubes, are able to operate unusually well at low voltages and low output impedances, so that one ordinarily uses relatively high currents.

The performance of a transistor may be evaluated with the help of static characteristics, to which different load lines and bias conditions may be applied. Two of the important static characteristics are shown in Figs. 3 and 4 inclusive, in each of which an *n-p-n* and a *p-n-p* type are represented. Since the laboratory experiments did not extend to substantial numbers of transistors of any one design, the curves are representative but do not convey specific information on standardized models. Fig. 5 shows the type of variation in the current gain factor, α_{ce}, as a function of emitter current for both *n-p-n* and *p-n-p* power transistors. It should be noted that emitter areas were about twice as great for the *p-n-p* as for the *n-p-n* units used in this test.

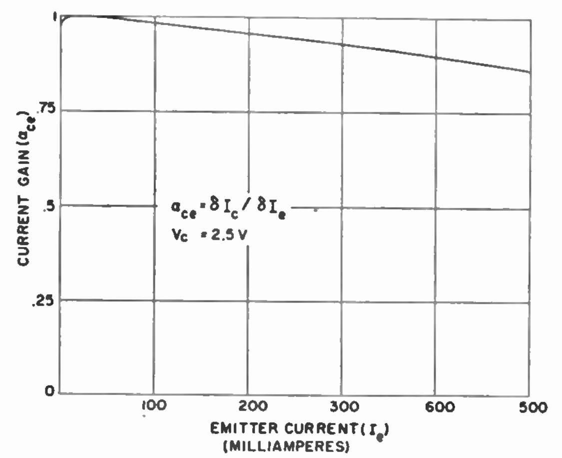

Fig. 5—Current gain α_{ce} as a function of emitter current for *n-p-n* or *p-n-p* power transistors.

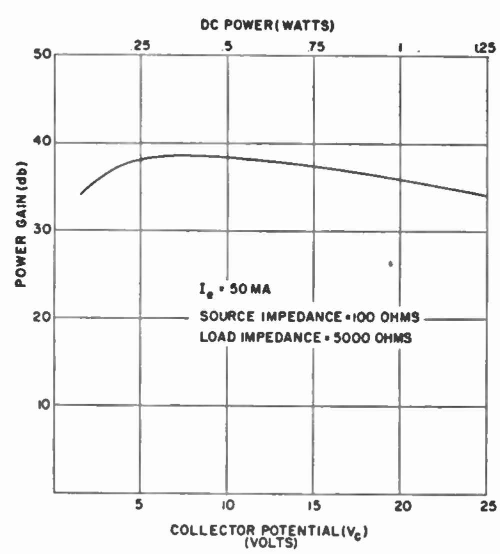

Fig. 6—Power gain as a function of collector voltage with constant emitter current for *n-p-n* or *p-n-p* power transistors.

Small-signal power-gain curves were taken with nearly matched impedances, as a function of power dissipation, with varying emitter current and collector potential, and are shown in Figs. 6 and 7. There was little difference between the two types in these respects. The base-input common-emitter circuit was used.

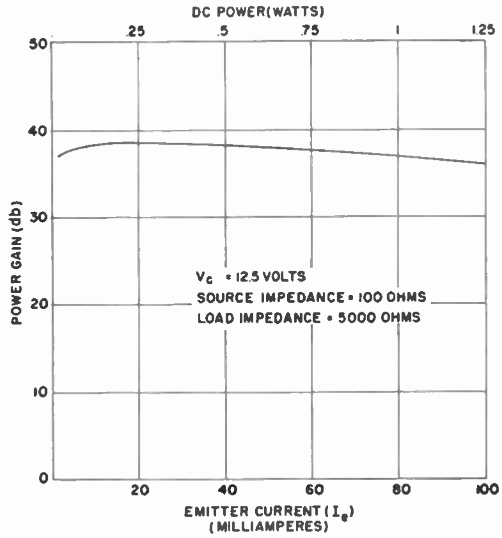

Fig. 7—Power gain as a function of emitter current with constant collector voltage for *n-p-n* or *p-n-p* power transistors.

Of greater interest for power units is the behavior as a class A audio-amplifier working into loads suitable for giving reasonable audio outputs. With the common-emitter connection, constant-current dc emitter supply and about 1 watt dc input to the collector, the data of Table I are presented as indicative of the performance obtained. In each case the input was increased to the point of 10 per cent distortion, which, as may be noted, sometimes allowed apparent efficiencies of over 50 per cent to be obtained.

TABLE I

Type of Unit	Collector Potential	Collector Current	Load Resistance	Signal Input	Signal Output	Power Gain	Efficiency
	(volts)	(ma)	(ohms)	(mw)	(mw)	(db)	(per cent)
p-n-p	7.2	130	100	0.94	340	26	36
p-n-p	17	65	400	0.30	430	32	39
p-n-p	28	35	800	0.37	560	32	56
n-p-n	10.5	100	100	0.45	480	30	46
n-p-n	22	40	400	0.20	420	35	48

Radio Communication by Scattering from Meteoric Ionization*

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Summary—**By a consideration of the amplitude and duration of echoes forward-scattered from individual meteor ionization trails, and of the probability of detecting randomly oriented trails over an oblique radio propagation path, an estimate of the contribution of meteoric ionization to extended range hf and vhf radio transmission has been obtained. It has been concluded that meteoric ionization alone would give a virtually continuous signal for a transmission path of about 1,000 km at frequencies near 15 mc. For the very high frequencies, scattering from meteor trails has been found to be at least an important contributing factor to the propagation of a signal over an oblique path. A precise evaluation of the role of this process must await a better determination of the number of trails as a function of their ionization density.**

Introduction

IN RECENT YEARS, the attention of propagation specialists has been increasingly directed to the study of ionospheric irregularities. At frequencies too high for normal layer reflection, scattering from these irregularities may be responsible for weak but useful signals received over path lengths of the order of 500 to 2,000 km. Meteoric ionization is an especially important source of nonuniformity in the lower *E*-region. Turbulent wind motion is also believed to be responsible for temporal and spatial variations in the average electron density. At very high frequencies, weak signals have been reported whose origin has been attributed to scattering from such turbulent sources.[1] At frequencies near 15 mc it has been suggested that forward scattering from meteoric ionization may be the primary mechanism of propagation in the absence of layer-type reflections.[2]

The goal of the present work is to make a theoretical estimate of the median signal strength that meteoric transmission will support under given conditions, and to evaluate the reliability of the signals. Such an estimate must be based upon knowledge of the number of meteoric reflections which contribute to the received signal at any given time, and of the amplitude and duration of the individual echoes. First, the effect of obliquity upon echo amplitudes and durations will be discussed. The fraction of the total number of trails oriented to produce echoes will then be found, assuming that the orientations of the meteor trails are random. From these estimates of the rate of occurrence of echoes and their amplitudes and durations, the properties of the signals propagated by scattering from meteoric ionization will be derived.

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† Radio Propagation Lab., Stanford Univ., Stanford, Calif.

[1] D. K. Bailey, R. Bateman, L. V. Berkner, H. G. Booker, G. F. Montgomery, E. M. Purcell, W. W. Salisbury, and J. B. Wiesner, "A new kind of radio propagation at very high frequencies observable over long distances," *Phys. Rev.*, vol. 86, pp. 141–145; April 15, 1952.

[2] O. G. Villard, Jr., A. M. Peterson, L. A. Manning, and V. R. Eshleman, "Extended-range radio transmission by oblique reflection from meteoric ionization" *Jour. Geophys. Res.*, vol. 58, pp. 83–93; March, 1953.

The Effect of Obliquity upon Echo Amplitude and Duration

When radio reflections are obtained from meteor trails, with the transmitter and receiver well separated, the amplitudes and durations of the echoes will be markedly affected by the obliquity of the path. In general, the voltage amplitude of an echo can be augmented with respect to that which would have been observed for back scatter by as much as sec ϕ, where 2ϕ is the interior angle formed by the rays from the transmitter and receiver to the meteor trail. The increased echo amplitude over an oblique path is a result of the lengthening of the principal Fresnel zone,[3] and depends on the orientation of the trail with respect to the transmitter-receiver base line.

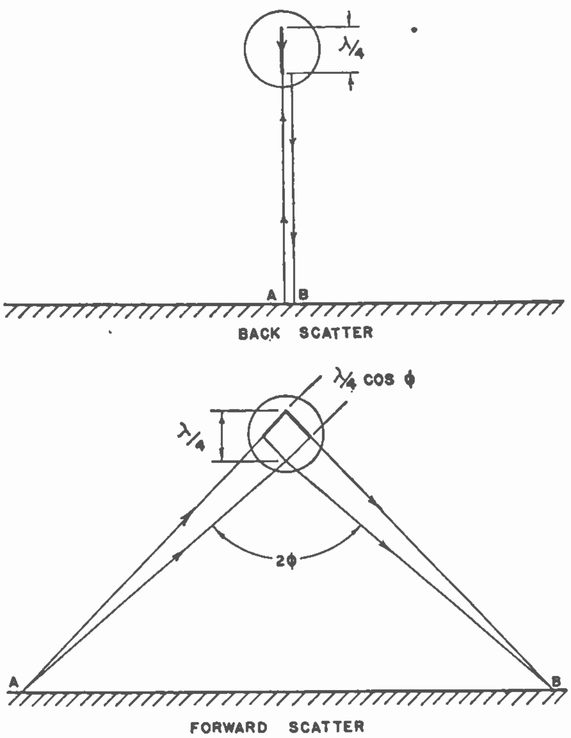

Fig. 1—The effect of geometry upon echo duration. Note that the effective diameter of the trail is reduced by cos ϕ for forward scatter.

Oblique geometry has an even greater effect upon echo duration than it does upon the amplitudes of the signals. Meteoric echoes are now known to decay in amplitude, not because of a reduction in the total ionization content in a unit length of the trail, but rather because of phase interference effects resulting from diffusive expansion. For the back-scattering case, contributions of scattered signal combine in opposite phase at the receiver when the respective scattering centers across the trail are separated by a quarter wavelength. As the trail expands to this diameter, the received signal quickly decreases in strength. For oblique reflection, however, the same scattering centers in the trail lead to a phase-path difference only cos ϕ times as great as for back scatter, as indicated in Fig. 1. The effect of obliquity upon the rate of decrease of echo strength is the same as if a wavelength of λ sec ϕ were in use at back scatter. It has been found experimentally that meteor-echo durations are proportional to wavelength squared. Consequently, oblique reflections may be expected to have durations proportional to $\sec^2 \phi$.

To get an equation for the signal strength forward-scattered from meteor trails, it is necessary to know something of the mechanisms of trail formation, and of scattering by the trail. On the basis of back-scatter results, it is believed that the trail is formed by diffusive expansion from a near line source. Thus, the radial distribution of electron density about the trail axis is Gaussian. Both back[4,5,6] and forward[7] scattering from such a trail have been analyzed theoretically. In MKS units, the power received by forward scattering from such a column is[8]

$$\frac{P_R}{P_T} = \frac{1}{32\pi^4}\left(\frac{\mu_0 e^2}{4m}\right)^2 \frac{2\lambda^3}{R_1 R_2(R_1 + R_2)} \frac{G_R G_T q^2 \sin^2 \alpha}{1 - \cos^2 \beta \sin^2 \phi} \cdot \exp\left(-32\pi^2 dt/\lambda^2 \sec^2 \phi\right), \quad (1)$$

where:

P_R, P_T = received and transmitted powers

$(\mu_0 e^2/4m) = 0.8852 \times 10^{-14}$ meters, where μ_0 is the permeability of free space, and e and m are the electronic charge and mass

λ = wavelength

R_1, R_2 = ranges of the meteor trail from the transmitter and receiver

G_R, G_T = receiving and transmitting antenna-power gains over an isotropic radiator, in the direction of the meteor trail

q = line density of electrons; i.e., the total number of electrons per meter of trail length

α = angle between the electric vector of the incident wave and the line R_2

2ϕ = interior angle between R_1 and R_2; i.e., the forward-scattering angle

β = angle between the axis of the column and the plane containing the transmitter, the receiver, and the center of the principal Fresnel zone

[3] In the oblique geometry of forward scattering, the center of the principal Fresnel zone is the point of tangency of the meteor-trail axis with a prolate spheroid having the transmitting and receiving locations as foci. The length of the principal Fresnel zone is that portion of the trail axis contained within a confocal prolate spheroid of major semi-axis one-quarter wavelength greater than that of the tangent spheroid.

[4] A. C. B. Lovell and J. A. Clegg, "Characteristics of radio echoes from meteor trails: I.," *Proc. Phys. Soc. A.*, vol. 60, pp. 491–498; 1948.

[5] J. Feinstein, "The interpretation of radar echoes from meteor trails," *Jour. Geophys. Res.*, vol. 56, pp. 37–51; 1951.

[6] N. Herlofson, "Plasma resonance in ionospheric irregularities," *Arkiv För Fysik*, vol. 3, pp. 247–297; 1951.

[7] V. R. Eshleman, "The Mechanism of Radio Reflections from Meteoric Ionization," Technical Report No. 49, Electronics Research Lab., Stanford Univ., Stanford, Calif.; July, 1952.

[8] Equation (1) differs by a factor of 2 from Eshleman's equation (99), which is in error.

d = diffusion coefficient (approximately $3m^2$/sec.)
t = time measured from the instant of formation of the principal Fresnel zone.

A discussion of the assumptions used in deriving (1) is given by Eshleman.[7] It is concluded that (1) is good if the trail is oriented to present a principal Fresnel zone, and if the line density of electrons q is less than about 10^{14} electrons per meter. It now appears that this value of line density corresponds to the charge due to a faint visual meteor (about +6 visual magnitude).[7,9,10] With good radio equipment, the rate of detection of meteor echoes is several powers of ten greater than the visual rate. For this reason, the theory which follows will be concerned only with those meteors with $q < 10^{14}$. The results given for the contribution of meteoric ionization to extended-range propagation will therefore be too small to the extent that they do not include the infrequent but long-duration echoes from the larger meteors.

The effects of obliquity just discussed in general terms are also apparent from (1) for scattering from the Gaussian trail model. In addition to its variation with R_1 and R_2, the maximum received voltage *amplitude* is proportional to sec ϕ when the trail is in a plane containing the transmitter-receiver base line; it does not depend on the forward-scattering angle when the trail is in a plane perpendicular to the base line. The echo *duration* t_F to 37 per cent of the initial voltage amplitude is given by

$$t_F = \frac{\lambda^2 \sec^2 \phi}{16\pi^2 d}. \qquad (2)$$

Measurements of the average durations of meteoric echoes for various path lengths[2] do show an increase with transmitter-receiver separation, but for reasons of geometry it is not feasible to make an exact check on individual echoes. The observed wavelength versus duration dependence for back scatter provides the strongest reason for believing in the magnitude of this effect.

The Probability Density of Detection

Assume first that a meteor trail produces an echo when at least half of the principal Fresnel zone is ionized, and does not produce an echo if less than half of this zone is filled. This requirement is an extension to oblique reflection of Pierce's suggestion that a meteor trail gives a strong reflection only when the incident and reflected rays meet the trail axis at right angles.[11] Pierce also looked into the probability of detecting sporadic meteors at back scatter. Manning[12] modified and extended Pierce's results to obtain expressions for the probability of detecting shower meteors as well. A method different from that employed by Pierce and by Manning will be used here to find the probability of detecting sporadic meteors in the oblique geometry of forward scattering.

Assume, second, that all meteor trails have the same length L, and that the midpoints of these trails occur at the same height h above the surface of the earth. The plane containing the midpoints of the trails will be called the h-plane. The trail length co-ordinate is z, with $z=0$ at the trail midpoint. While both L and h are not truly constants due to the variable size, speed, and direction of the incident meteoric praticles, the use of their mean values should cause little error in the theory because of the statistical nature of the problem.

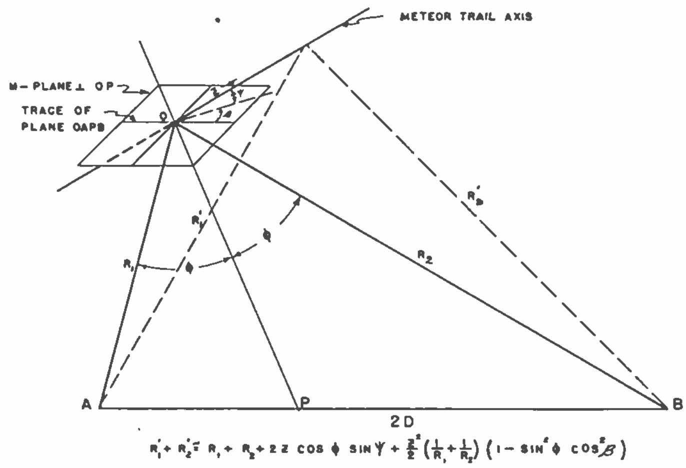

Fig. 2—Co-ordinates used in determining the location of the principal Fresnel zone of a meteor trail. The transmitter and receiver are at A and B.

Now define the probability density of detection p as the fraction of those trails that pierce a differential area of the h-plane, which are oriented to produce a reflection. Thus, given a distribution of meteor radiants, finding p is a purely geometrical problem. Referring to Fig. 2, let ψ be the angle between the z-axis and the plane (M-plane) which is perpendicular at $z=0$ to the bisector of the forward-scattering angle. The center of the principal Fresnel zone occurs at that value of z for which the total radio-path length between A and B is a minimum. It can be shown that the center of this zone lies within $z = \pm L/2$ if ψ is less than ψ_m, where

$$\psi_m = \frac{L(R_1 + R_2)}{4R_1R_2 \cos \phi}(1 - \sin^2 \phi \cos^2 \beta), \qquad (3)$$

and it is assumed that $L \ll R_1$ and R_2.

All trails which pass through a general differential area in the h-plane are normal to the surface of a unit hemisphere centered at the differential area, as pictured in Fig. 3. The intersection of the M-plane with the hemisphere makes a great semicircle which is the center of a narrow band on the surface of the hemisphere; the trails under consideration must pass through this band, of width $2\psi_m$, for an echo to result. Assuming that the oc-

[9] J. S. Greenhow and G. S. Hawkins, "Ionizing and luminous efficiencies of meteors," *Nature*, vol. 170, pp. 355–357; August 30, 1952.
[10] V. R. Eshleman, "The effect of radar wavelength on meteor echo rate," Trans. I.R.E., P.G.A.P., vol. AP1, pp. 37–42; October, 1953.
[11] J. A. Pierce, "Abnormal ionization in the E-region of the ionosphere," Proc. I.R.E., vol. 26, pp. 892–902; July, 1938.
[12] L. A. Manning, "The theory of the radio detection of meteors," *Jour. Appl. Phys.*, vol. 19, pp. 689–699; August, 1948.

currence of all sporadic meteor radiants is equally probable, the flux density of meteor trails through the differential area in the h-plane varies as $\cos \zeta$, where ζ is the zenith angle of the meteor radiant. Thus,

$$p = \frac{\iint_{\text{band}} \cos \zeta dA}{\iint_{\text{hemisphere}} \cos \zeta dA}. \quad (4)$$

From (4), the evaluation of p is straightforward, though involved. In elliptic co-ordinates, where $\xi = (R_1+R_2)/2D$, $\eta = (R_1 - R_2)/2D$, and $2D$ is the straight-line distance between A and B,

$$p = \frac{2L}{3\pi D} \frac{[3(\xi^2 - \eta^2) - (1 - \eta^2)][(\xi^2 - 1)(\xi^2 - \eta^2) - \xi^2 h^2/D^2] - \eta^2(\xi^2 - 1)h^2/D^2}{(\xi^2 - \eta^2)^2(\xi^2 - 1)[(\xi^2 - 1)(\xi^2 - \eta^2) - \xi^2 h^2/D^2]^{1/2}}. \quad (5)$$

the point $x = 500$ km, $y = 0$. (The orientation of the x and y axes in the h-plane is shown in Fig. 3.) There is a ridge of high-probability density forming roughly an ellipse of major semi-axis slightly greater than D and minor semi-axis equal to h. There is an elliptical "hole" over the midpoint of the path where very few meteor trails are oriented to produce echoes.

For back scatter, $D = 0$ and (5) reduces to

$$(p)_{D=0} = \frac{2Lr}{\pi R^2}, \quad (6)$$

where r is the polar co-ordinate in the h-plane, and R is the slant range to the meteor so that $R^2 = h^2 + r^2$.

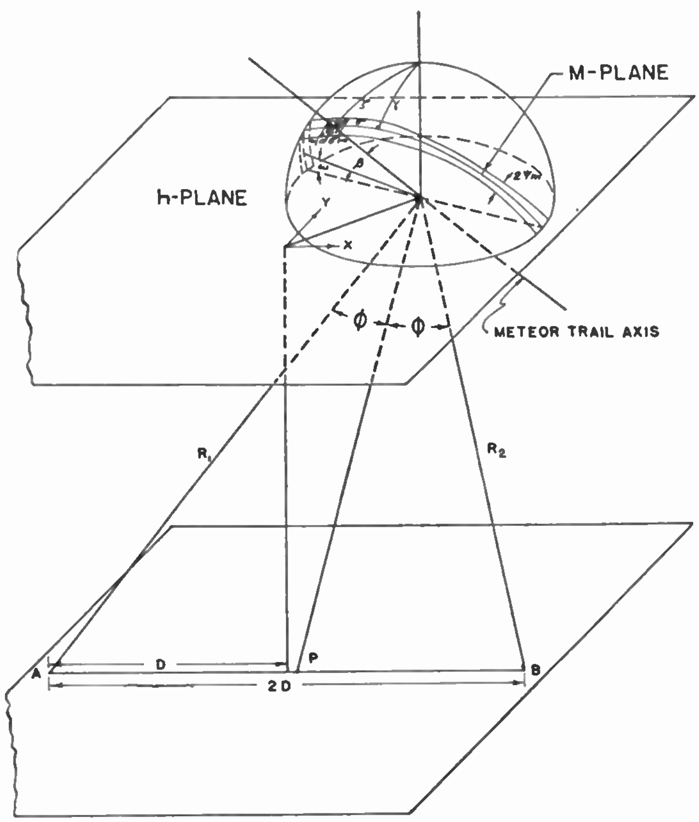

Fig. 3—Geometry for determining the probability of detecting a meteor falling in a given element of the h-plane.

A contour map showing the values assumed by p in the h-plane is presented in Fig. 4 with $L = 25$ km, $h = 100$ km, and $2D = 1{,}000$ km. This value of h corresponds roughly to the known mean height of meteor trails, and the value of $2D$ represents an interesting oblique communications path. The assumed value of L is from the radio determination of meteor trail lengths made by Manning, Villard, and Peterson.[13] The map is for one quadrant of the h-plane, and B (or A) is directly below

[13] L. A. Manning, O. G. Villard, Jr., and A. M. Peterson, "The length of ionized meteor trails," *Trans. A.G.U.*, vol. 34, pp. 16–21; February, 1953.

Standard Echo Units

From (5) and Fig. 4, it is seen that the number of trails detected per unit time and area in the h-plane is a function of the position of the area relative to the transmitter and receiver. It was also shown by (1) and (2) that the amplitudes and durations of the echoes are functions of trail orientation. These three quantities, echo amplitude, duration, and number of echoes, are the important parameters controlling the total effect of scattering from meteoric ionization. For a particular test path, one could find these quantities as a function of h-plane co-ordinates and plot contour maps of their magnitudes, as has already been done for p. Then, using the transmitter and receiver system parameters, the characteristics of the meteor-propagated signal could be computed. However, to reduce the number of contour maps required for each test path, the artifice of "standard echo units" will be introduced.

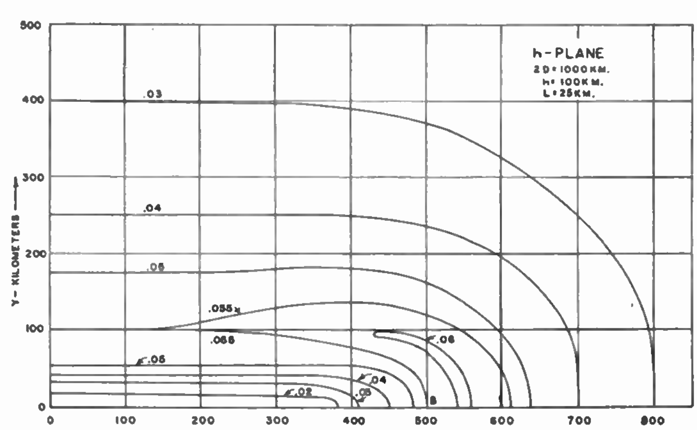

Fig. 4—The probability of detecting randomly-oriented meteor trails, as a function of position in the h-plane. Only one quadrant is plotted.

A "standard echo unit" is an artificial echo of standard size. Real echoes will be treated as being equivalent to a number of standard echoes. The amplitudes P_s and durations t_s of the standard echo units will be taken as the values that would be obtained from the actual trails if they were viewed at back-scatter at range D. Thus,

$$P_s = \frac{P_T}{32\pi^4}\left(\frac{\mu_0 e^2}{4m}\right)^2 q^2 G_R G_T \left(\frac{\lambda}{D}\right)^3 \tag{7}$$

and

$$t_s = \frac{\lambda^2}{16\pi^2 d}. \tag{8}$$

Some of the actual forward-scatter echoes will have amplitudes greater than P_s, some smaller. To compensate for this effect, p will be modified to include the variations of echo amplitudes with h-plane position. Using a new probability factor p', large-amplitude echoes are analyzed as a greater number of smaller-amplitude echoes in some parts of the h-plane; in other regions echoes of small amplitude are analyzed as a lesser number of large-amplitude echoes. Because of obliquity, note that all of the actual echoes have durations greater than t_s. This increased duration will be taken into account by using more standard echoes. For instance, one echo with an oblique duration increase of $\sec^2\phi = 10$ will be analyzed as 10 echoes with the back-scatter duration. Thus, the probability density of detection that should be associated with the standard echo units is $(p' \sec^2 \psi)$; it may be shown that this factor is given by

$$p' \sec^2 \phi = \frac{2L}{\pi D} \frac{[(\xi^2 - 1)(\xi^2 - \eta^2) - \xi^2 h^2/D^2]^{1/2}}{(\xi^2 - \eta^2)(\xi^2 - 1)^2}. \tag{9}$$

Equations (7), (8), and (9) will serve to find the properties of meteoric propagation from knowledge of the total meteoric activity. Note that only one contour plot is now required.

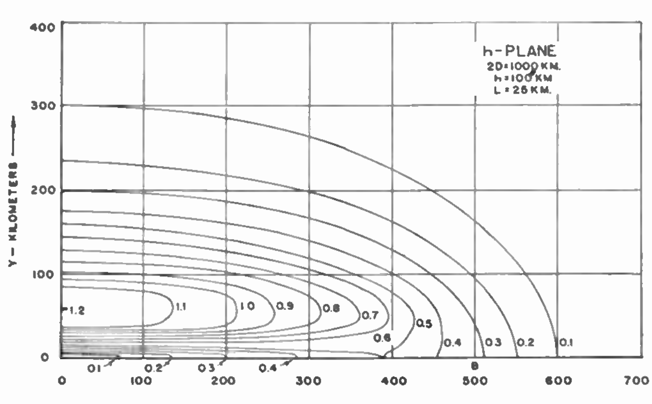

Fig. 5—The probability-duration factor (p' $\sec^2\phi$) for randomly-oriented meteor trails, as a function of position in the h-plane. Only one quadrant is plotted.

In Fig. 5 are shown the values of (p' $\sec^2 \phi$) at the various h-plane positions. This contour map was constructed for the same values of L, h, and D as were used in Fig. 4 for p. Unlike p, which is a purely geometrical factor indicating the relative number of favorably oriented meteor trails, (p' $\sec^2 \phi$) represents the relative contributions to meteoric propagation of the various h-plane areas, since echo amplitude and duration factors are included. A glance at Fig. 5 shows the regions of the h-plane where meteors will scatter a maximum (or minimum) amount of energy. In particular, a highly-directive antenna aimed at the midpoint of the path will produce less signal than would a beam having a lobe slightly to either side of this line.

The Total Meteoric Incidence Rate

In order to complete the analysis, it is necessary to relate the number of meteor trails incident per unit time on a unit area in the h-plane, to the meteoric electron line density q. With such a relation, the contour plot of Fig. 5 may be used to find the number of standard echo units received per unit time. Finally, using (7) and (8), the amount of signal propagated over the oblique path by scattering from all of the illuminated meteor trails may be found.

Watson[14] gives the number of sporadic meteor trails in each visual magnitude range. From his figures, it follows that

$$\log N_m = \frac{m}{2.5} - 7.8, \tag{10}$$

where N_m is the daily average number of trails per km² per second of visual magnitude m or less. Herlofson has predicted theoretically that the light to ionization energy is constant for a wide range of visual magnitudes.[15] This conclusion appears to agree with measurements by McKinley of echo rates *versus* transmitter power.[16] Herlofson made an estimate of the electron line density, but it now appears that his values are too low[7,9,10] by a factor of about 100. For example, echo amplitude and rate measurements at Stanford University indicate that a line density of 10^{13} electrons per meter corresponds to a visual magnitude of 7.5 instead of 2.5. Thus, from (10),

$$N_a = 1.6 \times 10^8 q^{-1.0}, \tag{11}$$

where N_a is the daily average number of trails per km² per second of line density q or greater. The subscript a means that echo-amplitude measurements were used to determine the coefficient of q. The value of the exponent results from the assumed constant ratio of light to ionization energy.

Additional evidence that q must be larger than suggested by Herlofson comes from the current theory of the duration of meteor echoes.[7,17,18] According to this

[14] F. G. Watson, "Between the Planets," The Blakiston Co., Philadelphia, Pa., pp. 114–117; 1941.

[15] N. Herlofson, "The theory of meteor ionization," *Phys. Soc. Rep. Prog. Phys.*, vol. 11, pp. 444–454; 1946–1947.

[16] D. W. R. McKinley, "Variation of meteor echo rates with radar system parameters," *Can. Jour. Phys.*, vol. 29, pp. 403–426; September, 1951.

[17] T. R. Kaiser and R. L. Closs, "Theory of radio reflections from meteor trails: I," *Phil. Mag.*, vol. 43, pp. 1–32; January, 1952.

[18] J. S. Greenhow, "Characteristics of radio echoes from meteor trails: III. The behaviour of the electron trails after formation," *Proc. Phys. Soc.*, vol. 65, pp. 169–181; March, 1952.

theory, the duration of the echoes when $q<10^{14}$ is independent of q, but for $q>10^{14}$ the echo duration is linearly dependent upon q. Greenhow and Hawkins[9] have used the theory of long duration echoes together with Millman's data,[19] to find the relationship between q and m. Their results, taken with (11), show that

$$N_d = 1.5 \times 10^{15} q^{-1.46}, \tag{12}$$

when $q=10^{15}$ to 10^{17} electrons per meter. The subscript d means that echo durations were used to find both the coefficient and the exponent of q.

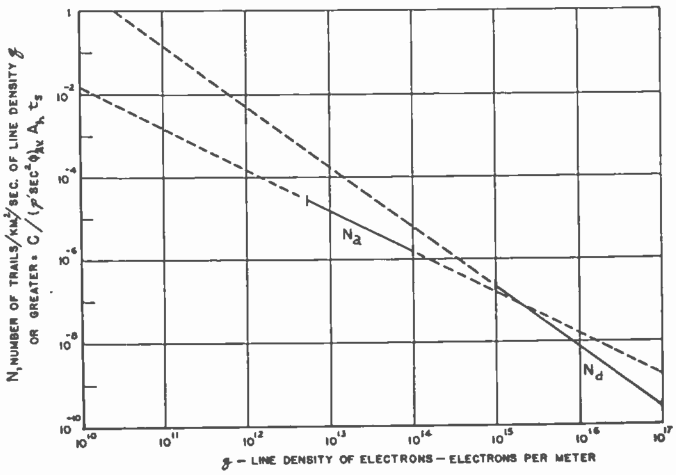

Fig. 6—Daily average number of meteor trails as a function of the limiting line density of electrons. The N_a curve is based on measurements of echo amplitudes, while the N_d curve was determined from echo-duration measurements. The ordinate may also be interpreted as the average number of coexisting echoes, C.

Expressions (11) and (12) for N as a function of q are plotted in Fig. 6. They agree reasonably well in the range of line densities where they were determined, i.e., from 10^{13} to 10^{17} electrons per meter. Unfortunately, the properties of the total signal are dependent upon which equation, if either, can be extrapolated to line densities of 10^{12} to 10^{10} electrons per meter. The critical dependence of the total signal on the exponent of q will be illustrated by means of examples.

Properties of the Total Signal

The total number of standard echo units received per second, having amplitudes above an arbitrary reference level, may be found from the contour plot of $(p' \sec^2 \phi)$. This factor must be averaged over the illuminated area of the h-plane, and multiplied by the area A_h and by the meteoric arrival rate N. In the expression for N, the value of line density q must be used which makes P_s equal to the desired reference level. Multiplying the total standard echo rate by the standard echo duration t_s gives the average number of coexisting echoes above the reference level. Calling this average number C,

[19] P. M. Millman, "Meteoric ionization," *Jour. Roy. Astr. Soc. Can.*, vol. 44, pp. 209–220; 1950.

$$C = N(p' \sec^2 \phi)_{av.} A_h t_s. \tag{13}$$

It may be desirable in computations to divide the h-plane into several regions over each of which the antenna-gain factors may be considered constant. It is evident from (13) that if the system parameters are known, the ordinate in Fig. 6 may be used to find C, as well as N, as a function of q.

If there are on the average C coexisting echoes, then the fraction of time that at least one echo exists is given by

$$1 - \exp(-C). \tag{14}$$

Thus, if N is fixed by the value of q needed to make P_s equal to the receiver-threshold amplitude, the fraction of the time that the meteor signal is present is given by (14). If C is taken as the value (0.693) which makes (14) equal to one-half, the corresponding value of P_s is the median-signal level propagated *via* meteoric ionization.

So far, exponentially decaying echoes have been treated as if they were rectangular echoes of duration t_s. The duration of an exponential echo is defined as the time taken for the amplitude to fall to 37 per cent of its initial value. Thus, when a noise or other reference level is introduced which is not of this relative amplitude, the use of duration t_s leads to error. For large amplitude echoes the signal is underestimated, while for small amplitude echoes it is overestimated. It can be shown that treating exponential echoes as if they were rectangular introduces an error in C given by

$$\frac{C_{\text{rect.}}}{C_{\text{exp.}}} = k, \tag{15}$$

where N is proportional to q^{-k}. In the case of N_a as given by (11), pulse analysis then introduces no error in finding either the median-signal level, or the per cent time the signal is present.

With N proportional to q^{-k}, it follows from (7), (8), (9), and (13) that the median-received signal power is proportional to $\lambda^{3+4/k}$. That is, the median-received power propagated via meteoric ionization is proportional to λ^7 if N_a describes the line-density distribution of the trails; the power is proportional to $\lambda^{5.7}$ if N_d is used. If the most favorable area of the h-plane is illuminated by pencil beams from the transmitting and receiving antennas, the median-received power depends on the forward-scattering angle approximately as $(\sec \phi)^{-3+10/k}$. The median power depends on antenna gain as $G^{2-2/k}$ if $G_R=G_T=G$ and if $(p' \sec^2 \phi)$ is essentially constant over the illuminated areas.

Examples

The theory will now be applied to estimate the contribution of meteors to the scatter signals described in references 1 and 2. In the test between Tucson, Arizona, and Stanford University, California,[2] the path length is

1,175 km; the contours of Fig. 5 may be used with little error. The transmitted power was about 500 w and the wavelength was 21 m. It is estimated that the h-plane was illuminated with an average combined transmitter and receiver antenna gain of 50 times out to the 0.3 contour of Fig. 5. Upon integration by a planimeter, $(p' \sec^2 \phi)_{av}$. $A_h t_s$ is found to be 2.0×10^5. Thus, using (13), (11), and (7), the median-signal level is 5.5×10^{-14} w if the N_a curve is used. It is estimated that the noise level in this test was about 10^{-14} w, so that the minimum value of q in a detectable meteor trail is found from (7) to be about 1.9×10^{13} electrons per meter. Using (11) and (13), or Fig. 6, it is seen that, on the average, 1.6 echoes are present above the noise level at a time. Equation (14) then shows that at least one echo is present about 80 per cent of the time.

If N_d had been used in the above computations, the median-signal level would have been 3.8×10^{-13} w. An average of about 10 echoes would have been present at once, and the signal would have been almost continuous. Thus, the use of either N_a or N_d leads to the conclusion that meteoric ionization alone could account for the nearly continuous signal received in the Stanford-Tucson test at a frequency and time of day when no layer transmission was present.

The results of another series of forward-scattering tests are also available.[1] They show the existence of an observable signal at all times between a transmitter and receiver separated by 1,245 km and operating on a wavelength of 6.02 m. The terminals of this test path are at Cedar Rapids, Iowa, and Sterling, Virginia. The transmitted power was about 23 kw, and the transmitting and receiving antennas, beamed to intersect at a height of 100 km over the midpoint of the path, had a combined power gain of about 10^4 over isotropic radiators. It was suggested that the mechanism of this type of propagation may be scattering, arising from turbulence and the resulting irregularities in the spatial distribution of electron density in the lower part of the E-region. Let us determine what contribution meteoric ionization might play in propagation over this test path.

The highly-directive antennas used in this experiment illuminated about 1.5×10^4 km^2 of the h-plane, where the value of $(p' \sec^2 \phi)_{av}$. is only 0.4. Thus, $(p' \sec^2 \phi)_{av}$. $A_h t_s$ is 5.2×10^{-17} w, and a signal is above their reference level of 4.2×10^{-16} w only 21 per cent of the time. On the other hand, using N_d rather than N_a results in a median signal of 1.5×10^{-14} w with at least one echo above the reference level virtually all of the time.

Conclusion

The importance of knowing the meteoric rate N for a wide range of electron line densities q is apparent from the examples. If the number of incident meteor trails increases rapidly enough with decreasing line density, meteoric ionization alone could support long-distance communication at the very-high frequencies. In any event, it appears that meteor echoes could support a useful signal, even with relative low-power transmitters, at frequencies on the order of 15 mc and path lengths around 1,000 km. The rate has been fairly well determined for the range of q's which are important for such a circuit.

The diurnal variation of signal strength measured in the Cedar Rapids-Sterling tests does not agree with what is presently known of the diurnal variation of echo rates for trails with line densities greater than about 10^{13} electrons per meter. However, this does not in itself mean that meteoric ionization could not be a major factor in the propagation of this signal; the diurnal rate variation for the very low line density trails, which may be of primary importance in this test, has never been determined. In addition, changes in radiant distribution may well be more important than rate changes in determining the variations of signal strength at the receiver. More accurate knowledge of diurnal and seasonal variations of echo rates, average height of occurrence, and radiant distribution are clearly needed in this type of study. Back-scatter observations would be adequate to determine these quantities.

Highly-directive antennas may be used to pick out areas in the h-plane where the contribution of meteroic ionization to the forward-scattered energy varies by a factor of 3 or 4. This characteristic of meteoric reflections might be used to assess the relative importance of meteoric scattering and scattering due to turbulence or other factors.

Acknowledgment

The authors gratefully acknowledge the helpful discussions and suggestions of their colleagues, O. G. Villard, Jr., and A. M. Peterson.

IRE Standards on Sound Recording and Reproducing: Methods for Determining Flutter Content, 1953*

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1. Scope

1.1 This standard specifies conditions which must be met in measuring or reporting flutter in sound recorders, reproducers, or records.

2. Definitions

2.1 *Flutter*

In recording and reproducing, flutter is the deviations in reproduced sounds from their original frequencies, which result in general from irregular motion during recording, duplication or reproduction.

Note 1: The colloquial term "wow" is defined in the same way, but is commonly applied to relatively slow variations (for example, one to five or six repetitions per second) which are recognized aurally as pitch-fluctuations, in contradistinction to the roughening of tones, which is the most noticeable effect of rapid fluctuations.

Note 2: A constant difference in pitch such as results from a difference in the average speeds during recording and reproduction is not included in the meanings of the terms "wow," "flutter," and "drift."

Note 3: By an extension of their meanings, the terms "flutter" and "wow" are used to designate variations in speed itself or variations in recorded wavelengths.

Note 4: Although most recorded sound comprises multitudes of tones, it is convenient to refer to flutter as variations in frequency, assuming the recorded sound to have been a single steady tone.

* Reprints of this Standard, 53 I.R.E. 19.S2, may be purchased while available from the Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y., at $.75 per copy. A 20 per cent discount will be allowed for 100 or more copies mailed to one address.

[1] Chairman, 50–52.

2.2 Flutter Rate

Flutter rate is the number of frequency-excursions in cycles per second, in a tone which is frequency-modulated by flutter.

Note 1: Each cyclical variation is a complete cycle of deviation, for example, from maximum-frequency to minimum-frequency and back to maximum-frequency at the rate indicated.

Note 2: If the over-all flutter is the resultant of several components having different repetition rates, the rates and magnitudes of the individual components are of primary importance. (See Appendix 1.)

2.3 Drift

The term drift is used to designate random-frequency variations which are continuously in one direction or the other for periods of the order of a second or more.

2.4 Per Cent Flutter

The per cent flutter in a reproduced tone is the root-mean-square deviation from the average frequency, expressed as a percentage of average frequency.

2.5 Per Cent Total Flutter

Per cent total flutter is the value of flutter indicated by an instrument which responds uniformly to flutter of all rates from 0.5[2] up to 200 cps.

Note: Except for the most critical tests, instruments which respond uniformly to flutter of all rates up to 120 cps are adequate, and their indications may be accepted as showing per cent total flutter.

3. Flutter-Measuring Instrument

3.1 The block diagram, Fig. 1, shows the principal elements of a typical flutter-measuring instrument.

Note: The limiter insures freedom from appreciable amplitude fluctuations which can cause error. A low-pass or bandpass filter is used after the limiter to remove the distortion products caused by the limiter.

Means are usually provided for checking that the input signal is within proper operating limits as to amplitude and frequency.

The discriminator converts frequency changes into amplitude changes, and the output of the rectifier fluctuates in identical manner with the input-frequency.

The low-pass filter eliminates the "carrier" or original tone.

Some flutter-measuring equipment is provided with a continuously variable oscillator whose output beats with the test tone to provide a sum or difference tone whose fluctuations are measured. This makes it possible to measure fluctuations in test tones whose frequency differs slightly from normal value.

[2] This would mean practically full response for once-around flutter of a 33$\frac{1}{3}$ rpm turntable. Only recording-type meters will satisfactorily show drift.

For the purpose of analyzing the causes of flutter in a recording or reproducing system, it is often desirable to make measurements in several ranges of flutter-frequency. For such purposes bandpass filters may be incorporated in the measuring instrument, as shown at *B*, *B*, *B*, in Fig. 1, or an adjustable bandpass filter or "analyzer" may be provided, so that flutter components at specific rates can be measured.

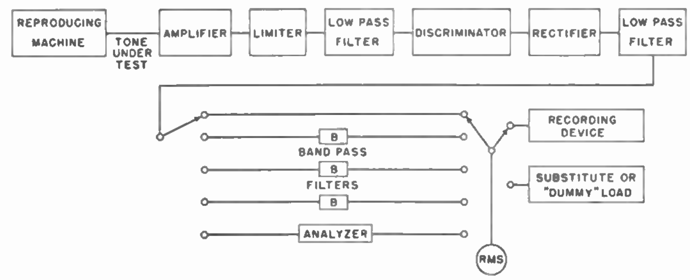

Fig. 1—Block diagram of a typical flutter-measuring instrument.

Valuable information is given by a record of instantaneous frequency deviations (flutter oscillogram, or "wowgram") covering a period of several seconds. The block diagram, Fig. 1, shows provision for such a recording device, which can be used in addition to the rms indicating instrument. (See 4.6.)

A simpler type of flutter-meter has had considerable use, particularly for servicing theater equipment. It employs a circuit which gives a null point or zero output at a certain frequency, which can be adjusted to the mean-frequency of the reproduced tone. The reading of the output-meter is an indication of flutter, provided the null point has been adjusted to the actual mean-frequency.

3.2 Range of Flutter Rates Covered

It is essential for accurate measurement of flutter, that the measuring equipment give full response for fluctuations at least as slow as the lowest known cyclic disturbance, such as the slowest rotating member in the driving system of a disk turntable, or the natural frequency of any mechanical filter which may be employed. It is equally important that the upper-frequency limit be high enough to include all of the high-frequency components of flutter which may occur in sufficient magnitude to appreciably affect the resulting measurements. As an example, in 35-mm motion picture work, 200 cycles for the upper limit has been recommended so as to include the second harmonic of 35-mm film sprocket hole modulation.

3.3 Type of Indicating Instrument

Instruments which respond to the average value of frequency deviations or to a function intermediate between average and root-mean-square shall be considered satisfactory for all but the most critical tests, provided the instrument has been calibrated to correctly indicate the root-mean-square value for a sinusoidal frequency variation at a single flutter rate.

Note 1: When flutter is predominantly of a single rate, meters which depend on peak, average or root-mean-square deviations, would read alike, provided they are appropriately calibrated. When, however, the total flutter is made up of several components of different frequencies of rates, the additions would take place in different manners. The root-mean-square measurement would give more weight to the larger resultant deviations than an average measurement, but it would not carry this to the extreme of giving relatively little weight to the lesser deviations, which is the characteristic of a peak-reading system.

Note 2: Indicating instruments for flutter-measurements should be unusually heavily damped, otherwise excessive swings are likely to occur when there is strung flutter at slow rates, making reading difficult. When it becomes necessary to estimate the average reading of the swinging needle of an rms instrument, the mean position of the needle should be estimated and the scale figure read at this point, rather than to take the mean of the highest and lowest figures.

3.4 Test Tones

The standard frequency for flutter-measurements is 3,000 cycles.

Note: Satisfactory flutter-measurements can be made using tones of different frequency, but interchangeability of records is highly desirable and use of 3,000 cycles is widespread. A number of flutter measuring equipments for disk records employ 1,000 cycles.

3.5 Flutter-Test Records and Films

The test films used in testing reproducers shall comply with the specifications for 3,000 cycles flutter-test films published by the Society of Motion Picture and Television Engineers, and Motion Picture Research Council. Test records for determining the flutter content of 33⅓ rpm disk reproducers should conform to specification published by the National Association of Broadcasters. At the present time, there are no standard specifications for 78 or 45 rpm disk test records.

4. Test Methods

4. General

Measurement of flutter in one element of a sound recording or reproducing system (recorder, re-recorder, reproducer, or test record) shall be made under such conditions that the flutter in the remaining portions in the system is relatively negligible.

4.2 Testing Recorders

To determine the flutter of the recording device, a tone of constant frequency and amplitude is recorded. This test sound record is then reproduced with a machine having relatively negligible flutter, and the rms frequency deviations of the resulting tone from the average are measured with a suitable measuring instrument.

4.3 Testing Reproducers

Similarly, to determine the flutter content of a sound reproducing device, a test record having relatively negligible flutter content is reproduced on the machine, and the rms deviations of the frequency of the resulting tone from the average are measured.

4.4 Testing Records

A test sound record is reproduced on a machine having relatively negligible flutter content, and the rms deviations of the resulting tone from the average are measured.

4.5 Flutter Determination of Recorders Adapted to Both Recording and Playback

In the case of recorders which can be used as reproducers, the flutter content can be determined by reproducing from a test record having relatively negligible flutter content, and measuring the deviations of the resulting tone from the average. If any factors are present, however, which may make the flutter during recording and reproducing differ, (for example, disk-cutter load and reproducer-stylus drag) there should be separate determinations for each case.

Note: Alternate Method (Nonstandard). If a machine under test is capable of operation both as a recorder and a reproducer, and is itself superior with respect to flutter to any other available machine, or record, it may be used to test its own records.

When this procedure is followed, flutter components due to a given cause, in recording and reproduction, add vectorially; but unless the relative phase of the two vectors is exactly known, a single measurement which shows the vector sum does not suffice for determining the magnitude of either disturbance alone. But the magnitude of one alone can be estimated from a series of measurements, with the range of possible phase-angles covered in substantially uniform steps. If two equal vectors are added at n equally spaced phase-angles covering the possible 360 degrees, and the squares of the n resultants are averaged, the square-root of this average is 1.41 times the length of one of the vectors. This holds independently of the starting or reference point, and for n equal to any whole number down to two.

Whence—In testing a machine with its own record, the flutter for the combined operation is the square-root of the average of the squares of the measurements, with record in a series of positions relative to driving system, such that range of possible phase-relations between cyclic disturbances in recording and reproduction is covered in substantially equal steps.

If the measuring equipment reads rms flutter, and if conditions are such that equal flutter is to be expected in recording and reproduction, the most probable value of flutter for either operation alone is 0.707 of the measured combined flutter.

Discussion of the application of this principle to several cases appears in Appendix II.

4.6 Instantaneous Flutter-Records

Flutter-tests are sometimes made by making records (wowgrams) of instantaneous frequency deviations. Such records give valuable information but do not afford a readily determined figure for the per cent flutter except that the peak-high and -low excursions of the frequency may be determined. It is desirable that rms measurements be made as part of the same test. (See 5.3.)

5. Reporting on Measurements

5.1 Statements of per cent flutter shall always be accompanied by a statement as to the range of flutter-rates wherein the measuring instrument has substantially uniform response. For this purpose it is recommended that the range limits be taken as the frequencies at which the response is 6 db below that at mid-range.

5.2 Statements of flutter should, when possible, include information as to predominant rates, or of the distribution with respect to flutter rate, as for example, amounts of flutter in different flutter-rate bands or ranges.

5.3 It is inevitable that in many cases it will be necessary to transmit information shown by an instantaneous flutter record or wowgram, of which no simultaneous rms flutter-reading will have been taken. When a figure for per cent flutter is reported on the basis of visual inspection of a flutter record or wowgram, the figure shall be one-half the extreme excursion between highest and lowest frequency and designated as "peak-flutter."

It should be recognized that such peak-flutter will, in practically all cases, exceed the rms value by considerably more than the well-known 1.41 factor which applies to sine waves.

Appendix I

Definition

Flutter Index is a measure of the perceptibility of frequency modulation of a single tone.

Note 1: Based on data presented in an article entitled "Analysis of Sound Film Drives," by W. J. Albersheim and D. MacKenzie, *Jour. Soc. Mot. Pict. Eng.*, vol. XXXVII, p. 453; Nov., 1941. An approximate formula for flutter index for continuous tones in a moderately live room is as follows:

$$I = \frac{\Delta f x}{r} = \frac{k f x}{100 r}$$

where

Δf = rms deviation of frequency from mean in cycles
f = frequency of tone
k = per cent rms flutter
I = flutter index
r = flutter rate
$x = \frac{1}{6}$ for rates greater than 5 cps.

Note 2: For flutter rates 1 to 5 cps, the following relations are suggested:

$$x = \frac{r}{30}$$

from which

$$\text{when } f = 3{,}000 \text{ cps, } I = k.$$

Note 3: For flutter rates less than 1 cps, the following relations are suggested:

$$x = \frac{r^2}{30}$$

from which

$$\text{when } f = 3{,}000 \text{ cps, } I = kr.$$

Note 4: For the general case per *Note 2*, wherein $x = \frac{1}{6}$, the flutter index, when multiplied by $6\sqrt{2}$, is the argument of the Bessel functions of the first kind and the coefficients of the various orders of the Bessel functions have been shown to represent the amplitudes of the corresponding orders of the side-frequencies present in a frequency-modulated tone.

Note 5: For flutter rates above 5 cps, the ear apparently hears the side-frequencies as extraneous effects, and therefore will perceive approximately the minimum-flutter at the same value of flutter index over a wide range of signal-frequencies, percentages of flutter, and rates (assuming relatively constant acoustic conditions).

Note 6: For flutter rates less than 5 cps, the ear apparently distinguishes the time-frequency variation rather than the discrete side-frequencies, and so the expression which describes the phenomena becomes more complicated.

Note 7: The flutter index of any given device having a constant per cent flutter will vary with the signal-frequency, so that the test-frequency should always be stated with flutter index in such cases. Unless otherwise stated, the flutter index will be assumed to refer to the standard test-frequency per section 3.4.

Appendix II

Applications of principle of testing with record in several positions as called for in 4.5 Note 1

The requirement that a record be tested in a series of positions with respect to the member which drives it, if no other cyclic disturbance is to be considered, requires no further explanation, beyond stating that the 360 degrees of possible relative positions should be covered in a number of equal steps. While two positions 180 degrees apart would give the correct relations so far as a pure sinusoidal, or once-per-revolution disturbance is concerned, a larger number is desirable, as better averaging the effects of harmonics of the fundamental rate, and for more nearly meeting the objective with regard to random variations. The number of different positions used should be in no case less than five.

If in addition to a disturbance at a fundamental rate, such as once-per-revolution of a disk turntable, there are other more rapid cyclic disturbances, it is possible generally to choose a series of record positions which will suitably distribute the angles of vector addition, for both the fundamental and the faster disturbance, provided these are in fixed relation, as in a geared driving system, and if their rates are in simple relation.

Let m stand for the speed or rate ratio of the two sources of disturbance. If m is a whole number, dividing the fundamental cycle into n equal steps (provided m is not divisible by n) will be found to also divide the faster cycle into n equal steps.

If m is not a whole number, the cycle of repetition will cover a number of revolutions of the slowest rotating member, and the reference point must be taken at some definite point in the repetition cycle (i.e., gears in certain relative positions). For example, if a turntable makes 3 revolutions while a driving gear makes 16, and five record positions are to be used, the record would be shifted $\frac{3}{5}$ of a turntable revolution between each test and the next. Assuming the record to have been made as one continuous recording, if no movement of the driving system takes place during the operation of shifting the record, it is not necessary to check gear positions to obtain the desired shift of the record with reference to the driving system, but only to keep track of the total angle from the first position. In the case just mentioned, with $n=5$ and $m=16/3$, the angles would be

Angle A (revolutions) repetition cycle	0	1/5	2/5	3/5	4/5
Angle on turntable	0	3/5	6/5	9/5	12/5
Angle at gear	0	16/5	32/5	48/5	64/5

To judge the distribution over the cycle, subtract from each fraction the largest possible whole number. Then the angles (in revolutions) are

at turntable	0	3/5	1/5	4/5	2/5
at gear	0	1/5	2/5	3/5	4/5

When shifting a film record with respect to a sound sprocket, there are only certain possible angles of shift, and if possible disturbances at higher rates than the sprocket rotation are in question, it may not be possible to choose a value of n which makes m/n other than a whole number. For example if the sound sprocket has 32 teeth, and cycles of 4 teeth and 16 teeth are suspected, the following positions, 0, 2, 8, 10, 16, 18, 24, 26 teeth, will be found to give one or more pairs of opposite phase relations for each cycle, and if each test can be paired with one in opposite phase, the sinusoidal part of the disturbance is properly averaged.

The endeavor to achieve a distribution of phase-angles for several rates of cyclic disturbance may be unimportant if the more rapid disturbances contribute a negligible part of the total flutter, as is often the case with machines which, as mentioned at the beginning of this note, are themselves superior to other available testing equipment or records.

Under these conditions, and in the case of nonsynchronous driving systems (and some synchronous systems) where it is not possible to predict or control the relative phases of possible sources of cyclic disturbance, the best that can be done is to shift the record to an appropriate series of positions to provide distribution for the fundamental cycle, and depend on an adequate number of tests to reduce the probable error with respect to all faster cycles and random disturbances. Repetitions in the same record positions in nonsynchronous systems, are in effect additional tests, with respect to flutter in random-phase relations. This applies to magnetic-tape recorder-reproducer machines employing pure friction drive, where definite positioning on the capstan can scarcely be accomplished, but random shifts on the capstan, between measurements, are better than depending entirely on creep or speed difference between recording and reproduction, to afford random-phase relations.

Although magnetic-tape machines are more frequently used in service to play their own records than other recorders or reproducers, their flutter rating is to be considered to be that for one operation alone, unless a measurement is stated to be for the combination of recording and reproduction.

It is recommended that the total number of tests be not less than five (which figure has been named arbitrarily as a compromise between inadequacy on the one hand and burdensome testing on the other).

When this alternate method is used, results reported should be accompanied by a statement of the procedure followed.

The Transistor as a Mixer*

JAKOB ZAWELS†, MEMBER, IRE

Summary—**This work contains analyses of both point-contact and junction transistors as mixers. Experimental results for signals up to 400 megacycles are presented. The conversion ability of transistor mixers is dependent on the IF and signal frequencies. The IF frequency is limited to the region of amplification of the transistor. The signal frequency range is ultimately limited by the capacitance which shunts the emitter when it is biased in the reverse direction.**

The analysis is simplified by dividing the signal frequency spectrum into three regions as follows: in the low-frequency range conversion is strongly dependent on alpha; in the medium-frequency range conversion depends primarily on base resistance; in the high-frequency range conversion is mainly dependent on emitter reverse shunting capacitance.

The conversion gain influences the noise factor. At low frequencies, a junction transistor mixer equals the performance of a crystal diode mixer followed by a junction transistor amplifier. At vhf frequencies conversion gain may still be obtained if point-contact transistors are used; however, at present, their noise factor is higher than that which can be obtained by the combination of the diode and the transistor amplifier.

Introduction

It is well known that the semi-conductor diode has established itself as the best mixer device at microwave frequencies. At lower frequencies, due to noise and gain considerations, it is superseded by the vacuum tube. However, when miniaturization or low power consumption is desired, the use of the crystal diode is often found essential even at low frequencies.

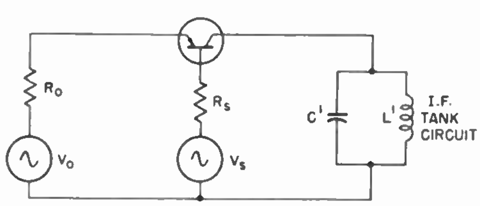

Fig. 1—Mixer circuit.

The transistor, the offspring of the crystal diode, has added further impetus to the trend of miniaturization. It is thus, necessary to evaluate capabilities of the transistor as a mixer device at both low and high frequencies.

Principle of Operation of the Junction Transistor Mixer

A typical transistor mixer circuit is shown in Fig. 1, where V_0 and V_s are the local oscillator and signal open circuit voltages respectively, while R_0 and R_s are the corresponding source resistances. The IF voltage is obtained across the parallel tuned circuit.

Since detection takes place in the emitter diode, the conversion ability of the transistor depends upon the nonlinear resistance of the emitter which for junction transistors is described by[1]

$$i_d = A\left(\exp \frac{qv_d}{kT} - 1\right) \qquad (1)$$

where

A = constant dependent on the semiconductor properties
q = electronic charge
k = Boltzmann's constant
T = temperatures in degrees K
i_d = total current through emitter junction
v_d = voltage across emitter junction
$kT/q \doteq 25.9$ millivolts (at room temperature).

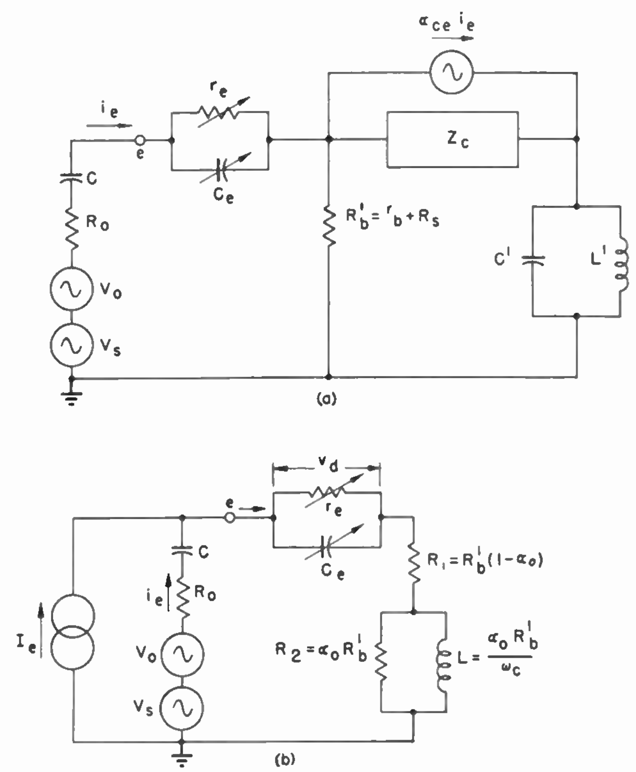

Fig. 2—Equivalent mixer circuits.

Assume the emitter is biased from a dc constant current source. The (large signal) local oscillator will vary the current flowing into the emitter. Experimentally it is found that for optimum operation it places a reverse voltage on the emitter junction only for a small fraction of its cycle. Thus, the modified T-equivalent circuit shown in Fig. 2(a) may be used.

In Fig. 2(a), r_e is the variable emitter resistance. It has a diffusion capacitance associated with it when the junction is biased in the forward direction and a barrier

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[1] W. Shockley, "Electrons and Holes in Semi-conductors," D. Van Nostrand Co., Inc., New York, N. Y., 1950, p. 316.

capacitance when biased in the reverse direction. The capacitances are represented by C_e. R_b' is the sum of the base resistance r_b, and R_s. V_s can be relocated in the emitter lead since this does not alter the emitter to base voltage and has only a negligible effect on collector current because the collector impedance is high. C is a blocking capacitor. Also the frequency dependence for the grounded-base short-circuit current amplification factor, α_{ce} is

$$\alpha_{ce} = \frac{\alpha_0}{1 + j\dfrac{\omega}{\omega_c}} \tag{2}$$

where α_0 is the low frequency value of α_{ce}. (This relationship has a theoretical basis.)

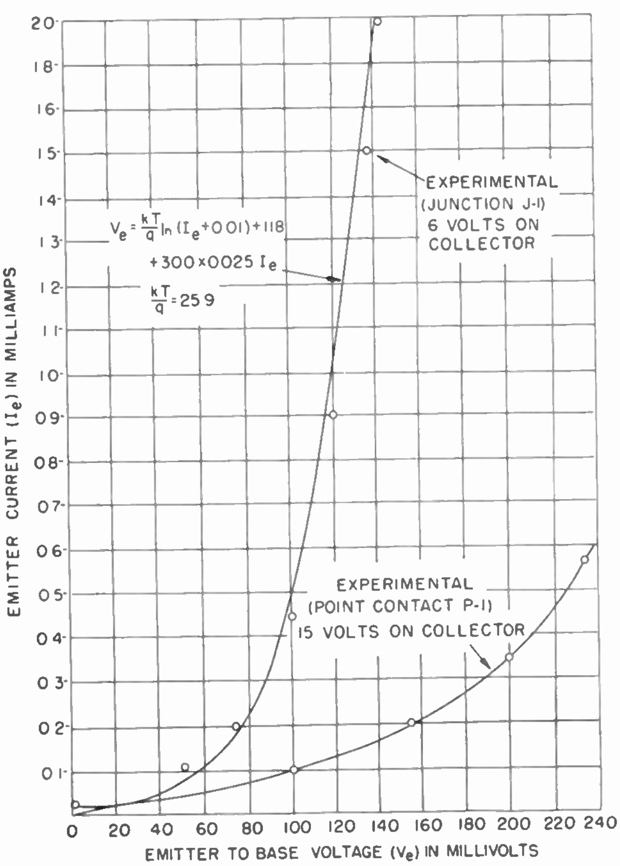

Fig. 3—Dc input characteristics of junction and point-contact transistors.

At the local oscillator frequency the collector to ground impedance is negligible and the short-circuit input impedance is

$$Z_{in} \doteq z_e + R_b'(1 - \alpha_{ce}) \tag{3}$$

where z_e consists of r_e in parallel with C_e.

Substitute (2) in (3)

$$Z_{in} = z_e + R_b'(1 - \alpha_0) + \cfrac{1}{\cfrac{1}{\alpha_0 R_b'} + \cfrac{1}{j\cfrac{\omega \alpha_0 R_b'}{\omega_c}}} \tag{4}$$

which may be synthesized into the equivalent circuit shown in Fig. 2(b).

If the current generator I_e, representing the emitter bias current is added, Fig. 2(b) can represent both the ac and dc conditions. Thus from Fig. 2(b)

$$V_e = v_d + R_b'(1 - \alpha_0)I_e \tag{5}$$

where V_e is the dc voltage from emitter to ground when ac voltage is zero, and, from (1),

$$v_d = \frac{kT}{q} \ln (I_e + A) - \frac{kT}{q} \ln (A). \tag{6}$$

Fig. 3 shows the calculated curve V_e vs. I_e, when $A = 0.01$ ma. The experimental values for a junction and a point-contact transistor are also shown.

The resemblance of Fig. 2(b) to the conventional dc diode mixer circuit is now evident.

Frequency Ranges

The conversion ability of a transistor mixer depends on the signal and IF frequencies. Fig. 4 shows experimental curves of conversion voltage gain (defined as the ratio of IF voltage at the collector to signal voltage) vs. signal frequency for point-contact and junction transistors. The IF frequency is 0.5 megacycles. Three main signal frequency regions of operation are found and are indicated in Fig. 4 for the P-1 transistor:

Region A or "Alpha Region": This is the lowest frequency range and here α determines the input impedance level. Except for very low frequencies, α has a phase shift (as indicated by the inductance L in Fig. 2(b)) and input impedance is partially reactive.

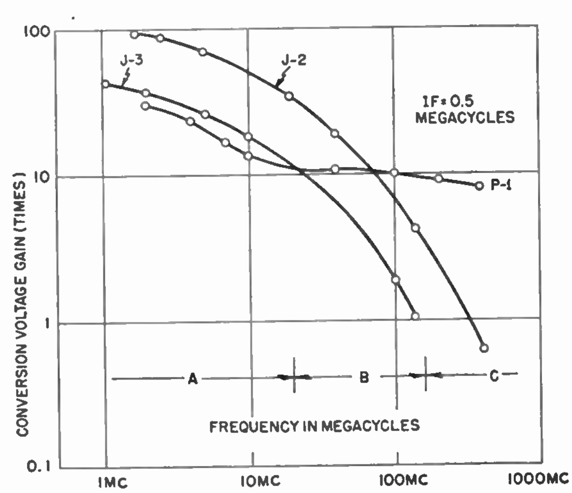

Fig. 4—Dependence of conversion voltage gain on signal frequency for transistor mixers.

Region B or "Base Resistance Region": This is the frequency range where α has fallen to a very low value and the input impedance in determined primarily by the base resistance. The inductance in Fig. 2(b), due to its high impedance, may now be neglected and the input impedance becomes

$$Z_{in} = z_e + R_b'(1 - \alpha_0) + \alpha_0 R_b' = z_e + R_b'. \tag{7}$$

Region C or "Capacitance Region": This is the high-frequency range where the conversion ability is dependent on the reverse capacitance shunting the emitter diode.

The P-1 experimental point-contact transistor, which has an α_{ce} cutoff frequency of 4.5 megacycles, has a conversion voltage gain which remains substantially constant in the B region and falls less than 3 decibels in the C frequency range plotted up to 400 megacycles. However, the experimental J-2 junction transistor, with an α_{ce} cut-off of 8 megacycles, shows a continuous fall of gain with frequency primarily due to a larger emitter reverse capacitance present in junction transistors. The same effect is seen for the experimental J-3 junction, having an α_{ce} cut-off of 1.2 mc.

It is now apparent that the ultimate signal frequency limitation on the conversion ability of transistors is set by the reverse emitter shunting capacitance. The maximum IF frequency, however, is limited by the same factors which limit the frequency in transistor amplifiers.

Evaluation of Conversion Gain

Two methods are given here for the calculation of the conversion gain. The method in (a) is simpler to apply but unlike that in (b), it is restricted to frequencies where the input impedance is resistive, and furthermore assumes that the IF output voltage has little effect on the input impedance.

(a) *The B frequency range.* The input impedance is here substantially resistive. Assuming the time independent expression (1) for the emitter, the voltage across the diode at room temperature is

$$v_d = 25.9 \ln (i_d + A) - 25.9 \ln (A) \qquad (8)$$

where

A = a constant

v_d = instantaneous voltage in mv

i_d = instantaneous current in ma.

Let

i_e = ac component of current in emitter,

then

$i_d = i_e + I_e$

where

I_e = dc current in emitter.

From Fig. 2(b), writing the voltage drops around the loop which hold for the B range,

$$\begin{aligned} V_{in} &= V_0 \cos \omega_0 t + V_s \cos \omega_s t \\ &= R_0 i_e + v_d + R_1(i_e + I_e) + R_2 i_e + V_c \qquad (9) \end{aligned}$$

where

V_c = average dc voltage across blocking capacitor.

From (8) and (9)

$$V_{in} = 25.9 \ln (i_e + I_e + A) + (R_b' + R_0)(i_e + I_e) + V_1 \qquad (10)$$

where

$$\begin{aligned} V_1 &= V_c - I_e(R_2 + R_0) - 25.9 \ln (A) \\ R_b' &= R_1 + R_2 \text{ (See Fig. 2(b))} \\ &\equiv r_b + R_s. \end{aligned}$$

Differentiating (10) and taking the inverse

$$g_{in} \equiv \frac{di_e}{dV_{in}} = \frac{(i_e + I_e + A)}{25.9 + (R_b' + R_0)(i_e + I_e + A)}. \qquad (11)$$

From (10) and (11) for a given value of V_1, g_{in} is found as a function of V_{in} and this is plotted in Fig. 5 for fixed values of $(R_b' + R_0) \equiv R$. It is noted that V_1 is a constant which is a function of I_e. The effect of V_1 is to shift the curves relative to the abscissa. In Fig. 5, V_1 is arbitrarily taken equal to 118 millivolts. Also shown are loci for $(i_e + I_e + A)$ = constant.

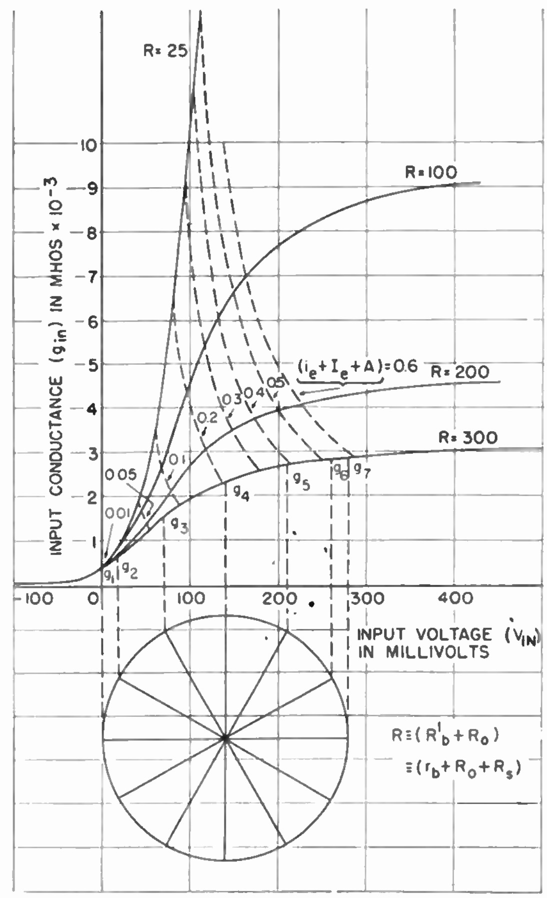

Fig. 5—Calculation of Fourier coefficients of time-varying input conductance caused by local oscillator voltage.

The IF current in the emitter circuit can now be found from Fig. 5 in a manner analogous to that used in the case of diode mixers.[2,3] Expanding g_{in} into a cosine series of period $2\pi/\omega_0$,

$$\begin{aligned} g_{in}(t) &= G_0 + G_1 \cos \omega_0 t + G_2 \cos 2\omega_0 t \\ &\quad + G_3 \cos \omega_0 t + \cdots + G_n \cos n\omega_0 t \qquad (12) \end{aligned}$$

where

$$\frac{\omega_0}{2\pi} = \text{local oscillator frequency.}$$

[2] E. W. Herold, "The operation of frequency converters and mixers for superheterodyne reception," Proc. I.R.E., vol. 30, p. 84; February, 1942.

[3] E. G. James and J. E. Houldin, "Diode frequency changers," *Wireless Eng.*, vol. 20, p. 15; January, 1943.

$$G_0 = \frac{1}{2\pi}\int_0^{2\pi} g_{in}(t)d(\omega_0 t) \quad (13a)$$

$$G_n = \frac{1}{\pi}\int_0^{2\pi} g_{in}(t) \cos n\omega_0 t d(\omega_0 t). \quad (13b)$$

Let $V_s \sin \omega_s t$ be the signal voltage. Thus if $V_s \ll V_0$, the small signal current in the emitter circuit is

$$i_e' = g_{in}(t)V_s \sin \omega_s t$$

$$= G_0 V_s \sin \omega_s t + \tfrac{1}{2}V_s \sum_{n=1}^{\infty} G_n \sin(\omega_s - n\omega_0)t$$

$$+ \tfrac{1}{2}V_s \sum_{n=1}^{\infty} G_n \cos(\omega_s + n\omega_0)t. \quad (14)$$

The IF current in the emitter for the nth harmonic operation of the local oscillator is now given by

$$i_{en} = \frac{G_n}{2} V_s \quad (15)$$

and the resulting IF voltage, developed at the output, follows by treating it as an amplifier problem.

The coefficients G_0, G_1, G_2, etc. can be evaluated by a 7-point analysis as shown in Fig. 5, where the circle diameter equals the local oscillator peak-to-peak voltage. Projecting 30 degree intervals onto the $R=300$-ohm curve, we obtain,

$$G_1 = \tfrac{1}{6}[(g_7 - g_1) + (g_5 - g_3) + 1.73(g_6 - g_2)] \quad (16)$$

where

$g_1, g_2, g_3, \cdots, g_7$ are the 7-point conductances.

Also from Fig. 5 the dc current which corresponds to the position of the circle on V_{in} axis is obtained by noting value $(i_e + I_e + A)$ at g_1, g_2, g_3, etc., and taking the average over one cycle. This dc current is I_e since A is very small (see discussion on principle of operation) and can be neglected.

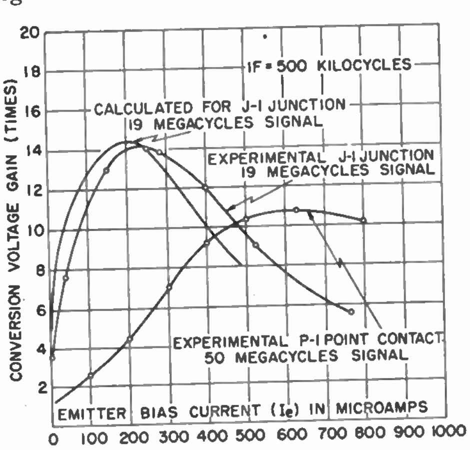

Fig. 6—Dependence of conversion voltage gain on emitter bias current for transistor mixers.

Fig. 6 shows the experimental and calculated conversion voltage gain vs. emitter bias current I_e for a junction transistor with an α cut-off frequency of 3.2 megacycles and a value for $(r_b + R_0 + R_s) = 300$ ohms. It is seen that optimum value for I_e is approximately 250 microamps.

(b) *The A-frequency range.* The reactive elements in the input circuit are important here. Let the current flowing through the junction diode, due to the local oscillator, be

$$i_d = I_e + i_1 \cos(\omega_0 t + \phi_1) + i_2 \cos(2\omega_0 t + \phi_2). \quad (17)$$

(The analysis using more terms in the series follows by analogy.)

Hence from Fig. 2(b) and (17), the voltage across the diode is

$$v_d = V_0 \cos(\omega_0 t + \phi_0) - i_1 z_1 \cos \omega_0 t$$

$$- i_2 z_2 \cos(2\omega_0 t) - R_1 I_e - V_c \quad (18)$$

where z_n and ϕ_n is the magnitude and phase angle respectively of the total impedance excluding the diode at the frequency $n\omega_0$, as seen from the diode terminals.

The currents i_1 and i_2 can now be evaluated (see Appendix) and for moderately large values of local oscillator voltage is given in closed form by

$$i_1 = 2Ae^{-V} \cdot I_1(aV_2) \quad (19)$$

and

$$i_2 = 2Ae^{-V} \cdot I_2(aV_2) \quad (20)$$

while

$$I_e = Ae^{-V} \cdot I_0(aV_2) \quad (21)$$

where

$$V = V_c + I_e R_1$$

$$V_2 \equiv V_0 - i_1 z_1$$

$$a = \frac{q}{kT}$$

and $I_0(aV_2)$, $I_1(aV_2)$, and $I_2(aV_2)$ are the modified Bessel functions of the respective orders.[4]

Differentiating expression (1), the input conductance of the diode alone is

$$g_{in}' \equiv \frac{di_d}{dv_d} = \frac{q}{kT}(i_d - A) \doteq ai_d. \quad (22)$$

(A is negligible compared to the dc bias current.)

Substitute (17) into (22)

$$g_{in}' = G_0' + G_1' \cos(\omega_0 t + \phi_1) + G_2' \cos(2\omega_0 t + \phi_2) \quad (23)$$

where

$$G_0' \equiv aI_e, \quad G_1' \equiv a_{i1}, \quad G_2' \equiv ai_1. \quad (24a)$$

Hence, from (1) and (24a)

$$G_0' = aI_e = aAe^{-V} \cdot I_0(aV_2) = g_0'. \quad (24b)$$

From (19), (21), and (24a)

$$G_1' = 2aI_e \cdot \frac{I_1(aV_2)}{I_0(aV_2)} \equiv 2g_1' \quad (24c)$$

[4] It may be noted that in continuous wave operation the amount of 2nd harmonic distortion, i.e. the ratio of second harmonic to fundamental current, is given by the ratio of the Bessel functions indicated.

and from (20), (21), and (24a)

$$G_2' = 2aI_e \cdot \frac{I_2(aV_2)}{I_0(aV_2)} = 2g_2'. \qquad (24d)$$

The small signal, 5-pole, equivalent circuit of Fig. 7 follows,[5] from which the necessary matching conditions for any required power transfer (and the mismatching conditions for parasitic currents) can be calculated.

In Fig. 7

E_s = terminal where the open circuit signal generator voltage acts in series with Z_s. (A current generator representation may, obviously, also be used.)

E_K = terminal where image frequency voltage appears.

E_4 = terminal where sum frequency voltage appears.

E_i = terminal where IF voltage appears, from which current in Z_i, i.e. emitter IF current, is found.

It should be noted that Z_s, Z_i, Z_K, and Z_4 are the total impedance of the circuit excluding the diode impedance, as seen from the diode terminals calculated at the respective frequencies at which each applies.

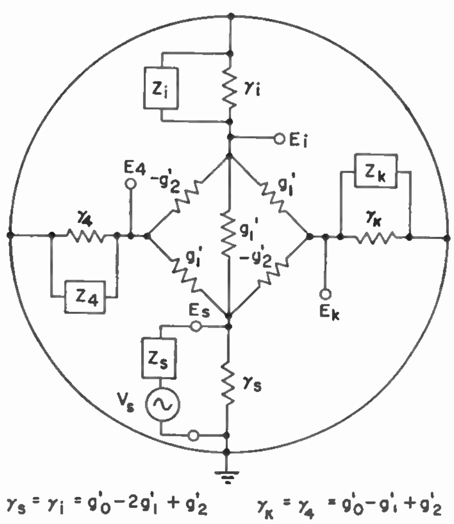

Fig. 7—Five-pole equivalent circuit for diode mixer including image and sum frequency impedances.

(c) *The C frequency range.* The emitter (reverse) capacitance which shunts r_e is important here. Its effect can approximately be taken into account in Fig. 5 by raising the curve near the origin and to the left of it by an amount equal to its reactance at the given frequency. This lowers G_1 as found from (16), hence reducing the conversion gain. In the limiting case the curve R = constant will be parallel to the voltage axis.

Operating Conditions

The dc input characteristics (Fig. 3) show emitter resistance of point-contact transistor to be considerably higher than the junction, which is generally true.

The higher emitter resistance in point contacts, and their reduced dependence on emitter current, results in the optimum dc emitter bias current being considerably larger. This fact is borne out in Fig. 6 for the P-1 point-contact transistor. Another result is that the optimum local oscillator voltage for a point-contact transistor will be at least twice that for junctions. In the latter case, often, little is gained by applying more than about 250 millivolts to the transistor at the local oscillator input. The reason for this is evident by inspection of Fig. 5. Fig. 8 shows a calculated curve for the J-3 junction, using the simplifying approximations stated (Appendix) for voltages below 120 millivolts.

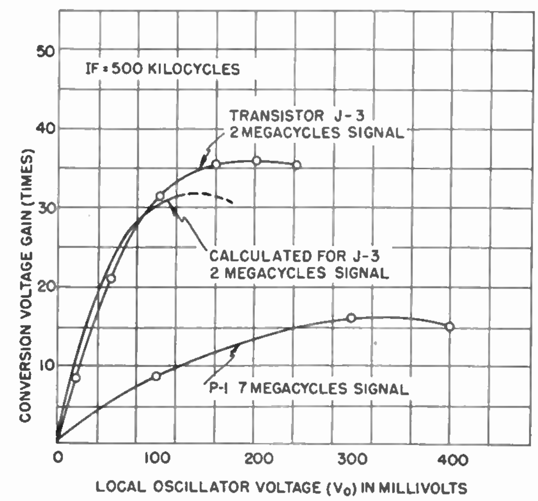

Fig. 8—Dependence of conversion voltage gain on local oscillator voltage for transistor mixers.

Conversion Gain

The concept of conversion transconductance, although easily defined, finds little use in transistors because of the comparatively low input and output impedances. A more usable quantity is the conversion gain defined as

$$\text{Conversion Gain} = \frac{\text{Available IF power from mixer}}{\text{Available power from signal source}}.$$

Thus the conversion gain is a function of the source resistance and can be calculated using the equivalent circuit of Fig. 7. Fig. 9 shows the experimental curves of conversion gain at 2 and 40 megacycles vs. signal source resistance (located in the base), for both the experimental P-1 point-contact and the J-3 junction transistors. It is seen that the matching impedance is not too critical. The IF frequency in Fig. 9 is 500 kilocycles.

The conversion gain of a transistor mixer at broadcast frequencies is, as expected, about 6 to 10 decibels lower than the gain of the transistor when used as an IF amplifier under the same bias conditions. Table I (next page) shows both IF amplifier gain and conversion gain for various transistors, at the frequencies indicated.

The large loss at 400 megacycles for junction transistors is largely ascribed to the emitter shunting capacitance of the C frequency range.

[5] The derivation for the equivalent circuit of Fig. 7 will be given in a forthcoming publication. If E_4 is grounded, Fig. 7 reduces to the equivalent circuit of E. W. Herold, R. R. Bush, and W. R. Ferris, "Conversion loss of diode mixers having image frequency impedance," Proc. I.R.E., vol. 33, p. 605; September, 1945.

TABLE I

Transistor	IF Amplifier Gain db at 500 kc	Conversion Gain in Decibels			
		2 mc	40 mc	100 mc	400 mc
Point Contact					
P-1	20	14	0	−1	−2
P-2	24	14	2	2	1
Junction					
J-2	24	17	2	−10	large loss
J-3	14	6	−8	large loss	large loss

Noise

Although at low frequencies the noise power spectrum of a transistor is described by the expression[6,7]

$$P(f) = \frac{K}{f^n}$$

where n is near unity, this law does not apply at rf frequencies and a rise in noise factor may be found.

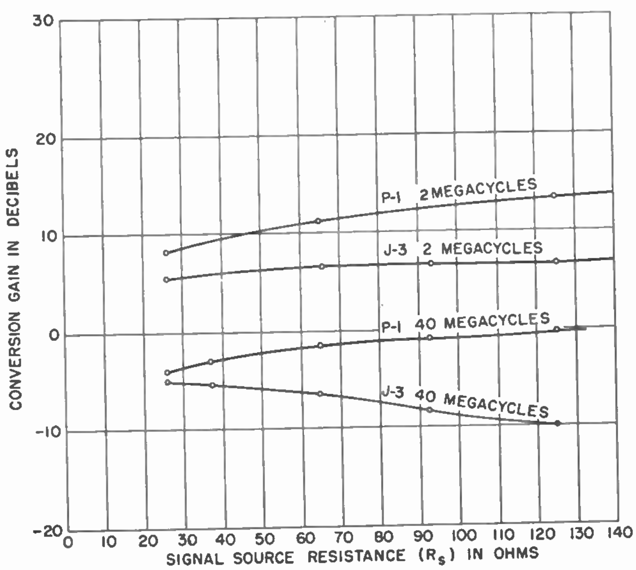

Fig. 9—Dependence of conversion gain on source resistance for transistor mixers.

In transistor mixers the output noise in the IF range can be ascribed to:

(a) noise originating in the signal source generator;
(b) noise associated with the emitter at IF frequencies;
(c) noise associated with the collector at IF frequencies;
(d) high-frequency noise converted by the mixer to IF frequencies.

Using a signal source resistance of 120 ohms in the base, the noise factor of various transistors used as IF amplifiers are compared in Table II with that of the same transistors used as mixers for the signal frequencies indicated. The IF frequency is 500 kilocycles with 15 volts dc on the collector for point contacts and 6 volts dc on the collector for junctions:

The collector voltages used are not the optimum values for low noise factor, which for junctions is closer to 1 volt. The following conclusions may be drawn:

(a) Since the noise figure for the point-contact transistor mixer remains fairly constant while the conversion gain decreases in the range 2 to 40 megacycles, a major portion of the noise in this frequency range appears to originate in the emitter.
(b) Since the noise factor for junction-transistor mixers rises with frequency while the conversion gain falls, the noise associated with the collector of junction transistors predominates.
(c) Junction-transistor mixers have a higher noise figure than point contacts at very high frequencies.

TABLE II

Transistor	N.F. of IF Amplifier in db at 500 kc	Conversion Noise Factor			
		2 mc	40 mc	100 mc	400 mc
Point Contact					
P-1	28	38	39	41	42
P-2	34	43	44	44	45
Junction					
J-2	10	22	39	44	51
J-3	10	24	39	44	51

Conclusions

The conversion ability of transistor mixers is dependent on the IF and signal frequencies. The IF frequency is limited to the region of amplification of the transistor. The signal frequency range is ultimately united by the capacitance which shunts the emitter when it is biased in the reverse direction.

Because transistors and crystal diodes are both semiconductor devices, it can be expected that the performance of a transistor mixer should be similar to that of a germanium diode followed by a transistor amplifier. The noise factor of a germanium diode mixer is often in the range of 10 to 15 decibels, while a conversion loss of 10 decibels is common. Thus at present, in the broadcast band a good junction transistor operated as a mixer easily equals, and in some cases may surpass, the performance of the germanium diode followed by the transistor amplifier with respect to noise and gain. However, in order to obtain a conversion gain with junction transistors at higher frequencies, a low base resistance and a low emitter barrier capacitance is required.

The point-contact transistor mixer, on the other hand, is capable of a conversion gain at frequencies at least as high as the VHF band. However, its noise factor is higher at present than the combination of a diode mixer and a junction-transistor amplifier.

[6] H. C. Montgomery, "Transistor noise in circuit applications," Proc. I.R.E., vol. 40, p. 1469; November, 1952.
[7] E. Keonjian and J. S. Schaffner, "An experimental investigation of transistor noise," Proc. I.R.E., vol. 40, p. 1457; November, 1952.

Appendix

From (1)

$$i_d \doteq Ae^{av_d} \quad \text{(a)}$$

where

$$a \equiv \frac{q}{kT}$$

(A is negligible compared to the dc bias current I_e.)

Substitute (17) and (18) into (a)

$$I_e + i_1 \cos (\omega_0 t + \phi_1) + i_2 \cos (2\omega_0 t + \phi_2)$$
$$= Ae^{a[V(t)-R_1 I_e - V_c)} = Ae^{-aV}e^{V(t)} \quad \text{(b)}$$

where

$$V \equiv V_c + I_e R_1 \quad \text{(c)}$$

and

$$V(t) \equiv V_0 \cos (\omega_0 t + \phi_0) - i_1 z_1 \cos \omega_0 t - i_2 z_2 \cos 2\omega_0 t. \quad \text{(d)}$$

Comparing Fourier coefficients in (b)

$$I_e = Ae^{-aV} \frac{1}{2\pi} \int_0^{2\pi} e^{V(t)} d(\omega_0 t) \quad \text{(e)}$$

$$i_n \cos \phi_n = Ae^{-aV} \frac{1}{\pi} \int_0^{2\pi} e^{V(t)} \cos n\omega_0 t d(\omega_0 t) \quad \text{(f)}$$

$$-i_n \sin \phi_n = Ae^{-aV} \frac{1}{\pi} \int_0^{2\pi} e^{V(t)} \sin n\omega_0 t d(\omega_0 t). \quad \text{(g)}$$

For a first-order approximation rewrite (d)

$$V(t) = (V_0 - i_1 z_1) \cos \omega_0 t \equiv V_2 \cos \omega_0 t \quad \text{(h)}$$

where

$$V_2 \equiv (V_0 - i_1 z_1).$$

Substitute (h) in (e), (f) and (g) to obtain

$$I_e \doteq Ae^{-aV} \cdot I_0(aV_2)$$
$$i_n = 2Ae^{-aV} \cdot I_n(aV_2)$$

where $I_n(aV_2)$ is the modified Bessel function of order n.

Acknowledgment

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Electromagnetic Shielding with Transparent Coated Glass*

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Summary—**Transmission of uniform plane waves at normal incidence through a multilayer transparent coated glass structure, with thin conductive layers, is investigated. Dependence of the degree of shielding obtainable on the type of construction, thickness and dielectric constant of the glass layers, and on the surface resistivity of the coating is studied from the standpoint of both analysis and design, and correlated with the resulting transparency. Dependence on frequency and, to some extent, reflection from the structure, are also investigated. Theoretical results are correlated with experimental data to show the applicability of this analysis to practical cases of more complex fields.**

Introduction

IN CERTAIN practical engineering applications, it is frequently desirable to isolate components of electrical equipment electromagnetically without the loss of visual access. Screened meshes constitute a partial solution only in some cases: they may not provide sufficient attenuation and they may limit visual access beyond the minimum requirements. One interesting possible solution to this problem consists of the use of conductively coated glass, recently developed for use in aircraft as windshields that may be easily deiced and de-fogged by a passage of current through the coating. There are at least three such coated glasses manufactured by different companies; these will be referred to in this paper as types A, B and C. The objective of this study was to investigate the possibilities with respect to the use of coated glass as effective transparent shields to radiation fields.[1] Some of the results of this investigation are here presented.

The shielding effectiveness is an ambiguous term which merits careful examination. When a discontinuity of any kind is inserted in a region in which there exists an electromagnetic radiation field, the resultant field may be conveniently separated into a reflected and a transmitted wave. The reflected wave may in turn alter the original "incident" field by reacting with its source and changing its radiation properties, or by the mechanism of multiple reflections in the region of the original incident wave. Similarly, the transmitted wave may, by the mechanism of multiple reflections from successive boundaries, cause further modifications in the field on

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[1] Shielding in the presence of induction fields is now under study as another phase of the project.

the incident side of the discontinuity. It is impossible to generalize the study of the effect of a shield under all types of boundary conditions. For metallic shields whose thickness is much larger than the depth of penetration, the degree of isolation of the two regions is large and a greater degree of generalization is possible.[2] The thickness of the conductive coating on glass, which is to retain appreciable transparency, is much smaller than the depth of penetration for wavelengths up to millions of megacycles. Any shielding theory for such a glass, particularly in multilayer construction, must take into account the interaction between the various regions of the coated glass structure and with the medium to follow.[3]

In view of the complexity of the over-all problem, the following specific problem will be investigated, the only one which may truly be generalized and which describes an inherent property of the coated glass structure itself. We shall be concerned with the total transmitted wave into an infinite homogeneous region (free space), through a parallel-plane coated glass structure, per unit of incident field, which will be assumed to be a uniform plane wave at normal incidence. This transmission will then be considered to measure the shielding effectiveness of the glass. Added effects of reflections beyond the coated glass structure, or a possible modification of the incident wave due to the presence of the glass, will, therefore, be ignored in the theoretical development. The inherent phenomenon of multiple reflections within coated glass structure will, however, be taken into account. It is hoped that this will provide a useful estimate of the effectiveness of coated glass under more complex field conditions; experimental evidence will be invoked to justify this hope.

General Expressions for a Multilayer Structure

Transmission line theory may be employed in the analysis of the propagation of a uniform plane wave through the general multilayer structure of Fig. 1, with each medium represented by an equivalent transmission line section, using the E-V and H-I analogy.[2] Furthermore, each coating may readily be shown to be representable by a shunting resistance, R_S, equal to the surface resistivity of the coating, to a very high degree of accuracy for all practical cases of appreciable shielding.[4,5] The transmission ratio,[6] P, defined as

$$P = E^i/E^t, \tag{1}$$

may be expressed for the structure of Fig. 1, using conventional transmission theory,[7] as follows:[8]

$$P = \frac{1+y}{2} \prod_n \left[\cos s_m + j \frac{\sin s_m}{\delta_m} \right]. \tag{2}$$

In (2) s_m is the thickness of the m-th dielectric in radians,

$$s_m = 2\pi \frac{t_m}{\lambda_m} = 2\pi \frac{t_m}{\lambda_0} \sqrt{k_m}, \tag{3}$$

where λ_m is the wavelength in the dielectric in centimeters, λ_0 is the wavelength in free space, k_m and t_m are the dielectric constant and the thickness in centimeters of the m-th dielectric, respectively. We may also write

$$f\lambda_0 = 30{,}000 \tag{4}$$

where f is the frequency in megacycles per second. Furthermore, δ_m in (2) is defined as

$$\delta_m = \frac{\sqrt{k_m}}{y_m} \tag{5}$$

where y_m is the output admittance of each dielectric, as indicated in Fig. 1, normalized to the admittance of free space of 1/377 mhos; y is the normalized input admittance of the entire structure. All y's are, in general, complex numbers, and j stands for $\sqrt{-1}$. Further analysis of this general case will not be presented here.[4]

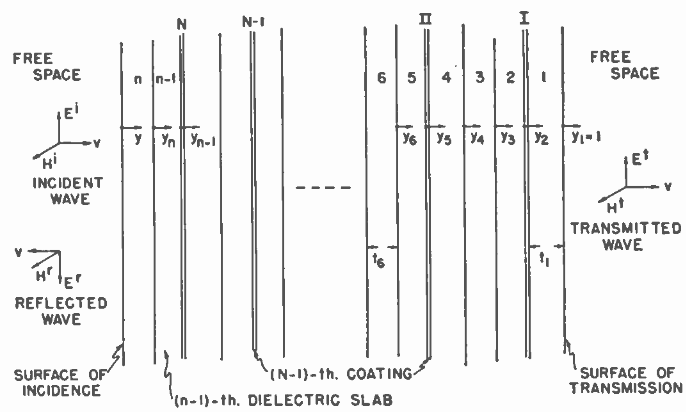

Fig. 1—General multilayer structure.

Transmission at Microwave Frequencies for Quarter-Wave and Half-Wave Thicknesses

We consider first the application of (2) to microwave frequencies where relatively large variation of s_m is practicable. It may be shown that minima and maxima of P occur for values of s_m which are integral multiples of $\pi/2$.[9] Consequently, sufficient information on shielding capabilities of coated glass is obtainable from the study of (2) under conditions of:[10]

[2] S. A. Shelkunoff, "Electromagnetic Waves," D. Van Nostrand Co., New York, N. Y. sec. 8.1; 1943.

[3] This is somewhat analogous to the conditions existing in the "Clogston Line" for suppression of skin effect (A. M. Clogston, "Reduction of skin effect losses by use of laminated conductors," *Bell. Syst. Tech. Jour.*, vol. XXX, pp. 491–529; July, 1950), but the nature of the problem here is quite different.

[4] Moore School of Elec. Eng., University of Pennsylvania, Research Division Report no. 53-11, "Investigation of the Shielding Properties of Conducting Glass," Appendix I; September, 1952.

[5] Note that if the thickness of the coating is much larger than the depth of penetration, the equivalent transmission line-section for the coating will be a long line rather than a lumped resistance; consequently the two regions will be isolated electromagnetically and the problem reduced to shielding theory of reference (2).

[6] Note that the conventional transmission coefficient, p, is just the reciprocal of P. Shelkunoff, op. cit., sec. 7.13.

[7] A. B. Bronwell and R. E. Beam, "Theory and Application of Microwaves," McGraw-Hill, New York, N. Y., sections 8.00–8.09; 1947.

[8] The dielectrics are assumed dissipationless, an excellent approximation for all present commercial coated glass up to 10,000 mc.

[9] Moore School of Elec. Eng., loc. cit., Appendix II.

[10] A combination of the two cases is also considered in reference (5) section V, but the slight improvement in over-all shielding, that is possible by these modifications, does not warrant complicating the development in this paper by their inclusion here.

first: all s_m equal to π; this defines P' in (2)
second: all s_m equal to $\pi/2$; this defines P'' in (2).

We immediately pass to the simplified structure of Fig. 2, applicable to type C glass, having low surface resistivities and capable, therefore, of more effective shielding applications.[11] In this configuration single, identical dielectrics separate the N individual coatings. The transmission P then becomes:

$$P' = 1 + Ng/2 \tag{6}$$

$$P'' = \frac{g^N}{2(\sqrt{k})^N}\left[\Pi_N + \frac{1}{g}\Pi_{N-1}\right] \tag{7}$$

where: $g = 377/R_S$ is the equivalent, normalized admittance of the coating, having a surface resistivity of R_S ohms per square; k is the dielectric constant of the dielectric (glass); and:

$$\Pi_N = (1 + x_0)(1 + x_1)(1 + x_2) \cdots (1 + x_N) \tag{8}$$

$$x_0 = 0;\ x_1 = \frac{k}{g};\ x_2 = \frac{k/g^2}{1 + x_1};\ \cdots\ x_N = \frac{k/g^2}{1 + x_{N-1}}. \tag{9}$$

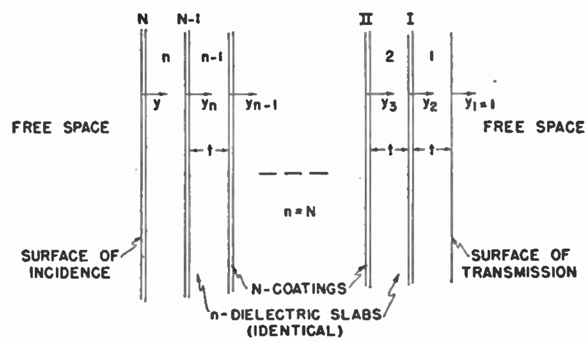

Fig. 2—Simplified configuration.

The functions P' and P'' depend on the three parameters: g, N, and k. The nature of this dependence is shown in Fig. 3, where P' and P'' are plotted as functions of $1/k$ for several values of N and R_S (i.e. g). It is apparent that shielding is always improved by lowering R_S (increasing g). This dependence is further illustrated by Fig. 4 where P' and P'' are plotted as functions of R_S for several N, for k assumed equal to 6.5 (type C coated glass at 10,000 mc). It is clear from both Fig. 3 and Fig. 4 that increasing N increases shielding effectiveness, particularly for quarter-wave sections. For $N>1$ considerable increase in shielding results from making the sections quarter-wave rather than half-wave, particularly for higher N. For $N=1$ the half-wave section is superior. Dependence on k is treated below.

Approximate Transmission at Low-Surface Resistivities

The shape of curves on Figs. 3 and 4 suggests that for

$$g^2 \gg k, \quad \text{or} \quad R_S \ll 377/\sqrt{k} \tag{10}$$

the expression for P'' may be greatly simplified. In practice (10) represents the useful limit on R_S, since, for appreciable shielding, glass with low value of R_S should be employed. Under these conditions, the factors $(1+x_m)$ in (8) become nearly unity for $m=2, 3, \cdots$ and the expression (7) reduces, approximately, to:

$$P'' \cong \frac{g^N}{2(\sqrt{k})^N}\left(1 + \frac{k}{g}\right). \tag{11}$$

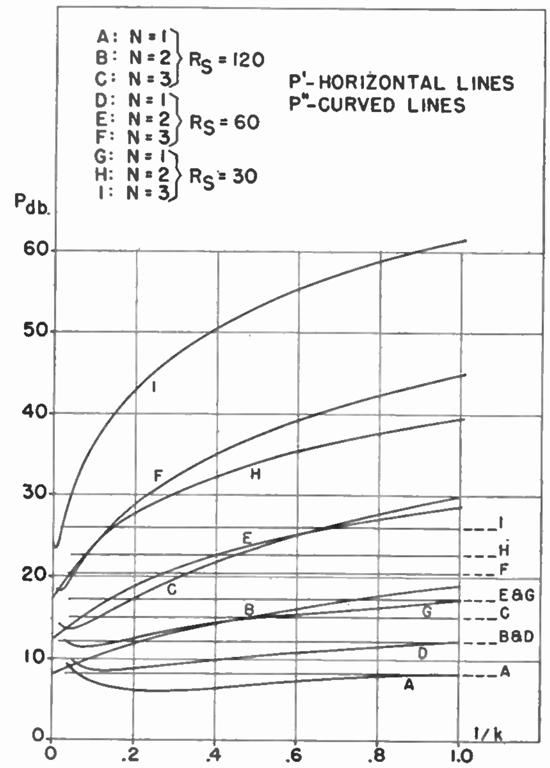

Fig. 3—Plot of P' and P'' vs. $1/k$ for several R_S and N (Fig. 2 configuration).

Dependence on the Dielectric Constant[12]

Figs. 3 and 4 indicate an increase of shielding with *decreasing* k, provided that the thickness is maintained constant in radians, i.e., is increased (3) as k is *decreased.* This may, of course, be objectionable, for reason of reduced transparency. A more meaningful optimization would result, if the over-all dimension, D, as well as surface resistivity, were kept fixed. Then, if quarter wave construction is adopted,[13] an *increase* of k permits a greater number of sections (greater N), while the shielding effect of each section is decreased. The reverse is true for smaller k. Clearly, there are then two opposing tendencies, and a specification of an optimum value of k should be possible. It will now be demonstrated that over-all improvement is obtained in practice by making k as large as possible.

It will be sufficient to consider the approximate expression (11) for P''. Since $s = \pi/2$, then for constant $D = Nt$ we have, from (3), that at any frequency

[11] A more complicated study of the general case, applicable to type A and type B coated glasses, is made in reference (5).

[12] Similar analysis, made in reference (5) for the structure applicable to type A coated glass, leads to the same conclusions as in this section for type C coated glass.

[13] This construction, as seen from Figs. 3 and 4 will result in greater shielding, except for $N=1$. Note, furthermore, that k has no effect on shielding for the half-wave construction.

$$\frac{N}{\sqrt{k}} = \frac{4D}{\lambda_0}. \tag{12}$$

Consequently (11) becomes

$$P'' = 1/2(g/\sqrt{k})^{(4D/\lambda_0)\sqrt{k}}\left(1 + \frac{k}{g}\right). \tag{13}$$

Neglecting the $(1+k/g)$ term in (13) for small k, taking the Napierian logarithm of both sides, and differentiating with respect to $\sqrt{k}$, we have:

$$\frac{d}{d\sqrt{k}} \ln P'' = \frac{4D}{\lambda_0}\left[\ln \frac{g}{\epsilon} - \ln \sqrt{k}\right]. \tag{14}$$

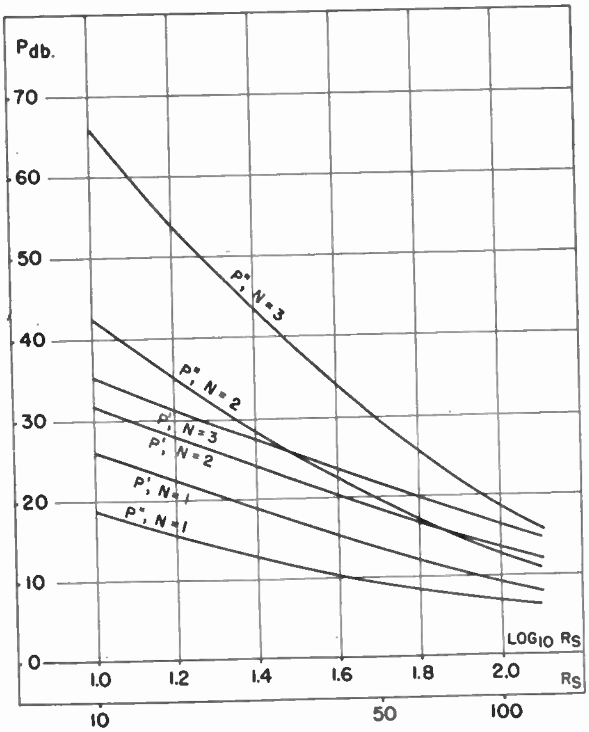

Fig. 4—Plot of P' and P'' vs. $\log_{10}R_S$ for several N (Fig. 2 configuration for $k=6.5$).

In (14) $\epsilon=2.71.\ldots$ Since we have assumed $R_S<100$ ohms, g is larger than ϵ and (14) is positive as k is increased from unity. P'' reaches a maximum at approximately:

$$k = k_c = (g/\epsilon)^2. \tag{15}$$

The optimum value of N is therefore, from (12)

$$N = N_c = \frac{4Dg}{\epsilon\lambda_0} \tag{16}$$

with D adjusted so that N_c is an integer. Under these conditions P_c'' becomes, in decibels:

$$P_{c_{db}}'' = 12.75\frac{gD}{\lambda_0} + 20\log_{10}\left(1/2 + \frac{g}{14.8}\right). \tag{17}$$

Note from (12), (15), and (16) that

$$N/N_c = \sqrt{k/k_c} \tag{18}$$

with D chosen so that N is an integer.

In applications where appreciable shielding is required, coatings having g of the order of 10 or more are desirable ($R_S \leqq 40$ ohms per square). Consequently, the optimum value of k, k_c of (15), is higher than that obtainable with practical glass. A useful criterion with large g for highest shielding with maximum transparency is, therefore, to select k as large as possible. As a typical illustration, consider type C coated glass of $g=13.6$ (or 5ϵ), corresponding to $R_S=27.7$ ohms per square, and $k=6.25$ at X-band ($\lambda_0=3$ cm). If an over-all D' is selected, for transparency reasons, to be, say, $0.3\,\lambda_0$ (or 3/8″), discussed below, then we calculate from (12), (15), (18): $N=3$, $k_c=25$, $N_c=6$. The optimum P_c'' would be from (17), 55 db, if glass having $k=25$ were available. The actual P'' for $k=6.25$ is, from (13), only 41.4 db. Use of higher-k glass would reduce this "loss" of 13.6 db of potential shielding still further.

Transparency vs. Shielding

It is now possible to formulate the problem of design by correlating the conclusions of the preceding sections with respect to shielding, with the data on the over-all transparency of the structure. This will be done for a typical type C coated glass of relatively high value of g, using glass of high dielectric constant at microwave frequencies and low dissipation, such as Corning plate glass ($k=6.5$). In practical application of transparent coated glass the upper limit on expected shielding is fixed by the requirement of transparency. The loss of transparency is due to two distinct effects: over-all thickness of the dielectric (glass) and the thickness and number of coatings. While the exact mathematical formulation of this loss of transparency is unwieldy, an approximate expression in the useful range is possible as a guide in design. The upper practical limit of coating thickness μ in hundredths of mils is about $\mu=4$; above that loss of transparency per coating increases rapidly. The lower limit from the standpoint of ease of manufacture and for appreciable shielding property is about $\mu=1$. Within this range the following approximation may be employed. The coating thickness is very nearly directly proportional to surface conductivity (i.e., the coating has a constant volume resistivity). The loss of transparency through each coating may be considered to be, roughly, proportional to the coating thickness. Furthermore, the loss of transparency through the glass may be taken as very nearly proportional to over-all thickness. Letting L denote the per cent loss of transparency, we may write for the structure of Fig. 2, approximately:

$$g = a\mu \tag{19}$$

$$L = b\mu N + ctN, \qquad 1 \leqq \mu \leqq 4. \tag{20}$$

For half-wave and quarter-wave construction, respectively, (20) becomes: ($k=6.50$)

$$L' = b\mu N + cN\lambda_0/5.1 \tag{21}$$

$$L'' = b\mu N + cN\lambda_0/10.2. \tag{22}$$

For type C coated glass a is approximately equal to (19) (corresponding to $R_S=20$ ohms per square for the 0.01

mil coating), while b and c may be taken as 2 per cent per hundredth of mil of coating and 10 per cent per centimeter of glass. The corresponding expressions for the transmission ratios, P's, and transparency loss factors, L's, then become:

$$P' = 1 + 9.5\mu N \tag{23}$$

$$P'' = \left(\frac{1}{2} + \frac{.17}{\mu}\right)(7.4\mu)^N \tag{24}$$

$$L' = 2N(\mu + \lambda_0) \tag{25}$$

$$L'' = 2N(\mu + \lambda_0/2). \tag{26}$$

The functions (23)–(26) are plotted on Fig. 5 for the X-band ($\lambda = 3$), as functions of μ, for $N = 1$, 2, 3, and 4.

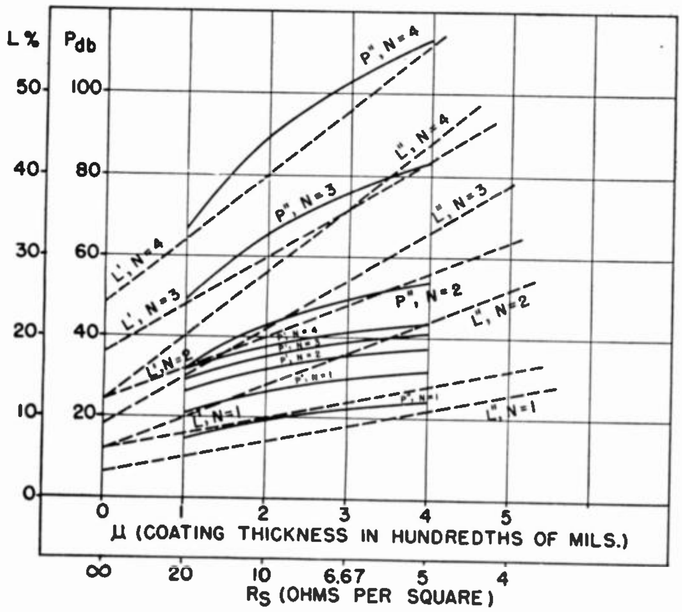

Fig. 5—Plot of P' and P'', and L' and L'' (approximate) vs. thickness of coating (approximate) for several N (Fig. 2 configuration for $k = 6.5$).

The general trend of the P and L curves is significant rather than the absolute values of the L and μ scales. In applications involving other types of glass, having different values of a, b, and c in (19) and (20), one needs merely to change the scales of μ and L and the slopes of the L lines in an appropriate fashion. The design procedure is as follows: draw a horizontal line corresponding to the maximum tolerable loss of transparency, L. The intersection with the corresponding L' and L'' lines specify the maximum μ's for corresponding N's. For each of these, the expected shielding may then be obtained from the corresponding P' and P'' curves. An optimum construction may thus easily be obtained.

Reflection

The reflection ratio, Q, defined with reference to Fig. 1 in a manner analogous to (1), as

$$Q = E^i/E^r \tag{27}$$

may be obtained from the transmission ratio P and the losses of each coating by the use of the Poynting's Theorem,[14] but this procedure is somewhat complicated. No simple formula, such as the one applicable to uncoated lossless dielectrics, i.e.,[15]

$$\frac{1}{Q^2} = \frac{1}{P^2} - 1 \tag{28}$$

applies here. An alternative expression for Q, more easily adaptable to situations where the approximation (10) is applicable, may be derived directly from transmission theory as:[16]

$$Q = \left|1 + \frac{2}{y - 1}\right| \tag{29}$$

where y is the over-all normalized input admittance, as defined previously in Fig. 1. For low surface resistivities defined by (10), for the configuration of Fig. 2, this reduces to:

$$Q = 1 + 2/\eta \tag{30}$$

$$\eta = Ng \text{ for half-wave sections} \tag{31}$$

$$\eta = g + (k - 1) \text{ for quarter-wave sections, } N = 1, \tag{32}$$

$$\eta \cong g - 1 \text{ for quarter-wave sections, } N > 1. \tag{33}$$

Several interesting conclusions may be drawn from the comparison of reflection and transmission ratio. Space does not permit further elaboration here.

Dependence on Frequency

Frequency dependence of the transmission ratio P is caused by the variation of the dielectric relative thicknesses, s_m, with frequency in (3). Since y_m also depends on s_m, the over-all effect of frequency on P is, in general, extremely complex. Fortunately, as stated heretofore, maxima and minima of P with respect to the s_m's (or frequency) occur at quarter- and half-wave thicknesses of the dielectrics. These P' and P'' functions, considered above, represent therefore the limiting conditions with respect to frequency. Between these extremes values approximate interpolation between corresponding P' and P'' curves may be employed or the exact expression (2) used.

At lower uhf and upper vhf frequencies further simplification is possible. At wavelengths larger than 30–50 cm the value of s_m becomes a small fraction of π radians, if a reasonable upper limit is placed on the thickness of the glass sections. Under these conditions, it is no longer meaningful to speak in terms of half-or quarter-wave sections, and (2) for P may be reduced to a much simplified general form. We limit our discussion here to the configuration of Fig. 2. The following discussion applies to frequencies sufficiently low, so that $s \leqq \pi/10$, or, by (3) and (4), for

$$f \leqq f_c = \left(\frac{600}{t}\right)\sqrt{6.5/k}. \tag{34}$$

[14] Moore School of Elec. Eng., *loc. cit.*, sec. XII.
[15] Shelkunoff, *op. cit.*, sec. 7.13.
[16] Bronwell and Beam, *op. cit.*, p. 164.

The variation of P with frequency is shown on Fig. 6 for the type C coated glass (dielectric = plate glass of $k=6.5$), where P in decibels is plotted against tf on a logarithmic scale for several N and R_S. In the frequency range whose upper limit is fixed by (34) and whose lower limit is given by:

$$\sqrt{k}/g \ll s \tag{35}$$

or, using (3) and (4), by

$$(8/g)(600/t) = f' \ll f, \tag{36}$$

the following approximate expression for P may be derived:[17]

$$P \cong 1/2g^N\sigma^{N-1} \tag{37}$$

where

$$\sigma = s/\sqrt{k} = 2\pi t/\lambda_0 = 2\pi ft/30{,}000. \tag{38}$$

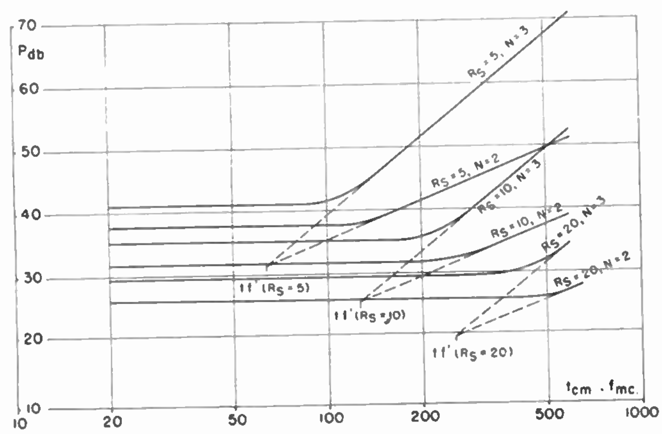

Fig. 6—Variation of P with frequency in the vhf and low uhf range, for several N and R_S (Fig. 2 configuration).

Clearly, this "intermediate" frequency range exists for materials of high g (i.e., R_S of the order of 10 ohms per square or less), and for $N>1$. At still lower frequencies the expressions for P reduce very nearly to (6) for the half-wave sections, i.e., for sections of thickness which is a multiple of half-wave, including zero, in radians, and become independent of frequency. For $N=1$, and for $R_S>20$ ohms per square, approximately, these "lower" frequency asymptotic values of P are reached immediately at the frequency of (34). While the upper frequency, f_c, of (34) depends on k, the frequency f' (36), dividing the two regions of (37) and (6), and the expressions (37) and (6) for P in these two regions, are all independent of k. This represents an interesting extension that P' in (6) was independent of k.[17]

Experimental Data

A limited number of experimental data was obtained at 10,000 mc and 500 mc for several samples of type A coated glass and type C coated glass of various thicknesses and construction, to support some of the conclusions of this paper. The limits of experimental error were ascertained to be of the order of 2 to 3 db. The dielectric constant of type A glass was presumed to be 4.5 at 10,000 mc. The surface resistivity of the type A coating was taken as 90 ohms per square, known only to about ±10 per cent. To facilitate experimental investigation and improve accuracy it was found desirable to measure the relative transmission ratio, T, rather than P, defined as:

$$T = P/\hat{P} \tag{39}$$

where $\hat{P}$ is the transmission ratio for an identical uncoated structure ($R_S=\infty$).[18] The theoretical expressions for T, corresponding to each P, were therefore determined and compared with experimental results. These are summarized on Table I below for typical conditions.

TABLE I
Comparison of Experimental Results with Theory

Sample	Frequency Megacycles	Experimental T_{db}	Theoretical T_{db}
Type A Construction No. 2	10,000	8.5	6.6
Type A Construction No. 3	10,000	15.0	15.2
Type C Construction No. 1	10,000	18.5	20.8
Type C Construction No. 2	10,000	41.5	48.2
Type A Construction No. 3	2,500	15.0	17.24
Type C Construction No. 1	2,500	13.0	14.8
Type C Construction No. 3	2,500	33.0	35.4
Type B Construction No. 1	500	24.0	24.5
Type C Construction No. 1	500	10.0	14.2
Type C Construction No. 2	500	26.0	29.1

Conclusions

It appears that transparent coated glass shows considerable promise as a means of shielding electrical components at high frequencies where transparency is desirable. Judicious design for a particular application of a given maximum tolerable loss of transparency may result in attenuations as high as 40 or 60 db through the glass, particularly if improvements are sought in the manufacture of coated glass, aimed at lower surface resistivities for the same transparency. Theoretical results of this paper for uniform plane waves at normal incidence seem quite well applicable to actual conditions involving more complex fields. Thus, it appears that the development in this paper may be employed with some success as a basis for analysis and for design of coated glass configurations in practical shielding applications.

Acknowledgements

The author is indebted to Messrs. R. F. Schwartz, D. B. Geselowitz, and P. P. Lombardini, of the Moore School Staff, for their aid in obtaining some of the experimental data. Co-operation of the Corning Glass Co., Corning, N. Y., in supplying samples of and information on coated glass is gratefully acknowledged.

[17] Moore School of Elec. Eng., *loc. cit.*, sec. XI and Appendix III.

[18] $\hat{P}$ is usually a very small number of decibels. Space does not permit the listing here of all the corresponding expressions for the T's. These, however, may be derived on the basis of the development of this paper.

IRE Standards on Circuits: Definitions of Terms in the Field of Linear Varying Parameter and Nonlinear Circuits, 1953*

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Amplitude Distortion. See **Amplitude-Frequency Distortion, Waveform-Amplitude Distortion** and **Harmonic Distortion.**

Amplitude-Frequency Distortion. Distortion due to an undesired amplitude-frequency characteristic.

Note 1—The usual desired characteristic is flat over the frequency range of interest.

Note 2—Also sometimes called *Amplitude Distortion* or *Frequency Distortion.*

Delay Distortion. That form of distortion which occurs when the rate of change of phase shift with frequency of a circuit or system is not constant over the frequency range required for transmission.

Distortion. An undesired change in waveform.

Frequency Distortion. See **Amplitude-Frequency Distortion.**

Fundamental Component. The fundamental frequency component in the harmonic analysis of a wave.

Fundamental Frequency. The reciprocal of the period of a wave.

Harmonic. A sinusoidal component of a periodic wave.

Harmonic Distortion. Nonlinear distortion characterized by the appearance in the output of harmonics other than the fundamental component when the input wave is sinusoidal.

Note—Also sometimes called *Amplitude Distortion.*

* Reprints of this Standard, 53 I.R.E. 4. S1 may be purchased while available from the Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y., at $.25 per copy. A 20 per cent discount will be allowed for 100 or more copies mailed to one address.

Limited Stability. A property of a system characterized by stability when the input signal falls within a particular range and by instability when the signal falls outside this range.

Linear Varying-Parameter Network. A linear network in which one or more parameters vary with time.

Nonlinear Distortion. Distortion caused by a deviation from a desired linear relationship between specified measures of the output and input of a system.

Note—The related measures need not be output and input values of the same quantity; e.g., in a linear detector the desired relation is between the output signal voltage and the input modulation envelope.

Nonlinear Network (Circuit). A network (circuit) not specifiable by linear differential equations with time as the independent variable.

***N*th Harmonic.** The harmonic of frequency N times that of the fundamental component.

Phase Distortion. See **Phase-Frequency Distortion.**

Phase-Frequency Distortion. Distortion due to lack of direct proportionality of phase shift to frequency over the frequency range required for transmission.

Note 1—*Delay Distortion* is a special case.

Note 2—This definition includes the case of a linear phase-frequency relation with the zero frequency intercept differing from an integral multiple of π.

Waveform-Amplitude Distortion. *Nonlinear Distortion* (q.v.) in the special case where the desired relationship is direct proportionality between input and output.

Note—Also sometimes called *Amplitude Distortion.*

RC Active Filters*

J. G. LINVILL†, ASSOCIATE, IRE

Summary—**Inductorless filters are attractive for numerous practical reasons. Passive RC filters, however, suffer from the defects of high in-band loss and poor economy of elements. These defects are overcome in active RC filters in which amplifying elements supply power to the filter in addition to that applied by the signal. A class of active filters is described in which one active component, a transistor negative-impedance converter, is employed. Simple unbalanced network configurations are obtained in which the number of capacitors in the RC circuits is equal to the total number of reactive elements in the corresponding LC filter. The ultimate limit in performance in this class of active filters is the drift in the converter. The drift in input impedance in converters employing Darlington's compound transistors is only a few tenths of a per cent of the load impedance for a wide range of loads. Such stability is more than adequate for many practical filter applications. The theory of this type of active RC filters is discussed and experimental tests are reported on low-pass, high-pass and band-pass filters.**

Introduction

THE USE of only resistive or capacitive elements in filters is attractive on the grounds that usually these elements are cheaper, simpler, and more nearly ideal elements than are inductors. Passive RC filters, though they have been applied for some purposes, suffer from two defects: they introduce loss in the pass band, and, because of restrictions on impedance functions realizable with R's and C's only, the network complexity of RC filters to meet a given filter specification is ordinarily much greater than that of an equivalent RLC filter. These defects may be overcome by using active elements in addition to R's and C's. One type of active RC filter employing a stabilized amplifier as the active element has been proposed by Dietzold.[1] Bangert of Bell Telephone laboratories has successfully built several filters of this type employing transistor amplifiers. In this paper a different kind of filter is described in which the active element is a negative-impedance converter using transistors. A negative-impedance converter[2] is an active four-pole which presents at either of its terminal pairs the negative of the impedance connected to the other terminal pair. A negative-impedance converter has voltage-current relationships for its terminal pairs exactly like those of an ideal one-to-one transformer except for a polarity reversal in the voltage transformation ratio. RC filters employing negative-impedance converters (called simply *converters* hereafter) can be constructed to provide characteristics corresponding to those of the usual types of RLC filters using only as many capacitors in the RC circuit as the sum of reactive elements in the RLC circuit. Moreover, simple network configurations are required; unbalanced forms giving a common ground connection can be obtained. The pass-band losses are reduced by the active portion; in fact, in some circuits gains are obtained.

* Decimal classification: R143.2. Original manuscript received by the Institute, July 6, 1953; revised manuscript received September 16, 1953. The principal results given in this paper were presented by the author at the National Electronics Conference, Chicago, Ill., on September 29, 1953, under the title "A New RC Filter Employing Active Elements."

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[1] R. L. Dietzold, U. S. Patent 2,549,065, April 17, 1951.

[2] J. G. Linvill, "Transistor negative-impedance converters," Proc. I.R.E., vol. 41, pp. 725–729; June, 1953.

Theory of Operation and Design

The transfer functions of filters employing lumped elements are rational functions of frequency. Accordingly one writes as the transfer impedance of a filter

$$Z_T(p) = \frac{N(p)}{D(p)}. \tag{1}$$

The denominator polynomial has zeros at complex frequencies which are the natural frequencies of the circuit. In passive RC circuits these zeros are restricted to the negative real axis of the complex frequency plane, and this constraint seriously limits the quality of approximation to an ideal filter characteristic which one can make using polynomials of a limited degree for N and D. Active RC circuits can have natural frequencies anywhere in the left-half plane, the same restriction applying to passive RLC filters. For the active RC filter of Fig. 1, one obtains for the transfer impedance by a straightforward analysis,

$$\left.\frac{E_2}{I_1}\right|_{I_2=0} = Z_{21} = \frac{Z_{12a}Z_{12b}}{Z_{22a} - Z_{11b}}. \tag{2}$$

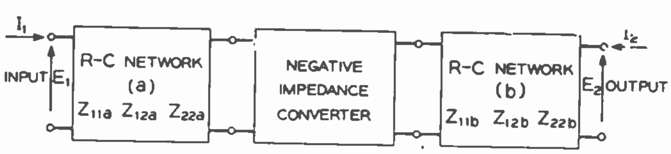

Fig. 1—RC active filter.

In (2), Z_{12a} and Z_{12b} are the transfer impedances of networks a and b; Z_{22a} and Z_{11b} are their driving-point impedances from the terminal pairs connected to the negative-impedance converter.

The zeros of N of (1) are associated with the structure of the filter, not with its natural frequencies. For instance, ladder networks have zeros of transfer impedance at frequencies where shunt elements become short-circuits or frequencies where series elements become open-circuits. Thus, an RC ladder with three shunt capacitors with resistances in the series arms possesses three zeros of transfer impedance at infinity (where the capacitors are short circuits), irrespective of the element values or natural frequencies. Lattices, bridged-T networks and twin-T networks possess zeros of transmission at frequencies where a bridge-like balance occurs, independent of the location of natural frequencies of the complete network.

The principle of design of an RC active filter is simply this: for a transfer impedance (1) prescribed within a constant multiplier, the zeros of $D(p)$ are selected as the natural frequencies of the complete structure of Fig. 1. From this, by a method to be described, are obtained the driving-point impedances of structures a and b, Z_{22a} and Z_{11b}. Lastly, in the realization of the RC circuits, the structure form is selected to provide zeros of transmission at required frequencies, zeros of $N(p)$.

To illustrate the procedure it is convenient to describe the design of an active RC filter with a low-pass Butterworth characteristic and an attenuation level of 18 db/octave, cut-off occurring at 1,000 cps. For such a characteristic, the poles of the transfer impedance (zeros of $D(p)$) are known to fall on a semi-circle as shown in Fig. 2(a). The three zeros of transfer impedance all fall at infinity and $N(p)$ is a constant. The natural frequencies of the network to be designed must be at the complex frequencies noted on Fig. 2(a). If one breaks any loop of a network and determines the impedance between the terminals thus created, it is zero at the natural frequencies of the network. For Fig. 1 with attenuation on the loop at the input of the converter, natural frequencies occur where

$$Z_{22a} - Z_{11b} = 0. \tag{3}$$

The poles of the function of (3), must, by the nature of RC networks, fall singly on the negative real axis of the frequency plane. One can now pick three points on the negative real axis [σ_1, σ_2, σ_3, see Fig. 2(b)] and identify these as the poles of $Z_{22a}-Z_{11b}$. Hence, one has

$$Z_{22a} - Z_{11b} = \frac{D(p)}{(p-\sigma_1)(p-\sigma_2)(p-\sigma_3)}. \tag{4}$$

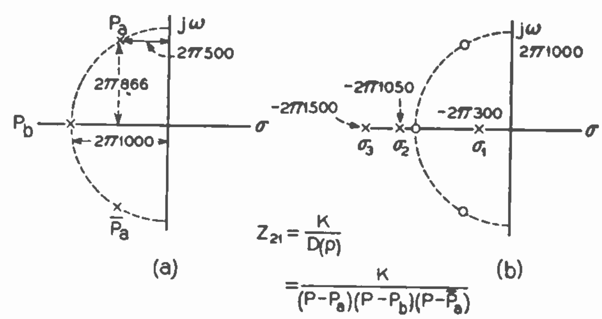

Fig. 2—Frequency-plane distributions of poles and zeros.

The selection of σ_1, σ_2, and σ_3 is arbitrary as far as the transfer impedance of the filter is concerned (of course, none of these three values should coincide with any zero of $D(p)$. As will be seen, the driving-point impedance and other characteristics are influenced by the selection. In expanding $Z_{22a}-Z_{11b}$ in partial fractions one finds that the residues are always real, but may be positive or negative. It is well known that any function with simple poles on the negative real axis and positive real residues in those poles is the driving-point impedance of an RC network. Hence in the partial fraction expansion of (4), if one groups together all terms with positive residues and groups all terms with negative residues, the first group should be associated with Z_{22a}, the second group with Z_{11b}. Finally, one makes a Cauer[3] synthesis

[3] E. A. Guillemin, "Communication Networks," vol. II, p. 213, John Wiley & Sons, New York, N. Y.; 1935.

of RC ladders with capacitor shunt elements and the filter synthesis is complete. For the critical-frequency distributions shown in Fig. 2, the network form will be that shown in Fig. 3(a). That this is the correct form of the filter can be understood by observing from the distribution of poles of $Z_{22a}-Z_{11b}$ in Fig. 2(b) that the residues in the poles at σ_1 and σ_2 are positive, while the residue in the pole at σ_3 is negative. The constant K and the partial fractions associated with the poles at σ_1 and σ_2 are accordingly identified with Z_{22a} and the partial fraction associated with the pole at σ_3 is identified with $-Z_{11b}$. The network synthesizes to realize Z_{22a} and Z_{11b} accordingly require two and one capacitors, respectively, as indicated in Fig. 3(a), which gives element values for a filter of this type. The plot of the measured transfer characteristic is shown in Fig. 3(b), along with a few calculated points of the characteristic.

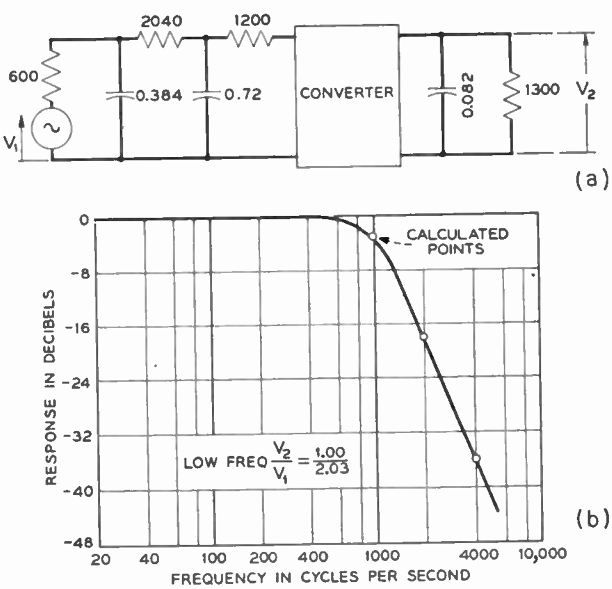

Fig. 3—Network and characteristic of active filter with Butterworth characteristic.

The synthesis of active filters employing RC ladder networks and providing high-pass or band-pass characteristics follows precisely the same pattern illustrated by the low-pass design except for the fact that the RC structures have capacitors in the series arms for the high-pass case in both series and shunt arms in the band-pass case. Fig. 4 illustrates typical pole-zero locations for high- and band-pass filters along with corresponding network configurations which are obtained.

The filters illustrated so far are all of the ladder type, and all of the zeros of transmission occur at zero or infinite frequency. With simple RC ladders, it is impossible to obtain zeros of transmission at a real frequency between zero and infinity. However, internal zeros of transmission are produced with RC lattice structures, or unbalanced equivalents to the lattice, bridged-T, or twin-T structures. The synthesis of filters to provide internal points of infinite attenuation proceeds as has been described for the ladder types

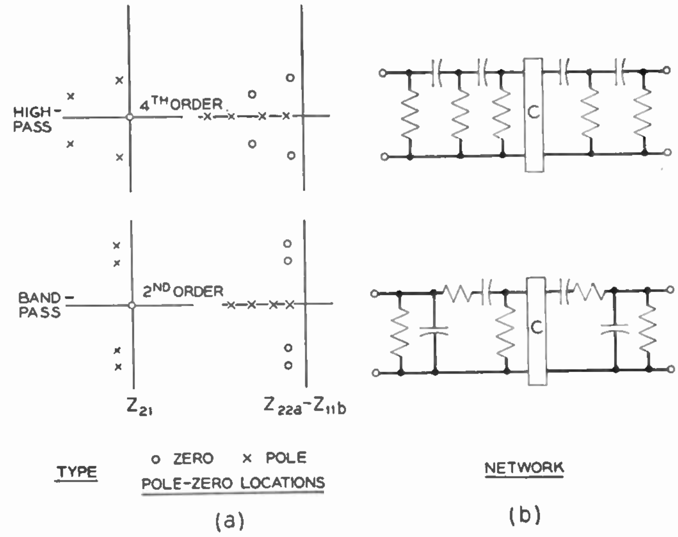

Fig. 4—Pole-zero locations and network configurations of H-P and B-P filters.

through the specification of transfer impedance, the selection of $Z_{22a}-Z_{11b}$, and the evaluation of Z_{22a} and Z_{11b}. At this point the driving-point impedances of the RC networks have been selected, and the frequencies at which these networks should introduce zeros of transmission are known. For the lattice structure (Fig. 5), the driving-point impedance is

$$Z_{11}=Z_{22}=\frac{Z_a+Z_b}{2}=\frac{n(p)}{d(p)}. \tag{5}$$

Further, the transfer impedance is

$$Z_{12}=\frac{Z_b-Z_a}{2}=\frac{t(p)}{d(p)}. \tag{6}$$

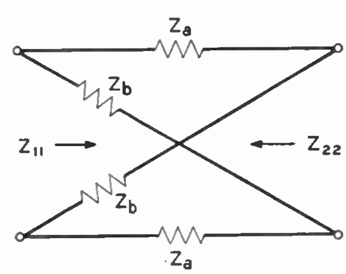

Fig. 5—The lattice structure.

Knowing the driving-point impedance for each of the RC networks, Z_{22a} or Z_{11b}, one can associate with each of networks a and b the appropriate number of factors of $N(p)$ [see (2)], thus obtaining the transfer impedance of each within a constant multiplier. For the case in which an RC network is to be a lattice, Z_a and Z_b can be found through (5) and (6) as follows: Z_{12} is specified with an undetermined constant multiplier and then Z_{11} is added to Z_{12} to obtain Z_b, Z_{12} subtracted from Z_{11} to find Z_a. Finally, the largest constant multiplier of Z_{12} is selected to permit Z_a and Z_b to still be realized as RC networks.[4,5] Instead of employing the physical networks in the lattice form it is ordinarily preferable to seek by well-known means an unbalanced equivalent network.

The technique of designing networks in the general lattice form and then subsequently finding an unbalanced equivalent is a familiar one, but it suffers from the defect that it is difficult, if not impossible, to predict the nature of the unbalanced equivalent circuit from the form of the lattice. An alternate, less general but possibly more practical technique, is to constrain the nature of the lattice to a form which has a practical equivalent (a twin-T requiring only three capacitors and three resistors, for instance) and carry through the synthesis on this basis. This technique is satisfactory for the RC filter case because inherent in the synthesis method employed is a latitude in the choice of the poles of $Z_{22a}-Z_{11b}$, and this latitude can be exchanged for a constraint in the form of the unbalanced equivalent. A later example will illustrate this in detail.

The synthesis procedure described in the foregoing to obtain an RC active filter with prescribed pole and zero locations for its transfer impedance is complete, but it does not lead to a unique network because of the latitude in the choice of poles of $Z_{22a}-Z_{11b}$. Different networks can be found which have the same poles and zeros of transfer impedance and hence the same filtering properties, but their driving-point impedances will be different and the effects of imperfections in the converter will differ from one to the other. The driving-point impedances are important for some applications and it is also important to build networks whose properties as filters are reasonably independent of changes in the characteristics of the converter.

Simple relationships between driving-point impedance and transfer impedance have been determined, but an explicit technique has not been found in which both are prescribed. Further, simple relationships express the imperfections of the filter characteristics in terms of the imperfections in the converter properties.

Driving-Point Impedance of RC Active Filters

The driving-point and transfer impedances of the active circuit shown in Fig. 1 are easily written in terms of the four-pole parameters of the RC networks. One obtains:

$$Z_{21} \text{ (Input to Output)} = \frac{E_2}{I_1} = \frac{Z_{12a}Z_{12b}}{Z_{22a}-Z_{11b}}, \quad (I_2=0) \tag{7}$$

$$Z_{12} \text{ (Output to Input)} = \frac{E_1}{I_2} = \frac{-Z_{12a}Z_{12b}}{Z_{22a}-Z_{11b}} = -Z_{21}, \quad (I_1=0) \tag{8}$$

$$Z_{11} = \frac{E_1}{I_1} = Z_{11a} - \frac{Z_{12a}^2}{Z_{22a}-Z_{11b}}, \text{ and} \quad (I_2=0) \tag{9}$$

$$Z_{22} = \frac{E_2}{I_2} = Z_{22b} - \frac{Z_{12b}^2}{Z_{11b}-Z_{22a}}. \quad (I_1=0) \tag{10}$$

Some interesting conclusions can be drawn on the basis of the relationships indicated for the driving-point and transfer functions. In the first place, the filter obeys reciprocity in magnitude only as the transfer impedance exhibits a change in sign as the input and output terminal pairs are reversed.

The second conclusion has to do with the relationship between driving-point and transfer impedance. One recalls that passive two-element-kind four-poles obey what is referred to as the residue condition.[6] This condition simply requires that the residue of transfer impedance in any pole of transfer impedance not exceed the geometric mean of the residues of the driving-point impedances in that pole. In a sense, it amounts to stating a limit on the size of transfer impedance for a given level of driving-point impedance. For the more general active RC networks employed here a related similar relationship can be stated. The product of residues in a pole of Z_{12} and Z_{21} is equal to the product of residues of Z_{11} and Z_{22} in that pole. This means that the level of transfer impedance is, in a sense, inflexibly related to driving-point impedance. The proof is direct. Suppose that the impedance functions have a pole of p_1; this means that $Z_{22a}-Z_{11b}$ is zero there. The residues of the functions in that pole are given by setting p equal to p_1 in the following expressions:

$$\begin{aligned} &\text{for } Z_{11}, \text{ the residue } r_{11p_1} = \frac{-Z_{12a}^2(p-p_1)}{(Z_{22a}-Z_{11b})}; \\ &\text{for } Z_{22}, \text{ the residue } r_{22p_1} = \frac{-Z_{12b}^2(p-p_1)}{(Z_{11b}-Z_{22a})}; \\ &\text{for } Z_{21}, \text{ the residue } r_{21p_1} = \frac{Z_{12a}Z_{12b}(p-p_1)}{(Z_{22a}-Z_{11b})}; \\ &\text{for } Z_{12}, \text{ the residue } r_{12p_1} = \frac{Z_{12a}Z_{12b}(p-p_1)}{Z_{11b}-Z_{22a}}. \end{aligned} \tag{11}$$

From the above it is obtained directly that

$$r_{11p_1}r_{22p_1} = r_{12p_1}r_{21p_1}. \tag{12}$$

Observe from (7), (8), (9) and (10) that Z_{12}, Z_{21}, Z_{11} and Z_{22} have poles at zeros of $Z_{22a}-Z_{11b}$ and that there are no other poles of Z_{21} or Z_{12}. However, Z_{11} and Z_{22} have as additional poles, respectively, the frequencies which are poles of Z_{11a} or Z_{22b} at which the residue condition for the passive RC structures is fulfilled with the "greater than" sign. Ladder networks of the forms illustrated for

[4] E. A. Guillemin, M.I.T. Radiation Laboratory Report No. 43, Cambridge, Mass.; October 11, 1944.
[5] J. L. Bower, and P. F. Ordung, "The synthesis of resistor-capacitor networks," Proc. I.R.E., vol. 38, pp. 263–269; March, 1950.

[6] Guillemin, *op. cit.*, p. 217.

the active filters fulfill the residue condition with the equals' sign in all poles of their open-circuit driving-point impedance. However, the lattice structure ordinarily fulfills the residue condition at some poles of its open-circuit driving-point impedance with the "greater than" sign.

Effect of Inaccuracies in the Converter

The foregoing analysis has assumed perfect negative-impedance converters. Physical converters are not perfect and the effect of this imperfection must be assessed. The principal imperfection is described by indicating that the input impedance is not the negative of the load impedance but is that quantity plus an increment, ΔZ (see Fig. 6). Imperfections in a converter are of two sorts. The first and most serious is a drift with time or temperature or other environmental condition; the second arises because the conversion factor is not -1, or there are parasitic impedances not shown in the circuit.

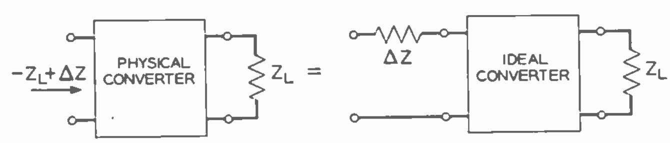

Fig. 6—Representation of parasitic impedance in a converter.

The first-mentioned imperfection puts an upper limit on the operation of the device once specifications are set regarding stability of characteristics with time. The second imperfection is something which can be compensated for within the limit of one's patience. In the following the first kind of imperfection only will be considered. The quality of a converter may be characterized for filter-synthesis problems by a statement like the following: ΔZ drifts less than a per cent for all magnitudes of Z_L between A and B ohms. Once such a characterization has been made, the stability of characteristics of filters employing the converter can be assessed. The filter characteristic is influenced in that a corresponding drift in natural frequencies of the complete circuit occurs for a drift in converter performance. The zeros of transmission, stated in (1), are not affected. A drift in the natural frequencies can be translated into a change in the characteristic. For instance, a motion of a natural frequency toward the $j\omega$ axis to the fraction f of the original displacement from the $j\omega$ axis causes a maximum change in the amplitude characteristic of 20 log $1/f$ db. Thus a motion of 10 per cent results in a maximum change of 0.9 db in the characteristic.

As pointed out earlier, natural frequencies occur where $Z_{22a}-Z_{11b}$ (Fig. 1) equals zero. If the input impedance of the converter changes from $-Z_{11b}$ by ΔZ, the natural frequencies shift until $Z_{22a}-Z_{11b}+\Delta Z$ is zero. Thus a natural frequency at p_a moves approximately

$$\Delta p_a = -\left.\frac{\Delta Z}{\dfrac{d(Z_{22a}-Z_{11b})}{dp}}\right|_{p=p_a}. \qquad (13)$$

On the basis of (13) one observes that poles of $Z_{22a}-Z_{11b}$ should be selected with a view to making $Z_{22a}-Z_{11b}$ possess the largest possible rate of change at the natural frequencies of the filter.

The value of $d(Z_{22a}-Z_{11b})/dp$ at a zero of $Z_{22a}-Z_{11b}$ is simply expressed in terms of the pole and zero locations. For the pole-zero distribution of Fig. 2(b),

$$\left.\frac{d(Z_{22a}-Z_{11b})}{dp}\right|_{pa} = K\frac{(p_a-\bar{p}_a)(p_a-p_b)}{(p_a-\sigma_1)(p_a-\sigma_2)(p_a-\sigma_3)}, \qquad (14)$$

where K is the value approached by $Z_{22a}-Z_{11b}$ as p approaches infinity. In general, $d(Z_{22a}-Z_{11b})/dp$ at a zero of $Z_{22a}-Z_{11b}$ is K times the product of vectors from other zeros of $Z_{22a}-Z_{11b}$ to p_a, divided by the product of vectors from the poles of $Z_{22a}-Z_{11b}$ to p_a.

For the design illustrated in Fig. 3 an evaluation based on the above relationship shows that for the natural frequency at $(-500+j866)2\pi$

$$\left.\begin{aligned} &\frac{d(Z_{22a}-Z_{11b})}{dp} = .275 \angle -51.4^\circ, \\ &\text{while at } (-2\pi)1{,}000 \\ &\frac{d(Z_{22a}-Z_{11b})}{dp} = 10.9. \end{aligned}\right\} \qquad (15)$$

Using these values, one can determine the sensitivity of the filter characteristic to changes in the converter. If the converter were to drift in such a manner that its input impedance exhibits a magnitude of change of 13 ohms (1 per cent of the load resistance), the position of p_a would change by 13/0.275 or 47.4 units. If the argument of the 13-ohm change were of the correct value to move p_a directly toward the $j\omega$ axis, the transmission of the filter is multiplied by the factor 3,187/3,140 at 866 cycles, an increase of 0.08 db. At other frequencies the effect of the motion of p_a would be less than this. The pole at p_b is moved also, but by a much smaller amount. A change of 13 ohms at the input of the converter moves p_b by 13/10.6 or 1.23 units. If p_b is moved toward the $j\omega$ axis by this amount, at low frequencies the transmission is multiplied by the factor 6,281.2/6,280, which is less than a 0.02 per cent change.

Transistor Converters Used in Active Filters

The transistor negative-impedance converters employed for the filter application are generally similar to those which have been described elsewhere in the literature.[7] The circuit configuration is shown in Fig. 7. The operation of the unbalanced converter can be qualitatively explained by approximating the properties of transistors by statements that the emitter current all flows out from the collector and that the emitter potential always follows the base potential. For a qualitative explanation one can neglect the shunting effects of the emitter and collector resistors of the upper transistor

[7] Linvill, *ibid.*

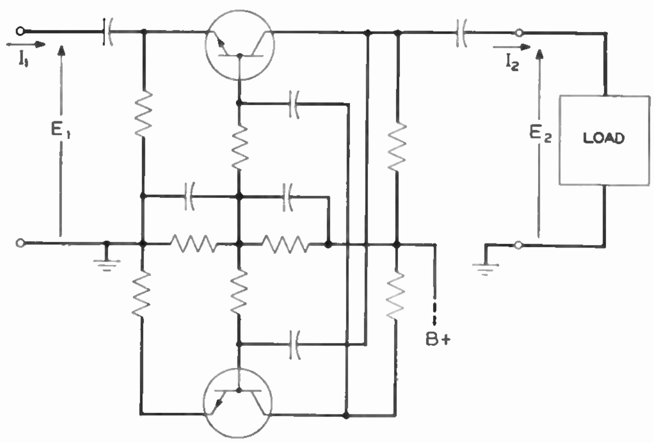

Fig. 7—A transistor converter.

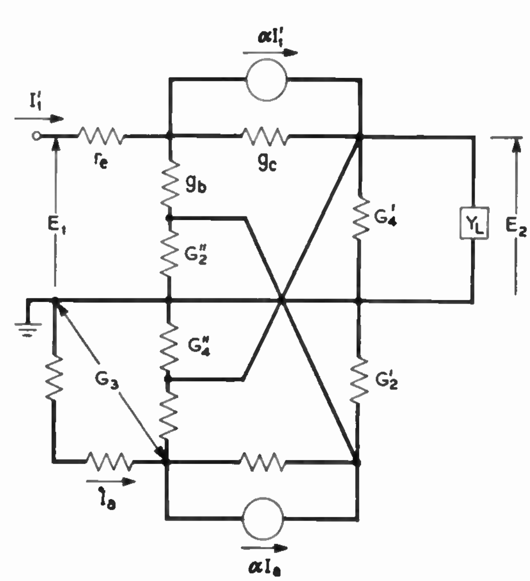

Fig. 8—Equivalent circuit of unbalanced converter.

in Fig. 7, along with the resistors connected to the bases of both transistors and the voltage drops across the coupling and by-pass condensers. A current I_1 injected into the upper emitter flows out through the output terminal to the connected load. The voltage E_2 developed across the load by virtue of the current fed into it is transferred by a coupling condenser to the base of the lower transistor and results in a current in the resistor being connected to its emitter, since the emitter potential follows that of the base. The same current flows through the resistor connected to the collector and if these two resistors are of equal size, the incremental voltage from collector to ground is $-E_2$. This voltage is fed to the base of the upper transistor and thence to the emitter of the upper transistor. Thus E_1 is simply $-E_2$. The idealization of the circuit indicated in Fig. 7 exhibits the properties that its input current equals the output current, while its input voltage is the negative of the output voltage. These properties characterize a negative-impedance converter.

The equivalent circuit, shown in Fig. 8, which better approximates the converter in the frequency regions where coupling condensers are effective, can be readily analyzed. When the collector conductance is taken to be zero, one finds

$$\frac{E_1}{I_1'} = \frac{-\alpha^2 G_3}{G_2 + G_2''} \frac{1}{Y_L + G_4' + G_4'' + G_3(1-\alpha)\left(1 + \dfrac{G_4' + G_4'' + Y_L}{g_b}\right)} + r_e + (1-\alpha)\frac{G_2' + G_2'' + g_b}{(G_2' + G_2'')g_b}, \tag{16}$$

and

$$\frac{E_2}{I_1'} = \frac{\alpha}{Y_L + g_b + G_4' + G_4'' - \dfrac{g_b^2}{g_b + G_3(1-\alpha)}}. \tag{17}$$

For perfect conversion E_1/I_1' should be simply $-(1/Y_L)$. The multiplying factor, $-\alpha^2 G_3/(G_2+G_2'')$, should be -1; this value can be obtained by the proper choice of G_3. If the multiplying factor is -1, one still has as imperfections two parasitic impedances, one in parallel with Y_L and a second in series with the converter at its input, as illustrated in Fig. 9. Merrill[8] has pointed out

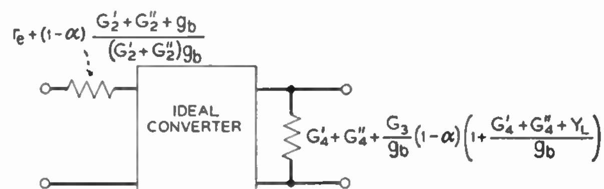

Fig. 9—Representation of converter of Fig. 8.

that one can cancel the effect of parasitic elements on the performance of a converter as illustrated in Fig. 10. With the parasitics shown in Fig. 9, a perfect compensation is impossible, one of the inherent parasitics being in parallel and dependent upon Y_L, the other being in series. However, a satisfactory compensation can be effected with the arrangement shown in Fig. 11. By proper choice of the settings of the variable resistors one obtains a converter which converts at 1,000 cps any resistance from 100 to 10,000 ohms to the negative of itself within a few per cent. However, because of the phase shift in alpha with frequency, it is not possible to obtain

[8] J. L. Merrill, "Theory of the negative impedance converter," *Bell Sys. Tech. Jour.*, vol. 30, pp. 88-109; Jan., 1951.

accurate −1 to 1 conversion at frequencies higher than a few thousand cycles. The imperfections in the converter, if they are static ones, can be compensated for in the RC networks associated with the accessible terminals of the converter. The only problem in this connection becomes some loss of simplicity in the design and alignment of the filter. The use of Darlington's connection of compound transistors, as will be described presently, effects a large improvement in the conversion properties.

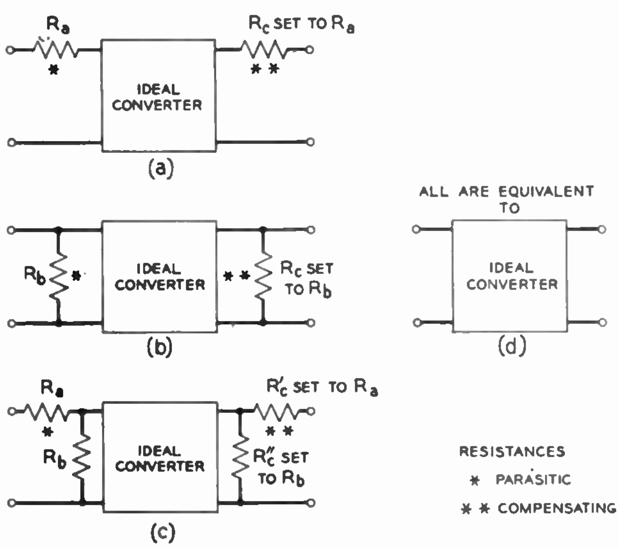

Fig. 10—Merrill's technique for compensating a converter for parasitic impedances.

A more significant characteristic than the value of the conversion ratio is the constancy of the ratio with time, temperature and other environmental conditions. The converter shown in Fig. 11 has been tested with the circuit shown in Fig. 12, which is a balancing arrangement whereby one can accurately measure the input impedance of the terminated converter. For a conversion of

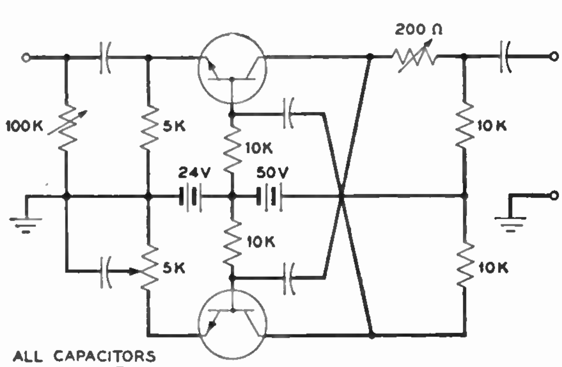

Fig. 11—Unbalanced converter with compensating variable resistors.

−1 to 1 a balance is obtained when Z_b equals Z_L. Typical converters of the type shown in Fig. 11 exhibit changes with time for the same supply voltage of about 1 per cent, for impedance levels in the hundreds or thousands of ohms.

Converters which are more stable with −1 to 1 conversion more nearly obtained can be constructed using four transistors as in the configuration shown in Fig. 13. The transistor arrangement shown is substantially that of the compound transistor suggested by Darlington.

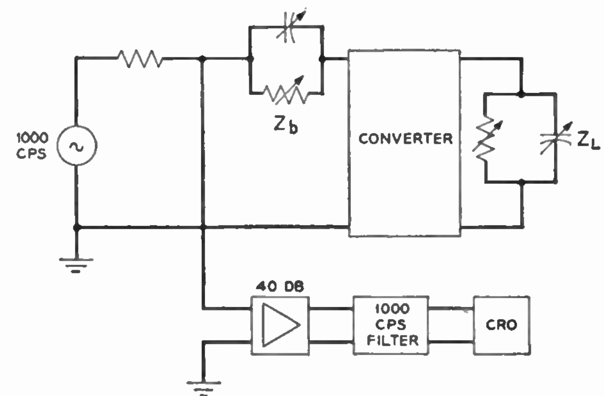

Fig. 12—Circuit for measurement of conversion factor.

The basis of the desirability of the unit in the present circuit is that the equivalent alpha of the compound unit is much more nearly equal to one. A simple expression indicating this fact is

$$1 - \alpha_{\text{compound}} = (1 - \alpha_1)(1 - \alpha_2). \qquad (18)$$

For example, using units with alphas of 0.98, one has a compound transistor with the value of alpha of 0.9996.

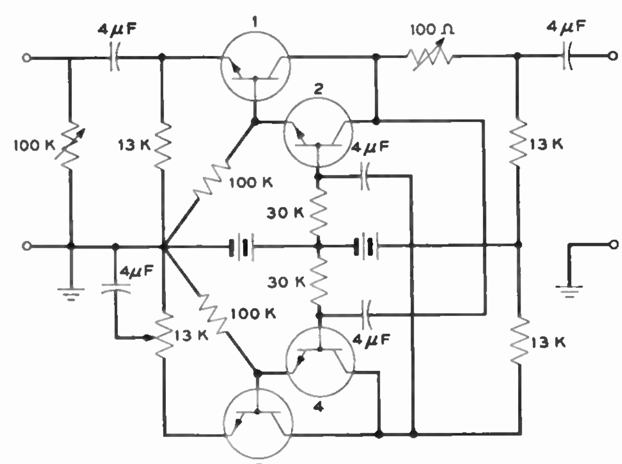

Fig. 13—Converter using four transistors.

Further, changes in the value of alpha for the two transistors effect a far less significant change in the value of alpha of the compound unit than for the individual units. The conversion ratio can be held with the compound transistor through a much larger frequency range to nearly −1 to 1, in spite of the phase shift in alpha. For instance, at 10 per cent of the alpha cut-off frequency, the phase shift of alpha in a single transistor is approximately 5.7 degrees, while for the compound transistor it is only 0.1 degree. Converters using compound transistors can be adjusted to give conversion ratios of −1 to 1 within about 1 per cent for impedance levels between 100 and 10,000 ohms and for frequencies beyond 10 kilocycles. The stability of converters with the compound transistor is also much better. With the circuit shown in Fig. 13, converters for loads in the thousands of ohms at 1,000 cps have maintained their conversion factor constant to within a few tenths of a per cent.

Most of the filters which have been built in the laboratory have been built with the converter as a separate unit. Actually this is not necessary; the biasing elements of the converter can frequently be identified with certain elements of the filter. Converters which operate down to dc can be obtained by replacing the cross-coupling condensers with Zener diodes and omitting the coupling condensers at the input and output terminals. Such converters have operated successfully in the laboratory.

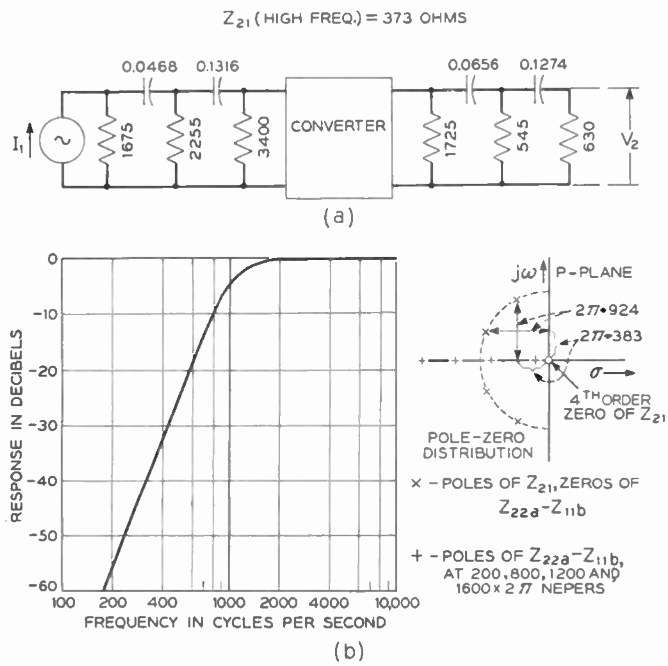

Fig. 14—High-pass active filter.

Details of Experimental Filter Designs

In Fig. 14 is shown the pole and zero distributions of transfer-impedance function and function $Z_{22a}-Z_{11b}$, the network configuration, and measured characteristics of a high-pass filter of Butterworth type.

In Fig. 15 are shown the corresponding characteristics for a low-pass filter with a single point of infinite attenuation at twice the cut-off frequency. In connection with the design of this filter, techniques were employed which differ from those described earlier. At the outset, the distribution of poles and zeros for the transfer impedance was selected to give a desirable pass-band characteristic and the point of high attenuation at 2,000 cycles.[9] Next the three-condenser three-resistor twin-T network was decided upon as a simple configuration to

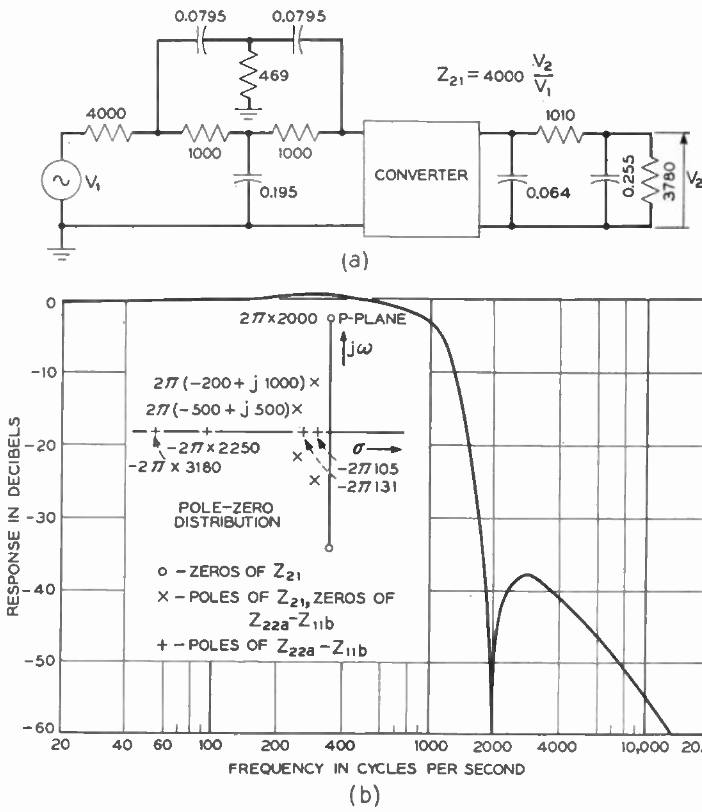

Fig. 15—Low-pass active filter with point of infinite rejection.

give the point of infinite attenuation. It is in this point that the technique differs from that suggested previously, where unbalanced forms are determined as the equivalents of a symmetrical lattice which is first obtained. The twin-T structure selected to provide infinite attenuation at 2,000 cps is analyzed to determine Z_{22a}, obtaining

$$Z_{22a} = 235 + \frac{555}{p + 2\pi\, 105} + \frac{957}{p + 2\pi\, 2250}. \quad (19)$$

At this point $Z_{22a}-Z_{11b}$ can be expressed as

$$Z_{22a} - Z_{11b} = \frac{K[p + 2\pi(200 + j1000)][p + 2\pi(200 - j1000)][p + 2\pi(500 + j500)][p + 2\pi(500 - j500)]}{(p + 2\pi\, 105)(p + a)(p + 2\pi\, 2250)(p + b)} \quad (20)$$

where K, a and b must be determined in such a manner that Z_{11b} is a driving-point impedance and the residues in the poles of $-2\pi\, 105$ and $-2\pi\, 2250$ are those of Z_{22a}.

[9] J. G. Linvill, "The Selection of Network Functions to Approximate Prescribed Frequency Characteristics," Tech. Report No. 145, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass.; March, 1950.

An infinite number of choices will work, so arbitrarily select a suitable value of K and then solve for a and b explicitly. Thus the design illustrated in Fig. 15 is obtained.

As explained below, band-pass filters impose more severe requirements on the stability of negative-impedance converters for a given permissible drift in their transmission than do low-pass or high-pass filters of comparable complexity. Moreover, as the ratio of mid-band frequency to bandwidth increases, the requirements on the converter become greater as they do with an increase in the complexity of the filter.

The requirements on the stability of converters can be discussed in a semi-quantitative manner by considering the pole-zero distribution as shown in Fig. 16 for the simple function $Z_{22a}-Z_{11b}$ which might be applied for a filter. From the discussion of this simple case, it is possible to obtain salient facts which can easily be extended to apply to other more complicated situations.

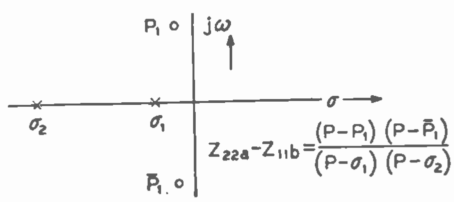

Fig. 16—Distribution of poles and zeros of $Z_{22a}-Z_{11b}$.

Equation (13) illustrates that the stability of characteristics as far as any particular natural frequency is concerned is directly proportional to the derivative of $Z_{22a}-Z_{11b}$ at that natural frequency. Further, the influence of a given shift in a natural frequency on the transmission characteristic is inversely proportional to the displacement of the natural frequency from the $j\omega$ or real-frequency axis. It is simple to interpret these statements in terms of the pole-zero distribution shown in Fig. 16. The derivative of $Z_{22a}-Z_{11b}$ at p_1 is found by applying (14). It is quite clear that moving the point p_1 much closer to the real-frequency axis does not influence the derivative significantly. Hence the motion of the natural frequency at p_1 associated with a small change ΔZ in the input impedance of the converter is nearly constant as this natural frequency is brought toward the axis. Since the effect of a shift in a natural frequency of the transmission characteristic increases as the natural frequency moves toward the real-frequency axis (as does the Q of the filter) it is clear that drift in the converter influences high-Q filters more than it does less selective ones. One recalls that the selection of the poles of $Z_{22a}-Z_{11b}$ is arbitrary and the question arises as to what represents a satisfactory spacing of the poles at σ_1 and σ_2. Referring to Fig. 16, consider leaving σ_1 fixed and moving σ_2. One can determine the location of σ_2 which minimizes the change in natural frequency at p_1 resulting from a change in the converter. Suppose the conversion factor of the converter changes from -1 by ΔC. Through (13) one can write

$$\Delta p_1 = \left. \frac{-\Delta C Z_{11b}}{\dfrac{d(Z_{22a}-Z_{11b})}{dp}} \right|_{p_1}. \tag{21}$$

But

$$-Z_{11b} = \frac{K\dfrac{(\sigma_2-p_1)(\sigma_2-\bar{p}_1)}{(\sigma_2-\sigma_1)}}{p-\sigma_2}, \tag{22}$$

and by (14)

$$\left.\frac{d(Z_{22a}-Z_{11b})}{dp}\right|_{p_1} = K\frac{(p_1-\bar{p}_1)}{(p_1-\sigma_1)(p_1-\sigma_2)}. \tag{23}$$

Thus

$$\Delta p_1 = \Delta C\frac{(p_1-\sigma_2)(\bar{p}_1-\sigma_2)(p_1-\sigma_1)}{(\sigma_2-\sigma_1)(p_1-\bar{p}_1)}. \tag{24}$$

From (24) one observes that placing the point σ_2 far out makes the first two factors of the numerator very large placing the point σ_2 close to σ_1 makes the first term of the denominator very small. Between these undesirable extremes lies the optimum. It lies at the point where a small motion of σ_2 toward σ_1 results in a fractional decrease of $|\sigma_2-\sigma_1|$ which is just twice the fractional decrease of $|\sigma_2-p_1|$.

To illustrate that increases in the complication of a band-pass filter increase the demands on the stability of the converter, consider Fig. 17, which shows the pole-zero distribution for a filter with a 12 db/octave cut-off characteristics at high and low frequencies. As one considers the derivative at p_1, observe that the addition of p_2, $\bar{p}_2$, σ_3 and σ_4 decreases the derivative in that one new factor, p_2-p_1, is much smaller than the other three new factors and it appears in the numerator of the expression analogous to that of (14). The value of Z_{11b} at p_1 is not decreased as is the derivative, the short vector p_2-p_1 not appearing in the calculation of residues. To illustrate numerically, using Fig. 17, the values of

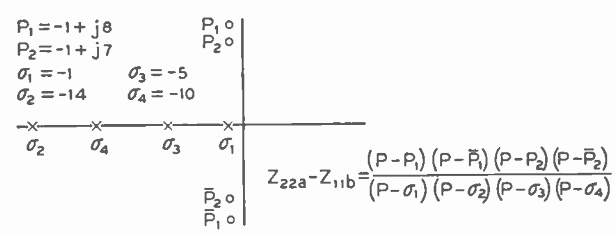

Fig. 17—Distribution of poles and zeros of $Z_{22a}-Z_{11b}$ for band-pass filter.

$$\left|\frac{\dfrac{d(Z_{22a}-Z_{11b})}{dp}}{Z_{11b}}\right|_{p=p_1}$$

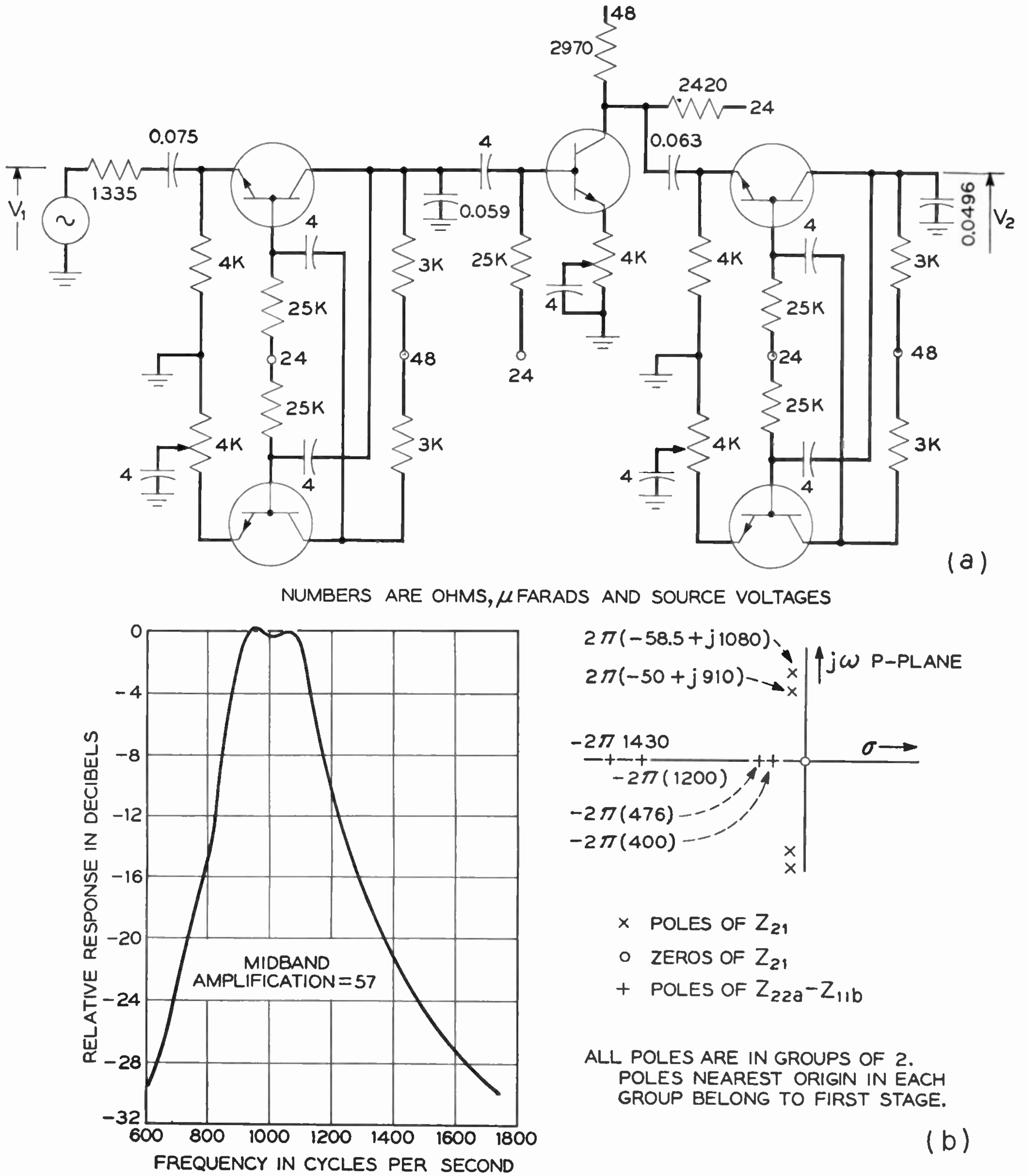

Fig. 18—Two-stage active band-pass filter.

before and after p_2, $\bar{p}_2$, σ_3 and σ_4 are added, amount to 0.112 and 0.00172, respectively.

One can cascade filters isolating one stage from the other in a simple manner with transistor amplifiers. Circuit above is a band-pass filter constructed in this manner employing only R's and C's. This filter achieves considerable gain in addition to its filtering properties. Calculations based on (14) reveal that a converter whose input impedance drifts no more than ½ per cent will make possible a filter characteristic which drifts less than 1 db at every frequency.

Valve Noise Produced by Electrode Movement*

PAMELA A. HANDLEY† AND PETER WELCH†

Summary—**The causes of valve noise are analyzed and the distinction is made between rattle noise and that produced by resonances.**

The contribution of various electodes to the total noise produced is discussed, and it is shown that the resonant frequencies of these electrodes may be calculated. Data are given proving the validity of these empirical equations.

Methods of measuring noise are outlined.

Finally, the implications of the findings are applied to valve-design improvements.

Introduction

THE major requirement for valves that are to be used in aircraft or guided missiles is that the noise output when the valves are subjected to high accelerations or continuous vibration sha!l be of a small order compared with the signal. In addition to this special requirement, there is a growing industrial demand for valves that will operate satisfactorily in equipment used with mechanical and electromechanical systems.

The special design of Reliable Valves to fulfill these exacting requirements has necessitated a closer study of the factors that cause noise in the valve.

Causes of Valve Noise

The most serious source of trouble to the circuit engineer is microphony. Normal receiving valves have a satisfactory level of microphony for the particular use for which they have been designed, but in practically all cases the noise level is too high when the valve is subjected to severe shock or continuous vibration. Apart from troubles caused by small pieces of fluff or hairs, which become carbonized during the valve processing and give rise to leakage noise, the main source of microphony can be traced to the movement of individual valve electrodes. This may be either due to inadequate positioning, in which case it is termed electrode "rattle," or it may be caused by an electrode vibrating at its own fundamental frequency.

Besides these mechanical sources of noise there are noises due to hum and hiss. The former is caused by ac heating of the cathode while the latter is fundamental to the nature of electron emission. Usually neither is of great importance compared with microphony.

The amount of noise produced by the movement of an electrode will depend upon its position in the electron stream as well as its rigidity and the method of fastening used. Almost all normal valve structures are made in such a way that they may be considered as if they were two identical halves joined across the line of grid support members.

The anode current in either half-section of a planar system comprising cathode, grid, and anode is given by an expression of the type:

$$i = \frac{2.34 \times 10^{-6}\,(V_g + DV_a)^{3/2}}{(l_g^{4/3} + Dl_a^{4/3})^{3/2}}, \text{ amps per unit area}^1 \quad (1)$$

where V_g is corrected for contact potential, l_g and l_a are distances of grid and anode from the cathode, and $D = 1/\mu$.

It is a simple matter to differentiate this expression with respect to the appropriate distance l_g or l_a and arrive at a relationship between change in distance and change in anode current. By a simple extension of the triode case, tetrode and pentode half-structures may be investigated.

The application of such an analysis, however, involves consideration of both halves at the same time. A movement in one half due to simple vibration is accompanied by an opposite movement in the other, and the changes in anode current produced in each section tend to cancel out by an amount that is proportional to the difference between the two currents. In spite of this fact the analysis shows that the changes of anode current will be greatest for the movement of the cathode and least for that of the anode, and this order of sensitivity may be inferred for the double-sided structure.

Noise produced by the vibration of the individual lateral wires can be investigated by using one of the standard expressions for the calculation of amplification factor. Here again, however, the results are very inconclusive because in general each grid turn will have its individual resonant frequency and therefore the noise produced will vary with the frequency of excitation.

From the foregoing it has been realized that the exact amount of noise produced cannot be calculated by a simple method. It is possible to generalize the results in the following way. Firstly, the rattle noise must be reduced by engineering design and secondly the resonant frequency of the electrodes must be as high as possible as the movement at resonance for a given excitation is smaller at the higher frequencies. Up to the present it has been the practice to design the valve and to test for resonant frequencies afterwards. It can be appreciated that valuable time could be saved if a method of evaluating the resonant frequencies existed in the design stage.

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[1] J. H. Fremlin, "Calculation of Triode Constants," *Elec. Commun.*, vol. 18, pp. 33–49; July, 1939.

Resonant Frequencies—General

All valves undergo certain heating treatments during the process of manufacture. These may produce changes in the structure of the materials used and hence changes in the modulus of elasticity. Since the resonant frequency will depend upon the physical dimensions, the method of mounting, and the modulus of elasticity, then a knowledge of the variations brought about during these heating cycles must be gained before any attempt is made to arrive at an empirical relationship between these parameters and the resonant frequency.

The most important of these processes from the point of view of the softening effect upon the material is the high temperature baking in hydrogen that is done to ensure that the part is free of grease and high vapor pressure impurities, and also the heating cycles associated with eddy current heating of the valve components during the exhaust process.

Experiments have been conducted to evaluate the changes in Young's modulus with the normal heating cycles. Retreatment showed little extra variation after the initial change. The following results have been obtained and are shown in Table I.

TABLE I

Material	Mean value of Young's Modulus in dynes/cm$^2\times10^{-11}$	
	Before baking	After baking
Nickel	19.90	19.90
Copper	10.69	14.09
5 per cent Chrome-Copper	10.70	14.18
Mild Steel	21.20	21.20
Copper Flashed Steel	14.40	14.40
Manganese Nickel	22.3	22.3
Tungsten	34.15	34.15
Molybdenum	34.15	34.15

The particular relationship between the parameters established and time of periodic motion or frequency at resonance will now only depend on the special way in which the electrode is mounted. Grid supports, the cathode, and other components, are held at each end in a relatively thin insulator whilst the grid laterals, on the other hand, are usually clamped tightly in slots cut in the support members. The grid support members were investigated first of all.

Grid Resonance—The Grid Support

It was expected that the resonant frequency of the support wire would be of the form

$$\frac{1}{f} = T = 2\pi\left\{\frac{kwl^4}{YI}\right\}^{1/2} \qquad (2)$$

or since the wire is of circular cross section

$$\frac{1}{f} = T = 2\pi l^2\left\{\frac{4k\rho}{Yr^2}\right\}^{1/2} \qquad (3)$$

where

k is a constant to be determined
w is the weight per unit length
l is the length
Y is the Young's modulus
I is the moment of inertia of cross section
r is the radius of the wire
ρ is the density of the material.

Wires of various materials and diameters were inserted into two insulators held at right angles to the wire, by being a push fit into a glass tube of the same size as that used for miniature valves. The assembly was then mounted on the coil of a moving-coil vibrator excited by a variable-frequency oscillator, and the point of resonance found. Each wire was arranged so that the overhang beyond the insulator at each end was 0.10 inch, and the length between the insulators was measured by means of a traveling microscope.

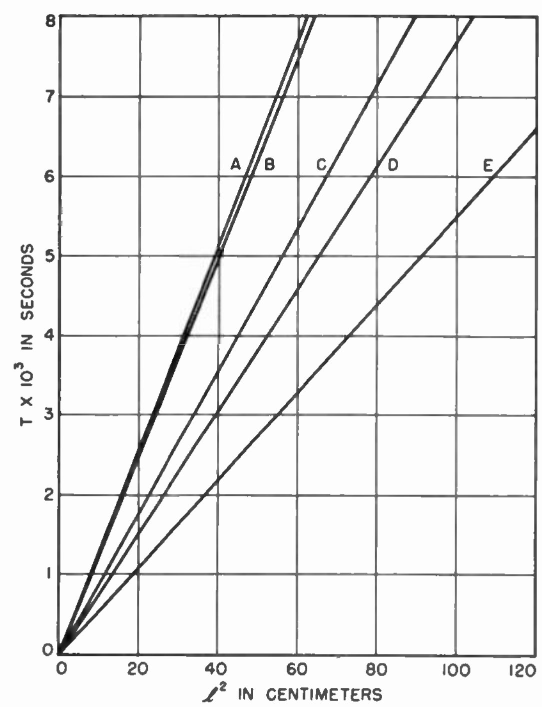

Fig. 1—Period of resonant oscillation plotted against the square of the length between insulators for a number of representative wires. A = 5 per cent chrome-copper of 0.0622-cm diameter, B = copper of 0.0622-cm, C = nickel of 0.0622-cm, D = copper and 5 per cent chrome-copper of 0.1002-cm, and E = nickel of 0.1002-cm.

To check that the vibration was of the form given in (3) l^2 was plotted against T for each type of wire (Fig. 1). Thence a relationship between Y/w and l^4/T^2r^4 was deduced as in Fig. 2. From the slope of this line the constant k was evaluated giving

$$\frac{1}{f} = T = 2\pi\left\{\frac{wl^4}{90.4YI}\right\}^{1/2}, \qquad (4)$$

i.e., for the round wire

$$\frac{1}{f} = T = 2\pi l^2\left\{\frac{\rho}{22.6Yr^2}\right\}^{1/2}. \qquad (5)$$

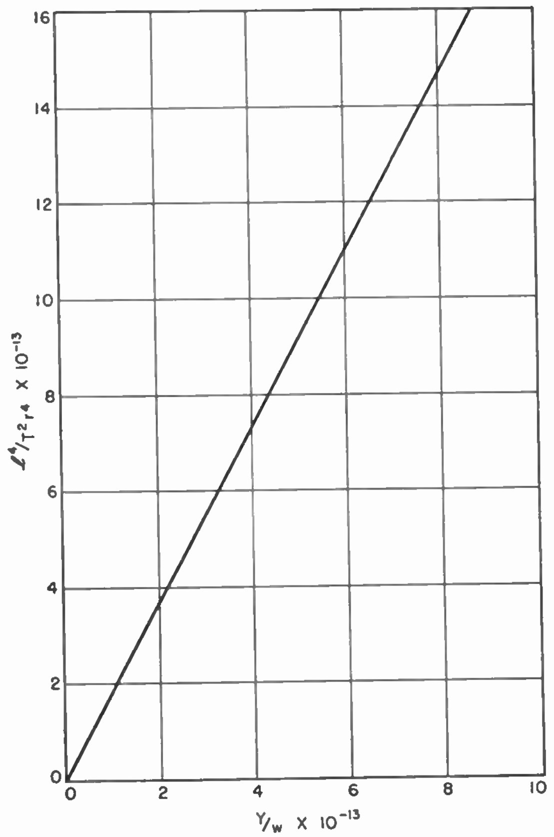

Fig. 2—Evaluation of the empirical equation for the resonant frequency of wires supported between insulators.

This equation in itself is not sufficient to define the resonant frequency of a grid support because, first, the section of a grid support is modified when the grid is manufactured by the "nick" and "swage" method, and, second, there will be a certain loading effect due to the weight of the individual lateral wires.

The section through the support will be similar to that sketched below (Fig. 3).

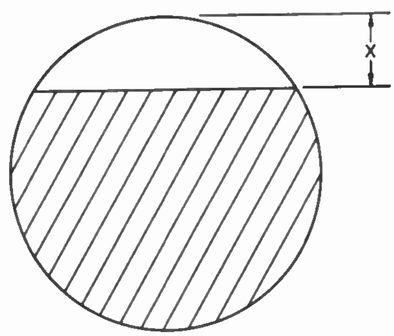

Fig. 3—Section through grid support.

The mean ratio of X to the diameter for a number of common grids showed that the correction to be applied to the expression for the moment of inertia was

$$I = \frac{\pi r^4 m}{4} \times 0.84. \tag{6}$$

The damping effect of the grid lateral wires attached to the supports may be said to constitute an extra weight $\bar{w}$ per unit length, where half the length of lateral either side of the grid is considered. Hence the total weight per unit length is

$$w\left(1 + \frac{\bar{w}}{w}\right). \tag{7}$$

Using (6) and (7) in (4)

$$\frac{1}{f} = T = 2\pi\left\{\frac{w\left(1 + \frac{\bar{w}}{w}\right)e^4}{90.4YI0.84}\right\}^{1/2} \tag{8}$$

i.e.

$$\frac{1}{f} = T = 2\pi l^2\left\{\frac{\left(1 + \frac{\bar{w}}{w}\right)\rho}{19Yr^2}\right\}^{1/2}. \tag{9}$$

Using the values $\rho = 8.8$, 8.89, 8.88, 7.8, and 8.18, respectively, for nickel, copper, 5 per cent chrome-copper, mild steel, and copper-flashed steel, (9) gives

$$f_{(\mathrm{Ni})} = \frac{1.3 \times 10^5 \times r}{l^2\left(1 + \frac{\bar{w}}{w}\right)^{1/2}} \tag{10}$$

$$f_{(\mathrm{Cu})} = \frac{1.088 \times 10^5 \times r}{l^2\left(1 + \frac{\bar{w}}{w}\right)^{1/2}} \tag{11}$$

$$f_{(\mathrm{Cr\cdot Cu})} = \frac{1.09 \times 10^5 \times r}{l^2\left(1 + \frac{\bar{w}}{w}\right)^{1/2}} \tag{12}$$

$$f_{(\mathrm{Fe})} = \frac{1.42 \times 10^5 \times r}{l^2\left(1 + \frac{\bar{w}}{w}\right)^{1/2}} \tag{13}$$

$$f_{(\mathrm{Cu/Fe})} = \frac{1.147 \times 10^5 \times r}{l^2\left(1 + \frac{\bar{w}}{w}\right)^{1/2}}, \tag{14}$$

where l and r are in inches.

As examples of the use of these relationships, the valve types shown in Table II were checked for resonance by practical measurement and compared with the calculated figures.

TABLE II
RESONANT FREQUENCIES OF VALVE GRIDS

Valve Type	Grid	Calculated Resonant Frequency	Observed Resonance
5763	No. 1. (Cu)	1,570	1,580
5763	No. 2. (Ni)	2,084	2,100
6BW6	No. 1. (Cu)	1,880	1,900
6BW6	No. 2. (Ni)	1,890	1,910

Grid Resonance—The Lateral Wires

The evaluation of an empirical relation for grid laterals is difficult because of the complexity of grid profiles. It was decided therefore to approximate all grid profiles either to the arc of a circle or to a rectangle.

The arc of a circle was considered first and the mode of oscillation as if it were a cantilever as shown in the sketch below (Fig. 4).

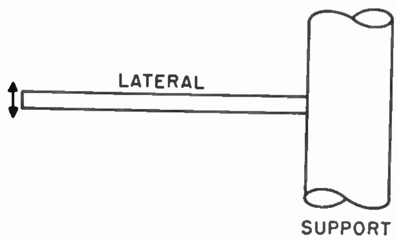

Fig. 4—Grid-lateral profile considered as a cantilever.

Because the lateral wires of grids are so small, the investigational work was conducted with nickel wires of 0.025 inch and 0.040 inch diameters. The semicircle was treated first and the dependence of the time of periodic motion on the square of the radius was investigated. Fig. 5 shows R^2 against T and from this it is clear that T/R^2 is constant. For the various sizes of wire used it was shown further that for nickel

$$\frac{Tr}{R^2} = 4.086 \times 10^{-5}, \tag{15}$$

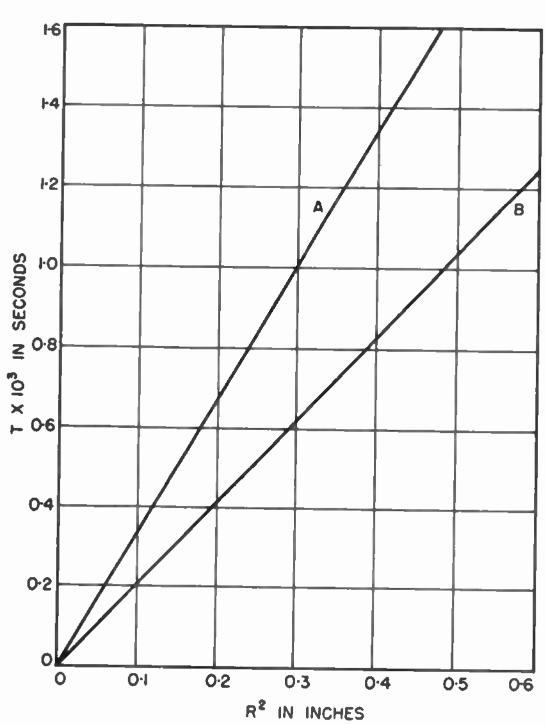

Fig. 5—Evaluation of the empirical equation relating the period of oscillation with the square of the radius of a semicircle. The material is nickel and the diameters are $A = 0.0245$ inch (0.0622-cm), and $B = 0.0395$ inch (0.1002-cm).

where R and r are the radius of the semicircle and the wire itself in inches.

It follows therefore that the resonant frequency of a semicircle of nickel is defined by

$$f_{(Ni)} = \frac{r \times 10^5}{4.086R^2}. \tag{16}$$

Where Y' and ρ' are Young's modulus in dynes/cm² and the density in gm/cm³ for any other material

$$f = \frac{r}{19.41R^2}\left\{\frac{Y'}{\rho'}\right\}^{1/2}. \tag{17}$$

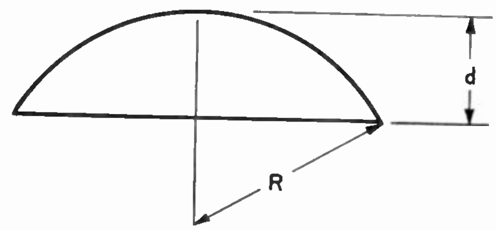

Fig. 6—Circular-grid profile.

The depth of the arc as a function of the time of periodic oscillation was then investigated (Fig. 6), where d is taken to the center of the wire.

For a constant value of R, d^2 was found to be a linear function of T (Fig. 7) i.e.

$$T = (2.78d^2 + 0.18) \times 10^{-3} \tag{18}$$

for 0.025 inch diameter nickel.

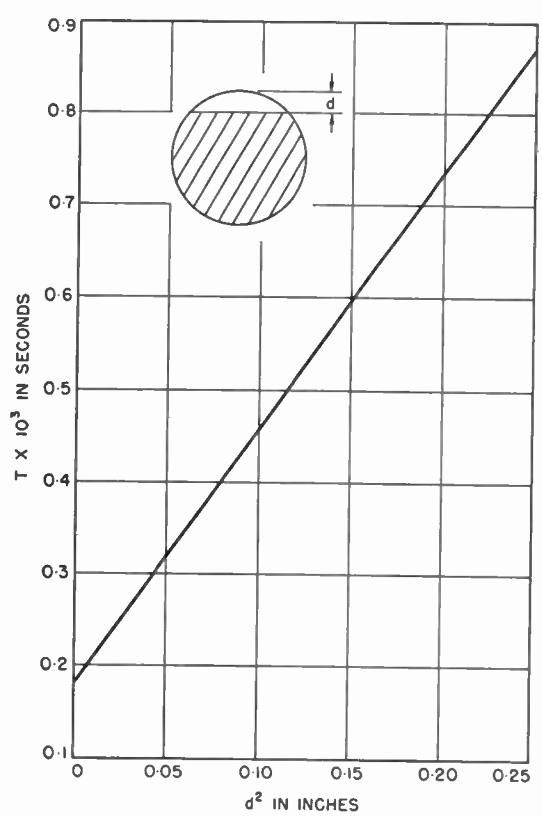

Fig. 7—Evaluation of the empirical equation relating the period of oscillation with the square of the depth of an arc of a circle for a nickel wire of 0.0245-inch (0.0622-cm) diameter.

From the relation

$$d_2 = \frac{R_2 d_1}{R_1}, \qquad (19)$$

the periodic time for similar arcs of different diameters was evaluated. Fig. 8 shows T_1 against T_2 for similar arcs of radii 0.568 and 0.70 in 0.025 inch diameter nickel wire. From the semicircle relations and this graph it is clear that

$$\frac{T_1}{T_2} = \frac{R_1^2}{R_2^2}$$

and in particular for the two sizes used

$$\frac{R_1^2}{R_2^2} = \frac{1}{1.54} = \frac{T_1}{T_2}. \qquad (20)$$

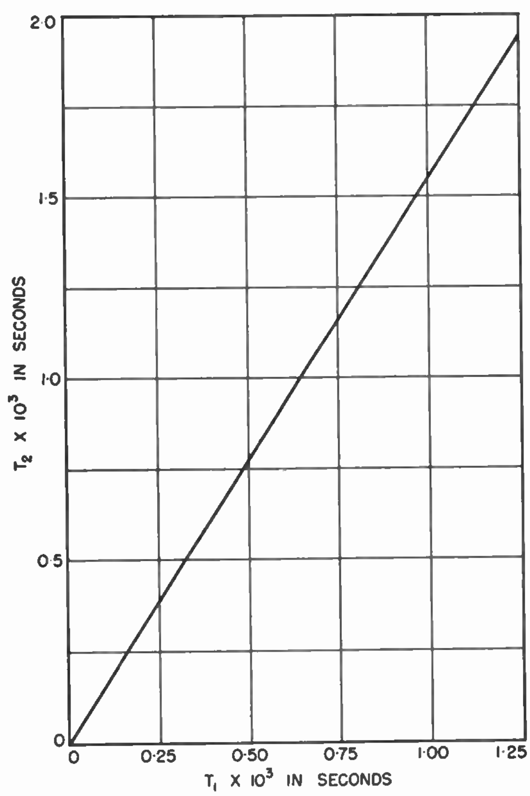

Fig. 8—Relation between periods of resonant oscillations of similar arcs of 0.568 and 0.70 inch in 0.0245-inch-(0.0622-cm) diameter wire to different diameters of circles.

From (18) we may proceed as follows:

$$T_1 = (2.78 d_1^2 + 0.18) \times 10^{-3}.$$

Hence

$$T_2 = (2.78 d_1^2 + 0.18) \left\{\frac{R_2}{R_1}\right\}^2 \times 10^{-3}$$

and

$$T_2 = \left(2.78 d_2^2 \left[\frac{R_1}{R_2}\right]^2 + 0.18\right) \left\{\frac{R_2}{R_1}\right\}^2 \times 10^{-3}$$

and in particular for the radius R_2

$$T_2 = (2.78 d_2^2 + 0.558 R_2^2) \times 10^{-3} \qquad (21)$$

For the sizes of wire used it was clear that

$$\frac{Tr}{(2.78 d^2 + 0.558 R^2)} = \text{constant}. \qquad (22)$$

From which it follows that for nickel wire of any size

$$f_{(\text{Ni})} = \frac{0.81 \times 10^5 \times r}{(2.78 d^2 + 0.558 R^2)} \qquad (23)$$

where r, d, and R are in inches.

By putting $R = d$ we re-establish (16).

For any other material we shall have

$$f = \frac{0.171 r}{(2.78 d^2 + 0.558 R^2)} \left\{\frac{Y}{\rho}\right\}^{1/2}, \qquad (24)$$

where r is the radius of the wire and d and R the depth and radius of the arc in inches respectively, and Young's modulus for the material is in dynes/cm² and the density is in gm/cm³.

TABLE III

RESONANT FREQUENCY OF 6BE6 GRIDS

Grid	Calculated Resonant Frequency	Observed Resonance
No. 3.	2150	2050–2190 (Mn Ni)
No. 5.	1320	1295–1330 (Mn Ni)

Table III shows a comparison between figures calculated from the formula and measured by practical methods.

Last, the rectangular grid profile was investigated. The profile was as sketched below (Fig. 9).

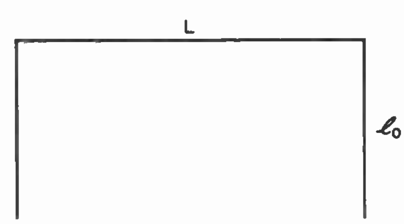

Fig. 9—Rectangular-grid profile.

Figs. 10 and 11 show the dependence of l_0^2 and L^2 on the periodic time for nickel wire of 0.025 inch diameter. From these the following relations were evaluated:

$$\left.\begin{aligned} T &= 2.9 l_0^2 \times 10^{-3} + \text{function } (L) \\ T &= 0.325 L^2 \times 10^{-3} + \text{function } (l_0) \end{aligned}\right\}. \qquad (25)$$

When $l_0 = 0$

$$T = \text{function } (L) = 0.325 L^2 \times 10^{-3}.$$

Hence in general for this particular diameter of wire

$$T = 2.9 l_0^2 \times 10^{-3} + 0.325 L^2 \times 10^{-3}. \qquad (26)$$

Using reasoning similar to that used with the circular

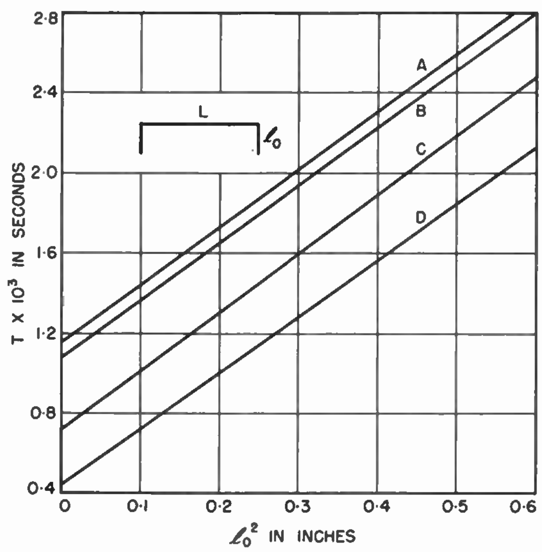

Fig. 10—Relation between the period of oscillation and breadth l_0 of a rectangle of nickel wire of 0.0245-inch (0.062-cm) diameter for four values of L, which in curve $A=1.98$ inches, $B=1.885$ inches, $C=1.5$ inches, and $D=1.15$ inches.

the expression for the resonant frequency becomes

$$f_{(\mathrm{Ni})} = \frac{0.81 \times 10^5 \times r}{(2.9l_0^2 + 0.325L^2)} \tag{27}$$

and for any other material

$$f = \frac{0.171r}{(2.9l_0^2 + 0.325L^2)} \left\{\frac{Y}{\rho}\right\}^{1/2} \tag{28}$$

where l_0, L, and r are in inches, Y in dynes/cm², and ρ in gm/cm³.

The accuracy of this formula applied to a high-slope valve is shown in Table IV.

TABLE IV

Grid	Calculated Resonant Frequency	Observed Resonance
No. 3.	1190	1090–1350

Cathode Resonance

For a cylindrical rod where r_1 and r_2 are the internal and external radii then

$$I = \frac{\pi(r_1^4 - r_2^4)m}{4}, \tag{29}$$

where m is the mass per unit area.

Using (4) we have for the resonant frequency:

$$f = \frac{1}{2\pi l^2}\left\{\frac{22.6Y(r_1^4 - r_2^4)\pi m}{w}\right\}^{1/2}, \tag{30}$$

which reduces to

$$f_{(\mathrm{Ni})} = \frac{1.42 \times 10^5 (r_1^2 + r_2^2)^{1/2}}{l^2}.$$

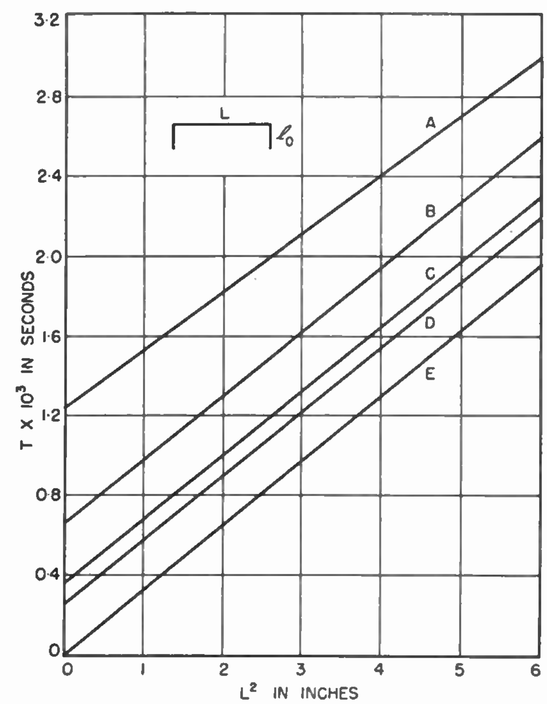

Fig. 11—Relation between the period of oscillation and the length L of a rectangle of nickel wire of 0.0245-inch (0.062-cm) diameter for 5 values of l_0, which in curve $A=0.65$ inch, $B=0.48$ inch, $C=0.35$ inch, $D=0.30$ inch, and $E=0$ inches.

Similarly where a and a' are respectively the external and internal dimensions of a rectangular cathode across either of the principal axes through the center of gravity of cross section then

$$f_{(\mathrm{Ni})} = \frac{1.64 \times 10^5 (a^2 + aa' + a'^2)^{1/2}}{l^2}, \tag{31}$$

where the dimensions are in inches and the damping effect of the cathode coating is ignored. If coating weight is considered then the frequency of vibration will be modified by the term

$$\left\{1 + \frac{\bar{w}_c}{w}\right\}^{1/2}.$$

Where w and $\bar{w}_c$ are the weight of sleeve and weight of coating per unit length.

Measurement of Noise and Resonance

The chief advantage of the relationships that have been derived is that they permit the valve to be designed so that the resonant frequency of the electrodes will occur at points other than those at which mechanical vibration is expected. It is still necessary to study the magnitude of the effects of both resonance and loose electrodes on the valve space current.

Fig. 12 shows a photographic record of an oscilloscope trace of the noise voltage developed across a 2,000 Ω anode load resistor for a noisy miniature RF pentode operated under normal conditions. The valve was vibrated at a constant acceleration of 2.5 g through the frequency spectrum 0–3 kc. It will be seen that there is a very high continuous noise output from about 40–400 cps. This is typical of electrode "rattle" and in this particular case was due to cathode movement.

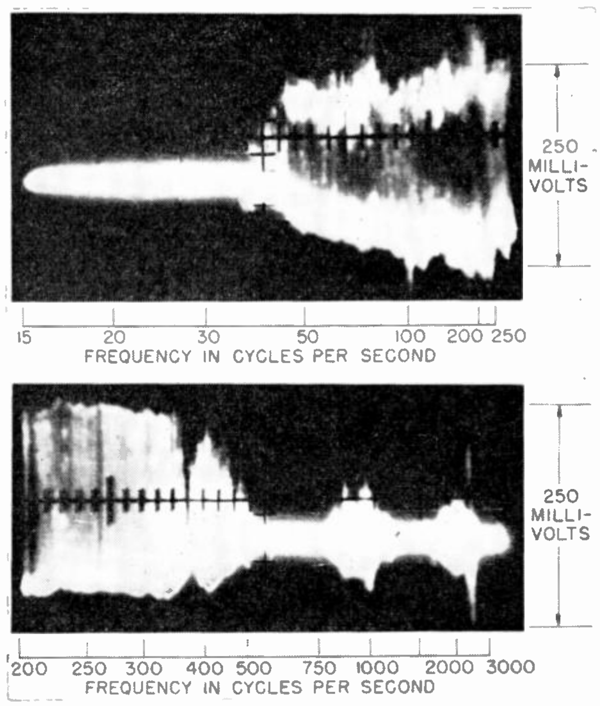

Fig. 12—Noise spectrum of a miniature radio-frequency pentode.

While this method of measurement may be satisfactory for individual valves it is not an easy production test. Since the noise may be excited by any low frequency vibration it is convenient to use a simple mechanical device giving sinusoidal vibrations at 50 cps

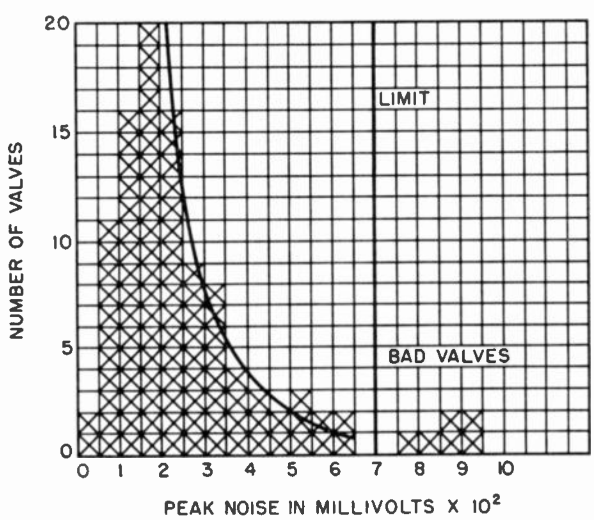

Fig. 13—Distribution of noise output across an anode load of 2,000 ohms for a batch of 100 high-slope miniature pentode valves.

with an acceleration of about 4*g* and then to check each valve. This method has advantages over the previous types of test which have always necessitated tapping the valve by an indeterminate amount to excite a disturbance. Results of testing in this way show a very high degree of repeatibility. Fig. 13 shows the distribution of noise output in a batch of high slope miniature pentode valves. The effect of design changes may be studied by comparing distributions of this type.

The resonant frequency, which is a design feature, and noise at resonance may be measured by vibrating the valve through the audio frequency spectrum by the coil and magnet method. Resonances or even harmonics are not encountered much above 7 kc, up to which point the response characteristics of the system are usually satisfactory so that the value of acceleration may be defined. Again, the method consists of measuring the noise output. While the resonant frequency of individual electrodes remains the same from valve to valve the amount of noise varies since it depends on the symmetry of the structure and on the minor damping effects that can occur. Once again the only satisfactory method of attacking the problem is by a quantitative analysis.

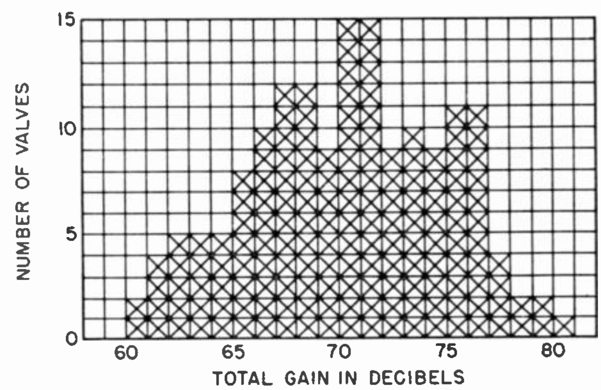

Fig. 14—This batch of 158 pentodes of modified design were tested by being placed approximately 8 inches from a loudspeaker in a position giving regenerative feedback. Maximum gain to which amplifier between valve and loudspeaker could be adjusted before oscillations started is indicated. The mean value was 70.3 db.

Since practically all objectionable valve resonances occur in the audio frequency spectrum, a form of microphony test is a satisfactory means of assessing the noise because it is more easily applied than the method of varying the frequency of the exciting device and searching for resonant points. When a valve with a high-resonance noise is placed in the first stage of an audio-frequency amplifier terminated by a loudspeaker it will produce a condition of regenerative feedback. Unless special precautions are taken however, a circuit of this type will tend to become very selective in certain bands. It is important therefore that the valve shall be freely mounted in front of the speaker which must face free space. Any attempt at producing a test box or making mechanical connections between the valve and the speaker limits the device to a response characteristic that usually invalidates the results. The normal method of measuring is to obtain a level of total gain around the system that is just insufficient to maintain regenerative feedback. If, in addition, the valve is moved about in front of the speaker until an antinode is found for the particular resonance that it has selected, then a repeatability of ±1 db in about 80 db is easily achieved. Fig. 14

shows the distribution of gain in a batch of RF pentodes measured under these conditions. The alternative method of testing all the valves in a fixed position relative to the speaker produces a distribution that is slightly skew (Fig. 15). Using this method, the effect of changes in design to increase the damping effect at resonance is capable of accurate quantitative assessment. In addition, when the gain level is adjusted to a particular test figure the apparatus may be used as a production test for resonance noise.

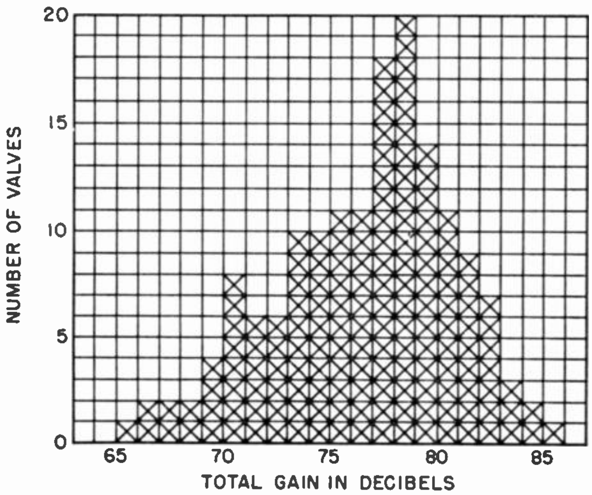

Fig. 15—This batch of 163 pentodes were placed 1 foot from the loudspeaker and amplified gain adjusted to the start of regenerative feedback. The mean value was 76.7 db.

Interpretation of Resonance Diagrams

Figs. 16 and 17 are diagrams showing the noise output recorded on samples of straight and vari-μ RF pentodes. Calculated resonant frequencies are given in Table V.

TABLE V
Calculated Resonant Frequencies

	Vari-μ Valve	High Slope Valve
Cathode	13,720 (Circular)	38,000 (Rectangular)
Grid No. 1 Support Lateral	 3,218 (Ni) 11,570 (Mn Ni) (Arc)	 9,900 (Cu) 7,500 (Mo) (Rectangular)
Grid No. 2 Support Lateral	 3,080 (Ni) 4,720 (Mo) (Arc)	 7,520 (Ni) 2,500 (Mo) (Rectangular)
Grid No. 3 Support Lateral	 3,840 (Ni) 2,280 (Mn Ni) (Arc)	 11,900 (Ni) 1,190 (Mo) (Rectangular)

From the diagrams it is evident that there are a number of resonances at the natural frequencies of the lateral wires. Visual examination of the high slope pentode showed that each lateral wire of the suppressor grid had a separate resonance in the band 1,020–1,350 cps where the calculated value is 1,190 cps. Fig. 18 shows this feature diagrammatically.

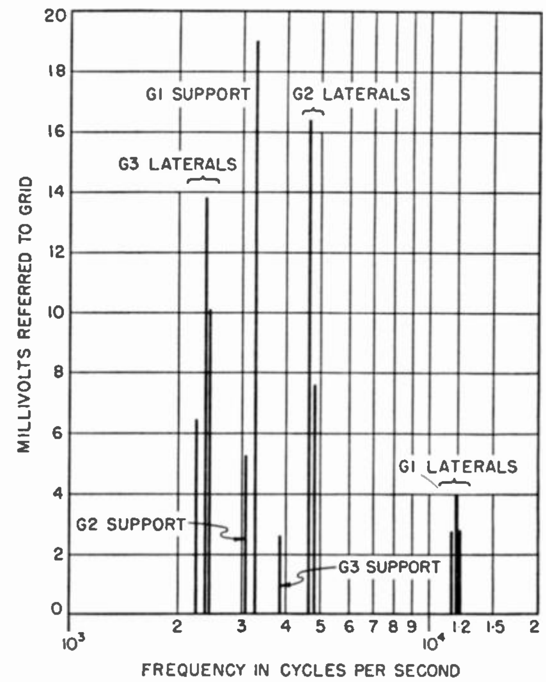

Fig. 16—Resonance diagram for a vari-μ radio-frequency pentode.

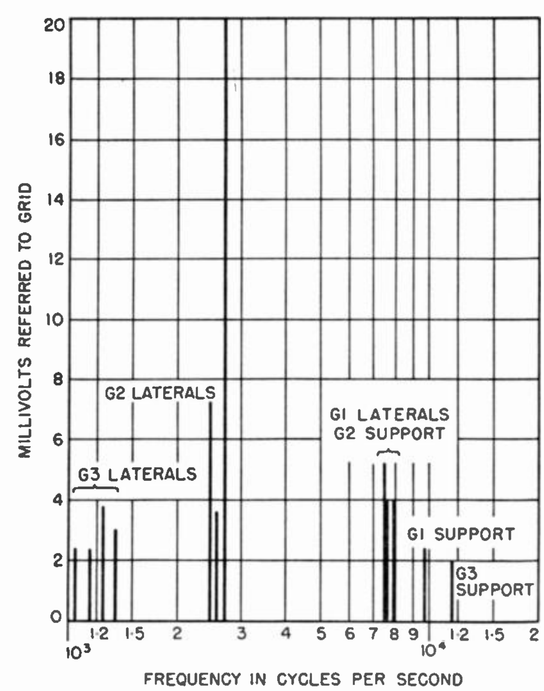

Fig. 17—Resonance diagram for a high-slope radio-frequency pentode.

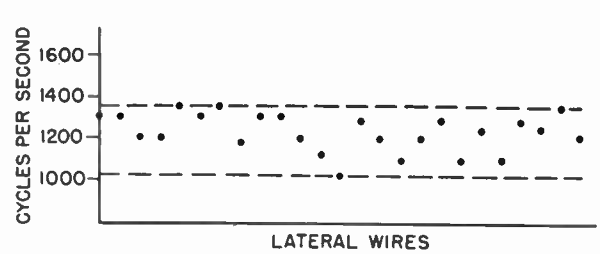

Fig. 18—Resonant frequencies of individual lateral wires of grid 3 in a high-slope pentode. Maximum and minimum frequency limits are indicated by dashed lines.

At each of the resonant frequencies a check was made on the effect of increasing the acceleration. Fig. 19 shows a typical graph of one of the resonances. In all cases it was found that the noise increased approximately with the square root of the acceleration.

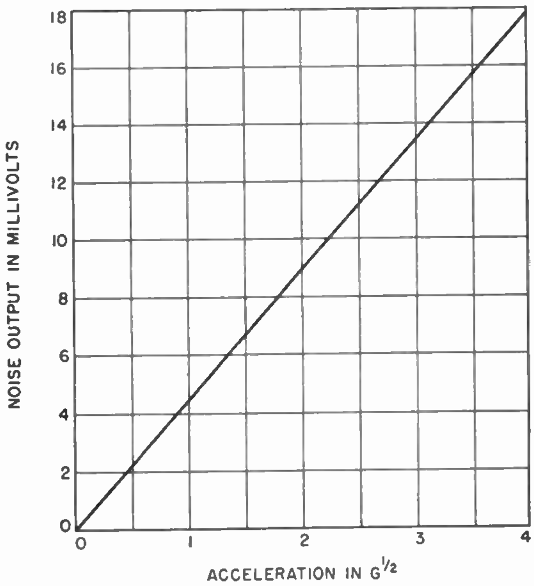

Fig. 19—Noise output plotted against acceleration at a frequency of 2,400 cps for a lateral wire of grid 3 of a high-slope pentode.

Design Improvements

Noise produced by electrode rattle may be overcome easily, but excessive noise due to electrodes resonating can only be avoided by basic design of the structure.

A general improvement in "rattle" noise will nearly always result from a reduction of the tolerances on the insulator holes into which the electrodes fit. This is especially important at the top end of the structure because the movement is not restricted by the connecting bars and tapes as it is at the bottom. Direct connections of pin to electrode in the case of miniature valves also helps. The additional rigidity that is necessary for Reliable Valves is obtained by locking the cathode and grids in the top insulator by means of special pips, beads, or stakes formed on the electrodes, or better by using tapes that are clamped to the insulators and then welded to the electrode. Fig. 20 shows the rattle noise output in the case of a Reliable Valve during initial development, after the initial precautions had been taken, and finally when all precautions had been taken.

Apart from the fact that it is desirable to make the resonant frequencies of the electrodes as high as possible because they are not so liable to excitation by normal mechanical vibrations, the amplitude of the electrode movement will be proportionally less with the time of periodic motion for constant excitation.

From the point of view of the supporting members and electrodes held between the insulators the frequency will vary inversely with the square of the length, proportionally with the diameter, and with the square root of Young's modulus. If the supports are fixed rigidly at each end instead of being free in the insulators the resonant frequency is given by

$$\frac{1}{f} = T = \frac{2\pi l^2}{r}\left\{\frac{\rho}{62.8Y}\right\}^{1/2}. \qquad (32)$$

The frequency is actually increased by 1.67 times compared to the nonrigid fixing.

The resonant frequency of the lateral wires may only be increased by using small values of major axis and large diameters of wire. Except for suppressor grids however, the frequency of lateral wires of normal valves is well above 1,000 cps.

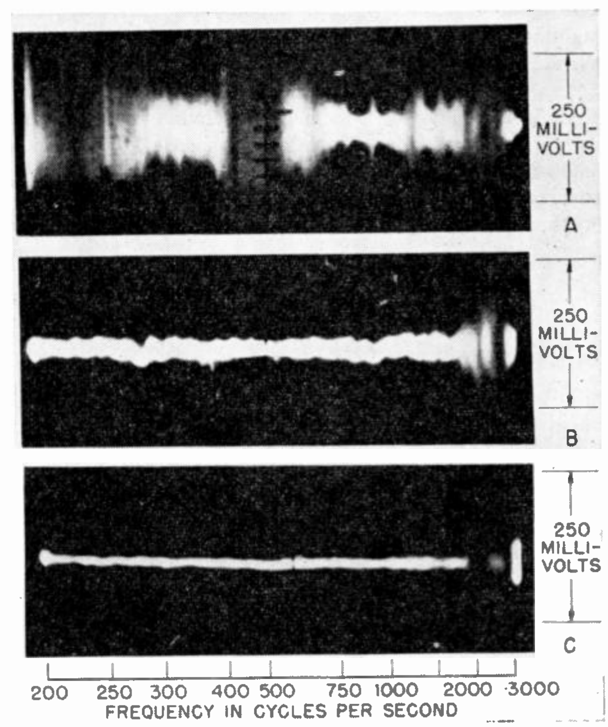

Fig. 20—Noise spectrum for radio-frequency pentode designs. A = normal commercial value, B = the results of early design efforts, and C = final reliable value.

Conclusion

It has been shown that the resonant frequencies of valve electrodes may be calculated, and indication has been given respecting their usefulness in basic valve design.

Present trends are to produce valves that will not have resonant frequencies or rattle noises at frequencies so low that they are excited by mechanical disturbances but there is need for more research into the field of impacts and nonlinear accelerations in order that a clearer picture of the precise requirements for future designs can be obtained.

Acknowledgment

The authors wish to thank Standard Telephones and Cables Ltd., and the Admiralty, for permission to publish this information, and to acknowledge the assistance given by Mr. E. G. Rowe.

FM Transient Response of Band-Pass Circuits*

R. E. McCOY†, MEMBER, IRE

Summary—While in a steady state the output frequency of an amplifier must be the same as its input frequency, transient differences occur whenever the input frequency changes. A general formula has been derived for the output voltage resulting from an abrupt frequency shift; and by manipulating the terms of this formula, the instantaneous frequency deviation has been determined. Detailed computations have been made for large frequency shifts in a single tuned circuit, and for small frequency shifts in amplifiers having various numbers of tuned circuits. For large steps of frequency deviation, the shape of the output deviation depends on the magnitude of the step, the initial frequency (before the step), and whether the step is toward or away from the midband frequency. For small steps near midband, the transient response of a given band-pass filter is the same for frequency modulation as for amplitude modulation, and can be described as the response to a voltage step in an equivalent video circuit. Stagger tuning causes overshoot in the transient response, but such overshoot will be small if the stagger is no more than enough to provide maximally-flat amplitude response in the steady state.

Introduction

In recent years frequency modulation has been used for a number of applications where the modulating signal changes rather abruptly. Among these applications may be listed telegraphy (by frequency-shift keying), telemetering (with frequency-modulated transmission after time-division multiplexing), and television relay transmission (using frequency modulation in microwave links). One advantage of frequency-modulation systems is that both amplifiers and passive circuits have unity transfer ratio for frequency; i.e., steady-state input and output frequency are always the same. This ideal relation does not hold, however, for sudden changes. In circuits of finite bandwidth the output can never change quite as precipitously as the input, and for a short time after any change the instantaneous frequencies of input and output may differ significantly. The analysis below outlines a method of determining the instantaneous output frequency, for any practical circuit, in response to a rectangular step of input-frequency deviation. A narrow-band approximation (valid for high-Q circuits) is shown to simplify the general formula, and its use is illustrated by several examples.

General Method of Analysis

Frequency modulation of a carrier wave by a rectangular step function—i.e., an abrupt change of carrier frequency from one value to another—can be expressed simply as the resultant of two rectangular steps of amplitude modulation, namely, a step up from zero to unity in the amplitude of a carrier wave at the new frequency, and a step down from unity to zero in the amplitude at the old frequency. To maintain continuity, it must be assumed that the two amplitude-modulated carriers have the same phase angle (say ϕ_0) at the time of transition. For example, taking the instant of transition as time zero and the amplitude as one unit of voltage, the frequency-modulated wave may be written as

$$\left.\begin{aligned} e_i &= \cos(\omega_1 t + \phi_0), & -\infty < t < 0 \\ e_i &= \cos(\omega_2 t + \phi_0), & 0 < t < \infty \end{aligned}\right\}, \tag{1}$$

where ω_1 and ω_2 are the angular frequencies before and after the step, respectively.

If the input voltage specified by (1) is applied to a particular circuit such as a band-pass amplifier, the response to each AM step can be computed[1] by the use of Laplace transforms, and the response to the FM step then can be computed by addition. Usually the result so obtained contains a series of terms representing damped oscillations; each term may have a different frequency or a different degree of damping, depending on the circuit characteristics. In the case of an amplifier designed to pass the specified wave, all terms in the series expressing the output voltage as a function of time will have nearly the same frequency. Their sum can be interpreted as a wave of approximately the midband frequency, with a combination of amplitude and phase modulation, in the following form:

$$e_0 = A\cos(\omega_0 t + \Phi), \tag{2}$$

where A and Φ are rather complicated functions of time, representing amplitude and phase, respectively; and ω_0 is a constant arbitrarily chosen to make $\omega_0 t$ take up most of the rapid variation that otherwise would have to be included in Φ.

The instantaneous frequency deviation of output voltage e_0 can be computed from the rate of change of Φ. In angular units, it is

$$\omega_d = 2\pi f_d = \frac{d\Phi}{dt}. \tag{3}$$

The analysis outlined above can be simplified to some extent by dealing with complex exponential functions instead of sinusoids. Then the input voltage is

$$e_i = 0.5(E_i + E_i^*), \tag{4}$$

* Decimal classification: R143.2. Original manuscript received by the Institute, May 23, 1953; revised manuscript received August 31, 1953.

† Hughes Research and Development Labs., Culver City, Calif., now with Electronic Control Systems, Inc., Los Angeles, Calif.

[1] M. F. Gardner and J. L. Barnes, "Transients in Linear Systems," John Wiley & Sons, Inc., New York, N. Y.; 1942.

where

$$E_i = \underline{/\omega_1 t + \phi_0} + 1_0(\underline{/\omega_2 t} - \underline{/\omega_1 t})\underline{/\phi_0}. \quad (5)$$

By definition,

$$1_0 = 0 \quad \text{for} \quad t < 0,$$
$$1_0 = 1 \quad \text{for} \quad t > 0,$$
$$\underline{/\theta} = \exp(j\theta),$$

and E_i^* is the complex conjugate of E_i.

The output voltage resulting from each term in (5) can be computed separately—by steady-state analysis, for the first term, and by Laplace-transform methods for the rest. Corresponding outputs due to E_i^* then can be found simply by reversing the sign of the angles in those computed from E_i.

The Laplace transform of $1_0(\underline{/\omega_2 t} - \underline{/\omega_1 t})\underline{/\phi_0}$ is

$$\int_0^\infty (\underline{/\omega_2 t} - \underline{/\omega_1 t}) \exp(j\phi_0 - st)dt$$
$$= \{(s - j\omega_2)^{-1} - (s - j\omega_1)^{-1}\}\underline{/\phi_0} \quad (6)$$

where s is a complex variable. Equation (6) specifies the driving function applied to the circuits. The next step is to determine the transfer function of the circuits. In amplifiers consisting of several single-tuned stages, the over-all transfer functions can be determined from those of the individual stages.

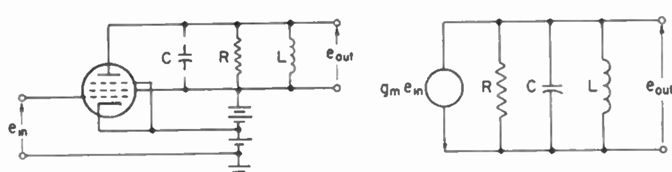

Fig. 1—Single-tuned amplifier, equivalent RF circuit.

For a typical single-tuned amplifier stage, with equivalent circuit as shown schematically in Fig. 1, the transfer function may be written

$$G_1(s) = -g_m/(1/R + Cs + 1/Ls) \quad (7)$$

or

$$G_1(s) = -2M\alpha s/(s^2 + 2\alpha s + \alpha^2 + \beta^2), \quad (8)$$

where

$\alpha = 1/(2RC)$ is a damping constant,

$\beta = \sqrt{1/LC - \alpha^2}$

$\approx (LC)^{-0.5}$ is the resonant frequency in angular units,

and

$M = g_m R$ is the gain of the stage at resonance.

For an amplifier using N tuned circuits, the transfer function $G_N(s)$ will have N factors like (8), with each α and β determined by a corresponding tuned circuit. Assuming, then, a transfer function $G_N(s)$ with N conjugate pairs of poles, at $s = -\alpha_n \pm j\beta_n$, by multiplying $G_N(s)$ by the Laplace transform in (6) and by taking the inverse transform of the product, the output caused by input $1_0(\underline{/\omega_2 t} - \underline{/\omega_1 t})\underline{/\phi_0}$ is found to be[2]

$$1_0 G_N(j\omega_2)\underline{/\omega_2 t + \phi_0} - 1_0 G_N(j\omega_1)\underline{/\omega_1 t + \phi_0}$$
$$+ 1_0 \sum_{n=1}^{n=N} K_{1n} \exp(-\alpha_n t)\underline{/\beta_n t + \phi_0}$$
$$+ 1_0 \sum_{n=1}^{n=N} K_{2n}^* \exp(-\alpha_n t)\underline{/-\beta_n t + \phi_0}$$

where

$$K_{1n} = \lim_{s \to -\alpha_n + j\beta_n} [\{(s - j\omega_2)^{-1} - (s - j\omega_1)^{-1}\}(s + \alpha_n - j\beta_n)G_N(s)]$$

and

$$K_{2n}^* = \lim_{s \to -\alpha_n - j\beta_n} [\{(s - j\omega_2)^{-1} - (s - j\omega_1)^{-1}\}(s + \alpha_n + j\beta_n)G_N(s)].$$

K_{2n} is K_{1n} with the signs of ω_1 and ω_2 reversed, and K_{2n}^* is the complex conjugate of K_{2n}, or simply K_{1n} with the sign of β_n reversed. The steady-state response to input $\underline{/\omega_1 t + \phi_0}$ is the same as the second term of the output above, except for a factor unity instead of the unit step 1_0. Adding this, and the conjugate output terms caused by input E_1^*, it may be seen that the total output is

$$e_0 = 0.5(E_0 + E_0^*) \quad (9)$$

where

$$E_0 = (1 - 1_0)G_N(j\omega_1)\underline{/\omega_1 t + \phi_0} + 1_0 G_N(j\omega_2)\underline{/\omega_2 t + \phi_0}$$
$$+ 1_0 \sum_{n=1}^{N} K_{1n} \exp(-\alpha_n t)\underline{/\beta_n t + \phi_0}$$
$$+ 1_0 \sum_{n=1}^{N} K_{2n} \exp(-\alpha_n t)\underline{/\beta_n t - \phi_0}, \quad (10)$$

$$K_{1n} = \lim_{s \to -\alpha_n + j\beta_n} [\{(s - j\omega_2)^{-1} - (s - j\omega_1)^{-1}\}(s + \alpha_n - j\beta_n)G_N(s)],$$

and K_{2n} is K_{1n} with the signs of ω_2 and ω_1 reversed.

The last term in (10) comes from the response to input E_i^*, while the preceding terms come from the response to input E_i. An opposite division of terms applies to E_0^*, the conjugate of E_0, so that between them E_0 and E_0^* include all the output terms; but E_0 has only terms with positive phase rotation, while E_0^* has only terms with negative phase rotation.

If some of the poles of $G_N(s)$ are equal, (10) must be modified[3] to eliminate the duplicate terms it indicates.

[2] *Ibid.*, Function-Transform Pair no. 0.11, p. 338.
[3] *Ibid.*, Function-Transform Pair no. 0.21, p. 334.

For example, if M equal poles are listed first in the n-summations, $\alpha_n+j\beta_n=\alpha_1+j\beta_1$, for $n=1, 2, \cdots, M$, and the corresponding terms of the two n-summations must be replaced by

$$\sum_{m=1}^{M} \frac{K_{3m}t^{M-m}}{(m-1)!(M-m)!} \epsilon^{-\alpha_1 t}\underline{/\beta_1 t + \phi_0}$$

and

$$\sum_{m=1}^{M} \frac{K_{4m}t^{M-m}}{(m-1)!(M-m)!} \epsilon^{-\alpha_1 t}\underline{/\beta_1 t - \phi_0},$$

respectively, where

$$K_{3m} = \lim_{s\to-\alpha_1+j\beta_1} \left[\frac{d^{m-1}}{ds^{m-1}} \{(s-j\omega_2)^{-1} - (s-j\omega_1)^{-1}\}(s+\alpha_1-j\beta_1)^M G_N(s)\right]$$

and K_{4m} is K_{3m} with the signs of ω_1 and ω_2 reversed.

Comparing (2) and (9), and making use of the relation between exponential and trigonometric functions, it may be seen that

$$E_0 = A\underline{/\Phi + \omega_0 t}. \qquad (11)$$

If (11) is differentiated with respect to t, and the derivative then divided by the original equation, the quotient is

$$\frac{1}{E_0}\frac{dE_0}{dt} = \frac{1}{A}\frac{dA}{dt} + j\frac{d\Phi}{dt} + j\omega_0.$$

By definition, both A and Φ are real, as is t; so the real and imaginary parts of the quotient are separate, as indicated on the right. The imaginary part of the quotient differs only by a constant ω_0 from the right side of (3); thus

$$\omega_d = \frac{d\Phi}{dt} = \Im\left\{\frac{1}{E_0}\frac{dE_0}{dt}\right\} - \omega_0. \qquad (12)$$

Even for the case of a single tuned circuit, the process of differentiation and division required by (12) is simpler than the procedure suggested by Gardner and Barnes,[4] which would involve trigonometric manipulation to determine Φ explicitly before differentiating it.

Approximations Used to Simplify Analysis

To produce a band-pass effect, all the β_n in (10) must be near some average value such as ω_0; and if ω_1 and ω_2 are to be within the pass band, they also must be near ω_0 with differences not large in comparison to the α_n. These conditions make K_{1n} larger than K_{2n} by at least four times the ratio of mid-band frequency to bandwidth, when $N=1$, and by a larger margin in more complicated cases. Ordinarily that ratio will be so large that terms involving K_{2n} may be neglected in (10). All the results below are based on this "high-Q" approximation. Because of the terms it eliminates from E_0, the high-Q approximation makes frequency deviation ω_d independent of the initial phase angle ϕ_0, permitting the latter to be dropped from the equations.

As a further consequence of the high-Q approximation, factors like $G_1(s)$, in (8), may be approximated by simpler forms, since

$$2\alpha s/(s^2+2\alpha s+\alpha^2+\beta^2) \approx \alpha/(s+\alpha-j\beta)$$

when both numerator and denominator of the latter expression are small in comparison to β. Such approximations halve the amount of arithmetic required to evaluate K_{1n} for (10).

It is convenient to normalize the various parameters used here, expressing frequencies on a scale with zero at midband and ± 1 at the edges of the nominal passband of the amplifier, by means of the following substitutions:

$$\left.\begin{aligned} a_n &= \alpha_n/\alpha_0; \\ b_n &= (\beta_n-\omega_0)/\alpha_0; \quad p = (s-j\omega_0)/\alpha_0; \\ x_1 &= (\omega_1-\omega_0)/\alpha_0; \quad x_2 = (\omega_2-\omega_0)/\alpha_0; \\ \theta &= \alpha_0 t; \quad \text{and} \quad E_0' = E_0\underline{/-\omega_0 t - \phi_0} \end{aligned}\right\}, \qquad (13)$$

where $\alpha_0/\pi=B$, the nominal bandwidth in cycles per second, and $\omega_0/2\pi=f_0$, the midband frequency in cycles per second.

Using the normalized parameters defined by (13), assuming $G_N(s)$ is composed entirely of factors like (8), applying the high-Q approximation, and dropping constant factors that represent merely a change of amplitude, the normalized transfer function is

$$G_{NN}(p) = \prod_{n=1}^{N} a_n/(p+a_n-jb_n). \qquad (14)$$

Continuing the approximation on this basis and considering only positive time ($\theta>0$) where the distinction between unity and the unit step may be ignored, (10) becomes

$$E_0' = G_{NN}(jx_2)\underline{/x_2\theta} + \sum_{n=1}^{N} K_{1n}\exp(-a_n+jb_n)\theta, \qquad (15)$$

where

$$G_{NN}(jx_2) = \prod_{m=1}^{N} a_m/\{a_m+j(x_2-b_m)\}$$

and

$$\begin{aligned} K_{1n} &= \lim_{p\to-a_n+jb_n} [\{(p-jx_2)^{-1} - (p-jx_1)^{-1}\}(p+a_n-jb_n)G_{NN}(p)] \\ &= j(x_2-x_1)a_n[-a_n+j(b_n-x_2)]^{-1} \\ &\quad \cdot[-a_n+j(b_n-x_1)]^{-1}\prod_{m\neq n} a_m/(a_m-a_n+jb_n-jb_m) \end{aligned}$$

[4] *Ibid.*, pp. 247–249.

In a synchronously-tuned amplified with all its tuned circuits alike, $b_n = 0$ and $a_n = a = (2^{1/N} - 1)^{-0.5}$, the ratio of the bandwidth of a single stage to the over-all bandwidth of the amplifier. Then K_{1n} assumes an indeterminate form, but by the method of limits (15) can be reduced to the following:

$$E_0' = \sum_{m=0}^{N-1} \frac{(a\theta)^m}{m!} \left\{ (1 + jx_2/a)^{m-N} - (1 + jx_1/a)^{m-N} \right\} \epsilon^{-a\theta} + (1 + jx_2/a)^{-N}/x_2\vartheta. \quad (16)$$

From (12), using the normalized parameters defined by (13),

$$\frac{\omega_d}{\alpha_0} = \Im \left\{ \frac{1}{E_0'} \frac{dE_0'}{d\theta} \right\}. \quad (17)$$

In general, applying (17), to either (15) or (16) produces a formula cumbersome and tedious to evaluate; but the nature of the results can be shown fairly well by a few simple examples, assuming either that $N = 1$ or that x_1 and x_2 are very small.

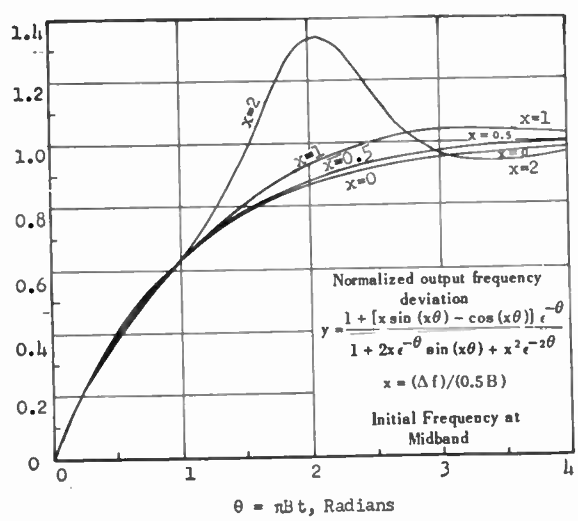

Fig. 2—Response of a single tuned circuit to a rectangular-step frequency shift, starting at midband frequency.

Typical Results for a Single Tuned Circuit

For a single tuned circuit $N = 1$, $a_n = 1$, and $b_n = 0$; hence, from either (15) or (16),

$$E_0' = (1 + jx_2)^{-1}/x_2\vartheta + \left\{ (1 + jx_2)^{-1} - (1 + jx_1)^{-1} \right\} \exp(-\theta). \quad (18)$$

Three cases will be considered: making x_1 and then x_2 zero, and making $x_1 = -x_2$.

Example 1. Frequency Shift Starting from Midband

Let $x_1 = 0$, $x_2 = x$, and $y = \omega_d/\alpha_0 x$. Then from (17) and (18):

$$y = \frac{1 + [x \sin (x\theta) - \cos (x\theta)] \exp (-\theta)}{1 + x^2 \exp (-2\theta) + 2x \sin (x\theta) \exp (-\theta)}. \quad (19)$$

If there were no transient distortion, the normalized output frequency deviation y would be simply a rectangular step of unit amplitude. Actually, it is a rounded step, with shape depending on the relative frequency shift x, as shown in Fig. 2.

For small frequency shifts, the shape of the output step is nearly independent of x; but as the frequency shift at the input increases, particularly beyond $x = 1$ (which means a shift from midband to either edge of the nominal passband), the output step changes shape and shows a tendency to overshoot. Hatton has reported similar results.[5] Salinger, on the other hand, has found overshoots for all ratios of bandwidth to frequency deviation; however, Salinger's analysis was based on a rectangular passband, which cannot be achieved in any practical circuit.[6]

Example 2. Frequency Shift Ending at Midband

Let $x_1 = x$, $x_2 = 0$, and $y = \omega_d/\alpha_0 x$. Then

$$y = \exp(-\theta) / \left\{ 1 + x^2 [1 - \exp(-\theta)]^2 \right\}. \quad (20)$$

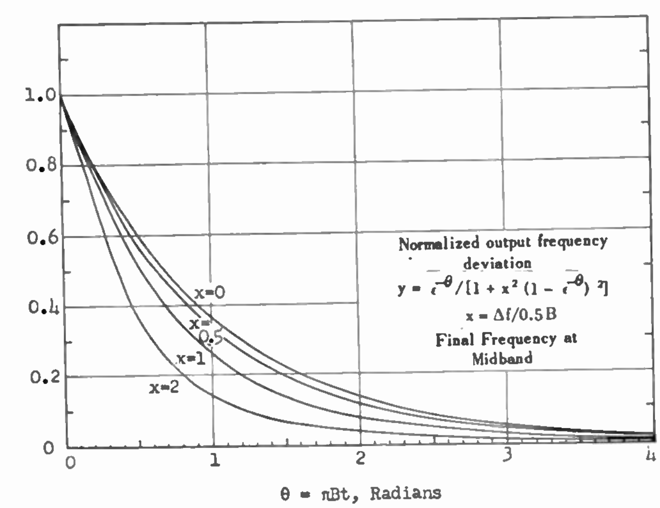

Fig. 3—Response of a single tuned circuit to a rectangular-step frequency shift, ending at midband frequency.

In this case, as shown by Fig. 3, the shape of the output step approaches the ideal rectangle more closely as the input frequency shift (x) increases, and there is no tendency to overshoot. When the input frequency shifts toward the resonant frequency of the circuit, the circuit seems more co-operative than for a shift away from its natural frequency, and the output follows the input more closely.

Example 3. Frequency Shift Centered at Midband

Let $x_1 = -x$, $x_2 = x$, and $y = \omega_d/\alpha_0 x$.

[5] W. L. Hatton, "Simplified FM Transient Response," Technical Report No. 196, Research Laboratory for Electronics, Massachusetts Institute of Technology, Cambridge, Mass.; April 23, 1951.
[6] H. Salinger, "Transients in frequency modulation," Proc I.R.E., vol. 30, pp. 378–383; August, 1942.

$$y = \frac{(1 + x^2)\{1 - 2\cos(x\theta)\exp(-\theta)\}}{1 + x^2 + 4x^2\exp(-2\theta) + 4x\{\sin(x\theta) - x\cos(x\theta)\}\exp(-\theta)}. \tag{21}$$

This case is plotted in Fig. 4. As may be seen by comparison with Fig. 2 and 3, the transient distortion is of a character intermediate between those found in the two previous cases, where the shift was all on one side of midband. While approaching midband, the output frequency rises steeply, as in Example 2, but after passing midband it follows a curve more like that of Example 1, and shows a similar tendency to overshoot when the frequency shift is large. For a given frequency shift, however, the overshoot is less than in Example 1; and the change of step shape with increasing frequency shift is more gradual than in Example 1. Gold[7] has reported similar results, with minor differences which are apparently due to errors in numerical computation or plotting, since the (unpublished) formula he used was exactly equivalent to (21).

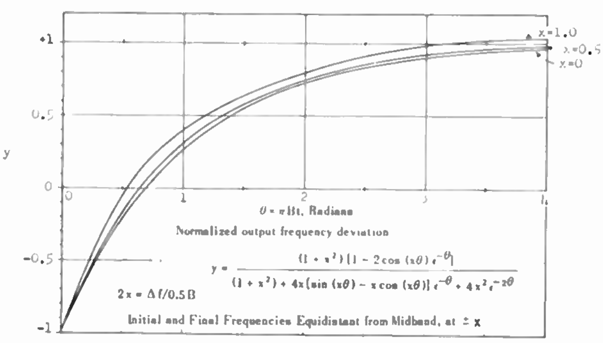

Fig. 4—Response of a single tuned circuit to a rectangular-step frequency shift, centered at midband frequency.

Results for Small Frequency Shifts

When x_1 and x_2 are nearly zero, the coefficients depending on them in (15) become approximately

$$G_{NN}(0) = \prod_{m=1}^{N} a_m/(a_m - jb_m)$$

and

$$K_{1n} \approx j(x_2 - x_1)a_n(-a_n + jb_n)^{-2} \cdot \prod_{m\neq n} a_m/(a_m - a_n + jb_n - jb_m).$$

Similarly, the coefficients in (16) become approximately

$$(1 + jx_2/a)^{-N} \approx 1$$

and

$$\{(1+jx_2/a)^{m-N} - (1+jx_1/a)^{m-N}\} \approx j(x_2 - x_1)(m - N).$$

Substituting these values and applying (17), the following results are obtained.

Example 4. Amplifier with All Stages Different, Frequency Shift Small

$$y = \frac{(\omega_d/\alpha_0 - x_1)}{(x_2 - x_1)} = 1 - \Re\sum_{n=1}^{n=N}\exp(-a_n + jb_n)\theta \cdot \prod_{m\neq n}\frac{(a_m - jb_m)}{(a_m - a_n - jb_n - jb_m)}. \tag{22}$$

Example 5. Amplifier with All Stages Alike, Frequency Shift Small

$$y = \frac{(\omega_d/\alpha_0 - x_1)}{(x_2 - x_1)} = 1 - \epsilon^{-a\theta}\sum_{m=0}^{N-1}\frac{(a\theta)^m}{m!}. \tag{23}$$

The right member of (23) can be evaluated directly from tables by Molina.[8] Equations (22) and (23) resemble equations describing the output voltage of a direct-coupled video amplifier when its input is a rectangular step of dc voltage. The resemblance becomes exact if the video amplifier has a transfer function proportional to

$$G_{LN}(s) = 0.5\prod_{m=1}^{N}(a_m - jb_m)/(a_m - jb_m + s) + 0.5\prod_{m=1}^{N}(a_m + jb_m)/(a_m + jb_m + s)$$

or

$$G_{LN}(s) = 0.5\{G_{NN}(s) + G_{NN}^*(s)\} \tag{24}$$

with the same normalized time scale (θ, instead of t) as in (14) defining the normalized transfer function $G_{NN}(p)$ of the band-pass amplifier. Equation (24) makes the transfer characteristics of the equivalent low-pass circuits an average of the transfer characteristics of the band-pass circuits for corresponding frequencies above and below the midband frequency. Thus the bandwidth of the equivalent video amplifier is half that of the band-pass amplifier.

From (22) it may be seen that stagger tuning (b_n not zero) introduces oscillatory terms, thereby tending to produce overshoot. For example, in a two-stage amplifier with tuning staggered to produce maximally-flat amplitude response, $a_1 = a_2 = b_1 = -b_2 = 0.7071$. Then from (22),

$$y = 1 - 1.414\cos(0.7071\theta - \pi/4)\exp(-0.7071\theta). \tag{25}$$

In this case the maximum overshoot, which occurs when $0.7071\theta = \pi$, is 4.3 per cent of the magnitude $(x_2 - x_1)$ of the step.

Overshoot decreases as the degree of stagger tuning is reduced, and vanishes completely for the case of syn-

[7] B. J. Gold, "Frequency transients in idealized linear systems," Convention Record of the I.R.E., 1953, part 5—Circuit Theory, pp. 95–101.

[8] E. C. Molina, "Poisson's Exponential Binomial Limit," D. Van Nostrand Co., Inc., New York, N. Y.; 1942.

chronous tuning leading to (23). Fig. 5 shows the results in that case, for amplifiers having the same over-all bandwidth but differing in number of stages.

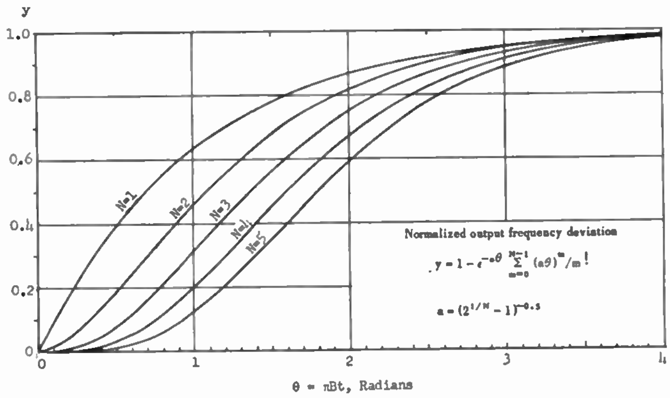

Fig. 5—Response of N-stage synchronously-tuned amplifier to a small rectangular-step frequency shift, near midband frequency.

Conclusion

For small step variations of input in the middle of the passband, the transient response of a band-pass filter has substantially the same form for frequency modulation as for amplitude modulation. For large steps, the steeply rising or falling part of the transient response is somewhat steeper in the frequency-modulation case. If the input frequency swings outside the filter passband, the output frequency deviation will swing even farther before settling down. The principle of superposition does not apply to transient frequency deviations of a magnitude comparable to the bandwidth of the circuits affected, but it provides a close approximation (accurate within 5 per cent of the peak deviation) so long as the instantaneous frequency remains within the middle half of the passband of each circuit.

In applications where the allowable transient distortion is small, stagger tuning (and its equivalent, tuned circuits with close coupling) must be avoided or used sparingly; and the instantaneous input frequency must be kept within the over-all passband. Then the over-all bandwidth of a multi-stage amplifier will be considerably less than that of any one stage; the input frequency generally will remain close enough to the mid-band frequency of each tuned circuit to justify use of the small-deviation approximation.

Acknowledgement

The author gratefully acknowledges the assistance of Albert Deutsch, a member of the Numerical Analysis Unit at Hughes Aircraft Company, who computed numerical results and plotted the graphs presented here.

Calculation of the Resonant Properties of Electrical Cavities*

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***Summary*—It is shown that the resonant properties of axially symmetric cavities can be calculated using data obtained on an analogous static system in an electrolytic tank. The electrodes simulating the cavity are split into segments to allow a measurement of the current distribution along the electrodes. This current distribution is then used to obtain an approximation to the distribution of dynamic charge density over the walls of the cavity, and so yields the current distribution in the cavity. Calculations of the cavity parameters from the estimated current distribution yield results within a few per cent of the values measured on an actual cavity.**

Introduction

THIS PAPER PRESENTS a new method for the calculation of the properties of re-entrant-type structures as used in microwave systems. The method utilizes measurements made in an electrolytic tank to obtain an approximation to the current distribution in the structure. Once the current distribution is known, the properties of the structure can be determined. The procedure is shown in detail for a re-entrant-type cavity; it could also be used to determine the properties of ridge-type waveguides.

The type of cavity used to illustrate the method is shown in Fig. 1. An approximation to the characteristics of cavities of this type may be obtained by neglecting the electric field in the outer region and the magnetic field in the gap region. The effective inductance (outer region) and capacitance (gap region) are readily calculated. The approximate cavity characteristics can then be obtained by using the methods of ordinary circuit theory.[1]

It is possible to obtain an "exact" solution to the cavity problem by an analysis of the fields within the cavity. For this purpose the volume of the cavity is divided into two regions, each of simple geometry (such

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[1] S. Ramo and J. R. Whinnery, "Fields and Waves in Modern Radio," John Wiley and Sons, Inc., New York, N. Y., pp. 404–411; 1944.

as the gap and outer regions used in the approximate analysis). The field of the cavity is then found by expressing the field for each region in terms of its normal modes, where the amplitudes of the contributing modes are determined by requiring the field to be continuous across the (mathematical) boundary between the two regions.[2]

The approximate method of calculating cavity parameters is useful because of its simplicity; however, except for heavily loaded cavities (large gap capacitance) the errors involved may be large. The "exact" method, on the other hand, requires the use of a large number of field components if a good description of the field is to result; hence the calculations required for reasonable accuracy are quite tedious.

The method of this paper makes use of an electrolytic tank to obtain an approximation to the effect of the higher modes. A good description of the field is thus obtained so that the cavity parameters can be calculated quite accurately.[3] The method will be introduced by first outlining the technique used for an exact calculation. It will then be shown how appropriate electrolytic tank measurements can be used to advantage.

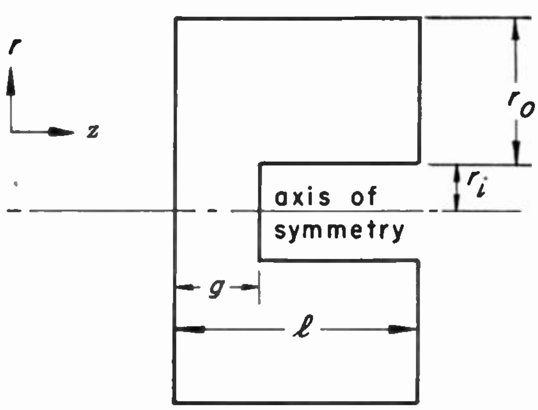

Fig. 1—Axially symmetric re-entrant cavity.

Analytical Solution

It is convenient to divide the cavity of Fig. 1 into two simple volumes consisting of the gap region ($r<r_i$) and an outer region ($r_i \leqq r \leqq r_0$). The axial (z) component of the electric field is found first; the other field components can then be obtained. A suitable expression for E_z satisfying Maxwell's equations and the boundary conditions that $E_z=0$ along $r=r_0$ and along $r=r_i$ for $g<z<l$, and that $\partial E_z/\partial z=0$ along $z=0$, along $z=g$ for $r<r_i$, and along $z=l$ for $r_i<r<r_0$ (this requirement follows from the requirement that $E_r=0$ on these surfaces) is that:

for $r_i \leqq r \leqq r_0$:

$$E_z = A_0J_0(\beta r) + B_0N_0(\beta r) + \sum_{n=1}^{\infty} \cos\left(\frac{n\pi z}{l}\right)[A_nI_0(\alpha_n r) + B_nK_0(\alpha_n r)], \quad (1a)$$

and for $r \leqq r_i$:

$$E_z = \frac{J_0(\beta r)}{gJ_0(\beta r_i)} + \sum_{m=1}^{\infty} C_m \cos\left(\frac{m\pi z}{g}\right) I_0(a_m r) \quad (1b)$$

(one volt is assumed across the gap at $r=r_i$); here

$$A_0J_0(\beta r_0) + B_0N_0(\beta r_0) = 0, \quad (1c)$$

$$A_0J_0(\beta r_i) + B_0N_0(\beta r_i) = 1/l, \quad (1d)$$

$$A_nI_0(\alpha_n r_0) + B_nK_0(\alpha_n r_0) = 0, \quad (1e)$$

$$\alpha_n = \frac{n\pi}{l}\sqrt{1-\left(\frac{2l}{n\lambda}\right)^2}, \quad (1f)$$

and

$$a_m = \frac{m\pi}{g}\sqrt{1-\left(\frac{2g}{m\lambda}\right)^2}. \quad (1g)$$

The remaining coefficients, A_n, B_n and C_m, must be chosen so that the fields defined by (1a) and (1b) are continuous across $r=r_i$. This requires that (1a) and (1b) be equal on $r=r_i$ and also that $rH=j\omega\epsilon\int rE_z dr$, as determined from (1a) and (1b), be equal on $r=r_i$.

If the constants of (1) are all known, the characteristics of the cavity can be calculated. The evaluation of these constants involves the solution of a doubly infinite set of simultaneous equations and requires various approximations to make calculation practical.

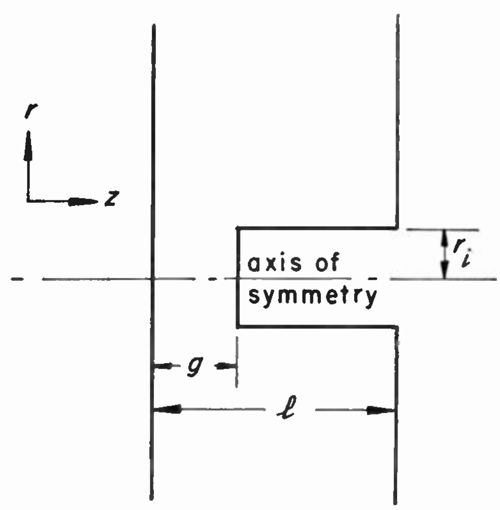

Fig. 2—Static system analogous to re-entrant cavity.

The Analogous Static System and its Application to Calculation of Cavity Field

A knowledge of the field distribution in an appropriate static system can be helpful in solving the dynamic problem. This static system (Fig. 2) has the same geometry as the cavity under consideration except that the radial transmission line is not shorted but, rather, is extended to infinity. The equations (1) can be made to apply to this case by taking $\lambda \to \infty$ so that $\beta \to 0$; one has then for $r \leqq r_i$:

[2] W. C. Hahn, "A new method for the calculation of cavity resonators," *Jour. Appl. Phys.*, vol. 12, pp. 62–68; January, 1944.

[3] In principle the measurements could be used as the basis of an exact calculation. The results would be used with the equations of the exact method to make them converge more rapidly. However, it is unlikely that the electrolytic process inherent in the tank measurement would permit accuracies sufficient to take advantage of this scheme.

$$E_z = \frac{1}{l} + \sum_{n=1}^{\infty} B_n' \cos\left(\frac{n\pi z}{l}\right) K_0(\alpha_n' r), \quad (2a)$$

and for $r \leqq r_i$:

$$E_z = \frac{1}{g} + \sum_{m=1}^{\infty} C_m' \cos\left(\frac{m\pi z}{g}\right) I_0(a_m' r), \quad (2b)$$

where

$$\alpha_n' = \frac{n\pi}{l} \quad (2c)$$

and

$$a_m' = \frac{m\pi}{g}. \quad (2d)$$

Suppose that the coefficients in (2) are known for g, l and r_i corresponding to the cavity.[4] The close similarity between (1) and (2) suggests that the cavity equations be reformulated to take advantage of the known coefficients of (2) to make the cavity equations converge more rapidly. It is particularly significant here that for cavities operating in their fundamental mode $a_m' \approx a_m$ for all m and, except for $n=1$, $\alpha_n' \approx \alpha_n$. For the fundamental mode $0.87\ \alpha_1' < \alpha_1 < \alpha_1'$ since $(2l/\lambda) < \frac{1}{2}$.

An approximate solution for the coefficients in (1) can be obtained from (2) in a particularly simple manner by noting that the electric field distribution in the gap region of the cavity (where the magnetic field is small) will be nearly the same as that in the corresponding region of the static system. This enables one to equate (1a) to (2a) and (1b) to (2b) for $r = r_i$; thus

$$A_1 I_0(\alpha_1 r_i) + B_1 K_0(\alpha_1 r_i) \approx B_1' K_0(\alpha_1' r_i) \quad (3a)$$

$$B_n' \approx B_n \quad (3b)$$

and

$$C_m' \approx C_m. \quad (3c)$$

Equation (3b) follows from the assumption that $\alpha_n' \approx \alpha_n$ for $n \neq 1$ and from the fact that $B_n K_0(\alpha_n r_i) \gg A_n I_0(\alpha_n r_i)$ (the signal reflected off the outer wall as observed at $r = r_i$ is small compared to the original signal); (3c) follows since $a_n' \approx a_m$. Equations (3) and (1) could be used to find the field in the cavity. It will be shown, however, that the cavity parameters can be obtained without a detailed knowledge of the field.

Calculation of Cavity Currents Using Static Model

It is common practice to use an electrolytic tank to plot the equipotential contours of static systems; such a plot could be used to obtain the desired cavity characteristics. However, a modification of the use of the tank (to be described) results in a simpler measuring technique and greatly enhanced accuracy.

[4] The coefficients in (2) might be obtained by analytical methods or by a Fourier analysis of $E_z(r_i, z)$ as measured in an electrolytic tank.

Electrolytic tanks are useful in evaluating static field configurations because the potential distribution in a homogeneous conducting medium obeys Laplace's equation, just as the potential distribution in a homogeneous dielectric obeys Laplace's equation. This is easily shown from Maxwell's equations:

Let $\overline{H}$ be the magnetic field intensity, $\overline{D}$ the electric displacement, σ the electric conductivity, ϵ the dielectric constant and, for steady-state conditions $\partial/\partial\omega = j\omega$; from Maxwell's equations

$$\nabla \times \overline{H} = \overline{J} + \frac{\partial \overline{D}}{\partial t} = (\sigma + j\omega\epsilon)\overline{E}, \quad (4a)$$

so that

$$\nabla \cdot \nabla \times \overline{H} = (\sigma + j\omega\epsilon)\nabla \cdot \overline{E} = 0. \quad (4b)$$

For very low frequencies, where the effect of the magnetic field is negligible, the electric field may be written as the gradient of the scalar potential V; Laplace's equation, $\nabla^2 V = 0$, then follows for any homogeneous isotropic medium. Thus the potential distribution in the vicinity of a given electrode system is independent of the conductivity and dielectric constant of the medium. It is useful to model a given electrode system in a medium of high conductivity to facilitate measurements of the field distribution. Of particular interest here is the proportional relationship between total current density, $(\sigma + j\omega\epsilon)E_n$, at an electrode in a conducting medium and the surface-charge density ϵE_n that would exist in a corresponding current-free system; this follows from (4a). Thus current to a portion of an electrode in an electrolytic tank model provides a measure of the static wall charge on the corresponding element of a similar current-free system.

If the charge distribution over the walls of a cavity is known, the distribution of wall current can be found from the relationship $I = j\omega Q$, where Q is the total charge contributing to the current.[5] The external characteristics of a cavity (resonant frequency, shunt conductance, and Q) can be calculated from the current distribution. The technique of approximating to the charge distribution using electrolytic tank measurements and of using the distribution to calculate the cavity parameters will now be shown.

Measurements and Calculations

A photograph of the static model used to simulate the cavity of Fig. 1 is shown in Fig. 3. The axial symmetry of the cavity is simulated by the use of a wedge-type tank[6] with the wedge angle sufficiently small to permit

[5] The validity of this relationship for a distributed system follows from the zero divergence of total current $\overline{J} + (\partial\overline{D}/\partial t)$.

[6] The use of a wedge tank is justified in any axially symmetric system because there is no angular component of the electric field. Its use requires that the fringing fields from the edge of the electrodes be negligible. This condition can be satisfied only if a low frequency is used and if there are no conducting surfaces, other than the electrodes, in the vicinity of the tank. The first measurements were made with an electrode system mounted on a $\frac{1}{2}$ inch lucite plate placed on a $\frac{1}{4}$ inch glass bottom plate in a metal tank; even at 30 cps the measurements were not useful because of the fringing field to the metal tank.

cylindrical surfaces to be represented by plane sections. The outer end of the radial transmission line is terminated by a ½ inch lucite plate to prevent fringing of the field from the end so that it simulates an "infinite" line. The electrodes are divided into segments so that the current distribution can be measured. The re-entrant section of the model is made removable so that the resulting plane electrode structure can be used to determine current distribution in the principal mode.

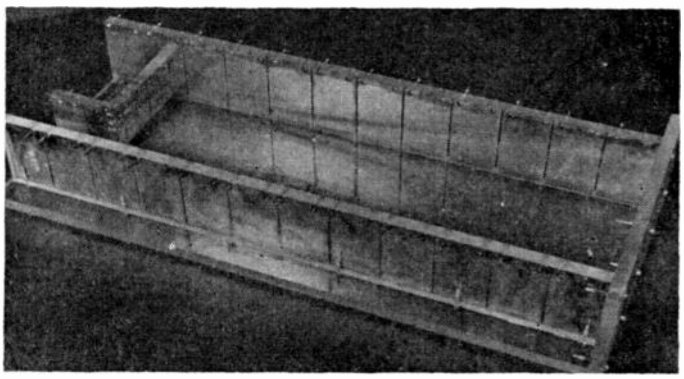

Fig. 3—Electrolytic tank for use in cavity studies showing re-entrant section in place.

The electrical arrangement for the measurement is diagrammed in Fig. 4. All of the segments on one electrode, except the one to be measured, are placed in parallel and connected to one terminal of a low-frequency (30 cps) oscillator through a decade resistance box (R_1). The isolated segment is connected through a second decade resistance box (R_2) to the same side of the oscillator. The other side of the oscillator is connected to the second electrode whose segments are all connected together. A high impedance detector (oscilloscope or vacuum-tube voltmeter) is bridged between the isolated element and the remaining paralleled

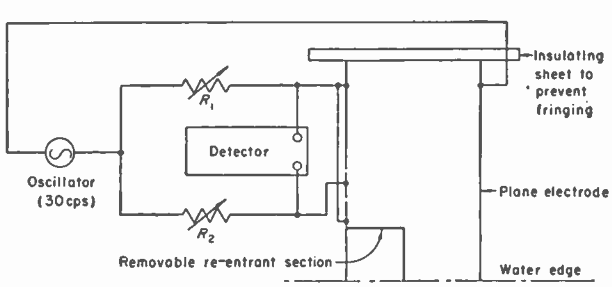

Fig. 4—Experimental arrangement for measurements on simulated cavity.

elements on the same electrode. Measurements are made by adjusting the decade resistance boxes to minimize the signal to the detector. At balance the segmented electrode becomes an equipotential surface. The values of the resistances at balance are used to find the ratio of current in the isolated segment (I_n) to the total current (I_t) (or the ratio of charge on the corresponding element of a current-free system to the total charge). The balance condition for the nth element yields $I_nR_2 = (I_t - I_n)R_1$ so that

$$\frac{I_n}{I_t} = \frac{R_1}{R_1 + R_2} = \text{fractional current.} \tag{5}$$

Two sets of data are taken:

1. Measurements are first made on the planar electrode system. These serve to evaluate the principal mode field and to provide a check on the behavior of the measuring system. The current density in the segments, found by dividing the fractional currents by the respective areas, should be the same for all segments. Any systematic deviations indicate an improper adjustment of the water level or an excessively large fringing field.

2. The measurements are then repeated with the re-entrant section(s) in place to simulate the cavity being studied.

The radial length of the tank model is made large compared with the dimensions of the re-entrant section. The effect of the re-entrant section in the outer segments is therefore very small, so that in these segments the current density for a given voltage between electrodes should be the same as it was with the planar system. The currents in the re-entrant system are adjusted by multiplying them by a constant chosen so that the currents in the outermost segments on both sides are, as nearly as possible, equal to the currents found for the same segments measured with the planar system.

The charge on the walls of the corresponding segments of a current-free system is found (except for a constant multiplying factor) from the difference (ΔI) between the two sets of data:

a. In the radial transmission-line region the differences between the fractional currents for the planar system and the adjusted currents for the re-entrant system are proportional to wall charges attributable to higher-order modes in the current-free system.

b. Inside the radius of the re-entrant section the adjusted fractional currents are proportional to the wall charges in the corresponding elements of the current-free system.

Once the distribution of wall charge is known, the corresponding RF current distribution can be calculated from the total of the wall charge passing any plane. The relationship between the tank measurements and the RF currents is readily found by considering the susceptance relationships for a free-space radial line corresponding to the tank model. For such a line

$$\omega C = \frac{\omega \epsilon_0 A}{l} = 2\pi \sqrt{\frac{\epsilon_0}{\mu_0}} \frac{\pi R^2}{l\lambda}, \tag{6a}$$

where C is the capacitance formed by the two planar electrodes (assumed now to be complete circular electrodes rather than wedges) to the outer radius, R, (giving a plate area $A = \pi R^2$); l is the separation between the two electrodes; ϵ_0 is the dielectric constant and μ_0 the permeability of free space; and λ is the wavelength to the scale of the tank. The susceptance relationship is conveniently written in the form

$$\omega C = \frac{\pi R^2}{60l\lambda} \qquad (6b)$$

since in rationalized MKS units $\sqrt{\mu_0/\epsilon_0} = 120\pi$. It is significant that ωC is invariant to a change in scale of the system (including a corresponding change in wavelength). Since the susceptance, ωC, corresponds to total fractional current (unity) for the radial transmission line model, one has for an element of the re-entrant system $(r < r_i)$

$$\Delta B = \frac{\pi R^2}{60l\lambda} \times [\text{adjusted current}]. \qquad (7a)$$

Since susceptance is just current per volt, (7a) yields the RF current components required for the cavity calculations.

For the higher-order modes in the radial sections (outside the radius of the re-entrant section) the multiplying factor is somewhat higher than the value given in (7a). This is because of the difference between α_n and α_n'. The correction for the nth term is just the ratio $\alpha_n'/\alpha_n = 1/\sqrt{1-(2l/n\lambda)^2}$. Actually the correction is small for the first term, and, since most of the current is from the first term, this correction may be applied to all terms without serious error. The RF current contributions in this region $(r > r_i)$ then become

$$\Delta B = \frac{\pi R^2}{60l\lambda\sqrt{1-\left(\frac{2l}{\lambda}\right)^2}} [\text{adjusted current}]. \qquad (7b)$$

Once the contribution to the capacitive current from each part of the cavity wall is known, the contributions may be summed to find the total capacitive current at any location in the cavity. The current builds up to a maximum at the discontinuity formed by the junction of the re-entrant section and the radial transmission line; hence in the re-entrant region the contributions are summed from the center out, while in the radial line they are summed from the outside in.

Calculation of Cavity Parameters

The sum of the currents at the junction of the re-entrant section and the radial line is the total capacitive loading current (per volt at $r = r_i$); it is thus the susceptance loading the radial line at $r = r_i$. The negative of this susceptance is equal to the susceptance presented by the radial line at $r = r_i$; this may be found from the principal wave electric field (from 1a and 1c):

$$E_z = \frac{A_0}{N_0(\beta r_0)} [J_0(\beta r)N_0(\beta r_0) - J_0(\beta r_0)N_0(\beta r)], \qquad (8a)$$

and magnetic field (using $H_\phi = (1/j\omega\mu_0)(\partial E_z/\partial r)$ obtained from $\nabla \times \overline{E} = -j\omega\mu_0 \overline{H}$ with $E_r = 0$):

$$H_\phi = \frac{jA_0}{\sqrt{\frac{\mu_0}{\epsilon_0}}\, N_0(\beta r_0)} [J_1(\beta r)N_0(\beta r_0) - J_0(\beta r_0)N_1(\beta r)]. \qquad (8b)$$

These yield

$$B_{in} = \frac{2\pi r_i H_\phi}{l E_z} = \frac{r_i}{60l}\left[\frac{J_1(\beta r_i)N_0(\beta r_0) - J_0(\beta r_0)N_1(\beta r_i)}{J_0(\beta r_i)N_0(\beta r_0) - J_0(\beta r_0)N_0(\beta r_i)}\right]. \qquad (8c)$$

The total RF current in the radial line can be determined by adding the current in the transmission-line wave (I_p), found from $I = 2\pi r H_\phi$ with H_ϕ as obtained from (8b), to the capacitive current as already found; the value of A_0 is obtained from (8a) with $E_z = 1/l$ at $r = r_i$.

The distribution of copper loss in the cavity may now be calculated and summed to find the total loss. Since this loss is just the loss per volt across the gap at $r = r_i$, it is also the effective conductance across the gap at this radius. The shunt conductance across the gap at the center (the conductance that would be paralleling an axial beam if the cavity were used as part of a tube structure) could be found if the effective voltage across the gap at the center were known. For the cavity of Fig. 1 this voltage is simply $1/J_0(\beta r_i)$, since the gap forms a simple radial transmission line. With more complex geometries this voltage could be estimated with sufficient accuracy from a crude plot of the magnetic field (estimated by using the wall currents at the boundaries) and the relationship $\oint \overline{E}\cdot d\overline{l} = -j\omega\int_s \overline{B}\cdot d\overline{s}$. The shunt conductance on the axis becomes $G_0 = G_i/V_0^2$; here G_i is the loss and V_0 is the voltage across the gap on the axis per volt across the gap at $r = r_i$.

The Q of the cavity may be calculated by using the relationship $Q = \omega C/G$ if the shunt capacitance is known. The shunt capacitance can be calculated from the behavior of the susceptance function near resonance. For this purpose it is useful to consider the admittance across the gap at $r = r_i$ to be represented by a parallel resonant circuit; the susceptance can then be written

$$B = \omega C - \frac{1}{\omega L} = B_L - B_{in}, \qquad (9a)$$

where B_L is the loading susceptance. The rate of change of susceptance near resonance can now be used as a measure of the effective capacitance. Thus

$$\frac{\partial B}{\partial \omega} = C + \frac{1}{\omega_r^2 L} = 2C = \frac{\partial B_L}{\partial \omega} - \frac{\partial B_{in}}{\partial \omega}. \qquad (9b)$$

Since B_L is obtained as the sum of terms of the forms given in (7a) and (7b), one obtains

$$\frac{\partial \Delta B}{\partial \omega} = \frac{\Delta B}{\omega} \qquad (9c)$$

on the re-entrant portion, and

$$\frac{\partial \Delta B}{\partial \omega} = \frac{\Delta B}{\omega\left[1 - \left(\frac{2l}{\lambda}\right)^2\right]} \qquad (9d)$$

on the radial line.

The numerical value of the second term of (9b),

$$\frac{\partial B_{in}}{\partial \omega} = \frac{\beta}{\omega} \frac{\partial B_{in}}{\partial \beta},$$

is most readily obtained from (8c) using numerical differentiation.

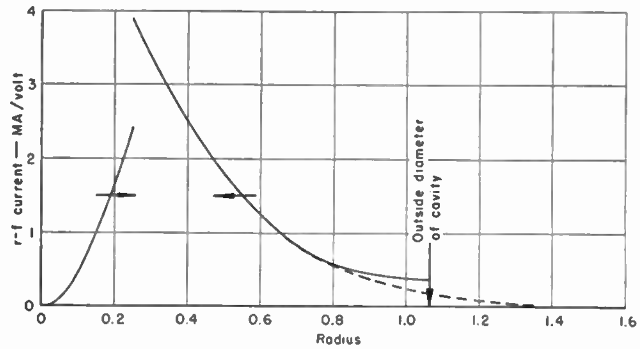

Fig. 5—Capacitive current of flat side of cavity (showing correction for reflection off the outer wall—dashed line is uncorrected current).

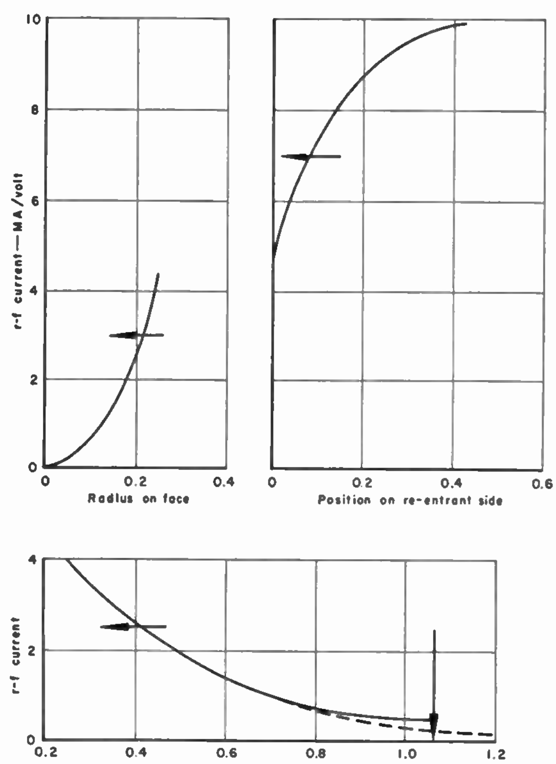

Fig. 6—Capacitive current on re-entrant side of cavity (showing correction for reflection off the outer wall—dashed line is uncorrected current).

Example

The cavity of Fig. 1 with $r_i = 0.250$ inch, $r_0 = 1.065$ inches, $g = 0.300$ inch and $l = 0.738$ inch will be used as an example. A cavity of these dimensions had a measured wavelength of 3.86 inches; the other measured parameters were $B_{axis} = 0.0095$ mhos (found from the shift in resonant wavelength when a small polystyrene rod was inserted across the gap on the axis) and $Q = 8{,}060$ (for a silver-plated and polished cavity).

The capacitive current set up by the re-entrant section is shown in Figs. 5 and 6. This was calculated for one volt across the gap at $r = r_i$, using $\lambda = 3.86$ inches in (7a) and (7b) and the data from the tank model. (If λ is unknown an estimated trial value would be used.) The capacitive current is shown reflected in phase off the short-circuiting outer wall of the cavity.

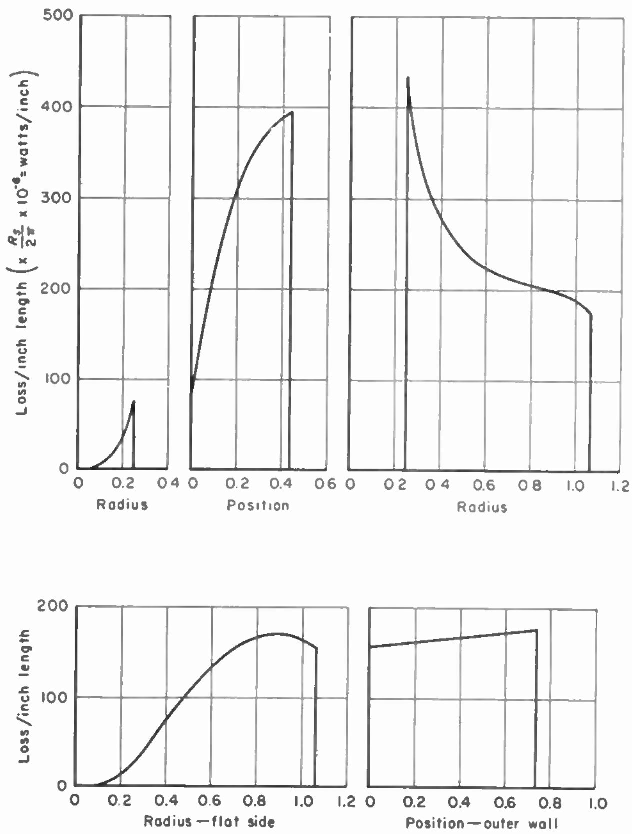

Fig. 7—Loss distribution over cavity surface.

The resonance susceptances can now be checked. Using the flat-side values ($B = 2.43$ for $r < r_i$, $B = 3.87$ for $r > r_i$ as shown in Fig. 5) yields a capacitive susceptance of $B = 6.30$ millimhos. This should equal the input susceptance to the radial line found, using (8c), to be $B_{in} = 6.42$ millimhos. The difference corresponds to a wavelength error of about one per cent. (Calculation from the re-entrant side data is not as accurate since it involves a difference.)

The total current is found by adding the principal mode current $I = 2\pi r H_\phi$, with H_ϕ from (8b), to the capacitive current shown in Figs. 5 and 6. This current is used to find the distribution of I^2R loss over the walls of the cavity (Fig. 7). Summing this loss distribution yielded a value of 1.23×10^{-6} watts/volt at $r = r_i$. Multiplying by $J_0^2(\beta r_i)$ yields the loss per volt across the center of the gap, i.e., the gap admittance. A value of 1.14 μmhos is indicated.

The equivalent capacitive susceptance across the gap at $r = r_i$ is found using (9). A value was obtained (for the flat side) of $B = \omega C = 0.01024$. Converting to the axis by multiplying by $J_0^2(\beta r_i)$ yields $B_{axis} = 0.00945$. Combining the susceptance with the admittance then yields the Q, i.e.,

$$Q = \frac{\omega C}{G} = 8{,}330.$$

Conclusion

It has been demonstrated that the parameters of a cavity can be calculated from data obtained using an electrolytic tank. The procedure has been shown for a singly re-entrant cavity with results that have been verified experimentally with indicated accuracies of about one per cent for resonant wavelength and about two per cent for Q.

The accuracy of the work described here was limited principally by the accuracy of the measurements made in the electrolytic tank. This could be improved by the use of a larger model and, more particularly, by the use of a larger wedge angle so that the water level would not be too critical.

Acknowledgment

The author is grateful to the members of the Electron Tube Laboratory of the Department of Electrical Engineering, The Ohio State University, for many stimulating discussions on the cavity problem. The assistance of Roy Ward and Lewis Goodrich, of the laboratory, on some of the measurements and calculations was particularly helpful.

The Direct Method of Filter and Delay Line Synthesis*

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Summary—**An introductory comparison is made between the classical or indirect method of designing nondissipative filter networks, and the direct method of designing recurrent filters or delay lines with arbitrarily assigned frequency phase relationships within the passbands. A few examples are given of the application of the latter method to the design of ideal structures.**

Introduction

THERE ARE TWO BROAD METHODS of attacking the problem of designing passive, nondissipative, linear filters consisting of a network of capacitances, inductances, and transformers.

The classical or indirect method consists in postulating a finite network, which may be a complete filter, or one finite element of an indefinitely recurrent filter network, and in studying the amplitude and phase characteristics of this network and the approximation to the desired characteristics which can be utilized with a proper adjustment of its parameters. The essential mathematical tools of this attack are the algebraic theory of the zeros and poles of the characteristic polynomials of the complete network or of one of its recurrent elements, and the theory of functions of a complex variable.

The direct method consists in postulating an indefinitely recurrent network in which each recurring element is coupled to all elements of the network, and in determining the values of these elements and of their indefinitely extended couplings which will yield the exact phase characteristics desired within the exact pass band desired. The essential mathematical tool of this attack is the Fourier expansion theorem, which is applied to the "criterial relation" resulting from the elimination of the voltage, current, and frequency between the network conditions derived from the Kirchhoff laws and a pre-assigned frequency-phase relationship. This procedure yields the value of the indefinitely extended couplings required for an exact solution.

When contrasted with the classical indirect method, the direct method is seen to have the advantages of exactness and of mathematical simplicity, and the disadvantages of yielding an indefinitely cross-connected network, with which a compromise must be made for the actual construction, and of requiring further compromises for the connections to the generator and the load. Conversely, reflexionless terminations can be nicely approximated by introducing dissipative components in a few terminal sections, and exact reflecting terminations with or without phase reversal can be determined by the device of imagining the actual line continued into a virtual image line with image currents and voltages, and of deriving from this consideration the proper modifications of the couplings near the termination.

The disadvantages mentioned above are mitigated by the fortunate circumstance that in many actual designs the couplings over more and more extended portions of the network become so rapidly negligible that they can be either completely left out, or replaced by fewer couplings not repeated for every sectional element. Furthermore, many inductive couplings arising from the geometrical configuration of the network can be utilized to advantage instead of being designed out of the network by shielding, etc. Thus, it is seen that networks of this type are particularly advantageous

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when many sections are desired, in which the cumulative phase distortions of the simply coupled networks would become objectionable, while the input and output difficulties mentioned above occur only once for the whole network. The possibility that a suitable theory of input and output terminations can be elaborated is not to be ruled out, but this study will not be concerned with this problem, nor with the behavior of this class of filter beyond the cutoff frequencies. Indeed, it should be underlined that the very essence of the concept developed here is to emphasize that which cannot be accomplished by the classical theory, namely, the improvement in over-all characteristics, including sharpness of cutoff, which will result from an increase in the number of sections and of couplings between increasingly distant sections, while de-emphasizing correspondingly the relative importance of the terminations of the network and of its behavior beyond cutoff.

The prototype of the direct attack on the filter problem was published some time ago[1] in the form of a discussion of the ideal low-pass filter, i.e., one in which the frequency-phase relationship is linear, albeit other, more general relationships can be postulated. For instance, the design of corrective low-pass networks with any preassigned, monotonic frequency-phase relationship within the passbands can be undertaken by this method.

The purpose of the present discussion is to indicate how the application of this general attack to the ideal low-pass case can be extended to the ideal band-pass case, and to suggest a few additional structures.

The Ideal Band-pass Filter Derivable from a Low-pass Structure

A band-pass equivalent can always be determined for any low-pass filter containing no transformers or mutual inductances, by the simple process of substituting series and parallel resonant pairs for the respective inductances and capacitances of the low-pass structure.

If the low-pass structure has a linear frequency-phase characteristic, the corresponding band-pass structure will have nearly the same characteristic, the departure from linearity becoming rapidly small for increasing center frequency over bandwidth ratios. Accordingly, this part of the discussion will be limited to a consideration of ideal low-pass filters without mutual inductances, from which nearly ideal band-pass filters are readily derivable.

As a preliminary remark, it will be noted that the general structure with capacitive couplings illustrated by Fig. 2 of the article referred to could have ideal low-pass characteristics without mutual inductances if negative capacitive couplings were available to connect tie joints which are an odd number of sections distant.

This suggests that the desired corrective couplings could be obtained by providing an image line with voltages of opposite polarity and with positive capacitive couplings between each tie joint of each side and the images of the tie joints which are distant an odd number of sections.

Fig. 1 illustrates such a network, in which a single capacitance between each tie point and its image has been substituted for a capacitance between each and ground.

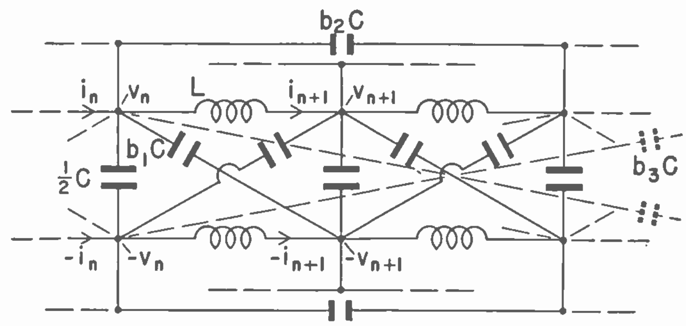

Fig. 1—Schematic diagram of twin low-pass filter with capacitive couplings between tie points.

The application of Kirchhoff's relations to this network gives:

$$v_n - v_{n+1} = j\omega L i_{n+1}. \tag{1}$$

$$\begin{aligned} i_n - i_{n+1} = j\omega C[&v_n + b_1(2v_n + v_{n-1} + v_{n+1}) \\ &+ b_2(2v_n - v_{n-2} - v_{n+2}) \\ &+ b_3(2v_n + v_{n-3} + v_{n+3}) \\ &+ b_4(2v_n - v_{n-4} - v_{n+4}) + \cdots]. \end{aligned} \tag{2}$$

The recurrent character of the network permits us to write:

$$\frac{v_n}{v_{n+1}} = \frac{v_{n+1}}{v_{n+2}} = \cdots = \frac{i_n}{i_{n+1}} = \frac{i_{n+1}}{i_{n+2}} = \cdots = e^{j\phi}. \tag{3}$$

Substitution in (1) and (2) of all v's and i's in terms of v_n and i_n, multiplication of (1) and (2) member by member, and division by $v_n i_n$ yields:

$$\begin{aligned} 2(1 - \cos\phi) = \omega^2 LC[&1 + 2b_1(1 + \cos\phi) \\ &+ 2b_2(1 - \cos 2\phi) + 2b_3(1 + \cos 3\phi) \\ &+ 2b_4(1 - \cos 4\phi) + \cdots]. \end{aligned} \tag{4}$$

The requirement that there be no attenuation and no phase distortion below cutoff will be met if ϕ is real and proportional to the frequency in the pass region. This requirement can be expressed by the condition:

$$K\phi^2 = \omega^2 LC \tag{5}$$

which, in combination with (4), yields the "criterial relation":

$$\begin{aligned} \frac{2(1 - \cos\phi)}{K\phi^2} = 1 &+ 2(b_1 + b_2 + \cdots) \\ &+ 2b_1 \cos\phi - 2b_2 \cos 2\phi + \cdots . \end{aligned} \tag{6}$$

Examination of relation (6) indicates that if the second member can constitute in fact the Fourier expan-

[1] M. J. E. Golay, "The ideal low-pass filter in the form of a dispersionless lag line, Proc. I.R.E., vol. 34, pp. 138–144P; March, 1946.

sion of the first within the limits 0 and π for the variable ϕ, the requirements stated above will be met, while the necessarily complex character of ϕ when ω exceeds the value $\omega_0=\pi\sqrt{K/LC}$ in (4) indicates that ω_0 constitutes indeed the cutoff frequency.

Setting $\phi=\pi$ in (6) causes all but the first term of the second member to vanish, and yields the value of K:

$$K = \frac{4}{\pi^2}$$

and the application of the Fourier expansion theorem to the first member of (6) between the limits 0 and π yields the b's:

$$b_n = (-1)^{n+1}\frac{\pi}{2}\int_0^\pi \frac{1-\cos\phi}{\phi^2}\cos n\phi d\phi$$

$$= (-1)^n\frac{\pi}{4}\left[2nS_i(n\pi) - (n-1)S_i(n-1)\pi - (n+1)S_i(n+1)\pi\right]. \quad (7)$$

The positive sign of the b's given by (7) indicates that the criterial relation (6) can be satisfied with a physically realizable network. The first six b's are, to four places:

$b_1=0.3186$	$b_4=0.0129$
$b_2=0.0547$	$b_5=0.0082$
$b_3=0.0233$	$b_6=0.0057$.

For higher values of n, the b's can be calculated with the approximate expression:

$$b_n = \frac{.203}{n^2}. \quad (8)$$

Ideal Low-pass Structures Not Convertible to the Band-pass Structures

The use of an image line for the purpose of avoiding inductive couplings in a low-pass filter has suggested the investigation of two connected and staggered lines.

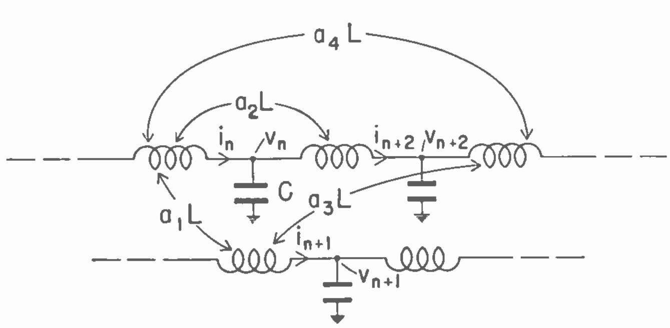

Fig. 2—Schematic diagram of two connected and staggered low-pass lines.

Fig. 2 illustrates such a staggered line, with capacitances to ground only, and inductive couplings.

The criterial relation for this structure can be easily derived, and is:

$$\frac{2(1-\cos 2\phi)}{K'\phi^2} = 1 + 2a_1\cos\phi + 2a_2\cos 2\phi + \cdots. \quad (9)$$

The application of the Fourier expansion theorem to (9) yields:

$$\pi K' = 2\int_0^\pi \frac{1-\cos 2\phi}{\phi^2}d\phi = 4S_i2\pi = 5.6726, \quad (10)$$

and:

$$a_n = \frac{2}{\pi K'}\int_0^\pi \frac{1-\cos 2\phi}{\phi^2}\cos n\phi d\phi$$

$$= \frac{1}{\pi K'}\left[-2nS_in\pi + (n-2)S_i(n-2)\pi + (n+2)S_i(n+2)\pi\right]. \quad (11)$$

The first six values of a_n are, to five places:

$a_1=0.55924$	$a_4=0.00127$
$a_2=0.05219$	$a_5=0.00049$
$a_3=0.00473$	$a_6=0.00023$.

For higher values of n, the a's can be calculated with the expression:

$$a_n = (-1)^n\frac{.27}{n^4}. \quad (12)$$

Comparison of (12) with (8) indicates that the staggered structure can be more nearly approximated than the single structure, without affecting the ideal characteristics sought.

It can be verified that triply staggered structures, and more generally structures with an odd number of connected and staggered lines, require couplings which decrease with the inverse square of their order, whereas the inverse fourth-power relationship obtains for an even number of connected and staggered lines. This can be gathered from an examination of the domains over which the function $(1-\cos\phi)/\phi^2$ must be expanded in a Fourier series. For odd or even number of connected staggered structures this integration domain terminates at odd or even multiples of π, respectively, and the expression for the Fourier expansion of this function in terms of sine integrals indicates that the terms decrease with the second and fourth power of the order, respectively, for these two cases.

It can also be verified that staggered structures of the type illustrated by Fig. 2 require inductive couplings for ideal characteristics, and that the device of providing image lines in order to utilize capacitive couplings only, cannot lead to realizable structures. This impossibility can be gathered from an examination of the terms of the criterial relation corresponding to capacitances. These terms are generally of the form $2b_n(1-\cos n\phi)$ and the second member cannot vanish for certain values of ϕ, as required by a first member containing $1-\cos\kappa\phi$, where κ designates the number of staggered and connected lines.

Ideal Band-pass Structures Not Convertible to a Low-pass Structure

It has been noted above that low-pass structures requiring inductive couplings are not convertible to band-pass structures. Likewise, band-pass structures can be built up with inductive couplings, and these will not be convertible to low-pass structures.

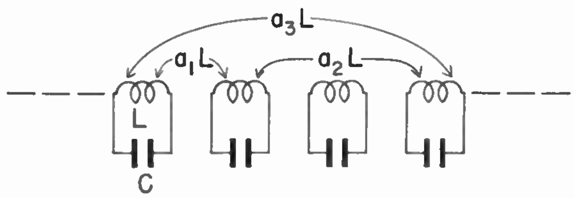

Fig. 3—Schematic diagram of band-pass structure with inductive couplings only.

Fig. 3 illustrates such a structure, for which the structural frequency-phase relationship can be immediately obtained:

$$1 = \omega^2 LC(1 + 2a_1 \cos\phi + 2a_2 \cos 2\phi + \cdots). \quad (13)$$

Let ϵ denote the ratio of the bandwidth of the structure to the mid-band frequency and assume an ideal characteristic corresponding to the following linear frequency-phase relationship:

$$\omega = \frac{1}{\sqrt{LC}}\left[1 + \frac{\epsilon}{\pi}\left(\phi - \frac{\pi}{2}\right)\right], \quad 0 \leqq \phi \leqq \pi. \quad (14)$$

Substituting this value for ω in (13), and neglecting terms containing higher powers of ϵ, gives the criterial relation:

$$1 - 2\frac{\epsilon}{\pi}\left(\phi - \frac{\pi}{2}\right) = 1 + 2a_1 \cos\phi + 2a_2 \cos 2\phi + \cdots. \quad (15)$$

Application of the Fourier expansion theorem to (15) gives the a's:

$$a_{2n} = 0, \quad a_{2n+1} = \frac{4\epsilon}{\pi^2(2n+1)^2}. \quad (16)$$

Conclusion

The direct method of synthesis of nondissipative recurrent filter networks with pre-assigned phase characteristics is applicable to band-pass as well as to low-pass structures.

Acknowledgment

The writer takes pleasure in acknowledging the many stimulating discussions of this general subject he has had with Mr. W. Bradley, Director of Research of the Philco Corporation, who has encouraged the writer to develop further the direct attack on the filter problem prototyped in the former article, and who has suggested the last structure described here, and its ideal band-pass possibilities.

Radio-Frequency Phase-Difference Networks: A New Approach to Polyphase Selectivity*

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Summary—**It is shown that phase-difference networks operating at radio rather than at audio frequency may be used to obtain selectivity by polyphase methods. Design and practical realization of such networks are considered. A polyphase selective system suitable for single-sideband transmission or reception is described, in which the selective action takes place directly at radio frequency so that a number of individual systems may be cascaded in situations where a very high degree of over-all selectivity must be obtained.**

Introduction

In recent years increasing interest has been shown in polyphase techniques for obtaining selectivity, particularly in connection with the generation and reception of single-sideband signals. General features common to the systems[1–4] disclosed so far are:

(a) Frequency conversion occurs (modulation in the transmitting case, demodulation in the receiving one).

(b) Phase-controlling circuits working at audio frequencies are used.

The increased interest in polyphase techniques has been an incentive for improvement in the design of phase-controlling circuits. The results achieved in this design, in turn, have further extended the interest in polyphase techniques. The most successful kind of

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[4] N. F. Barber, "Narrow band-pass filter using modulation," *Wireless Engineers*, vol. 24, pp. 132–134; May, 1947.

phase-controlling circuit yet developed is the phase-difference network, the design of which has now reached a high degree of perfection.[5–9]

This paper shows that it is possible to design and to build phase-difference circuits working at radio frequencies. What is meant is that, given an audio-frequency phase-difference network, another network can be synthesized whose characteristic is very closely the result of a change of the frequency variable ω into $\omega-\omega_0$, where ω_0 is some conversion frequency. This is quite different from a simple change of scale (ω into $k\omega$), which would also transform the audio-frequency into a radio-frequency network, but which requires no change in design procedure. This latter kind of radio-frequency phase-difference network has been considered elsewhere.[10]

The new radio-frequency phase-difference networks can give most of the results obtained with audio frequency networks. The radio-frequency networks, however, are more complicated to build and there seems to be no practical advantage in substituting them in situations where audio-frequency networks give satisfactory performance. But the possibilities of polyphase methods are enlarged by the new approach. For example, it will be shown that single-sideband selection can be obtained directly at the radio-frequency level in a receiver. This cannot be done with the systems disclosed so far, all of which introduce demodulation in the same process giving selectivity, in such a way that the desired sideband is obtained only at audio frequency.

Radio-Frequency Phase-Difference Networks

The transformation which converts a low-pass into a band-pass filter is well known in filter theory.[11] In making this transformation, the amplitude-versus-frequency characteristic is normally of importance; in most situations it need not be specified very precisely. In the case of phase-difference systems for polyphase selectivity, on the other hand, all-pass networks are exclusively used. There is no amplitude characteristic to be translated and only a phase characteristic, which, in contrast with the amplitude one, is very critical. The translation of the phase characteristic will be considered here in some detail, by means of a pole-zero plot of the transfer function of the network in the complex frequency plane.

Modern audio-frequency phase-difference networks are composed of RC elements only, since the absence of inductance results in better control of stray capacitances, etc., and allows for closer realization of theoretical possibilities. The incidental insertion loss is of no consequence.

The transfer functions of RC all-pass networks have only real poles and zeros and these are the negative of each other. Therefore, the pole-zero plot of an RC all-pass network can be regarded as being made up of a number of pole-zero "doublets," a doublet being a zero and the pole which is its negative. The transfer function of such a network may be expressed as a rational fraction

$$\frac{E_{\text{out}}}{E_{\text{in}}} = \frac{\prod (p - p_n)}{\prod (p + p_n)}, \tag{1}$$

where p is the familiar complex frequency variable $\sigma+j\omega$ and p_n is real and positive.

The geometrical representation of the poles and zeros is very helpful in visualizing the behavior of a particular network. For a given value of p, each factor of the form $p-p_n$ or $p+p_n$ is a complex number and is represented in the p-plane by a vector. Fig. 1 shows a doublet of an all-pass network. The net contribution of this doublet to the total phase shift of the network for the value of p shown is

$$\underline{/p - p_n} - \underline{/p + p_n} = -\beta_n, \tag{2}$$

where the sign $\angle$ denotes the phase angle or argument of the vector inside.

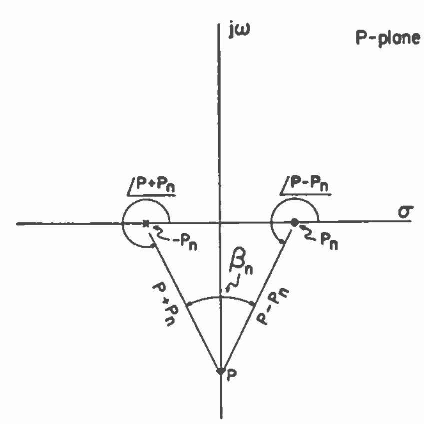

Fig. 1—Pole-zero plot of a single-doublet all-pass network.

For values of p on the imaginary axis varying from $-\infty$ to $+\infty$, the contribution of the doublet decreases continuously and undergoes a total change of 2π. Since an angle of π is immaterial, the phase angle is taken as zero for $\omega=0$. If the network has only one doublet, its phase characteristic will be as shown in Fig. 2. The phase characteristic of a network having n doublets will be as in Fig. 3. (Figs. 2 and 3 appear on the next page.)

It is clear that in order to obtain a translation of the phase characteristic, a network must be synthesized whose poles and zeros are the translation in the p plane of those of the original network. If the pole and zero of Fig. 1 could be translated vertically upwards a distance ω_0, the same translation would be performed in the phase characteristic. Such a pure translation alone, however,

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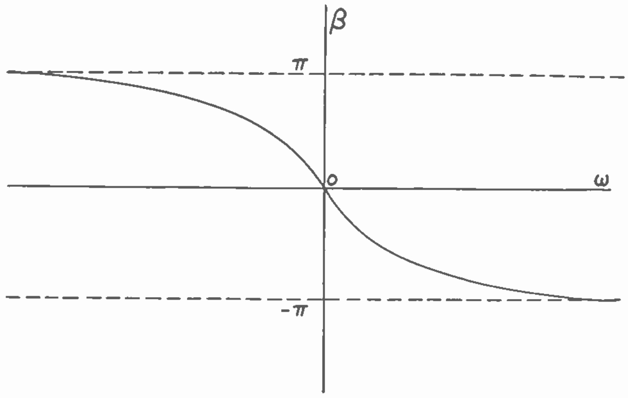

Fig. 2—Phase characteristic of a single-doublet all-pass network.

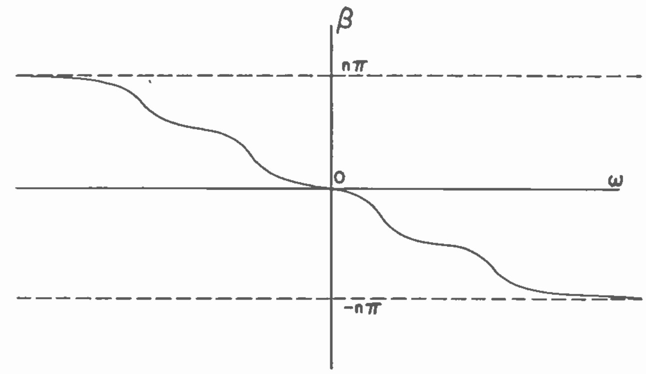

Fig. 3—Phase characteristic of a multiple-doublet all-pass network.

is impossible, since the poles and zeros of any network, when complex, appear always in conjugate pairs.

But even if the pure translation is not possible, a good approximation can be realized in many cases. When the frequency translation is much larger than the largest $|p_n|$ in the network, the approximation is possible. Fig. 4 is the pole-zero plot of a network containing two doublets after translation. Inspection will show that the effect of the poles and zeros in the lower half-plane for values of ω in the vicinity of ω_0 is almost constant and nearly equal to zero. In the vicinity of ω_0 only the poles and zeros in the upper half-plane are effective, and their effect on the over-all phase characteristic will be much the same as that due to the poles and zeros of Fig. 1. The frequency range of importance is now close to ω_0 instead of close to $\omega=0$.

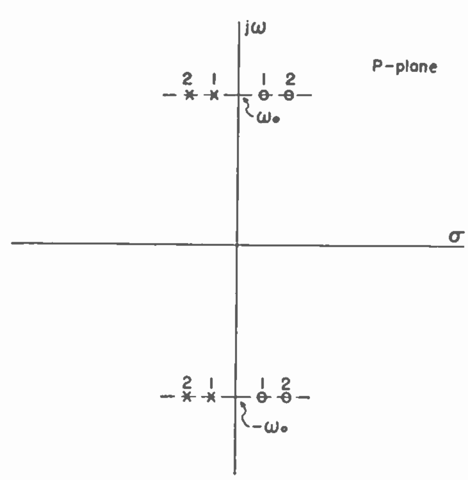

Fig. 4—Pole-zero plot of a translated all-pass network equivalent to a two-doublet version of Fig. 1.

In principle, then, the approximate frequency translation is made possible if the amount of frequency translation is much larger than the largest absolute value of the poles and zeros of the original network. If this condition is fulfilled, the synthesis requires only to find a network giving a "quadruplet" for each doublet of the original network, a quadruplet being a complex zero and its complex conjugate, plus the two poles which are their negative. The quadruplet corresponding to a doublet $\pm\sigma$, is $\pm\sigma\pm j\omega_0$.

Fig. 5 shows what seems to be the simplest circuit which can produce a quadruplet as required. The quadruplet is

$$\pm\frac{R}{2L}\pm j\sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}. \qquad (3)$$

R^2 must be less than $4L/C$ in order that the p's be complex.

It is seen that

$$\sigma = R/2L \qquad (4)$$

and

$$\omega_0 = \sqrt{1/LC - R^2/4L^2}. \qquad (5)$$

From these expressions the circuit may be designed. Let ω_r be the resonant frequency of the LC circuit alone, then $\omega_r^2=1/LC$. If Q_r is the Q of the series LCR circuit, then $Q_r=\omega_r L/R$. The p's are

$$\pm\frac{R}{2L}(1\pm j\sqrt{4Q_r^2-1}). \qquad (6)$$

Therefore,

$$\frac{\omega_0}{\sigma} = \sqrt{4Q_r^2-1}. \qquad (7)$$

Since ω_0/σ must be much larger than unity, it follows that the Q of the LCR circuit must be much larger than unity. In practice, the Q of the coil sets a limit to the highest frequency translation ω_0 which can be performed for a given doublet $\pm\sigma$.

The circuit of Fig. 5 is particularly easy to compensate for the unavoidable effect of the dissipation of a real coil. When the resistance of the coil is taken into account the circuit appears as in Fig. 6. If the two input voltages are kE and $-E$ instead of $(1/2)E$ and $-(1/2)E$, the transfer function of the network has the same quadruplet of (3) with $R_T=R_L+R$ in the place of R. The magnitude of the output voltage is E. The ratio k between the two voltages k is given by:

$$k = 2R_1/R + 1. \qquad (8)$$

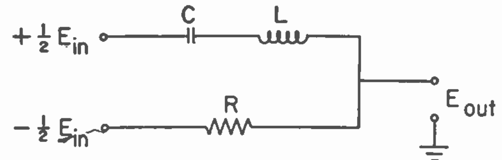

Fig. 5—Simplest all-pass circuit corresponding to one "quadruplet" of Fig. 4.

This ratio may be obtained in practice by means of any of the well-known circuits which produce a balanced output from an unbalanced voltage. The simplest one seems to be a tube with a plate-load resistor R_p, and a cathode resistor R_k. The ratio of these resistors must be:

$$R_p/R_k = 2R_1/R + 1 = k. \quad (9)$$

The semilattices of Figs. 5 and 6 do not offer a constant impedance between the input terminals. In order for the input voltage not to be affected by the changes in this impedance, the network's minimum resistance (which is R_L+R) must be large compared to the internal resistance of the source of voltage. This means that R_L and R_k must be small compared to $R_T=R+R_L$. But there is a limit to the minimum value of the resistances R_p and R_k into which a tube can work, and there is therefore a limit to the minimum value which R_T may have. Since the Q of the circuit cannot be made too small, the L of the coil cannot be made too small either. High Q, high L coils are required.

In order to determine the order of magnitude required for the Q of the circuit, a quantitative appraisal can be made. If $Q_r \gg 1$, then $\omega_0/\sigma \cong 2Q_r$. In Fig. 7 it is seen that the angle β_l, which is the contribution of the lower half-plane pole and zero of a quadruplet to the total phase angle (for values of ω near to ω_0) is:

$$\beta_l \text{ (in radians)} \cong \tan\beta \cong 2\tan\frac{\beta}{2} = \sigma/\omega_0 = 1/2Q_r \quad (10)$$

or

$$Q_r = 1/2\beta_l \text{ (radians)}. \quad (11)$$

Therefore, the smaller the allowable β, the larger Q_r must be.

This requirement can be lessened if, instead of a small β_l, a small β_l variation can be tolerated in the operating frequency range. This is actually the case in most situations. Assume that the frequency range of interest is from ω_a to ω_b where $\omega_a<\omega_0<\omega_b$. It is also assumed that $(\omega_b-\omega_a)/\omega_0=\epsilon\ll 1$. Then, $(\omega_b-\omega_0)/\omega_0<\epsilon\ll 1$ and $(\omega_0-\omega_a)/\omega_0<\epsilon\ll 1$. The extreme values of β_l in the range ω_a to ω_b are approximately $\beta_l(\omega_a)\cong\sigma/\omega_a$ and $\beta_l(\omega_b)\cong\sigma/\omega_b$ and the difference is given by:

$$\Delta\beta_l = \beta_l(\omega_a) - \beta_l(\omega_b) \cong \frac{\sigma(\omega_b-\omega_a)}{\omega_a\omega_b} \cong \frac{\sigma\epsilon\omega_0}{\omega_0^2} = \frac{\epsilon}{2Q_r}. \quad (12)$$

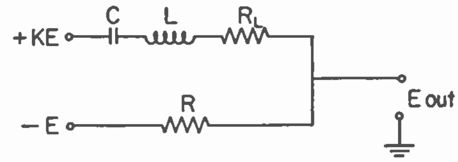

Fig. 6—Method of compensating circuit of Fig. 5 for effect of coil dissipation.

The following expression can then be substituted for (11):

$$Q_r = \frac{\epsilon}{2\Delta\beta}. \quad (13)$$

For a given required tolerance in $\Delta\beta_l$, the required Q is roughly ϵ times smaller than before. Because of the several approximations involved, the true lower value for Q_r should be computed directly from the given data in a particular case. The variation $\Delta\beta_l$ allowed to each quadruplet must be such that their sum, which will be the variation of β_l for the whole network, will be within the prescribed tolerance.

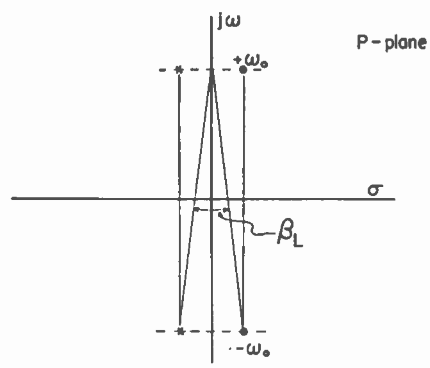

Fig. 7—Method of estimating contribution of lower half-plane poles and zeros to over-all phase characteristic.

Sources of Error

Two main sources of error appear when the circuit of Fig. 6 is realized in practice. One is the change with frequency of the resistance of the coil; the other is the effect of the distributed capacitance of the coil.

The resistance of a coil changes with frequency. The analysis of the circuit, which assumes that only constant elements are used, may still be carried along the same lines, except that the poles and zeros are no longer fixed, but experience a displacement in the p-plane as the frequency varies. When the Q of the circuit is high, the effect of a change in R_L is approximately a change only in σ, in the quadruplet $\pm\sigma\pm j\omega_0$. The maximum error $\delta\beta$ in radians due to this cause is approximately

$$\delta\beta_{max} \cong \frac{\Delta R_L}{R_L+R} = \frac{\Delta R_L}{R_L}\cdot\frac{1}{\frac{R}{R_L}+1}. \quad (14)$$

It is seen that for a given relative change $\Delta R_L/R_L$ in the value of R_L in the operating frequency range, the relative error in σ is smaller the larger the ratio R/R_L. It is convenient for this reason to have a large coil Q, and to adjust the Q of the circuit to the desired value by means of a large R. The coil, however, should not be built for a high Q alone; a small distributed capacitance is also important.

The distributed capacitance C_d of the coil has the effect of changing the true inductance L_t into an apparent inductance L_a given by:

$$L_a = L_t/(1 - \gamma^2) \tag{15}$$

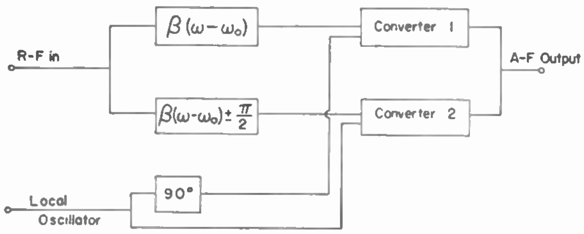

Fig. 8—Block diagram of single-sideband receiving arrangement using radio-frequency phase-difference networks.

where γ is the ratio of the actual to the natural resonant frequency, and does not exceed 0.8. The effect in the pole-zero plot of a variable L_a is also a displacement of the singular points as frequency changes. If the Q of the circuit is high, the change in L will produce approximately a change only in ω_0, in the quadruplet $\pm\sigma\pm j\omega_0$. The maximum relative error $\Delta\beta$, in radians, is approximately

$$\Delta\beta \text{ (radians)} = 2Q_r \frac{\Delta L}{L}, \tag{16}$$

which shows the relative error in L is multiplied by a factor Q_r. It is therefore important to keep C_d small.

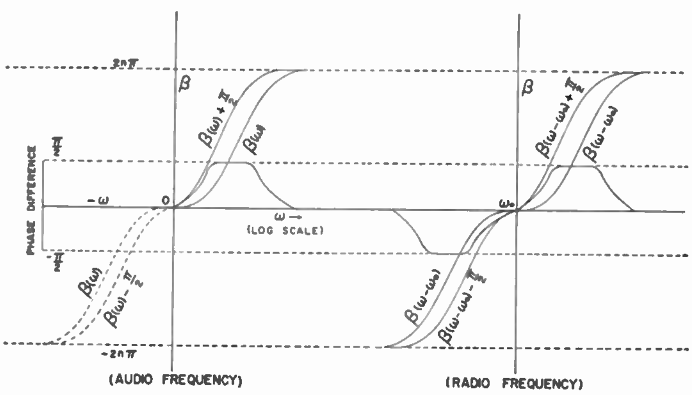

Fig. 9—Phase characteristics of audio and radio-frequency phase-difference networks.

Applications

Fig. 8 shows the block diagram of a receiving single-sideband selector with radio-frequency phase-difference networks. In Fig. 9, OA and OB are the phase characteristics of an audio-frequency 90-degree constant-phase-difference system. These can be expressed, in the frequency range of operation as the functions $\beta(\omega)$ and $\beta(\omega)+(\pi/2)$, approximately. The phase characteristics of the branches of a radio-frequency network which is derived by translating the former characteristics by an amount ω_0 in frequency can be expressed as $\beta(\omega-\omega_0)$ and $\beta(\omega-\omega_0)\pm(\pi/2)$, where the + sign applies for $\omega>\omega_0$ and the − sign for $\omega<\omega_0$. It can be shown, by the same reasoning as that used by Villard,[3] that cancellation of one sideband will occur in the arrangement of Fig. 8.

In a similar way, Fig. 10 is a modulator system producing single-sideband modulation.

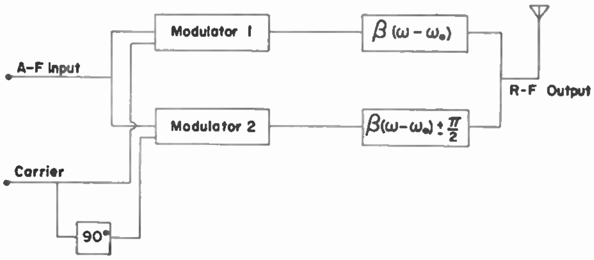

Fig. 10—Block diagram of single-sideband modulator using radio-frequency phase-difference networks.

If desired, in Figs. 8 and 10, one phase-difference network can be in the radio-frequency end of the circuit, and one in the audio.

Particularly interesting is the possibility of obtaining selectivity in a single-sideband receiver without actually demodulating the signal; that is, of obtaining selectivity suitable for single-sideband selection directly at radio frequency. Such an arrangement allows for the cascading of more than one selective system of this sort, where very high over-all selectivity must be obtained.

Since polyphase systems obtain their selectivity by balancing out undesired voltages, which may be large, it is difficult to obtain in practice much more than about 40 db of rejection in any single stage. Considerably more rejection than this is frequently needed, as in radio receivers where a strong undesired signal falls in the frequency interval of the rejected sideband.

Polyphase selectivity without demodulation may be accomplished by taking advantage of the variable loading which a diode mixer produces on the input or radio-frequency side of the circuit, depending on the magnitude of the impedance connected to the audio-frequency terminals. One phase-difference network must then operate at radio frequency; the other at audio. The over-all block diagram is that of Fig. 11. Fig. 12 is a simplified schematic of the block marked "Converter 1" in Fig. 11. To prevent oscillator voltage from reaching the output terminals, a balanced arrangement can be used, as in Fig. 13. (These Figs. appear on the next page.)

It can be shown that at points a and b in Fig. 11, voltages produced by signals whose frequency is smaller than ω_0 will have the same polarity, whereas voltages produced by signals whose frequency is higher than ω_0 will have opposite polarity. By connecting a and b together, the apparent audio-frequency impedance as seen from the diode (converter 1) will be large for the first, and small for the second case. Accordingly, the radio-frequency impedance at the input terminals of the diode mixer will be large in the first case, small in the second one. If the internal impedance of the radio-frequency signal source to which the diode is connected is high, selective action will take place.

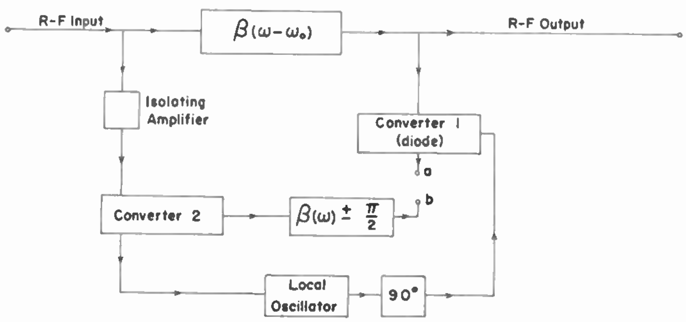

Fig. 11—Block diagram of arrangement for producing polyphase selectivity directly at radio frequency, so that several systems may be cascaded.

An alternative but more complicated arrangement would be to translate the voltage at terminal *b* of Fig. 11 back up to radio frequency by means of a single-sideband modulator, and then to combine this translated voltage with the signal voltage in phase opposition. This may be done, but in addition to the extra modulation equipment required, two sets of cascaded radio-frequency phase-shift networks must then be used.[12]

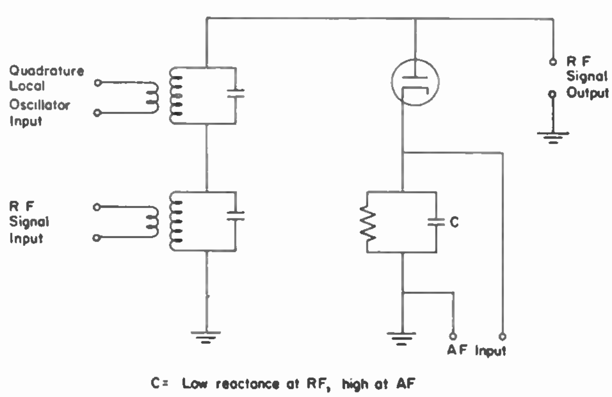

Fig. 12—Simplified schematic of "Converter 1" in Fig. 11. Oscillator voltage reaches output.

A radio-frequency selective system is particularly practical for single-sideband reception with the local oscillator locked to the frequency of the incoming carrier,[13] since leak-through of oscillator voltage via the diode mixer will not cause difficulty. Otherwise, elimination of local oscillator voltage in the output of the circuit of Fig. 11 must be done by balancing (as in Fig. 13), or by means of selective circuits.

The system of Fig. 11 has been tried out in the laboratory,[12] and the principle shown to be sound. More work is needed before a practical evaluation of its utility can be made.

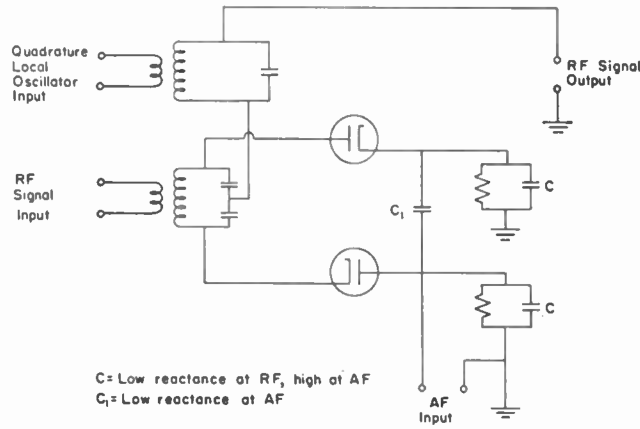

Fig. 13—Balanced form of Fig. 12. Oscillator voltage prevented from reaching output.

Conclusion

All polyphase methods for obtaining selectivity involve the balancing out of undesired signals. In view of the difficulty of minimizing the difference between large quantities, the greatest undesired-signal rejection from any one stage of this type that can reasonably be expected in practice, appears to be of the order of 40 db. Although this figure is barely adequate for single-sideband transmission, it is decidedly unsatisfactory in single-sideband reception where rejections of the order of 60 to 80 db are needed. The polyphase selectivity systems disclosed thus far, have incorporated frequency translation as part of the means by which selectivity is obtained. This translation prevents the cascading of such systems to obtain higher over-all selectivity.

Polyphase selectivity systems based on radio-frequency phase-difference networks, however, may be made to give selectivity directly at radio frequency. The circuit is simplified when practical advantage is taken of the fact that the radio-frequency input impedance of a diode mixer is dependent on the audio-frequency impedance connected to its output terminals. Just as is the case with conventional band-pass filters, polyphase systems giving selectivity directly at radio frequency may be cascaded to obtain any desired degree of over-all selectivity.

[12] M. G. Cifuentes, "A New Method for Obtaining Selectivity at Radio Frequencies by Means of Frequency Conversion and Audio-Frequency Networks," Doctoral Dissertation, Dept. of Elec. Eng., Stanford Univ., Stanford, Calif.; February, 1952.

[13] E. W. Rosentreter, "Single-signal single-sideband adaptor," *Electronics*, p. 124; July, 1948.

A Stroboscopic Frequency Meter*

C. W. McLEISH†, MEMBER, IRE, AND D. H. RUMBLE‡

Summary—**A simple frequency meter is described which, if properly coupled to the signal source, can produce a direct reading of frequency to the nearest kilocycle in the range of 3 to 30 megacycles. Present techniques could be used to extend the range above or below the one presently used by some modification of the system described.**

Introduction

It is well known that methods are already available for reading frequency with great accuracy in the high-frequency ranges. These vary from accurate harmonic generators with interpolation devices to the high speed counter circuits, and include combinations of both. This frequency meter combines some desirable characteristics which are particularly useful. It requires no separate adjusting controls if it can be roughly ganged to the tuning of the frequency source. It is an instantaneous indicator as far as the eye is concerned, and can be direct reading in terms of kilocycles. It does not require a sinusoidal input and will read several frequencies simultaneously, within certain practical limits. It can indicate to some degree the side-band frequencies in a modulated wave.

It should be mentioned here that the meter is best adapted to the case where it is built in to the frequency source such as transmitter vfo, receiver local oscillator, signal generator, and so on.

An instrument which has to read to 1 part in 30,000, and therefore has an error of less than 1 part in 60,000, generally requires more than one dial, especially if the answer is desired to be direct reading in the decimal scale. Also the most economical procedure in achieving this accuracy is to make full use of the inherent accuracy of the source. If the scale of the signal source is calibrated in divisions spaced such that there can never be any ambiguity of reading, a second dial can then be made to interpolate automatically between divisions on the first dial to obtain the desired precision.

For instance on a signal generator dial the absolute error is greatest at the high end of its operating range. If an upper limit can be set on this error, the scale divisions of the dial should be separated by at least twice this amount to prevent ambiguity in this range, and preferably should be more like four times the maximum error apart. Without using any special techniques the accuracy of the second dial can be made to be about one part in 400, giving an over-all accuracy about 100 times that of the signal source.

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Description

The following describes the system as applied to a communications receiver which tunes from 3 mc to 30 mc. The desired reading accuracy is to be the nearest kc. The frequencies used are not basic to the system, but serve as an example to simplify the description.

To make reading of frequency easy, it was decided to make the secondary dial cover 100 kc, in which case the divisions on the primary dial were made 100 kc apart on all bands. To avoid ambiguity, the stability of the oscillator must remain within ±50 kc preferably about ±25 kc. Good variable condensers and oscillator circuitry can produce this up to 30 mc.

The block diagram in Fig. 1 shows the principle of the frequency meter as applied to this receiver.

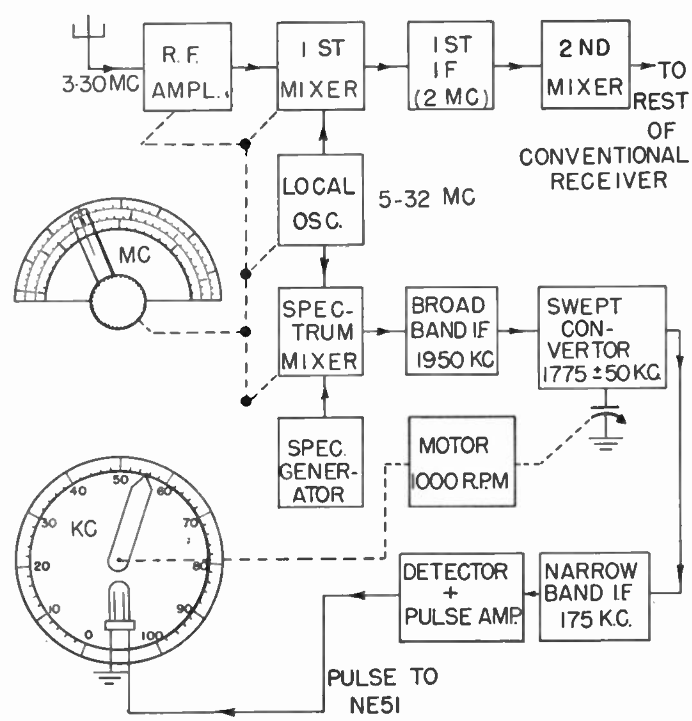

Fig. 1—Receiver block diagram.

The spectrum generator produces all the harmonics of a 100-kc temperature controlled crystal, up to and above the top tuning frequency. These are generated in a simple circuit employing a short pulse line which produces 0.02 μsec pulses at 100-kc repetition frequency. This circuit is shown in simplified form in Fig. 2.

Ganged to the usual radio frequency and local oscillator tuning circuits is an extra one, tuning the input to the spectrum mixer. It selects those crystal harmonics that are about 2,000 kc below the local oscillator. One of these harmonics, after mixing with the local oscillator, passes as the difference frequency through the broad band intermediate frequency amplifier, which is flat from 1,900 kc to 2,000 kc. The oscillator section of the convertor is made to sweep over a 100-kc range, or slightly more. The difference frequency passed by the broad band intermediate frequency amplifier beats with this oscillator to produce a frequency-modulated beat note in the output of the convertor. A second intermediate frequency amplifier, tuned to a conveniently-low center frequency, acts as a "slit" because of its narrow bandwidth. The output response is in the form of a pulse of energy which occurs at a time when the sweeping convertor produces a beat note which passes through the second intermediate frequency amplifier. When the receiver local oscillator, whose frequency is to be measured, is shifted in frequency, the difference frequency passed into the broad band intermediate frequency amplifier changes by the same amount, and the relative time at which an output is received at the detector shifts across the sweeping cycle. All that is now needed to read this relative time interval is a scale which interpolates accurately over the 100-kc sweeping range and which is stably ganged to the sweeping oscillator section

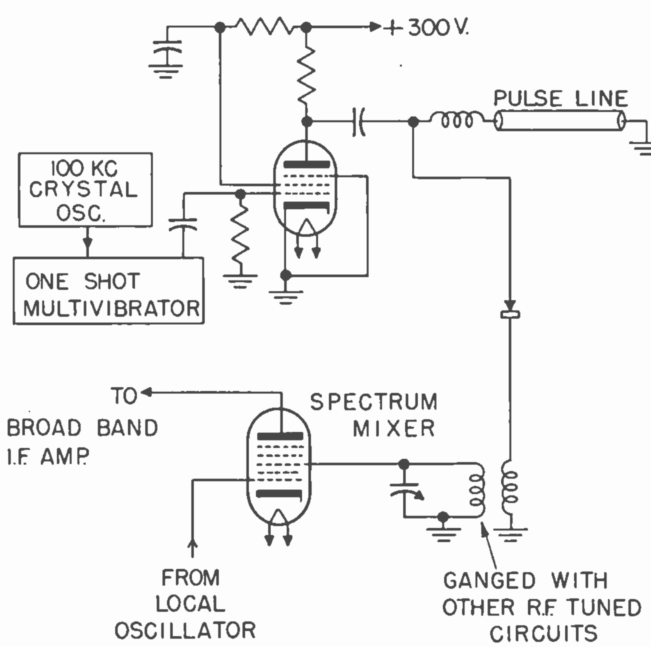

Fig. 2—Spectrum generator.

of the convertor. The most straightforward way of doing this is by a mechanical linkage between the dial pointer and the variable reactance producing the sweep. To make the indication of frequency appear instantaneous to the eye, the pointer and variable reactance are swept about 15 to 20 times per second through the range of 100 kc. To provide an indication of the pointer position at this speed a neon tube is used to illuminate it the instant a pulse is produced in the output of the narrow-band intermediate frequency amplifier. The effect is simply that of a stroboscope which is indicating angular increment on a rotating pointer. A clear plastic pointer was neatly illuminated by the neon tube (NE51) when the neon was inserted into a hollow shaft carrying the pointer. Light from the neon passed through a window in the shaft and up the pointer to its tip.

Variations in the input level from the local oscillator or the spectrum generator, and also variations of motor speed cause changes in the rate of rise of the pulse at the output of the narrow-band intermediate frequency amplifier. This in turn causes slight shifting of the pointer reading. This difficulty can be overcome by using differentiating circuits in the output or by using a frequency discriminator as a detector preceded by sufficient limiting.

To establish properly the absolute value and the center frequency of the sweeping range indicated on the stroboscopic dial, calibrating frequencies may be introduced into the broad-band intermediate frequency amplifier direct from the spectrum generator. The 19th and 20th harmonics of the 100-kc crystal, one of which occurs at each edge of the pass band, provide this calibration through a switch. Adjustments to the trimmers on the motor-driven condenser and to the slug-tuned coil in parallel with it provide three-point tracking of the pointer across the scale. An occasional adjustment of the center frequency of the convertor sweeping range can be made by the slug-tuned coil which takes care of long-term drifts.

Both variable capacity and variable inductance have been tried with success as the motor-driven reactance. A slug-tuned coil with moving slug offers some advantage in size and linearity. A completely electronic circuit using a reactance-tube modulator and cathode-ray-tube display eliminated moving parts but was difficult to keep stable.

Tests on a crude model show it to offer a very rapid and accurate means of setting or reading frequency. Random error is due partly to the mechanical tolerances of the rotating assembly and its bearings. In the model it appears to be about 100 cycles. Changes of local-oscillator or spectrum-generator signal input levels to the spectrum mixer can also cause reading errors. Using a discriminator-type frequency-sensitive detector at the output of the narrow-band intermediate-frequency amplifier reduces this error to less than 100 cycles for a five to one change of input level. The 100-kc crystal oscillator can be kept stable with negligible error from its harmonics up to 30 mc, and only occasional checks against a primary standard are needed. With proper circuit design, the drift of the sweeping-oscillator section of the second convertor can be made small and experience thus far shows only a need for a daily check on its center frequency. The maximum total error of the present instrument appears to be somewhat less than 300 cycles, and any refinement of the technique will certainly considerably reduce it. Fig. 3 shows the meter incorporated into a communications receiver.

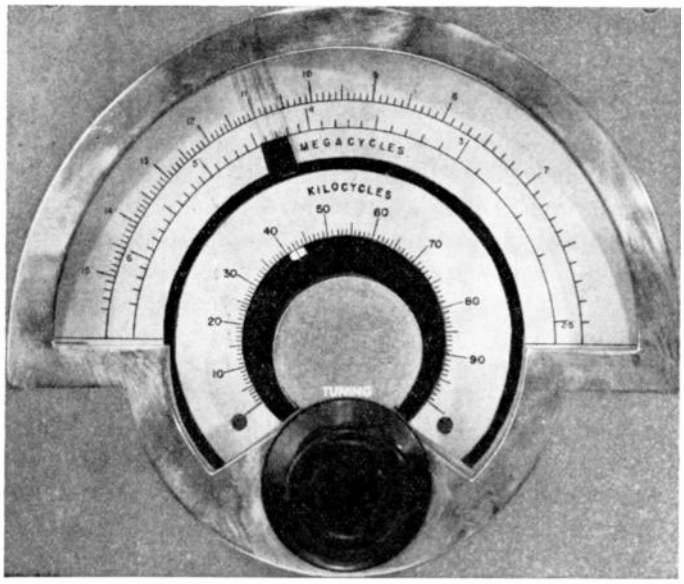

Fig. 3—Closeup of receiver dial, frequency setting 4,342 kc on low band.

Other Features

Several frequencies can be read simultaneously, providing a primary coarse dial gives the frequency to the nearest 0.1 mc. The limitation so far as the above system is concerned is the ability to ionize and de-ionize the neon rapidly enough to indicate readings which are adjacent on the 100-kc scale. The present limit is a minimum spacing of about 5 kc, but there are various ways to circumvent this difficulty, if necessary. It is also feasible to read the frequency of a modulated carrier. In the system described above a modulated carrier shows the pointer flickering between sideband frequencies on wide band modulation. The flickering is due to the inability of the neon tube to reproduce faithfully rapidly succeeding pulses.

Acknowledgment

This project was carried out by the Navy Section, Division of Radio and Electrical Engineering, National Research Council of Canada and is published by permission of the Royal Canadian Navy.

Discussion on

"Distributed Amplifier Theory"*

D. V. PAYNE

R. W. A. Scarr:[1]—A recent paper by Payne gives mathematical theory of the operation of the anode line of a distributed amplifier. In two places the development of the theory is not altogether clear; a more detailed explanation would be appreciated.

There appears to be a discrepancy in (9), page 761 of the paper, for by substituting the expressions for E' and I' in the relation at the top of the same page:

$$\frac{E'}{I'} = \frac{c_{13}}{c_{23}}$$

one obtains:

$$\frac{c_{13}(Z_{02}' - Z_{01}')}{c_{23}(Z_{02}' + Z_{01}')} = \frac{c_{13}}{c_{23}}$$

i.e.

$$+ Z_{01}' = - Z_{01}'.$$

It is not clear how the expressions of (10) are obtained from the matrix relation of the line above. It will be shown below that an alternative method of solution results, for a specific case, in an answer which is not compatible with Payne's result for the same case.

Using the same notation and proceeding from the relationship:

$$\begin{bmatrix} X_0 \\ i_0 \end{bmatrix} = \begin{bmatrix} D & F \\ 0 & \zeta \end{bmatrix}^n \begin{bmatrix} X_n \\ i_n \end{bmatrix}.$$

Expanding using (5) we get:

$$X_0 = D^n X_n + (D^{n-1} + D^{n-2}\zeta + D^{n-3}\zeta^2 + \cdots + \zeta^{n-1})F i_n.$$

To determine D^n we note that the matrix

$$\begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

corresponds to the matrix

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

of Guillemin.[2] Using the relationships of equation (370) of the same chapter and (6) to express the matrix elements in terms of Z_{01}, Z_{02}, e^{γ} and $e^{-\gamma}$, we obtain after some manipulation

$$D = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

$$= \frac{1}{Z_{01} + Z_{02}} \begin{bmatrix} Z_{01}e^{\gamma} + Z_{02}e^{-\gamma} & Z_{01}Z_{02}(e^{\gamma} - e^{-\gamma}) \\ e^{\gamma} - e^{-\gamma} & Z_{02}e^{\gamma} + Z_{01}e^{-\gamma} \end{bmatrix} \quad \text{(a)}$$

* D. V. Payne, "Distributed amplifier theory," Proc. I.R.E., vol. 41, pp. 759–762; June, 1953.

[1] Elec. Eng. Dept., Queen Mary College, Univ. of London, London, Eng.

[2] E. A. Guillemin, "Communication Networks," John Wiley and Sons, Inc., New York, N. Y., vol. II, chap. IV, p. 137; 1935.

this result is also quoted by Cutteridge in Table II of a recent paper.[3]

It follows from physical considerations,[3] or if required it may be proved mathematically, that:

$$D^n=\frac{1}{Z_{01}+Z_{02}}\begin{bmatrix} Z_{01}e^{n\gamma}+Z_{02}e^{-n\gamma} & Z_{01}Z_{02}(e^{n\gamma}-e^{-n\gamma}) \\ e^{n\gamma}-e^{-n\gamma} & Z_{02}e^{n\gamma}+Z_{01}e^{-n\gamma}\end{bmatrix}. \quad \text{(b)}$$

As

$$F=\begin{bmatrix} c_{13} \\ \hline c_{23}\end{bmatrix}$$

$$D^{n-1}.F=\frac{1}{Z_{01}+Z_{02}}\begin{bmatrix} c_{13}(Z_{01}e^{(n-1)\gamma}+Z_{02}e^{-(n-1)\gamma}+c_{23}Z_{01}Z_{02}(e^{(n-1)\gamma}-e^{-(n-1)\gamma}) \\ c_{13}(e^{(n-1)\gamma}-e^{-(n-1)\gamma})+c_{23}(Z_{02}e^{(n-1)\gamma}+Z_{01}e^{-(n-1)\gamma})\end{bmatrix}. \quad \text{(c)}$$

Hence

$$(D^{n-1}+D^{n-2}\zeta+\cdots+\zeta^{n-1})Fi_n$$

$$=\frac{i_n}{Z_{01}+Z_{02}}\begin{bmatrix} c_{13}(Z_{01}\xi_1+Z_{02}\xi_2)+c_{23}Z_{01}Z_{02}(\xi_1-\xi_2) \\ c_{13}(\xi_1-\xi_2)+c_{23}(Z_{02}\xi_1+Z_{01}\xi_2)\end{bmatrix}. \quad \text{(d)}$$

As

$$X_0=\begin{bmatrix} E_0 \\ I_0\end{bmatrix}$$

$$E_0=\frac{1}{Z_{01}+Z_{02}}[(Z_{01}e^{n\gamma}+Z_{02}e^{-n\gamma})E_n+Z_{01}Z_{02}(e^{n\gamma}-e^{-n\gamma})I_n$$
$$+i_n\xi_1(c_{13}Z_{01}+c_{23}Z_{01}Z_{02})+i_n\xi_2(c_{13}Z_{02}-c_{23}Z_{01}Z_{02})] \quad \text{(e)}$$

$$I_0=\frac{1}{Z_{01}+Z_{02}}[(e^{n\gamma}-e^{-n\gamma})E_n+(Z_{02}e^{n\gamma}+Z_{01}e^{-n\gamma})I_n$$
$$+i_n\xi_1(c_{13}+c_{23}Z_{02})+i_n\xi_2(c_{23}Z_{01}-c_{13})].$$

Solving the equations and inserting the boundary conditions

$$\frac{E_n}{I_n}=Z_r \quad \text{and} \quad \frac{E_0}{I_0}=-Z_s$$

we have

$$E_n=-\frac{i_nZ_r}{Z_r+Z_{02}}\left\{\frac{(c_{23}Z_{02}+c_{13})\xi_1+(c_{23}Z_{01}-c_{13})\xi_2r_s}{(e^{n\gamma}-e^{-n\gamma}r_rr_s)}\right\}. \quad \text{(f)}$$

Where

$$r_r=\frac{Z_r-Z_{01}}{Z_r+Z_{02}} \qquad r_s=\frac{Z_s-Z_{02}}{Z_s+Z_{01}}.$$

We note that $C_{13}=-a_{12}$ and $C_{23}=-a_{22}$ (this follows from the first three equations at the top of page 760 and (1)), and also that if a T-section is considered in place of the blocks in Fig. 2 $C_{23}=-1$ and $C_{13}=-\frac{1}{2}Z$ where Z is the impedance of the full series arm. The case of greatest practical interest is that in which $Z_{01}=Z_{02}=Z_0$ say, and $Z_{01}'=Z_{02}'=Z_0'$. For this case:

$$c_{23}Z_{02}+c_{13}=-\sqrt{Z_0Z_0'}\,e^{\gamma/2}$$
$$c_{23}Z_{01}-c_{13}=-\sqrt{Z_0Z_0'}\,e^{-\gamma/2}.$$

Assume that $i_n=g_mv_n$ where v_n is the voltage at the grid of the nth tube, and let $v_n=\alpha v_0e^{-(n-1/2)\gamma},(\zeta=e^\gamma)$, where v_0 is the mid-series voltage at the left hand end of the grid line, (which is assumed to have the same number of sections as the anode line), and α is a factor relating the magnitude of the mid-shunt voltage to that of the mid-series voltage.

Substituting these relations in (f) above, we get:

$$E_n=\frac{\alpha v_0g_m\sqrt{Z_0Z_0'}}{2}\left\{\frac{n+r_s(e^{-(2n-1)\gamma}+e^{-(2n-3)\gamma}+\cdots+e^{-\gamma})}{(e^{n\gamma}-r_rr_se^{-n\gamma})}\right\}\{1+r_r\} \quad \text{(g)}$$

rearranging and summing the series which is the coefficient of the r_s term

$$E_n=\frac{\alpha v_0g_m\sqrt{Z_0Z_0'}}{2}\left\{\frac{ne^{-n\gamma}+r_s\frac{\sinh n\gamma}{\sinh\gamma}e^{-2n\gamma}+r_rne^{-n\gamma}+r_rr_s\frac{\sinh n\gamma}{\sinh\gamma}e^{-2n\gamma}}{(1-r_rr_se^{-2n\gamma})}\right\} \quad \text{(h)}$$

If the grid and anode lines are both constant k sections and $\gamma=j\beta$, for a line correctly terminated at both ends (h) reduces to

$$E_n=\frac{1}{2}\frac{nv_0}{\sqrt{1-x^2}}R_0g_me^{-nj\beta} \quad \text{(i)}$$

where $x=\omega/\omega_c$ and $\omega_c/2\pi$ is the cutoff frequency, $\sqrt{Z_0Z_0'}=R_0$, $\alpha=1/\sqrt{1-x^2}$.

The magnitude of this expression is identical with that obtained by Ginzton, Hewlett, Jasberg and Noe[4]

[3] O. P. D. Cutteridge, "Four terminal networks," *Wireless Engineer*, vol. 30, pp. 61–68; March, 1953.

[4] E. L. Ginzton, W. R. Hewlett, J. H. Jasberg, and J. D. Noe, "Distributed amplification," Proc. I.R.E., vol. 36, pp. 956–969; August, 1948.

((6) page 958 for $m=1$) but does not agree with Payne's (13) for $Rr=0$.

The equation (h) can be made to give a physical picture of the operation by analogy with the transmission line. The first term represents the required output, which is the sum obtained by the addition in phase of all the voltages traveling from left to right due to the injected currents at the tube anodes. The second term represents the reflection from the left hand end of the line of the injected voltages which initially travel from right to left and add at the termination in a complex manner. The third and fourth terms represent the reflection of the first and second terms at the right-hand end of the line. Higher order reflection terms are obtained by expanding the denominator.

It is difficult to see how the equations resulting from the solution of (10) can be explained by a similar analogy, or alternatively on what grounds such an analogy would not be valid in this case.

Acknowledgment

The writer would like to thank Mr. O. P. D. Cutteridge for some very helpful suggestions and for checking some of the algebra.

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The Effect of the Anode Aperture on Potential Distribution in a "Pierce" Electron Gun*

A method of obtaining the potential distribution in the vicinity of an anode aperture (in the presence of a high-intensity electron beam), first described in unpublished work by one of the authors,[1] has been adapted recently to an experimental technique by the other.

In the original application, the potential distribution between the cathode and anode of a gridless klystron was to be computed for the purpose of establishing actual electron trajectories. The potential off the cathode of an electron gun designed by the well known method of Pierce should follow the so-called "Langmuir" distribution, which has been computed for rectilinear electron flow between simple surfaces. (In the case under consideration, for instance, the cathode was a spherical cap and the theoretical distribution was proportional to $\alpha^{4/3}$, where α is a certain function of the ratio of cathode radius to anode radius, as tabulated by Langmuir.[2]

In a gridless klystron, or any other diode in which the anode consists merely of an aperture, it is very difficult to arrange the shape and location of the auxiliary electrodes (employed to give the prescribed distribution along the beam edge) in such a manner that the potential follows the prescription all the way to the anode. Even if it does so along the beam edge, the potential distribution in the region *inside* the beam will be considerably affected by the presence of an anode aperture.

If it is now desired to make an equipotential plot, for the purpose of finding the exact electron trajectories, the problem arises as to how the "Langmuir" potential distribution might be joined to an ordinary Laplace distribution, which could then be computed by some numerical method such as that of Shortley *et al.*[3] The two distributions, for the case under consideration, are shown by the solid curves of Fig. 1.

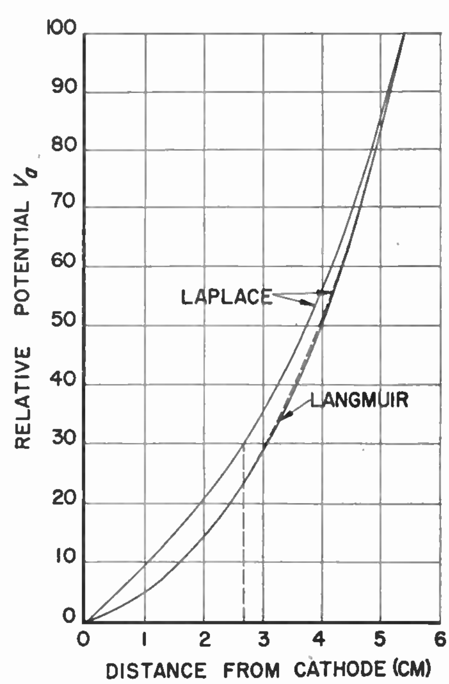

Fig. 1—A comparison between the Laplace and the Langmuir potential distribution in a gridless klystron.

In most configurations, the anode aperture does not greatly affect the shape of the off-cathode equipotentials up to, say, one-half of the distance to the anode; in this region, they remain substantially parallel to the cathode. A reasonable procedure, therefore, would be to use the Langmuir potential along the beam edge up to the halfway point, together with the equipotential passing through this point (i.e., a line through the beam region and parallel to the cathode), as boundary values in the solution of Laplace's equation for the remainder of the cathode-anode region. An additional justification for this method is found in the fact that the two solutions join smoothly, as shown in Fig. 1, where a Laplace solution based on the new boundary value is indicated by the dashed curve.

The above method may be also applied to an experimental technique which yields an accurate equipotential plot very quickly; electrolytic-tank plotting. In the design of "Pierce" electron guns, an electrolytic-tank model of the desired configuration is usually already available. If this model is probed, it yields equipotentials which correspond to a region free from space charge, as there is no direct way of simulating an electron beam in the electrolytic tank.

Now let the equipotential passing through the halfway point along the beam edge (corresponding to about 0.30 V_a in the example illustrated by Fig. 1) be replaced by an additional electrode, at a potential corresponding to the Langmuir prescription for that point (about 0.23 V_a in the present example). This additional electrode should extend only over the region covered by the beam, and have the same shape as the equipotential which it is replacing. The plot which may now be obtained in front of the additional electrode (i.e., in the critical region of the anode aperture) has been thus adjusted to account for the depression of potential due to the presence of space charge.

The above techniques were developed in the course of investigations sponsored at Stanford University by the Office of Naval Research.

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* Received by the Institute, Sept. 29, 1953.

[1] K. L. Brown, "Focusing of the electron beam in a high-power pulsed klystron," Stanford University M. S. Thesis; June, 1949.

[2] K. R. Spangenberg, "Vacuum Tubes," McGraw-Hill Book Co., Inc., New York, N.Y., appendix VII; 1948.

[3] G. Shortley, R. Weller, P. Darby, and E. H. Gamble, "Numerical solution of axisymmetrical problems, with applications to electrostatics and torsion," *Jour. Appl. Phys.*, vol. 18, pp. 116–129; Jan., 1947.

Graphical Analysis of Measurements on Multi-Port Waveguide Junctions*

With reference to a recent paper on the graphical analysis of measurements on a two-port waveguide junction,[1] the following extension to analysis of measurements on an n-port (or "n terminal-pair") junction may be of interest. For brevity, a 4-port section will be considered, with the results immediately generalizable to any n. Reciprocity will be assumed.

Let the ports be designated 1, 2, 3, 4, and terminate ports 2, 3, and 4, in loads having reflection coefficients Γ_2, Γ_3, Γ_4 respectively. Further, let measurements be made of the reflection coefficient $\Gamma_{obs.}$ for the impedance looking in at port 1. Then the usual definition of the elements $S_{ij}(i, j=1, 2, 3, 4)$ of the scattering matrix which completely characterizes the junction,[2] leads to a determinantal equation for $\Gamma_{obs.}$:

$$\begin{vmatrix} S_{11}-\Gamma_{obs.} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22}-\dfrac{1}{\Gamma_2} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33}-\dfrac{1}{\Gamma_3} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44}-\dfrac{1}{\Gamma_4} \end{vmatrix} = 0. \quad (1).$$

Using standard determinantal addition rules, this may be solved with the dependence of $\Gamma_{obs.}$ on Γ_2 shown explicitly, in the "canonical" form

$$\Gamma_{obs.} = T_{11}^{(3)} + \frac{[T_{12}^{(3)}]^2\Gamma_2}{1 - T_{22}^{(3)}\Gamma_2}. \quad (2)$$

Here $T_{ij}^{(3)}$ are each a ratio of symmetrical determinants containing Γ_3 and Γ_4; their explicit dependence on Γ_3 may next be brought out in terms of ratios of determinants of lesser order as

$$T_{11}^{(3)} = U_{11}^{(2)} + \frac{[U_{12}^{(2)}]^2\Gamma_3}{1 - U_{22}^{(2)}\Gamma_3} \quad (3)$$

$$T_{22}^{(3)} = V_{11}^{(2)} + \frac{[V_{12}^{(2)}]^2\Gamma_3}{1 - V_{22}^{(2)}\Gamma_3}. \quad (4)$$

Finally, each of the ratios $U_{ij}^{(2)}$ or $V_{ij}^{(2)}$ can be expanded in a form involving only the elements S_{ij} as coefficients. For example, $U_{11}^{(2)}$ contains S_{11}, S_{44}, S_{14}^2 in the form

$$U_{11}^{(2)} = S_{11} + \frac{S_{14}^2\Gamma_4}{1 - \Gamma_4 S_{44}} \quad (5)$$

and similarly the others contain

$$U_{22}^{(2)}: S_{33}, S_{44}, S_{34}^2 \quad (6)$$

$$V_{11}^{(2)}: S_{22}, S_{44}, S_{24}^2 \quad (7)$$

$$V_{22}^{(2)}: S_{33}, S_{44}, S_{34}^2. \quad (8)$$

It is now clear that the graphical method described[1] may be applied as follows, if measurements can be made by terminating ports 2, 3, 4 in movable short circuits:

If the shorts terminating ports 3 and 4 are fixed, and measurements are made for four positions of the short in arm 2, Deschamps' graphical method gives the corresponding values of $T_{11}^{(3)}$, $T_{22}^{(3)}$, $[T_{12}^{(3)}]^2$. If now the short in arm 3 is moved to another position, and fixed, four new settings of short #2 give another set of values of $T_{11}^{(3)}$, $T_{22}^{(3)}$, $[T_{12}^{(3)}]^2$. Repeating this twice more, the $T_{11}^{(3)}$ and $T_{22}^{(3)}$ can each be found for four values of Γ_3.

But then, by (3) and (4), the $U_{ij}^{(2)}$ and $V_{ij}^{(2)}$ can be found by graphical method.

If now the settings for the short in port 4 are changed, and for each setting the entire set of calculations described above is carried out, then each of the $U_{ij}^{(2)}$ and $V_{ij}^{(2)}$ will be known for the four appropriately chosen values of Γ_4. Then by (5)–(8), Deschamps' method will give the values of S_{ij} as follows:

From

$$U_{11}^{(2)}: S_{11}, S_{44}, S_{14}^2$$

From

$$U_{22}^{(2)}: S_{33}, S_{44}, S_{34}^2$$

From

$$V_{11}^{(2)}: S_{22}, S_{44}, S_{24}^2$$

From

$$V_{22}^{(2)}: S_{33}, S_{44}, S_{34}^2.$$

Clearly this procedure requires measurements for all combinations of four settings (selected in pairs, as required by the graphical method) on each of the shorts in ports 2, 3, and 4, i.e. $4\times4\times4=64$ measurements. If the experimental checks suggested[1] are kept, then even $6\times6\times6$ measurements may be desirable. It is clear that the same data may now be taken and regrouped; e.g., $\Gamma_{obs.}$ may be expanded first in terms of Γ_3, and the resulting coefficients in terms of Γ_4, and finally in terms of Γ_2 (a cyclic permutation $2\rightarrow3\rightarrow4\rightarrow2$). This sequence gives, in addition to parameters found previously, S_{12}^2 and S_{23}^2. Finally the cyclic permutation $2\rightarrow4\rightarrow3\rightarrow2$ will give the last missing parameter S_{13}^2.

The extension to an n-port junction is immediate from the above. Clearly, complete determination of an n-port junction with any accuracy will require at least 4^{n-1} or perhaps even 6^{n-1} measurements of $\Gamma_{obs.}$. Perhaps worse, the basic graphical construction will have to be carried out $(n-1)4^{n-1}$ times. For a 4-port junction, this means 64 measurements, and 192 constructions. However, the author knows of no other systematic scheme for measuring the parameters of an n-port junction, so this is certainly worth serious consideration. Also, the apparently tremendous number of computations may be reduced if only certain scattering-matrix elements are required, by choosing appropriate groupings of the data. Actually it has been pointed out that only 3 properly chosen data points are minimally necessary to perform the graphical construction, and this could be used to reduce the labor (at the sacrifice of most of the useful checks against errors).

Some of the matrix elements will be calculated several times over during the computations, providing a check against computational errors. Unfortunately, no way has been found to use the $T_{12}^{(3)}$, or other "mutual" terms; conceivably, a method using them would shorten labor.

The helpful suggestions of Prof. J. E. Storer of Cruft Laboratory, Harvard University, are gratefully acknowledged.

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* Received by the Institute, September 25, 1953. These results are from an internal memorandum prepared at Cruft Lab., Harvard University, Cambridge, Mass., in June, 1953, while the author was an RCA Fellow in Electronics, under the National Research Council.

[1] J. Storer, L. Sheingold, and S. Stein, "A simple graphical analysis of a two-port waveguide junction," PROC. I.R.E., vol. 41, pp. 1004–1013; August, 1953.

[2] C. G. Montgomery, R. H. Dicke, and E. M. Purcell," Principles of Microwave circuits," Radiation Lab. Series, vol. 8, pp. 146–149, McGraw-Hill Book Co., New York, N. Y.; 1948.

Instantaneous Frequency*

Since it seems fashionable these days to write letters to the editor on the subject of "instantaneous frequency," I should like to add a note to the letter of J. J. Hupert in the September, 1953, issue of PROCEEDINGS OF THE I.R.E. with which I am in full agreement, directing attention to some pertinent remarks of Gabor.[1]

Let us assume a function of time $s(t)$ which, if periodic, we might represent as the Fourier series

$$s(t) = \sum_{k=1}^{k=m} A_k \cos(\omega_k t + \phi_k). \quad (1)$$

Gabor shows that one may add to such a real function of time an imaginary part $\sigma(t)$ defined by the Hilbert transform

$$\sigma(t) = \frac{1}{\pi}\int_{-\infty}^{\infty} s(\tau)\frac{d\tau}{\tau - t} \quad (2)$$

(where the improper integral is to be considered as the limit of the sum of two integrals, one on either side of $\tau=t$). The resulting complex function of time

$$\psi(t) = s(t) + j\sigma(t) \quad (3)$$

has the interesting property that its Fourier spectrum

$$\Phi(f) = \int_{-\infty}^{\infty} \psi(t)e^{-2\pi jft}dt \quad (4)$$

is zero for negative frequencies.

For the function $s(t)$, given by (1), the associated imaginary part is

$$\sigma(t) = \sum_{k=1}^{k=m} A_k \sin(\omega_k t + \phi_k) \quad (5)$$

and the complex time function is

$$\psi(t) = \sum_{k=1}^{k=m} A_k \exp j(\omega_k t + \phi_k). \quad (6)$$

The instantaneous frequency may be defined as the time derivative of the phase of $\psi(t)$, and in the case of (6) this corresponds to the definition of Hupert.

However, Gabor's work is much more general. For any function $s(t)$, periodic or not, the phasor whose real projection is the function $s(t)$ is uniquely defined by (2) and (3). The instantaneous frequency, defined as the time rate of change of the phase of $\psi(t)$, is uniquely specified and, as pointed out by Hupert, "useful . . . when judiciously applied."

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[1] D. Gabor, "Theory of communication, *Jour. IEE* III, vol. 93, pp. 429–457; 1946.

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For a photograph and biography of J. G. Linvill see page 298 of the February, 1953 issue of the PROCEEDINGS OF THE I.R.E.

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From 1946 to 1951 Mr. McCoy was an independent consulting engineer in Portland, Oregon. In 1951 he became a member of the technical staff at the Hughes Aircraft Company Research and Development Laboratories, engaged in radar-systems research. Since October 1953, he has been employed by the Electronic Control Systems.

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After leaving the University, Dr. Salpeter entered the incandescent lamp and radio tube industry, first in Hungary, and later in Austria. There he invented a novel process for manufacturing small grain coiled tungsten filaments, which is still in use in Europe today for vibration proof lamps. In 1939, he left Austria for London, and then Australia, where he joined the Philips Electrical Industries Pty. Ltd., as research physicist, engaged mainly in fluorescent lighting, television optics, and magnetic materials and their applications.

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O. G. VILLARD

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P. WELCH

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Dr. Armstrong was associated with the National Research Council of Canada as research physicist from 1941 to 1947. He joined the Radio Corporation of America in 1949, working on ceramic seals and high-frequency power tubes at the RCA Laboratories Division in Princeton, N. J., from 1949 until 1951. Since 1951 he has been engaged in research work on transistors.

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S. Bertram (A'36–SM'47) was born in Winnipeg, Canada, on July 7, 1913. He attended the Los Angeles City College from 1930 to 1933. From 1934 to 1936 he was an instructor at the Radio Institute of California. He received the B.S. degree in engineering from the California Institute of Technology in 1938.

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M. Golmayo Cifuentes (S'50–A'52) was born in Madrid, Spain, September 17, 1915. In 1936 he graduated from the Escuela Naval Militar (Spanish Naval Academy) and received his commission. From 1940 to 1944 he was a member of the teaching staff of the Escuela Naval Militar. In 1945 he received a postgraduate degree from the Escuela de Transmisiones de la Armada (School for Communications of the Spanish Navy). From 1946 to 1949 he taught electrical engineering at the Escuela de Transmisiones de la Armada. He received the degree of M.S. in E.E. from Stanford University in 1950, and the Ph.D. degree in 1952. From 1952 to 1953 he was chief of the electronics division of the L.T.I.E.M.A. (Research Laboratory of the Spanish Navy). Dr. Golmayo holds the rank of lieutenant-commander, and is at present in charge of the training vessel "J. S. Elcano."

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M. J. E. Golay (SM'51) was born on May 3, 1902, in Switzerland. He received the Baccalaureat Scientifique from the Gymnase de Neuchatel in 1920, the licenciate in electrical engineering from the Federal Institute of Technology at Zurich in 1924, and the Ph.D. in physics from the University of Chicago in 1930.

M. J. E. Golay

From 1924 to 1928 Dr. Golay worked on telephone cables for the Bell Telephone Laboratories. In 1930 and 1931 he worked on automatic telephone systems for the Automatic Electric Company, and since 1931 has been a member of the Signal Corps Laboratories, Fort Monmouth, N. J., working on subaqueous acoustics, terrestrial sound ranging, heat detection, radio relays, and electronic controls. He is now Chief Scientist of the Squier Signal Laboratory.

In 1946 Dr. Golay disclosed a new attack on the ideal electrical filter problem and also described a new detector for infrared and short radio waves. In 1948 he announced the principle of multislit spectrometry, which alleviates the intensity problems in far infrared spectrometry. He received the Harry Diamond award in 1951.

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P. A. Handley was born in 1929 in Portsmouth, England. She received an Honours B.Sc degree in Mathematics (London) from Southampton University in 1951.

P. A. Handley

In that year of her graduation, she joined the development staff of the Brimar valve engineering division of Standard Telephones and Cables, Limited. Since her employment with them, Miss Handley has devoted her time principally to working on reliable valves.

❖

Edward I. Hawthorne (SM'53) was born in Poland on September 25, 1921. He came to the United States in November, 1937, and became a naturalized citizen in 1943.

E. I. Hawthorne

After receiving the B.S. degree in E.E. in February 1943 from the Cooper Union School of Engineering, he joined the RCA Victor Corporation in Camden, New Jersey. His work as test equipment design engineer and transmitter development engineer continued, except for two years of service as radio officer in the Signal Corps, until February 1947, when he accepted an appointment to the Staff of the Moore School of Electrical Engineering of the University of Pennsylvania. Since then he has been engaged in teaching, in graduate studies culminating in an M.S. in E.E. degree in August 1948 and a Ph.D. in E.E. in February 1953, and in research work on varying parameter circuits, nonlinear devices and electromagnetic field problems, as an instructor, associate, and now assistant professor of electrical engineering.

Dr. Hawthorne is a Member of AIEE, Tau Beta Pi and Sigma Xi.

1954 I-R-E National Convention Program

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Registration

Registration facilities have been increased this year to help make the registration procedure operate more smoothly and efficiently than ever before. Members and visitors may register during the following days:

Waldorf-Astoria Hotel

Monday	9 A.M.–5:30 P.M.
Tuesday	9 A.M.–8 P.M.
Wednesday	9 A.M.–6 P.M.
Thursday	9 A.M.–2:30 P.M.

Kingsbridge Armory

Monday	10 A.M.–10 P.M.
Tuesday	10 A.M.–10 P.M.
Wednesday	10 A.M.– 5 P.M.
Thursday	10 A.M.–10 P.M.

Exhibits

The Radio Engineering Show, the largest in the history of IRE, will be held at the Kingsbridge Armory, New York City, where there will be over 600 firms sponsoring product exhibits. This gigantic show will fill a four-acre space all on one floor, a solid mile and a half of high-interest recent developments in radio-electronics.

Nearly 40,000 people are expected to view this vast display during the four days of this record-shattering event, from March 22nd through the 25th.

Annual Meeting

Of particular interest to all IRE members is the Annual Meeting of the Institute, which inaugurates the opening of the 1954 National Convention program. This will be held Monday, March 22nd, in the Grand Ballroom of the Waldorf-Astoria Hotel. Professor John D. Ryder is to be the principal speaker, with a talk titled "Electronic Horseless-Carriages."

Convention Record

All available Convention papers will be published in the 1954 Convention Record of the I.R.E. The Convention Record will be issued in eleven Parts according to subject and will be available in June, 1954.

If you are a paid member of an IRE Professional Group as of April 30, 1954, you will receive gratis that Part of the Convention Record pertaining to your Group's field.

If you are not a paid Group member and want to receive a Part of the Convention Record free of charge, join the corresponding IRE Professional Group and pay the Group assessment at the Convention Record desk.

To purchase a Convention Record Part, order at the Convention Record desk.

SCHEDULE OF TECHNICAL SESSIONS

	SHELTON HOTEL	WALDORF-ASTORIA HOTEL			KINGSBRIDGE ARMORY		
	Ballroom	Grand Ballroom	Astor Gallery	Jade Room	Marconi Hall	Faraday Hall	Morse Hall
Monday, March 22 **2:30 P.M.–** **5:00 P.M.**	Session 1 Vehicular Communications *Symposium:* Advances in Mobile Communications	Session 2 Information Theory I—Application of Information Theory to Communication Systems	Session 3 Aeronautical and Navigational Electronics I	Session 4 Quality Control and Reliability	Session 5 Radio Telemetry and Remote Control I—Systems and Elements	Session 6 Electronic Components I—Techniques	Session 7 Radio Communications I—*Symposium:* Facsimile
Tuesday, March 23 **10:00 A.M.–** **12:30 P.M.**	Session 8 Aeronautical and Navigational Electronics II	Session 9 Engineering Management I	Session 10 Radio Telemetry and Remote Control II—Telemetry	Session 11 Audio I—High Fidelity	Session 12 Information Theory II—Coding and Noise	Session 13 Broadcast and TV Receivers I—General	Session 14 Electronic Components II—Application
Tuesday, March 23 **2:30 P.M.–** **5:00 P.M.**	Session 15 Aeronautical and Navigational Electronics III	Session 16 Engineering Management II—*Symposium:* Personnel Training and Selection for Engineering Management	Session 17 Medical Electronics	Session 18 Audio II—General	Session 19 Information Theory III—Speed and Computation	Session 20 Broadcast and TV Receivers II—Color Television	Session 21 Radio Communications II—General
Tuesday, March 23 **8:00 P.M.–** **10:30 P.M.**		Session 22 Medical Electronics *Symposium:* Engineering Base on Biological Design			Session 23 Audio-Seminar High Fidelity in Audio Engineering		
Wednesday, March 24 **10:00 A.M.–** **12:30 P.M.**	Session 24 Nuclear Science I—*Symposium:* Progress Report	Session 25 Electron Devices I—Electron Tubes	Session 26 Broadcast Transmission Systems I—*Symposium:* TV Broadcasting	Session 27 Electronic Computers I—Computer Design and Techniques	Session 28 Circuit Theory I—*Symposium:* Network Equalization	Session 29 Instrumentation I	Session 30 Antennas and Propagation I—General
Wednesday, March 24 **2:30 P.M.–** **5:00 P.M.**	Session 31 Nuclear Science II—*Symposium:* Reactor Electronics	Session 32 Electron Devices II—Transistors	Session 33 Broadcast Transmission Systems II—*Symposium:* Color TV Broadcasting	Session 34 Electronic Computers II—Computer Components	Session 35 Circuit Theory II—Circuit Theory	Session 36 Instrumentation II—*Symposium:* High Frequency Measurement and Control	Session 37 Antennas and Propagation II—Microwave Antennas
Thursday, March 25 **10:00 A.M.–** **12:30 P.M.**	Session 38 Industrial Electronics	Session 39 Circuit Theory III—Network Synthesis	Session 40 Electron Devices III—Storage Tubes	Session 41 Ultrasonics I	Session 42 Antennas and Propagation III	Session 43 Microwave Electronics I—Ferrites and Strip Lines	Session 44 Instrumentation III
Thursday, March 25 **2:30 P.M.–** **5:00 P.M.**	Session 45 Radio Telemetry and Remote Control III—Remote Control	Session 46 Circuit Theory IV—Transistor Circuits	Session 47 Electron Devices IV—Microwave Tubes	Session 48 Ultrasonics II	Session 49 Antennas and Propagation IV—*Symposium:* UHF Television—Boom of Bust	Session 50 Microwave Electronics II—Components	Session 51 Electronic Computers III—Discussion

SUMMARIES OF TECHNICAL PAPERS

SESSION I

Symposium: Advances in Mobile Communications

(Organized by the Professional Group on Vehicular Communications)

Chairman: NEWTON MONK (Bell Telephone Laboratories, Inc., New York, N. Y.)

1.1. Transient Response of Selective Networks and Impulse Noise in Narrow Band FM Receivers

S. P. LAPIN, *Motorola, Inc., Chicago, Ill.*, AND J. J. SURAN, *General Electric Co., Syracuse, N. Y.*

Impulse noise in frequency-modulation communication systems is known to be related to the transient response of the selective networks in the receiver. In communication systems where selectivity is important, the selective networks usually consist of many stages of tuned high-Q circuits. The transient responses of these tuned networks are, in general, of complex nature.

This report is an analysis of the transient responses of networks having selectivities in the order of those employed in two-way mobile communication units, together with an analysis of the effect of these transients upon communication signals. The report is divided as follows: (a.) Theoretical considerations relating to the transient response of linear selective networks. (b.) Experimental analysis of the transient response of linear selective networks. (c.) Impulse noise in narrow-band FM receivers.

1.2. Advances in Petroleum Mobile Communications

L. A. M. BARNETTE, *Humble Oil and Refining Co., Houston, Texas*

A brief history of the early development and uses of radio in drilling and oil producing operations is given. An outline is presented of current petroleum radio uses from prospecting through to final retail sales.

Recent trends in frequency co-ordination have extended from purely Petroleum Radio to include co-operation with other industrial groups sharing certain frequency bands, including 72–76 mc, with more recent efforts at an industry-wide frequency co-ordinating council for microwave users. In recent years petroleum people have made great progress toward universal use of narrow-band receivers capable of operation on 20-kc spacing in the 25–50 mc bands. Greater use of directional antennas, introduction of selective calling systems and the appearance of radio operator handbooks to assist in message handling and shortening of time on the air all are contributing to more efficient use of the greatly congested radio spectrum.

1.3. A New Approach to 450–470 mc Communication Equipment

R. W. TUTTLE, *Conn. Tel. & Electric Corp., Meriden, Conn.*

The majority of 450–470 mc communication equipment of today uses low-frequency overtone crystal oscillator circuits and a high order of multiplications to reach the 450–470 mc band. Crystal ovens are employed for stability, phase modulation, and audio limiters to control deviation.

This paper describes four changes in circuitry for a new approach to 450–470 mc communication. The first is a vhf oscillator based on the Lister patents. The crystal operates on its *7th* or *9th* overtone in the 75-mc region producing better than one watt of power output with very low crystal current. Thus a multiplication factor of six may be used to reach 450–470 mc.

Secondly, this oscillator is easily modulated with a simple reactance-tube modulator to produce frequency modulation. To eliminate the use of a crystal oven the circuit components were chosen using temperature compensating capacitors. By use of proper temperature coefficients a stability of better than .005 per cent is achieved.

Automatic deviation control is accomplished by the selection of a proper value of coupling capacity between the modulator and the crystal. This limits the amount of capacity change introduced by the modulator and therefore limits the amount of frequency shift of the crystal oscillator.

These changes in basic circuitry simplify the new uhf communication equipment.

1.4. Operation and Planning of A Utility Radio System

A. B. BUCHANAN, *The Detroit Edison Co., Detroit, Mich.*

The 48-mc mobile radio system of The Detroit Edison Company uses eleven base stations to cover its 7,500 square-mile-area in southeastern Michigan. Five additional low power base stations, using low antennas, are installed in Detroit to reduce intra-system interference, and incidentally increase traffic handling ability. Recently a significant reduction in the need for field servicing of mobile units has been achieved as a result of careful measurements of forward and reflected power. Exact cutting of the antenna for each mobile installation reduced reflected power from as much as ninety-five per cent to not more than three per cent.

SESSION II

Information Theory I—Application of Information Theory to Communication Systems

(Organized by the Professional Group on Information Theory)

Chairman: W. G. TULLER (Melpar, Inc., Alexandria, Va.)

2.1. Information Theory—Past, Present and Future*

R. M. FANO, *Massachusetts Institute of Technology, Cambridge, Mass.*

Six years have elapsed since the official birth of the mathematical theory of communication known as "Information Theory." The initial great interest in the potentialities of this theory has by now given way, in some quarters, to a certain amount of impatient skepticism about its usefulness to communication engineers. The object of this paper is the reassessment of the proper position of Information Theory in the broader field of communication engineering. An attempt will be made to evaluate its practical achievements up to date and to speculate on its future development and on the help that communication engineers may reasonably expect from it.

* This work has been supported in part by the Signal Corps, the Air Materiel Command, and the Office of Naval Research.

2.2. Optical Filters—Their Equivalence to and Difference from Electrical Networks

T. P. CHEATHAM, JR., *Harvard University, Cambridge, Mass.*

Many optical systems perform a linear transformation of an object plane into an image plane. This is the two-dimensional, spatial equivalent of the one-dimensional time transformation performed by a linear filter. Many of the mathematical techniques which have been developed for treating linear filters can be easily carried over to optical systems with minor modifications. The major difference between the two cases is that in optics one usually deals with intensity (power) and not amplitude.

A survey will be given of recent work in this field, including methods of synthesizing optical filters.

2.3. Theoretical Improvement in S/N of TV Signals by Equivalent Comb Filter Technique

N. H. STATEMAN, AND M. B. RITTERMAN, *Sylvanic Electric Products Inc., Bayside, L. I., N. Y.*

The redundancy inherent in the video signal is used to improve S/N. Methods are considered which modify the incoming signal in relation to the past stored signals. Qualitative consideration is given to nonlinear systems which limit the absolute change in successive signals. Quantitative results are obtained for linear methods which fix the percentage change in successive signals. Each of these methods leads to comb filter action wherein the signal band is covered by successive pass and stop bands which conform to the signal spectrum. Noise is attenuated in the stop bands where signal components are negligible.

2.4. Information Losses in Regenerative Pulse-Code Systems

W. D. WHITE, *Airborne Instruments Laboratory, Mineola, N. Y.*

On the reception of pulse-code-modulation signals, it is common practice to regenerate the pulses or, in other words, to generate new pulses completely free of noise. This regeneration process is shown to result in a loss of a portion of the information contained in the received signal. When the only perturbation is additive Gaussian noise, this loss is of minor importance but when fading is present in addition to the additive noise component, the loss can be substantial. One method of partially overcoming this loss is discussed.

2.5. A Gaussian Noise Generator for Frequencies down to 0.001 Cycles per Second

D. F. WINTER, *Washington University, St. Louis, Mo.*

Gaussianly distributed noise at extremely low frequencies may be obtained by a sampling technique employing high-frequency Gaussian noise. Two sampling schemes are discussed. Drift problems are minimized by using a high signal level at the sampler input. Noise with a root mean square voltage of 0.5 volts per $(\text{cycle})^{1/2}$ of bandwidth is easily obtainable. This is more than ten to the sixth times the voltage from a one-megohm resistor at room temperature. The mechanization of this noise generator is simple enough to be readily built from standard laboratory parts in a day or two. The research reported was done under a Naval Ordnance Plant Indianapolis contract at Washington University, St. Louis, Missouri.

SESSION III
Aeronautical and Navigation Electronics I

(Organized by the Professional Group on Aeronautical and Navigational Electronics)

Chairman: HARRY DAVIS (Rome Air Development Center, Rome, N. Y.

3.1. An Impulse Generator for Receiver Performance Measurement

J. R. VOGELMAN, *Rome Air Development Center, Rome, N. Y.*

An impulse generator has been developed consisting of uniform transmission line which is periodically charged and discharged into a specified output impedance. The ratio of the transmission line impedance and the load impedance being selected so as to produce the flattest possible frequency spectrum over a frequency band from the very low frequencies to 15,000 mc. The spectral analysis of the current in the output wave form of the idealized impulse generator shows a flat response to about 85 per cent of resonant frequency of transmission line. The general design will be considered with particular emphasis on sources of instability and calibration error. The effectiveness of this type of signal generator for measuring the performance of receiving circuits with a pseudo rectangular band pass with arbitrary phasing will be considered. It will be shown that the resultant pulse amplitude passing through the receiver will be modified by the band width characteristics of the receiver itself. The cases of linear receivers and the receivers with phase discontinuities will be considered. The results obtained by impulse measurement of receiver performance will be compared to other means now being utilized.

3.2. Antenna Methods in Microwave Survey

MARC SHELDON, *Microwave Services Inc., New York, N. Y.* AND LEWIS DICKERSON, *Lockwood, Kessler & Bartlett, Great Neck, N. Y.*

The reasons for the current importance of antenna survey methods in the design of microwave systems are explained, and a brief history of antenna survey is given as background material.

The objectives of a microwave survey are considered in terms of the nature of the information required. Four specific types of antenna survey are described in detail, including the equipment used, procedures followed, nature and accuracies of results obtained, and limitations imposed by each method. Antenna reconnaissance (visual), antenna reconnaissance (photographic), radar profiling (with various kinds of control), and antenna photogrammetry are described.

Under the "Applications" section the foregoing methods are discussed in terms of the use to which each is suited, and a comparison of these methods with each other and with ground survey techniques is made.

3.3. The Development of a Production Radome Tester

R. P. WALCUTT, *Thompson Products, Inc., Columbus, Ohio*

3.4. A Correlation Direction Finder for Guided Missile Range Instrumentation

M. S. FRIEDLAND, *Air Force Missile Test Center, Patrick Air Force Base, Fla.* AND NATHAN MARCHAND *Marchand Electronic Labs., Byram, Conn.*

A direction-finder employing information theory techniques is proposed for use against various types of signals, including FM/FM telemetering signals. The basic theory for a suitable direction-finder antenna system is presented. The signal-to-noise ratio is optimized by converting all of the energy in the received signal into a narrow bandwidth giving only the direction information. The receiver operation is independent of the signal, and will give optimized bearings on any complex signal including noise fronts. A system of data determination and recording in digitalized form is also presented. A sampling method is employed which converts the bearings into a digitalized form, and records it. Equipment simplification employing sampling techniques is demonstrated.

3.5. Present Status of Microwave Radiometric Receiver Development

R. M. RINGOEN, *Collins Radio Co., Cedar Rapids, Ia.*

The microwave-radiometric receiver was first introduced by R. H. Dicke in 1945. Since that time various methods have been devised for detecting very low noise powers in the microwave spectrum—some systems being capable of detecting noise power changes of less than 10^{-16} watts which may be equivalent to an antenna temperature change of less than one degree C. The various types of receivers used for this work are described and their relative merits discussed. The introduction of the use of ferrites to obtain unidirectional transmission in waveguide has made it possible to isolate the receiver from the antenna—resulting in a great improvement in the "switching" type of radiometer at some wavelengths. The use of ferrites is discussed along with the additional fields of measurement created by their inception.

SESSION IV
Quality Control and Reliability

(Organized by the Professional Group on Quality Control)

Chairman: J. R. STEEN (Sylvania Electric Products, Inc., New York, N. Y.)

4.1. Improving Reliability of Electronic Equipment by Effective Analysis of Field Performance

R. R. LANDERS, *General Electric Co., Syracuse, N. Y.*

This paper describes a system developed for the *acquisition* and *analysis* of electronic equipment field data and the *action* taken, based on this information, to improve product reliability and performance.

The *acquisition* concerns and consists of obtaining complete and detailed data on malfunctions and reducing it onto International Business Machine cards.

The *analysis* concerns and consists of tabulating, weighing, and summarizing these malfunctions into one report.

The *action* takes place at a meeting of the product analysis group, consisting of the department supervisors, where the report is reviewed. Every malfunction exceeding limits previously determined for it is acted upon to eliminate its recurrence.

4.2. Survey of Electronic Failure Prediction Techniques

J. H. MUNCY, *National Bureau of Standards, Washington, D. C.*

This paper proposes the adoption of incipient failure detection techniques in high performance electronic designs. Although most such designs are military, some civilian applications exist. The several techniques developed by computer, telephone, broadcast, and radar groups are reviewed and the principles discussed. Advantages and disadvantages along with available results are summarized.

The need for failure prediction is shown by citing examples of impractical field maintenance routines that have been recommended to obtain reliable equipment operation. Semi-automatic tests are suggested for these examples.

4.3. A New Approach to Attainment of Reliability in the Production of Airborne Electronic Systems

A. WARSHER AND F. HANUSEK, *Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.*

Present methods for inspection of mass-produced electronic components permit the use of sampling plans for the determination of the acceptability of such products. It is shown that this method of inspection cannot be used for the determination of the quality level of "reliable" components for use in critical end-use equipments where component failures may cause serious consequences.

Two practical means of attaining the required reliabilities are given, and supporting evidence supplied, from the results of a program involving such determinations on high quality electron tubes. One such means is the use of automatized incoming component inspection; the other, removal of the component-choice function, normally a project engineer's responsibility, to an impartial standards and components engineering section.

The latter group, restricted to, and specialists in, the field of component application under simulated environmental conditions, is better equipped for this activity. Improvement achieved by application of these methods to component reliability problems within a guided missiles program, will be set forth.

4.4. A Method of Testing and Evaluation of Complex Missile Systems

R. J. ALTHAUS, S. C. MORRISON, AND W. R. TATE, *Hughes Research and Development Laboratories, Culver City, Calif.*

In tests of complex systems, test errors are often of the order of magnitude of the tolerances on the parameter being measured. Such large errors not only make uncertain the quality of accepted product, but cause inefficiency through rejection of good product in test.

A procedure is discussed for minimizing both these adverse effects. Rejection of product in test is reduced by using relaxed test tolerances, while quality is assured by tight adjustment tolerances and by quality-control analysis of test data. Specification in statistical terms and advance estimation of test errors are considered part of a planned production scheme.

SESSION V
Radio Telemetry and Remote Control I—Systems and Elements

(Organized by the Professional Group on Radio Telemetry and Remote Control)

Chairman: R. E. RAWLINS (Lockheed Aircraft, Burbank, Calif.)

5.1. Guided Missile Range Instrumentation—a New Electronic Art

M. S. FRIEDLAND, *Air Force Missile Test Center, Patrick Air Force Base, Fla.*

A brief history of the evolution of the Instrumentation at the Air Force Missile Test Center, Florida, is presented as background for the present configuration. The philosophy of instrumentation for long range missiles is presented. The two basic complementary methods of evaluating the free flight performance, viz., external observation of missile trajectory, and measurement of conditions by remote recording, are analyzed. The external systems for determination of space-position information are described and evaluated. Such systems as Radars, Phase Comparison, and Optical are contrasted as to their utility and performance. The internal performance as measured by telemetering equipments is described, and the usefulness of such data to complement the external behavior of test missiles is shown. The time collation and data reduction to produce useful results are described; and the many ancillary supporting equipments required to conduct safe and co-ordinated flight tests are analyzed. An over-all system of operation, including communications and control via the wideband submarine cable system, is described, and the general method of Range Operations summarized.

5.2. Interpretation of Sequential Samples from Commutated Data

L. L. RAUCH, *University of Michigan, Ann Arbor, Mich.*

The choise of interpolation method used by the telemeter "decommutator" to generate a continuous function passing through the regularly spaced data-sample points is considered. The relation of interpolation method to the time delay required by the interpolation process and to the available knowledge concerning the general nature of the sampled data is described and illustrated. Several filters for the interpolation process are described.

5.3. Comparison of Required Radio Frequency Power in Different Methods of Multiplexing and Modulation

M. H. NICHOLS, *University of Michigan, Ann Arbor, Mich.*

As rapidly as advances in technology permit, attention should be given to those methods of telemetry which display inherently good signal-to-noise ratio and economical use of bandwidth. With this in mind, a comparison of the various methods of multiplexing and modulation is made on the basis of required RF power for minimum acceptable individual channel-output signal-to-noise ratio and required rf bandwidth. The comparison is also made for various methods of subcommutation. An information efficiency is defined and evaluated for each method.

5.4. Flight Testing of an Airborne Digital Computer

E. M. GRABBE AND D. W. BURBECK, *Hughes Research and Development Center, Culver City, Calif.*

Flight tests of a digital computer as part of the aircraft control system are described. The inputs of the computer consisted of co-ordinate information from a radio link and instrument readings. The computer solves the equations for co-ordinate transformation, position determination, and periodically puts out control signals which automatically control the aircraft through the autopilot. Analog-to-digital conversion is required for the inputs and outputs. The computer is a general purpose serial machine with magnetic drum memory. Advantages of digital computation for this type of problem are discussed.

5.5. Evaluation for Magnetic Tape Equipment for Telemetering Instrumentation

R. E. RAWLINS, *Electronics Research Lab., Lockheed Aircraft Corp., Burbank, Calif.*

SESSION VI
Electronic Components I—Techniques

(Organized by the Professional Group on Electronic Components)

Chairman: F. A. PAUL (Northrop Aircraft, Inc., Hawthorne, Calif.)

6.1. The Effect of Maintenance on Reliability of Complex Military Electronic Equipment

J. B. ARNOLD, *Aeronautical Radio Inc., Washington, D. C.*

From data collected by Aeronautical Radio, Inc. through field surveillance of electron tubes in military use, it can be shown that maintenance as generally performed today cannot cope with the extreme complexity of many present-day military equipments. Not only are some individual circuits difficult to analyze, but interdependency of associated circuits presents problems so intricate that diagnosis of equipment trouble cannot be readily accomplished. Wholesale replacement of tubes is often resorted to as an alternative remedy. Maintenance is further complicated by the precision adjustments necessary for successful operation of the equipment.

It can be demonstrated, that these existing conditions not only cause unnecessary tube usage but also increase the probability of catastrophic tube failure. This, in turn, decreases the reliability of equipment. Some typical examples are shown, and methods of alleviating the problem are suggested.

6.2. Miniaturized Computer Applications of the Hughes Diode

S. G. LUTZ, *Hughes Research & Development Laboratories, Culver City, Calif.*

The Hughes germanium diode has a glass envelope approximately 0.095 inch in diameter by 0.260 inch long. Exploiting these minute dimensions is a challenge, spotlighting the need for other small components, better packaging and greatly miniaturized wiring; problems which will become acute with transistorized equipment.

Encapsulation, "3-dimensional" mounting and spot-welded wiring permit component densities up to 180/cu. inch in computer-diode matrices. The techniques discussed lead in one direction to semi-automatic production with 26 components/cu. inch, and in another direction to 128/cu. inch with simple wiring ability to replace individual components. Condenser-discharge spot-welds are made easily to the dumet leads as close to the glass seals as desired.

6.3. Subminiaturization Techniques for UHF Communication Equipment

GUSTAVE SHAPIRO, *National Bureau of Standards, Washington, D. C.*

Subminiaturization techniques as they apply to uhf transmitting and receiving equipment are described. A combination chassis-plug system permits convenient air cooling and interconnection (dc, ac, and mechanical) of its plug-in assemblies. Where their application permits a production advantage, printed circuits are used. Novel time-saving design and fabrication methods are disclosed. Special miniature components of wide utility are used in small assemblies. Many techniques described can be applied to other subminiature electronic assemblies.

6.4. Synthetic Quartz Crystals for the Electronic Industry

D. R. HALE AND W. H. CARBONNET, *The Brush Laboratories Co., Division of Clevite Corp., Cleveland, Ohio*

Quartz crystals suitable for frequency control have been grown experimentally under contract with the U. S. Signal Corps. They are substantially free from electrical twinning. Optical twinning affects only a small fraction of the material grown. Crystal size and shape is widely variable by choice of seed dimension and orientation. Crystals weighing up to three pounds have been grown. Tests results so far have shown entirely adequate Q values. The angle of the AT cut needs a slight modification for best frequency versus temperature relation. Several hundred pounds have been made available for test by oscillator manufacturers.

6.5. Application of Precise Components in Permeability Tuned Oscillators

D. M. HODGIN, *Collins Radio Co., Cedar Rapids, Ia.*

In order that the frequency output be made nearly independent of environment it is necessary that the best combination of capacitors, inductors, and tuning cores be used. These conponents must have repeatable, linear, small temperature coefficients with small absolute drift during and after environmental cycling.

A specially developed ceramic plate, hermetically sealed capacitor will be discussed. The temperature coefficient and its differential linearity will be analyzed along with capacitance drift and other important parameters.

The inductor properties will be shown. Temperature coefficient of tuning core and final performance of the combination will be discussed.

SESSION VII

Radio Communications I—Symposium: Facsimile

(Organized by the Professional Group on Communication Systems)

Chairman: J. V. L. HOGAN (Hogan Laboratories, Inc., New York, N. Y.)

7.1. Facsimile Systems

A. S. HILL, *Western Union Telegraph Co., New York, N. Y.*

The economical application of the facsimile method of telegraphy to the public message and private wire communication services required the development of many types of facsimile machines, new features of operation and control, special necessary provision to insure the maximum of reliability of service, and recording papers needing no developing or other processing in required operation.

Several arrangements of facsimile machines, associated equipments, and lines have been engineered to satisfy different requirements.

7.2. Operation of International Commercial Radiophoto Circuits

M. P. REHM, *RCA Communications, Inc., New York, N. Y.*

This paper will trace the early experimental operations of RCA radiophoto from 1924 through the first commercial circuit in 1926 and on through World War II up to the present time. RCA Communications, Inc., now operates over forty direct radiophoto circuits out of New York and San Francisco to all parts of the world. Many of these circuits can be interconnected with wire-photo facilities in various countries. Improvements in terminal equipment and radio circuit operations, including direct customer-to-customer service and changes contemplated for the future will be described.

7.3. Applications of Facsimile in the USAF

H. R. JOHNSON, *Andrews AF Base, Washington, D. C.*

This paper deals with the applications of wire and radio facsimile to specialized USAF needs. Principal among these specialized applications is the use of facsimile for the collection and dissemination of weather data. The paper points out the scope and operational concept of the present USAF facsimile network both in the Zone of Interior and overseas and covers, in general terms, the augmentation of the system that will take place in the immediate future. Emphasis has been placed upon manpower and monetary savings that accrue to the Air Force through use of facsimile techniques.

7.4. Application of Cathode-Ray Tubes in Facsimile Systems

W. H. BLISS, *Radio Corporation of America, Princeton, N. J.*

Flying-spot cathode-ray tubes have recently been used in four different facsimile projects. Problems encountered in these which will be discussed are a special optical system with provision for adjustable magnification, automatic brightness control, blanking and synchronizing, maximum screen utilization and protection, and linear deflection. Emphasis will be on the electronics employed. A brief treatment of recorders is also to be included.

SESSION VIII

Aeronautical and Navigational Electronics II

(Organized by the Professional Group on Aeronautical and Navigational Electronics)

Chairman: L. B. HALLMAN, JR. (Communications & Navigation Lab., Wright-Patterson Air Force Base, Ohio)

8.1. The Digitac Airborne Digital Computer

E. E. BOLLES, *Hughes Research & Development Laboratories, Culver City, Calif.*

A description is given of a general purpose airborne digital computer that was developed for the automatic navigation of an aircraft. The paper covers the physical characteristics of the computer, including the form of construction.

A description is given of the operation speed, memory capacity, and the physical characteristics of the memory. The operation control, the operations performed and the results of optimum coding are presented.

8.2. A New Fixed-Beam Instrument Approach System for Aircraft

R. A. HAMPSHIRE, *Federal Communication Laboratories, Nutley, N. J.*

There has been developed for the USAF a new fixed-beam instrument landing system which functions interchangeably with existing instrument landing systems but which provides fundamentally improved service. Attributes formerly thought impossible to achieve within standard frequency bands are now available.

The localizer which provides lateral guidance utilizes highly directive, narrow beams of radiation so as to obviate spurious effects due to siting difficulties. Superimposed is another set of beams providing complete azimuthal coverage so as to guide aircraft into the narrow, precise beams. Operation on two carrier frequencies with a supersonic beat note between the signals of the two beams provides smooth transition of the aircraft between broad beams and narrow beams and by "capture effect" precludes intereference between the beams.

The glide path which provides vertical guidance utilizes a new "null-reference" antenna system which greatly improves stability under conditions of snow and/or variable ground reflectivity.

8.3. The Role of Flight Directors in Present-Day Aircraft

N. L. GRAHAM, *Collins Radio Co., Cedar Rapids, Ia.*

This paper deals with the practical aspect of Flight Director systems. It explains how the flight director fits into the over-all picture of instrumentation on present-day aircraft; how it enables the pilot to consistently make precise low approaches without the continued practice necessary with standard instrumentation; how a properly designed system is not just an approach instrument, but aids the pilot in enroute navigation and in making standard maneuvers such as procedure turns, and holding patterns. It explains how the Collins Integrated Flight System functions in these various applications.

8.4. The Navaglobe Long-Range Navigation System

C. T. CLARK, R. I. COLIN, M. DISHAL, *Federal Telecommunications Labs., Nutley, N. J.*, I. GORDY, *Rome Air Development Center, N. Y., N. Y.* and M. ROGOFF, *Mc-Dermott Co., Trenton, N. J.*

Navaglobe is a long distance radio navigation system and plan under development by the Federal Telecommunication Laboratories for the United States Air Forces. To accomplish and obtain this reliable long-range service, it operates in the low frequency band and at very narrow bandwidth. The service is omnidirectional and the airborne-bearing indications are spontaneous and automatic. The principles and ultimate basis of the transmitting and receiving equipment are described, including the features created and designed for minimizing as much as possible the effects and results of atmospheric noise. Views of the actual equipment constructed are displayed, and the many various stages through which the continuing progressive development program has advanced are discussed. Performance of this experimental equipment is described, including results of transcontinental and transatlantic flight tests completed during the summer of 1952.

8.5. The N-1 Compass

R. C. Rosaler, *Kearfoot Co., Inc., Little Falls, N. J.*

Aircraft flights over the polar regions have in the past been hampered by the lack of suitable navigational instrumentation. Conventional magnetic compass is little use at higher latitudes, because the useful directional component of magnetic field becomes very erratic.

A solution to this problem has been developed. Designated by the Air Force as N-1 Compass, this system has proven a reliable directional reference without regional limitations.

The heart of the N-1 system is a highly accurate directional gyro. At the lower latitudes, the gyro may be slaved to a magnetic compass. At the upper latitudes, the gyro may be operated independently, maintaining any desired directional reference. Effect of earth's rotation is compensated for in the system. Random drift is maintained at average rate of ½° per hour for long flights, never exceeding 1½° per hour.

Such accuracy is achieved only by extreme care in fabrication and careful control of construction materials. Hermetic sealing of gyro and all mechanical assemblies assures dependable performance for periods with minimum maintenance.

The N-1 system in use has achieved an enviable record for accuracy and dependability. Its wide acceptance brings us closer to the era in which polar flights will be commonplace.

Session IX

Engineering Management I

(Organized by the Professional Group on Engineering Management)

Chairman: C. R. Burrows

(Cornell University, Ithaca, N. Y.)

9.1. The Engineer and Return on Investment

S. C. Peek, *Sylvania Electric Products, Inc., Salem, Mass.*

Since the primary purpose of a business enterprise is to give the stockholder a decent return on his investment, it is almost ridiculously obvious that each department of a particular company should keep "return on investment" uppermost in their mind. Most engineers, however, are motivated by much narrower concepts. The purpose of this paper is to describe the importance of "return on investment" and what factors influence it. It will then proceed to show how the engineer can control the independent variables which go to make up the "return on investment" formula.

Emphasis will be on the following items: cost reduction; sales promotion; inventory control; and the choice of new products.

An illustration of a hypothetical electronic product will be given in detail so the theory of "return on investment" can be put to practice.

9.2. Technical Information: Communication for Research

Charles DeVore, *Naval Research Laboratory, Washington, D. C.*

The technical information program of the Naval Research Laboratory is aimed at informing scientists within the Laboratory as well as scientists outside the Laboratory of research and development achievements. Within the Laboratory, the information exchange is provided largely through the services of the Library, including reference services, bibliographies, translations and extensive document collection and Library and Document Bulletins, issued weekly. Beyond the Laboratory, scientists are informed of NRL research and development accomplishments through the publication of a monthly Report of NRL Progress, formal reports on individual Laboratory problems, interim Memorandum Reports, an NRL Reprint Series, and motion picture service projects. Exhibits at scientific society meetings and press releases supplement the publication program. Examples of each kind of technical information media are illustrated and discussed and a brief account is given of the organization making the program possible.

9.3. A Working Philosophy for Engineering Management

T. G. Slattery, *American Machine and Foundry Co., Boston, Mass.*

Due to the increasing complexity of the engineering art, a working philosophy for administrative engineers is needed. Without a practical philosophy engineers may fall into three pitfalls: (1) the urge to study detail; (2) the urge to build at once; (3) the reluctance to change a weak program.

To aid in avoiding these three pitfalls an organized method of handling engineering jobs is recommended. This procedure includes: a method of deciding what jobs to do; a method of first analyzing the job; a method of re-examining the job periodically; and a method of capitalizing on lessons learned. The following general engineering principles are then emphasized: the best use of available devices; the place of mathematical analysis; and the importance of intercompany communication.

9.4. Organization for Operations Research

F. L. Weldon, *Johns Hopkins University, Baltimore, Md.*

Organization for operations research is discussed from the standpoint of both the work relationships within the research group and the group's relationships with the "customer" organization it serves. Three general levels of operations research are defined and the implications of each with regard to organizational problems are explored. From consideration of the primary functions of operations research at different levels in different organizational environments it is concluded that proper organization for operations research should provide: (a) a "mixed" research team of viable size; (b) organization-wide access for direct observations and measurements; (c) group freedom of action to initiate studies supporting their assigned missions; and (d) a direct reporting channel to executives who have full authority to act on study recommendations.

9.5. Training for Operations Research Groups

Thornton Page, *Johns Hopkins University, Baltimore, Md.*

Since the ideal organization for operations research is the research team, it might seem that conventional training of individuals in the contributing fields of engineering, statistics, economics, psychology, etc. would be sufficient. From a recapitulation of the difficulties of communication in such a mixed research team, it is shown that broader, formal training is desirable. Various university curricula in operations research are described and the difficulties arising from military and industrial security are recounted. References are given to the growing literature in the subject, and the possibilities of "clinical" training are explored. It is concluded that in so new and so broad a discipline, the best training is obtained from actual research experience.

Session X

Radio Telemetry and Remote Control II—Telemetry

(Organized by the Professional Group on Radio Telemetry and Remote Control)

Chairman: J. T. Mendel

(Naval Research Laboratory, Washington, D. C.)

10.1. A 227-MC Pulse Position Modulation Telemetering Unit

D. G. Mazur, *Naval Research Laboratory, Washington, D. C.*

Operation and performance of a 15 channel PPM telemetering unit is described. Designed for use in medium size rockets and to be compatible with existing ground equipment, the present transmitter has a power output of 10 watts peak during the 3 μs pulse. Sampling rate is nominally 312.5 cps but one channel may be gated four times during each frame yielding a sampling rate of 1250 cps. Over-all accuracy has proved to be within 1 per cent and performance has been excellent in 10 rocket flights. Commercial units will have increased power and crystal controlled rf.

10.2. Crystal Control Low Distortion FM Telemetering Transmitter

R. E. Rawlins, *Lockheed Aircraft, Electronic Research Laboratory, Burbank, Calif.*

10.3. A Crystal Controlled FM Telemetry Transmitter

F. N. REYNOLDS, *The Ralph M. Parsons Co., Pasadena, Calif.*

This paper discusses an ever present source of error and drift in the FM/FM telemetry system. The radio frequency transmitter with its inherent carrier center frequency drift has necessitated in the past complex AFC stabilizing methods. The approach taken on the design of this unit was first that crystal stability of the carrier is a necessity due to the extreme increase in demand for operating time in the allocated telemetry RF bands. Secondly, the problem of a convenient method of modulation by the outputs of the lower frequency sub-carrier oscillators was taken into consideration. Phase modulation was rejected due to its inability to produce a given deviation with constant input voltage. A second undesirable feature is that excessive crystal frequency multiplication is necessary and hence a greater number of vacuum tubes must be employed. The transmitter described herein utilizes a closed loop servo system which controls the frequency of a self-excited reactance modulated oscillator. The output of a crystal controlled oscillator is mixed with a multiple of the self-excited oscillator to provide a difference frequency which is fed to a frequency discriminator to provide servo voltage for reactance tube modulator.

The result, therefore, is a transmitter with a very stable center frequency which has a flat frequency response with modulation from 100 cycles per second to 100 kilocycles per second and which has less than 1 per cent harmonic distortion. The transmitter is also capable of being modulated with a variable width pulse for use in a PDM/FM system without necessitating pulse reshaping circuits in the ground receiving equipment which are normally required when a phase modulated transmitter is employed for a PDM system. A nominal power output of 3½ watts is available using six subminiature vacuum tubes.

10.4. High Gain Multiple-Receiving Installations

J. B. WYNN, JR., *The Ralph M. Parsons Co., Pasadena, Calif.*

Multiple transmissions' requirements and long-range reception needs led to consideration of the simultaneous operation of telemetry receivers from a single-tracked antenna and the use of preamplifiers and multicouplers. Specifications, design criteria, and prototypes of a rf amplifier and associated multicoupler will be discussed. These units permit increased coverage with existing equipment and multiple operation of additional receiving stations using existing antennas. A new helical antenna will be described.

SESSION XI
Audio I—High Fidelity

(Organized by the Professional Group on Audio)

Chairman: MARVIN CAMRAS (Armour Research Foundation, Chicago, Ill.)

11.1. Large Area Microphones for Distant Pickup Use

T. AAMODT AND F. K. HARVEY, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

Large area microphones are useful in sound reproduction systems where the talker remains at a distance from the pickup unit. The increased directivity of this type of microphone maintains a high ratio of direct to reverberant sound, tending to preserve the good articulation and fidelity normally obtained under close-talking conditions with less directional high quality microphones. The construction of a large-area condenser transducer using a thin, foam rubber sheet as the working dielectric element is described. A demonstration will accompany the presentation.

11.2. The Enhancement of Music by Reverberation

D. W. MARTIN, *The Baldwin Co., Cincinnati, Ohio*

The effects of natural room reverberation upon the tone of traditional musical instruments such as the grand piano and the pipe organ will be discussed. Examples will be shown by magnetic tape recordings. Simple electroacoustic means, for simulation of reverberation of electronic organ tone in a non-reverberant environment, will be described and demonstrated.

11.3. Some New Developments in High Fidelity Loudspeakers

H. F. OLSON AND JOHN PRESTON, *RCA Laboratories, Princeton, N. J.*

Three direct-radiator dynamic-loudspeaker mechanisms have been developed for high-fidelity sound reproduction. These units are of three sizes, namely, 8-, 12-, and 15-inch mechanisms. The improvements include smoother response frequency characteristics, broader directivity patterns, improved transient response, and lower nonlinear distortion. These characteristics have been obtained by employing the proper configuration for the cone, a special pulp for the material of the cone and a damping ring in the outside suspension of the cone. In the case of the 15-inch duo cone loudspeaker an additional feature, namely, a series of conical domes are cemented to the low-frequency cone. The high-frequency response is improved by these domes because of the smaller solid angle into which the high-frequency cone operates. The directivity pattern is broadened due to the diffraction effects produced by the domes.

11.4. High Fidelity and the Hearing Process

W. E. KOCK, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

Certain aspects of hearing will be discussed which bear on high-fidelity audio reproduction. This will include a review of the frequency analysis process in the cochlea and certain fundamental concepts in binaural hearing. The Haas effect, a serious problem in stereophonic reproduction, will be demonstrated.

11.5. Some Aspects of Stereophonic Sound in Motion Picture Theaters

R. H. RANGER, *Rangertone, Inc., Newark, N. J.*

Analyses of stereophonic sound reproduction generally start with a paraphrase of Huygen's Principle, which might be stated "if an infinite series of microphones is set up across a sound wave front, and a complete record of all these microphone inputs is made and later reproduced through a similar setup of loud speakers, perfect stereophonic sound reproduction will result." But for practicality this infinite series must be reduced to 8, 6, 4, 3, or even 2 sources, with the hope that the principle will still hold. With many sound wave lengths between the positioned microphones and subsequent speakers this principle of course breaks down quite completely. Fortunately, the auditor has only two ears to hear stereophonic sound, and he has been conditioned to note slightest changes to assist in localizing the direction of sound sources. So that by appropriate directivity and intensity it still is possible to get over a very real sense of direction where all factors of intensity and time are fully used. Objective tests of all these factors have indicated that intensity changes are the most readily controlled to give clarity as well as directivity, and equipment for making such a system most effective are described.

SESSION XII
Information Theory II—Coding and Noise

(Organized by the Professional Group on Information Theory)

Chairman: M. J. E. GOLAY (Squier Signal Laboratory, Ft. Monmouth, N. J.)

12.1. Matched Filters for Detecting Pulsed Signals in Noise*

J. S. ROCHEFORT, *Northeastern University, Boston, Mass.*

The optimum filter for detecting a given signal in the presence of white noise is one whose impulse response is the image of the signal. A rectangular pulse and a pulsed carrier are considered as signals. The desired impulse response for the former is obtained from a simple network consisting of a delay line and a low-pass filter. The output from this network is proportional to the cross-correlation function of the input and the stored signal. Furthermore, the cross-correlator (or matched filter) for a given pulse train results from following the network by a tapped delay line and an adding circuit. The desired impulse response for the pulsed carrier is obtained with a delay line and a narrow-band filter. The signal-to-noise ratio at the output of either matched filter is approximately 5 db greater than that obtained with conventional filtering.

* The research reported in this paper was supported by the U. S. Air Force under a contract issued by the Air Force Cambridge Research Center.

12.2. An Experimental Study of the Bandwidth of a Digital Computer

N. R. SCOTT, *University of Michigan, Ann Arbor, Mich.*

A digital computer may be considered to be a low-pass filter of adjustable cut-off frequency, the cutoff being determined by the program. A highly accurate solution requiring long computing time results in a narrow bandwidth, as does a low accuracy solution requiring short computing time. A solution of intermediate accuracy gives maximum bandwidth. These conclusions were verified by using the MIDAC, (Michigan Digital Automatic Computer) to solve a problem of known answer by four methods of different accuracy. Starting from the measured computing time and the number of bits found to be correct in each answer, the computer bandwidth was found for each of the four programs.

12.3. Time-Varying Quasi-Linear Method of Speech Noise Suppression

M. J. DiToro, *Fairchild Guided Missiles Div., Wyandanch, N. Y.*

The separation of speech after mixture with uncorrelated nonstationary white and impulsive type noise is considered by a method originally due to Llewellyn[1] and recently rediscovered and described elsewhere.[2] This paper describes the results obtained in the further development of this device at this laboratory.

As originally conceived by Llewellyn, this method of speech noise suppression comprises subdividing the audio bandwidth into sub-bands and squelching those sub-bands in which only noise is present. The new improvements described herein are concerned with the decision circuitry needed in each sub-band to decide whether mostly speech or noise is present. Such decision circuitry is designed with the use of the first probability density functions and the correlation functions (with respect to both time and frequency) of the speech and noise energy in each sub-band. It is shown that both inverse probability and the Wiener optimum filter concepts are directly applicable to effect a large reduction of noise.

A demonstration of this new noise suppressor will be given.

[1] F. B. Llewellyn, "Noise Suppression Circuit," U. S. Patent 1968460, July 31, 1934 (Filed December 29, 1932).

[2] M. J. DiToro and H. A. Carlson, "Noise Suppressor for Speech Communication Systems." Presented at the IRE National Conference on Airborne Electronics, Dayton, Ohio, May, 1953. Abstract published in the Proceedings of the Conference, pages 240–242.

12.4. Discriminatory Analysis Applied to Speech Sound Recognition*

H. L. Stubbs, *Northeastern University, Boston, Mass.*

In the problem of identifying speech sounds by means of measurable acoustical parameters, no single parameter gives reliable identification. The statistical techniques of discriminatory analysis are appropriate to determine the optimum combination of several parameters. This approach requires the assumption of a suitable probability distribution of these parameters for each class of speech sound. When the parameters are fractions of total power or normalized rectified outputs in several frequency bands, certain distribution functions related to the multinomial or depending on the angle between two vectors have been assumed. Promising results have been obtained in identifying vowel sounds.

* The research reported in this paper was supported by the U. S. Air Force under a contract issued by the Air Force Cambridge Research Center

12.5. A Discussion of Auto-Correlated Error Terms in Time Series Analysis

R. K. Weller, *Rome Air Development Center, Rome, N. Y.*

In many examples of time series analysis, the nature of the error terms is such that an autocorrelation of a series of residuals is often indistinguishable from a true trend. In this situation, the objective, of course, is to make an autogressive transformation of the dependent variable such that the error term becomes random. The problem that arises is to estimate the autogressive properties of the error term. A suggested procedure is to approximate the autogressive properties of the error term by a one-lag linear difference equation. Only then is it possible to make a choice of an autogressive transformation which will result in residuals that are sufficiently random.

Session XIII

Broadcast and Television Receivers I—General

(Organized by the Professional Group on Broadcast and Television Receivers)

Chairman: E. I. Anderson (RCA Laboratories Division, New York, N. Y.)

13.1. Ferrite Cored Antennas for Broadcast Band Receivers

C. A. Grimmett, *General Electric Co., Syracuse, N. Y.*

This paper is a report on the results to date in the design and development of ferrite cored antennas for broadcast band use. The report shows the effect on sensitivity of the various design parameters such as core length, core diameter, type of winding, wire size, and core material. It includes a comparison of ferrite cored antennas and air loops in regard to their sensitivity, directivity, noise rejection, temperature effects and other considerations. A conclusion is drawn as to the design which will give the best results within receiver limitations.

13.2. Transistor AM Broadcast Receivers

A. P. Stern and J. A. A. Raper, *General Electric Co., Syracuse, N. Y.*

The requirements relating to the component circuits of AM broadcast receivers and the problems connected with the application of transistors to these circuits (local oscillator, RF amplifier, converter, IF amplifier, second detector, AGC, audio amplifiers) are discussed separately and several "transistorized" solutions are proposed for each of the individual circuits. Diagrams of complete transistor receivers are shown and their performance is described. Finally, desirable over-all characteristics of various receiver types and problems of meeting these requirements with transistors are discussed.

13.3. Wide-Band Amplification with Surface-Barrier Transistors

J. B. Angell, *Philco Corp., Philadelphia, Pa.*

The surface-barrier transistor has properties which make possible wide-band amplification while maintaining the low-power-consumption advantages of junction transistors. A high alpha cut-off frequency, together with low base resistance and very low collector capacitance, results in a type of transistor with which amplifiers having bandwidths of many megacycles can be built.

Experimental results on both low-pass and band-pass amplifiers will be presented.

13.4. Automatic Damping in Television Vertical Deflection Circuits

H. E. Thomas, S. DeMars, and M. Jones, *Federal Telecommunication Laboratories, Inc., Nutley, N. J.*

The output tube in a deflecting system contains inductive reactance in its plate circuit. Due to rapid reversal of sweep currents in this circuit it is common, simple practice to damp the resultant transients by so shaping the driving sawtooth voltages that, in effect, electronic damping of these transients occurs. However, a fixed amount of damping will not be sufficient, due to the fact that the degree of damping must and should vary with the amplitude of the sawtooth voltages, which in turn may vary with the height, the linearity, or the tube changes in the course of the operation.

This paper further touches on various ways and means of automatically controlling the driving waveform and, consequently, the damping. The many variations in the control procedure, the performance curves, and the photographs showing improvements in the picturere production on studio equipment, are discussed and explained in more detail.

13.5. A Wide Range Television Tuner

H. T. Lyman, H. Rosse, and F. G. Mason, *Johnson Laboratories, Norwalk, Conn.*

A wide-range tuning system employing a movable coil and two stationary coupling elements to the coil is described. The tuning system is applied to a continuous television tuner covering the complete range from Channel 2 to Channel 83 without switching of the tuning elements and circuit parts. A typical circuit diagram, electrical characteristics, and mechanical details of design are given.

Session XIV

Electronic Components II—Application

(Organized by the Professional Group on Electronic Components)

Chairman: A. W. Rogers
U. S. Signal Corps, Ft. Monmouth, N. J.)

14.1. Magnetic-Core Delay Cables

D. R. Stein, *Columbia Technical Corp., New York, N. Y.*

Delay elements with characteristic impedances of several thousand ohms are often required in modern electronic equipment. Conventional distributed-parameter lines are impractical for such applications because of excessive attenuation and phase distortion. This paper describes delay cables with a continuous, flexible, low-loss ferromagnetic core which eliminate the limitations of distributed-parameter delay lines. Design charts are presented and several standard delay cable types with characteristic impedances up to 3000 ohms and delays of the order of 0.6 microsecond per foot are discussed. Oscillograms are used to illustrate the pulse response of these cables. Some fundamental considerations regarding the electrical termination of high-impedance delay elements are presented.

14.2. Improvements in the Field of Electrolytic Capacitors

D. A. Altenpohl, *Aluminum-Walzwerke, Singen, Western Germany*

Interest in high quality electrolytic capacitors with extended shelf life is on the increase. Tantalum anodes produce excellent results but are generally too expensive. However, there is a possibility of considerably improving capacitors using etched aluminum anodes. Special attention must be given to the composition of the dielectric, which consists of two strata of aluminum oxide, of different solubility and dielectric properties. The upper stratum, more readily soluble, must be kept at a minimum and an extra pure aluminum should be selected in order to eliminate the semi-conductive heterogeneities of iron oxide which are ordinarily present in forming layers. Lately, capacitors have been produced with attributes hitherto unattained. This is illustrated by an example (photo flash capacitor).

14.3. An Investigation of Lowest Resonant Frequency in Commercially Available Bypass Capacitors

D. T. Geiser, *Sprague Electric Co., North Adams, Mass.*

Examination of paper, mica, and ceramic capacitors for lowest resonant frequency was made of samples intended for the mass home equipment market. The investigation was limited to the range 0.001 to 1.0 microfarads and zero to 100 megacycles. Effort was made to minimize external circuit effects, and suggestion is made for standard methods and jigs. Application information is included.

14.4. Resolution in Precision Potentiometers

R. J. Sullivan, *Fairchild Camera and Instrument Corp., Hicksville, N. Y.*

Various types of potentiometer resolution for which some standardization has been accomplished are described and defined as well as various methods of measuring them. Discussion and illustration of shorting resolution, effects of contact with high wires, broad spacing of wires and speed of rotation of potentiometers is made. Resolution as an important and decisive factor in establishing potentiometer accuracy and its influence on potentiometer performance are summarized.

14.5. Evaluation of Core Materials for Magnetic Amplifier Applications

R. D. Teasdale and H. R. Brownell, *Magnetic Metals Co., Camden, N. J.*

A method of obtaining test data on core materials for magnetic amplifier applications is discussed in which the normalized output voltage is plotted against the dc control ampere-turns per inch to yield a curve which is characteristic of the core material. A voltage compensation technique is used to obtain results which are independent of the gain of the amplifier used in the output circuit. Therefore, measurements are obtained which are fundamental to the core itself and which are more readily reproducible.

Normalized curves are given which compare core materials of high nickel, low nickel, and silicon-iron alloys at 400 cps. For materials of 2 mil, 4 mil, and 6 mil thicknesses, additional normalized curves are used to reach conclusions regarding the desirability of using the same material in the form of laminations, stamped rings, or wound cores.

It is shown that there is definite correlation between this type of presentation and the more familiar presentations employing hysteresis loops and magnetization curves.

Session XV

Aeronautical and Navigational Electronics III

(Organized by the Professional Group on Aeronautical and Navigational Electronics)

Chairman: C. M. Russell
(U. S. Naval Air Test Center, Patuxent River, Mo.)

15.1. Operational Analysis of Track-While-Scan Radars

S. J. O'Neil, *Air Force Cambridge Research Center, Cambridge, Mass.*

The optimum relationship between antenna-scan rate, azimuth beamwidth, and pulse-repetition frequency is determined for track-while-scan radars with linear-velocity extrapolation. Small movements of the target aircraft cause large variations in reflected radar signal. With a large number of hits per target per beamwidth the probability of receiving at least one signal above the threshold increases, but the distance travelled by the aircraft between radar looks and the probability that the aircraft will not be within the tracking gate if some signals are missed is also increased. Optimum radar scan rates are determined for maneuvering aircraft of all types with and without provision for improvement of signal-to-noise ratio by integration.

15.2. A Study of the UHF Omnidirectional Aircraft Antenna Problem and Proposed Methods of Solution

W. Spanos and J. J. Nail, *Federal Telecommunication Laboratories, Inc., Nutley, N. J.*

This paper discusses the coverage afforded by single antennas, operating in the 1000–3000 mc frequency range, when mounted at various locations on different types of aircraft. Dual antenna systems are considered as a solution to the omnidirectional coverage problem. Dual antenna systems which will fit the requirements for either, or both DME and radar safety beacon are described. A top and bottom and a nose and tail antenna system are compared on an instantaneous and on a time sharing basis.

An omnidirectional nose and tail antenna system is described in detail showing the application of probability in the overlap region about the wing tips where interference results. Results of flight tests on a 1000 mc nose and tail antenna are also discussed.

15.3. A Modulator Technique for Producing Short Pulses in High-Powered Magnetrons

T. J. Parker, *U. S. Navy Electronics Laboratory, San Diego, Calif.*

A "pedestal" technique is described for producing very short pulses (less than 0.1 microsecond duration) in high powered magnetrons. The pedestal technique applies a low-powered pulse, well rounded, to the magnetron as a pre-operating pulse bringing the magnetron RF output to 5 per cent to 10 per cent of the full power level. Thereupon, a short high-powered pulse is applied to carry the magnetron output to the full power level. Experimental circuits were constructed for pulsing the type 4J50 magnetron at pulse lengths of 0.15, 0.1, 0.05 and 0.03 microsecond duration. Magnetron current, RF envelope and RF spectrum oscillograms were recorded for each pulse duration.

15.4. The Role of Stereo in "3-D" Radar Indicating Systems

W. R. Tower, *Sperry Gyroscope Co., Great Neck, N. Y.*

Indicator presentation of three-dimensional radar data has been accomplished for many years but in many cases in less than ideal manner. A survey of generalized methods heretofore in use is given in this paper. Present day methods and contemplated systems are set forth. The stereo type of indicator is described, including the general theory of operation and the human factors involved. Examples of various optical arrangements are discussed. A typi-

cal stereo electronic circuit is described. Test results using an artificial indicator and also an actual indicator operating with a fire control radar are mentioned. Advantages and disadvantages of the system are brought out and application possibilities stressed.

15.5. An Automatic Antenna Matching Unit

E. W. SCHWITTEK, *Collins Radio Co., Cedar Rapids, Ia.*

An automatically operating antenna impedance matching unit designed for operation in the 2- to 25-mc frequency range will be described. This device is intended for operation with aircraft transmitters which are designed to deliver power into a 52-ohm resistive load. Its purpose is to automatically transform the impedance presented by all ordinary aircraft antennas to a 52-ohm resistive impedance for coupling to the aircraft transmitter.

SESSION XVI

Engineering Management II—Symposium: Personnel Training and Selection for Engineering Management

(Organized by the Professional Group on Engineering Management)

Chairman: D. R. PUTT

(Air Research and Development Command, Baltimore, Md.)

16.1. For the Universities

S. C. HOLLISTER, *Cornell University, Ithaca, N. Y.*

There are four different patterns of education advanced as being adequate and proper for preparation for engineering management: (1) broad general education in a nonengineering field; (2) some general education together with some elementary engineering education; (3) a strong basic engineering education supplemented with general education; (4) a strong basic engineering education supplemented by further specialized, higher level scientific education. This speaker supports the third pattern as preparation for engineering management.

16.2. For Industry

W. R. G. BAKER, *General Electric Co., Syracuse, N. Y.*

Broadly, two methods of training and selecting engineering management seem most widely recognized. The first, the selection of those men for management positions who have shoved their heads and shoulders up above the pack, is without doubt, the most widely used. The second, the scientific approach, replete with training courses, analyses and fitness reports, is held in considerable esteem, but even where used in the lower echelons, is often discarded when it comes to promotion in the upper brackets.

Which of the two is better? Obviously the method that produces the largest number of good potential engineering managers. But there is a third method, which may seem to be a compromise, that encourages initiative, provides on-the-job training to help equip the engineer for greater responsibilities and constantly tests the abilities and potential abilities and capabilities of the engineer.

The development of good managers is an important problem, and managing is becoming a professional kind of work in and by itself. We must, I believe, improve our management techniques in step with our advances in technology and productivity.

16.3. For the Government

J. M. MITCHELL, *Assistant Secretary of Defense for Manpower and Personnel, Washington, D.C.*

The Department of Defense employs about 30,000 civilian engineers, and many of them have management responsibilities. They are recruited, trained, promoted, and paid under the Civil Service system. Engineering positions at the junior level are filled through competitive examinations that are open to all qualified applicants. Engineering management positions are usually filled by promotion of the best qualified engineers from within the service. Increased emphasis is being placed on management training, and on selecting persons for promotion on the basis of their management ability and skills rather than primarily on the basis of their technical competence.

SESSION XVII

Medical Electronics

(Organized by the Professional Group on Medical Electronics)

Chairman: L. M. MONTGOMERY

(*Metal Products Co., Nashville, Tenn.*)

17.1. Visualization of the Distribution of Gamma Emitters In-Vivo by Means of the Gamma Ray Pinhole Camera and Image Amplifier

R. K. MORTIMER, H. O. ANGER, AND C. A. TOBIAS, *University of California, Berkeley, Calif.*

In order to obtain a visual and photographic record of the distribution of radioactive isotopes administered to the animal and human body in microcurie quantities, the gamma ray pinhole camera with image intensification has been developed.

The gamma rays emitted from an object produce an image after passing through a pinhole in a heavy lead shield. This image is converted to a light image in a lattice of sodium iodide crystals. The light is intensified in an image amplifier tube. An image may be viewed directly or a photographic record may be obtained.

For one-half million volt gamma rays the resolution is about $\frac{1}{4}$ inch and the size of the image is 5 inches in diameter. Surface distributions of 1 microcurie/cm^2 may be photographed within a few minutes.

17.2. Expansion Chamber for Measurement of Red Cell Permeation by Water

A. K. SOLOMON AND C. V. PAGANELLI *Harvard Medical School, Boston, Mass.*

Human red cells placed in a radioactive water solution reach equilibrium in about 1 second. An expansion chamber, a modified form of cloud chamber, has been designed to measure this process, which requires sampling times of 20 milliseconds. The mixture of red cells and radioactive solution is ejected through a jet mixer into the chamber bottom at atmospheric pressure. After a suitable interval a piston is released opening a communication to an adjacent vacuum chamber. Twenty milliseconds later the piston closes, and the sample of water vapor which has expanded into the vacuum chamber is taken for radioactive analysis.

17.3. Color and Enhanced Contrast X-Ray Images

R. S. MACKAY, *University of California, Berkeley, Calif.*

Two processes will be described for bringing more information into an X-ray picture. One method is to photograph the subject three times, using different wavelength distributions each time; then make a color print from the resulting monochromes. The eye's sensitivity to color differences introduces another degree of freedom that allows discrimination by small differences in absorption spectra. The wavelengths used need not be monochromatic (c.f. the tristimulus curves) but processes auxiliary to variation of tube voltage and anode material prove desirable. Any frequency range can be expanded or contracted and these processes can be applied to ultra violet rays, infra red, and combinations. Principles of color fluoroscopy and color film are considered.

A particular element (e.g. an iodine tracer) is best searched for by noting the difference in transmission of two monochromatic wavelengths on each side of the element's absorption edge. Photographic and electronic methods are described.

17.4. Measurements of Slow Neutron Depth Doses

E. STICKLEY, *Brookhaven National Laboratory, Upton, N. Y.*

Slow neutron flux density measurements have been made throughout plastic, gel, and liquid phantoms constituted to simulate the neutron-sensitive characteristics of tissue. This work is part of the investigation of dosimetry in the slow neutron capture therapy process used in the experimental treatment of glioblastoma multiforme.

The principal method employed is based on the activation of foils of gold or indium, which are placed in the phantom during an irradiation in the slow neutron beam which is used in the experimental therapy program. Certain measurements of similar nature have been made during the actual treatment, with gold wires inserted through the path normally used by the neurosurgeon in the ventricular tap process. The results calculated from an analysis of the activity induced in the metals are used to derive iso-flux contour lines throughout the space subjected to the radiation.

17.5. Use of Charged Particles to Measure Skin Thickness and Other Surface Properties

F. Hutchinson, *Yale University, New Haven, Conn.*

Charged particles, such as electrons or protons, have a finite range in tissue, the range depending on the energy of the charged particle. If the energy is made sufficiently low, the irradiation of an organism will be confined completely to the surface. Increasing the energy enables the charged particles to penetrate more deeply. By this method it is possible to measure the thickness of a surrounding protective layer of skin, to ascertain the location of a biologically active unit (such as an antigenically active site) with respect to the surface, and to inactivate or otherwise interfere with a surface unit without directly affecting the underlying material.

The paper will discuss the technique used, and its application to viruses and bacteria.

Session XVIII
Audio II—General

(Organized by the Professional Group on Audio)

Chairman: R. A. Miller

(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

18.1. Some Aspects of Clipped Speech

R. K. Saxe and R. E. Lacy, *Signal Corps Engineering Laboratories, Ft. Monmouth, N. J.*

Research results are described whereby all amplitude variations are removed from a speech wave form by electronic means, yet surprisingly, intelligibility, voice inflections, emphasis of words or syllables, and all the essential voice characteristics by which the emotion and person of the speaker are normally identified, seem to be virtually unaffected by the sequence of extreme distortions to which the voice wave is subjected. Such processed speech is demonstrated by means of a tape recording. Implications are discussed which indicate that linearity becomes a meaningless concept in any device handling this processed speech. Nonlinear transistor characteristics are applicable. Many linear radio and wire communication functions may be replaced by radically different nonlinear electronic techniques.

18.2. A Miniature Uni-Directional Microphone

B. B. Bauer and John Medill, *Shure Brothers, Inc., Chicago, Ill.*

A new high-fidelity, inobtrusive and highly uni-directional microphone has been developed for television, motion pictures and similar applications. It is known that unobtrusiveness of microphones is a function of both the size and directional characteristics which influence the distance between the microphone and the performer. The new microphone which has been developed has a depth of 1⅞ inches, a width of 1⅛ inches and a super-cardioid directional pattern. The super-cardioid pattern provides a directivity factor of 3.7 and a distance factor of 1.9 as compared with 1 for omni-directional microphones. The directional characteristic is obtained by the method of using a miniature ribbon element in combination with a phase shift network.

18.3. A High-Efficiency High-Quality Audio Power Amplifier

B. Bereskin, *University of Cincinnati, Cincinnati, Ohio*

This paper will present a discussion on the design and performance of a new class B power amplifier capable of developing 50 watts of audio power at 70 per cent over-all plate circuit efficiency with less than 1 per cent distortion. The factors which control the performance of class B power amplifiers and the manner in which these factors apply to this and other high quality power amplifiers will also be discussed. Criteria and tests have been developed for the determination of the permissible high-frequency roll off of the power-delivering capacity for high quality audio power amplifiers. Experimental verification of these criteria and tests which have been made at the University of Cincinnati will be presented.

18.4. System Design Factors for Audio Power Amplifiers

M. V. Kiebert, Jr., *P. R. Mallory and Co., Inc., Indianapolis, Ind.*

Medium-level power amplifiers of conventional design configuration are considered with particular attention given to their overload characteristics.

These medium-level power amplifiers range in power level from 10 to 50 watts; they employ "receiving"-type tubes and plate voltages and dissipations within the manufacturers design ratings for the particular tubes used.

A beam power amplifier using an electronic servo-balance of the plate currents of the push-pull output stages is described. This circuit employs a differential dc amplifier and cascade stage for bias and balance control and incorporates other design features considered above. The judicious use of feedback results in an amplifier with excellent characteristics for laboratory use.

18.5. Driver System for Single Ended Push-Pull Amplifiers

C. T. Hall, *Hall Radio Laboratories, Pittsburgh, Pa.*

A system of two driver tubes is employed to provide signals at the grids of power stages consisting of a cathode follower and a plate loaded tube in parallel for signal output. The papers of Sinclair and Peterson and Chay Yeh point out the problems involved and the need for means of providing greater signals at lower source impedance. This system provides signals differing by a constant which may be any developed signal, such as the output voltage of a single-ended push-pull system.

The advantages are much greater drive with conventional tubes and voltages, a high order of balance with a constant difference, nominal source impedance, and tolerance to conventional differences in tubes and parameters. It has been utilized to provide low distortion triode and beam power amplifiers of high efficiency and relatively low cost.

Session XIX
Information Theory III—Speed and Computation

(Organized by the Professional Group on Information Theory)

Chairman: B. M. Oliver

(Hewlett-Packard Co., Palo Alto, Calif.)

19.1. Optimized Data Encoding for Digital Computers

W. H. Kautz, *Stanford Research Institute, Stanford, Calif.*

A method of data encoding for digital computers and information-processing machines is described which attempts to make efficient use of message redundancy to (1) automatically correct as many errors in data transmission as possible, (2) detect as many of the uncorrected errors as possible, and (3) minimize the "confusion" in the message resulting from uncorrected and undetected errors. Examples demonstrating the method of coding are presented: (1) Several four- and five-bit binary codes for decimals are compared for reliability and confusion on error; (2) a seven-bit alphanumeric code which provides greater reliability for numerals and symbols than for letters is described; (3) factors influencing the arrangement of characters on the periphery of printer typewheels are discussed; (4) the teletype code is evaluated, and an alternate version having several desirable properties is presented.

19.2. Symbolic Methods in the Design of Delay- and Cycle-Free Logical Nets

G. W. Patterson, *Burroughs Corp., Philadelphia, Pa.*

Several papers and monographs have been written in the literature which have applied Boolean algebras to the design and analysis of relay-contact networks, electronic gating circuits, neuron nets, and other control and calculating systems. This paper traces the pertinent history and development both of Boolean algebras in general, and of their application to nets. It will be emphasized that there are many different kinds of Boolean algebras. It will also be urged that a single one, the propositional calculus of mathematical logic, is comprehensive enough to handle all the desired applications, and that it serves to unify the existing concepts and has other important advantages which will be discussed and enumerated.

19.3. Threshold Detection

B. L. Basore, *Sandia Corp., Albuquerque, N. M.*

The presentation by C. E. Shannon in which signals are represented as vectors is extended to solve the case of detection by the mean square difference falling below a fixed threshold. The available channel capacity is found to be less than the theoretical capacity by an appreciable amount. For large signal-to-noise ratios, the available capacity is not a function of signal-to-noise ratio, but the formula given by H. Nyquist in 1924 applies. The results are related to recent work obtained in connection with ppm by Golay and by Woodward and Davies in connection with cross-correlation.

19.4. The Nature of the Uncorrelated Component of Induced Grid Noise

T. E. Talpey, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*, and A. B. Macnee, *University of Michigan, Ann Arbor, Mich.*

Experimental and theoretical evidence is presented showing that the uncorrelated component of the induced grid noise in a vacuum tube is caused by fluctuations in a small number of electrons which are elastically reflected at the plate. These electrons are able to penetrate the grid-cathode region again, inducing additional current pulses in the grid circuit. Both an excess component of grid noise and an additional component of input admittance are produced. This enables predictions of total induced grid noise to be made from input admittance measurements. Values are given for the induced grid noise of modern receiving tubes.

19.5. Effect of Limiting on the Information Content of Noisy Signals

G. O. Young and B. Gold, *Hughes Aircraft Co., Culver City, Calif.*

It is generally assumed that any nonlinearity suppresses the signal relative to noise at low S/N ratios. The validity of this depends on the nature of the desired information. In certain cases, limiting may enhance signal relative to noise at low S/N ratios and deteriorate it at higher S/N ratios. Techniques are described for finding absolute signal level, S/N ratio, and power spectrum after a limiter, particularly for pulse-type signals, also curves showing variation with change in parameters. Examples show enhancement and deterioration of information content by limiting.

Session XX

Broadcast and Television Receivers II—Color Television

(Organized by the Professional Group on Broadcast and Television Receivers)

Chairman: Kurt Schlesinger

(Motorola, Inc., Chicago, Ill.)

20.1. Self-Balancing Phase Detector for Color Receiver Reference Oscillators

E. G. Clark, *Philco Corp., Philadelphia, Pa.*

The conventional balanced diode phase detector is shown to have desirable characteristics once exact balance is achieved, but that the upper limit on sensitivity is determined largely by the exactness of balance and the level of subcarrier available with good phase stability vs. time. The reproducibility of the performance of such a system is determined by the quality of the balance. This constitutes a factory alignment problem as well as a field service problem.

Alternate approaches employing synchronous detectors have been suggested to improve system line voltage stability by changing loop gain distribution to favor reactance tube stabilization. Previous systems have suffered from phase center voltage instability as a result of being susceptible to either supply voltage or gating voltage drift.

The self-balancing phase detector system is shown to achieve excellent stability through the combination of a time gated synchronous detector and a bi-polar detector. In addition, the system has the feature of almost unlimited dc sensitivity. A practical circuit is described and compared to conventional systems. Performance of complete loop is described both from the theoretical effect on system design parameters and from field test observations.

20.2. Color Fidelity in TV Receiver Having Nonstandard Primaries

F. J. Bingley, *Philco Corp., Philadelphia, Pa.*

The color signal specifications of NTSC provide for the transmission of chrominance information directly related to specified primaries. When these primaries are available at the receiver, information abstracted from the chrominance subcarrier at phases respectively in phase and in quadrature to the burst reference can be used directly to control the receiver primaries. When the receiver primaries are not those specified in the transmission signal, further signal processing is necessary to obtain color fidelity. The effect of omitting this further signal processing is, of course, to cause lack of color fidelity. Methods for calculating the resulting nonfidelity are discussed.

20.3. Color Distortion in Sequential Displays

D. C. Livingston, *Sylvania Electric Products Inc., Bayside, N. Y.*

Through use of colorimetric principles, a method is developed for theoretical prediction of the nature and extent of color distortions to be expected from a color television receiver employing a sequential picture display device. The method is illustrated by its application to a Lawrence tube using sequenced color signals which are bandlimited to approximately 0–8 mc. It is shown that relatively little color distortion should occur in this case, a prediction which has been confirmed experimentally. The method is versatile enough to be of use in studies on comparative merits of various methods for operating any given sequential display device.

20.4. Single-Gun Picture Tubes in NTSC Color Television

S. K. Altes and A. P. Storn, *General Electric Co., Syracuse, N. Y.*

Single-gun picture tubes require a sequential video signal. The NTSC signal is a dot sequential signal. It has, however, been designed with optimum transmission characteristics in mind and would cause considerable color distortion if applied to a single-gun tube.

Direct modification of the NTSC signal in the receiver is possible and can be achieved in various ways.

Several methods of signal modification are discussed. The described circuitry is not more complex than that used in three-gun-tubes.

20.5. Significance of Some Receiver Errors on Flesh Color Reproduction

Harold Weiss, *General Electric Co., Syracuse, N. Y.*

The deviations in chromaticity caused by errors in various color television receiver signals are evaluated in terms of MacAdam's "just noticeable color difference units." Graphs summarize the significance to flesh color reproduction of errors in the R', G', and B' signals, in the composite subcarrier amplitude and phase, in the detected $R'-Y'$, B' Y', I', and Q' signals, as well as in the Y' signal. Greatest sensitivity is found to departures from optimum values by the R' and G' signals and by Y' in the negative direction. Preliminary experiments which have been made indicate that much larger signal errors than are generally believed permissible will prove acceptable to the average viewer.

Session XXI

Radio Communications II—General

(Organized by the Professional Group on Communications Systems)

Chairman: John Hessel

(Signal Corps Engineering Laboratories, F. Monmouth, N. J.)

21.1. System Aspects and Trends of Modern Communication

I. S. Coggeshall, *Western Union Telegraph Co., New York, N. Y.*

Communication systems are organizations of facilities, equipment, and personnel adapted to fulfilling at justifiable cost the needs of users for rapid transfer of intelligence or exericse of control.

This definition, while broad enough to cover everything from postal service to missile guidance, also outlines common-carrier, military, and privately operated wire, cable, and radio telegraph, telephone, broadcasting, and television requirements and problems. Whereas in the past electrical communication systems have evolved in response to demonstrated needs or foresight, the trend is toward over-all system designs based upon organized market research, incorporating measures of adaptation to varying demands and new technology.

21.2. Predicted Wave Radio Teletype

M. L. Doelz and E. T. Heald, *Collins Radio Co., Burbank, Calif.*

The characteristics of a new radio teletype system are discussed. The advantages of fully synchronous operation and near optimum detection as used in this system result in an approximate 8.5 db. improvement over conventional FSK. Synchronous operation permits weighting of the receiver response in accordance with the expected signal for improved detection and additionally results in freedom from false-starts. This detection system yields minimum equivalent noise bandwidth (phase variable) and is less subject to adjacent channel interference. Computed and experimental error rate versus signal to noise ratio curves are presented and the special circuits required to perform these specific functions are described.

21.3. Design Consideration for FSK Circuits

Walter Lyons, *RCA Communications, Inc., New York, N. Y.*

Communications demands operation during marginal conditions and the maximum utilization of the frequency spectrum. For these reasons the usual precept of trading bandwidth for noise does not hold and methods for FSK working are re-examined to establish an optimum shift and keying wave shape. Methods for implementing the suggested modes of operation are given.

Specifically, it is found that a considerable gain in S/N can be realized by using sine wave keying and unity deviation ratio. At high speeds, multipath delay distortion precludes the use of sine wave keying and therefore an optimum keying speed is determined for maximum frequency utilization.

21.4. Binary Control System for Digital-to-Shaft Position Mechanisms

A. H. Wulfsberg, *Collins Radio Co., Cedar Rapids, Ia.*

A system for the control of rotary actuators or indicators from binary-coded information is described. By means of this system mechanisms having considerable output torque can be controlled by punched cards or other forms of binary registers. A simple 8-digit, 256-position digital-to-analog mechanism is described. The control system has also been found useful in performing the remote frequency-selection function in communications and navigation equipment.

21.5. UHF Diversity System for Long-Range Ship-to-Air Communication

F. J. Altman and J. J. Nail, *Federal Telecommunication Laboratories, Nutley, N. J.*

The post-war shift from vhf to uhf for ship-to-air communications roughly doubled the number of lobes in the vertical radiation pattern, placing a deep null in the center of the former operating region. To return to a favorable pattern fore and aft sector arrays at about half the former height have been found effective. Lobes in the horizontal pattern are avoided, for reception, by mixing the two receiver outputs. For transmission, the transmitters may be operated individually. However, a type of small frequency diversity is preferred, a shifter maintaining one transmitter's carrier frequency about ten kilocycles from the other's. Thus both carriers are within the receiver's pass band, but the best note is eliminated by the receiver's voice filter, insuring continuous null-free communication.

Session XXII

Medical Electronics Symposium: Engineering Based on Biological Design

(Organized by the Professional Group on Medical Electronics)

Chairman: W. R. G. Baker (General Electric Co., Syracuse, N. Y.)

22.1. Human Engineering

L. C. Mead, *Tufts College, Medford, Mass.*

This paper outlines the field of human engineering and shows the relationship of this field to the theme of the symposium: "engineering based on biological design." Human engineering is defined as "engineering for human use." Its growth during World War II is described briefly. In developing equipment for human use the following "biological design" characteristics must be considered: sensory capacities, mobility and muscle strength, body dimensions, intellectual capacities, learned skills and learning potentials, and special physical environmental effects. Illustrations of each of these characteristics are given. A comparison of men to machines in terms of their functional capabilities is made.

22.2. Information Theory

Norbert Wiener, *Massachusetts Institute of Technology, Department of Mathematics, Cambridge, Mass.*

22.3. Biological Transducers

S. S. Stevens, *Harvard University, Cambridge, Mass.*

Man's reaction to his environment is mediated by transducers that convert various kinds of energy into nerve impulses. The eye and the ear are transducers in this sense; one reacts to electromagnetic and the other to mechanical energy. As transducers they are in many ways more remarkable than any devised by man. In some respects the eye and the ear behave differently; in other ways they are remarkably similar.

Both the eye and the ear react differentially to frequency. The eye sees different hues; the ear hears different pitches. But the ear can resolve about ten times as many pitches as the eye can resolve hues. Furthermore, the ear can resolve a mixture of frequencies into its separate components, whereas in the eye the components of the stimulating spectrum are not separately preserved. The same sensation can be produced by many different visual spectra.

The eye and ear also react differentially to intensity. Here the advantage is reversed, however; the eye can resolve two or three times as many levels of intensity as can the ear.

Despite this difference in resolving power, the visual and auditory systems react to physical energy in amazingly similar fashion. In other words, both the loudness we hear and the brightness we see are functions of the intensities of the physical stimuli. These intensities cover the enormous dynamic range of more than a trillion to one, and loudness and brightness are, to a rough approximation, proportional to the cube root of the stimulating energy. This means that, in order to double the apparent magnitude of a man's sensation, we must increase the stimulating energy approximately tenfold.

We may assume that this over-all relation between sensation and energy level will ultimately be explainable in terms of the various stages of transduction in the visual and auditory systems. As yet, however, the techniques of electrical recording by which we sample events at the various levels of sensory systems in animals have not revealed input-output relations that parallel the over-all function relating stimulus and sensation.

The activity of a sense organ gives rise to electrical potentials whose magnitude varies with the stimulating intensity. The sense organ in turn, by an unknown process, initiates impulses in the sensory nerves. The frequency of these impulses also varies with the stimulating intensity, but neither the form of the function relating these effects to intensity nor the range over which they vary can as yet account for the remarkable transduction process by which in vision and hearing we respond to a dynamic range of some 150 db.

22.4. Biological Servomechanisms and Control Circuitry

Otto H. Schmitt, *University of Minnesota, Minneapolis, Minn.*

It is now becoming possible through recent advances in the biological sciences to understand the workings of some of the communication, control, and supervisory functions in biological systems and to translate these from biologists' shop talk into engineering terminology. After translation it becomes obvious that many biological engineering tricks are directly applicable in engineering developments with relatively minor adaptations.

Adaptation of biological designs is especially appropriate in electronic engineering fields for it is found that most biological control systems are based upon electrical mechanisms and consequently already utilize components startlingly closely related in function to standard electronic components. Usually, however, the components are much more compact, reliable, and low in maintenance cost than their electronic equivalents.

Several examples of biological engineering designs will be examined at the component level, at the functional unit level, and at the systems engineering level. Concrete engineering developments based on these analogs including a distributed gain component, redundant self-stabilizing servo systems, and bivalent grey-logic computers will be suggested.

SESSION XXIII

Audio Seminar—High Fidelity in Audio Engineering

(Organized by the Professional Group on Audio)

Chairman: H. S. KNOWLES

(Industrial Research Products, Inc., Franklin Park, Ill.)

This seminar will present the viewpoints of a panel of experts on high fidelity in sound systems. Following the presentation of preliminary comments by panel members, there will be a roundtable discussion in which the audience will be invited to participate with questions and comments. By means of discussion between members of the panel, and between members of the panel and audience, attention will be focused on aspects of high fidelity that are becoming of increasing interest to audio engineers. Topics related to high-fidelity audio systems and the panel members who will present the preliminary discussions follow.

23.1. Microphones

J. K. HILLIARD, *Altec Lansing Corp., Beverly Hills, Calif.*

23.2. Loudspeakers

H. F. OLSON, *RCA Laboratories Division, Princeton, N.J.*

23.3. Room Acoustics

R. L. HANSON, *Bell Telephone Laboratories, Inc., Murray Hill, N.J.*

23.4. Broadcasting Systems

J. V. L. HOGAN, *Hogan Laboratories, Inc., New York, N.Y.*

23.5. Stereophonic System

J. E. VOLKMAN, *RCA Laboratories, Camden, N.J.*

SESSION XXIV

Nuclear Science I—Symposium: Progress Report

(Organized by the Professional Group on Nuclear Science)

Chairman: L. V. BERKNER

(Associated Universities, Inc., New York, N. Y.)

24.1. Secrecy and the Electronics Engineer

J. G. BECKERLY, *Atomic Energy Commission, Washington, D.C.*

A short report will be presented on the current status of "information control" of technical atomic energy data as practiced under the Atomic Energy Act. It will be shown that the effect on activities of interest to electronics engineers is almost negligible. Some comments will be made on the apparent advantages and disadvantages to the national security of secrecy practices in technical fields with specific illustrations taken from nearly a decade of such practices.

24.2. Nonreactor Electronics at Oak Ridge

P. R. BELL, *Oak Ridge National Laboratory, Oak Ridge, Tenn.*

Multi-channel analyzer work and the development of linear amplifiers for scintillation and proportional counter spectrometry will be discussed as examples of the electronic work in progress.

Four different multi-channel analyzers are under development, two are based upon the usual multiple tube discriminators, one upon electron beam discrimination and the fourth is based on delay line storage.

The linear amplifiers are designed to have exceptional overload and linearity performance.

A survey of the electronic projects at Oak Ridge will also be given.

24.3. Brookhaven Electronics Work

W. A. HIGINBOTHAM, *Brookhaven National Laboratory, Upton, N. Y.*

The Brookhaven Electronics Division is primarily concerned with instrumentation and analysis of nuclear radiations. All relevant components from radiation detectors through data recording systems are under development. Research programs are conducted in co-operation with other departments to evaluate instruments, to develop techniques for their use, and to suggest means for improving them.

Elements employed in scintillation counting will be described as illustrative of the whole program. This will summarize work on scintillation phosphors, photomultiplier tubes, pulse amplifiers, stable power supplies, counting circuits, single and multiple channel pulse height analyzers.

24.4. Progress Report on Non-Reactor Electronics Work at Argonne

T. BRILL, *Argonne National Laboratory, Lemont, Ill.*

The major work of Argonne National Laboratory Electronics department will be outlined. Two instruments will be described in some detail; these are the Neutron Chopper (Neutron Velocity Selector) and the Bent Crystal Gamma Ray Spectrometer. Primary emphasis will be on the electronic equipment included for the operation of the instruments, without any significant description of the physics involved in the experiments. Both these instruments use considerable counting equipment. In addition, the neutron chopper includes quite a bit of gating equipment and the spectrometer includes some accurate position measuring equipment.

24.5. Progress Report on Non-Reactor Electronics at Los Alamos, New Mexico

R. J. WATTS, *Los Alamos Scientific Laboratory, Los Alamos, N. M.*

Slides and schematics will be shown of some of the basic instruments in use at Los Alamos. The Model 500 Pulse Generator and a Peak Pulse Voltmeter will be shown as a moderately precise method of obtaining and measuring the pulses needed for testing nuclear instruments. In the field of Multi-Channel Analyzers, operating experience with twenty Ten-Channel and five One Hundred Channel (Wilkinson type) analyzers will be discussed. In the field of Radiation Monitoring Instruments, Tritium Monitors, a Roentgenometer suitable for use in aircraft, Plastic Probes for Alpha Hand Counters, and some experiences with a simple Uranium Fluorophotometer will be described. As illustrative of the range of electronics at Los Alamos, some miscellaneous instruments will be discussed. These include a gracefully overloading amplifier, the Model 250, a n^2 scaler, an electronic precision delay good to plus or minus 0.02 microsecond in 100 microseconds, Coax Pulse Generators, and the Photoformer, an analogue device for solving simultaneously the nonlinear equations of the residual aberrations of optical lenses.

SESSION XXV

Electron Devices I—Electron Tubes

(Organized by the Professional Group on Electron Devices)

Chairman: G. A. ESPERSON

(Phillips Laboratories, Inc., Irvington-on-Hudson, N. Y.)

25.1. The Hollow Cathode in Cylindrical Geometry

R. D. KUMPFER AND H. BRETT, *Signal Corps Engineering Laboratories, Ft. Monmouth, N. J.*

This paper describes an experimental hollow cathode which provides an annular beam of the type used in magnetron and other radial beam devices. It provides emission densities comparable to the pencil beam type and has the advantages that the coated surface is shielded from electron back-bombardment and ion bombardment. The radial beam is double, supporting the assumption that the emission occurs from the edges of the circumferential slot.

25.2. The Machining of Tungsten and Its Application in the Fabrication of Philips Dispenser Cathodes

ROBERTO LEVI, *Philips Laboratories, Inc., Irvington-on-Hudson, N. Y.*

The most important component of both the "L" and "Impregnated" cathode, is a densely sintered tungsten part having accurately controlled dimensions, porosity, and gas permeability: its outer surface is the emitting area.

In the past, densely sintered tungsten could not be machined. Therefore, the parts were made either by pressing tungsten powder in a die or by shaping them from a partly sintered bar, and subsequently sintering them to the required degree. During this sintering, shrinking and warping occurred, making it, in many cases, exceedingly difficult to attain the required shape and dimensions.

The author developed and will describe a process for machining densely sintered tungsten by which parts can be made in shapes and with tolerances comparable to those possible with steel or brass. Since the tungsten has been sintered to the required degree before machining the problem of shrinking and warping is eliminated.

25.3. The GE Post Acceleration Color Tube

C. G. Lob, *General Electric Co., Syracuse, N. Y.*

The tube to be described is a high brightness, high-definition color tube using three electron guns and a viewing screen consisting of vertical phosphor stripes alternating red-green-blue, red-green-blue, etc.

Performance data obtained from developmental models of this tube will be presented and many of the advantages of such a device pointed out.

25.4. Amperex Type EIT, Decade Counter Tube

I. Rudich, *Amperex Electronic Corp., Hicksville, N. Y.*

The EIT is a cathode-ray tube having roughly the dimensions of a radio receiving tube and operating with a supply voltage of only 300 v. According to the number of counting pulses applied, its ribbon-shaped electron beam is shifted in a horizontal plane and passes in succession through the ten apertures of a cylindrical anode, thus impinging on the fluorescent layer with which the envelope is lined. The number of pulses can thus be read on the outside of the envelope, a rectangular luminescent spot appearing opposite one of the figures 0 to 9 indicated on the circumference of the bulb.

The features of the EIT render this decade counter tube particularly suitable for those applications where small dimensions, high counting speeds and reliability of operation are required, such as in telecommunication, in modern computers, in radiation counter apparatus, in industrial counting devices and for indication control and memory purposes.

25.5. A Developmental Thyratron Capable of Current Interruption by Grid Action

E. O. Johnson, *RCA Laboratories Division, Princeton, N. J.*, J. A. Olmstead, *RCA Victor Division, Camden, N. J.*, and W. M. Webster, *RCA Victor Division, Princeton, N. J.*

This paper describes a new type of thyratron whose grid can interrupt as well as initiate conduction. In addition to having an essentially zero recovery time this developmental tube has the added feature of being free of noise and oscillations commonly observed with conventional hot cathode gas tubes. With respect to initiation of current flow, arc drop during conduction, and other salient characteristics, the tube is similar to conventional thyratrons. Design aspects, performance, and principles of operation of this tube will be presented.

Session XXVI

Broadcast Transmission Systems I—Symposium: TV Broadcasting

(Organized by the Professional Group on Broadcast Transmission Systems)

Chairman: George P. Adair

(George P. Adair Engineering Co., Washington, D. C.)

26.1. Antenna System for Station WOR-TV Channel 9, Installed on the Empire State Building in New York City

G. J. Adams, Andrew Alford, H. H. Leach, R. Rubin, and F. Abel, *Consulting Engineers, Boston, Mass.*

The antenna for WOR-TV is built around the top of the Empire State Building at a level where the building forms a cylinder 28 feet in diameter. The antenna consists of an array of 24 bays. Each bay consists of two dipoles with shaped reflectors. The effective vertical aperture of the array is approximately 13 feet. The radiation pattern in the horizontal plane is essentially omnidirectional. The antenna array is designed for use in conjunction with a 50-kilowatt television transmitter. This paper deals with the theory, the model tests, the design, and the construction of the antenna system on the building, which includes the array, the feeding system, the transformers, and the auxiliary equipment.

26.2. A Pulse Distribution System for a Television Network Originating Center

J. S. Auld and Anthony Gallonio, *DuMont Television Network, New York, N. Y.*

A large television network studio center requires an elaborate system of feeding synchronizing pulses and blanking pulses to the various studios, projection rooms, monitoring locations and video recording locations.

The system must be fully flexible, yet protected for emergencies, and must also be capable of being locked with synchronizing information received from network lines or other remote locations.

This paper describes the design and installation features of the pulse distribution system recently put into service at the Du Mont Television Network Telecentre in New York City.

Pulse sources, together with methods of routing and switching, will be covered.

26.3. An Improved Television Clamp Circuit Employing Feedback

K. R. Wendt and W. K. Squires, *Sylvania Electric Products, Inc., Buffalo, N. Y.*

The clamp circuit is one of the most useful devices employed in television broadcasting. It is at the same time one of the most troublesome. Whereas it can repair most of the low frequency errors that occur, it occasionally fails, in which case the signal becomes unusable. This radical operation at failure is partly due to the correction being applied in steps. A means whereby the correction is applied continuously is described, and an anlaysis given of the old and new circuits.

26.4. A High Level Plate Injection Mixer for Use at UHF

R. E. Western, *Collins Radio Co., Cedar Rapids, Ia.*

Plate injection mixers have been used to an advantage in synthesized frequency generating systems where the desired output frequency is obtained by combining a number of lower frequencies in one or more mixers. Spurious frequency generation has been reduced to 70 to 100 db below the desired frequency level with the plate mixer. Spurious generation in conventional grid or cathode injection mixers is caused by operating off the linear portion of the g_m characteristic of the mixer tube. As a result oscillator voltages at low frequencies are reduced for mixing and amplified at higher frequencies where high gains are difficult to achieve. The plate mixer injection levels are limited only by the tube power capabilities. A graphical method of determining the approximate mixer level is given. A comparison is made of spurious and power output levels of a uhf transmitter operating with a conventional mixer at high level, later converted to plate mixer system.

26.5. Coax Line Transfer Switch for Television Transmitters

Carl F. Schunemann, *Thompson Products, Inc., Cleveland, Ohio*, and J. B. Epperson, *Scripps-Howard Radio, Inc., Cleveland, Ohio*

The design and application of a 3⅛ inch 51.5 ohm vhf coax line switch is analyzed.

Electrical and mechanical design features will be described, and the results of swr, cross talk and power measurements will be shown. General applications of the switch will be covered. In addition, a typical application of these switches at WEWS and WCPO-TV to provide transmitter power cutback, transfer to standby transmitter, or transfer to standby antenna, will be detailed.

Session XXVII

Electronic Computers I—Computer Design and Techniques

(Organized by the Professional Group on Electronic Computers)

Chairman: Daniel Haagens

(Control Instrument Co., Inc., Brooklyn, N. Y.)

27.1. The Role of General Purpose Digital Computers in Automatic Control and Information Systems

A. A. Cohen, *Remington Rand, Inc., St. Paul, Minn.*

In today's complex military and industrial situation, solving an operational problem of broad scope depends to an increasing extent on the integration of a variety of engineering efforts in the field of automatic information handling and control systems. A program of this kind can become prohibitively expensive, both in dollars and calendar time. Fortunately, digital information technology has arrived at a state of development where it is practical to choose an existing computer system with general purpose properties to serve as the principal part of a more extensive system for handling the specialized operational problem. A suitable general purpose central system can be augmented with peripheral equipments to produce an integrated whole which is well adjusted to the problem and its environment. Problem changes occurring after installation can be accommodated without equipment modification. It will be demonstrated, with specific illustrative examples, how digital equipments already designed and available are being adapted to a variety of open and closed loop systems. The choice of computer characteristics for such usage, as well as design considerations relating to connected equipments, will be discussed.

27.2. Design Features of Current Digital Differential Analyzers

E. L. Braun, *Librascope, Inc., Glendale, Calif.*

The general design features of current digital differential analyzers are discussed. The limits of complexity possible for this type of machine are considered. Its logical organization and mode of computation are analyzed. Certain difficulties and disadvantages as well as desirable logical and operational features are pointed out. Criteria are given as a basis for comparison of the digital and analog differential analyzer. Modifications, extensions, and potential applications of the digital differential analyzer, in the solution of scientific and engineering problems, and for use in control systems, are discussed in the light of computer systems requirements and economic considerations.

27.3. Design Features of The JAINCOMP-C AND JAINCOMP-D Electronic Digital Computers

D. H. Jacobs, *The Jacobs Instrument Co., Bethesda, Md.*

JAINCOMP-C is a 24-digit all-electronic, all-parallel digital computer of very high speed and very small size. It fits in a cabinet $21\frac{7}{8}\times 24\frac{1}{4}\times 27\frac{5}{8}$ inches in size. Designed for use on 400 cps power, it was built for a real-time control application. It has 9 continuous inputs and 3 continuous outputs. JAINCOMP-D is a proposed general-purpose high-capacity digital computer of unusual flexibility and very small size. It fits into three cabinets, each $21\frac{7}{8}\times 24\frac{1}{4}\times 27\frac{5}{8}$ inches. It utilizes the same components (all plug-in; subminiaturized) as JAINCOMP-C. Its preliminary logical design has been completed. It is intended for general-purpose computation and for real-time control and simulation use.

27.4. A Germanium Tape Reader

R. A. Langevin, *Transistor Products Products Inc., Boston, Mass.*

The photo conductive properties of Germanium have been utilized in a comb-like structure to provide linear array of photo cells for use in tape reading applications. The method of construction makes it possible to obtain an array of photo sensitive units in which the center to center spacing between adjacent channels is as low as .050 inch. The sensitivity of the individual photo units is sufficient to permit direct relay operation from punched tape. The operating characteristics of a photo electric tape reader based on this device will be discussed in detail.

27.5. Electrostatic Reading of Perforated Media

Samuel Lubkin, *Underwood Corp., Long Island City, N. Y.*

A scheme for reading holes in tape or sheet is described which utilized the unperforated material as a shielf to prevent capacitative coupling between the electrodes on opposite sides of the medium in a possible hole position. Presence of a hole permits coupling to occur. One of the electrodes is generally connected to an oscillator and the other to a tuned amplifier-rectifier which has an output, if a hole is present, and no output if a hole is absent. Several variations of the basic concept are indicated.

Session XXVIII

Circuit Theory I—Symposium: Network Equalization

(Organized by the Professional Group on Circuit Theory)

Chairman: C. H. Page

(National Bureau of Standards, Washington, D. C.)

28.1. Limitation on Amplitude Equilizers

H. J. Carlin, *Polytechnic Institute of Brooklyn, Brooklyn, N. Y.*

If an equalizer amplitude response curve shape is specified, it will be shown that the minimum flat loss obtainable with physical networks is determined. This flat loss, or scale factor on the response curve, is a function of the equalizer output terminating impedance which is arbitrary but prescribed, and the specified tolerance on input mismatch.

If the output impedance is purely reactive, the limitations on maximum voltage transfer are obtained from a consideration of the open circuit impedance parameters of the system. If power transfer to a load with finite real part is to be optimized, the scattering parameters of the system are used to determine the limits of performance.

These results may be used to assess the merits of practical equalizer networks and guide design techniques. Some examples of this will be given.

28.2. Synthesis of Resistively-Terminated RLC Ladder Networks

E. C. Ho and D. L. Trautman, *University of California, Los Angeles, Calif.*

Many equalizer problems reduce to the design of a network with specified transmission characteristics between given resistive terminations. A new technique for doing this with ladder RLC structures having no mutual coupling is described.

Any rational function, regular at $\lambda=\infty$, having its poles restricted to the left half-plane and its zeros restricted to the left half-plane and on the j-axis is acceptable as a transmission function (output over input) of a resistively-terminated minimum-phase network. The synthesis problem in this paper concerns itself with (a) a given transmission function of this type and (b) arbitrarily given, finite, resistive terminations (at both input and output). It is shown to be always possible to synthesize a physical RLC ladder network having the exact terminations as given and the transmission function as prescribed except within a constant multiplier.

The first step for achieving this realization is to extract a suitable A-matrix (general circuit parameter matrix) from the given transmission function and terminations of the network. Then the A-matrix is synthesized by a matrix factorization procedure. The resultant network is always in simple RLC ladder configuration employing no ideal transformers or mutual inductances.

28.3. Equalization of Video Cables

P. W. Rounds, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

The local intracity transmission of video signals over paired cables requires a cable equalization plan of flexibility and precision. The need is met with a combination of fixed and adjustable equalizers. For these equalizers, a design technique has been followed which permits advanced specification of the equalizer complexity and configuration in terms of the desired precision of match. With the configuration known, the locations and magnitudes of the parasitic elements can be anticipated and their effects minimized or absorbed in the paper design, thus simplifying the problem of construction and manufacture of paired cables for transmission of video signals.

28.4. Application of a Minimum Phase Matrix to Adjustable Equalizer Design

W. R. Lundry, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

Network functions whose singularities lie in the left half plane have been called "minimum phase" functions. Integrals for evaluating the imaginary part of such functions from a knowledge of the real part (or vice versa) have been given by Bode. Numerical evaluation of such an integral on an IBM 604 calculator is obtained by using a "minimum phase matrix."

To show one application of the matrix, a relatively involved example, the design of an adjustable equalizer, is described. By successive application of the matrix a difficult problem is reduced to two simpler problems. These may be treated by well-known design methods or reduced further by additional minimum-phase matrix calculations.

28.5. Equalization in the Time Domain

M. S. Corrington, R. W. Sonnenfeldt, and T. Murakami, *RCA Victor Division, Camden, N. J.*

In system such as television broadcasting, the limitations on the transmitted bandwidth may cause undesired transients in the receiver. It is often possible to equalize the receiver to restore the original signal, except for a time delay. Networks can be designed so the response to received transient gives a better picture.

Tapped delay lines with various terminations can be used to equalize parts of the transient without affecting the other parts. Ripples can be added or removed whenever desired. Parallel and cascade methods will be described.

Session XXIX
Instrumentation I

(Organized by the Professional Group on Instrumentation)

Chairman: I. G. Easton

(General Radio Company, Cambridge, Mass.)

29.1. Phase Measurements in the Video Frequency Range

W. W. Graunstein and R. W. Houghton, *Technology Instrument Corp., Acton, Mass.*

With increased interest in the field of color television, the designer of video frequency amplifiers has found himself to be in need of a means for measuring signal envelope time-delay. The requirement, that the delay be constant over this range of frequencies, prescribes a phase response increasing linearly through the frequency spectrum. The subject instrument has been designed for the analysis of this phase response.

Earlier methods of phase analysis have required that measurements be carried on directly at the fundamental frequency, or at a fixed intermediate value. The proposed system presents a frequency coverage extending to 4 mc, and provides for detector operation at one half of the input frequency. The instrument indicates the phase difference between non-sinusoidal waves, but is limited to wave shapes having no more than one positive-going zero-axis crossing per cycle.

29.2. An X-Band Rapid-Sweep Oscillator

H. H. Rickert and David Dettinger, *Wheeler Laboratories, Great Neck, N. Y.*

A rapid-sweep oscillator has been designed which enables the characteristics of microwave circuits to be displayed on a cathode-ray tube over the frequency range from 8.5 to 9.6 kmc. The modulated output of the oscillator is about 20 mw, constant within ±1 db; the sweep rate is 12 cps. Two tuned amplifiers are included in the assembly, operating on alternate half-cycles of the sweep, to permit the simultaneous observation of two signals from the circuit under test. The packaged assembly is useful in adjustint broadband filters. in investigating complicated microwave structures and in many other applications which require continuous monitoring of the *X*-band.

29.3. A Shielded Two-Wire Hybrid Junction and Its Use as a UHF Impedance Bridge

E. W. Mathews, Jr., *Harvard University Cambridge, Mass.*

The properties of a shielded two-wire hybrid junction have been examined theoretically and an experimental model has been constructed and incorporated into a uhf impedance bridge. Two major auxiliary components necessary for the impedance bridge—a new type of balun transformer with very good balance, and a transmission-line-type adjustable standard impedance—have also been designed, built, and tested. The operation of the bridge has been evaluated by measuring a series of antenna impedances at 750 megacycles and comparing results with measurements of the same antennas on a shielded two-wire slotted line.

29.4. High-Speed High-Resolution Spectrum Analyzer

N. L. Duncan, *Raytheon Manufacturing Co., Newton Mass.*

A high-speed, high-resolution spectrum analyzer in which an array of narrow-band, mechanically resonant rod filters, covers the desired frequency spectrum. These filters are excited in parallel time and the output of each filter is sampled consecutively by means of a capacitor commutator into a single output. The response is proportional in time or position of the sample plate to frequency and the amplitude is proportional to the relative response of the filters to the exciting signals. A typical rotation speed of the capacitor commutator is 12,000 rpm or for a 420-element analyzer one complete scan in each 5 milliseconds. This system circumvents the dependence of scan speed on the width of the band-pass filter, characteristic of conventional spectrum analyzers. It thereby permits far higher scanning rates and better resolution with improved detection of weak signals in broad-band noise.

The high-speed, high-resolution analyzer is useful as a general laboratory tool for spectrum analysis of short term signals and microphonics. In the laboratory it performs in real time a function that is both time consuming and difficult to do with other techniques.

This analyzer is rugged, long-lived, and adjustment free.

29.5. Rapid, Precision Impedance Measurement in the 400–1600 Megacycle Frequency Range

D. M. Goodman, *New York University, New York, N. Y.*

A system is described, together with preliminary results obtained from the experimental model, which accurately and rapidly plots the magnitude and phase of the reflection coefficient of coaxial line elements, terminations, networks, etc. By means of a Smith Chart overlay on a flat-face oscilloscope the data is immediately transcribed into impedance or admittance loci. Provisions are available for wide band sweeps, or for single frequency plots, with intensifying and blanking controls to locate discrete frequencies. The frequency bands of approximately 100 megacycles are swept at one cycle per second rates. The sensitivity of the instrument will allow measurements to be made on any element capable of dissipating fractions of a milliwatt on a steady state basis.

Session XXX
Antennas and Propagation I—General

(Organized by the Professional Group on Antennas and Propagation)

Chairman: J. T. Bolljahn

(Stanford Research Institute, Stanford, Calif.)

30.1. Empirical Approximations to the Current Values for Large Dolph-Tchebyscheff Arrays

L. L. Bailin, R. S. Wehner, and I. P. Kaminow, *Hughes Aircraft Co., Culver City, Calif.*

The demand for radar antennas exhibiting a narrow beam and low side lobes led to the development of the so called Dolph-Tchebyscheff array which optimizes the relationship between beamwidth and side lobe level. Unfortunately, however, the calculation of the excitation coefficients for the Tchebyscheff array is quite time consuming and tedious for arrays with a large number of elements. The present paper describes a simple approximate method for calculating Tchebyscheff arrays which cuts the calculating time by 95 per cent for a 40 element array and which does not increase in complexity with the number of elements in the array. Furthermore, sample calculations indicate errors of only 3 or 4 per cent in the excitation coefficients which is tolerable for most practical arrays. In addition, the paper contains a table of all the coefficients for Tchebyscheff arrays computed in the course of antenna development at the Hughes Aircraft Company. The table contains the exact excitation coefficients and the gain values relative to the corresponding uniform array.

30.2. Gain Pattern of a Terminated-Waveguide Slot Antenna by an Equivalent Circuit Method

L. B. Felsen, *Polytechnic Institute of Brooklyn, Brooklyn, N. Y.*

The terminated-waveguide slot antenna consists of a slot cut in the wall of a waveguide terminated in a known impedance; its gain pattern in a half-space changes markedly for different values of the termination. From a network viewpoint, the half-space may be represented approximately by two spheridal transmission lines, the feeding waveguide by a single uniform transmission line, and the slot by a coupling network. The network parameters are determined either experimentally by simple measurements in the feeding waveguide, or theoretically by a variational procedure. For a given waveguide termination, the spherical mode voltages and currents are computed by a simple network calculation, and the gain pattern is obtained by modal synthesis. Described in detail is a rectangular slot in the broad face of a rectangular waveguide.

30.3. A Four Slot Cylindrical Antenna for VOR Service

R. M. SPRAGUE AND ANDREW ALFORD, *Consulting Engineers, Boston, Mass.*

This antenna was originally developed for the Air Navigation Development Board under a U. S. Navy contract. Four equally spaced longitudinal slots in the wall of a cylindrical cavity constitute the radiating elements. The four slots are energized by three independent feeders in such a way that one circular radiation pattern and two figure of eight patterns are obtained. When the antenna is used in conjunction with a goniometer, a rotating limacon pattern results. Intercoupling among the feeders is very low. The antenna is 7 feet high, 15 inches in diameter and weighs 110 pounds. The antenna may be readily tuned with the aid of a calibration chart to any frequency between 108 mc. and 118 mc. Experience with a number of installations shows that the over-all course errors are around ±1.5 degrees although the antenna error itself can be kept down to about one half of this value. The design of the antenna, flight tests and the several sources of course errors are discussed in detail.

30.4. Trapped Wave Antennas

H. EHRENSPECK, W. GERBES, AND F. J. ZUCKER, *Air Force Cambridge Research Center, Cambridge, Mass.*

The question is first raised as to how a "trapped" wave radiates, and what beam shapes it can produce. The results are contrasted with the radiation fields produced by conventional antenna apertures.

A flush-mounted type of antenna is discussed which utilizes waves trapped in single and multiple dielectric layers. The calculated mode characteristics are in very good agreement with experimental results. Slight bends in the surface can be taken into account. By means of phase and amplitude control, antennas can be designed with a great variety of beam shapes in azimuth and elevation.

30.5. Scattering of Electromagnetic Waves by Wires and Plates

J. WEBER, *Naval Ordnance Laboratory, White Oak, Md.*

The scattering of electromagnetic waves by wires and plates is discussed, particularly with reference to new polarization components which appear. Formulas are given for parallel and cross polarization scattering of plates. The problem is formulated, for wires.

SESSION XXXI

Nuclear Science II—Symposium: Reactor Electronics

(Organized by the Professional Group on Nuclear Science)

Chairman: W. M. BREAZEALE (Pennsylvania State College, State College, Pa.)

31.1. A Nuclear Reactor Simulator

K. H. FISCHBACK, *Bendix Aviation Corp., Detroit, Mich.*

A simulator has been designed to solve thermal-reactor dynamic problems in true time.

The basic analog provides for the explicit study of leakage, absorption, delayed neutrons, and poisoning effects. The influence of reactor control rods or other control devices is introduced through their affect on these individual parameters.

An auxiliary thermodynamic section simulates heat transfer and removal phenomena as well as lumped power-system characteristics in the case of power-generating reactors.

Temperature and density dynamics are introduced to the basic analog through high-speed multipliers and function generators making possible the study of circulation and boiling of liquid fuels and/or moderators.

The wide-band width of the simulator components makes it possible to study fast transient phenomena as might occur from an accident to the reactor or actuation of scram controls.

The true-time base permits the simulator to be used as a system tester to evaluate the effectiveness of control systems by coupling to the actual mechanisms through electrical transducers.

A "Hold" control on the simulator permits the problem to be interrupted, held, and resumed at any time during its solution. Maximum solution time is five minutes. However, longer problems can be solved in five-minute increments. The simulator can accurately solve problems involving parameter variations of four decades.

31.2. Safety Aspects of Control Circuitry

T. E. COLE, *Oak Ridge National Laboratory, Oak Ridge, Tenn.*

The approach toward solution of the problems encountered in nuclear-reactor control has progressed from the situation of a few years ago in which preoccupation with the design of safety systems was characteristic of the field. The present approach is one in which safety considerations are important but over-all operating characteristics receive a large share of attention.

The primary hazard which must be guarded against is the possible release of fission products to the atmosphere. The steps leading to the establishment of requirements for an adequate safety system should begin with an attempt to design the reactor so as to have as great a degree of inherent safety as is compatible with the design purpose. From this follows the fact that the control designer is involved in nearly every phase of reactor design.

The instruments necessary in order for the reactor to be operated so as to fulfill its design purpose may vary greatly from one reactor application and type to another. However, the wide range of levels in reactor operation is a common denominator in its design. The characteristics of these instruments are one of the major determining factors in the over-all performance and safety of the reactor.

31.3. Instruments Used with Experimental Reactors

E. T. WADE, *Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N. Y.*

Types of Electronic Instruments used with Experimental Reactors: Counting circuits—Scalers and counting-rate meters, Linear amplifiers, Logarithmic amplifiers, Period circuits, Trip circuits.

Functions of various instruments: A discussion of the reasons for the use of each type and a functional description.

Design of specific circuits.

31.4. Synthesis of Control Systems for Nuclear Power Plants

J. N. GRACE, *Westinghouse Atomic Power Div., Pittsburgh, Pa.*

SESSION XXXII

Electron Devices II—Transistors

(Organized by the Professional Group on Electron Devices)

Chairman: R. M. RYDER (Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

32.1. Transistors for High-Power Application

J. S. SABY, *Electronics Laboratory, General Electric Co., Syracuse, N. Y.*

High-power transistors must be designed to meet three nearly independent requirements:

1. The transistor must be capable of dissipating the required power over a wide range of ambient temperatures.
2. The collector characteristic must be usable over a sufficiently wide-volt ampere range to deliver the designed output using the available power supply voltage.
3. The power gain at full output must be sufficient to avoid the necessity of numerous intermediate driver stages.

The above aspects will be discussed.

32.2. New Type High-Temperature Silicon Diode

L. D. HANLEY, C. G. THORNTON, *Sylvania Electric Products Inc., Electronics Div., Ipswich, Mass.*

A miniature size, point contact, silicon rectifier has been developed which will meet the need for a fast-switching computer-type diode to operate at temperatures up to 150 degrees C. A process of surface bombardment similar to that originally proposed by Ohl is used to lower the Fermi level of the silicon at the surface and to thereby thicken the barrier layer. Typical operating characteristics show a forward resistance of 1,000 ohms at +2 volts with a reverse resistance at −50 v of one megohm. The forward to reverse resistance ratio at 10 volts is 3,000 with a peak inverse voltage in excess of −70 v. The unit is designed to complement the silicon-junction diode by providing a short transient, rapid-recovery device. Typical values for recovery time to 400,000 ohms after a forward pulse of 5 milliamperes are from less than 0.1 to 0.5 μsec. The power conversion efficiency cutoff is greater than 200 megacycles as compared with a 10 megacycle maximum for silicon-junction devices. Methods of manufacture and circuit applications will be presented.

32.3. Small-Signal Parameters of Grown-Junction Transistors at High Frequencies

R. L. Pritchard and W. N. Coffey, *General Electric Research Laboratory, Schenectady, N.Y.*

Measurements have been made of four independent, complex, small-signal parameters as a function of frequency for a number of experimental grown-junction transistors. The results indicate that the concept of a lumped constant base spreading resistance r_b' in series with an ideal transistor is not valid for these units. A theoretical analysis has been made of a new model in which the *distributed* nature of the transistor parameters and of the base spreading resistance is taken into account. Under simplifying assumptions, parameters can be calculated for this model which are in fairly good agreement with experimental results.

32.4. The Study and Design of Alloyed-Junction Transistors

L. J. Giacoletto, *RCA Laboratories Div., RCA, Princeton, N. J.*

The design of transistors with predetermined characteristics is a desirable objective. In studies along these lines it was found that existing theories must be modified to accommodate the unequal areas that are often employed and to incorporate certain extrinsic elements as well as the various reactive effects of the basic transistor.

These factors were found to be related to measurements including those of complex small-signal nodal parameters as functions of frequency, voltage, and current.

On the basis of this study, it was concluded that a satisfactory transistor design can be carried out provided that certain fundamental constants are known.

32.5. An Analytic Study of *z*, *y*, and *h* Parameter Accuracies in Transistor-Sweep Measurement

H. G. Follingstad, *Bell Telephone Laboratories, Murray Hill, N. J.*

A comparison is made of measurement accuracies which can be realized for low frequency *z*, *y*, and *h* parameters using practical sweep techniques.

The comparison includes all regions of the transistor characteristic and involves both point contact and junction transistors in the grounded base and grounded emitter connections. Formulas have been developed which determine error due to finite terminations. Errors are calculated, assuming typical transistor parameter values in each region and realizable, practical source and terminating impedance values.

The analysis shows that at low frequencies the most generally useful and accurate sweep measurements are obtained with hybrid (*h*) parameters.

Session XXXIII

Broadcast Transmission Systems II—Symposium: Color TV Broadcasting

(Organized by the Professional Group on Broadcast Transmission Systems)

Chairman: E. T. Jett (Station WMAR-TV, Baltimore Sunpapers, Baltimore, Md.)

33.1. Color Film Scanner—Circuits

J. F. Fisher, *Philco Corp., Philadelphia, Pa.*

This article will describe the electronic circuits used in the color-film-scanner. A block diagram will illustrate the signal flow, and also indicate the video signal levels existing at the input and output of the various units. The function of such units as the phosphor-compensation amplifiers, and the gamma correctors will be described in some detail. The article will include a description of all the equipment necessary to obtain three channel voltages E_R', E_G', E_B' at 1 volt levels into 75 ohm lines.

Methods of calibrating the gamma correctors, using a ten-step staircase signal, will be described; and the operational method of adjusting white balance will also be explained.

33.2. Color Characteristics of a Television Film Scanner

J. H. Haines, *Allen B. Du Mont Laboratories, Inc., Passaic, N. J.*

The criteria for judging the picture quality of 16 mm color film television reproduction are described. These are namely, sharpness, steadiness, signal-to-noise ratio, and color quality. The reproduction of the film as a color television picture is accomplished by a flying-spot scanner associated with a rotating optical polygon-continuous film transport combination.

The relationship of the above criteria to the design of the equipment will be considered. The first three factors, which are directly measurable, influence the design of the optical pickup and the phosphor correction, gamma correction and amplifier circuitry. The fourth, color quality, is evaluated on the basis of a subjectively adequate picture rather than on the premise of accurate reproduction of the color film which is known to have color deficiencies. Color masking circuits are used to achieve good subjective pictures and the paper deals in detail with the design and operation of these circuits. A method for predicting in advance, on the basis of measurable film characteristics, the masking constants necessary for a good subjective picture will be discussed.

33.3. Factors in the Design of Keyed Clamping Circuits

R. N. Rhodes, *RCA Laboratories Div., Princeton, N. J.*

Keyed clamping circuits are employed in several of the pieces of electronic equipment commonly used in the generation of the color television signal specified by the NTSC. This paper describes means for analyzing these circuits from qualitative and quantitative points of view.

Starting with the cases of the simple dc restorer and pulse-peak detector an expression is developed which relates the clamped dc level established by the circuit to the values of the components and voltages associated with it, under loaded as well as open-circuit conditions. In addition some of the factors which influence the stability of the clamping action and related problems are discussed.

33.4. Photographic Simulation of Proposed Brightness Modifications for Televising Color Film

J. H. Ladd and W. L. Brewer, *Eastman Kodak Co., Rochester, N. Y.*

In a recent paper[1] some of the quality limitations of pictures from a color television film chain were described and analyzed. The major limitations were attributed to the limited brightness scale range of the television system. This, in combination with film characteristics, also restricts the saturation of reproduced colors. Suggestions were given whereby the picture quality of televised film might be improved. These suggestions involve electronic modifications in the color television film chain, but the results can be simulated photographically. Photographs designed to simulate the brightness scale-reduction method described in the earlier paper have been prepared and viewed both directly and over television systems. The photographs and reactions to their appearances are described.

[1] W. L. Brewer, J. H. Ladd, and J. E. Pinney, "Brightness modification proposals for televising color film," Proc. I.R.E., vol. 42, pp. 174–191; January, 1954.

33.5. Feasibility and Technique of Storing Color Video Information on Black and White Film

W. L. Hughes, *Iowa State College, Ames, Ia.*

This paper is concerned with the problems involved in producing a positive black and white film in which specular transmission is predetermined by both the spectral characteristics and brightness of the original scene to which the negative was exposed. It is necessary to control the negative film in such a way that when the positive film is placed in an ordinary flying-spot scanner the video signal that results corresponds to that of a given color channel in a color television system. This makes it necessary to control the spectral sensitivity of the negative film and also the development process of both negative and positive films.

Various problems of interpretation are encountered when dealing simultaneously with photographic and television concepts of spectral sensitivity and gamma. These problems are treated in some detail. Also, the advantages and disadvantages of reproducing a color television picture in this manner are discussed.

33.6. A System for Recording and Reproducing Television Signals

H. F. Olson, W. D. Houghton, A. R. Morgan, Joseph Zenel, Maurice Artzt, J. G. Woodward, and J. T. Fischer, *RCA Labs., Princeton, N.J.*

A system for recording and reproducing television signals by means of magnetic tape has been developed. This system will record and reproduce both monochrome and color pictures. In recording and reproducing monochrome pictures two channels are used, one for the video signal and one for the sound signal. These signals are recorded as two tracks on ½ inch magnetic tape. In recording and reproducing color pictures, five channels are used, a video channel for the color signals red, green, and blue and the synchronizing channel and an audio channel. These signals are recorded as five tracks on ½ inch magnetic tape. An electronic servomechanism provides the speed constancy required for the reproduction of television signals from magnetic tape. The present tape speed is 30 feet per second. The recorded and reproduced frequency band is well over 3 mc. A formal demonstration of recording and reproducing both black and white and color television signals on magnetic tape was presented to several hundred representatives of the press, motion picture, electronic, and chemical industries, financial world and armed forces on December 1 and 2, 1953 at the RCA Laboratories, Princeton, N. J. All of the action originated in Studio 3H in the National Broadcasting Company in New York City and was carried by microwave radio relay to the recording and reproducing equipment in Princeton. Prerecorded programs of both monochrome and color were reproduced. In one part of the demonstration, in order to demonstrate the fidelity of reproduction, a comparison was made between the live show from the microwave radio relay and the recording and immediate playback of the same show on magnetic tape.

33.7. Wide-Band Magnetic-Tape Recording

J. T. Muller, *Bing Crosby Enterprises, Inc., Los Angeles, Calif.*

Session XXXIV
Electronic Computers II—Computer Components

(Organized by the Professional Group on Electronic Computers)

Chairman: H. S. Duncan

(Remington Rand, Inc., South Norwalk, Conn.)

34.1. Considerations for the Selection of Magnetic-Core Materials for Digital-Computer Elements

O. J. Van Sant, *U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.*

This paper contains the principal factors to be considered in selecting core materials for magnetic digital-computer operations. An analysis is presented of the basic circuit required for a computer-core element to function as a memory or decision element as approached from the current source and voltage source points of view. It is possible for one to determine how a magnetic core will behave when used as a computer element from simple pulse magnetization measurements. It is also shown how, in some applications, the operating frequency is limited by the inherent properties of the core material while in others the frequency limit is largely determined by the amount of power available to drive an element.

34.2. Magnetic Core Selection Systems

S. Guterman and R. D. Kodis, *Raytheon Mfg. Co., Newton, Mass.*

Three-dimension selection systems are described for use with Magnetic Drum Storage systems. One selection system is suitable for writing, the other for reading on magnetic drums. Both selection systems use saturable reactors, based however, on different principles. The address is given in the binary system, by conventional vacuum tube circuits and the selection system "switches" on the chosen track. The switching times are less than 50 microseconds.

34.3. Circuits to Perform Logical and Control Functions with Magnetic Cores

S. Guterman, R. D. Kodis, and S. Ruhman, *Raytheon Mfg. Co., Newton, Mass.*

The "single-line" magnetic shift register has led to similar circuits for control and logical functions. The wide margins of operation inherent in the single-line register make branching easily accomplished. The logical functions of Inhibit, And, Or, and Complement have been studied. Almost every computer function has been synthesized with these magnetic core circuits. Circuits for gating, sampling, timing, and manipulation have been investigated. Tests have been made on full adders, multipliers, special purpose arithmetic units, function generators, and control circuits.

The characteristics of the circuits are discussed. The probable impact of these circuits, not directly using vacuum tubes, on computer equipment is considered.

34.4. Packaged Logical Circuitry for a 4 MC Computer

N. Zimbel, *Raytheon Mfg. Co., Newton, Mass.*

This paper describes the electronic circuitry of packages which are the building blocks for the implementation of a computing machine which operates at a maximum prf of approximately 4 mc.

In line with present computer-circuit techniques, all logical operations are performed by means of diode networks, and amplification is achieved with a vacuum tube-transformer combination:

The three basic package types are:

1. A logical structure of the or-and-or form with positive and negative-output amplifiers. Two delay-line sections are provided which allow half and/or integral pulse-period phasing at the two-clock phases which are used.
2. A two-tube package which contains non-inverting amplifiers for use as auxiliary positive pulse amplifiers.
3. A delay-line package which contains a number of half-pulse period delay lines for logical delay.

A new gate design, which yields lower power dissipation and higher efficiency than a conventional gate, is used in the logical structure. This design is dependent upon the use of reshaping and retiming at the output of the second level of buffers. The method of reshaping not only makes improved gate design possible but also requires less power for clock pulse trains than conventional methods.

34.5. Transistor Shift Registers

C. Huang, E. Slobodzinski, and B. White, *Sylvania Electric Products, Inc., Ipswich, Mass.*

Three-shift registers are described that employ transistor circuits to store binary digits or to act as pulse-delay elements. Reliability and versatility regarding the pattern of the binary digits to be stored are stressed. Emphasis is placed on circuit-design and transistor-parameter requirements. The problems of interstage coupling, output waveform shaping, trigger sensitivity, and stability of the monostable and bistable transistor circuits involved, are considered in detail. One transistor-shift register described is capable of stable operation at advance-pulse frequencies in excess of 500 kc.

Session XXXV
Circuit Theory II—Circuit Theory

(Organized by the Professional Group on Circuit Theory)

Chairman: L. A. Zadeh

(Columbia University, New York, N. Y.)

35.1. The Group-Theoretical Aspect of Linear Four-Pole Theory

W. W. Gaertner, *Evans Signal Laboratories, Belmar, N. J.*

This paper shows under what restrictions and for what rule of combination the matrices of passive linear four-poles form a group. The properties of this group are investigated. Resistanceless four-poles and four-poles that do not satisfy the reciprocity relation are considered. The role which the ideal gyrator plays in four-pole theory is treated from the standpoint of group-theory. The paper tries to frame a new classifying principle for four-pole analysis and it is shown to what extent group-theoretical considerations may be used for network synthesis. The physical significance of certain group-theoretical results is pointed out.

35.2. A Mathematical Technique for the Analysis of Linear Systems

J. R. Ragazzini and R. Bergen, *Columbia University Electronics Research Laboratories, New York, N. Y.*

A system or network is often specified by its time-domain response to a test function. While classical or transform methods of analysis yield this response, the labor required is generally prohibitive particularly in the case of feedback systems. The mathematical method described here employs the pulsed Laplace transform otherwise known as the "z-transform." Applied to continuous systems, time domain solutions are obtained by mathematically inserting sample and hold operations at some convenient point in the system. The output is then obtained for sampling instants by application of relatively simple numerical procedures to an accuracy dependent on the sampling rate. The z-transform approach organizes numerical computation reducing the labor required to a point where time domain analysis and, indirectly, synthesis of linear systems or networks is expedited.

35.3. Weighting Functions for Time-Varying Feedback Systems

J. A. Aseltine and R. R. Favreau, *Hughes Research and Development Labs., Culver City, Calif.*

This paper describes a technique called the Method of Equivalent Inputs which can be applied to time-varying feedback systems. The technique is based on simple physical considerations and yields formulas for the weighting function of the system and the responses due to steps, ramp functions, etc. It is shown that the adjoint system for a feedback system used in analog computation can be arrived at through physical arguments by the use of this technique. Since the method is based largely on the properties of the system-block diagram, considerable physical intuition into the operation of the system is provided.

35.4. Interconnection of Linear Transducers

Herbert Kurss, *Microwave Research Inst., Polytechnic Institute, Brooklyn, N. Y.*

The current popularity of scattering matrices and gyrators underlines the need for a revision and extension of classical-network analysis. To supply this need the interconnection of multi-port linear transducers by arbitrary but linear constraints is shown to be directly reducible to the form which is solved by the Campbell formula (for the elimination of concealed circuits) or the Kron (partitioned matrix) reduction formula. (This reduces to the classical discriminant method of Kirchhoff-Campbell when the transducers degenerate into branches and the interconnections are merely the Kirchhoff constraints.) In important special cases, such as the inter-connection of scattering matrices or the gyrator connection of networks, the analysis is seen to be particularly simple. Finally, the applicability of the connection tensor of Kron is discussed.

35.5. Dynamic Characteristics of Four-Terminal Networks

W. W. Happ, *Sylvania Electric Products, Inc., Electronics Div., Ipswich, Mass.*

A set of six anti-commuting symbols is used to establish systematically relationships between dynamic characteristics of four-terminal networks. Numerous examples are given, several from transistor circuits. The method is particularly useful in conjunction with signal-flow diagrams.

Session XXXVI

Instrumentation II—Symposium: High Frequency Measurement and Control

(Organized by the Professional Group on Instrumentation)

Chairman: B. M. Oliver (Hewlett-Packard Co., Palo Alto, Calif.)

36.1. An Approach to a Company-Owned Frequency Standard

J. W. Smith, *Collins Radio Co., Cedar Rapids, Ia.*

Background material is presented to establish the need for a highly accurate Frequency Standard as a company-owned asset. A Frequency Standard system is developed. Both long-term accuracy and short-term stability monitoring facilities are described and explained. What is believed to be a unique method of time difference measurement is presented. Installation problems and costs are considered.

36.2. Frequency Standard Controlled Wide-Range Oscillator

E. P. Felch, J. O. Israel, and O. Kummer, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

An AFC system has been developed for the control of a wide-range oscillator by reference to a fixed-standard frequency and an interpolation oscillator. Continuous coverage of the frequency range is achieved with a frequency accuracy limited only by the accuracy of the reference sources. The oscillator output contains no spurious modulation products. A novel design of the control loop allows the use of high gain with stability. A specific example of an oscillator covering the range 50 kc to 20 mc with an accuracy of ± 2 cps is described.

36.3. Performance of the Bell System Primary Standard of Frequency

G. N. Packard, *Bell Telephone Laboratories, Murray Hill, N. J.*

A new standard of frequency using the latest techniques has been in operation at the Bell Telephone Laboratories at Murray Hill, N. J., since June, 1951. Bridge stabilized 100 kc oscillators using Meacham's circuit together with frequency dividing and multiplying circuits generate highly accurate discrete frequencies ranging from 60 cycles to 10 megacycles. The generated frequencies are measured by comparisons with standard time as determined by the U. S. Naval Observatory. Results of measurements show average aging rate of oscillators to be less than 2 parts in 10^9 per day.

36.4. A Computer-Type Decade Frequency Synthesizer

R. W. Frank, *General Radio Co., Cambridge, Mass.*

A system, which uses a high-speed divider in an integrating feedback loop for the generation of standard frequencies with quartz crystal stability, will be described. An oscillator with suitable frequency-control elements drives the divider. The output from the divider is compared in phase with a standard signal derived from a quartz-crystal oscillator. The phase error is used to correct the frequency of the controlled oscillator.

A model of the system has been demonstrated in which the division ratio may be set to any integer between 100 and 999. The range of frequencies 100 kc–999 kc is covered in the 1-kc increments, and the range 1.00 mc–9.99 mc in 10-kc increments. Extension of the frequency range and the possibility of additional significant figures for the divider will be discussed.

36.5. A High-Speed Digital Frequency Divider of Arbitrary Scale

R. W. Stuart, *General Radio Co., Cambridge, Mass.*

The problem of arbitrary-scale frequency division, using high-speed electronic computer techniques, will be discussed in detail. Principal emphasis will be placed upon the logical and theoretical aspects of the problem. Using the criterions of switching simplicity, maximum possible number of significant divider digits, circuit economy and appropriate experimentally determined circuit limitations, two methods will be demonstrated as being logically superior among many of the ones which will be considered.

An arbitrary-scale divider, based upon one of the two alternative methods, and being used at present in a decade frequency synthesizer, will be described. This divider is capable of performing frequency division by any number from 1 to 999 at frequencies from dc to approximately 2.0 mc.

Session XXXVII
Antennas and Propagation II—Microwave Antennas

(Organized by the Professional Group on Antennas and Propagation)

Chairman: G. A. Woonton

(Eaton Electronic Research Lab., Magill University, Montreal, Quebec, Can.)

37.1. Reflections in Microwave Antennas and Their Harmful Effects

P. W. Hannan, *Wheeler Labs., Great Neck, N. Y.*

In a microwave antenna, there is a reflection from the surface of the focusing element when it receives energy from its waveguide assembly. This reflection, returning to the waveguide assembly, may contribute to instability of the transmitting oscillator. Formulas for computing this reflection are presented, and techniques for its reduction are reviewed.

There is also a reflection from the waveguide assembly when it receives energy from the focusing element. This reflection is composed of two components: the energy re-radiated from the feed, and that reflected from within the attached plumbing.

Combination of the reflections from the focusing element and from the waveguide assembly produces a sinusoidal variation of antenna gain with frequency, at a rate dependent on the distance between the two reflections. In a lobing antenna, these reflections, if unsymmetrical, cause an error of its direction-finding information, which likewise varies sinusoidally with frequency. Formulas for computing these effects are presented, and techniques for their reduction are reviewed.

37.2. Surface Matching of Dielectric Lenses

E. M. T. Jones and S. B. Cohn, *Stanford Research Inst., Stanford, Calif.*

Two methods of canceling the surface reflections of dielectric lenses are described in this paper. The first utilizes a simulated quarter-wave matching layer, and the second a reactive wall embedded within the dielectric. The reactive wall may take a variety of physical forms, such as arrays of thin-conducting discs, which have a capacitive reactance, or arrays of thin wires, which have an inductive reactance. Surface matching is obtained when the discs are placed approximately $\frac{3}{8}$ wavelength inside the lens, or the wires $\frac{1}{8}$ wavelength.

The reactance of the array of discs for waves incident at various angles and polarizations is computed by means of Bethe's small-aperture theory, and Babinet's principle. Measurements of the reactance of an array of circular discs have been made in waveguide for various angles of incidence and polarization to determine the range of applicability of the theory. Curves are presented that show how the air-dielectric surface reflections are reduced for various angles of incidence and polarization when quarter-wave-layer and reactive-wall matching are employed.

37.3. Double Parabolic Cylinder Pencil-Beam Antenna

R. C. Spencer, F. S. Holt, and H. Beauchemin, *Air Force Cambridge Research Center, Cambridge, Mass., and* J. Samson, *U. S. Navy*

Radiation from a point source placed on the focal line of a parabolic cylinder is reflected in succession from this cylinder and from a second parabolic cylinder crossed so that its focal line coincides with the directrix of the first cylinder. Each cylinder collimates the beam in one plane. The two reflections result in a parallel beam equivalent to a single reflection from a paraboloid of revolution. The theory is applicable to both microwaves and light. The advantages of shipment of the cylinders in the form of flat sheets and the possibilities of independent control of horizontal and vertical beamwidths and shapes are pointed out.

37.4. Diffuse Radiation in Pencil-Beam Antennas

David Carter, *Consolidated Vultee Aircraft Corp., San Diego, Calif.*

In many applications of pencil-beam antennas it is important to know the amount of energy directed at large angles away from the axis of the main beam. In reflector-type antennas this energy consists of direct radiation from the feed and scattered energy from the reflector.

Approximate methods for the evaluation of these contributions are discussed together with their simplifying assumptions.

To get some numerical indications, calculations were made for paraboloidal reflectors of different f/D ratios and a class of primary patterns which provide an approximate representation of a grant many common feeds. The results are presented in graphical form.

37.5. Theoretical Gain of Flat Microwave Reflectors

D. R. Crosby, *Communications Engineering Section, RCA Victor Corp., Camden, N. J.*

Flat sheets are sometimes used as microwave reflectors at the top of towers. Calculations are presented showing these reflectors may produce a system gain rather than a loss. The gain exists by reason of taking the primary antenna at the ground level as the gain standard. Using as a gain standard an antenna having the same area as the reflector, the reflectors exhibit no gain.

Session XXXVIII
Industrial Electronics

(Organized by the Professional Group on Industrial Electronics)

Chairman: C. E. Smith

(Consulting Radio Engineer, Cleveland, Ohio)

38.1. The Design of Automatic Factories

Geoffrey Post, *Allen B. DuMont Laboratories, Inc., Clifton, N. J.*

The generalized automatic factory will be discussed in block-diagram form and its functional basis discussed. Correlation and application will be shown between Project Tinkertoy and other present designs to the generalized technique, and suggestions will be made to optimize present design with the inclusion of higher-control functions. These higher-control functions will have analytical description and a means of practical evaluation will be shown so that suitable circuitry can be synthesized.

The analysis and synthesis techniques will be noted to be those of applied cybernetics, including methods in analogue and digital computers and associated control and communication problems.

38.2. Industrial Punch Card Automatic Control

W. L. Atwood, *Electrical Engineer, Warren, Ohio*

This paper deals with a new combination of industrial automatic controls to give greater flexibility and utility to co-ordinated-process control. The term "co-ordinated-process control" is used in the sense of industrial automatic-control instruments used together with such auxiliary equipment as pneumatic and electrical and electronic relays, valve positioners, timers, solenoid valves and the like, so interconnected that all of the control equipment is interdependent.

A typical industrial batch process will be described, showing how the punch card is used as the master control to set up control points in a process so that an unskilled operator may operate the equipment to give optimum results on various grades of a parent material. The punch card is useful in many ways among which is that it is a permanent instructive card for the automatic controls so that consistent repetitive cycles are assured. It also permits the use of an unskilled operator who merely matches the punch card to the particular grade of material to be processed. Another very valuable use is in setting up cycles for processing particular grades of the material. A series of cards are punched with minor differences between the various control points. A cycle is run for each punch card and the results evaluated. The run which gives the best results is correlated to the particular card used for the run and that card is now filed in the permanent file for the processing of that particular grade of material.

In the processing of natural organic materials, there are usually changes in the product from time to time and these changes may be easily handled by variations in the punchings of the cards. The system is limited in scope only to restrictions of the individual industries.

38.3. Considerations in the Automatic Assembly of Components

Ben Warriner, *General Electric Co. Advanced Electronics Center, Cornell University, Ithaca, N. Y.*

38.4. Electronic Flow Measurement and Control

EUGENE MITTELMANN, *Consulting Engineer, Chicago, Ill.*

Magnetic induction-type flowmeters are well adapted not only to accurate measurement of flowrates but also, thanks to their instantaneous response, to precise control of flows. Accurate control demands either a servosystem with sufficiently high-frequency response of the entire loop including the measuring element, or a system where control is based on the measurement of the correct mean value of flow in a chosen time interval. Recording and controlling systems with both dc and ac integration methods of the true mean flowrate are described in the paper. The dc system is based on the use of a truly-linear amplifier with extremely wide-operating range of the input signal; the ac system on the use of frequency-compensated tuned circuits. The ratio of the exciting-unit magnetic field of the flowtransducer to the flow-signal at unit liquid velocity is a true constant for any given flowtube dimension. This property was used in the development of a rugged and greatly simplified recorder-controller system in which high accuracies were obtained without the customary use of standard cells as reference. Relatively simple electronic circuitry makes the use of the electromagnetic flowmetering principle possible in wider fields heretofore closed, due mainly to economic considerations.

38.5. Photosensitive Germanium Devices and Some Device Applications

R. G. SEED, *Transistor Products, Inc., Boston, Mass.*

The general characteristics of four types of photosensitive germanium devices will be presented and some of their applications discussed. These four types include:

(1) the *n-p* grown junction germanium photodiode;
(2) the *n-p* grown-junction germanium photovoltaic cell;
(3) the *n-p-n* grown-junction germanium phototransistor; and
(4) the *n*-germanium photo-conducting cell.

The sensitivities of the photodiodes range around 30 microamperes per millilumen, of the phototransistors from 0.5 to 5 millamperes per millilumen. The dynamic impedances of the former may reach 100 megohms, the latter 1 megohm. Preliminary measurements indicate the open circuit noise voltage of the diodes ranges in the region 10–30 microvolts at 1,000 cycles per second, and with a 1 cycle bandwidth. The phototransistors range in value from around 50–100 microvolts under the same conditions.

In addition, other interesting characteristics such as frequency response, temperature behavior, etc. will be presented.

Some typical circuit application will be described and analyzed. Finally a short comparison with other competitive photosensitive devices will be presented.

SESSION XXXIX

Circuit Theory III—Network Synthesis

(Organized by the Professional Group on Circuit Theory)

Chairman: E. A. GUILLEMIN (Massachusetts Institute of Technology, Cambridge, Mass.)

39.1. Some Techniques for Network Synthesis

G. L. MATTHAEI, *Div. of Electrical Engineering, University of California, Berkeley, Calif.*

A method is presented for realization of any minimum-phase transfer function in a cr (i.e., constant-resistance) ladder. Such networks have similar application to cr bridged-*T*'s, but possess the advantages of more flexibility in design, fewer elements, and often less loss.

Cr networks using two-pole and zero arm immittances are particularly easy to design. Then simple formulas can guide the designer to networks without unnecessary elements. Straightforward techniques are presented for realization of the arm immittances. The realization process is facilitated by rules for making RLC continued-fraction expansions by "forward" and "reverse" division.

39.2. An Iterative Method for RC Ladder Network Synthesis*

R. E. SCOTT AND N. DECLARIS, *Research Laboratory of Electronics and Dept. of Electrical Engineering, M.I.T., Cambridge, Mass.*

On examining the present methods of modern network synthesis one is impressed by the fact that not a single numerical procedure is available, although a numerical evaluation of the physically realizable elements is required.

It is the purpose of this paper to introduce such a method for the synthesis of 2-pair terminal RC networks and to evaluate the merits and engineering value of the approach.

The method is one of systematic relaxation of the pole constraints. That is, given an analytical expression for the desired transfer impedance (or voltage ratio), one systematically establishes the zeros of the function while the poles are obtained, by a process of successive approximations on the values of the elements determining the poles. For the case of RC ladder networks, where both poles and zeros are real and negative, the constraints are easily determined and the method is very elegantly applied. A mathematical treatment in determinants and simultaneous *n*-Hilbert spaces provides the necessary proof for the convergence of the process.

The technique is illustrated through several numerical examples and is shown to be related to the zero-shifting technique of RC ladder development. The numerical nature of the method makes possible the design of RC ladder networks by digital computing machines.

* This work was supported in part by the Signal Corps, the Air Materiel Command, and the Office of Naval Research.

39.3. Networks Terminated in Resistance at Both Input and Output

LOUIS WEINBERG, *Hughes Research and Development Labs., Culver City, Calif.*

In this paper a lattice with a resistive termination at both input and output is realized. Any physically realizable transfer function—impedance, admittance, or dimensionless voltage ratio—may be realized by the method presented. The method used is based on a previous procedure that realized a transfer impedance as an open-circuited lattice. If the given transfer function has a numerator of lower degree than its denominator and contains no multiple order poles, then an even more practical termination may be obtained at both input and output, namely, one that has a shunt capacitance in addition to the resistive termination. The lattice arms contain no mutual inductance and may be designed with no pure inductances, that is, every inductance present in an arm has an associated series resistance.

39.4. Approximating Band-Pass Attenuation and Phase Functions

V. H. GRINICH, *Stanford Research Institute, Stanford, Calif.*

This paper discusses two types of network approximation in the frequency domain: (1) derivative matching (Taylor) and (2) nearly equal-ripple (quasi-Chebyshev). The second type utilizes techniques of the first as an intermediate step.

Using Chebyshev polynomial series, nearly equal-ripple approximations for attenuation and/or phase in the "low-pass" interval were previously obtained. For "band-pass" intervals only attenuation functions have been treated.

A method for obtaining band-pass approximations to attenuation and/or phase functions will be given. The procedure uses an elliptic function conformal mapping. In the cases of linear phase and/or constant attenuation the quasi-Chebyshev is easily derived from the Taylor approximation.

39.5. An Application of Modern Network Synthesis to the Design of Constant-Time-Delay Networks with Low-*Q* Elements

LEO STORCH, *Hughes Research Laboratories, Culver City, Calif.*

In Part I a rational approximation to the ideal delay operator e^{-pt_0}(t_0 = delay time) in terms of Lommel polynomials is developed, which is realizable as the transfer function of a passive, lumped-constant, unbalanced, low-*Q* network. This transfer function possesses a particularly large delay-bandwidth range, over which the phase vs frequency curve follows a straight line and the delay is constant; its amplitude response approaches a Gaussian curve; its impulse response is centered about $t=t_0$ and tends to be Gaussian as the degree of the approximation increases.

In Part II, this transfer function is realized as the transfer impedance of a low-pass ladder network, which contains an inductance and series resistance in each series arm, a capacitance paralleled by a resistance in each shunt arm, and does not require any mutual inductances. The ratio of inductance to resistance is pre-determined and is such that only coils of low *Q* need to be used. The presence of these resistive elements does not cause distortion but merely adds a fixed loss. The synthesis process consists principally of a zero-shifting step and the continued-fraction expansion of a single two-terminal impedance. It does not require solving for the roots of any equations nor does it involve trial and error steps, as is common with some synthesis methods.

Fig. 3 is the circuit diagram of the nine-pole synthesized delay network for Q's of 4 at 160 cps, a delay of 1.25 milliseconds, and a load impedance of 4,000 ohms. Its squarewave-response for several repetition rates is displayed in (b) of Fig. 4. For comparison, in (c) of Fig. 4, the square-wave response of a conventional bridged-T delay network (Fig. 5) is shown, with 1½ times as many coils as in the maximally-flat network of Fig. 3 and the weight per coil 10 times as much.

Session XL

Electron Devices III—Storage Tubes

(Organized by the Professional Group on Electron Devices)

Chairman: J. B. Little

(International Business Machines Corp, Poughkeepsie, N. Y.)

40.1. The Metrechon—A New Halftone Picture-Storage Tube

L. Pensak, *RCA Laboratories Division, RCA, Princeton, N. J.*

The Metrechon is an experimental storage tube designed primarily for scan conversion of radar patterns to television signals for transmission and display on kinescopes at high-brightness levels. It can store such patterns for as many as 20,000 read-out copies or until erased. The read-out is continuous and independent of writing or erasure. The output signals can be proportional to the input signals or to the integral of a number of input signals and thereby has a half-tone range. The tube has two cathode-ray guns on opposite sides of a special storage target.

40.2. Characteristics of Viewing Storage Tubes with Halftone Display

M. Knoll, H. O. Hook, and R. P. Stone, *RCA Laboratories Division, Princeton, N. J.*

Typical characteristics of transmission control-type viewing storage tubes are discussed, using as an example a new version of halftone storage tube with primary current modulation for writing, and grid-control reading. This tube has 400 line resolution, a highlight brightness of 400 feet-Lamberts at 7 kv anode voltage, and is able to store single television halftone frames up to 15 seconds without holding.

Calculated and experimental static viewing-current characteristics are compared, showing a considerable decrease in slope with increasing gradient across the storage layer. Dynamic characteristics of the visual output as a function of the electrical input are approximately linear. To keep the amplification factor sufficiently constant variations in storage, grid-wire diameter must be $< \pm 1$ per cent for accurate halftone display. Viewing durations without holding are mainly limited by the residual gas pressure. Using pulse-holding techniques, black-and-white pictures have been viewed for 27 hours.

40.3. A High-Writing-Speed Dark-Trace Tube

S. Nozick, N. H. Burton, and S. Newman, *U. S. Naval Material Laboratory, Brooklyn, N. Y.*

As an outgrowth of several years of dark-trace tube study, an improved skiatron is presented with a writing speed better than three times that previously obtainable. The improvement was obtained by special electron optical design rather than by raising anode voltage. The analysis of skiatron writing-speed qualities is presented as a function of electron gun and screen characteristics with experimental verification. Special design characteristics are analyzed. The tube and system are discussed and contrasted with previous dark-trace tubes.

40.4. Large Capacity Storage Tube for Digital-Computer Application

R. B. DeLano, Jr., *International Business Machines Corp., Poughkeepsie, N. Y.*

This tube, called the IBM-93, has been designed to have a high-reference number for use in digital computers. This paper describes the construction of the tube including the features which reduce secondary redistribution. The special amplifier, which is required to operate the tube in a complete memory cycle of 8 microseconds, will be treated briefly. A method of operation, which reduces the effect that fringe electrons in the beam have on the reference number, will also be described. A group of these tubes has been tested on a machine which determines reference number existing in a raster composed of 8,192 bits. This test shows that the tube will store 10,000 bits with 100 references.

40.5. Noise Limitations on Storage Tube Operation

S. Nozick and S. Winkler, *U. S. Naval Material Laboratory, Brooklyn, N. Y.*

In practice, the operation of storage tubes is limited by presence of noise. The experience obtained in using storage tubes is presented together with the techniques and methods of optimizing the signal-to-noise ratio. The difficulties introduced by gas, lack of voltage regulation, the ripple content of supply voltages, sweep-circuit jitter, the choice of beam current, and other factors are discussed. The effects of inhomogeneous storage surfaces in both electrostatic and electromagnetic tubes, misalignment of the electron gun, and the various distortion factors are considered. The requirements for obtaining satisfactory operational conditions are given, with emphasis placed on practical information to assist the equipment designer.

Session XLI

Ultrasonics I

(Organized by the Professional Group on Ultrasonics)

Chairman: M. D. Fagen

(Bell Telephone Laboratories, Inc., Murray Hill, N. J.)

41.1. The Ultrasonic Burglar-Alarm System

S. Bagno, J. B. Cooper, and E. A. Levi, *Alertronic Protective Corp., Long Island City, N. Y.*

The Alertronic Ultrasonic Intruder Detection System is designed to detect an intruder by his motion. The air of the room to be protected is filled with ultrasonic waves. There is an echo from each object in the room and if an object is moving, the frequency of the echo from the moving object is slightly different from the pitch of the original waves. The original waves and echos are picked up by a unit acting as a microphone, amplified, and any frequency difference is used to set off an alarm. The unit also detects the presence of a flame. Because of the low density of the hot air that composes a flame, it reflects ultrasonic waves in the same manner as a solid object. The flickering of the flame and the cone of hot air above it behave like a moving intruder and set off the alarm. In general, the size of flame that the instrument will detect depends on the setting of its sensitivity. At any given setting it will detect a flame about one-quarter the size of the minimum detectable intruder.

41.2. A Complex Impedance Recorder

H. M. Sharaf, *Laboratory of Electronics, Inc., Boston, Mass.*

An instrument capable of continuously recording the complex impedance of a passive network throughout the frequency range of 100 to 500 kc has been developed. This instrument will record a variation of impedances from zero to infinity in two discrete steps; the range of 0–100 ohms is detected directly while the impedance range of 100 ohms to infinity is detected as its reciprocal, or admittance. A nominal accuracy of 5 per cent full scale reading is obtained, though a greater accuracy may be secured by reducing the sweep-frequency range.

41.3. Ultrasonic Delay Lines

D. L. Arenberg, *Arenberg Ultrasonic Laboratory, Jamaica Plain, Mass.*

Ultrasonics has recently developed a type of memory device which has received wide application in high-speed computers, radar systems, and certain gating circuits. Time delays of from two to several thousand microseconds can be obtained with great accuracy and exceedingly wide bandwidths.

While many authors have approached the behavior of the transducers from different points of view, it appears that, in the simplest cases at least, general agreement is obtained among these which concurs with experimental data.

While the first delay lines used either water or mercury, only the latter has been used extensively. Newer types use solids, generally either a glass for short delays, or fused quartz for the longer.

It is possible to compare the types electronically by using as a figure of merit the gain-bandwidth product and also to compare these mechanically in terms of microseconds per unit of weight or volume, although added features such as secondary signal level, temperature and shock resistance, etc. enter into the choice of a final design.

41.4. Wide-Band Large Dynamic Range-Fused Quartz Delay Lines for Increased Capacity, High-Speed Computer Memories*

D. A. SPAETH, *Lincoln Lab., Mass. Inst. of Tech., Cambridge, Mass.*, T. F. ROGERS, *Air Force Cambridge Research Center, Cambridge, Mass.* AND S. J. JOHNSON, *Anderson Labs., Inc., W. Hartford, Conn.*

A solid ultrasonic delay-line memory has been developed using inexpensive fused quartz as the propagation medium. Digital storage rates in excess of 6 megacycles, with a dynamic range of greater than 40 decibels is characteristic of the performance obtainable with delay lines operated at a 40-megacycle carrier frequency. Improved folded-path configurations and transducer bonding methods have resulted from optical studies of high-frequency acoustic beams in fused quartz.

* The research in this document was supported jointly by the Army, Navy, and Air Force, under contract with the Mass. Inst. of Technology.

41.5. Contour Modes of Plates Excited Piezo-electrically and Determination of Elastic and Piezoelectric Constants

RUDOLF BECHMANN, *The Brush Laboratories Co., Cleveland, Ohio*

This paper deals with determination of elastic and piezoelectric constants using different modes of plates. Piezoelectric constants can be determined from dynamic capacitance and from resonance and antiresonance frequencies. It is shown that the shunt capacitance involved in the second method is in general not the clamped capacitance but an effective capacitance dependent on the resonance spectrum as a whole. In plates with a single series of resonance this influence is minor, but in plates with multiple modes it is very significant. Some effects of dielectric constant observed on ADP and Rochelle salt plates are explained.

The two-dimensional equations of state for plates are discussed.

SESSION XLII

Antennas and Propagation III

(Organized by the Professional Group on Antennas and Propagation)

Chairman: H. G. BOOKER

(Cornell University, Ithaca, N. Y.)

42.1. Isotropic Variable Index Media

W. O. PURO AND K. S. KELLEHER, *Melpar, Inc., Alexandria, Va.*

An inherently strong artificial dielectric medium is formed by embedding spherical voids in a dielectric base. A theoretical and experimental investigation of such media has been carried out using a number of base dielectrics. A formula for the dielectric constant in terms of the radii of the spherical voids, the number of voids per unit volume, and the dielectric base material was obtained. Measurements were made of the dielectric constant of twenty sample media, using the shorted-line technique. In each case, the experimental data showed close correlation with the values predicted by the analytical expression.

42.2. The Characteristics of Vertical Antenna with a Radial-Conductor Ground System

J. R. WAIT AND W. A. POPE, *Radio Physics Lab., Defence Research Board, Ottawa, Can.*

Employing an approximate method the input impedance of a ground based top-loaded vertical radiator is derived. The ground system consists of a number of radial conductors buried just below the surface of the soil. The integrals involved in the solution are evaluated, in part, by graphical methods. The final results are plotted in a convenient form illustrating dependence of impedance on number and length of radial conductors for a specified frequency antenna height, and ground conductivity.

The relation between the ground wave signal intensity and the size of the ground screen is also investigated. It is shown that under usual conditions the radiated fields are modified to within only a few per cent due to the presence of the ground system.

42.3. Toward an Information Theory of Propagation through Time Varying Media

J. FEINSTEIN, *National Bureau of Standards, Washington, D. C.*

The ideal channel capacity of a communications system which involves wave propagation through a time-varying medium such as the ionosphere or troposphere is evaluated in terms of the statistical properties of the medium and of the noise. The signal fading in such a system reduces the channel capacity.

Information-theory concepts are broadened to include the possibility of multiple reception at spaced receiving sites, and the consequent increase in theoretical channel capacity is computed as a function of the number and spacing of such sites. Current practices in the use of diversity reception and the directional antennas are examined in the light of these results.

42.4. Comparative 100 Mc Measurements at Distances Far Beyond the Radio Horizon

A. P. BARSIS, *National Bureau of Standards, Central Radio Propagation Laboratory, Boulder, Colo.*

Results of 100 mc recordings are evaluated in terms of distributions of hourly medians of transmission loss, fading range, and fading rate of the received signal.

Transmitters were located at elevations of approximately 6,200, 8,800, and 14,100 feet above mean sea level on the eastern slope of the Rocky Mountains.

Receiving sites were located near Garden City and near Anthony, Kansas, at distances of 230 and 400 miles from the transmitters. Various types of antennas were employed for transmitting and receiving.

42.5. The Measurement of the Polarization of Radio Waves Reflected from the Ionosphere at Non-vertical Incidence

G. T. INOUYE, *Harvard University, Cambridge, Mass.*

Measurements of direction of arrival as well as polarization have been made on 9.1 mc pulsed transmissions over a 1,300 KM path from Glenville, North Carolina to Lexington, Massachusetts. The vertical and horizontal angles of arrival are required in order to obtain the polarization of the downcoming wave from that measured at the receiving site. A method for the continuous automatic recording of the information has been built; the directional data being in the form of two-phase measurements, and the polarization data as a phase and an amplitude ratio measurement. Data are recorded simultaneously for each pulse of the series of pulses arriving for each one transmitted. Samples of the data obtained are shown. Correlation with magneto-ionic theory is discussed.

SESSION XLIII

Microwave Electronics I—Ferrites and Strip Lines

(Organized by the Professional Group on Microwave Theory and Techniques)

Chairman: A. C. BECK

(Bell Telephone Laboratories, Inc., New York, N. Y.)

43.1. Nonreciprocal Microwave Components

H. N. CHAIT, *Antenna Research Branch, Radio Div. I, Naval Research Lab., Wash., D. C.*

The tensor permeability of magnetized ferrite materials has allowed the microwave engineer to produce a variety of nonreciprocal microwave components. Two of such components developed at the Naval Research Laboratory will be described. The first of these is of an absorption type, whereby for one direction of propagation a large amount of power is absorbed, while for the other direction of propagation, absorption is relatively small. Such a component can be used as a broadband isolator at both high and low pulsed or cw powers.

The second is of a reflection type and is based upon the fact that it is possible to design a section of ferrite-loaded guide which reflects most of the power for one sense of the incident circular polarization but transmits most of the power for the other. Such a waveguide section combined with a few other reciprocal waveguide components can effectively isolate the

generator from its load and also decouple the receiver from the generator.

An optimum design for the construction of a section of waveguide having a differential electrical length of 180 degrees is described.

43.2. Ferrite Quarter-Wave and Half-Wave Plates at X-Band

N. G. Sakiotis, *Antenna Research Branch, Radio Div. I, Naval Research Lab., Wash., D. C.*

Propagation characteristics of waves in a waveguide containing a ferrite cylinder are affected by the application of a static magnetic field to the ferrite cylinder. If the static magnetic field is perpendicular to the axis of a waveguide of circular cross section, the section of line containing the ferrite will present different electrical lengths to incident waves which are linearly polarized either parallel or perpendicular to the direction of the static field. These electrical lengths depend on both the strength of the magnetizing field and the configurations of the ferrite cylinder and waveguide. In particular, these parameters can be chosen so that the two electrical lengths differ by either 90 degrees or 180 degrees, thus yielding a component which acts as a quarter-wave plate or a half-wave plate.

The design of such quarter- and half-wave plates is described and the measured characteristics over the X-band are compared with the characteristics of standard dielectric quarter- and half-wave plates. The application of such ferrite devices to the design of amplitude modulators, phase modulators, constant insertion loss polarization rotators and phase shifters is discussed in connection with the applications which have been made by the Antenna Research Branch, Radio Division I, of the Naval Research Laboratory.

43.3. The Radiation Conductance of a Series Slot in Strip-Transmission Line*

A. A. Oliner, *Microwave Research Institute, Polytechnic Institute, Brooklyn, N. Y.*

Theoretical expressions are developed for the radiation conductance of a symmetrical series slot cut in the outer plate of strip-transmission line of the sandwich type possessing a flat inner conductor. A good physical assumption is first employed in deriving a simple approximate expression for the conductance; a more exact evaluation based on a rigorous conformal mapping is then obtained which indicates that this approximation is a very good one. The effect of a rotation of the slot is also determined.

Good agreement is obtained between the results of these theoretical expressions and measurements previously taken at the Hughes Aircraft Company.

* This work was begin at the Microwave Laboratory of the Hughes Aircraft Company during a three-month leave of absence, and completed as part of consulting services since that time.

43.4. New Techniques for High-Q Strip Microwave Components

E. Fubini, W. Fromm, and H. Keen, *Airborne Instruments Laboratory, Inc., Mineola, N. Y.*

Strip-transmission lines possess advantages in the design and construction of microwave equipment. Such lines can be constructed to have losses as low as waveguide and are fabricated much more easily, with substantial savings in cost, size, and weight. Etching, printing, and stamping techniques widely used for wiring radio chassis at low frequencies are also used for quantity production of microwave striplines and components.

New methods of construction for very low loss, dielectric-supported, microwave stripline will be described. These methods substantially eliminate the effect of all supporting dielectric material on the losses and electrical length of the line. Since the lines to be described are basically nonradiating structures, very high Q's are obtained. The electrical and mechanical characteristics of such lines will be given.

New filter and resonator structures using these techniques will be described briefly, and their adaptability to low-power microwave circuits will be indicated.

43.5. Microwave Applications of High-Q Strip Components

E. Fubini, W. Fromm, and H. Keen, *Airborne Instruments Laboratory, Inc., Mineola, N. Y.*

High-Q stripline components have wide application in low-power microwave circuits, though such application is only now being realized. The electrical performance of high-Q strip components is equivalent to that of their counterparts in coaxial line and waveguide but the cost is much less. Savings in size and weight are also very significant.

Basically new resonator and filter structures will be described and their characteristics given. Their use in such circuit applications as preselectors, microwave-receiver front ends, and low, power transmitters will also be described. Performance characteristics, such as losses, selectivity, and noise figure in these applications will be given.

The importance of stripline techniques to the microwave designer is due to the ease of fabrication of complex circuits with accompanying significant savings in cost, size, and weight. Examples of such savings in typical systems will be indicated.

Session XLIV
Instrumentation III

(Organized by the Professional Group on Instrumentation)

Chairman: A. B. Girodano (Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

44.1. A Novel Approach to Transistor Testing

N. J. Gottfried, *Production Engineer, Electronic Research Associates, Inc., Caldwell, N. J.*

With the advancement of the transistor art the need has arisen for a method of transistor testing which permits a simplified but effective evaluation of over-all properties of all classes of transistors. This paper describes the development of a novel means of testing transistors, diodes, or other semi-conductor devices on a direct-reading basis. Both static and dynamic characteristics are evaluated by this method and results are independent of voltage and temperature variations.

The method of testing developed utilizes a precision-bridge circuit in which the pertinent characteristics of the transistor under test are compared with known reference transistors. The variation from standard for a given test is read directly on a calibrated meter scale. The reference transistor may be an operating unit whose characteristics are required to be duplicated, or an equivalent circuit or resistance to yield either comparative or quantitative measurements.

A tester has been constructed utilizing the above principle. The following representative tests have been incorporated into the unit:

1. Comparison of emitter-input resistance with that of a reference unit.
2. Comparison of collector resistance with that of a reference unit.
3. Comparison of amplifying ability with that of a reference unit.
4. Check of feedback characteristics by testing ability to oscillate.

In this tester the current supplied to the transistors in the bridge circuit consists of a periodically varying unidirectional waveform produced from the ac line input. By this means the emitter currents are varied from zero to near the maximum rating. The dc null-indicating meter will, as a result, give a reading depending on the relative average emitter-input resistance. This procedure is of advantage since the measurement averages the entire emitter-voltage-current characteristic in contrast to the measurement over a small portion of the characteristic as would be obtained by a small signal method.

The features of this tester, together with its simplicity of operation, has made it particularly suitable for both laboratory development work and factory production.

44.2. Transistor Frequency Scanner

O. Kummer, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

An instrument has been designed for the oscilloscopic display of transistor-input impedance and alpha as a function of frequency. Several frequency bands are provided from 0.1–2 to 0.1–20 mc. The instrument will accommodate transistors of all polarities.

As a laboratory tool, it is a basic instrument in correlating circuit performance with the frequency variations of transistor parameters. As a production inspection tool it facilitates the rapid accurate measurement of transistor frequency cutoff.

Along with a discussion of the factors entering into the design of the frequency scanner, an evaluation of the scanner measurements in terms of other methods of measurement will be made.

44.3. A Simple Transistor-Noise and Gain-Test Set

R. W. Carlisle and H. A. Pearson, *Sonotone Corporation, Elmsford, N. Y.*

Equipment is described for selecting transistors for low-noise level for use in the progressive stages of sub-miniature audio amplifiers, such as hearing aids.

It operates on the principle of comparing the noise level with a signal inserted at the input. Measurements are made on an audio band of moderate width, which is determined by simple RC circuits. Since bursts of noise are objectionable to a listener, a peak-reading voltmeter is used. Noise measurements can be referred to the classical Noise Figure, but it has been found convenient to express them as decibels re one microvolt at the input. Gain is determined from the value of output voltage for the insert voltage used.

44.4. Wide-Band Amplitude Distribution Analysis of Voltage Sources

L. W. Orr, *Engineering Research Inst., University of Michigan, Ann Arbor, Mich.*

This report describes a method of wide-band amplitude distribution analysis of voltage sources such as random noise. It employs two commercial oscilloscopes and a phototube. A minimum set-up may be assembled in two hours from available laboratory equipment, which gives approximately 5 per cent accuracy, and performs the analysis in five seconds. It is free from the severe bandwidth restrictions of other methods and can often be employed up to 500 mc.

A discussion of the technical details is given, and results on two different noise sources are included for illustration. A modification of the minimum set-up for improving the resolution and increasing the accuracy is presented.

44.5. A Generator of Uniformly Distributed Random Noise

R. Bernstein, H. Bickel, and E. Brookner, *Columbia University Electronics Research Laboratories, N. Y.*

Many problems arising in engineering, physics, biology, and other fields of science, involve random processes in which the random variables are uniformly distributed. The best way to solve fairly complicated problems is to simulate the system and its inputs on a computer. In order to simulate a random process it is necessary to employ a noise generator whose output has an amplitude-probability distribution and power spectrum which are the same as, or proportional to, those of the actual process.

In order to generate uniformly distributed noise, it is possible to take advantage of the phenomenon, that when Gaussian noise is passed through a narrow-bandpass filter, the output can be regarded as a sine wave at the filter's center frequency with random phase and amplitude modulation. The amplitude modulation has a Rayleigh distribution, while the phase modulation causes the instantaneous phase to be uniformly distributed over the range of zero to 2 Π radians. If this waveform is fed to a phase detector, the output of the detector will be a random voltage with a uniform amplitude probability distribution. The power spectrum of the random voltage is determined by the characteristics of the narrow-bandpass filter. If statistically independent samples of uniform noise are required, they can be obtained by sampling the output of the phase detector at a rate which is slow compared to the frequencies at which most of the uniformly distributed noise power is contained.

In order to reject the carrier-frequency component that feeds through the phase detector, it is necessary to employ a post-detection filter. Unless the fractional bandwidth of the pre-detection filter is limited to one per cent, it is found that the post-detection filter causes the noise amplitude probability distribution to tend towards the Gaussian instead of remaining uniform.

The theory and circuitry of the uniformly distributed noise generator are explained, and oscillograms of the noise wave forms and measured probability distributions are presented.

Session XLV

Radio Telemetry and Remote Control III—Remote Control

(Organized by the Professional Group on Radio Telemetry and Remote Control)

Chairman: G. M. Grittain

(Armour Research Foundation, Chicago, Ill.)

45.1. A Proportional Data Transmission System

W. C. Petrie, *Collins Radio Co., Cedar Rapids, Ia.*

A system for radio transmission of continuously variable data is described. The dc input signal is amplitude modulated on a subcarrier which is then transmitted. In order to provide polarity sense and a reference zero for the demodulation process, an unmodulated subcarrier is also transmitted. The system features a stable zero and good linearity with a tolerance for reasonable incidental phase shifts. The dynamic response of the system extends from dc to above 25 cps, and the dc-to-dc gain is limited only by the gain and dynamic range of the ac amplifiers.

45.2. A Digital Autopilot Coupler

W. L. Exner and A. D. Scarbrough, *Hughes Research and Development Laboratories, Culver City, Calif.*

A system has been developed which automatically controls the heading of an aircarft in response to the output of a digital computer. This involves the use of a coupler unit which converts the binary steering signal supplied by the computer to a form acceptable to a conventional autopilot.

Factors which must be given consideration in the design of such a coupler include the operational features of the computer and autopilot, and the potential instability due to the finite iteration time of the computer. A successful coupler and its performance is described.

45.3. System Compensation with a Digital Computer

J. M. Salzer, *Hughes Research and Development Laboratories, Culver City, Calif.*

A digital computer can be programmed to compensate the performance of a closed-loop system. The design of such programs can be conducted along much the same lines as that of conventional filters. Specific examples are given of the design of compensating programs having six independent parameters. The analytical work has been verified by experiments with a digital computer in a simulated system. The combination of analytical and experimental steps in improving the quality of compensation is discussed.

45.4. Binary Control System for Digital-to-Shaft-Position Mechanisms

A. H. Wulfsberg, *Collins Radio Co., Cedar Rapids, Ia.*

45.5. Optimization of Servosystems (for time-varying spectra)

R. C. Lyman and W. P. Caywood, Jr., *Carnegie Institute of Technology, Pittsburgh, Pa.*

An analytical method is presented for synthesis of optimum-servosystem-transfer functions using the spectral densities of the input signal and the noise. Also treated are the problems of optimization and evaluation of given system transfer functions. The method treats those cases in which there are changes from time to time in either the spectral densities of signal or noise, in the system transfer function, or in dependent combinations of them. It makes use of the averages and the mean squares of the values of the spectral components existing in the various intervals, and it yields the system having the minimum mean square error. A derived expression reduces to that of Wiener, $S^2/(S^2+N^2)$ as a special case.

Session XLVI

Circuit Theory IV—Transistor Circuits

(Organized by the Professional Group on Circuit Theory)

Chairman: J. H. Felker

(Bell Telephone Laboratories, Inc., Whippany, N. J.)

46.1. A Transistor Analog

R. D. Lohman, *RCA Laboratories Div., Princeton, N. J.*

The usefulness of the transistor equivalent circuit concept may be extended by constructing a transistor analog. The analog employs a pentode vacuum tube as the active element of the equivalent circuit and variable resistances and capacitances as the passive elements. By adjusting the control voltages on the tube and choosing the proper values for the passive elements, the analog may be made to perform exactly like a transistor except for a transformation of impedance level and frequency scale.

There are certain advantages to be found in studying transistors by making measurements on the analog: 1. Circuit performance of realizable transistors may be evaluated before the transistors are actually available, 2. The effect of varying the parameters of the equivalent circuit may be quickly determined, 3. Measuring equipment may be simplified and stray capacities ignored if the analog is designed to operate at frequencies lower than those at which the transistor will operate.

46.2. Junction-Transistor Multivibrators and Flip-Flops

EUGENE SARD, *Airborne Instruments Laboratory, Inc., Mineola, N. Y.*

The analogy between junction-transistor triodes and vacuum-tube triodes is sufficiently close that conventional vacuum-tube switching circuits such as multivibrators can be transistorized simply by changing the values of the circuit constants and replacing the vacuum-tube by a junction transistor. The associated circuits will be at lower impedances and will operate at lower voltages, but the currents will remain of the same magnitude. Because of the alpha cut-off frequency, a transistorized switching circuit operates from dc to hundreds of kilocycles a second. Such measured characteristics of multivibrators as dc potentials, gate widths, and repetition periods are in good agreement with theoretical values.

46.3. A Synthesis Procedure for Linear Transistor Circuits

J. R. BURNETT, *Purdue University, Lafayette, Ind.*

The design of transistor circuits is hindered by the loading effects demonstrated by transistors which is not usually present in vacuum-tube circuits. A pure synthesis procedure takes into account these loadings. It is shown that a complete transistor can be removed at a time during a passive synthesis procedure, thus making possible an active synthesis procedure for transistors. The technique involves finding the relationship between the impedance parameters of a partitioned network and the original network. An example is shown to illustrate the technique.

46.4. Network Partitioning Techniques Applied to the Synthesis of Transistor Amplifiers

H. MARKARIAN, *Purdue University, Lafayette, Ind.*

Two methods for applying network partitioning techniques to the synthesis of transistor amplifiers are described. The syntheses of a differentiating and a Butterworth amplifier serve to illustrate and to bring out some of the advantages of these methods. In the case of the differentiating amplifier a passive network realizing a given transfer function is synthesized first. This is then partitioned, and each part resynthesized using transistors and passive elements. In the second example the partitioning is achieved by mathematical manipulation; and through a proper choice of transistor connections complex poles of the transfer function are realized without using inductors.

46.5. A New Equivalent Circuit for Junction Transistors

GE YAO CHU, *Sylvania Electric Products, Inc., Electronics Div., Ipswich, Mass.*

Based upon Shockley's and Early's work on junction transistors, a new equivalent circuit consisting essentially of two transmission lines will be presented. One line is used in the emitter circuit to represent Shockley's forward diffusion process of minority carriers in the base region. The other line used in the collector circuit represents the Early Effect which feeds the collector signal back to the emitter circuit.

Approximate equivalent circuits for grounded base and for grounded emitter connection will also be derived and will be compared with conventionally established equivalent circuits. Thus a unified view is established. Typical measured transistor parameters will be given. It will be shown that their frequency dependence verifies the above two lines.

SESSION XLVII

Electron Devices IV—Microwave Tubes

(Organized by the Professional Group on Electron Devices)

Chairman: S. WESTON

(Amperex Electronic Corp., Hicksville, L. I., N. Y.)

47.1. A Voltage-Tunable Magnetron for Operation in the Frequency Range 1,500 to 3,000 Megacycles

J. A. BOYD, *Engineering Research Institute, University of Michigan, Ann Arbor, Mich.*

A voltage-tunable magnetron has been developed for operation in the frequency range of 1,500 to 3,000 mc. This magnetron can be electrically tuned over a frequency range of approximately 800 mc, at a tuning rate of approximately 1-mc per volt change in anode potential. The power output is of the order of 250 mv throughout this frequency range.

This magnetron is of the external-cavity interdigital type. An associated cavity structure suitable for wide-band voltage-tunable operation has been developed and tested with the tube. It has been shown that this magnetron is useful as a local oscillator in spectrum analyzers, microwave receivers, and so forth.

A theoretical voltage-tuning equation for a magnetron has been derived and the experimental data have been interpreted in terms of this theoretical curve and the properties of the rf circuit arrangement.

47.2. Control of Electron-Beam Spread by Positive Ion Traps*

E. L. GINZTON AND B. WADIA, *Microwave Laboratory, Stanford University, Calif.*

The negative charge of an electron beam can be neutralized by confining positive ions in the beam space. The residual gas within the tube envelope forms positive ions by electron collision and these ions can be held within the beam by placing a "trapping" electrode with an appropriate potential at the cathode end of the drift tube.

Since this simple method was first proposed,[1] attempts to make the scheme work have yielded unsuccessful results[2] which could not be explained by the prevailing theory.

A study of the phenomenon reveals that the trapping process is more complex than was originally believed.

A qualitative theory is advanced which is consistent with experiment and leads to suggestions for improved performance.

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[1] Field, Spangenberg, and Helm, *Electrical Communication*, vol. 24, pp. 116–118; 1947.

[2] Conferences with Varian Associates of San Carlos, Calif., and experiments by the author.

47.3. The Multipactor Effect in Klystrons

KEES BOL, *Sperry Gyroscope Co., Great Neck, N. Y.*

A factor in the design and operation of klystrons is a secondary electron loading effect known as multipactor. It arises when a secondary electron emitted from one side of the interaction gap crosses the gap under the influence of the rf field in an odd number of half cycles. Then any electrons released by it can recross, and the process can build up until considerable rf power is being dissipated.

A simplified analysis of the phenomenon and an evaluation of the critical factors will be presented. Ways of avoiding multipactor in its more virulent manifestations will also be discussed.

47.4. Backward-Wave Oscillator Characteristics

H. R. JOHNSON, *Hughes Research and Development Laboratories, Culver City, Calif.*

This paper contains theoretical and empirical design information on backward-wave oscillators with power outputs below 100 watts. The main design parameters which are discussed are tuning range, power output, and frequency stability. All the experimental work has been carried out with helix-type tubes with hollow beams. Tuning ranges of 9:1 have been obtained, with reasonably constant output power over a 2:1 range. One tube oscillated from 500 to 4,500 mc, another from 7,000 to 14,000 mc. At 3,000 mc, 30 watts output has been obtained for 400 watts input.

47.5. The Propagation Properties of Cross-Wound Twin Helices Suitable for Traveling-Wave Tubes*

M. CHODOROW, E. L. CHU, AND J. R. NEVINS, JR., *Microwave Laboratory, Stanford University, Calif.*

A cross-wound twin helix used as a propagating structure for traveling-wave tubes has advantages over the conventional single helix, particularly for high-voltage operation. Because of the symmetry of the fields in a twin helix, impedance of the fundamental component is much higher than for the single helix, and impedance of the backward-wave harmonics is much less. This will improve the gain in amplifier operation and make backward-wave oscillation much less apt to occur for the twin helix. Calculations of propagation constants and impedances for a range of dimension have been made, and measurements of these properties are in good agreement with the theory.

* The research reported in this document was supported jointly by the U. S. Army Signal Corps, U. S. Air Force, and the U. S. Navy (Office of Naval Research) under Office of Naval Research Contract No. N6onr-25123.

SESSION XLVIII
Ultrasonics II

(Organized by the Professional Group on Ultrasonics)

Chairman: J. F. HERRICK
(Mayo Clinic, Rochester, Minn.)

48.1. Applications of Ultrasonic Energy to Industrial Use

A. L. BAYLES, *Bayles, Hollenbeck & Co., Pittsburgh, Pa.*

The paper stems from the condition that many scientists, engineers, and laymen, including the writer are fascinated by the phenomena accompanying ultrasonic energy and their possible application to industrial use. Allusions to applications are numerous but in some cases are almost as mythical as the roc's egg. Pin-pointing attempts have resulted only in hearsay accounts. In other cases such efforts are met with disappointment since the applications are either out of the ultrasonic range or fall short of the objectives which they were intended to achieve. The writer, over a period of time, has attempted to identify and codify as many ultrasonic applications as possible. The purpose was to gain enlightenment and make an evaluation of the extent of possible future use. This paper embodies a summary of those efforts.

48.2. The Effects of Ultrasonic Waves on Electrolytes and Electrode Processes

S. BARNARTT, *Westinghouse Research Laboratories, East Pittsburgh, Pa.*

The use of ultrasonic waves in determining properties of electrolytic solutions is discussed. Compressibility data, ionic hydration, and the temperature or pressure coefficient of conductivity can be determined. A large number of ultrasonic effects on electrode reactions are described. These include the appearance of an alternating component in the electrode potential, a marked decrease in electrode polarization, changes in grain growth of electrodeposits, preparation of fine metallic powders by ultrasonic dispersion during electroplating, and acceleration of metal corrosion by the degradation of passivating films.

48.3. The Application of Ultrasound to the Brain

P. A. LINDSTROM, *Veterans Administration Hospital, Pittsburgh, Pa.*

The effect of high-frequency sound on animal brains was studied and, on the basis of the findings, a method was developed for application of ultrasound to the brains of humans. Some structural and functional alterations following such irradiation are described. The results appear to be of clinical value.

48.4. Selective Action of Ultrasound on Nerve Tissue

W. J. FRY, *University of Illinois, Urbana, Ill.*

High level ultrasound applied for short periods of time can produce extremely selective actions on the tissue components of the central nervous system. These selective actions are not caused by temperature changes resulting from absorption of the sound in the tissue nor are they caused by cavitation.

It is possible to reduce the population of neurons in any desired region of the central nervous system without destruction of the vascular system on the nerve tracts passing through the irradiated region. By using a focused beam, disturbance to nerve tissue between the region to be affected and the position of entry of the sound into the system can be eliminated.

This tool is now being used in a series of experimental neurological studies. A survey of some of the possibilities and results already obtained will be presented.

48.5. Effects of Ultrasound on Living Cell Structure

E. H. NEWCOMER, *University of Connecticut, Storrs, Conn.*

Water-borne ultrasonic vibrations at a frequency of 400 kc and intensities of two, four, seven, and twenty watts/cm² produce cellular aberrations in plant tissues, the most obvious of which are chromosome breakages and nuclear aberrations. At intensities of seven and twenty watts/cm² genetic mutations were produced by treating the shoot tips of plants and the fruit fly, *Drosophila melanogaster*. There is also some evidence that the exposure of Sarcoma 37 in mice caused complete regressions of the tumor. The exposure of plant tissues below an intensity of 1 watt/cm² produced a stimulating effect without cellular aberrations resulting in a more rapid growth rate.

SESSION XLIX
Antennas and Propagation IV—Symposium: UHF Television—Boom or Bust

(Organized by the Professional Group on Antennas and Propagation)

Chairman: J. B. SMYTH
(Atmospheric Studies Branch, U.S.N. Electronics Lab., San Diego, Calif.)

49.1. F.C.C. Rules and Propagation Data

E. W. ALLEN, JR., *Federal Communications Commission, Washington, D. C.*

The engineering which is incorporated into the F.C.C. rules is designed to provide a satisfactory administrative tool for station assignment and licensing purposes. With the rapid growth of television, it was found necessary to include in the rules a national assignment plan based upon available propagation and equipment data and upon estimates of average service areas. The data and procedures used for the development of the mileage spacings employed in the assignment plan; for the development of the propagation curves; and for the estimates of field strengths required for various grades of service are examined and discussed.

49.2. Propagation in the UHF-TV Band

J. W. HERBSTREIT, *National Bureau of Standards, Boulder, Colo.*

The Central Radio Propagation Laboratory of the National Bureau of Standards has been conducting a program of research at frequencies of 418 and 1,046 mc in conjunction with an extensive 100 and 200 mc program of measurements throughout the United States. This research program has revealed many aspects of the frequency dependance of propagation from 100 to 1,000 mc, including the attenuation with distance and the magnitude of signal strength variations. Reception of 1,046-mc transmissions 400 miles from Cheyenne Mountain, Colo. has been found possible at all times. By far the most important factor determining the available signal power available to the receiver in the uhf band is the effective absorbing area of the receiving antennas. This is illustrated by the use of the transmission loss concept in presenting the results of propagation studies. Transmission loss and its variability versus distance will be presented for a number of frequencies in the vhf and uhf bands as derived from the National Bureau of Standards propagation research program and an interpretation of the results will be given in terms of expected service and interference ranges in the uhf band.

49.3. Overcoming the Line-of-Sight Shibboleth with the Air and High Power*

T. J. CARROLL, *Lincoln Laboratory, M.I.T., Cambridge, Mass.*

For both vhf and uhf, omnipresent weak fields are observed to be propagated from high power transmitters with attenuation rates of a few tenths db/mile well beyond the horizon. Conventional airless earth propagation theory can now be amended to understand these fields as an effect of the earth's air as a dielectric coating, occasionally or perpetually turbulent. The apparent possibilities for uhf-tv transmissions beyond the horizon, when 1 megawatt of effective radiated power becomes available, can be indicated. Historical parallels with the early days of other broadcast bands are easily traced, with the optimists being proved right by time.

* The research in this document was supported jointly by the Army, Navy, and Air Force under contract with the Mass. Inst. of Technology.

49.4. A Comparison of the Antenna Problems in UHF and VHF-TV

L. O. KRAUSE, *General Electric Co., Syracuse, N. Y.*

A comparison of the antenna problems between uhf and vhf television is primarily a study of those factors which are frequency sensitive. In a broad sense an antenna system includes the transmitting and receiving antennas, the associated transmission lines, and the wave propagating media including the atmosphere and the earth. Wave distortions due to the propagating media increase with frequency.

These distortions, among other things, handicap the possible effectiveness of receiving antennas. Hence, the best possible transmitting antennas are needed at uhf. At the same time, the higher frequencies of uhf influence the design approach to the antennas. A transmitting antenna for example has two distinct functions: 1. To transform efficiently the bounded wave energy fed it to an unbounded radiating wave, and 2. To shape the unbounded radiating wave front to produce the required pattern characteristics. The problem of satisfying these functions changes with frequency.

This paper does not detail the propagation variables, but recognizes their indirect effects in influencing the required antenna designs. The main emphasis is placed on the direct effects of frequency on antenna design.

SESSION L

Microwave Electronics II—Components

(Organized by the Professional Group on Microwave Theory and Techniques)

Chairman: A. E. SMOLL

(General Electric Co., Electronics Park, Syracuse, N. Y.)

50.1. Design of Stable Tunable Microwave Oscillators

J. G. STEPHENSON, *Airborne Instruments Laboratory, Inc., Mineola, N. Y.*

Stable triode oscillators that can be tuned over a 15 per cent range at frequencies up to 3,000 mc have been built. Under favorable laboratory conditions, most of the rf energy from these oscillators is concentrated in a bandwidth of about one part in 10^8. Ripple in the plate voltage varies the frequency only a few cycles per megacycle per volt. Such oscillators are useful where high short-term stability is required together with ease in tuning to any frequency in a fairly wide range. High inherent stability and immunity from external influences are obtained by careful co-ordination and compromise between design factors.

50.2. Microwave Measurements with a Lossy Variable Short Circuit

H. M. ALTSCHULER AND A. A. OLINER, *Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.*

The use of a lossy variable short circuit becomes an undesirable necessity in certain measurement situations, while in others its deliberate use facilitates the measurement of low-loss structures.

In both of these cases, the present approach permits the analysis of the data to proceed in a manner identical to that employed when lossless short-circuits are used. It results in a composite two-port from which the desired parameters are separated via particularly simple relations.

Applications are made to a variety of measurements, including those of two-ports, attenuation constants, and cables.

50.3. Survey of Design Techniques and Operating Characteristics of Directional Couplers

P. J. SFERRAZZA, *Sperry Gyroscope Co., Great Neck, N. Y.*

Specific applications of directional couplers are discussed. The errors caused by nonideal behavior in these applications are presented. Design techniques for several classes of couplers, including ones constructed in coaxial and rectangular waveguides, are covered in this paper.

In the analysis of slot-type coupling structures, the effects of the width, length, thickness, location, and orientation of the slots are considered. Arrays considered include iterative, binomial, and Tchebyscheff distributions. Experimental data supporting design techniques are presented.

50.4. Diplexing Filters

M. E. BREESE, *Sperry Gyroscope Co., Great Neck, N. Y.*, AND S. B. COHN, *Stanford Research Institute, Stanford, Calif.*

The application of the image-parameter method utilizing standard filter sections to the design of broadband lumped element filters is described. Series-derived *m*-type sections are used. By paralleling a low-pass and high-pass filter using the method of fractional terminations, a band-separation or diplexing filter is obtained.

The image-parameter method is extended to the design of coaxial filters using structures analogous to the lumped element filter sections, and taking exact account of the transmission line effects. The same technique can be applied to waveguide filters. However, the resulting circuit is the dual analog of the coaxial filter, and is obtained directly from coaxial design.

50.5. A High Precision Compensated Reference Cavity for C-band

JOHN HALL AND FRANK MCCARTHY, *Sylvania Electric Products Inc., Electronics Div., Woburn, Mass.*

A high-precision reference cavity for use in C-band is described. An accuracy of ±0.2 mc (0.004 per cent) over a 75 degree C. temperature range has been obtained. This has required the solution of many problems of design and construction. These problems are discussed.

The methods of measurement used to determine conformance to these extreme limits of frequency tolerance are also of interest. Conventional methods cannot be used both because of the precision required and because of the high Q of the cavity. The solution to this problem is discussed.

SESSION LI

Electronic Computers III—Discussion

(Organized by the Professional Group on Electronic Computers)

Chairman: G. M. AMDAHL

(International Business Machines Corp., Poughkeepsie, N. Y.)

Discussion Leaders

N. ROCHESTER, *International Business Machines Corp., Engineering Laboratory, Poughkeepsie, N. Y.*

JOHN VON NEUMANN, *Institute for Advanced Studies, Princeton, N. J.*

W. B. HUSKEY, *Institute for Numerical Analysis, University of California, Los Angeles, Calif.*

J. W. MAUCHLY, *Remington Rand, Inc., Philadelphia 3, Pa.*

L. N. RIDENOUR, *International Telemeter Corp., Los Angeles, Calif.*

CLAUDE SHANNON, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

E. F. MOORE, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

A. L. SAMUEL, *International Business Machines Corp., Poughkeepsie, N. Y.*

J. B. WIESNER, *Massachusetts Institute of Technology, Cambridge, Mass.*

Two topics of general interest will be discussed:

(1) Can Computers be made more Autonomous?

(2) Can Computers be made to Repair Themselves?

These topics will be introduced by discussion leaders, and then opened to the floor. After completion of discussion, further subjects of import and interest will be picked up and talked on by members of the audience. One of these suggested subjects is "Diode Testing."

IRE News and Radio Notes

General Wood to Speak at PGANE Luncheon

General Floyd B. Wood, USAF, will speak on "The Air Weapons System Management Plan and the Electronics Industry" on Tuesday, March 23, at the luncheon of the Professional Group on Aeronautical and Navigational Electronics to be held during the IRE National Convention in New York City. General Wood is Deputy Chief of Staff for Development at the Air Force Air Research and Development Command Headquarters in Baltimore, Md.

The original Air Weapons System Management Plan, under which a single prime airframe contractor purchased all electronic equipment used in his airframe, has recently been revised by a new Air Force regulation. General Wood will discuss the new regulation and its effects on the aviation electronics industry. Following his formal remarks, General Wood has agreed to entertain questions from the floor.

General Wood's talk and the luncheon will highlight "Aviation Electronics Days," commemorating the 50th anniversary of powered flight, which will also include three PGANE technical sessions on March 22–23. The luncheon and the Tuesday PGANE sessions will be held at the Hotel Shelton, Lexington Avenue and 49th Street, New York City. Tickets for the luncheon can be purchased from local PGANE chairmen or by writing to W. P. McNally, The W. L. Maxson Corp., 460 W. 34 Street, New York 1, N. Y.

Cumulative Index to Be Available Soon

The Cumulative Index for the Proceedings of the I.R.E., the Professional Group Transactions, and the I.R.E. Convention Record, for the period 1948–1953, will soon be available. The Index will be sold to members at a price of $1.00, and to nonmembers at a price of $3.00. Orders with payments should be sent to The Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y.

International Symposium to Be Held

"Information Networks" is the topic of the third of a series of annual international symposia to be held April 12–14 at the Engineering Societies Building in New York City.

The Symposium will deal with network theory, particularly network synthesis as it is influenced by the newer concepts developed in information and general communication theory. In particular, the first part will concentrate on the performance of networks and their design for specific types of information such as pulses, pulse modulation, statistical inputs, etc. The second part will concentrate on the generalized network concepts and their application to computer and switching systems, neuron networks and optical systems. American and European authorities who have made original contributions to the art, will participate.

The co-operation of the IRE Professional Group on Circuit Theory and the co-sponsorship of the Office of Naval Research, the Air Force Office of Scientific Research and the Signal Corps permits this symposium to be held without admission charge or registration fee. The "Proceedings of the Symposium on Information Networks" will be published October 1954, at a cost of $4.00 per copy. Members of the Professional Group on Circuit Theory may obtain a copy at a cost of $3.00. Orders for the "Proceedings," accompanied by check or money order made out to the Treasurer, Network Symposium, will be accepted in advance. Copies of the detailed program, hotel accommodation information and registration forms are available on request. All correspondence should be addressed to The Polytechnic Institute of Brooklyn, Microwave Research Institute, 55 Johnson Street, Brooklyn 1, N. Y.

Are You Eligible for Higher Grade of IRE Membership

Every member of the IRE should be registered as a member in the highest grade for which he is qualified. If you feel that you are eligible for a higher grade, contact your local Section officers, or write to the IRE Headquarters, for a transfer form and full details, at the following address: The Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y.

Calendar of COMING EVENTS

1954 IRE National Convention, Waldorf-Astoria Hotel and Kingsbridge Armory, New York, N. Y., March 22–25

The Association of Radioelectricians, International Sound Recording Congress, Paris, France, April 5–10

RETMA Conference on Reliability of Electrical Connections, Illinois Institute of Technology, Chicago, Ill., April 15–16

Stanford Research Institute-United States Air Force Symposium on Automatic Production of Electronic Equipment, Fairmont Hotel, San Francisco, Calif., April 19–20

Electrochemical Society Semiconductor Symposium, La Salle Hotel, Chicago, Ill., May 2–6

Society of Motion Picture & TV Engineers, 75th Semi-Annual Convention, Hotel Statler, Washington, D. C., May 2–7

IRE-AIEE-RETMA Electronic Components Symposium, Washington, D. C., May 4–6

IRE Seventh Region Technical Conference, Multnomah Hotel, Portland, Ore., May 5–7

IRE New England Radio Engineering Meeting (NEREM), Sheraton Plaza Hotel, Boston, Mass., May 7–8

IRE National Airborne Electronic Conference, Biltmore Hotel, Dayton, Ohio, May 10–12

IRE-AIEE-IAS-ISA National Telemetering Conference, Morrison Hotel, Chicago, Ill., May 24–26

IRE Symposium on Global Communications, Washington, D. C., June 10–12

IAS Annual Summer Meeting, IAS Building, Los Angeles, Calif., June 21–24

British Iustitute of Radio Engineers, 1954 Convention, Christ Church, Oxford, England, July 8–12

IRE-WCEMA Western Electronic Show & Convention, Pan Pacific Auditorium, Los Angeles, Calif., August 25–27

National Electronics Conference, Hotel Sherman, Chicago, Ill., October 4–6

Society of Motion Picture & TV Engineers Seventy-sixth Semi-Annual Convention, Ambassador Hotel, Los Angeles, Calif., October 17–22

IRE-RETMA Radio Fall Meeting, Hotel Syracuse, Syracuse, N. Y., October 18–20

IRE News and Radio Notes

Authors for 1954 IRE West Coast Convention

F. G. Suffield, Chairman of the Technical Program Committee for the 1954 WESCON scheduled for August 25–27 in Los Angeles, requests that prospective authors of papers to be considered for presentation submit the following information to him as soon as possible: (1) name and address of author; (2) title of paper; and (3) a 100-word abstract and additional information of from 500 to 1,000 words, both in duplicate, to permit an accurate evaluation of the paper for inclusion in the Technical Program.

All material should be addressed to F. G. Suffield, Triad Transformer Corp., 4055 Redwood Avenue, Venice, Calif. The deadline for acceptance is April 1, 1954.

Tape Recorded Papers Available for IRE Meetings

Under the auspices of the IRE, a plan has been set up for stimulating the issuance of tape recordings of technical papers accompanied by lantern slides by various industrial and technical organizations. These tapescripts are intended primarily for use by IRE Sections, Subsections, Student Branches, and Professional Group Chapters which are so located that speakers for their meetings are not always readily available.

The IRE Ad Hoc Committee on Tapescripts has prepared a binder giving information on tapescripts presently available. The binder has been distributed to Section Secretaries and to Institute Representatives in colleges. Additional copies may be obtained by interested Subsection and Professional Group Chapter Officers upon request to IRE Headquarters, 1 East 79 Street, New York 21, N. Y.

Plans Made for Women Guests at IRE National Convention

In addition to the Tea to be held on March 23rd, arrangements have been made for the West Foyer of the Waldorf-Astoria Hotel to be open for the women guests of the National Convention. A professional hostess will give information on local current activities. Special passes for free bus service will be provided for those women who want to visit the Kingsbridge Armory to see the exhibits. These passes will be available in the West Foyer of the Waldorf, or at a special booth at the Armory.

Social Events

The IRE Convention Cocktail Party will be held from 5:30 P.M. to 7:30 P.M., Grand Ballroom of the Waldorf Astoria Hotel, Monday, March 22nd.

The Annual Banquet will be held in the Waldorf-Astoria Grand Ballroom March 24th, at 6:45 P.M.

Both functions may be attended by subscription only. Early reservations are desirable, and may be obtained by mail. Write to Miss Emily Sirjane, at the Institute, 1 East 79th Street.

Professional Group News

New Chapters Approved

At the IRE Executive Committee meeting held on January 5, the following Professional Group Chapters were officially approved: the Dayton Chapters of the Professional Groups on Component Parts and Nuclear Science; the Cleveland Chapter of the Professional Group on Audio; the Phoenix Chapter of the Professional Group on Audio; the Houston Chapter of the Professional Group on Vehicular Communications; and the New York Chapters of the Professional Groups on Electronic Computers, Aeronautical, Navigational Electronics. This is a total of 81 Chapters approved in 23 Sections.

Technical Committee Notes

The **Standards** Committee convened November 12th under the chairmanship of Ernst Weber in the absence of A. G. Jensen. IRE objections to ASA C42, Communications Definitions, were first considered. Copies of the proposed ASA Standard, Definitions of Electrical Terms—Group 65—Communications, were distributed to the members of the committee for comment. M. W. Baldwin explained that he had received comments from members among whom were Messrs. Cady, Goodale, Sandretto, and Shea. In addition, he himself had contributed comments on six television definitions. All of the above comments were reviewed by the committee and action was taken. M. W. Baldwin expressed appreciation to the people who had contributed their comments on these definitions. Next considered were the Proposed Standards on Television: Methods of Measurement of Aspect Ratio and Geometric Distortion (53 IRE 23. PS1). A. J. Baracket advised that the originator of this standard was I. C. Abrahams of Subcommittee 23.3 of which A. J. Baracket is the Chairman. Chairman Weber pointed out that this Standard has gone on Grand Tour and has had favorable comment with few suggestions for changes or additions. A. J. Baracket stated that the suggested changes had been incorporated in the standard. The use of Fig. 3 was questioned. M. W. Baldwin was to check with RETMA concerning this figure. It was also decided that this standard would have to conform to the accustomed style of IRE Standards. W. J. Poch made the motion that the Standards Committee approve this proposed standard with the changes made. This was seconded by W. P. Mason.

Under the chairmanship of D. C. Ports the **Antennas and Waveguides** Committee met on December 9th. The committee gave a vote of thanks to John Ruze for his work in preparing the Annual Review material. The work was reviewed in detail and approved with minor modifications. The West Coast Subcommittee has agreed to relinquish to members on the East Coast the task of preparing IRE Standards on Methods of Testing Waveguide Components and instead will work on a revision of Antenna definitions. Henry Jasik has agreed to form a subcommittee to prepare a draft on the above Methods of Testing. Proposed members of this subcommittee (2.4) are E. Fubini and A. Oliner. The goal was broadly outlined by the Chairman with the help of the committee. The remainder of the meeting was spent in a discussion of Waveguide Component terms.

The **Feedback Control Systems** Committee convened on December 8th under the chairmanship of J. E. Ward. Chairman Ward discussed the possibility of increasing the committee membership in order to have a larger working group. The Chairman described the action taken by Subcommittee 26.1 at their meeting on December 7th relative to the comments of the committee on the subcommittee report 53 IRE 26.1 R. The committee discussed G. A. Biernson's memorandum to Chairman Ward dated December 1, 1953, which was distributed to the committee and subcommittee prior to the meeting. Chairman Ward summarized the discussion of the committee in regard to G. A. Biernson's memorandum and the Subcommittee's report 53 IRE 26.1 R. It was the feeling of the committee that the only fundamental question remaining was in the use of a summing point or a mixing point in the Basic Feedback Control Loop and that there may have been an error in the interpretation of the intent of the committee by the subcommittee. The committee suggested that the summing point for the mixing point modification be incorporated into the report of the subcommittee and that the subcommittee review the remainder of the report with this in mind. It was the consensus of the committee, however, that only minor changes would result and with this exception, the committee expressed complete satisfaction with the subcommittee report and again gave a vote of confidence to their work. The committee was given copies of a rough draft of the report on Feedback Control Systems for their review. Comments on the report were to be given to G. A. Biernson.

The **Video Techniques** Committee met on December 3rd under the chairmanship of W. J. Poch. Television definitions included in the ASA proposal—American Standard, Definitions of Electrical Terms were reviewed at some length. J. L. Jones, Chairman of the Subcommittee on Video Transmission, sent a telegram to Chairman Poch stating that as a result of his subcommittee meeting the following decisions had been made: First, to ask for approval to extend the work of the subcommittee to include color transmission; second, to concentrate on a single standard for the measurement of differential gain and phase which seems most urgent and quite capable of prompt completion; third, to meet January 12th with new drafts of material on definitions, apparatus and procedures for six methods of measurement likely to be included. There was general agreement concerning the desirability of including both phase and amplitude measurements in the same standard. It was hoped that completion of the standard proposal will not be seriously delayed by inclusion of the added material.

IRE People

Major Edwin H. Armstrong (A'14–F'27), the inventor of frequency modulation and one of the leaders in radio development, died recently.


E. H. Armstrong

Major Armstrong was born in New York City on December 18, 1890. He entered Columbia University in 1909, and in 1913 he received his Bachelor's degree in Electrical Engineering. He remained at Columbia as an assistant in the Department of Electrical Engineering for one year. In 1915 he received the Trowbridge Fellowship at Columbia, and continued his work, begun in 1914, with Professor Michael I. Pupin at the Marcellus Hartley Research Laboratory. From 1917–1919 he served in the A.E.F. with the Signal Corps. He received the degree of Doctor of Science from Columbia University in 1929, and became Professor of Electrical Engineering at that Institution in 1937, continuing in this post until his death.

Major Armstrong was the inventor of four of the most important processes in radio development. In 1913 he invented the regenerative circuit, a development which made possible loud-speaker reception. In 1918, while he was serving with the Signal Corps, he developed the superheterodyne receiver circuit, which is used universally in ordinary radio receivers. The super-regenerative receiver circuit, which he invented in 1920, provided even greater amplification and made high-frequency short wave much more effective. As early as 1914 he began looking for a static eliminator, and by 1933 his experiments led him to the invention of the system of frequency modulation which eliminated electrical disturbances and brought about a marked increase in radio stations. His most recent work was in the development of a system of multiplexing FM so that more than one program could be sent out simultaneously on the same wavelength.

Major Armstrong had published many technical articles in the PROCEEDINGS OF THE I.R.E. and other professional journals. He was the recipient of a Presidential citation for his contribution to military communications, and in 1919 was made a Chevalier de la Legion d'Honneur. His other honors included: the first Medal of Honor of the IRE, awarded in 1917; the Egleston Medal, Columbia University, 1939; the "Model Pioneer" Plaque, National Association of Manufacturers, 1940; the Holley Medal, American Society of Mechanical Engineers, 1940; the Franklin Medal, Franklin Institute, 1941; the John Scott Medal, Board of City Trusts, City of Philadelphia, 1941; the first Armstrong Medal from the Radio Club of America, 1935; and the Medal for Merit, 1947.

The appointment of **Arthur C. Weid** (M'44) as a vice president of Melpar, Inc., Alexandria, Va., a subsidiary of and central laboratory for Westinghouse Air Brake Co., has been recently announced.


A. C. Weid

Mr. Weid was graduated from Alabama Polytechnic Institute in 1936 with a B.S. degree. He received his Master of Science degree from New York University in 1938. After graduate work in mathematics at the University of North Carolina, he joined in the war research project at Columbia University which later became the Airborne Instrument Laboratory. During the post-war period, when the Laboratory became an independent commercial organization, Mr. Weid was director of military engineering projects.

Mr. Weid has been chief engineer for Melpar since 1951, and executive assistant to the executive vice president and general manager since 1952. After joining Melpar in 1947, Mr. Weid became project engineer in charge of the engineering development of microwave systems and other complex electronic and sonar devices.

Mr. Weid is a member of the American Physical Society, Eta Kappa Mu, and Phi Kappa Tau.

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The promotion of **Louis D. Stevens** (S'47–A'50) to the position of Development Engineer in the San Jose Laboratory of the IBM Corp. was announced recently.

Mr. Stevens received training in radio, radar and allied electronics at several naval schools, and upon his discharge from the service, attended Texas Institute of Technology, from which he received his Bachelor's degree in Electrical Engineering. He was then accepted as a graduate student and teaching assistant in the Division of Electrical Engineering at the University of California, from which institution he received his Master's degree in Electrical Engineering.

Mr. Stevens joined IBM in 1949 at the Poughkeepsie Laboratory. He assisted in the initial planning for the Tape Processing Machine and Auxiliary Machine for the IBM System. He was also in charge of a group concerned with the design and construction of the general input-output control circuits and magnetic tape and drum units of the 701 Calculator. In May, 1953, he was transferred to the San Jose Laboratory where he assumed the position of technical assistant to the Manager.

Mr. Stevens is a member of the AIEE, Sigma Xi, and the Association for Computing Machinery.

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Frank R. Norton (A'31–M'40–SM'43), until recently the chief radar and magnetic devices engineer for the Magnavox Co., has been appointed Director of Engineering for the Sparton Radio-Television Division of The Sparks-Withington Co.


F. R. Norton

A native Californian, Mr. Norton is a graduate of the University of California and Columbia University. He takes over his Sparton assignment after more than 23 years of service in top engineering posts for major firms. For 14 years, starting in 1930, he served as a member of the technical staff of Bell Telephone Laboratories, Inc., in which position he took part in the development of numerous advances in the fields of radio broadcasting, television, radar and related branches of electronics. From 1944 to 1945, Mr. Norton was senior development engineer of the Curtiss-Wright Corp. Development Division at Bloomfield, N. J., where as chief of the electronics laboratory, he participated in the development of radar and flight trainers. For five years afterward he was affiliated with the Bendix Aviation Corp., serving first as principal research engineer of the radio division and later as chief engineer of the television and broadcast receiver division. For the Bendix Co., he was responsible for the entire television and radio engineering program for home receivers. Mr. Norton went with the Magnavox Co. in 1950 as chief television engineer, later becoming chief radar and magnetic devices engineer.

He is the author of a number of professional papers, holds several domestic and foreign patents, and is a member of several professional fraternities and associations

Books

Principles of Automatic Controls by Floyd E. Nixon

Published (1953) by Prentice-Hall, Inc., 70 Fifth Ave., New York, N. Y. 346 pages+5-page index+52-page appendix+3-page bibliography+xi pages. Illus. 5¼×8¼. $9.35.

Floyd E. Nixon is an electro-mechanical group engineer with the Glenn L. Martin Company.

As the author writes in his preface, "this book is concerned with all aspects of linear system design and covers transient response, frequency response, stability criteria, numerical integration, automatic computers and transient analysis. The book is intended as a reference, self-study, or under-graduate level text."

The first impression one gets on paging through the book is very favorable. There is a profusion of fine photographic illustrations, line drawings, block diagrams, curves, and tables; there is some new material, including a chapter on automatic computers; the presentation appears to be well organized and the author's style seems to be clear and concise.

Unfortunately, careful reading does not sustain the initial impression. There is no one major reason for this. The disappointment is probably brought about by the cumulation of many minor irritations. One frequently finds that a basic concept is treated sketchily and with little, if any, motivation; that a technique of analysis or design is presented in a cook-book fashion; and that the descriptive material does not explain adequately the operation of various types of regulating systems. One notices also many instances of carelessness in the wording of definitions, many ambiguous statements, and many cases in which the reader would be at a loss to follow the presentation unless he knew a great deal more about mathematics than first year calculus—which is all that is presupposed by the author.

To cite a few examples: on page 48 the author gives an expression for a time-function in terms of a contour integral of its Laplace transform, but fails to specify the contour of integration and does not explain what is meant by a contour integral; in Chapter 3 the author does not discuss methods of handling problems in which the opening or closing of a switch modifies the structure of a circuit, and yet the collection of problems at the end of the chapter includes three problems of this type; on page 134 the author makes the ambiguous, if not incorrect, statement: "In every physical system, if the system gain is increased sufficiently, the system becomes unstable"; pure time-delay (linear) systems are treated in the chapter headed "Nonlinear Systems," in which, incidentally, the author concludes that "linear techniques are fully applicable to many nonlinear problems."

It has long been recognized that the theory of linear systems rests on the principle of superposition. This reviewer, however, could not find a statement of it in the book—not even a passing reference to it. Nor could he find a definition of the impulsive response or an expression for the superposition integral. By completely ignoring the time-domain approach, the author has taken, in this reviewer's opinion, a long step backward.

Although the book might not be as good as it appears on summary glance, it unquestionably contains a great deal of useful factual information, particularly on the design of compensating networks. It may attain wide usage as a text on automatic controls at an intermediate level.

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Electricity & Magnetism by Edson Ruther Peck

Published (1953) by McGraw-Hill Book Company Inc., 330 W. 42nd St., New York 36, N. Y. 470 pages +6-page index+xii pages. 181 figures. 6×9. $7.50.

Edson Ruther Peck is Associate Professor of Physics at Northwestern University.

The aim of this work is to give a modern presentation of the subject at an advanced level. It is mainly theoretical in character and is in no wise intended as a textbook on instruments, apparatus, or measurements. The subject matter relates, rather, to the mathematical formulation of the basic laws of the electromagnetic field. For this treatment, a background of physics and a knowledge of the elements of calculus are assumed. Vector algebra is used throughout, but the basic theorems of this notation are explained.

An unusual feature of the work lies in the extensive and detailed attention to electrostatics and dielectric theory and to steady-state magnetism, magnetic properties of matter and electromagnetic induction. More than half of the book is devoted to these subjects.

The treatment is scholarly and rigorous. The derivation of the Maxwell equations and their simple applications to electromagnetic waves and radiation leads out of this background and is accomplished in a masterly manner.

The chapters on direct current and alternating current circuits and elementary transients are more conventional. Considering the relatively small space devoted to them, they may be considered thoroughly done. However, these chapters will hardly take the place of textbooks devoted to these subjects. No attempt is made to include sections on transmission line theory, theory of filters, or electronics.

The book is written for undergraduates at advanced level, but to this reviewer it seems more clearly to minister to the needs of the graduate student or advance college physics major. The numerous well-chosen problems which accompany each chapter are designed to relate the results of the text to the practical needs of the student, but it seems possible that to the average undergraduate college student the book may appear abstruse and difficult.

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Television Broadcasting by Howard Chinn

Published (1953) by McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York, N. Y. 690 pages+10-page index+vii pages. 346 figures. 6¼×9¼. $10.00.

Howard Chinn is Chief Engineer of the Audio-Video Division, General Engineering Dept., CBS, Inc.

As the author states in the preface, his book is primarily directed to those "interested in the technical aspects of television broadcasting." Such a group includes people with extremely varied interests and backgrounds. Accordingly, *Television Broadcasting* does not treat in highly technical fashion matters which are of primary concern to the equipment designer. It does cover, however, those aspects of equipment operation which are directly related to design, and which should be known to development and manufacturing engineers as well as to television broadcasters. There is practical consideration of the many facets of television broadcasting from the studio to the radiated signal. Among the items discussed are studio lighting, lenses, camera adjustment, the video signal, projection devices, program transmission and measurement, terminal facilities, transmitters, antennas, and channel allocation principles. Receivers are not described. Some of the information presented has, in the past, been available only in broadcasters' engineering memoranda. Examples: field surveys, page 135; grounding procedures, page 602. Clearly, this volume will fill specific needs not presently covered in the literature.

The author evidently did not intend to list or describe all available makes of equipment, and one whose principle interest lies therein will find it desirable to augment his reading. In this connection, it is believed that additional references to more diversified material would have helped in presenting a more comprehensive picture of past and present practices and contributions. Some omissions were noted; for example, the use and characteristics of waveguide for uhf transmission line, studio type Zoomar lens, uhf transmitters using demountable cavity klystrons, remote control of cameras and lighting equipment.

The style of this book is clear and easy; the explanations lucid; and unnecessary complex technical discussions are avoided. Liberal use of schematic block diagrams facilitates rapid understanding. Certain chapters will be of special interest to nontechnical personnel as well as to engineers and operating technicians. Without question, program producers and directors should read the basic material in Chapters 4, 6, and 7. In a field filled with specialists, a volume such as this can promote better understanding among various persons and groups working together. Mr. Chinn's book is a valuable contribution and should be available to everyone engaged in television broadcasting.

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Books

Wheeler Monographs—Vol. I by Harold A. Wheeler and Associates

Published (1953) by Wheeler Laboratories, Great Neck, N. Y. 500 pages+4-page index. 151 figures. 5¼×8¼. $5.00.

This collection of eleven monographs makes available to scientists and engineers a critical review of selected topics in the field of radio and television receivers, antennas and lines, radar and microwaves, and the theory of communication networks. Style ranges all the way from the considerationof basic ideas (with examples of their application) to reference material arranged in handbook form. Clearly presented and easy to understand, these monographs may be read in any order.

The topics treated are indicated by the following sequence of titles: (1) transmission lines and equivalent networks; (2) slide-rule operations for radio problems; (3) a simple theory and design formulas for super-regenerative receivers; (4) geometric relations in circle diagrams of transmission-line impedance; (5) generalized transformer concepts for feedback amplifiers and filter networks; (6) a simple theory of powdered iron at all frequencies; (7) super-selectivity in a super-regenerative receiver; (8) the piston attenuator in a waveguide below cutoff; (9) measuring the efficiency of a super-heterodyne converter by the input impedance circle diagram; (10) the transmission efficiency of linear networks and frequency changers; and (11) the maximum speed of amplification in a wide-band amplifier. Selected references appear at the end of each monograph and altogether the text lists about 295 references.

Convenient either for purposes of reference or for acquiring familiarity with present-day techniques, this new volume is up-to-date and is free from important inconsistencies, inaccuracies, and unnecessary repetitions of subject matter. Treatment of basic principles is logical and numerous examples are worked out so that a reader may, with a minimum expenditure of time, acquire ideas and concepts applicable to his daily work. Of inspirational value are the author's explanations of how he came upon his contributions and how he enlarged upon them. Several of the monographs stimulate creative thinking as, for example, the one on maximum speed of amplification.

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Microwave Theory and Technique by H. J. Reich, P. F. Ordung, H. L. Krauss and J. G. Skalnik.

Published (1953) D. Van Nostrand Company, Inc. 250 Fourth Avenue, New York 3, N. Y. 878 pages+23 page index+3 appendices+xii pages. 584 figures. 6×9¼. $12.50.

H. J. Reich, P. F. Ordung, H. L. Krauss and J. G. Skalnik are members of the staff of the Department of Electrical Engineering, Yale University.

This new volume is intended primarily as a textbook for an undergraduate or a first-year graduate course in Microwaves. It also will be useful to microwave research and development engineers as a reference book. Its scope is greater than the title indicates; about one-fourth of the book is devoted to material which had been published prior to the advent of the microwave art. The introduction is a condensed development of vector mathematics, and the first two chapters give the theory of static and dynamic electromagnetic fields. Transmission line theory, impedance charts and impedance matching are covered in the next two chapters.

A good analytical approach to waveguide theory is presented in Chapter V which also includes a comprehensive set of figures and tables describing the field configurations and the propagation parameters of various possible modes of propagation in waveguides and coaxial transmission lines. The treatment of microwave components, measurements, and to some extent antennas is largely descriptive and presented at a relatively low level in three brief chapters. The last six chapters deal at length with the theory and practice of microwave oscillators and amplifiers, but vacuum tube converters (or modulators) are not discussed. A number of simple laboratory experiments are outlined to serve as a guide in a laboratory course on microwaves. With one exception, problems to emphasize fundamental principles are included at the end of each chapter. Usually, but not always, they are worded so that there will be no doubt in the student's mind when he reaches the correct solution. The omission of answers is considered by some sincere educators to be a fault.

Although there are many references to published works, there are, unfortunately, omissions of references to some important, original and basic contributions. This is not serious from the students' point of view, however, because the average student pays little or no attention to references which suggest additional homework.

The chapter on microwave measurements is too brief. The important subject of Noise Figure (Noise Factor) is treated inadequately and handled poorly. The student is taught how to measure it long before he learns what it is. Also, the two terms Noise Figure and Noise Factor, which are synonomous, are used interchangeably without benefit of an explanation to the effect that they are the same.

The material on impedance charts and impedance matching is good. Sometimes, however, the origin on a Smith chart appears at the left and sometimes at the top.

Submerged in a sentence in Chapter III the authors say, "... at ultra-high frequencies ... the concept of circuit elements in the ordinary sense is completely useless." This slip of the pen to the contrary notwithstanding, equivalent circuits are surely useful to some degree in the microwave field. (See, for example, the subsequent treatment of obstacles in waveguides in this book.)

Although there are a few minor inconsistencies, the information, in general, is clearly presented and easily read. The subject matter is organized and presented, for the most part, in an orderly manner and it is reasonably up to date.

This book fills a need in a rapidly expanding field.

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Engineering Electronics by George E. Happell and Wilfred Hesselberth

Published (1953) by McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y. 485 pages+10-page index+12-page appendix+x pages. 470 figures. 6¼×9¼. $7.50.

George E. Happell and Wilfred M. Hesselberth are members of the School of Electrical Engineering at Purdue University.

The authors have succeeded in preparing a first edition textbook which contains the essential material of the usual required courses as offered to undergraduate electrical engineering students in many of our colleges and universities. It is well adapted for use in a beginning course in electronics with sufficient and accurate text information provided for two semesters' work in electronic tube circuits. Although essentially a textbook, because of its clarity of presentation, it could be used to advantage as a reference book by engineers not directly engaged in electronics. It has an easy reading quality for those desiring some self-instruction or review.

The arrangement of the technical material follows a very logical order of presentation with an ample selection of problems at the end of most chapters. The first chapter dealing with electron ballistics is exceedingly well done, using as a basis the fundamental laws of physics which are presented as a brief review. Of the 485 pages of text, approximately 300 are devoted to electronic tube circuits and tube applications; this portion is also quite complete in its coverage. However, there are a few exceptions throughout the remaining pages of the book. For example, the treatment of fundamental processes within electron tubes is extremely brief as is the coverage of gaseous conduction. Furthermore, the last chapter attempts to cover in 24 pages, energy states in solid matter, thermistors, large area rectifiers, varistors, transistors, photoconductive and photovoltaic cells, magnetic amplifiers, and dielectric amplifiers. This means that much of the relatively new material (for textbooks) is covered in a cursory fashion. However, in fairness to the authors, it may be said that many of the subjects treated so briefly in the last chapter would most likely be taught in elective courses for undergraduate or graduate students. Therefore, in my opinion, the authors have competently fulfilled their stated purpose in preparing an undergraduate textbook for beginning students in electronics.

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Books

Mathematical Methods for Scientists and Engineers by Lloyd P. Smith

Published (1953) by Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y. 448 pages+5-page index +x pages. 96 figures. 6¼×9¼. $13.35.

In a field already relatively crowded, this book on mathematical methods is nevertheless a valuable addition. It is carefully and clearly written, contains a larger variety of topics than most other books of its type, and is designed both as a textbook for graduate students and as a reference book for workers in physics and engineering. In the author's own words, its contents, except for the subject of differential equations, "represent the minimum knowledge in the field that any Ph.D. in physics should acquire." In order to permit an adequate treatment of the rather large variety of topics contained in this book of approximately 450 pages, the author has chosen to omit differential equations entirely. In this way he finds space to treat the subjects of differential and integral calculus, space geometry, multiple integrals, functions of a complex variable, conformal mapping, infinite series, linear algebra, vector and tensor analysis, orthonormal function systems, integral equations, variational methods, and probability theory. The last chapter of the book, on probability theory, is written by Professor Mark Kac, an authority in this field. Because of the author's lucid and concise style, the topics above, though numerous, are in general very well treated.

A number of topics are included which generally do not appear in other books of this type. For example, we might mention the reduction to normal form of elliptic integrals, the method of steepest descents for asymptotic expansions, the inversion of series, and the infinite product representation of a function. As is generally true of books of this type, the derivations and proofs presented are not rigorous in nature, but contain the mathematical substance. Simple illustrative examples are often presented after the derivations to facilitate the understanding of foregoing material. In some cases, more complicated examples (such as the electric field in the cyclotron does as an example of the Schwartz-Christoffel mapping procedure) are included to illustrate further details. In the section on the method of steepest descents, however, the inclusion of an involved example defeats its purpose. Those features characteristic of the method in general are not clearly distinguished from those of the example in particular, and the complexity of the example (6 pages long) may lead one to the erroneous conclusion that the basic method itself is complicated in nature. It would have been preferable to present a simpler example, such as a Hankel function, and especially to point out that the first term in the expansion can be obtained with relative ease.

There is an extensive selection of problems appearing at the end of each chapter, a feature which enhances the value of the book as a textbook. A small list of suggested reference texts is also presented at the end of each chapter. The book also seems well indexed.

The weakest chapter in the book is that on "Orthonormal Functions with a Continuous Spectrum." The reviewer was disappointed in its limited treatment; except for the last section, the chapter concerns itself exclusively with Fourier transforms. In view of the variety of discrete spectra discussed in the chapter preceding it would seem appropriate to include at least the Fourier-Bessel transform. The contents of the two chapters on orthonormal function systems seem chosen to suit the needs of the quantum physicist; for the microwave physicist, on the other hand, an expansion of the last section on functions with discrete and continuous spectra would have been desirable. (In electromagnetic waves, the discrete and continuous portions of the spectrum correspond to surface waves and the radiation field, respectively.) The relation, employed in the chapter on integral equations, between the kernel (or Green's function) and the spectrum eigenfunctions could also have been further exploited to indicate how the complete normalized spectrum can be obtained in a practical fashion via the resolvent kernel.

Despite the few flaws noted above, the book succeeds admirably in its purpose. The lucid and concise treatment of a large and well-chosen variety of topics recommends it highly for those interested in applied mathematics on a graduate level.

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Abstracts and References

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The Index to the Abstracts and References published in the PROC. I.R.E. from February 1953 through January 1954 is published by Wireless Engineer and included in the March 1954 issue of that journal. Copies of this issue may be purchased for $1 (including postage) from the Institute of Radio Engineers, 1 East 79th Street, New York 21, N.Y. As supplies are limited, the publishers ask us to stress the need for early application for copies. Included with the Index is a selected list of journals canned for abstracting with publishers' addresses.

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.

A new section has been introduced covering the general technique of electromagnetic waves, oscillations and pulses (i.e. transmission lines and circuits), as distinct from specific applications to telecommunications. The new section is numbered 621.37, with subdivisions. Full details of the new classification, and of the numbers which become obsolete as a result of its introduction, are given in PE Note 535, obtainable from The International Federation for Documentation, Willem Witsenplein 6, The Hague, Netherlands, or from The British Standards Institution, 2 Park Street, London, W.1., England.

Section 621.396.67, dealing with Antennas, has been modified and expanded; details of the new classifications are given in PE Note 519.

Section 621.396.96, with subdivisions, has been introduced to cover Radar; details of the new classifications are given in PE Note 518.

New Subject Section

A section headed Automatic Computers has been introduced.

ACOUSTICS AND AUDIO FREQUENCIES

534.21-13 294
Finite-Amplitude Sound Waves—J. B. Keller. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 212–216; March, 1953.) Exact solutions of the one-dimensional gas dynamic equations, representing periodic sound waves of finite amplitude, are obtained for a particular medium. The progressive wave from a vibrating piston and the standing wave in a closed tube are examined in detail.

534.213.4-13 295
The Theory of the Propagation of Plane Sound Waves in Tubes—D. E. Weston. (*Proc. Phys. Soc.*, vol. 66, pp. 695–709; Aug. 1, 1953.) Propagation in gases within cylindrical tubes of widely differing diameters is considered. The phase velocity, attenuation and cross-section profile of particle velocity are investigated theoretically and their interrelation pointed out. The factors affecting the validity of Kirchhoff's formulas are considered and the theory is applied to Lawley's experimental results (2408 of 1952).

534.222.1 296
A Particular Case of the Propagation of Sound in an Anisotropic Medium—L. M. Brekhovskikh. (*Compt. Rend. Acad. Sci. U.R.S.S.*, vol. 87, pp. 715–718; Dec. 1, 1952, In Russian.) A theoretical treatment of the case when the velocity of sound in the direction of the z co-ordinate is given by $c=c_0$ for $0\lesseqgtr z\lesseqgtr h$ and $c=c_0[1+2a(z-h)]^{-1/2}$ for $h\lesseqgtr z<\infty$.

534.232 297
Transient Loading of a Baffled Strip—J. W. Miles. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 204–205; March, 1953.) The relation between the applied force and the resultant velocity variation is investigated for a plate mounted in an infinite baffle.

534.232:621.395.623.7 298
Transient Loading of a Baffled Piston—J. W. Niles. (*Jour. Acoust. Soc. Amer.*, vol. 25, pp. 200–203; March, 1953.) The relation between the applied force and the resultant velocity variation of a circular piston is investigated using the Laplace transform. The results indicate that a loudspeaker system designed for critical damping in the steady state will be slightly overdamped in its initial motion, i.e. for about 10^{-3} sec.

534.26 299
Diffraction of Sound Waves by a Circular Aperture—G. Bekefi. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 205–211; March, 1953.) Measurements of the pressure in the aperture and in the near field, using a wavelength of about 3 cm and apertures of diameter 5λ–10λ, are reported and discussed. A new formula, which represents conditions in the field more accurately than Kirchhoff's formula, is derived theoretically.

534.321.9+535 300
Recent Developments in Ultrasonics and Optics—(*Nature* [*London*], vol. 172, pp. 443–444; Sept. 5, 1953.) Summaries of papers read at the Summer Provincial Meeting of the Physical Society.

534.612.4 301
Comparison of Microphone Calibrations using Pure Tones or using a Noise Source—P. Chavasse and L. Pimonow. (*Ann. Télécommun.*, vol. 8, pp. 267–270; Aug./Sept., 1953.) Microphone response curves obtained by use of pure tones and by use of white noise are reproduced and discussed. If the microphone curve obtained with pure tones is flat, or nearly so, the response to white noise, using an analyzer for which $\Delta f/f$ is constant, will rise towards the higher frequencies. Apart from this difference, the response curves obtained by the two methods are very similar. It appears to be absolutely necessary to determine, for any measurement microphone, both the distortion and the maximum sound pressure that may be applied to it.

534.64 302
The Acoustic Waveguide: Part 1—An Apparatus for the Measurement of Acoustic Impedance using Plane Waves and Higher-Order-Mode Waves in Tubes—E. A. G. Shaw. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 224–230; March, 1953.) Apparatus operating in the frequency range 1–3 kc is described. See also 2537 of 1953.

534.64 303
The Acoustic Waveguide: Part 2—Some Specific Normal Acoustic Impedance Measurements of Typical Porous Surfaces with respect to Normally and Obliquely Incident Waves—E. A. G. Shaw. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 231–235; March, 1953.) Techniques described in part 1 (302 above) were used for measurements on rock-wool, hair-felt and acoustic tile backed by a rigid wall.

534.75 304
Effect of Different Types of Electrodes in Electrophonic Hearing—G. Flottorp. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 236–245; March, 1953.)

534.79 305
The Variation of Modulation Thresholds by Masking Tones and Noises—E. Zwicker. (*Akust. Beihefte*, no. 2, pp. 274–278; 1953. In German.) Experiments on a subject with average hearing are reported. Masking tends to raise the threshold of audibility for sound and for modulation of sounds at levels of intensity within 30 db above the new threshold. For sounds at higher intensity levels the modulation threshold is unaffected by masking.

534.833:532.13:534.321.9 306
Viscosity as a Factor in the Anomalous Absorption of Ultrasonic Waves in Liquids—S. Parthasarathy and A. F. Chhapgar. (*Ann. Phys., Lpz.*, vol. 12, pp. 316–320; July 2, 1953, In English.) The loss in the oscillating quartz crystal, due to internal friction and radiation of energy to the surrounding medium, was found to be proportional to $\eta^{1/2}$, where η is the coefficient of viscosity.

534.833.1 307
Notes on the Transmission of Sound through Plates—R. D. Fay. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 220–223; March, 1953.) A formula that can be readily evaluated is derived for the transmittivity of steel plates immersed in a fluid. Discrepancies between values calculated from the formula and observed values indicate that losses associated with shear waves in steel are not negligible.

534.834 308
Measurement of Sound Propagation in Liquid-Filled Pipes having Zero-Impedance Walls—W. Kuhl and K. Tamm. (*Akust. Beihefte*, no. 2, pp. 303–316; 1953. In German.) Suppression of sound in pipes with a circular, a subdivided circular, or a rectangular cross section, can be realized by means of a cellular rubber lining. Good agreement with theoretically predicted results is obtained.

534.834 309
Theory of Sound Attenuation in Ducts of Rectangular Cross-Section with one Absorbent Wall, and the Resulting Maximum Attenuation Factor—L. Cremer. (*Akust. Beihefte*, no. 2, pp. 249–263; 1953. In German.) Charts are presented from which the attenuation constant can be read off directly at any one of five frequencies. These are derived from the Morse diagram noted in 680 of 1940. For a report of experimental work see 310 below.

534.834 310
Experimental Investigations for the Realization of the Maximum Theoretically Attainable Sound Attenuation in a Rectangular Air Duct with Absorbent Walls—O. Gerber. (*Akust. Beihefte*, no. 2, pp. 264–270; 1953. In German.) Using a specially designed single absorption wall, attenuations up to 170–200 db were obtained at certain frequencies in a rectangular air duct at 5 cm wide. The average attenuation over a wide frequency band was ~60 db. Experimental details are given. The application of the results to air ventilation ducts and similar systems is noted.

534.84 311
Directional Distribution and Time Sequence of Sound Reflections in Rooms—R. Thiele. (*Akust. Beihefte*, no. 2, pp. 291–302; 1953. In German.) The results are reported of comprehensive experiments performed in broadcast studios, theatres and a church, using a fixed omnidirectional sound radiator, and a directional microphone at various points. A formula is given for the "directional diffusion," which is found from the microphone reception pattern, and has the value 100 per cent for uniform omnidirectional reception; actual values found ranged between 13 per cent and 66 per cent. Oscillograms of short pulses and echoes are shown. The "definition" of the sound at the microphone was calculated from the ratio between the energy received in the first 50 ms and the total energy received; values between 10 per cent and 90 per cent were found, the latter corresponding to a high intelligibility of speech.

534.846 312
The Acoustics of the Royal Festival Hall, London—P. H. Parkin, W. A. Allen, H. J. Purkis and W. E. Scholes. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 246–259; March, 1953.) Shortened version of paper noted in 2198 of 1953.

534.851:621.317.35:621.3.019.78 313
Distortion in Phonograph Reproduction—H. E. Roys. (*RCA Rev.*, vol. 14, pp. 397–412; Sept., 1953.) Reprint. See 2736 of 1953.

621.395.61 314
Microphone Sensitivity Conversion—L. Rosenman. (*Electronics*, vol. 26, p. 194; Nov., 1953.) A chart gives the relation between the values of microphone sensitivity rated according to three different commonly used methods.

621.395.61:546.431.824-31 315
Broad-Band Directional Barium-Titanate Transducers—L. Camp. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 297–301; March, 1953.) Transducers suitable for underwater operation, and having desired directional characteristics, are constructed from arrays of short thin-walled $BaTiO_3$ tubes in a fluid medium.

621.395.61:621.395.623.7 316
Loudspeaker-Microphones—H. Gemperle. (*Elektrotech. Z.*, *Edn B*, vol. 5, pp. 259–263; Aug. 21, 1953.) A discussion of the conditions to be satisfied to obtain an electroacoustic transducer operating efficiently in either direction.

621.395.616 317
The Sensitivity Limits for a Capacitor Microphone in a Low-Frequency Circuit—H. Grosskopf. (*Akust. Beihefte*, no. 2, pp. 279–290; 1953. In German.) General relations are derived for the sensitivity of a microphone the dimensions of which are small compared with the wavelength of the highest frequency. The transmission coefficient of the microphone and the noise component of the amplifier input circuit are considered separately. An equivalent circuit-noise level of 10 phon can be attained with a uniform response over the af range.

621.395.616 318
New High-Grade Condenser Microphones—F. W. O. Bauch. (*Jour. Audio Eng. Soc.*, vol. 1, pp. 232–240; July, 1953.) Reprint. See 1230 of 1953.

621.395.616:534.6 319
A Capacitive Velocity Pickup for Vibrations of Structure—K. Tamm and E. Aha. (*Akust. Beihefte*, no. 2, pp. 270–273; 1953. In German.) A pickup with a frequency response level between 20 cps and 2 kc is described. When used in a bridge circuit, operating with a 10-V 1.8-mc input, the velocity sensitivity is 3 v/(m/sec).

621.395.616:534.612.2 320
Microphones measure High-Intensity Sound—J. K. Hilliard. (*Electronics*, vol. 26, pp. 160–163; Nov., 1953.) Three different types of capacitor microphone are discussed, suitable for measurement of sound levels in the range 40–220 db referred to 0.0002 dyne/cm². A pistonphone for calibration is described and applications to investigations of industrial, explosion and jet noise are indicated.

621.395.623.75 321
An Investigation of the Air Chamber of Horn-Type Loudspeakers—B. H. Smith. (*Jour. Acous. Soc. Amer.*, vol. 25, pp. 305–312; March, 1953.) A boundary-value treatment leads to the solution of the wave equation for the general case in which the horn throat enters the air chamber in any rotationally symmetrical manner. Special cases are analyzed. Design methods for eliminating undesired higher-order modes are discussed.

621.395.625.3 322
The Development of a Variable Time Delay—K. W. Goff. (Proc. I.R.E., vo. 41, pp. 1578–1584; Nov., 1953.) A magnetic-drum system for acoustic studies amenable to correlation techniques is discussed. Two recording and reproducing channels are provided by using two tracks; the time difference between them can be varied from −15 ms to +190 ms by shifting one of the recording heads. Uniformity of the layer of magnetic material is obtained by spraying the drum with a dispersion of iron oxide. The dependence of the performance on the spacing between the head and the magnetic material is analysed. A flutter-free mechanical drive system is described.

621.395.625.3 323
Structure and Performance of Magnetic Transducer Heads—O. Kornei. (*Jour. Audio Eng. Soc.*, vol. 1, pp. 225–231; July, 1953.) The influence of various structural features and properties of the materials used on the performance of ring heads is discussed; a particular commercially available head is described.

621.395.625.3 324
Studies on Magnetic Recording: Part 3—The Recording Process. Part 4—Calculation of the Fields in and around the Tape—W. K. Westmijze. (*Philips Res. Rep.*, vol. 8, pp. 245–269; Aug., 1953.) Biasing methods and the longitudinal and transverse magnetization of tape are discussed from the experimenatl and theoretical points of view. Part 2: 9 of January.

621.395.92 325
An Electronic Hearing Aid—P. Blom. (*Philips Tech. Rev.*, vol. 15, pp. 37–48; Aug., 1953.) Details are given of a range of models permitting adaptation for various types of hearing defect. A piezoelectric-crystal microphone is used, with the alternative of switching to a pickup coil for direct induction e.g. from a telephone receiver. Automatic volume compression at seven different levels is available. Either a magnetic or a crystal-type earphone is used.

ANTENNAS AND TRANSMISSION LINES

621.372 326
Recent Research on the Transmission of Signals along Metal and Dielectric Lines—H. Kaden. (*Fernmeldetech. Z.*, vol. 6, pp. 432–438; Sept., 1953.) Theory of propagation along metal and dielectric waveguides and wires is reviewed. Measurements made at λ 12 cm on a 70-m line comprising copper helices with a pitch of 2 cm indicate marked dependence of attenuation on conditions of rain and hail, due to the formation of a nonuniform surface and consequent radiation of energy. See also 908 and 1893 of 1952.

621.372.22:621.372.51 327
The Hyperbolic Transmission Line as a Meeting Section—H. J. Scott. (Proc. I.R.E., vol. 41, pp. 1654–1657; Nov., 1953.) Coaxial-line sections in which the variation of characteristic impedance along the section is represented by a hyperbolic function are relatively insensitive to variations of frequency. The performance of such lines is described in terms of reflection coefficients. Two types are considered; in the one, the characteristic impedance varies as a hyperbolic tangent, in the other the reflection per unit length varies as the square of a hyperbolic secant.

621.372.8 328
Propagation of Microwaves Through a Cylindrical Metallic Guide Filled Coaxially with Two Different Dielectrics—S. K. Chatterjee. (*Jour. Indian Inst. Sci.*, section B, vol. 35, pp. 1–16; Jan., 1953.) The field components for the TE_{01} modes are derived from Maxwell's equations; the attenuation constant for this mode is then calculated, using the Poynting vector.

621.372.8 329
Modification of the Electrical Field Strength in a Rectangular Waveguide excited in the Fundamental H_{10} Mode due to the Introduction of a Current-Carrying Thin Circular Wire—R. Müller. (*Arch. elekt. Übertragung*, vol. 7, pp. 451–457; Sept., 1953.) The field strength is given by an infinite series involving Hankel functions corresponding to the series of superposed interfering cylindrical waves reradiated by the wire; all but one of these decay very rapidly. The single reradiated wave remaining at a little distance from the wire is of the same type as the primary wave, on which it is superposed. Hence line theory is applicable outside the limited interference region.

621.372.8 330
Matching Nonstandard Waveguide Sections—A. Chlavin. (*Electronics*, vol. 26, pp. 192–193; Nov., 1953.) An experimental proce-

dure is described for designing junctions between waveguides of different types.

621.396.67 331
Excitation Coefficients and Beamwidths of Tschebyscheff Arrays—R. J. Stegen. (Proc. I.R.E., vol. 41, pp. 1671–1674; Nov., 1953.) Exact expressions are obtained for the excitation coefficients of a Tchebycheff array by equating the array space factor to a Fourier series whose coefficients are readily calculated. Curves are presented showing the variation of half-power beam width with antenna length for various side-lobe levels. An expression for beam width is derived which is exact for small values of beam width.

621.396.674.3 332
Radiation from a Vertical Electric Dipole over a Stratified Ground—J. R. Wait. (*Trans. I.R.E.*, vol. AP-1, pp. 9–11; July, 1953.) Expressions are derived for the radiation fields at low frequencies. An "effective numerical distance" is defined, by means of which numerical data for homogeneous ground can be applied to ground-wave propagation over plane ground with any number of parallel stratifications.

333
621.396.677.3.029.62:523.854.22:621.396.822
The Distribution of the Discrete Sources of Cosmic Radio Radiation—B. Y. Mills. (*Aust. Jour. Sci. Res., Ser. A*, vol. 5, pp. 266–287; June, 1952.) The outputs from two co-planar 101-mc beam antennas, 60 m or 270 m apart, were combined and recorded, the output of one antenna being reversed at 25 cps. The antennas, each of which consisted of 24 end-fed half-wave dipoles and similarly constructed reflector, could be tilted about an *E-W* horizontal axis. 77 sources were observed and recorded.

621.396.677.71 334
Traveling-Wave Slot Antennas—J. N. Hines, V. H. Rumsey and C. H. Walter. (Proc. I.R.E., vol. 41, pp. 1624–1631; Nov., 1953.) The traveling-wave slot antenna may be considered as an array of $\lambda/2$ slot antennas, but is sometimes easier to design and construct than such an array. Four types are distinguished according to the mode of the wave propagated; two of these are hybrid types, giving end-fire operation. Measured propagation constants for antennas of various shapes are shown graphically. Control of radiation pattern by variation of the slot width along the antenna is discussed. A design technique is described by means of which the pattern can be predicted exactly from measurements of individually excited array elements.

621.396.677.833.2.029.64 335
A New Wide-Angle Microwave Reflector—K. S. Kelleher. (*Tele-Tech.*, vol. 12, pp. 98–99, 169; June, 1953.) The characteristics and the applications of an X-band wide-angle and a medium-angle parabolic torus reflector are compared with those of the paraboloid type. The applications include simultaneous reflection of a number of beams for controlling a number of remote stations, and a marine-navigation radar scanner.

621.396.677.85 336
A Two-Dimensional Microwave Luneberg Lens—G. D. M. Peeler and D. H. Archer. (*Trans. I.R.E.*, vol. AP-1, pp. 12–23; July, 1953.) Detailed description of the design and performance of a lens antenna for radar scanning. Design is based on TE_{10}-mode propagation by nearly parallel plates. The space between two conducting plates, of diameter 36 inches, is filled with polystyrene, the thickness of which varies with the normalized radius, r, to give the desired refractive index $n=\sqrt{2-r^2}$. The lens maintains constant gain and beam shape throughout the scan, with side-lobe level at least 18 db below peak power. A 360° scan can be effected using peripheral flares on the plates. The stacking of lenses to concentrate the beam is investigated.

AUTOMATIC COMPUTERS

681.142 337
Application Factors for Electrical Resolvers—S. Davis. (*Elect. Mfg.*, vol. 51, pp. 128–133, 328; March, 1953.) The device described resembles a small motor and was originally designed for solving trigonometry problems in conjunction with analogue computers. Possible applications for control purposes in industry are discussed.

681.142 338
Magnetic Drum Design—D. G. O'Connor. (*Electronics*, vol. 26, p. 196; Nov., 1953.) A chart relates the various parameters involved.

339
Step-Switch Converter Digitizes Analog Data—R. R. Bennett and H. Low. (*Electronics*, vol. 26, pp. 164–165; Nov., 1953.)

CIRCUITS AND CIRCUIT ELEMENTS

621.314.2 340
Review of New Materials and Techniques in High-Fidelity Transformer Design—L. W. Howard. (*Jour. Audio. Eng. Soc.*, vol. 1, pp. 265–267; July, 1953.)

621.314.7:621.375.4 341
Transistors: Theory and Application: Part 9—Grounded Emitter and Collector Circuits—A. Coblenz and H. L. Owens. (*Electronics*, vol. 26, pp. 166–172; Nov., 1953.) Formulas and typical values of parameters are tabulated for various circuit arrangements for junction and point-contact transistors. Part 8: 283 of January.

621.314.7:621.375.4.015.3 342
Transient Analysis of Transistor Amplifiers—W. F. Chow and J. J. Suran. (*Electronics*, vol. 26, pp. 189–191; Nov., 1953.) See 3513 of 1953.

621.316.86:[537.311.32+621.396.822 343
The Electrical Conductivity and Current Noise of Carbon Resistors—I. M. Templeton and D. K. C. MacDonald. (*Proc. Phys. Soc.*, vol. 66, pp. 680–687; Aug. 1, 1953.) The variation of resistance with temperature, pressure, and magnetic field in several types of carbon resistor was measured down to liquid He temperatures. The dependence of the noise spectrum on the current intensity, temperature and magnetic field was also investigated; the $1/f$ law holds at all temperatures.

621.316.923 344
Basic Fuse Types for Electronic Equipment—E. V. Sundt and A. J. Steele. (*Elect. Mfg.*, vol. 51, pp. 144–146, 366; April, 1953.) Types with slow, medium and fast action are described.

621.318.4:621.318.134 345
Tolerances and Temperature Coefficient of Coils with Ferroxcube Slugs—H. van Suchtelen. (*Electronic Appl. Bull.*, vol. 14, pp. 27–32; Jan./Feb., 1953.) Extension of a previous discussion (939 of 1953). From the point of view of insensitivity to variations of core permeability and of temperature, the closed core with air-gap is best, the rod core with long coil next, and the rod core with short coil worst. See also 3636 of 1953.

621.318.42 346
A Variable Inductor—R. E. Allison. (*J. Audio Eng. Soc.*, vol. 1, pp. 262–264; July, 1953.) An af inductor is described in which core hysteresis effects are eliminated, the inductance being controlled by moving a magnet in relation to the cores. Q values >100 at 1 kc and >30 at 100 cps are possible. Experimental filters using the inductors are also described.

621.318.5 347
Current Trends in Miniature Relay Design—I. S. Mayer. (*Elect. Mfg.*, vol. 51, pp. 135–137, 364; Feb., 1953.) Design of relays for airborne electronic equipment is discussed.

621.318.572 348
The Optimum D.C. Design of Flip-Flops—D. K. Ritchie. (Proc. I.R.E., vol. 41, pp. 1614–1617; Nov., 1953.) A simple criterion is derived by means of which it can immediately be seen whether or not a flip-flop circuit corresponding to specified requirements is realizable. A numerical example is given.

621.318.572:621.385.832 349
The E 1 T Decade Counter Tube—(*See* 603.)

621.318.572:621.387 350
Polycathode Counter Tube Replications—J. H. L. McAuslan and K. J. Brimley. (*Electronics*, vol. 26, pp. 138–141; Nov., 1953.) The use of dekatrons in millisecond timers, batching counters and cro time markers is described. The basic decade units are capable of counting up to 20,000 per second. See also 3485 of 1952 and 771 of 1953 (McAuslan).

621.372 351
A Method of Approximate Steady-State Analysis for Non-Linear Networks—G. R. Slemon. (*Proc. IEE*, part I, vol. 100, pp. 275–287; Sept., 1953.) Approximate solutions for the fundamental and third harmonic are obtained by a three-stage method involving (*a*) a first approximation to the fundamental-frequency solution, usually accurate to within 10 per cent (*b*) a third-harmonic solution (generally within 15 per cent) using an equivalent circuit which is dependent on the first fundamental solution, (*c*) a correction to the fundamental solution, using third-harmonic quantities, which brings its accuracy to within about 3 per cent. Adaptations of some standard techniques of solving linear steady-state problems for use with this method of analysis are described. Appendix by G. H. Rawcliffe.

621.372.41:621.396.822 352
Effective Circuit Bandwidth for Noise with a Power-Law Spectrum—P. R. Karr. (*Jour. Res. Nat. Bur. Stand.*, vol. 51, pp. 93–94; Aug., 1953.) Analysis is developed for a tuned *RLC* circuit, for noise with a frequency spectrum given by an arbitrary power law. The effective bandwidth is presented in terms of that for white noise.

621.372.412 353
The Piezoelectric Oscillations of a Quartz Crystal at its Odd, Even and Half-Odd Harmonics—S. Parthasarathy, M. Pancholy, and A. F. Chhapgar. (*Ann. Phys., Lpz.*, vol. 12, pp. 1–7; April 16, 1953. In English.) The results reported in *Jour. Sci. Industr. Res.*, 1944, were confirmed by observing the diffraction patterns of the oscillating quartz. See also 1619 of 1953.

621.372.412:621.373.421.13.029.4 354
Flexure Mode Quarts Oscillators—N. J. Beane and R. C. Richards. (*Marconi Rev.*, vol. 16, pp. 141–168; 4th Quarter, 1953.) Details are given of the modes of motion, electrode arrangements and electrical performance of the duplex, *XY* and *NT* types. Typical frequency/temperature curves and graphs of other crystal characteristics are shown. A crystal-controlled af oscillator is described and the circuit diagram, including component values, is given.

621.372.5.012.029.6 355
Loci-Curve Theory applied to High-Frequency Networks—E. Schelisch. (*Marconi Rev.*, vol. 16, pp. 169–183; 4th Quarter, 1953.) The application of the method is shown for the evaluation of such response curves of four-terminal networks as are produced by the variation of one parameter. Examples are given of

the calculation of (*a*) a wideband thermistor mount, using a rectangular admittance chart, and (*b*) the variation of the input reflection coefficient with frequency of a given transformer, using a Smith chart.

621.372.51.012.3:621.396.67 356
Antenna-Matching Network Efficiency—R. L. Tanner. (*Electronics*, vol. 26, pp. 142–143; Nov., 1953.) Charts are presented for estimating the transfer efficiency of matching networks.

621.372.54 357
Conformal Mappings for Filter Transfer Function Synthesis—G. L. Matthaei. (PROC. I.R.E., vol. 41, pp. 1658–1664; Nov., 1953.) Conformal mapping provides a practical way of solving the es-potential problems previously considered (1611 of 1953). Analysis in the mapped plane also yields convenient methods for predetermining the number of poles and zeros required to meet given design specifications.

621.372.54 358
Theory of Maximally Flat and Quasi-Tchebycheff Filters—F. S. Atiya. (*Arch. elekt. Übertragung*, vol. 7, pp. 441–450; Sept., 1953.) The synthesis of a quadripole with a prescribed attenuation function is described. This function has to satisfy certain conditions. The synthesis is carried out for maximally flat and quasi-Tchebycheff low-pass filters, the results being presented in curves suitable for calculating the values of the circuit components. The treatment is extended to bandpass filters by means of a well-known frequency transformation.

621.372.54 359
RLC Lattice Networks—L. Weinberg. (PROC. I.R.E., vol. 41, p. 1667; Nov., 1953.) Correction to paper noted in 3535 of 1953.

621.372.543.2 360
Band-Pass Filters—F. S. Atiya. (*Wireless Eng.*, vol. 30, pp. 307–311; Dec., 1953.) A method is presented for synthesizing constant-resistance networks to have maximally flat or Tchebycheff-type response characteristics. A numerical example of each type is calculated.

621.372.543.2:621.397.61 361
High-Frequency-Filter Problems in Television Transmitters—W. Burkhardtsmaier. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 150–154; 1953.) Coaxial-line filters for the partial suppression of the lower sideband are discussed. Particular attention is paid to arrangements suitable for high-level modulation, in which the filter is spatially separated from the output stage and its input impedance is maintained constant over the frequency band.

621.373.4:621.316.726 362
Electrical Control of Valve-Transmitter Frequency by means of an Electrodeless Gas Discharge—B. Koch. (*Z. angew. Phys.*, vol. 5, pp. 292–294; Aug., 1953.) The tuned-circuit inductor of an oscillator was wound round an argon-filled cylindrical container, in which an electrodeless discharge could be maintained. The oscillator frequency was nearly linearly proportional to the anode voltage and was also dependent on the gas pressure. See also 90 of January (Koch and Neuert).

621.373.4:621.396.822 363
Noise Properties of *LC* Oscillators—J. van Slooten. (*Electronic Appl. Bull.*, vol. 14, pp. 33–39; March/April, 1953.) Previous analyses based on the concepts of (*a*) forced oscillations [362 of 1953 (Lerner)] and (*b*) disturbed free oscillations (2940 of 1953) are discussed; the extent of the am and the fm resulting from the presence of noise is examined.

621.373.421 364
Pseudoresonant and Phase-Shifting Quadripoles as Frequency-Determining Elements in RC Oscillators—R. Hennicke. (*NachrTech.*, vol. 3, pp. 354–358; Aug., 1953.) *RC* oscillators with a sinusoidal output are divided into two main groups, according to the type of *RC* passive network they include. Equivalent circuits are obtained and simple expressions are derived for the frequency of stable oscillation and for the condition for self-excitation.

621.373.421.1:621.385.3 365
Theory of Triode Oscillators with Coaxial Resonators—E. Hauri. (*Bull. schweiz. elektrotech. Ver.*, vol. 44, pp. 761–768; Aug. 22, 1953.) A study of disk-seal-triode oscillators. The conditions necessary for maintaining oscillations are derived. The width of the frequency range with a fixed-tuned grid circuit is calculated from the tube parameters; deviations from the theoretical value encountered under working conditions are discussed. A general criterion for mode separation is established. 35 references.

621.373.43 366
Pulse Generator with Variable Repetition Frequency and Pulse Width—H. Spalding and W. Vogt. (*Fernmeldetech. Z.*, vol. 6, pp. 428–431; Sept., 1953.) An instrument designed around the EQ40 nonode tube is described; the principle of operation is that of the "ϕ-detector" [505 of 1950 (Jonker and van Overbeak)]. The pulse-repetition frequency can be varied between 50/second and 20,000/second (or higher), the duty factor from 0 to 50 per cent and the amplitude from 0 to 100 v. The pulse flank occupies <0.2 per cent of the pulse period. Pam, pwm and pphm can be used. A complete circuit diagram, including component tubes, is given.

621.375.2:621.385.15 367
Wide-Band Amplifiers using Secondary-Emission Tubes—C. H. Chandler and G. D. Linz. (*RCA Rev.*, vol. 14, pp. 367–378; Sept., 1953.) The applications of an experimental valve, particularly at vhf, in RF or IF amplifiers, cr-tube deflection amplifiers and distributed amplifiers are described and discussed. The transconductance of this tube is 15mv, the input and output capacitances are 6.3 pf and 4.8 pf respectively, and the sum of anode and screen currents is 15.7 ma. The tube construction has been described by Mueller (1814 of 1950).

621.375.2.024 368
A Method for the Amplification of Extremely Small Thermoelectric Voltages—W. Kroebel. (*Z. angew. Phys.*, vol. 5, pp. 286–291; Aug., 1953.) A more detailed account of the dc amplifier noted in 2276 of 1953 is given. The threshold voltage is $>1.5>10^{-9}$v, with a source impedance of $\sim 10\,\Omega$. A circuit diagram including component values is given.

621.375.2.029.62+621.385.3]:621.396.822 369
Noise Factor of Conventional V.H.F. Amplifiers—N. Houlding. (*Wireless Eng.*, vol. 30, pp. 281–290 and 299–306; Nov./Dec., 1953.) A simple treatment is presented; the various types of circuit and tube noise are indicated, the concept of available power is explained, and noise factor is defined in terms of available power gain. Analysis is given for triode input stages based on common-cathode, common-grid and common-anode connections. Experimental results are given for various amplifiers for a mid-band frequency of 45 mc. Curves show the effect of source resistance on the mid-band noise factor and the variation of single-frequency noise factor over the band, and results are also tabulated for different tubes and circuits. The best noise factor with a given tube can only be determined experimentally. The need for further improvement in the noise performance of tubes is emphasized.

621.375.23.029.3 370
• **Multiple-Feedback Audio Amplifier**—J. M. Diamond. (*Electronics*, vol. 26, pp. 148–149; Nov., 1953.) The power output of the Williamson circuit is increased and the power-supply requirements reduced by using tetrode output tubes with anode-to-grid feedback. See also 3387 of 1952 (Williamson and Walker).

621.375.232.4 371
Stability of a Grounded-Grid Amplifier—W. P. Mundrashi. (*NachrTech.*, vol. 3, pp. 345–348; Aug., 1953. German translation of an article in *Radiotekhnika, Moscow*, vol. 6, pp. 64–71; 1951.) The general conditions are investigated for the self-excitation of uhf grounded-grid amplifiers. The precise formula and an approximate one for the frequency, and the condition for self-excitation, are derived. The dependence of the stability of the amplifier on circuit constants is considered; the results are shown graphically.

621.375.3 372
Methods of Magnetic Amplifier Analysis—L. A. Finzi and G. F. Pittman, Jr. (*Elect. Eng., N.Y.*, vol. 72, pp. 690–694; Aug., 1953.)

621.376.56 373
P.C.M. Coding System uses Special Tubes—A. G. Fitzpatrick. (*Electronics*, vol. 26, pp. 173–175; Nov., 1953.) The system uses a ten-target ribbon-beam switching tube for sampling and a tube with ten stable positions determined by crossed electric and magnetic fields for coding. Descriptions of tubes and circuit are given.

621.396.6 374
Printed Circuits: Some General Principles and Applications of the Foil Technique—P. Eisler. (*Jour. Brit.* I.R.E., vol. 13, pp. 523–538; Nov., 1953. Discussion, pp. 538–541.) Methods of producing printed circuits are discussed from the viewpoint of the printer, the foil technique is suitable for both general and special applications. The main processes involved, namely printing, etching, fusing, mechanical patterning, transfer and multilayer technique, are described. Various characteristics of foil conductors are examined and some particular applications are indicated.

621.396.822 375
Johnson Noise and Equipartition—D. A. Bell. (*Proc. Phys. Soc.*, vol. 66, pp. 714–715; Aug. 1, 1953.) Discussion on 2847 of 1953 (Lindsay and Sims).

GENERAL PHYSICS

535.233 376
The Value of the Constant in Wien's Displacement Law—A. H. Boerdijk. (*Philips Res. Rep.*, vol. 8, pp. 291–303; Aug., 1953.) The observed value of the wavelength at which maximum radiation occurs for a black body at a given temperature depends on the band-pass characteristics of the instrument used; as a consequence, Wien's constant can assume different values.

535.376 377
Demonstration of Electroluminescence by means of a Multilayer Colour Film—G. Wendel. (*Ann. Phys., Lpz.*, vol. 12, pp. 222–226; July 2, 1953.) Contact photographs were made of electroluminescence effects in a ZnO, ZnS-Cu phosphor, at field strengths of 10–100 kv/cm and a frequency of 50 cps. The results indicate a direct excitation process, without the intermediate step of a gas discharge.

535.42 378
The Diffraction of an Arbitrary Pulse by a Wedge—I. Kay. (*Commun. Pure. Appl. Math.* vol. 6, pp. 419–434; Aug., 1953.) An extension of the conical-flow method used by Keller and Blank (2963 of 1951). The co-ordinates chosen are such that the characteristic cone and the two planes intersecting to form the wedge each become constant co-ordinate surfaces. The problem is then solved by separating variables and expanding the boundary conditions in terms of solutions of the ordinary differential equations which appear. The results are shown to apply to the special case investigated by Keller and Blank.

535.42:538.566 379
Theory of Diffraction of Electromagnetic Waves at a Perfectly Conducting Disk, and Related Problems—J. Meixner. (*Ann. Phys., Lpz.*, vol. 12, pp. 227–236; July 2, 1953.) The problem considered in 2767 of 1950 (Meixner and Andrejewski) for plane em waves is solved generally for the case of spherical waves. Particular solutions are also obtained for the diffraction at an ellipsoid of revolution for a solenoidal em field. A method for the numerical solution is outlined for the case of diffraction at a disk, at a circular aperture and at an ellipsoid of revolution, valid for $\lambda > 0.6a$ approximately, where a is the radius or half the distance between the foci, as appropriate.

535.43:538.566 380
Scattering of Electromagnetic Waves at an Uneven Surface—Yu. P. Lysanov. (*Compt. Rend. Acad. Sci. U.R.S.S.*, vol. 87, pp. 719–722; Dec. 11, 1952. In Russian.) Scattering of waves incident at an angle such that no part of the surface is in a shadow is considered theoretically. Application of the results to two particular cases shows that surfaces of a trochoidal form will give appreciably greater backscatter than a sinusoidal surface of the same "amplitude" and "wavelength."

537.311.33:537.311.1 381
The Theory of Electronic Conduction in Polar Semiconductors—D. J. Howarth and E. H. Sondheimer. (*Proc. Roy. Soc. A*, vol. 219, pp. 53–74; Aug. 11, 1953.) The present problem has been considered before by several authors [e.g. Wright (1577 of 1952)], but many of the results which have been given are either incorrect or only correct within certain limits. By solving the Boltzmann equation for the velocity distribution function of the conduction electrons in a crystal in which the scattering is due to the polarization waves of the lattice, excat expressions are obtained for the electrical conductivity and the thermoelectric power in the form of ratios of infinite determinants. Simple approximate solutions are derived and are used in the discussion of the dependence of conduction phenomena upon the temperature and upon the degree of degeneracy of the electron gas.

537.311.62 382
The Transient Period of the Skin Effect—D. Zanobetti. (*R. C. Accad. naz. Lincei*, vol. 14, pp. 791–795; June, 1953.) Analysis is given for the distribution of current in cylindrical conductors (solid or hollow) during the period between application of a voltage and attainment of a steady state.

537.311.62 383
Impedance of Solid and Hollow Cylindrical Conductors to Current Pulses—D. Zanobetti. (*R. C. Accad. naz. Lincei*, vol. 15, pp. 200–202; Sept./Oct., 1953.) Continuation of work noted in 382 above. A quantitative solution is obtained for the initial value of the ratio between the instantaneous voltage and current.

537.52 384
Electrical Discharges—F. L. Jones. (*Rep. Progr. Phys.*, vol. 16, pp. 216–265; 1953.) Recent work on electrical discharges is surveyed under the following headings:—the breakdown of gases in static fields; high frequency discharges; cold-emission phenomena; the regime of space charges. Breakdown is regarded as a consequence of the development of pre-breakdown ionization currents by primary and secondary processes which are themselves controlled by the nature and geometry of the cathode. The important part played by surface films in the cold extraction of electrons from electrodes is described. Rf plasma oscillations and the generation of noise by discharges is discussed. 216 references.

537.523.4:537.533 385
Fundamental Processes of the Initiation of Electrical Discharges—C. G. Morgan and D. Harcombe. (*Proc. Phys. Soc.*, vol. 66, pp. 665–679; Aug. 1, 1953.) The production of electrons initiating the spark discharge from polished and tarnished metal surfaces was investigated. The field applied was of the order of 10^6 v/cm.

537.533:537.534.8 386
Electron Emission resulting from the Impact of Ions on Molybdenum and Carbon Targets—G. Philbert. (*Compt. Rend. Acad. Sci., Paris*, vol. 237, pp. 882–883; Oct. 14, 1953.) Experiments were made using normally incident polyatomic ions of energy between 1 and 2 kev. The number and energy distribution of the emitted electrons did not depend on the target material. The energy distribution of the electrons was independent of the nature and energy of the incident ions, but the number of electrons emitted per ion increased with the energy of the ions and depended on the nature of the ions.

538.3:537.122 387
A Variational Formulation of the Multi-stream Electrodynamic Field Equations—P. N. Butcher. (*Phil. Mag.*, vol. 44, pp. 971–979; Sept., 1953.) "A nonrelativistic approximation to Dirac's new variational formulation of the single-stream electrodynamic field equations is presented using 3-vector notation and mks units throughout. The Hamilton-Jacobi theory of a rotational space charge stream is developed. The variational formulation is generalized to the multi-stream case—both for a finite number and a non-denumerably infinite number of streams."

538,52 388
Induction Phenomena consequent on the Movement of Material in Primary Magnetic Fields, and their Experimental Applications: Part 2—Translation—H. Hinteregger. (*Acta phys. austriaca*, vol. 7, pp. 129–145; May, 1953.) The Minkowski field equations are presented in a form to suit the particular conditions. A definition is given of apparent dielectric constant. Somerfeld's treatment of unipolar induction is extended to magnetizable bodies. Unipolar induction in the case of translational motion is identified with e.s. induction in the material at rest. Part 1: 118 of January.

538.561:537.523.5 389
The Hissing Arc and Radio-Frequency Self-Generated Oscillations in the D.C. Carbon Arc—B. H. List and T. B. Jones. (*Elect. Eng.*, vol. 72, pp. 638–686; Aug., 1953.)

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523:621.296.822 390
Radio Astronomy: Part 1—Methods of Observation—W. Dieminger. (*Arch. elekt. Übertragung*, vol. 7, pp. 421–427; Sept., 1953.) Theory and technique of methods of observing extraterrestrial sources of rf radiation are reviewed.

523.72:621.396.822 391
Evidence of Harmonics in the Spectrum of a Solar Radio Outburst—J. P. Wild, J. D. Murray, and W. C. Rowe. (*Nature* [*London*], vol. 172, pp. 533–534; Sept. 19, 1953.) Measurements of rf outbursts on November 21, 1952, and May 5, 1953, show a dynamic spectrum comprising two widely spaced frequency bands having a drift with time from high to low frequencies. The ratio between frequencies of corresponding peaks was close enough to 2 to suggest a harmonic relation between the bans. The emission may take place in the corona at frequencies equal to the natural plasma frequency and its harmonics.

523.752:523.72:621.396.822 392
Radio Observations at the Time of an Ascending Solar Prominence—R. D. Davies. (*Nature* [*London*], vol. 172, pp. 447–448; Sept .5, 1953.) The solar prominence reported by Das and Sethumadhavan (393 below) was observed in Sydney, and records of radiation on 62, 98, 200, 600, 1,200, 3,000, and 9,400 mc were obtained. Noise bursts preceding and following the eruption were also recorded.

523.752:621.396.822 393
Eruptive Prominence of February 26, 1953, and Associated Radio Noise-Burst—A. K. Das and K. Sethumadhavan. (*Nature* [*London*], vol. 172, pp. 446–447; Sept. 5, 1953.) Three bursts of noise associated with the prominence were recorded at Kodaikanal, with a radio telescope working on 100 mc. These occurred when the topmost parts of the prominence were at about 50,000, 140,000, and 184,000 km respectively above the limb, though present-day theory indicates that at 100 mc radiation cannot ordinarily escape from the sun unless generated at a height $>$100,000 km. No active sunspot group was observed in the vicinity of the prominence.

523.8:621.396.822 394
Radio Radiation from the Supergalaxy—J. D. Kraus and H. C. Ko. (*Nature* [*London*], vol. 172, pp. 538–539; Sept. 19, 1953.) A low-intensity source was observed in March 1953 on 250 mc with position corresponding approximately to the plane of the local supergalaxy described by de Vaucouleurs.

523.85:621.396.822 395
The Galaxy Explored by Radio Waves—H. C. van de Hulst. (*Observatory*, vol. 73, pp. 129–139; Aug., 1953.) The full text of the Halley Lecture for 1953. This includes a short account of radio astronomy and of the results of observations made at 21.1049 cm and other wavelengths.

523.852.21:621.396.822 396
A Search for Radio Emission from the Orion Nebula—J. E. Baldwin. (*Observatory*, vol. 73, pp. 155–157; Aug., 1953.) Short report of interferometer observations at a frequency of 210 mc.

523.854:621.396.822.029.55/.63 397
A Model of the Radio-Frequency Radiation from the Galaxy—R. H. Brown and C. Hazard. (*Phil. Mag.*, vol. 44, pp. 939–963; Sept., 1953.) The model has been designed to give agreement both with the observed values of equivalent aerial temperature and with the observed isophotes over the frequency range 18.3 mc–1.2 kmc. The actual mechanism of generation of radio energy is not discussed.

523.854.22:621.396.822:621.396.677.3.029.62 398
The Distribution of the Discrete Sources of Cosmic Radio Radiation—Mills. (*See* 333.)

550.38 399
The South Magnetic Pole in 1952 and the Comparative Displacements of the North and South Poles from 1842 to 1952—P. N. Mayaud. (*Ann. Géophys.*, vol. 9, pp. 266–276; July/Sept., 1953.)

550.38 400
Recording the Geomagnetic Field at Port Martin—P. N. Mayaud. (*Ann. Géophys.*, vol. 9, pp. 256–265; July/Sept., 1953.) The records were obtained by the Adélie Land expedition during the period April, 1951–January, 1952. Details are given of methods and results.

550.384:621.317.7 401
Electromagnetic Variometer for the Vertical Component [of the geomagnetic field]—I. Özdogan. (*Ann. Géophys.*, vol. 9, pp. 161–163; April/June, 1953.) An instrument for studying rapid field variations is described; it operates on the same principles as the electromagnetic seismograph.

551.510.534:523.38 402
Further Determinations of the Vertical Distribution of Ozone during Eclipses of the Moon

—H. K. Paetzold. (*Z. Naturf.*, vol. 7a, pp. 325–328; May, 1952.)

551.510.535 403

Propagation Measurements in the Ionosphere with the Aid of Rockets—J. C. Seddon. (*Jour. Geophys. Res.*, vol. 58, pp. 323–335; Sept., 1953.) Measurements made at White Sands are reported. Continuous waves with harmonically related frequencies, namely 4.274 and 25.644 mc, were radiated from the rocket to two ground stations. The higher-frequency wave is practically unaffected by the E layer, and serves as a reference. The ordinary and extraordinary components of the lower-frequency wave, with frequency multiplied by 6, are separately heterodyned with the reference wave. The refractive indices of the medium are determined from the resulting beat frequencies together with a determination of the geomagnetic field and of the electron collision frequency at one altitude; the Lorentz polarization term can be neglected. Results are given and discussed.

551.510.535 404

The Reflection Coefficient of the Long Wave—T. Sato. (*Rep. Ionosphere Res. [Japan]*, vol. 7, pp. 69–70; June, 1953.) The propagation equation is solved and the reflection coefficient deduced for long waves incident vertically on a region of low electron concentration such as that situated below the E layer. Results are given for two cases based on different assumptions regarding the vertical gradient of concentration; comparison of these calculated results with observations on 16-kc and 150-kc waves indicates that there is a considerable gradient of electron concentration in the layer.

551.510.535 405

Dissociative Recombination in the E Layer—E. Gerjuoy and M. A. Biondi. (*Jour. Geophys. Res.*, vol. 58, pp. 295–303; Sept., 1953.) An examination is made of the consequences of assuming that electrons in the E layer disappear mainly by dissociative recombination. It is shown that this assumption provides a far more satisfactory basis for explaining actual E-layer observations than ion-ion recombination, and that most of the atomic processes involved are amenable to accurate laboratory measurement.

551.510.535 406

Ionosphere Observations in the Kerguelen Islands—J. Le Gall, B. Mongin, and H. Munier. (*Compt. Rend. Acad. Sci., Paris*, vol. 237, pp. 927–928; Oct. 19, 1953.) An ionosphere station has been established by the S.P.I.M. at Port aux Français (49.6 degrees S, 70 degrees E); regular observations started in February, 1953. Monthly mean values of f_0F_2 and f_0E_s for six months are tabulated; the results demonstrate the great influence of the geomagnetic field.

551.510.535 407

Some Regularities of the Ionospheric F Region—B. Chatterjee. (*Jour. Geophys. Res.*, vol. 58, pp. 353–362; Sept., 1953.) The F_2-layer regularities observed by Ratcliffe (1294 of 1952) are confined to a few stations only, and disappear when the bifurcation of the F layer is large. If the ion content of the F_1 and F_2 layers is considered as a whole, the regularities become much more marked and are observed at Slough, Falkland Islands and Singapore, even when the bifurcation is large. Peaks observed in the monthly mean values are attributed to tidal effects. The results are in conformity with the view that the F_1 and F_2 layers constitute a single ionization region.

551.510.535:525.624 408

Lunar Tidal Variations in the Sporadic-E Region—S. Matsushita. (*Rep. Ionosphere Res., [Japan]*, vol. 7, pp. 45–52; June, 1953.) Lunar tidal variations in the E_s layer are deduced from a statistical study of records from various stations. The maximum amplitude of the lunar semidiurnal variation of fE_s for a period of a year resembles that of the F_2 layer; in summer it is larger than that of the F_2 layer, especially in middle latitudes. The magnitude of the height variation is similar to that of the F_1 layer. The maximum height variation occurs about six hours after the lunar culminations, and the maximum value of fE_s two or three hours later. Possible explainations of the phenomena are discussed.

551.510.535:550.384 409

The Distribution of the Ionospheric Disturbances during the Geomagnetic Bay—H. Kamiyama. (*Rep. Ionosphere Res., [Japan]*, vol. 7, pp. 70–71; June, 1953.) A statistical analysis based on ionospheric data obtained at 35 widely distributed stations.

551.510.535:550.384 410

On a Change in Geomagnetic Declination accompanying Intense Sporadic-E-Layer Ionization—H. Hojo and T. Yonezawa. (*Rep. Ionosphere Rres., [Japan]*, vol. 7, pp. 61–67; June, 1953.) Analysis of geomagnetic and ionospheric data obtained at Kakioka and Kokubunji respectively indicate that the geomagnetic declination exhibits increased diurnal variation a few hours after the appearance of an intense E_s layer. It is inferred that the E_s-layer ionization is probably due to the incidence of particles.

551.510.535:551.594.12 411

A Procedure for the Determination of the Vertical Distribution of the Electron Density in the Ionosphere—D. H. Shinn. (*Jour. Geophys. Res.*, vol. 58, pp. 416–418; Sept., 1953.) Comment on 409 of 1953 (Kelso). See also 1997 of 1953 (Manning).

551.510.535:621.396.11 412

Optic Axes and Critical Coupling in the Ionosphere—N. Davids. (*Jour. Geophys. Res.*, vol. 58, pp. 311–321; Sept., 1953.) The similarity between the phenomena of double refraction in crystals and in the ionosphere is discussed [2868 of 1952 (Lange-Hesse)]. The ionosphere problem is studied by introducing a reference system based on the principal directions of the three-dimensional dielectric ellipsoid; these depend only on the direction of the earth's field, and are essentially constant over the ionosphere. Optic axes can exist in the ionosphere in the presence of collisions, and this is precisely the condition for critical coupling between the ordinary and extraordinary modes. The analysis is illustrated by reference to a possible set of ionospheric conditions.

551.578.1:551.594.25 413

Raindrop Charge and Electric Field in Active Thunderstorms—R. Gunn and C. Devin, Jr. (*Jour. Met.*, vol. 10, pp. 279–284; Aug., 1953.) Measurements on over 7000 drops are reported; the average charge was 0.022 esu for positively charged drops and 0.031 esu for negatively charged drops.

551.578.4:551.594.6 414

On the Electrification of Snow—H. Norinder and R. Siksna. (*Tellus*, vol. 5, pp. 260–268; Aug., 1953.) An account is given of experimental investigations of the charging produced by (*a*) pouring snow from a vessel into a funnel, and (*b*) blowing snow on to an insulated target. The results are relevant to problems of precipitation static.

551.578.7:621.396.96 415

Radar Echoes from a Growing Thunderstorm—R. Wexler. (*Jour. Met.*, vol. 10, pp. 285–290; Aug., 1953.) The growth of hail in cumulus clouds is studied theoretically in relation to the first appearance of radar echoes. The results are in good agreement with earlier observations.

551.594.5 416

Auroral Radio-Echo Table and Diagram for a Station in Geomagnetic Latitude 56°—J. C. Cain. (*Jour. Geophys. Res.*, vol. 58, pp. 377–380; Sept., 1953.)

551.594.5:621.396.822 417

Radio Noise from Aurora—R. P. Chapman and B. W. Currie. (*Jour. Geophys. Res.*, vol. 58, pp. 363–367; Sept., 1953.) Failure of attempts made during 1951 and 1952 to detect 10-cm auroral radiation observed in 1949 [3139 of 1949 (Forsyth et al.)] is attributed to the decreased intensity of auroral displays and of sunspot activity.

551.594.6:551.555.6 418

Electrical Properties of the Blizzard—M. Barré. (*Ann. Géophys.*, vol. 9, pp. 164–183; April/June, 1953.) The program of the 1951 expedition to Adélie land was not intended to cover the study of blizzards, but the interference with radio reception due to this cause was found to be so bad that an investigation was instituted. When a meter was connected between the aerial feeder of the atmospherics receiver and earth, a current of 30–50 μA was observed, varying with the intensity of the wind; some days later, in identical weather conditions, the same current intensities were measured, but with reversed sign. To explain this result, extended measurements were made of the charge collected, using horizontal antennas arranged at right angles to the wind. The rf noise spectrum of the blizzard was also studied, using a receiver with a frequency range of 4–15 mc. Records were also made of reception of WWV and WWVH on 5, 10, 15, and 20 mc, for correlation with anemometer and charge records. The results indicate that the sign of the charge collected depends on the temperature of the blizzard, reversal occurring at about −15 degrees C. The rf noise is closely related to the wind and intensity of the blizzard.

551.594.6:621.396.11 419

Audio-Frequency Spectrum of Atmospherics—F. W. Chapman and W. D. Matthews. (*Nature [London]*, vol. 172, pp. 495–496; Sept. 12, 1953.) Results are reported of simultaneous recordings of the frequency components in the band 40 cps–16 kcps. The frequency of the largest component in the "slow tail" decreases as source distance increases and is higher at night than by day, while for the oscillatory part the opposite effect occurs. Selective attenuation of frequencies around 2 kc is indicated.

551.594.6:621.396.11 420

The Variation with Distance in the Range 0–100 km of Atmospheric Waveforms—R. B. Morrison. (*Phil. Mag.*, vol. 44, pp. 980–986; Sept., 1953.) Records of the electric-field variation of a violent thunderstrom, made at distances of 10–100 km, are analysed over portion (*b*), which covers the large and rapid increase in field strength corresponding to the return stroke of the lightning discharge. Theoretical and experimental results for the waveform, the ratio of the maximum es field to the net es change, and the current in the discharge, are in fair agreement.

551.510.535 421

Die Ionosphäre [Book Review]—K. Rawer. Publishers: P. Noordhoff N. V., Groningen, 1952, 189 pp., 14.50 florins. (*Nature, [London]*, vol. 172, p. 514; Sept. 19, 1953.) ". . . intended primarily for the physicist who wishes to make a rapid survey of ionospheric physics. . . . Space has been found, in most cases, not only for a brief review of the background but also for an indication of more recent developments."

LOCATION AND AIDS TO NAVIGATION

621.396.91:551.508.1 422

A New Radio Theodolite—V. Väisälä. (*Proc. Ind. Acad. Sci.*, *A*, vol. 37, pp. 223–228; Feb., 1953.) A preliminary account is given of a fixed-antenna system developed for tracking the Finnish Väisälä-7 radiosonde, which uses a wavelength of 12.5 m.

621.396.96 423
An Improved Marine Radar Set—(*Eng.* [*London*], vol. 196, pp. 248–249; Aug. 21, 1953; *Eng.* [*London*], vol. 176, pp. 236–237; Aug. 21, 1953.) Description of the Kelvin Hughes Type-2C equipment, which has a 12-in. ppi with four scale ranges, with a maximum range of 50 miles.

621.396.96:551.578.12 424
Utility of Radar in Measuring Areal Rainfall—G. E. Stout and J. C. Neill. (*Bull. Amer. Met. Soc.*, vol. 34, pp. 21–27; Jan., 1953.) A comparison was made of rainfall estimates for a 50-mile² area obtained from (*a*) radar observations and (*b*) a network of 33 rain gauges. The radar determination was, in the least satisfactory case, as accurate as that obtained with a network of 1 gauge/200 square miles; in other cases it was considerably more accurate.

621.396.96:621.397.26 425
Radar Relay—F. Kirschstein. (*Fernmeldetech. Z.*, vol. 6, pp. 389–395; Aug., 1953.) Several systems suitable for the transmission of ppi displays are considered theoretically and an estimate is made of the bandwidths required. The usefulness of such systems for air-traffic-control is noted.

621.396.963.3+621.396.932 426
Recent Maritime Radio and Radar Developments—Byrnes. (*See* 531.)

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.7 427
Sorption and Desorption of Gas in the Cold-Cathode Ionization Gauge—J. H. Leck. (*Jour. Sci. Instr.*, vol. 30, pp. 271–274; Aug., 1953.) The rate of clean-up was measured for several gases and vapors, including N, A and water vapor, at pressures between 10^{-6} and 10^{-4} mm Hg; an estimate is made of the influence of the process on the accuracy of the gauge.

531.788.7 428
Wide-Range Vacuum Gage—C. B. Sibley and J. R. Roehrig. (*Electronics*, vol. 26, pp. 176–177; Nov., 1953.) A development of the gauge described by Mellen (1867 of 1946). covering the range 10^{3}–10^{-4} mm Hg.

535.37 429
The Chemistry of Traps in Zinc Sulfide Phosphors—W. Hoogenstraaten. (*Jour. Elec. Soc.*, vol. 100, pp. 356–365; Aug., 1953.) By varying the coactivators in ZnS-Cu, the trap depth could be varied between 0.37 eV and 0.74 eV. The coactivators investigated were Cl, Br, Al, Sc, Ga and In ions. Additional glow peaks and traps were produced by oxygen and the killers Co and Ni. The formation of mixed crystals with CdS and ZnSe generally resulted in a shift of the glow curves towards lower temperatures.

535.37 430
Some Properties of Zinc Sulfide Activated with Copper and Cobalt—W. Hoogenstraaten and H. A. Klasens. (*Jour. Elec. Soc.*, vol. 100, pp. 366–375; Aug., 1953.) The thermal glow, decay and build-up of fluorescence, temperature dependence and the light sum for ZnS-Cu-Co phosphors excited by 3650 Å radiation, were investigated experimentally. Most of the results are explained by means of a model in which Co levels act both as 0.5-eV electron traps and as acceptors for holes ejected thermally from Cu centres with an activation energy of 1.1 eV.

535.37:621.385.832 431
The Efficiency of Fluorescence in Cathode-Ray Tubes—A. Bril and H. A. Klasens. (*Philips Tech. Rev.*, vol. 15, pp. 63–72; Aug., 1953.) See 3607 of 1953.

537.311.33 432
Conduction Mechanisms in Semiconductors—H. Krömer. (*Fernmeldetech. Z.*, vol. 6, pp. 438–443; Sept., 1953.) The first paper of a series on transistors, intended for engineers.

537.311.33:538.632 433
On the Theory of the Isothermal Hall Effect in Semiconductors—P. C. Banbury, H. K. Henisch, and A. Many. (*Proc. Phys. Soc.*, vol. 66, pp. 753–758; Aug. 1, 1953.) "The theory of the isothermal Hall effect is re-examined, taking into account the finite dimension of the specimen in the direction of the Hall emf. This involves consideration of concentration gradients, space charges, recombination processes and floating potential at the Hall electrodes. The analysis leads to recommendations concerning experimental technique."

537.311.33:546.281.26 434
Semiconductor Complexes forming Nonlinear Resistors: Recent Improvements—S. Teszner, P. Seguin, and J. Millet. (*Ann. Télécommun.*, vol. 8, pp. 271–298; Aug./Sept., 1953.) The properties of semiconductors and the nature of their departures from Ohm's law are discussed. A description is given of the preparation of materials with a SiC base; their electrical properties are described and a tentative theory of the mechanism of conduction is presented. Investigations are described with a view to the development of materials with more pronounced nonlinear characteristics. Two types of complex were developed. Type 1 incorporated BeO or MgO, the best results being obtained with 65–66 per cent SiC, 29–31 per cent clay and 4–5 per cent BeO or MgO. Type 2 received special thermal treatment, some containing 65 per cent SiC, 30 per cent clay and 5 per cent MgO, others consisting of 65 per cent SiC, 31 per cent clay and 4 per cent of a Ni-Be or Ni-Mg alloy. The results obtained with Type-1 materials show that the introduction of MgO or BeO increases considerably the l.v. resistance. In Type-2 materials the initial resistance on application of a high voltage is very great compared with the final resistance, the ratio being much greater than in the case of materials without the MgO or alloy additions. Various possible applications of these new materials are suggested.

537.311 33:546.289 435
On the Thermal Conversion of Germanium—F. van der Maesen, P. Penning, and A. van Wieringen. (*Philips Res. Rep.*, vol. 8, pp. 241–244; Aug., 1953.) Experimental results indicate that conversion of *n*-type into *p*-type Ge at 800 degrees C is due to the presence of acceptor impurities on the Ge surface prior to heating. Heating *n*-type Ge in contact with Cu or Ni resulted in a conversion; no conversion was observed with Mg, Fe or Ag.

537.311.33:546.561-31 436
The Semiconductor Properties of Cu_2O: Part 4—Conductivity Measurements at High Temperatures—O. Böttger. (*Ann. Phys., Lpz.*, vol. 12, p. 160; April 16, 1953.) Correction to paper abstracted in 1386 of 1953.

537.311.33:546.561-31 437
The Semiconductor Properties of Cu_2O: Part 6—The Temperature Dependence of the Electrical Conductivity at Temperatures between +20°C and −190°C—G. Blankenburg and G. Schubart. (*Ann. Phys., Lpz.*, vol. 12, pp. 281–296; July 2, 1953.) The results indicate the importance of the controlled cooling of semiconductors pre-treated at high-temperature, to obtain uniform, reproducible properties. Part 5: 1387 of 1953 (Blankenburg and Böttger).

537.311.33:546.561-31 438
The Semiconductor Properties of Cu_2O: Part 7—The Hall Effect below Room Temperature—H. Nieke. (*Ann. Phys., Lpz.*, vol. 12, pp. 297–308; July 2, 1953.) Hall-effect measurements at +50 degrees C to −150 degrees C are reported. The influence of the oxygen pressure during the cooling from the pre-treatment temperatures of 960 degrees C was investigated. Part 6: *see* 437 above.

537.311.33:[621.314.632+621.314.7 439
Semiconductor Circuit Elements—J. S. Blakemore, A. E. De Barr, and J. B. Gunn. (*Rep. Progr. Phys.*, vol. 16, pp. 160–215; 1953.) Theory of the conduction mechanism in semiconductors and semiconductor/metal systems is reviewed, mainly in relation to materials such as Ge and Si, whose special properties depend on the simultaneous flow of electrons and holes. Magnetic and optical effects and noise are discussed. Rectification and transistor action at semiconductor/metal contacts and *p-n* junctions are considered, and the properties of crystal diodes and transistors are described. 105 references.

537.311.33+621.385.032.21]:621.396.822 440
Note on Shot Effect in Semi-Conductors and Flicker Effect in Cathodes—van der Ziol. (*See* 605.)

537.311.33+621.385.032.21]:621.396.822 441
Theory of the Flicker Effect—Tomlinson and Price. (*See* 606.)

538.213 442
Complex Magnetic Permeability of Spherical Particles—J. R. Wait. (Proc. I.R.E., vol. 41, pp. 1664–1667; Nov., 1953.) Calculations are made of the effective permeability for an array of conducting particles embedded in a dielectric. The relations between conductivity, permeability, permittivity, particle radius and frequency are shown in curves.

538.221 443
Ferromagnetic Resonance in Colloidal Suspensions—D. M. S. Bagguley. (*Proc. Phys. Soc.*, vol. 66, pp. 765–767; Aug. 1, 1953.) Measurements have been made of the absorption at 290 degrees K and λ 314 cm and 1.20 cm, using suspensions of ferro-magnetic particles in paraffin wax. The results indicate that the method is useful for investigating the properties of ferromagnetic alloy systems.

538.221 444
The Dependence of Ferromagnetic Resonance in Parallel Wires on the Tension—A. G. Kotov. (*Compt. Rend. Acad. Sci. U.R.S.S.*, vol. 87, pp. 531–533; Dec. 1, 1952. In Russian.) The variation of the magnitude of the ferromagnetic-resonance effect in hardened Ni and Fe wires with the tensile stress and the axial magnetic field is shown graphically.

538.221 445
The Effect of Small Elastic Tensions on the Initial Susceptibility of Ferromagnetic Materials—Ya. S. Shur and D. D. Mishin. (*Compt. Rend. Acad. Sci. U.R.S.S.*, vol. 87, pp. 543–546; Dec. 1, 1952. In Russian.) The initial susceptibility/tensile-stress characteristics of permalloy and various other steels depend on the previous magnetic history and on the crystallographic structure of the specimen. The susceptibility/tensile-stress curves for several specimens are shown.

538.221 446
Comparison of the Effects of Tension and Compression on the Magnetic Characteristics of Mild Steel—G. Vidal and P. Lanusse. (*Compt. Rend. Acad. Sci. Paris*, vol. 237, pp. 902–904; Oct. 19, 1953.) The following sequence of operations was used for the tests:—(*a*) application of stress, (*b*) demagnetization, (*c*) application of magnetizing field, (*d*) measurement of induction. Results are presented graphically.

538.221 447
Secondary Recrystallization Textures in Soft Iron—R. Guihaumé, M. Sternberg, and P. Lacombe. (*Compt. Rend. Acad. Sci. Paris*, vol. 237, pp. 904–906; Oct. 19, 1953.) An account of experiments in which large crystals

were found to develop in armco specimens after cold working followed by heat treatment.

538.221 448
Recent Investigations of Magnetic-Reversal Domains—C. Greiner. (*Ann. Phys., Lpz.*, vol. 12, pp. 89–110; April 16, 1953.)

538.221 449
Magnetic Measurements on Iron Amalgam with Reference to the Problem of Ferromagnetism and Grain Size—A. Mayer and E. Vogt. (*Z. Naturf.*, vol. 7a, pp. 334–340; May, 1952.)

538.221 450
The Barkhausen Effect in Single Crystals—R. S. Tebble and V. L. Newhouse. (*Proc. Phys. Soc.*, vol. 66, pp. 633–641; Aug. 1, 1953.) The results of measurements on single crystals of Si/Fe and Ni show that the Barkhausen effect is small and the magnetization process is mainly reversible, if the demagnetization factor of the specimen is large. It is suggested that the Barkhausen effect is associated with the movement of 180 degree rather than 90 degree boundaries.

538.221 451
Ferromagnetic Domain Processes in Single Crystal Disc Specimens of Silicon Iron—D. H. Martin. (*Proc. Phys. Soc.*, vol. 66, pp. 712–714; Aug. 1, 1953.) Changes in the domain structure of the surface layer due to changes in the direction of application of a magnetic field were observed and photographed.

538.222:539.15 452
Paramagnetic Resonance—B. Bleaney and K. W. H. Stevens. (*Rep. Progr. Phys.*, vol. 16, pp. 108–159; 1953.) An account is given of the principal phenomena associated with electronic magnetic resonance. Problems involved in its detection are reviewed. The theory of paramagnetism of the solid state is outlined and the spin-Hamiltonian is derived. The ions of the iron (3d) group and the rare-earth (4f) group are examined in terms of the spin-Hamiltonian. The influence of exchange interaction is discussed, and resonance in gases and other special compounds is treated briefly. 103 references.

538.245.002.2 453
Recent Progress in the Manufacture of Magnetic Materials: Ferronickels with Oriented Structure—É. Josso. (*Ann. Télécommun.*, vol. 8, pp. 262–266; Aug./Sept., 1953.) Various methods of manufacturing oriented Ni-Fe materials are mentioned, the rectangular types of hysteresis curve for such materials are described and the magnetic characteristics are tabulated for a 50/50 Ni-Fe alloy (rectimphy) with a maximum permeability at 0.1 oersted of $8-14\times10^4$ and saturation induction of $15-16\times10^3$ gauss, and also for an alloy (permafix) with a constant permeability of 90–125, depending on heat treatment.

546.289 454
Theoretical Resistivity and Hall Coefficient of Impure Germanium near Room Temperature—P. G. Herkart and J. Kurshan. (*RCA Rev.*, vol. 14, pp. 427–440; Sept., 1953.) The temperature variation of resistivity ρ over the range -100 degrees C to $+140$ degrees C has been calculated and plotted for both *n*-type and *p*-type Ge with varying impurity content corresponding to a resistivity range of 0.1–60Ω. cm at 25 degrees C. The relations between ρ, impurity concentration and the Hall coefficient at 25 degrees C are shown graphically. The mol-fraction of impurity is approximately $3.8\times10^{-8}/\rho$ for *n*-type and $8.1\times10^{-8}/\rho$ for *p*-type Ge over the range $0.1<\rho<20\Omega$. cm.

546.289+546.92]:621.357.13 455
Electrolytic Polishing of Germanium and Platinum in the Presence of F^- or Cl^- Ions—P. Brouillet and I. Epelboin. (*Compt. Rend. Acad. Sci. Paris*, vol. 237, pp. 895–897; Oct. 19, 1953.) Previous research on electrolytic polishing is applied to the cases of Ge and Pt. Details are given of ClNa-ClK and FNa-FK mixtures suitable for revealing the structure of Ge.

548.0:53 456
Physical Properties and Atomic Arrangements in Crystals—W. A. Wooster. (*Rep. Progr. Phys.*, vol. 16, pp. 62–82; 1953.) A survey is made of the relation between the structure of crystals and their magnetic, optical, piezoelectric and elastic properties. Recent work on paramagnetic resonance absorption at high frequencies is discussed in connection with the spinels. The spontaneous electric polarization of Rochelle salt and KH_2PO_4 is attributed to co-operative movements of hydrogen ions.

548.0:53 457
The Physical Properties of Crystals and their Symmetry—M. Tournier. (*Cah. Phys.*, no. 44, pp. 44–73; July, 1953.) Certain properties of crystals can be predicted from the elements of symmetry in the cause-and-effect relations of the phenomena associated with them. Tensor and matrix methods are used to express the pyroelectric, dielectric, piezoelectric and elastic processes. Various crystalline systems are examined, and an indication is given of the properties to be expected of them according to this analysis.

548.1:537.1 458
Interface Area, Edge Length, and Number of Vertices in Crystal Aggregates with Random Nucleation—J. L. Meijering. (*Philips Res. Rep.*, vol. 8, pp. 270–290; Aug., 1953.)

548.5:549.514.51 459
Hydrothermal Synthesis of Quartz Crystals—A. C. Walker. (*Jour. Amer. Ceram. Soc.*, vol. 36, pp. 250–256; Aug. 1, 1953.) The method and the autoclave used to grow crystals, weighing over 1 lb each, in less than 60 days are described.

548.55:537.311.33:[546.28+546.289 460
Apparatus for Crystal Pulling in Vacuum using a Graphite Resistance Furnace—K. Lehovec, J. Soled, R. Koch, A. MacDonald, and C. Stearns. (*Rev. Sci. Instr.*, vol. 24, pp. 652–655; Aug., 1953.) Apparatus suitable for producing large single crystals of Ge or Si is described. Independent rotation of crucible and crystal is provided. The crystal is withdrawn at a rate of up to 6/hour.

548.73:549.731.11 461
Physical and Crystallographical Properties of Some Spinels—F. C. Romeijn. (*Philips Res. Rep.*, vol. 8, pp. 304–320 and 321–342; Aug. /Oct., 1953.) X-ray measurements on simple and complex spinels indicated regularities in ionic distribution and lattice constants. These are explained by a calculation of the Madelung potential, by geometrical considerations, and by the properties of the constituent ions. The calculated relation between the ionic distribution and the oxygen parameter u was confirmed. Some physical properties of the compounds investigated have been correlated with the ionic distribution.

621.314.632.1 462
Cuprous Oxide Rectifier Characteristics—J. Lees. (*Proc. Phys. Soc.*, vol. 66, pp. 622–632; Aug. 1, 1953.) The current/voltage and the capacitance/reverse-voltage characteristic were determined at 0, 30 and 70 degrees C; the latter was independent of temperature in this range. The assumption of a Schottky barrier is not compatible with the results obtained. A method of predicting the reverse current/voltage characteristic, giving results in good agreement with the experimental results, is derived.

621.315.612.4 463
Phase Equilibria in the System MgO-TiO_2—L. W. Coughanour and V. A. DeProsse. (*Jour. Res. Nat. Bur. Stand.*, vol. 51, pp. 85–88; Aug., 1953.) Report of an investigation in connection with the study of ceramic dielectrics.

621.315.612.4:537.226.2–972 464
Investigations in the Tenth-Millimetre Wavelength Region—R. Meier. (*Ann. Phys., Lpz.*, vol. 12, pp. 26–34; April 16, 1953.) Types of grating used in the wavelength range 0.15–0.6 mm are described. The absorption bands of water vapor were partially resolved into absorption lines. The dielectric constants of Condensa N and F and Epsilan 900 and 7000 were determined from reflection-coefficient measurements; the results are shown graphically.

621.315.613.1 465
Alternatives to Mica—E. R. Haines. (*Elect. Rev. [London]*, vol. 153, pp. 437–441; Aug. 28, 1953.) The electrical and mechanical properties of mica and various types of micanite are compared with those of materials of the glass-fibre and asbestos types. A material consisting of glass cloth backed with asbestos paper and fully impregnated with a plasticized-shellac varnish was found to have excellent electrical properties and, from the point of view of moulding, was superior to any mica-type material.

621.375.3.042 466
Evaluation of Core Materials for Magnetic Amplifiers—D. C. Dieterly. (*Elect. Mfg.*, vol. 51, pp. 68–73, 276 and 124–127, 380; Jan./Feb., 1953.)

MATHEMATICS

517.947.5 467
Self-Oscillation in Essentially Nonlinear Quasi-conservative Systems—G. V. Savinov. (*Compt. Acad. Sci., U.R.S.S.*, vol. 89, pp. 995–997; April 21, 1953.) Systems are considered which can be represented by the equation $x+g(x)=\mu f(x, \dot{x}, \mu)$, where μ is a small magnitude characterizing the degree of quasi-conservativeness. This class includes physical systems containing $BaTiO_3$ capacitors or permalloy-cored inductors.

518.5:621.3.011 468
Pocket Reactance and Resonance Calculator—V. J. Tyler. (*Wireless World*, vol. 59, pp. 560–562; Dec., 1953.) A simple calculator comprising six concentric discs and covering twelve decades without ambiguity.

MEASUREMENTS AND TEST GEAR

529.78 (083.74) 469
Pendulum, Quartz and Atomic Clocks as Time Standards—A. Scheibe. (*Z. angew. Phys.*, vol. 5, pp. 307–317; Aug., 1953.) A survey of the development of standard-time clocks from 1932 to date is given. Comparison of the several types indicates the superiority of the quartz clock, although a Cs resonator may be developed for short-period accuracy checking. 37 references.

529.786+621.3.018.4(083.74)]:621.372.412 470
Underearth Quartz Crystal Resonators—T. A. Pendleton. (PROC. I.R.E., vol. 41, pp. 1612–1614; Nov., 1953.) Precision quartz resonators are used in conjunction with oscillators for primary standards of frequency and time. Stable ambient conditions for such resonators are provided by locating them underground. A method is described for measuring resonator-frequency drift to within 2 parts in 10^{10}, using a direct voltage.

621.317:621.396.823 471
Measurement of Radio Interference generated by High-Voltage Lines—D. Renaudin. (*Bull. Soc. Franç. Elect.*, vol. 3, pp. 425–431; July, 1953.) Discussion of the principles of measurement based on a statistical analysis of interference pulse trains due to brush discharges, and on the response of a receiver to this type of interference, taking account of

bandwidth, circuit time-constants and type of detection. Specifications for a standard receiver for measurement purposes and the method of calibration by means of a special noise source are noted.

621.317.3:621.396.822 472

Fluctuation Theory in Physical Measurements—C. W. McCombie. (*Rep. Progr. Phys.*, vol. 16, pp. 266–320; 1953.) An elementary account is given of the ways in which fluctuation theory has been applied to some of the simpler types of physical measurement. Uncertainties in measurements involving suspended systems are discussed on the basis of simple correlation-function arguments, and consideration is given to the methods of measurement appropriate when there are various practical limitations on the parameters of the suspended system. The circumstances under which there is an absolute limit to the attainable accuracy are discussed; the use of feedback may enable such limits to be attained in practice. Some results are established concerning the optimum characteristics of an instrument used to follow a varying signal in the presence of noise. 78 references.

621.317.3.018.78:621.395.625.3 473

"Wow" Measurement—D. W. Thomasson. (*Wireless World*, vol. 59, pp. 579–580; Dec., 1953.) A laboratory method for detecting "wow" in tape recorders is described in which the output obtained on playing a test recording (e.g. of a 1-kc sine wave) is observed oscillographically. For production testing a further method is mentioned, using a frequency-measuring circuit in which a capacitor is charged and discharged during each signal cycle, the average discharge current being proportional to signal frequency.

621.317.33 474

The Measurement of the Electrical Resistance of Powders—H. v. Wartenberg. (*Z. angew. Phys.*, vol. 5, pp. 291–292; Aug., 1953.) The concentration of an electrolyte is adjusted until an addition of the powder has no effect on the conductivity. The resistivities of the powder and electrolyte are then equal. Precautions against the formation of surface layers are outlined.

621.317.34.029.5/.63 475

Filter Insertion Loss in the 10-1000-Mc/s Range—S. Shive. (*Tele-Tech*, vol. 12, pp. 95–97, 184; June, 1953.) Standard attenuation-measurement technique is described. The importance of correct impedance matching, in order to avoid standing waves in the generator-filter-detector line, is pointed out.

621.317.35:621.3.018.78:534.851 476

Distortion in Phonograph Reproduction—H. E. Roys. (*RCA Rev.*, vol. 14, pp. 397–412; Sept., 1953.) Reprint. See 2736 of 1953.

621.317.42 477

Three Methods of Measuring Magnetic Fields: Part 1—Measurement based on the Generator Principle—B. F. Jürgens. **Part 2—Measurement of the Field on the Axis of Magnetic Electron Lenses**—A. C. van Dorsten and A. J. J. Franken. **Part 3—Measurement by the Proton Resonance Method**—H. G. Beljers. (*Philips Tech. Rev.*, vol. 15, pp. 49–62; Aug., 1953.) The principles of the first two of these methods are well known. In the third method, a small vessel of water is placed in the field to be measured. Application of a weak alternating field at right angles to this field causes the hydrogen nuclei to resonate; the resonance frequency is proportional to the strength of the field to be measured. A model with a range up to 14000 gauss has been made. The error is <0.01 per cent.

621.317.7:621.396.82.029.62/.63 478

Measuring Equipment for Radio Interference in the U.S.W. Range—H. Leingang. (*Rhode und Schwarz Mitt.*, no. 3, pp. 120–125; May, 1953.) Equipment for measurement of continuous and discontinuous line and radiated interference in the frequency ranges 30–180 mc and 85–330 mc is described and illustrated. Calibration of the instruments is discussed. A graph showing the difference of the indicated interference level between British and German standard equipment is given.

621.317.73.029.6 479

Improved Accuracy and Convenience of Measurements with Type 1602-B Admittance Meter in V.H.F. and U.H.F. Bands—R. A. Soderman. (*Gen. Radio Exp.*, vol. 28, pp. 1–6; Aug., 1953.) A modified model of the instrument noted in 163 of 1951 (Thurston) is described. The ranges have been extended to 10^{-4}–$1\Omega^{-1}$ for measurement of conductance and susceptance at frequencies from 41 mc to 1 kmc.

621.317.733:621.314.7 480

Bridges measure Transistor Parameters—L. J. Giacoletto. (*Electronics*, vol. 26, pp. 144–147; Nov., 1953.) See 3359 of 1953.

621.317.755:621.375.221:621.376.3 481

A Method of Band-Pass Amplifier Alignment—J. J. Hupert and A. M. Reslock. (Proc. I.R.E., vol. 41, pp. 1668–1671; Nov., 1953.) The second-harmonic distortion is displayed on a cro as a function of the deviation of the carrier frequency from the centre of the pass band. The method is particularly useful for cases where linear variation of phase with frequency is required, e.g. in IF amplifiers for fm receivers. See also 3550 of 1953 (Hupert).

621.317.755:621.385 482

Determination of the Slope of an Electronic-Valve Characteristic by Time-Differentiation of the Anode Current—R. Counord. (*Compt. Rend. Acad. Sci. Paris*, vol. 237, pp. 879–881; Oct. 19, 1953.) The method presented makes use of differentiators described by Rateau (1688 of 1952). The grid of the tube under test is fed with linearly increasing voltages from a sawtooth oscillator, and the anode current is passed through a differentiating circuit, the output of which is displayed on a cro whose timebase is derived from the same oscillator.

621.317.763.029.64:621.372.413 483

Construction and Calibration of a Cavity-Wavemeter for Physical Measurements—J. C. van den Bosh and F. Bruin. (*Physica*, vol. 19, pp. 705–718; Aug., 1953.) The wavemeter described is constructed according to the design of Bleaney et al. (3187 of 1947) and operates in the 12.5-mm wavelength range. Using ammonia absorption lines for calibration, the resonance frequencies are determined to within 1 part in 10^4. Temperature dependence and compensation are discussed.

621.317.772 484

Zero-Intercept Phase Comparison Meter—Y. P. Yu. (*Electronics*, vol. 26, pp. 178–180; Nov., 1953.) Two waveforms to be compared are fed to two separate circuits and a pulse is produced in each circuit when its input voltage crosses the zero axis. The first pulse initiates generation of a sawtooth voltage, while the second cuts off the sawtooth generator. The amplitude of the sawtooth is measured with a calibrated tube voltmeter which gives the phase angle between the two waveforms.

621.317.772:621.317.727 485

Electronic A. C. Potentiometer—L. Tasny-Tschiassny. (*Wireless Eng.*, vol. 30, pp. 295–298; Dec., 1953.) A simple arrangement for measuring phase differences is based on comparison between an unknown voltage and an adjustable known fraction of a reference voltage; operation is independent of frequency. A square-law detector is used. The apparatus is built from standard radio components.

621.373.4.029.63/.64 486

S-Band Sweep Generator and Test Set—R. E. Larson. (*Tele-Tech.*, vol. 12, pp. 116–118, 164; June, 1953.) See 3671 of 1953 (Kluck and Larson).

621.373.42 487

A Novel Audio Sweep Generator—P. Pohl and H. Wolcott. (*Jour. Audio Eng. Soc.*, vol. 1, pp. 244–245; July, 1953.) Description of equipment for use with a cro to display a response curve. A frequency sweep between any two limits within the range 20 cps–200 kc is available.

621.373.421.13:621.317.361.029.6 488

Microwave Frequency Standard—L. C. Hedrick. (*Rev. Sci. Instr.*, vol. 24, pp. 565–568; Aug., 1953.) Details are given of a highly stable signal generator in which the final frequency of mcps is derived in five stages of multiplication from the output of a 5-mcps crystal oscillator. An unknown microwave frequency to be measured is heterodyned against harmonics from this generator, and the resulting beat-frequency signal is fed to a calibrated communication receiver.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.768:546.431.824–31 489

Symposium on Barium Titanate Accelerometers—(*Tech. News Bull. Nat. Bur. Stand.*, vol. 37, pp. 125–126; Aug., 1953.) Brief note indicating the scope of the discussions at the symposium held in Washington, May, 1953.

537.528:534.88:526.956.5 490

The Under-Water Spark as Sound-Pulse Generator—H. Drubba and H. H. Rust. (*Arch. elekt. Übertragung*, vol. 7, pp. 429–440; Sept., 1953.) The discharge of a capacitor through an under-water spark gap was investigated, using inductance-free capacitors of 0.75, 1.25, 2.25, 4.25 and 6.25 μF with voltages up to 5 kV and electrode spacings of 0.1 and 0.3 mm. Oscillographic records were obtained of the current/time curve, discontinuous increases being observed. The duration and shape of the pulses are interpreted on the assumption that the pulse traverses a gas/water boundary close to the spark channel. Photographs of the electrodes showing the effect of the spark, and photographs of the spark region taken 10^{-8}–10^{-4} seconds after the breakdown are included. 138 references. See also 223 of January.

550.837 491

Principle of the Magneto-telluric Method, a New Method for Geophysical Prospecting—L. Cagniard. (*Ann. Géophys.*, vol. 9, pp. 95–125; April/June, 1953.) The method is based on quantitative relations existing between the horizontal components of the electric field and the magnetic field when current flows in the subsoil.

550.837.6 492

Modelling of Alternating Electromagnetic Fields for Geophysical Prospecting—A. G. Tarkhov. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, no. 4, pp. 318–323; June/Aug., 1953. In Russian.) The effect of conducting bodies in the upper layers of the earth on the magnetic field of an hf em field was investigated experimentally by means of a scale model. The scaling-down factors for the conductivity γ and dielectric constant ϵ of the medium, the frequency f and the linear dimension l, were calculated from the equations $\gamma_1 f_1 l_1^2 = \gamma_2 f_2 l_2^2$ and $\epsilon_1 f_1^2 l_1^2 = \epsilon_2 f_2^2 l_2^2$. The observed distribution of the vertical component of the magnetic field is shown graphically.

621.383.2:536.521 493

A New Photoelectric Pyrometer—A. Peuteman. (*Compt. Rend. Acad., Sci.* [*Paris*], vol. 237, pp. 975–977; Oct. 28, 1953.) The vacuum-type photocell used has a Cs-Ag cathode and metal-cylinder anode; it is rendered effectively monochromatic (λ∼680 mμ) by means of optical filters. An ac amplifier is used, the incident radiation being interrupted at about 600 cps. The sensitivity is 1 mv for 5 degrees at 1600 degrees C.

621.384.611 494
The Design and Operation of a 4.5 MeV Microtron—C. Henderson, F. F. Heymann, and R. E. Jennings. (*Proc. Phys. Soc.*, vol. 66, pp. 654–664; Aug. 1, 1953.) Description of a machine similar to that described by Redhead et al. (1472 of 1950), and operating with a rf accelerating field generated by a 500-kw peak microwave source at 3 kmc.

621.384.611 495
The Theory of the Fixed Frequency Cyclotron—B. L. Cohen. (*Rev. Sci. Instr.*, vol. 24, pp. 589–601; Aug., 1953.)

621.384.612 496
Oscillator Switching for Variable Frequency Synchrotron Control—D. E. Caro and L. U. Hibbard. (*Phil. Mag.*, vol. 44, pp. 964–970; Sept., 1953.)

621.384.622.2 497
Effect of Anomalous Attenuation in a Linear Accelerator—C. W. Miller and G. Saxon. (*Nature [London]*, vol. 172, p. 463; Sept. 5, 1953.)

621.385.833 498
Double Focusing of Charged Particles by a System of Two Magnets with Nonuniform Fields—R. M. Sternheimer. (*Rev. Sci. Instr.*, vol. 24, pp. 573–585; Aug., 1953.)

621.385.833:530.145.6 499
Electron-Optical Image Formation based on Wave Mechanics—W. Glaser and P. Schiske. (*Ann. Phys., Lpz.*, vol. 12, pp. 240–280; July 2, 1953.)

621.387.422 500
On Energy Resolution with Proportional Counters—G. S. Hurst and R. H. Ritchie. (*Rev. Sci. Instr.*, vol. 24, pp. 664–668; Aug., 1953.) Investigation of the dependence of the height of the output pulse on the orientation of the ionizing track and on the amplifier time constant.

621.387.424 501
Recent Developments in the Production of Halogen-Quenched Geiger-Müller Counting Tubes—L. B. Clark, Sr. (*Rev. Sci. Instr.*, vol. 24, pp. 641–643; Aug., 1953.) G-M tubes have been constructed using transparent nonmetallic electrically conducting films as cathodes. Advantages of this construction are indicated.

621.387.424 502
The Starting Potential of Counter Tubes—K. H. Lauterjung. (*Z. Naturf.*, vol. 7a, pp. 344–351; May, 1952.)

PROPAGATION OF WAVES

621.396.11:551.510.52]:061.3 503
The 1953 Symposium on Tropospheric Wave Propagation within the Horizon at the U.S. Navy Electronics Laboartory.—W. C. Hoffman. (*Trans. I.R.E.*, vol. AP-1, pp. 28–30; July, 1953.) Report of the symposium held 30th March–2nd April, outlining papers read.

621.396.11:551.510.535 504
The Effect of Ions on Magneto-ionic Characteristic Polarization—W. Snyder. (*Trans. I.R.E.*, vol. AP-1, pp. 23–27; July, 1953.) A general formula for polarization in a mixture of ions and electrons is derived. The predicted polarization of a 100-kc and a 300-kc downcoming wave component in a neutral mixture of oxygen ions, nitrogen ions and electrons is plotted as a function of Goubau's mixture coefficient k (3571 of 1935). The plots show that, in a mixture, (*a*) polarizations are possible that cannot occur when only electrons are present, (*b*) a given polarization does not uniquely determine k, and (*c*) polarization depends on relative numbers of each type of charged particle but not on actual charge density when the proportion of electrons is small.

621.396.11:551.510.535 505
Optic Axes and Critical Coupling in the Ionosphere—Davids. (*See* 412.)

621.396.11:551.594.6 506
Audio-Frequency Spectrum of Atmospherics—Chapman and Matthews. (*See* 419.)

621.396.11:551.594.6 507
The Variation with Distance in the Range 0–100 km of Atmospheric Waveforms—Morrison. (*See* 420.)

621.396.11.029.6:550.38 508
Influence of the Geomagnetic Field on the Propagation of Short Waves. Application to the Calculation of Maximum Usable Frequency—E. Argence. (*Ann. Géophys.*, vol. 9, pp. 227–244; July/Sept., 1953.) The theory presented is developed from a more general method previously noted (2315 of 1952). Approximate expressions for the refractive index are used for calculating sw propagation paths, a plane earth and ionosphere being assumed. Three special cases are examined in detail, viz., (*a*) propagation at the equator, (*b*) east-west propagation at any geomagnetic latitude, (*c*) propagation in the plane of the magnetic meridian; both ordinary and extraordinary rays are calculated. Various methods are discussed for using the results to simplify muf calculations. The effect of curvature of earth and ionosphere is discussed briefly. The method enables the wave polarization to be determined at any point in the path.

621.396.11.029.62 509
Long-Distance Propagation of Metre Waves—B. Sadoun. (*Ann. Télécommun.*, vol. 8, pp. 299–308; Aug./Sept., 1953.) Since November, 1952 records have been obtained at the Laboratoire National de Radioélectricité of the field strengths of fm broadcasting transmitters operating at frequencies of 88–100 mc and at distances of 300–700 km from Paris. The method of measurement is described and typical records are reproduced. The results obtained show that, in addition to abnormal propagation phenomena of a sporadic nature, there exists at great distances a permanent field whose mean value is the more stable as the distance from the transmitter increases. This field strength is much greater than that calculated from wave diffraction round the earth. A tentative explanation is that a scattering of radio waves takes place in the troposphere. The records obtained during eight months show no marked diurnal effects; the variations observed during the day are often quite different from one day to another. Seasonal effects also are not very noticeable.

621.396.11.029.62 510
Note on the Frequency Bandwidth Usable for Long-Distance U.S.W. Transmissions—J. Voge. (*Ann. Télécommun.*, vol. 8, pp. 308–311; Aug./Sept., 1953.) The results of Rice's theory (1473 of 1953) are applied to the transmission path between Wrotham and Bagneux, one of the paths studied by Sadoun (509 above). The maximum usable bandwidth is found to be of the order of 100 kc at a distance of 300 km. The value is independent of the carrier frequency and varies inversely with the distance. This result has not yet been tested experimentally, but it should be noted that the application of Rice's formulas gives values in satisfactory agreement with the results obtained for the periods of fading and the dimensions of the volume in which scattering takes place.

621.396.81.029.64 511
Measurement of Path Loss between Miami and Key West at 3675 Mc/s—R. L. Robbins. (*Trans. I.R.E.*, vol. AP-1, pp. 5–8; July, 1953.) Report of measurements made of the received field strength using 1.5-μs pulses transmitted over five transmission paths about 130 miles long, largely water-covered. Path loss and fading characteristics were similar to those for mountainous paths elsewhere [1114 of 1953 (Bullington)]. No differences were observed due to different terrain in front of the antenna.

621.396.812.3:551.510.535 512
Studies on Mechanism and Distribution of Short-Period Fading Reflected from Turbulent Ionosphere—F. Minozuma and H. Enomoto. (*Rep. Ionsophere Res. Japan*, vol. 7, pp. 53–59; June, 1953.) Fading phenomena are discused in terms of the variations of optical paths produced by turbulence of the ionosphere. A simple model is proposed which fits observations of field strength made on 4-mc and 8-mc standard-frequency transmissions over distances of 90–830 km.

621.396.812.3.029.55 513
Statistical Investigations of Short-Wave Transmission Paths—J. Grosskopf. (*Fernmeldetech. Z.*, vol. 6, pp. 373–378; Aug., 1953.) The statistical distribution of the signal amplitudes was determined for WWV signals received at Darmstadt; it is represented by a log-normal distribution curve. The fading characteristics at 10, 15 and 20 mc were analysed statistically; the hourly scatter of the instantaneous field-strength values was 7 db and the monthly scatter of the hourly median values was 14 db. The device used for counting the frequency of occurrence of the various amplitudes is described.

RECEPTION

621.396.62 514
Development of German Broadcast Receivers from 1945 to 1953—O. Limann. (*Elektrotech. Z., Edn B*, vol. 5, pp. 246–251; Aug. 21, 1953.) As a result of Germany's post-war frequency allocation, work has been largely concentrated on usw receivers. Models briefly described include modern am/fm superheterodyne sets with built-in antenna.

621.396.621 515
Circuit Refinements of 1953/54 [West German] Broadcast Receivers—W. W. Diefenbach. (*Funk-Technik, Berlin*, vol. 8, pp. 456–457, 471; Aug. 1, 1953.)

621.396.621 516
Improvements to the Communications Receiver BRT 400—C. W. M. Read. (*G.E.C. Telecommun.*, no. 16, pp. 40–47; April, 1953.) Modifications to the receiver noted in 2310 of 1949 include an extension of the adjustable IF bandwidth to 13 kc and improved oscillator stability for frequency-shift reception. A tube phase changer is used for cancelling the dc ripple, so that electrolytic smoothing capacitors can be dispensed with.

621.396.621:621.396.8 517
Figure of Merit of Broadcast [receiving] Installations and Conditions for Undisturbed Reception—H. Schmalbruch. (*Z. Ver. dtsch. Ing.*, vol. 95, pp. 774–776; Aug. 11, 1953.) Antenna requirements in respect of height and interference-free location, and advantages of common-aerial reception are indicated. Criteria for estimating receiver performance as regards hum pickup, radiation, selectivity etc. are given; an over-all figure of merit for the installation is obtained by combining these assessments.

621.396.621.54:621.396.91 518
Radio Receiver for recording Time Signals—A. Godefroy. (*Ann. Géophys.*, vol. 9, pp. 245–247; July/Sept., 1953.) A stable highly selective 90.9-kc receiver is described. A double-heterodyne system is used, oscillations from a single quartz-controlled local oscillator beating (*a*) with the incoming signal to give an IF, and (*b*) with the IF to give the af.

621.396.823+621.397.823 519
Effect of Radio Interference generated by High-Voltage Lines on the Reception of Broad-

cast and Television Transmissions—P. Passerieux. (*Bull. Soc. Franç. Élect.*, vol. 3, pp. 432–444; July, 1953.) Detailed results of measurements on different power lines are presented, showing the influence of the arrangement, voltage and surface condition of the conductors on the noise level due to corona discharge, and the effect of coupling between parallel lines on the propagation of a disturbance. Three types of interference trace on a television screen were identified; the number of these traces was very small at normal line voltages but increased greatly at excessive line voltages.

621.396.823:621.315.1.027.8 520
Experimental and Theoretical Study of the Mechanism of Propagation and Radiation of Interference from High-Voltage Lines—J. Fabre. (*Bull. Soc. Franç. Élect.*, vol. 3, pp. 419–424; July, 1953.) Investigation of the field distribution and the spectrum of interference shows that receiver noise due to direct radiation from corona discharge is negligible compared with that due to propagation of the disturbance between line and earth. Frequency spectra of interference from short and long lines are compared. Attenuation as a function of distance along the line is calculated for 400- and 127-kv lines.

621.396.823:621.315.1.027.8 521
Radio Interference from Very-High-Voltage Lines—R. Pélissier. (*Bull. Soc. Franç. Élect.*, vol. 3, pp. 409–418; July, 1953.) The mechanism of corona discharge and the propagation of a disturbance along the lines are discussed with reference to measurements made on different power lines, particularly at a 500-kv experimental station at Chevilly. Received-noise spectra are analysed. A relation between effective noise power and the ratio applied-voltage/critical-voltage is derived by which the maximum noise field strength close to a projected line can be estimated.

621.396.823:621.317 522
Measurement of Radio Interference generated by High-Voltage Lines—Renaudin. (*See* 471.)

621.396.828 523
Progress in Radio-Interference Suppression—W. Scholz. (*Fernmeldetech. Z.*, vol. 6, pp. 385–388; Aug., 1953.) The measurement of interference at frequencies between 150 kc and 328 mc is briefly described [*see* also 478 above]. The generation of interference and its suppression by suitable design, with or without additional suppressors, is discussed; in particular, radiation from fractional-horsepower motors, fluorescent lamps, hf generators and radio and television receivers is considered.

621.396.828 524
A Codan for A.M. Receivers—J. B. Rudd. (*Jour. Brit. IRE*, vol. 13, pp. 558–568; Nov., 1953.) Reprint. See 2132 of 1953.

STATIONS AND COMMUNICATION SYSTEMS

621.396.333 525
Frequency Shift Keying Radio Telegraph Equipment—D. A. Brooke. (*Telecommun. Jour. Aust.*, vol. 9, pp. 42–51; June, 1952.) A brief survey of the historical development of frequency-shift technique is presented and a description is given of the equipment used on a typical circuit working between Perth and Melbourne; results of some performance tests are discussed.

621.396.5:621.396.932 526
Admiralty Radio-Telephone Equipment Type 619—(*Elec. Jour.*, vol. 151, pp. 419–420; Aug. 7, 1953.) An outline description is given of the receiver (60 kc–32 mc), the hf transmitter (1.5–16 mc), the mf transmitter (330–550 kc) and the power unit for operation from 100–125-v or 200–250-v 50–60-cps mains. The radiated field from the superheterodyne receiver is <0.1 μV/m at a distance of one nautical mile.

621.396.5.029.62:621.396.931 527
U.S.W. Radiotelephony for Mobile Services—H. v. Kobierski. (*Fernmeldetech. Z.*, vol. 6, pp. 379–384; Aug., 1953.) A survey and discussion of specifications for mobile R/T equipment.

621.396.65.029.62+621.397.26.029.62 528
Operational and Technical Structure of the Höhbeck V.H.F. Relay Station—Heuser and Pietz. (*See* 539.)

621.396.712.3 529
New Studio Installation at Radio Luxemburg—H. Petzoldt. (*Elektrotech. Z., Edn B*, vol. 5, pp. 263–265; Aug. 21, 1953.) A brief illustrated description of the af equipment and layout.

621.396.721 530
Two-Band Transmitter-Receiver—G. P. Anderson. (*Wireless World*, vol. 59, pp. 493–598; Dec., 1953.) A detailed description is given of low-power equipment for a fixed or portable station providing telephony and cw operation in the 160-m and 80-m bands. Transmitter and receiver are housed in identical boxes 8 inches ×4 inches×5 inches, with a separate unit for power supply. The audio stages of the trf receiver are used for modulating the transmitter.

621.396.932+621.396.963.3 531
Recent Maritime Radio and Radar Developments—I. F. Byrnes. (*RCA Rev.*, vol. 14, pp. 305–317; Sept., 1953.) An outline description of telegraphy and telephony equipment for cargo and passenger ships complying with F.C.C. requirements, the specifications of the Safety of Life at Sea Convention (London, 1948) and the 1947 Atlantic City Conference Radio Regulations. A surface-search radar with a 16-inch ppi display is also described.

621.396.97.029.6+621.397.743.029.6 532
Planning the U.S.W. Broadcasting Network for Sound and Television—F. Gutzmann, W. Knöpfel, and W. Stopp. (*Fernmeldetech. Z.*, vol. 6, pp. 353–372; Aug., 1953.) A survey is made of the development of the transmitter networks in the Federal German Republic before and after the Stockholm Conference [3560 of 1952 (Stopp)]. Frequency allocation, optimum transmitted power, transmitter siting, interference, etc., are discussed. Complete lists are given of the vhf sound and television transmitters, and their geographical position, frequency and radiated power. Field-strength contour and service-area maps are also given. To obtain complete television coverage it will be necessary to provide some uhf transmitters.

SUBSIDIARY APPARATUS

621-526 533
Design Charts for an On/Off Control System—W. T. Bane. (*Trans. Soc. Instr. Tech.*, vol. 5, pp. 52–70; June, 1953. Discussion, pp. 70–71.) A simple and rapid method is presented for determining the step-function response of an on-off system consisting of a pure time delay (or distance-velocity lag), an exponential time constant and an integration.

621.314.57 534
Self-Excited Two-Phase Thyratron Inverter—H. Hertwig. (*Elec. Appl. Bull.*, vol. 14, pp. 54–58; March/April, 1953.) Details are given of a unit providing an output of 30 w at 220 v 50 cps from a 220-v dc input.

TELEVISION AND PHOTOTELEGRAPHY

621.397.2:621.396.662.029.63 535
The Selection and Amplification of U.H.F. Television Signals—W. P. Boothroyd and J. Waring. (*Trans. I.R.E.*, No. PGBTR-3, pp. 5–14; June, 1953.) Maps showing the distribution and coverage of television stations in various parts of the U.S.A. are used to illustrate receiver selectivity problems. The design principles and features of some uhf tuners are described.

621.397.24:535.623 536
Color-Television Converter for Cable Networks—J. G. Reddeck and H. C. Gronberg. (*Electronics*, vol. 26, pp. 132–134; Nov., 1953.) In the NTSC color system, the color information is located towards the upper end of the video-signal spectrum, which extends over a band of 4 mc. In order to be able to transmit this information over the long-distance L-1 coaxial cable, which has a bandwidth of about 2.7 mc, the video signal is split into two bands, one covering 0–2 mc and the other covering the color subcarrier ±0.3 mc; the latter is heterodyned down close to the former to give a compressed video signal of width 2.7 mc.

621.397.26:621.396.65 537
Mobile Outside-Broadcast Decimetre-Wave Equipment for Television Transmission—H. Röschlau. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 144–147; 1953.) Equipment for operation on a wavelength of 21 cm is described. The mobile transmitter has an aerial reflector of diameter 1.1 m, giving a beam width of 16 degrees; the stationary receiver has a reflector of diameter 2.4 m, giving a beam width of 12 degrees. The modulation system is dsb am. Noise-free pictures have been transmitted over distances >40 km.

621.397.26:621.396.65 538
The Equipment of the Cologne-Frankfurt-Neustadt Decimeter-Wave Television-Relay Link—O. H. Appelt, K. Christ, and K. Schmid. (*Fernmeldetech. Z.*, vol. 6, pp. 406–410; Aug., 1953.) The design principles are noted and brief descriptions are given of the equipment and installations at the relay and terminal stations. The methods used for the determination of receiver sensitivity and signal/noise ratio, and over-all distortion, are described.

621.397.26.029.62+621.396.65.029.62 539
Operational and Technical Structure of the Höhbeck V.H.F. Relay Station—H. Heuser and H. Pietz. (*Fernmeldetech. Z.*, vol. 6, pp. 416–421, Sept., 1953.) Television, radio program and R/T relay services are provided for the Berlin-Hamburg vhf link. The equipment, installation and the relay system of operation are described. Frequencies in the 174–216-mc band are used for television and in the 41–68-mc band for sound.

621.397.3 540
The Television Picture—P. Lindner. (*NachrTech.*, vol. 3, pp. 359–364; Aug., 1953.) Perspective, contrast, definition, geometry, and the monochrome reproduction of coloured objects, are discussed.

621.397.5 541
Amateur Television Progress—M. Barlow. (*Wireless World*, vol. 59, pp. 589–592; Dec., 1953.) The total number of active amateur experimenters is estimated to be about 500, the number of amateur stations ≯25. Most of the work is done on the 430-mc band. Some details are given of the apparatus used.

621.397.5:535.623 542
Optimum Utilization of the Radio Frequency Channel for Color Television—R. D. Kell and A. C. Schroeder. (*Trans. I.R.E.*, No. PGBTR-3, pp. 33–39; June, 1953.) See 3431 of 1953.

621.397.5:535.623 543
Transient Considerations in the N.T.S.C. Color System—B. S. Parmet and L. M. Kaminsky. (*Trans. I.R.E.*, No. PGBTR-3, pp. 47–67; June, 1953.) A discussion of methods of reducing picture-signal distortion caused by bandwidth limitations. Fourier-integral analysis is used to determine the amount by which a unit step signal is distorted when the bandwidth and rates of cut-off of the filters are adjusted in ac-

cordance with NTSC specifications. Results are shown graphically.

621.397.5:535.623 544
Technical Signal Specifications Proposed as Standards for Color Television—(*RCA Rev.*, vol. 14, pp. 359–366; Sept., 1953.) NTSC revised specifications of July, 1953. These embody minor modifications to the February, 1953 specifications noted in 3428 of 1953 (Brown and Luck).

621.397.5:533.623 545
Band-1 Colour Television—(*Wireless World*, vol. 59, p. 599; Dec., 1953.) A note indicating the advantage, from the point of view of compatibility, of transmitting the color signal by the adjacent-channel system rather than by the NTSC subcarrier system.

621.397.61:621.372.543.2 546
High-Frequency-Filter Problems in Television Transmitters—Burkhardtsmaier. (*See* 361.)

621.397.611.2 547
Image Orthicon Camera Uubes—G. B. Banks, K. Frank, and E. D. Hendry. (*Jour. Telev. Soc.*, vol. 7, pp. 92–104; July/Sept., 1953.) Detailed description of construction and operation; various manufacturing stages are illustrated.

621.397.611.2 548
A Survey of the Development of Television Pickup Devices—H. A. McGhee. (*Jour. Brit. IRE*, vol. 13, pp. 543–557; Nov., 1953.) The survey includes the image dissector and cr-tube flying-spot scanner, and camera tubes of both anode-potential-stabilized and cathode-potential-stabilized types. The method of improving the operation of the image iconoscope by flooding the target with low-velocity photoelectrons is described.

621.397.62 549
The Design of Television Receivers utilizing Non-synchronous Power—G. D. Hulst. (*Trans. I.R.E.*, No. PBGTR-3, pp. 15–24; June, 1953.) An examination of problems involved in the design of sets to receive standard U.S.A. television broadcasts without adverse effects on the picture while using power supplies at frequencies other than 60 cps. Location of the power transformer and precautions regarding heater wiring are discussed particularly. Details are given of the performance of two commercial receivers.

621.397.62 550
German Television Receivers—H. K. Ibing. (*Z. Ver. dtsch. Ing.*, vol. 95, pp. 769–773; Aug. 11, 1953.) A review of current trends. Features mentioned include provision of high anode voltage, giving brighter pictures; ion traps; ten frequency channels; reduced number of valves; use of Ge diodes. There is little variety as regards IF amplifiers, but individuality is shown in the demodulating, filtering and timebase circuits.

621.397.62 551
German Television-Receiver Circuits, 1953/54—W. W. Diefenbach. (*Funk-Technik, Berlin*, vol. 8, pp. 485–489; Aug., 1953.) Features noted in this survey include multichannel reception, larger picture screens, improved sensitivity achieved by use of cascode input circuits, use of Ge diodes, good stability, and improved facilities for servicing.

621.397.62 552
The Importance of the D.C. Component—D. C. Birkinshaw. (*Jour. Telev. Soc.*, vol. 7, pp. 105–114; July/Sept., 1953.) A description is given of various undesirable effects produced at the receiver if the brightness of the picture is not controlled at the transmitter, i.e. by transmitting the dc component; the effects are illustrated by photographs. In some modern receivers the dc component is deliberately attenuated to suit other design requirements and to avoid brightness flutter due to passing aircraft; alternative methods of solving these problems are indicated.

621.397.62:621.396.662 553
A V.H.F.-U.H.F. Television Turret Tuner—T. Murakami. (*RCA Rev.*, vol. 14, pp. 318–340; Sept., 1953. *Trans. I.R.E.*, No. PGBTR-4, pp. 38–52; Oct., 1953.) Channels 2–83 are covered by using six different types of subassembly (channel strip) consisting of the rf amplifier, oscillator and mixer circuits. Sixteen channel strips are mounted on a turret-type channel selector and a variable impedance in the anode circuit of the oscillator is used to provide a fine tuning control. The vision IF is 45–75 mc, the sound IF 41. 25 mc. Cicruits and performance characteristics are described.

621.397.62:621.396.665 554
A Keyed Minimum-Signal Detector for Television Receiver Impulse-Noise Immunity—A. Macovski. (*RCA Rev.*, vol. 14, pp. 389–396; Sept., 1953.) The minimum, instead of the maximum, of a positive synchronizing pulse is used for the synchronizing-signal-separator and the a.g.c. reference voltages. Circuits are described of a minimum-signal detector, separator and agc systems, diode clipper and noise inverter.

621.397.62:621.396.665 555
A Level-setting Sync and Automatic-Gain-Control System for Television Receivers—E. O. Keizer and M. G. Kroger. (*RCA Rev.*, vol. 14, pp. 379–388; Sept., 1953.) The self-biased synchronizing-signal separator, which charges up on noise pulses, is replaced by a direct-coupled separator, biased by voltage obtained from the IF amplifier stage. This circuit also provides the agc amplification; the agc voltage is protected from noise pulses by clipping in the separator stage. A television receiver embodying the system is desdribed.

621.397.62.002.2 556
Approach to Mechanized Assembly of Electronic Equipment Applicable to TV Receivers—R. F. Newton and L. K. Lee. (*Trans. I.R.E.*, No. PGBTR-3, pp. 25–32; June, 1953.) A study of the immediate possibilities of mechanizing the production of television receivers. Flexibility of operation can be achieved by building up the automatic production line from machine units, individual members of which can be removed as required. Special-purpose machines, such as one for attaching resistors and capacitors, are discussed.

621.397.621:621.311.6 557
Ringing-Choke E.H.T. Unit—D. M. Melluish. (*Wireless World*, vol. 59, pp. 603–604; Dec., 1953.) Description of a circuit suitable for operating a 6-in. cr tube, and capable of providing a voltage of 2–3 kv at 250 μa from a 350-v 10 ma supply.

621.397.621.018.75 558
Pulse-Regeneration Equipment for Television Signals—G. Dröscher. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 148–149; 1953.) A circuit for use in relaying television is described and illustrated. Synchronizing pulses are separated from the incoming picture signal, the slope of the flanks is increased in two overmodulated amplifier stages, and the pulses are then recombined with the picture signal.

621.397.621.2:535.623 559
A Four-Gun Tube for Color Television Receivers—J. L. Rennick and C. H. Heuer. (*Trans. I.R.E.*, No. PGBTR-3, pp. 40–46; June, 1953.) The tube is similar to the three-gun aperture-mask type described by Law (844 of 1952), but each group of phosphor dots on the screen includes a fourth dot giving white fluorescence. The signal waveforms required for operating the system are indicated, and the implications of the modification as regards convergence and gamma correction are discussed.

621.397.7 560
New Directional Radio Links and Television Transmitters in the German Democratic Republic—(*NachrTech.*, vol. 3, p. 337; Aug., 1953.) A note on the inauguration of the Berlin-Leipzig uhf television link and the Leipzig transmitter. The vision transmitter frequency is 59.25 mc (ssb transmission), the fm sound transmitter frequency is 65.75 mc.

621.397.7 561
Special Effects for Television Studio Productions—A. M. Spooner and T. Worswick. (*Proc. IEE*, Part I, vol. 100, pp. 288–296; Sept., 1953. Discussion, pp. 296–299.) Three methods of producing special effects are described, viz., (*a*) optical-image back projection for providing scenery, (*b*) inlay, in which a picture from one camera is substituted by electronic means for part of the picture from a second camera, (*c*) overlay, in which a result similar to back projection is obtained by electronic means. Advantages and operational difficulties associated with these processes are discussed.

621.397.7 562
The 10-kW Television Transmitter Station on the Feldberg (Taunus)—(*Fernmeldetech. Z.*, vol. 6, pp. 396–405 and 449–454; Aug./Sept., 1953.) Technical details are given of the sound and vision transmitters and of the slotted-cylinder antenna. A power gain of 12, obtained by feeding the common wide-band aerial via a diplexer, results in effective radiated powers of 36 and 120 kw respectively for sound and vision. The present sound and vision transmission frequencies are 201.75 and 196.25 mc respectively. The account comprises four papers, as follows:

A. Picture and Sound Transmitters.—E. Heinecke and H. Hornung.

B. Modulation Amplifier and Video Frequency Monitoring Equipment.—R. Urtel and K. Jekelius.

C. Aerial Diplexer and Single-Sideband Filter.—A. Linnebach.

D. Slotted-Cylinder Aerial for the 174–216-Mc/s Television Band.—H. Bosse and W. Crone.

621.397.7 563
The New Television Building in Hamburg-Lokstedt—W. Nestel. (*Tech. Hausmitt. Nordw, Dtsch. Rdfunks*, vol. 5, pp. 125–127; 1953.) The considerations underlying the structural design and technical equipment of this studio centre are discussed. See also *Funk-Technik, Berlin*, vol. 8, pp. 670–671; Nov., 1953.

621.397.7 564
Architectural Aspects of the New Television Building in Hamburg-Lokstedt—K. Heinemann and K. Langer. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 128–133; 1953.)

621.397.7 565
Heating, Ventilating, Air-Conditioning and Refrigerating Installations in the New Television Building at Lokstedt—O. H. Brandi. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 134–135; 1953.

621.397.7 566
The Television Switching Equipment at the Lokstedt Studio—F. Below. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 137–139; 1953.) The facilities described correspond to an interim stage in which four studios are available. The circuits from the control cubicles and the film-scanning room are routed via a main control room.

621.397.7:534.861.1 567
The Problem of the Acoustics of a Television Studio—H. Kösters. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 135–136; 1953.) Acoustics problems associated with the need for frequent changes of scene are discussed.

621.397.712 568
Picture-Mixing Desk for Transmission Truck—H. Fünfstück. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, vol. 5, pp. 140–143; 1953.) A four-channel mixer is described in which the video-amplitude controls are lever actuated. A black-level-control diode prevents undesirable effects in the amplifier during cross-fades.

621.397.743.029.6+621.396.97.029.6 569
Planning the U.S.W. Broadcasting Network for Sound and Television—Gutzmann, Knöpfel and Stepp. (*See* 532.)

621.396.7:621.397.5:535.623 570
A Comparison of Monochrome and Color Television with Reference to Susceptibility to Various Types of Interference—G. L. Fredendall. (*RCA Rev.*, vol. 14, pp. 341–358; Sept., 1953.) The types of interference used in this series of subjective tests included co-channel, adjacent-channel, random-noise, sine-wave, impulse-noise and multipath interference. Color is more susceptible (by 6–8 db) than monochrome to upper-adjacent-channel interference, and slightly more susceptible to some of the other types.

621.397.823+621.396.823 571
Effect of Radio Interference generated by High-Voltage Lines on the Reception of Broadcast and Television Transmissions—Passerieux. (*See* 519.)

621.397.828 572
Ignition Interference with Television Reception—A. H. Ball and W. Nethercot. (*Proc. IEE*, Part I, vol. 100, pp. 299–300; Sept., 1953.) Oscillograms are shown of the discharge of a typical ignition circuit with and without an interference-suppressing resistor; in the latter case the discharge is oscillatory and the peak value of the current is ~220 a; in the former case the discharge is unidirectional and the peak value of the current is 0.8 a. Tests indicate that suppressors have no adverse effect on normal engines under normal operating conditions.

621.397.5 573
Television. [Book Review]—F. Kerkhof and W. Werner. Publishers: Cleaver-Hume Press, London, and Elsevier Press, New York, 1952, 434 pp., 50s. (*Nature [London]*, vol. 172, pp. 471–472; Sept. 12, 1953.) "As the first full modern study of the basic aspects of the subject, this work can be recommended with confidence both for general reading and, with the aid of the excellent bibliography provided, as a constant source of reference for more detailed study." For a review of the German edition see 2643 of 1952.

TRANSMISSION

621.396.61.029.55 574
A New 5-Kilowatt H.F. Multichannel Transmitter—F. R. Hill. (*Proc. I.R.E., Aust.*, vol. 14, pp. 219–227; Sept., 1953.) A detailed description is given of a telegraphy transmitter comprising four separate crystal-controlled rf units, with a rf output of 5 kw each at 3–25 mc, a single modulator and a power-switching unit. Independent cw transmission, or common mcw transmission, on up to four channels is obtained by a simple power-switching operation. With a different modulator the same rf units could be used for broadcasting.

621.396.662.6:621.396.933 575
Increasing Mean Modulation Depth by Peak Speech Clipping—(*Marconi Rev.*, vol. 16, p. 184; 4th Quarter, 1953.) In normal speech the peak power of the average vowel is considerably greater than that of the average consonant, hence a carrier modulated 100 per cent by vowel sounds is modulated much less by consonants. Improved intelligibility is obtained by "speech clipping," i.e. reducing this intensity difference before modulation. For 100 per cent modulation by peak vowel sounds, the mean modulation depth is 35 per cent with no clipping, 70 per cent with 12 db of clipping and 95 per cent with 24 db of clipping. The technique is used in air-to-ground communications.

TUBES AND THERMIONICS

537.533 576
Field Electron Emission and Gas Adsorption—F. Kirchner and H. Kirchner. (*Z. angew. Phys.*, vol. 5, pp. 281–283; Aug., 1953.) The variation with temperature of the field emission from a tungsten point with a layer of adsorbed oxygen was investigated experimentally. A critical temperature was found at which an abrupt change occurred in the electron emission; the observed effects indicate that above this temperature the oxygen forms only an incomplete coating.

621.314.632+621.314.7]:537.311.33 577
Semiconductor Circuit Elements—Blakemore, De Barr and Gunn. (*See* 439.)

621.314.632:546.289 578
Point-Contact Germanium Rectifiers—R. T. Lovelock. (*Wireless World*, vol. 59, pp. 511–514 and 600–602; Nov./Dec., 1953.) A simple exposition of semiconductor theory is given as a basis for a discussion of factors affecting the performance and reliability of Ge rectifiers. The influence of temperature and humidity is examined.

621.385.029.6:621.396.822 579
Noise in C.W. Magnetrons—D. Middleton, W. M. Gottschalk, and J. B. Wiesner. (*Jour. Appl. Phys.*, vol. 24, No. 8, pp. 1065–1066; Aug., 1953.) Measurements were made to determine whether the magnetron output should be regarded as carrier plus noise, carrier amplitude-modulated by noise, or carrier phase-modulated by noise; the last of these alternatives appears to fit the experimental results best. The frequency deviations observed could be accounted for by fluctuations in the density of the magnetron space charge due to cathode-noise effects or to the presence of gas ions.

621.385.029.63 580
Design and Performance of a High-Power Pulsed Klystron—M. Chodorow, E. L. Ginzton, I. R. Neilsen, and S. Sonkin. (Proc. I.R.E. vol. 41, pp. 1584–1602; Nov., 1953.) Development work at Stanford University on 3-cavity klystrons for operation at 3 kmc in the voltage range 100–400 kv, and delivering power of about 20 mw, is discussed. At the voltages used, relativity effects on the electron velocities must be taken into account. Problems connected with the magnetic focusing of the beam, the cathode design, the avoidance of voltage breakdown, and the generation and transformation of the pulses are examined. The collector is shaped so as to receive the beam over a large area, thus ensuring that the temperature rise is not too great. Details are given of the construction of a particular klystron giving pulses of duration 1–2 μs with a beam voltage of 400 kv and a beam current of 250 a. The longest life so far recorded is 200 hours at 17 mw output and >460 hours at 8 mw output, but it is considered that a life of >1000 hours could be attained with an operating voltage of about 300 kv.

621.385.029.63/.64 581
Influence of Secondary Electrons on Noise Factor and Stability of Traveling-Wave Tubes—R. W. Peter and J. A. Ruetz. (*RCA Rev.*, vol. 14, pp. 441–452; Sept., 1953.) The noise factor and stability of the experimental 3-kmc traveling-wave tube [277 of 1953 (Peter)] were improved by using a magnetically shielded collector, thus preventing secondary electrons emitted by the collector from reaching the helix. Experimental details are given.

621.385.029.63/.64 582
Measurement of the Cross-Sectional Non-uniformity of the Electron Beam in a Helix-Type Travelling-Wave Valve—H. Schnitger. (*Arch. elekt. Übertragung*, vol. 7, pp. 415–420; Sept., 1953.) As a result of radial components in the initial velocity of the electrons, the beam diameter varies periodically along its length. Using theory given by Wang (1395 of 1950), a relation is established between (*a*) the distance separating successive beam-radius minima (the "wavelength"), and (*b*) the ratio of maximum to equilibrium radius. The cross-sectional non-uniformity can then be determined from measurements of this "wavelength." The method used is to measure the helix current as a function of the position of a short double coil which is moved coaxially along the valve and whose windings carry equal and opposite currents.

621.385.029.63/.64 583
On the Excitation of Different Space-Charge Wave Modes in Travelling-Wave Tubes—O. E. H. Rydbeck. (*Arch. elekt. Übertragung*, vol. 7, pp. 409–414; Sept., 1953. In English.) Analysis is given for beams of moderate current density. The characteristic equation for the traveling-wave tube is shown to comprise two coupled equations, one associated with the beam and the other with the helix. These equations are used to investigate the excitation of the space-charge waves and their transformation into waves characteristic of traveling-wave tubes. All the transformed space-charge waves have practically the same propagation constants, and hence the same gain. Space-charge modes whose wavelength is $\sqrt{2}$ times that for an infinitely wide beam are most easily transformed. It is probable that no transformations of this kind occur at very high beam current density.

621.385.029.63/.64 584
Traveling-Wave-Tube Helix Impedance—Ping King Tien. (Proc. I.R.E., vol. 41, pp. 1617–1623; Nov., 1953.) Helix impedance K is given by the formula $K = E_z^2(0)/2\beta^2P$, where $E_z(0)$ is the maximum value of the longitudinal field on the axis, P is the power in the wave carried by the helix, and β the phase constant. The value of K is found by calculation to be smaller for the "tape-helix" model than for the "sheath-helix" model, and to decrease as the ratio of helix circumference to free-space wavelength increases. Conditions are analyzed for a tape helix surrounded by a dielectric. The theory indicates that the design of traveling-wave valves can be improved (*a*) by means of suitably designed dielectric supports for the helix, and (*b*) by reducing the space-harmonic component fields.

621.385.029.63/.64 585
Prediction of Traveling-Wave-Magnetron Frequency Characteristics: Frequency Pushing and Voltage Tuning—H. W. Welch, Jr. (Proc. I.R.E., vol. 41, pp. 1631–1653; Nov., 1953.) "Frequency pushing" is defined as the frequency variation associated with change of anode direct current when the anode voltage is varied, the resonator temperature being held constant. "Voltage tuning" is defined as the frequency variation associated with change of anode direct voltage when anode direct current, load impedance, magnetic field and resonator temperature are held constant. Formulas are derived expressing the relations involved, based on an approximate determination of the distribution of space charge for high rf voltage. Calculated characteristics for typical design parameters are presented. Theoretical and experimental results are compared.

621.385.029.64/.65 586
Backward-Wave Tubes—R. Kompfner and N. T. Williams. (Proc. I.R.E., vol. 41, pp. 1602–1611; Nov., 1953.) Experiments with traveling-wave tubes of the type described by Millman (547 of 1952) show that oscillations can be generated in modes such that rf power output is obtained at the gun end of the valve. The first and second spatial-harmonic modes

were excited with voltages of 1.6–4 kv and 600–900 v respectively on the electron beam constituting the feedback path; the corresponding wavelength ranges were 6–7.5 mm and 5.9–6.4 mm. A frequency band of 10 kmc is thus covered by purely electronic tuning. Power output of about 10 mw was obtained at 6.4 mm λ. The operation of the tubes as amplifiers was also studied. Theory is given.

621.385.029.65/.64:621.373.423 587
Backward-Wave Tube—H. Heffner. (*Electronics*, vol. 26, pp. 135–137; Oct., 1953.) An explanation is given of the production of the backward wave in a traveling-wave tube, and the conditions for oscillation are indicated. Continuous tuning over a 3:1 range is possible.

621.385.029.65 588
A Hairpin-Tube Backward-Wave Oscillator—G. E. Helmke. (*Bell Lab. Rec.*, vol. 31, pp. 286–291; Aug., 1953.) The construction of an experimental tube and, in particular, of the interdigital waveguide section containing the wire loops which resemble a row of hairpins, is described. The frequency of oscillation may be varied between 43 and 63 kmc by varying the beam voltage between 500 and 2500 v.

621.385.032.213.2 589
The Emission Constants of Metal Capillary Cathodes—H. Benda. (*Frequenz*, vol. 7, pp. 226–232; Aug., 1953.) Continuation of work noted in 1155 of 1952 (Katz and Rau). The emission constants of W-$BaCO_3$+Si cathodes were determined experimentally by measuring the current collected by the metal capillary cathode when connected as anode in relation to a heated counterelectrode; this current depends on the work function of the metal capillary cathode. The arithmetic mean of the work function over a period of aging at about 950 degrees C is 2 ev. The value thus found for the Richardson constant A is of the order of 10^2; the discrepancy between this value and that found by other methods is discussed.

621.385.032.216 590
Diffusion of Barium in an Oxide-Coated Cathode—R. S. Bever. (*Jour. Appl. Phys.*, vol. 24, pp. 1008–1010; Aug., 1953.) Measurements of the diffusion of BaO through activated BaO-SrO cathode coatings, using a technique similar to that described by Redington (432 of 1953), indicated that the law of temperature variation of diffusion was similar to that for Ba in BaO single crystals. The activation energy was 4.1 ± 0.6 ev above 1280 degrees K and 0.40 ± 0.07 ev below that temperature.

621.385.032.216 591
Space-Charge Effect in the Oxide-Cathode Layer: Part 2—T. Shindo. (*Jour. Phys. Soc. Japan*, vol. 8, pp. 494–499; July/Aug., 1953.) The theory previously given (2082 of 1952) is extended to include the retarding-field region. The emission characteristics for a planar diode are calculated.

621.385.032.216 592
A Theoretical Study of the Chemistry of the Oxide Cathode—E. S. Rittner. (*Phillips Res. Rep.*, vol. 8, pp. 184–238; June, 1953.) A comprehensive analysis, based on thermochemistry and on the theory of diffusion, is presented. The treatment is based on the assumption that excess Ba is required to activate the coating. Metals with sufficient reducing power to act as activators include Th, Mg, Be, Hf, Sc, Y, Sm, Nd, Pr, La, Zr, U, Al, Si, C and possibly Ti and Ce. The most favorable reaction mechanism for the generation of free Ba is that in which the reaction speed is limited by the rate of diffusion of the activator in the core metal. The free Ba penetrates the oxide crystals by Knudsen vapour flow and volume diffusion, and hence the coating should be porous.

621.385.15:621.375.2 593
Wide-Band Amplifiers using Secondary-Emission Tubes—Chandler and Linz. (*See* 367.)

621.385.15:621.385.5 594
Electron Multiplier Valve—A. Lempicki. (*Wireless Eng.*, vol. 30, pp. 312–317; Dec., 1953.) The multiplier tube considered is similar in construction to an ordinary rf pentode, the multiplier anode being of grid form and occupying the position of the usual suppressor, while the secondary emitter occupies the position of the usual anode; the performance of these two valves is compared. The multiplier type is recommended for wide-band operation, but the over-all multiplication factor should be not greater than about 10. Upper frequency limits due to electron transit times in the various sections of the tubes are discussed, and noise is considered.

621.385.2:621.316.722.1 595
Characteristics of the Temperature-Limited Diode Type 29C1—F. A. Benson and M. S. Seaman. (*Electronic Eng.*, vol. 25, pp. 462–464; Nov., 1953.) Static characteristics and long-term test results are given for the diode used in the stabilizer described by Richards (1742 of 1952) and in the differential voltmeter described by Attree (3501 of 1952).

621.385.2.032.21 596
Diode Characteristic of a Hollow Cathode—M. L. Babcock, D. F. Holshouser, and H. von Foerster. (*Phys. Rev.*, vol. 91, p. 755; Aug. 1, 1953.) Very much higher currents, particularly for small potentials, are obtained than would be expected from the I/V curve for the equivalent planar diode.

621.385.3+621.385.5 597
Performance Evaluation of "Special Red" Tubes—H. J. Prager. (*RCA Rev.*, vol. 14, pp. 413–426; Sept., 1953.) The term "Special Red" refers to some small receiving-type tubes specially selected for industrial applications. The results of life-tests are presented graphically and discussed. Both electrical and mechanical tests were made.

621.385.3 598
Variations of Triode Characteristics with Heater Voltage—F. A. Benson, G. V. G. Lusher, and M. S. Seaman. (*Elect. Jour.*, vol. 151, pp. 481–483; Aug. 14, 1953.) The I_a/V_g characteristic of a triode is modified by a deviation of the filament voltage from normal. It can be expressed by the equation $V_a=r_aI_a-\mu V_g-c_2R_a$ where r_a is the anode resistance, μ the amplification factor and c_2 a constant which is a function of the applied filament voltage and is important in the design of stabilizers and dc amplifiers.

621.385.3:621.387 599
Control of the Discharge Current in Gas-Filled Valves with Grids by Means of Small Alternating Voltages—A. Székely. (*Acta phys. austriaca*, vol. 7, pp. 164–180; May, 1953.) Measurements were made on a Philips type-4690 triode with the grid connected to the cathode via a high resistance. Application of a small alternating voltage to the grid or anode causes the mean grid potential to become negative with respect to the cathode, thereby raising the ignition voltage. If the circuit is tuned to the applied voltage, this rise in ignition voltage is eliminated. The true variation of ignition voltage with frequency is observed by tuning the circuit to a frequency very different from that of the applied voltage. Results are shown graphically. Application of small alternating voltages can also be used for extinguishing discharges.

621.385.3:621.396.662 600
The DM 70 and DM 71 Tuning Indicators—(*Elec. Appl. Bull.*, vol. 14, pp. 1–11; Jan./Feb., 1953.) These two subminiature valves are identical except for the external connecting arrangements. They have a straight directly heated filament (1.4 v, 0.025 a), a long flat control electrode with an aperture shaped like an exclamation mark, and a luminescent anode beyond the control electrode. Lowering of the potential of the control electrode reduces the length of the luminescent bar. Construction, characteristics and circuits are described. For another account see 3456 of 1953.

621.385.3+621.375.2.029.62]:621.396.822 601
Noise Factor of Conventional V.H.F. Amplifiers—Houlding. (*See* 369.)

621.385.5 602
The EL84 Power Pentode—P. J. Tijssen. (*Elec. Appl. Bull.*, vol. 14, pp. 40–53; March/April, 1953.) Design, construction and performance details are given of a 12-w output pentode.

621.385.832:621.318.572 603
The E1T Decade Counter Tube—(*Elec. Appl. Bull.*, vol. 15, pp. 13–26; Jan./Feb., 1953.) See 3762 of 1953 (van Overbeek et al.)

621.396.822 604
Johnson Noise and Equipartition—D. A. Bell. (*Proc. Phys. Soc.*, vol. 66, pp. 714–715; Aug. 1, 1953.) Discussion on 2847 of 1953 (Lindsey and Sims).

621.396.822:[537.311.33+621.385.032.21 605
Note on Shot Effect in Semi-Conductors and Flicker Effect in Cathodes—A. van de Ziel. (*Physica*, vol. 19, pp. 742–744; Aug., 1953.) A limitation of the theory previously given (3035 of 1950) is pointed out. It is shown that flicker effect due to emission centers can be treated in the same way as shot noise in semiconductors.

621.396.822:[621.385.032.21+537.311.33 606
Theory of the Flicker Effect—T. B. Tomlinson and W. L. Price. (*Jour. Appl. Phys.*, vol. 24, pp. 1063–1065; Aug., 1953.) Theories on the low-frequency fluctuation of emission current from oxide cathodes and on the similar effect of contact noise in semiconductors are critically reviewed. A modification to Macfarlane's theory (910 of 1951) is discussed which takes account of conditions in retarding-field operation.

621.385.029.6 607
Atomic Energy Research Establishment Report A.E.R.E. X/R 608, Mode-Separation Theory for Heavily Strapped Magnetrons [Book Notice]—A. W. Aikin. Publishers: H. M. Stationery Office, London, 1950, 2s. (*Govt. Publ.*, p. 20; Aug., 1953.)

MISCELLANEOUS

6:061.4 608
The British Instrument Industries Exhibition.—(*Engineer* [*London*], vol. 196, pp. 20–21, 53–54 and 71–73; July 3–17, 1953.) Description of some of the exhibits.

621.38/.39:629.13.018 609
Aviation Electronics—A. Van Dyck. (PROC. I.R.E., vol. 41, pp. 1572–1578; Nov., 1953.) Special problems introduced by the complexity and unreliability of aircraft electronic apparatus are discussed. The solution depends not only on increasing the reliability of tubes and components, but also on improved planning and specifications and on closer cooperation between the electronic engineers and the other personnel concerned.

621.39:061.4 610
The Leipzig Fair 1953—(*NachrTech.*, vol. 3, pp. 338–342 and 402–406; Aug./Sept., 1953.) A survey of communication equipment, amplifiers, tubes and test equipment exhibited by manufacturers in the German Democratic Republic.

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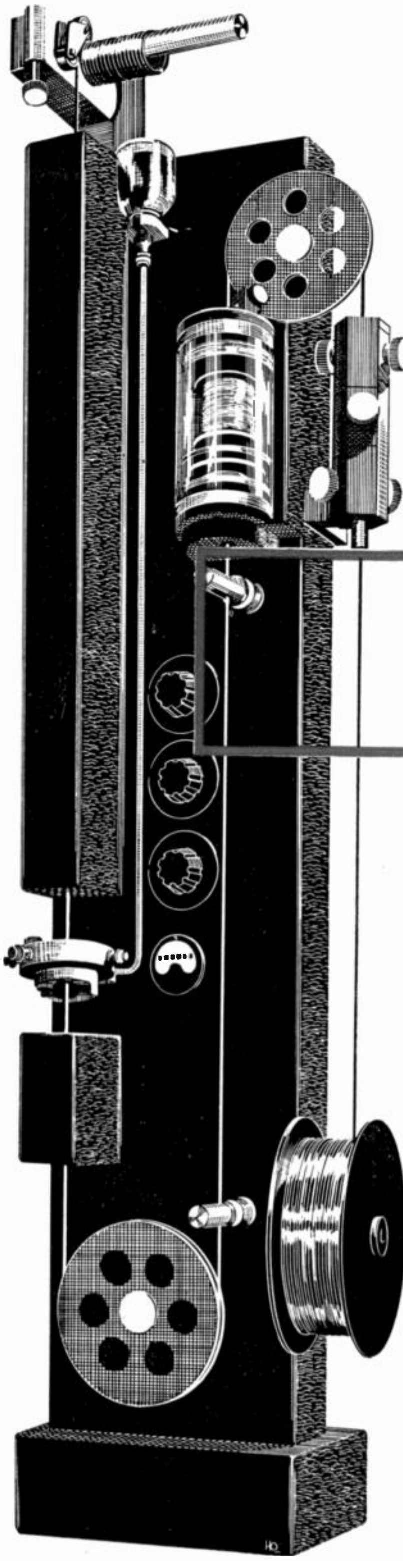

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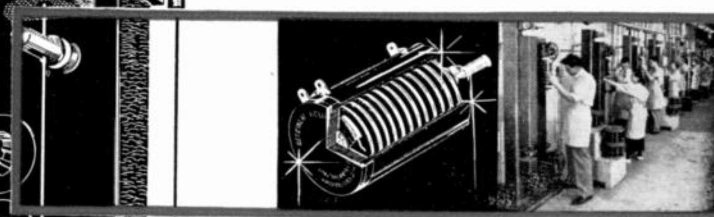

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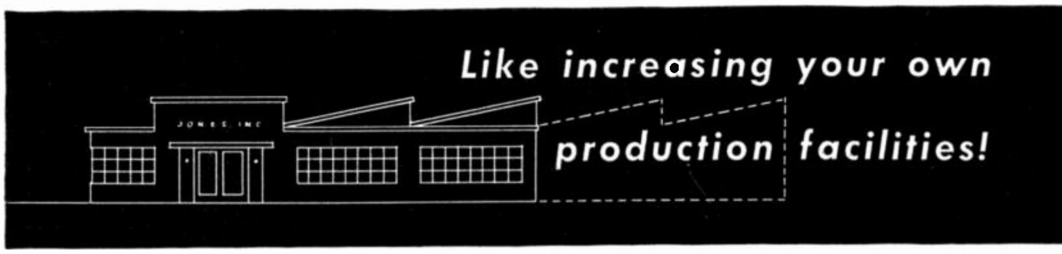

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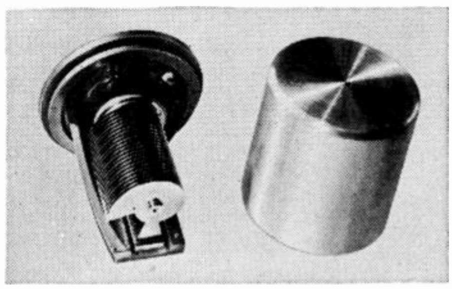

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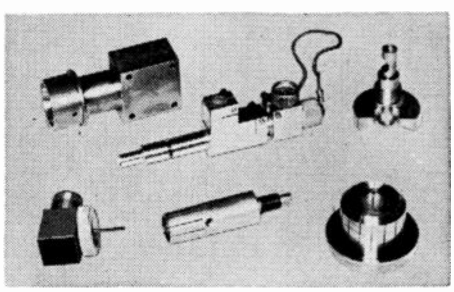

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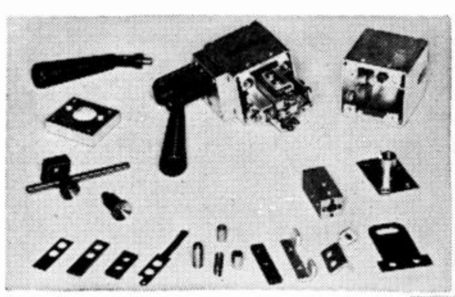

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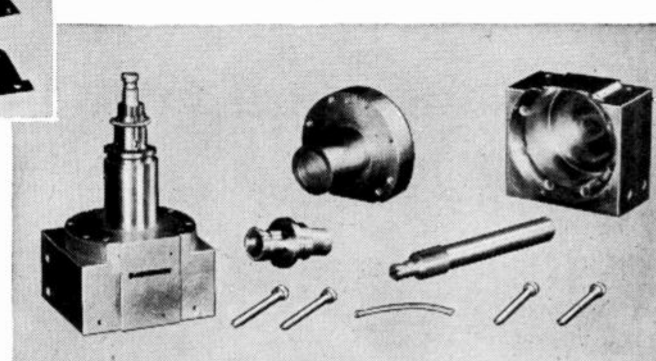

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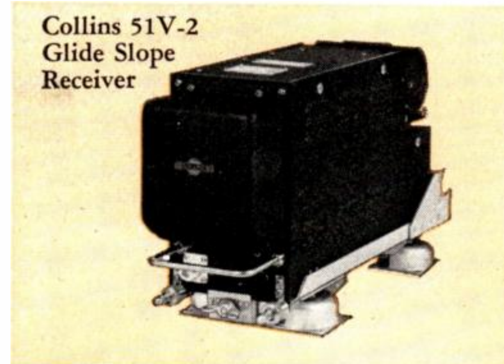


with the NEW Collins 51V-2 Glide Slope Receiver

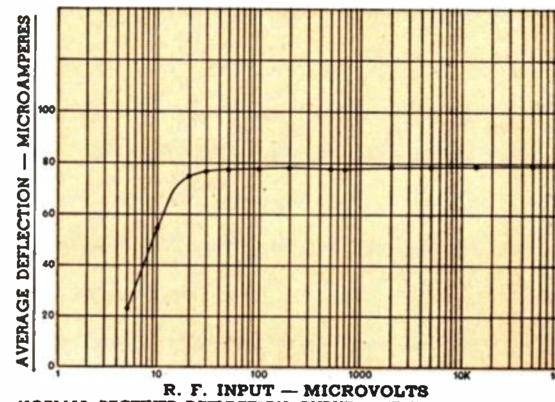
DEVELOPED expressly to meet airline requirements, Collins 51V-2 Receiver together with the Collins type 51R navigation equipment fulfills ILS requirements for commercial and private aircraft.

Negative feedback applied to the two audio stages stabilizes the receiver so that it will perform satisfactorily when the mutual conductance of any or all of the audio tubes is reduced by 50%. AVC voltage on the R.F., I.F. and first audio tubes provides a constant output with varying R.F. input. The AVC characteristic of the receiver is flat from 30 to 100,000 microvolts with standard factory adjustments. These features provide a flat flag current response and allow the flag to be set to very close limits to meet strictest airline requirements. If operating conditions require more or less course softening, a simple screwdriver adjustment of the potentiometer is all that's necessary.

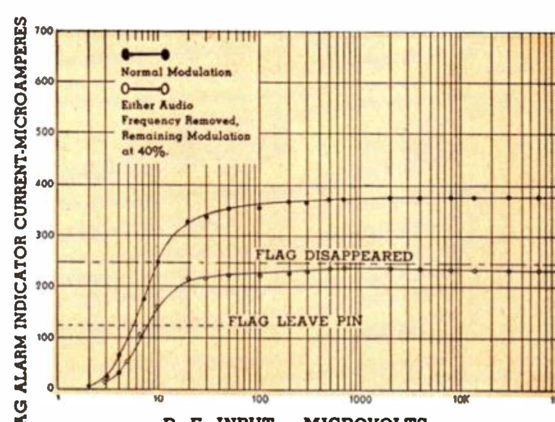
The receiver utilizes a high voltage d-c plate and screen supply obtained from a self-contained dynamotor or 400 cycle a-c power unit. Use of the appropriate dynamotor or a-c power unit makes the receiver operable from a 27.5 volt d-c source or 115 volt, 300-1000 cycle a-c source with 27.5 volts d-c for relays and filaments. The two types of power units are interchangeable.

Another important characteristic is the low value of conducted and radiated interference. Spurious responses are approximately 60 db or more below the level of the desired signal. Precise frequency stability is accomplished through use of a group of twenty crystals for control of the injection oscillator. These crystals are in accordance with MIL-C-3098, except for case marking.

Collins 51V-2 is the successor to the 51V-1, the Glide Slope Receiver noted for its astounding service life. Instrument accuracy of the 51V-2 is unaffected by tube aging. When you install Collins 51V-2, you can be sure of precise instrument approaches for the lifetime of your aircraft.



NORMAL RECEIVER DEFLECTION CURVE — (Falls within limits of ARINC Characteristic No. 519 and RTCA Paper 54-50/DO-33)



NORMAL FLAG ALARM CHARACTERISTIC

See new Collins developments in
AVIATION
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COMMUNICATIONS
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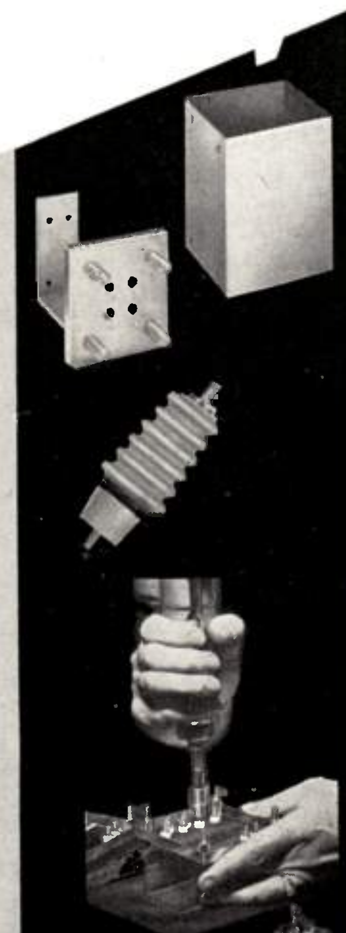


FAMOUS KINGS IN HISTORY

RICHARD I—affectionately surnamed "the Lion-Hearted"—was King of England from 1189 until his death in battle ten years later. In the first year of his reign he started on the Third Crusade. A major figure in English romance, Richard Coeur de Lion is a symbol of chivalry and famous for many deeds of valor.

In this scientific age, Connectors by Kings are a symbol of the most modern progress in engineering ingenuity and precision manufacture. Electronics engineers everywhere accord them a valued recognition earned by years of research and product development. For the finest "Solid Contact" Connectors make Kings your prime source.

FAMOUS
KINGS CONNECTORS

UHF SERIES

KINGS Electronics
40 MARBLEDALE ROAD, TUCKAHOE 7, N. Y.

See Our Exhibit at the IRE Show—Booths 506, 508 Components Avenue

Industrial Engineering Notes*

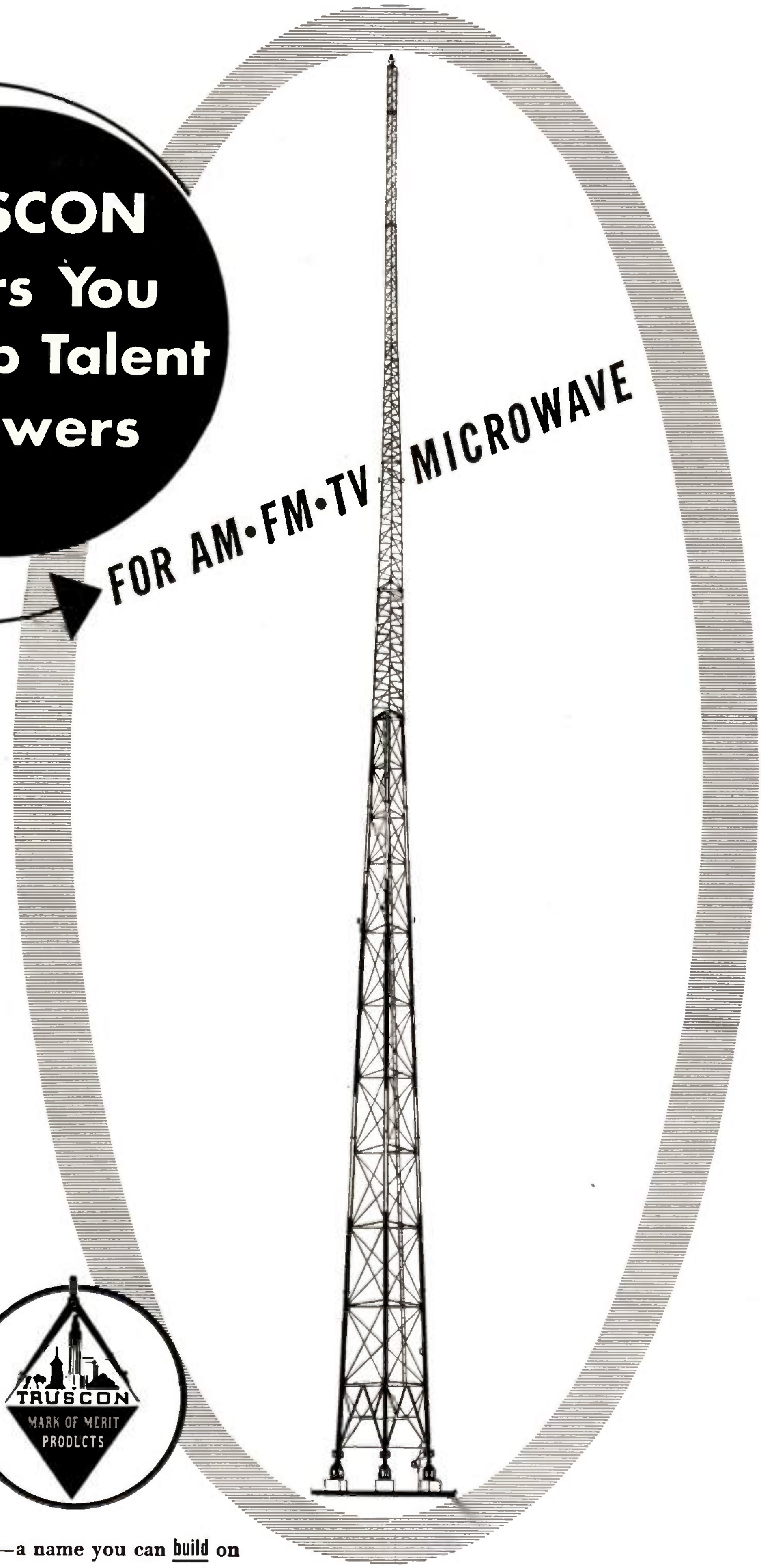
FCC Actions

Lauding the industry's co-operative effort, the Federal Communications Commission on December 17 issued its report and order approving the compatible color television standards "developed and advocated by industry through its National Television System Committee." The standards will become effective 30 days after publication in the Federal Register. Announcement of the Commission's decision came with dramatic suddenness following an FCC meeting at which the NTSC standards were approved by six of the seven Commissioners. Commissioner Frieda Hennock was present but did not vote. Commissioners George E. Sterling, E. M. Webster, and Robert E. Lee issued separate statements concurring with the decision. . . . **The Committee on Manufacturers Radio Use filed a petition recently with the Federal Communications Commission requesting that 40 of the 100 channels in the Citizens Radio Service be assigned to a proposed Manufacturers Radio Service on an exclusive basis.** These proposed new frequencies would be in addition to the presently-available channels in the Special Industrial Radio Service used by the manufacturers. The Committee's petition also requested that manufacturing companies be given the same advantages as other industrial groups in the use of point-to-point communications systems to link separate operating centers. To regain the frequencies proposed to be transferred from the Citizens Radio Service to the Manufacturers Radio Service, the Committee recommended that the FCC initiate a re-examination into the use made of the frequencies reserved for government purposes and for the FM broadcast service. The Committee on Manufacturers Radio Use is supported by 56 large manufacturing companies and is under the chairmanship of Herbert E. Markley, Chairman of the Timken Roller Bearing Co. . . . **Nearly 1.1 million radio authorizations were on the books of the Federal Communications Commission at the end of the fiscal year 1953, the Commission reported recently in releasing its 19th annual report.** Of these, over 235,000 were for safety and communication purposes on land, sea and air, while almost 5,500 others were broadcast, and the remainder consisted of various types of radio operator authorizations. The radio station authorizations, it was pointed out, cover the use of about 600,000 transmitters, of which more than 430,000 are mobile. Radio operator licenses and permits of varying grades outstanding at the end of the fiscal year totaled nearly 840,000, of which more than 730,000 were for commercial station operation and almost 109,000 were for amateur station operation. The largest group of radio stations are in the Safety and Special Radio Services, FCC said,

(Continued on page 137A)

* The data on which these NOTES are based were selected by permission from *Industry Reports*, issues of December 18, 30, January 11 and 18, published by the Radio-Electronics-Television Manufacturers Association, whose helpfulness is gratefully acknowledged.

TRUSCON Offers You The Top Talent in Towers



● Truscon knows towers. Truscon engineers have designed and built many hundreds of towers which now stand strong and tall in all parts of the world . . . in all types of topography . . . and exposed to all extremes of wind and weather.

Recently, Truscon completed the world's tallest radio towers. Today, Truscon's extensive tower experience is unmatched.

Truscon manufacturing facilities are modern and efficient—geared to quality production of guyed and self-supporting towers . . . tall or small . . . tapered or uniform in cross-section . . . for AM, FM, TV and Microwave transmission.

Truscon has the talent you need to help you get and maintain the tower performance you demand. Your phone call or letter to any Truscon district office, or to "tower headquarters" in Youngstown, will start your tower program as soon as defense requirements allow.

TRUSCON STEEL DIVISION

REPUBLIC STEEL CORPORATION
1072 Albert Street
Youngstown 1, Ohio

TRUSCON MARK OF MERIT PRODUCTS

TRUSCON®—a name you can build on

Industrial Engineering Notes

(*Continued from page 134A*)

where more than 235,000 authorizations for these 45 classes of nonbroadcast services represent the use of nearly 152,000 land and fixed transmitters and 433,000 mobile transmitters. Included are nearly 40,400 stations in the marine services, more than 39,000 in the aeronautical services, and over 13,600 land public safety stations such as police, fire, etc. The marine services use nearly 39,000 transmitters; the aeronautical services, over 44,000, and the public safety services, nearly 142,000. The land transportation services embrace nearly 10,000 stations and 116,000 transmitters, FCC reported, and the routing of taxicabs alone requires nearly 88,000 transmitters. The growing utilization of radio by industry is reflected in the nearly 17,000 authorizations for the use of 127,000 transmitters in the nine industrial services. Of these, FCC reported, the power industry has nearly 62,000 transmitters; special industrial, over 30,300, and petroleum, 21,800. Nearly 112,000 authorizations were outstanding for amateur stations at the end of the fiscal year. In the broadcast services, FCC pointed out that during the first 12 months following the lifting of the "freeze" on new television station construction, 398 new stations were authorized. Of these, 89 had received special temporary authorizations to start operating. At the end of the *calendar year*, FCC records show that 518 new TC stations had been authorized, including 213 VHF and 305 UHF outlets. The number of STAs totaled 251, of which 131 were for VHF stations and 120 were for UHF operations. At the close of *fiscal year* 1953, the Commission said there were 2,584 AM stations authorized, an increase of 164 over 1952. Most of the new AM stations, it was reported, were low-power, daytime outlets. The number of authorized and operating FM stations, continued to decline, FCC said, to 601 and 551, respectively. This was a loss of 47 construction permits and 31 licenses during the year. Noncommercial, educational FM grants gained 12 stations during the year, however, making a total of 116 on June 30. In addition to the AM, FM and TV broadcast services, the FCC noted that there were 259 auxiliary TV stations (an increase of 38); 1,305 remote pickup stations (a gain of 130); 47 studio-transmitter links; one developmental station, and a fluctuating number of international stations. In discussing its field engineering and monitoring services, FCC said in the report: "The number of interference complaints requiring field investigation increased to nearly 22,000 which was almost double the number for the previous year. Most of the broadcast interference complaints were due to increased TV operation and the high susceptibility of its reception to interference. Other complaints involved interference from noncommunications equipment and devices. The progress made in organizing FCC-sponsored local citizens interference committees has been helpful to TV viewers combatting interference in nearly 300 communities . . . ." . . . **The FCC is-**

(*Continued on page 138A*)

(Continued from page 137A)

sued a notice of proposed rule making looking toward amending its multiple ownership rules to increase the maximum permissible ownership of TV broadcast stations from five to seven, not more than five of which may be in the VHF band, in order to encourage UHF television operation. This action was taken on petitions filed by Allen B. DuMont Laboratories, Inc., National Broadcasting Co., and the American Broadcasting-Paramount Theaters, Inc. . . . **The Federal Communications Commission has given notice to all ship-owners and ship licensees authorized to use frequencies in the band 2,000 kc to 3,000 kc that an immediate enforcement campaign is developing in an effort to eliminate spurious emissions and interference caused to other services.** The campaign will be made effective, the FCC said, by taking steps to delete 2738 kc from the license of each ship station with a record of using the frequency 2738 in violation of Section 8.108. . . . **By action taken on December 30, the Federal Communications Commission issued a Notice of Proposed Rule Making looking toward amending its rules to permit FM stations to provide additional services incident to their regular broadcast operations, as a means of helping FM broadcasters improve their financial situation and, at the same time, make further use of the FM broadcast band.** The Commission would accomplish this by (1) relaxing the present minimum of 42 hours of operation a week to 36 hours a week for regular FM broadcast service, and (2) authorizing secondary or subsidiary licenses for FM stations to engage in nonbroadcast services, which will embarce the possibilities of "functional music" (background, storecasting, and transicasting), and such appropriate supplemental programming as news, music, time and weather announcements which would further utilize the FM frequencies and provide sources of additional income for FM broadcasters.

Television

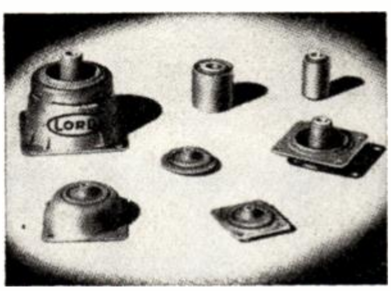
The following statement by Dr. W. R. G. Baker, Chairman of the National Television System Committee and of the RETMA Television Committee was issued to the press by RETMA simultaneously with the issuance of the FCC color decision: "Today's action by the Federal Communications Commission establishing new universal technical transmission standards for both black-and-white and color television marks an important forward step in the evolution of the television art. The new and improved standards just adopted are based on the three-year study by the all-industry National Television System Committee. In taking this action, however, the FCC has gone beyond the work of the NTSC to establish a single set of standards containing provisions for both black-and-white and color. By so doing the commission wisely has emphasized that the public's 7-billion-dollar investment in

(Continued on page 140A)

Lord Vibration Control Mountings . . . The Most Effective Protection For Electronic Equipment

In the rapidly advancing field of electronics, the control of destructive vibration and isolation of damaging shock are prime factors in the consideration of design engineers. Lord, Headquarters for Vibration Control, is constantly working with electronics engineers to improve the methods for protecting sensitive mechanisms.

For instance, Varo Static Converters which change alternating to direct current for aircraft with less than 1% voltage ripple are protected against shock and vibration by Lord Mountings. High fidelity Audio frequency electronic equipment such as Collins Radio Company manufactures is protected from vibration and shock through the use of Lord Mountings. The 212A-1 Broadcast Station Speech Input Console by Collins requires 28 Lord square Plate Form Mountings to protect each amplifier stage individually. This prevents mechanical interaction between stages and lessens acoustical feed-back effects.



Again the Agnew Spark Plug Welder by Agnew Electric Company uses Lord Mountings to support the electronic weld timers to prolong the useful service life of Mercury Vapor Tubes.

Lord Mountings, which you see illustrated in the accompanying advertisement, are used in a wide diversity of applications to protect electronic equipment and sensitive instruments. Business machines and such sensitive mechanisms, the accuracy of which must be perfect, are improved in operation and protected from damaging vibration and shock by Lord Mountings.

The Lord Manufacturing Company, Erie, Pa., offers a vast reservoir of recorded experience in the solution of vibration and shock problems. Your request for help on your own problem is welcomed.

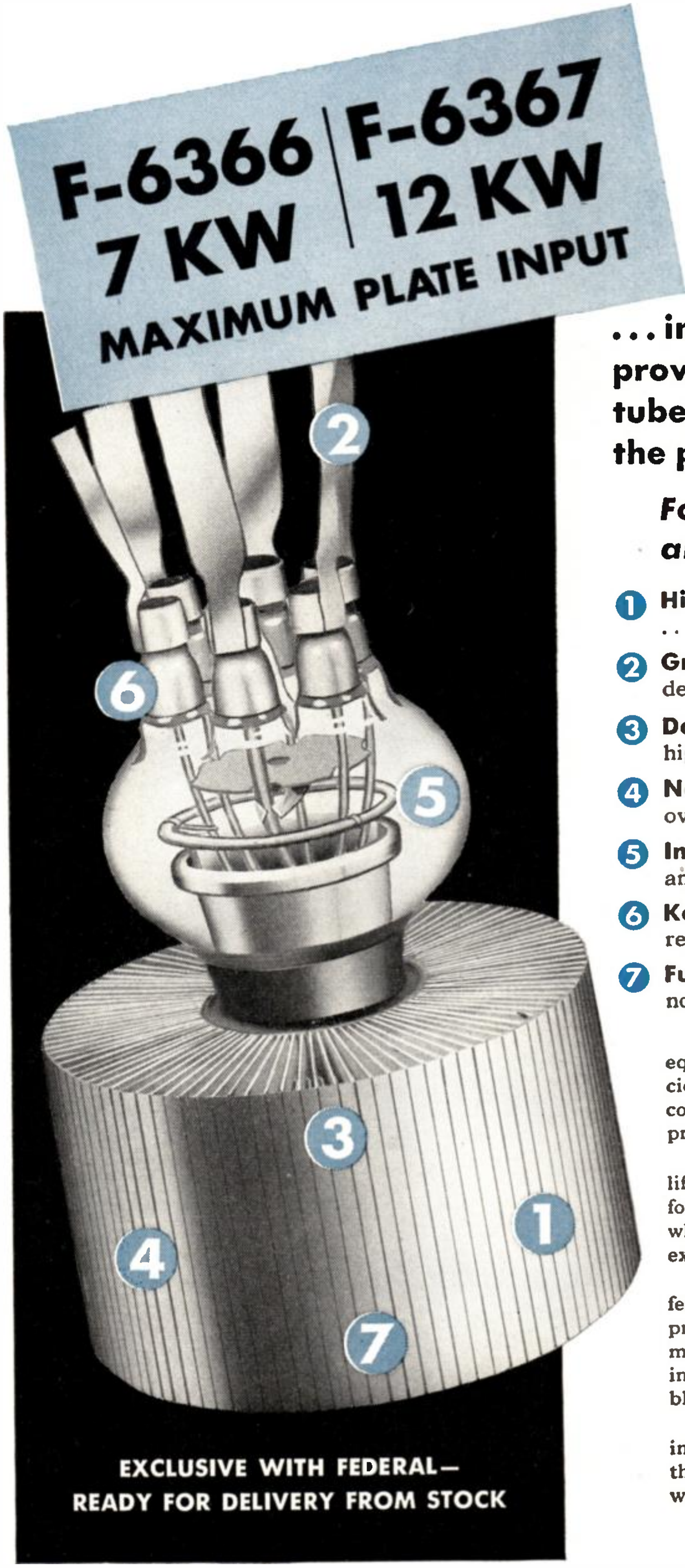
Industrial Engineering Notes

(Continued from page 138A)

black-and-white receivers has been fully protected. The millions who now own black-and-white receivers, together with those who are interested in purchasing black-and-white receivers, now have official assurance that they will lose nothing by the commission's action on color. Their sets will continue to receive all the transmissions now available. Even more important, when color transmissions are made by these stations, the quality of black-and-white reception of these sets will actually be improved. It should be understood that while the commission has approved basic color standards today, it will take manufacturers of color transmitting equipment and home receivers considerable time to develop, field test, and mass produce color equipment. It will be some time before more than a few hours weekly are devoted to color broadcasts. For a long time to come, most television programs will continue to broadcast in black-and-white. Color television is one more stage in the orderly evolution of the television industry. It will not destroy or impair the value of television receivers now in use. Only a trickle of color television receivers will be manufactured during 1954. It may be years before quantity production can be reached. Likewise, early color television receivers will be expensive; most manufacturers estimate that small screen sets giving a 12½-inch picture will cost in the neighborhood of $1,000. Meanwhile, the entertainment and cultural advantages which television offers now will continue to be available on large screen, high-quality black-and-white receivers at values never before offered." . . . **The Federal Communications Commission on December 30 released a survey covering the operation of post-freeze television stations.** Data on the availability of tramsitters—both UHF and VHF—and UHF receivers was included from a report supplied by RETMA. Financial data on 83 stations was gathered in a special survey of the 101 TV stations which started operating between the lifting of the freeze and August 1, 1953. In the data supplied by RETMA, it was reported that between January 1, 1952 and August 31, 1953, a total of 124 VHF and 108 UHF transmitters were manufactured. The rated power of VHF transmitters ranged up to 50 kw and for UHF up to 12 kw with the bulk of UHF transmitters having a rated power of 1 kw while the majority of the VHF transmitters were in the category of 10 kw and less. "The major transmitter manufacturers," FCC said, "indicated that UHF transmitters of 50 kw rated power are not expected to be in commercial production until late 1955 or early 1956." Through August 31, FCC said, RETMA reported that a total of 2.4 million sets (or devices to equip sets for UHF) had been produced. Included were one million UHF equipped sets produced at the factory and shipped to dealers or distributors; 0.7 million UHF tuners and converters shipped for field conversion, and 0.7 million UHF equipped sets and UHF tuners and converters in factory inven-

(Continued on page 142A)

DESIGNERS—Cut New-Equipment Costs



with *Federal's* 2 NEW TRIODES

...incorporating built-in savings and proved design features that increase tube dependability and life and multiply the performance quality of new units

For Electronic Heating, Broadcast and Communications Service

1. **High-Efficiency Radiator** requires reduced pressure drop ... cuts blower cost for new equipment.
2. **Grid and Filament Leads Attached** for convenience of designers ... for extra savings.
3. **Double Helical Filament** of thoriated tungsten ... for high peak emission ... lower temperature.
4. **No Internal Insulators** to expose tubes to danger of arc-over and gassiness.
5. **Internal Corona Ring** eliminates trouble with hot-spots and glass cracks.
6. **Kovar Terminal Cups** used throughout for ruggedness required in industrial service.
7. **Full Voltage** can be safely applied to the cold filament ... no step starting or high reactance transformers necessary.

Federal's F-6366 and F-6367 are the power triodes that new equipment designers have been waiting for ... to boost the efficiency of induction and dielectric heating units, broadcast and communications equipments ... to bring important savings to production lines!

Both tubes not only provide *more* ruggedness, *longer* service life and *higher-quality* performance, but they actually cut costs for manufacturers ... saving as much as 80% on blower costs, while factory-attached grid and filament leads eliminate this expense.

Federal's new triodes feature simplified construction ... with fewer potential trouble spots. Wide element spacing gives better protection against filament-grid shorts. Rated filament voltage may be applied to cold filament, eliminating need for step starting or high reactance filament transformers. Both tubes are operable up to 30 Mc/SEC at full ratings ... anode up or anode down.

Equipment manufacturers now using the F-6366 and F-6367 in new designs report they are "extremely well pleased" with their stamina and performance. For prices and technical data, write to Federal, Dept. K-437.

Handbook of Tube Operation

Federal's 72-page booklet gives complete data on efficient operation of tubes in service. Mail your request to the department listed above.

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Industrial Engineering Notes

(Continued from page 140A)

tory. From the special survey of post-freeze stations, FCC reported that eight VHF and eight UHF stations showed a profit, while the remaining either showed a substantial continuing loss or approached the break-even point on a monthly basis. The eight profitable VHF outlets showed monthly revenues of $26,000 and expenses of $20,400. The profitable UHF stations reported monthly expenses at $20,300 and revenues at $26,400. A breakdown of the 67 nonprofit television stations showed that 20 (12 VHF and 8 UHF) reported a profit during one or more months of operation, and 15 stations (7 VHF and 8 UHF) were approaching a break-even point on a montly basis. Data submitted by the remaining 32 stations (15 VHF and 17 UHF) indicated continuing substantial losses in each month of operation. . . . **Through the end of 1953, the FCC approved special temporary authorizations for 250 stations to start operating, including four educational outlets.** Listed below are all stations which received STAs from the lifting of the "freeze" to the end of 1953:

EDUCATIONAL

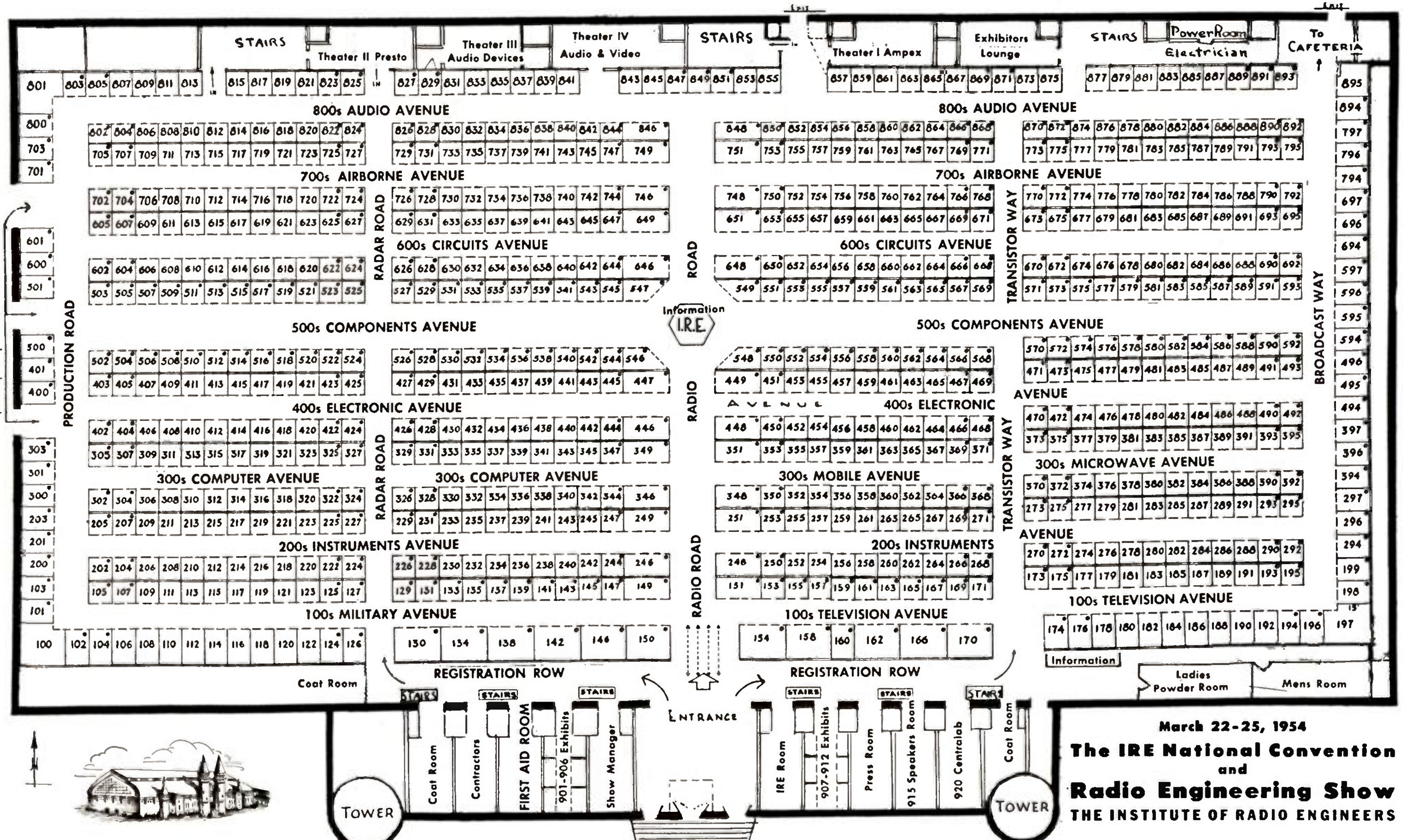
Location	*Permittee*	*Channel*
Houston, Tex.	U. of Houston and Houston Ind. School District	8
Los Angeles, Calif.	U. of Southern California	28
St. Louis, Mo.	St. Louis Ed. Tele. Commission	9
Pittsburgh, Pa.	Met. Pittsburgh Educational TV Station	13

COMMERCIAL

Location	*Permittee*	*Channel*
Denver, Colo.	Eugene P. O'Fallon, Inc.	2
Portland, Ore.	Empire Coil Co., Inc.	27
Denver, Colo.	Colo. Television Corp.	9
Lubbock, Tex.	Texas Telecasting, Inc.	13
Honolulu, T. H.	Radio Honolulu, Ltd.	11
Roanoke, Va.	Shenandoah Life Stations, Inc.	10
Austin, Tex.	Texas Broadcasting Corp.	7
Honolulu, T. H.	Hawaiian Broadcasting System, Ltd.	9
Tucson, Ariz.	Old Pueblo Broadcasting Co.	13
El Paso, Tex.	Roderick Broadcasting Corp.	4
Youngstown, O.	The Vindicator Printing Co.	73
Colorado Springs Colo.	TV Colorado, Inc.	11
Atlantic City, N. J.	Neptune Broadcasting Corp.	46
South Bend, Ind.	South Bend Tribune	34
Spokane, Wash.	KHQ, Inc.	6
Mobile, Ala.	Pape Broadcasting Co., Inc.	10
Spring Garden, Pa.	Susquenanna Broadcasting Co.	43
Mobile, Ala.	Pursley Broadcasting Service	48
Wilkes-Barre, Pa.	Louis G. Baltimore	28
Youngstown, O.	WKBN Broadcasting Corp.	27
El Paso, Tex.	Tri-State Broadcasting Co., Inc.	9
Jackson, Miss.	Mississippi Publishers Corp.	25
Altoona, Pa.	Goble Broadcasting Co.	10
Bangor, Me.	Community Telecasting Service	5
Peoria, Ill.	Robert S. Kerr—West Central Broadcasting Co.	43
Roanoke, Va.	Radio Roanoke, Inc.	27
Spokane, Wash.	Symons Broadcasting Co.	4
Lynchburg, Va.	Lynchburg Broadcasting Co.	13
New Britain, Conn.	New Britain Broadcasting Co.	30
Lincoln, Neb.	Cornhusker Radio & TV Corp.	12
Reading, Pa.	Eastern Radio Corp.	61
Wichita Falls, Tex.	Wichtex Radio & TV Co.	3
Tacoma, Wash.	Tribune Publishing Co.	11
Lawton, Okla.	Oklahoma Quality Broadcasting Corp.	7
Wichita Falls, Tex.	Wichita Falls TV, Inc.	6
Springfield, Mo.	Independent Broadcasting Co.	10

(Continued on page 144A)

Radio Engineering Show Floor Plan—1954



March 22-25, 1954

The IRE National Convention
and
Radio Engineering Show
THE INSTITUTE OF RADIO ENGINEERS

Kingsbridge Armory

NEW YORK CITY

Industrial Engineering Notes

(Continued from page 142A)

Location	Permittee	Channel
Bridgeport, Conn.	Southern Conn. & L. I. TV Co., Inc.	43
Sioux City, Ia.	Cowles Broadcasting Co.	9
Green Bay, Wis.	Norbertine Fathers	2
Agawam, (Springfield), Mass.	Springfield TV Broadcasting Corp.	61
Amarillo, Tex.	Plains Radio Broadcasting Co.	4
Little Rock, Ark.	Little Rock Telecasters, Inc.	17
Pueblo, Colo.	Pueblo Radio Co., Inc.	3
Galveston, Tex.	Gulf Television Co.	11
Ft. Lauderdale, Fla.	Gore Publishing Co.	23
Harrisburg, Pa.	WHP, Inc.	55
Minot, N. D.	North Dakota Broadcasting Co.	13
Amarillo, Tex.	Amarillo Broadcasting Co.	10
New Castle, Pa.	WKST, Inc.	45
Montgomery, Ala.	Capitol Broadcasting Co.	20
Springfield, Mass.	The Hampden-Hampshire Corp.	55
Reading, Pa.	Hawley Broadcasting Co.	33
Lima, O.	WLOK, Inc.	73
Baton Rouge, La.	Modern Broadcasting Co. of Baton Rouge, Inc.	28
Ann Arbor, Mich.	Washtenau Broadcasting Co.	20
Rockford, Ill.	Winnebago Television Corp.	39
Columbia, S. C.	Radio Columbia	25
Saginaw, Mich.	Lake Huron Broadcasting Corp.	57
Mesa, Ariz.	Harkins Broadcasting Co.	12
Bellingham, Wash.	KVOS, Inc.	12
Bethlehem, Pa.	Associated Broadcasters, Inc.	51
Lubbock, Tex.	Bryant Radio & TV, Inc.	11
Battle Creek, Mich.	Booth Radio & TV Stations, Inc.	64
Zanesville, O.	Orville Littick (Southern Ohio TV System)	50
Muncie, Ind.	Tri-City Radio Corp.	49
Sioux Falls, S. D.	Midcontinent Broadcasting Co.	11
San Luis Obispo, Calif.	Christena M. Jacobson & Leslie H. Hacker (Valley Electric Co.)	6
Rochester, Minn.	Southern Minn. Broadcasting Co.	10
Peoria, Ill.	Hilltop Broadcasting Co.	19
Elmira, N. Y.	John S. Booth (Elmira Television)	24
St. Petersburg, Fla.	City of St. Petersburg, Fla.	38
Fresno, Calif.	McClatchy Broadcasting Co.	24
Lincoln, Neb.	Cornbelt Broadcasting Corp.	10
Fargo, N. D.	WDAY, Inc.	6
Kansas City, Mo.	Empire Coil Co., Inc.	25
Scranton, Pa.	Scranton Broadcasters, Inc.	22
Duluth, Minn.	Great Plains Television Properties of Minn., Inc.	38
Akron, O.	Summit Radio Corp.	49
Lafayette, Ind.	WFAM, Inc.	59
Tucson, Ariz.	Arizona Broadcasting Co., Inc.	4
Nampa, Ida.	Frank E. Hurt & Son, Inc.	6
Roswell, N. M.	John A. Barnett	6
Charleston, S. C.	WCSC, Inc.	5
Harrisburg, Pa.	Harrisburg Broadcasters, Inc.	71
Pueblo, Colo.	Star Broadcasting Co., Inc.	5
Oshkosh, Wis.	Wm. F. Johns, Jr. (Oshkosh Broadcasting Co.)	48
Hutchinson, Kan.	Hutchinson TV, Inc.	12
Asheville, N. C.	Radio Station WISE, Inc.	62
San Angelo, Tex.	Westex Television Co.	8
Madison, Wis.	Bartell Television Corp.	33
Madison, Wis.	Monona Broadcasting Co.	27
Milwaukee, Wis.	Midwest Broadcasting Co.	25
Raleigh, N. C.	Sir Walter Television Co.	28
Rome, Ga.	WROM-TV, Inc.	9
Boise, Ida.	KIDO, Inc.	7
Las Vegas, Nev.	Las Vegas TV, Inc.	8
Butte, Mont.	Copper Broadcasting Co.	4
Pittsburgh, Pa.	Agnes J. Reeves Greer	53
Easton, Pa.	Easton Publishing Co.	57
Yakima, Wash.	Cascade Broadcasting Co.	29
Fort Smith, Ark.	Southwestern Publishing Co.	22
Belleville, Ill.	Signal Hill Telecasting Corp.	54
Austin, Minn.	Minnesota-Iowa Television Co.	6
Santa Barbara, Calif.	Santa Barbara Broadcasting & Telecasting Corp.	2
Waterbury, Conn.	WATR, Inc.	53
Lansing, Mich.	Lansing Broadcasting Co.	54
Buffalo, N. Y.	Buffalo-Niagara Television Corp.	59
Geeenville, S. C.	Greenville Television Co.	22
Kansas City, Mo.	WHB Broadcasting Co.	9
Kansas City, Mo.	Midland Broadcasting Co.	9
Tacoma, Wash.	KMO, Inc.	13
Medford, Ore.	Southern Oregon Broadcasting Co.	5
Salem, Ore.	Lawrence A. Harvey	24
Hampton, Va.	Peninsula Broadcasting Corp.	15

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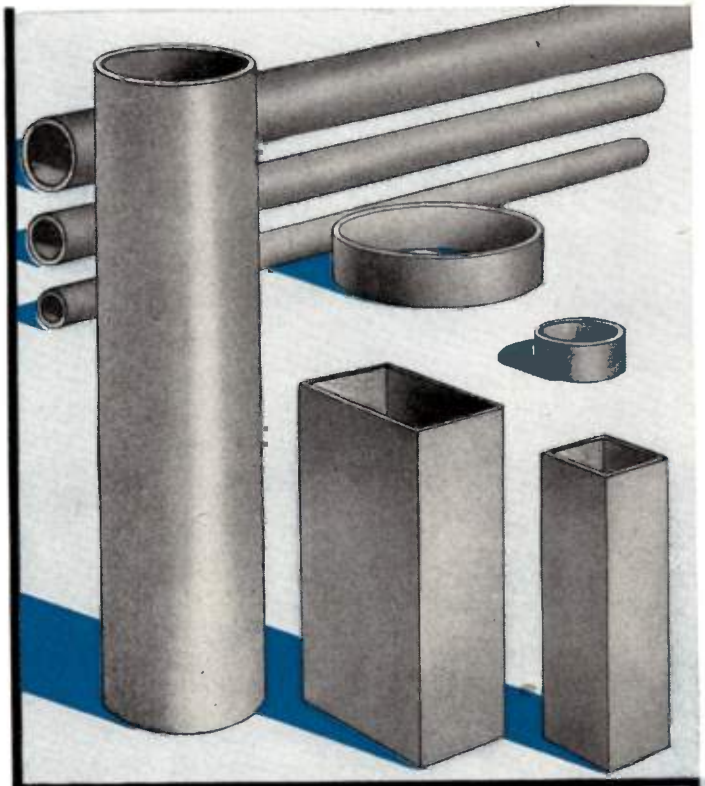

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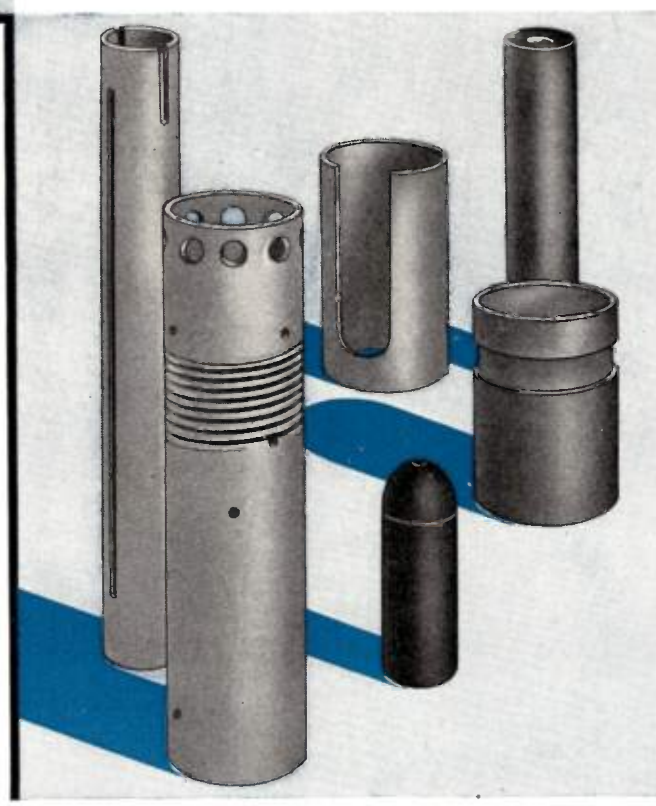

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Industrial Engineering Notes

(Continued from page 144A)

Location	*Permittee*	*Channel*
Portland, Ore.	Mount Hood Radio & TV Broadcasting Corp.	6
Evansville, Ind.	Premier Television Inc.	62
Decatur, Ill.	Prairie Television Co.	17
Billings, Mont.	The Montana Network	2
San Diego, Calif.	Airfan Radio Corp., Ltd.	10
Monroe, La.	Delta Television, Inc.	43
Texarkana, Tex.	KCMC, Inc.	6
Scranton, Pa.	Appalachian Co.	73
Buffalo, N. Y.	WBUF-TV, Inc.	17
Bakersfield, Calif.	Bakersfield Broadcasting Co.	29
Columbus, Ga.	Television Columbus	28
Butte, Mont.	Television Montana	6
Pittsburgh, Pa.	Telecasting Co. of Pittsburgh	16
Salinas, Calif.	Salinas Broadcasting Corp.	8
Monterey, Calif.	The Monterey Radio-Television Corp.	8
Chambersburg, Pa.	Chambersburg Broadcasting Co.	46
Albuquerque, N. M.	New Mexico Broadcasting Co.	13
Quincy, Ill	Quincy Broadcasting Co.	10
Macon, Ga.	Macon Television Co.	47
Hannibal, Mo.	Lee Broadcasting, Inc.	7
Wichita, Kan.	KEDD, Inc.	16
Tyler, Tex.	Jacob A. Newborn, Jr.	19
Columbia, S. C.	Palmetto Radio Corp.	67
Minneapolis, Minn.	Minnesota Television Public Service Corp.	11
Abilene, Tex.	The Reporter Broadcasting Co.	9
St. Louis, Mo.	Broadcast House, Inc.	36
Memphis, Tenn.	Harding College	13
Portland, Me.	The Portland Telecasting Corp.	53
Johnson City, Tenn.	WJHL, Inc.	11
Fresno, Calif.	O'Neill Broadcasting Co.	47
St. Paul, Minn.	WMIN Broadcasting Co.	11
Chico, Calif.	Golden Empire Broadcasting Co.	12
Knoxville, Tenn.	TV Services of Knoxville	26
Johnston, Pa.	Rivoli Realty Co.	56
Nashville, Tenn.	WSIX Broadcasting Co.	8
Cedar Rapids, Ia.	American Broadcasting Stations, Inc.	2
St. Joseph, Mo.	KFEQ, Inc.	2
West Palm Beach, Fla.	WIRK-TV, Inc.	21
Wilkes-Barre, Pa.	Wyoming Valley Broadcasting Co.	34
Albuquerque, N. M.	Alvardo Broadcasting Co., Inc.	7
Elmira, N. Y.	El-Cor TV, Inc.	18
Harrisonburg, Va.	Shenandoah Valley Broadcasting Corp.	3
Henderson, Ky.	Ohio Valley Television Co.	50
San Francisco, Calif.	Lawrence A. Harvey	20
Milwaukee, Wis.	Bartell Broadcasters, Inc.	19
Cambridge, Mass.	Middlesex Broadcasting Corp.	56
Steubenville, O.	WSTV, Inc.	9
Winston-Salem, N. C.	Winston-Salem Broadcasting Co., Inc.	26
Charleston, W. Va.	John L. Smith, Jr., Inc.	49
Augusta, Ga.	Georgia-Carolina Broadcasting Co.	6
Rockford, Ill.	Greater Rockford Television, Inc.	13
Warner Robins, Ga.	Southeastern Broadcasting Co.	13
Meridian, Miss.	Southern Television Corp.	11
Bakersfield, Calif.	Kern County Broadcasters, Inc.	10
Topeka, Kans.	The Topeka Broadcasting Assn., Inc.	13
Providence, R. I.	Cherry & Webb Broadcasting Co.	12
Knoxville, Tenn.	Mountcastle Broadcasting Co., Inc.	6
Springfield, Mo.	Springfield Television, Inc.	3
Winston-Salem, N. C.	Triangle Broadcasting Corp.	12
Reno, Nev.	Nevada Radio-Television, Inc.	8
Sacramento, Calif.	Capital City Television Corp.	40
Harlingen, Tex.	Harbenito Broadcasting Co., Inc.	4
Springfield, Ill.	Plains Television Corp.	20
Monroe, La.	James A. Noe	8
Cadillac, Mich.	Sparton Broadcasting Co.	13
Anchorage, Alsk.	Kiggins & Rollins	2
Meridian, Ida.	Boise Valley Broadcasting, Inc.	2
Newport News, Va.	Eastern Broadcasting Corp.	33
Dayton, O.	Skylord Broadcasting Corp.	22
Phoenix, Ariz.	KOY Broadcasting Co.	10
Phoenix, Ariz.	Maricopa Broadcasters, Inc.	10
Yuma, Ariz.	Valley Telecasting Co.	11
Houston, Tex.	KNUZ Television Co.	39
Parkersburg, W. Va.	West Va. Enterprises, Inc.	15
Longview, Tex.	East Texas Television Co.	32
Eureka, Calif.	Redwood Broadcasting Co., Inc.	3

(Continued on page 148A)

Industrial Engineering Notes

(Continued from page 146A)

Location	*Permittee*	*Channel*
Cedar Rapids, Ia.	Cedar Rapids Television Co.	9
Albany, N. Y.	Hudson Valley Broadcasting Co., Inc.	41
New Orleans, La.	Supreme Broadcasting Co., Inc.	61
Waco, Tex.	Central Texas Television Co.	34
Lebanon, Pa.	Lebanon Television Corp.	15
Louisville, Ky.	Mid-America Broadcasting Corp.	21
Pensacola, Fla.	WPFA-TV, Inc.	15
Norfolk, Va.	Commonwealth Broadcasting Corp.	27
Denver, Colo.	Aladdin Radio & Television, Inc.	7
Jackson, Miss.	Lamar Life Broadcasting Co.	3
Columbia, S. C.	WIS-TV, Corp.	10
Wheeling, W. Va.	Tri-City Broadcasting Co.	7
Rochester, N. Y.	Veterans Broadcasting Co., Inc.	10
Rochester, N. Y.	WHEC, Inc.	10
Kearney (Holdridge) Nebr.	Bi-States Co.	13
Temple, Tex.	Bell Publishing Co.	6
Bismark, N. D.	Meyer Broadcasting Co.	5
Fort Dodge, Ia.	Northwest Telecasting Co.	21
Lake Charles, Va.	KTAG-TV, Inc.	25
Oklahoma, City, Okla.	Republic TV & Radio Co.	25
Des Moines, Ia.	Rib Mountain Radio, Inc.	17
Waterloo, Ia.	Black Hawk Broadcasting Co.	7
Fort Wayne, Ind.	Northeastern Indiana Broadcasting Co., Inc.	33
York, Pa.	The Helm Coal Co.	49
Tulare, Calif.	Sheldon Anderson	27
Columbus, Ga.	Columbus Broadcasting Co., Inc.	4
Lewiston, Me.	Lewiston-Auburn Broadcasting Corp.	8
Seattle, Wash.	Fisher's Blend Station, Inc.	4
Meridian, Miss.	Mississippi Broadcasting Co.	30
Oklahoma City, Okla.	Oklahoma Television Corp.	9
Flint, Mich.	Trendle-Campbell Broadcasting Corp.	16
Champaign, Ill.	Midwest Television, Inc.	3
Festus, Mo.	Ozark Television Corp.	14
Oklahoma City, Okla.	KLPR Television, Inc.	19
Fort Lauderdale, Fla.	Gerico Investment Co.	17
Worcester, Mass.	Salisbury Broadcasting Co.	14
Jacksonville, Fla.	The Jacksonville Journal Co.	36
Anchorage, Alsk.	Northern Television, Inc.	11
Stockton, Calif.	San Joaquin Telecasters	36
Cheyenne, Wyo.	Frontier Broadcasting Co.	5
Panama City, Fla.	J. D. Manley	7
Harrisburg, Ill.	Turner-Farrar Assn.	22
Colorado Springs, Colo.	Pikes Peak Broadcasting Co.	13
Princeton, Ind.	Southern Indiana Telecasting, Inc.	52
Pittsburg, Kans.	Pittsburg Broadcasting Co., Inc. (Now Mid-Continent Telecasting, Inc.)	7
Midland, Tex.	Midessa Television Co.	2
Columbia, Mo.	Curators of the University of Missouri	8
Pinebluff, Ark.	Central-South Sales Co.	7
Eau Claire, Wis.	Central Broadcasting Co.	13
Greenville, N. C.	Carolina Broadcasting System, Inc.	9
Asbury Park, N. J.	Atlanta Video Corp.	58
Portland, Me.	Congress Square Hotel Co.	6
Anderson, S. C.	Wilton E. Hall	40
Wilmington, N. C.	WMFD-TV, Inc.	6
Danville, Ill.	Northwestern Publishing Co.	24
Idaho Falls, Ida.	Idaho Radio Corp.	3
Shreveport, La.	Interim TV Corp.	12
Denver, Colo.	Metropolitan Television Co.	4
Greenville, S. C.	WMRC, Inc.	4
Charlotte, N. C.	WAYS-TV, Inc.	36

Federal Personnel

Capt. Frederick R. Furth, Assistant Chief of the Bureau of Ships for Electronics, has been advanced to the rank of Rear Admiral and reassigned as Chief of the Office of Naval Research, the White House announced December 31, 1953. He succeeds Rear Admiral Calvin M. Bolster, who is retiring. . . . **J. G. Reid, Jr., Chief of the Electronics Division of the National Bureau of Standards, has resigned to head the ACF Electronics Co. The new** firm, which is establishing electronic re-

(Continued on page 150A)

PROVEN: KARP ENCLOSURES ARE YOUR MOST ECONOMICAL BUY

Karp customers, large and small, from coast to coast, know that Karp's complete "package"— ready for components—means lower costs.

Over 300 different jobs go through our plant every day. This volume allows us to apply mass production techniques to every job—whether simple or complex, long run or short —*and we pass the savings on to you.*

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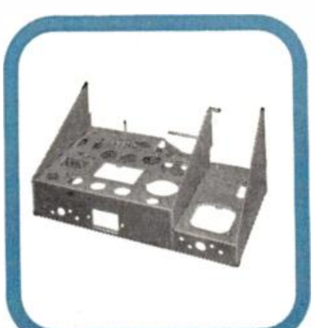

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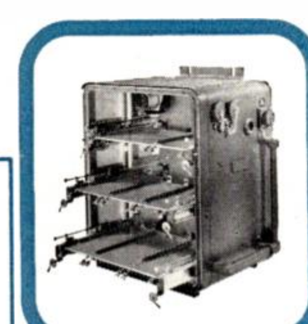

Industrial Engineering Notes

(Continued from page 148A)

search and development laboratories in Alexandria, Va., is a subsidiary of the American Car and Foundry Co. Dr. Robert D. Huntoon, Associate NBS Director for Physics, will serve as Acting Chief of the Electronics Division. Dr. Huntoon was Director of the Bureau's Corona Laboratories until its transfer to the Department of Defense last fall. He joined the NBS in 1941 to work on the proximity fuse and transferred to the War Department in 1944 as a consultant in that field. In 1945 he returned to the Bureau as Chief of the Electronics Section and later was named Chief of the Atomic and Radiation Physics Division.

International

The introduction of television service in India is planned during 1954, according to a report reaching the Department of Commerce. Estimates for the establishment of a station are being prepared and, if accepted, it probably will go into operation this year in Bombay, according to the report.

Industry Statistics

Despite a down-turn in television set production in November, more TV receivers were manufactured during the first 11 months of 1953 than in any similar period on record, according to a report from the RETMA Statistical Department. The radio output increased slightly in November and for the January–November period was above the level of the two previous years. For the first 11 months of 1953, the report showed production of 6,765,000 TV receivers and 12,267,441 radios. In the same period of 1952, TV output was 4,175,193 units, while 9,436,614 radios were manufactured.

RETMA Activities

Acting on the request of the Microwave Section and Committee TR-14 of the Engineering Department, RETMA recently asked the Federal Communications Commission to appoint an all-industry ad hoc committee to study the entire microwave field. Both the engineering group and the Microwave Section, under Chairman D. B. McKey, have approved the idea of a technical committee to study the problem with the view of recommending rules and regulations for the industry.

Mobilization

The U. S. Department of the Navy recently announced it is making available to industry drawings for hand tools required to set up pilot runs, or for model shop production, of electronic modules developed under "Project Tinkertoy." At the same time, the Navy said it is dropping the code name "Project Tinkertoy," originally assigned to the program during its development stage. In the future, the project will be referred to as "modular design of electronics," and "mechanized production of electronics." The drawings which include those of jigs, dies and fix-

(Continued on page 153A)

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Unit construction means either simultaneous transm sion on a number of frequencies or selection of sing channel best suited to your communication proble 125—525 kc/s . . . 2400 watts. 2—26 mc/s . . . 2500 wat Meters, transformers, capacitors are hermetically seal for failure-proof performance.

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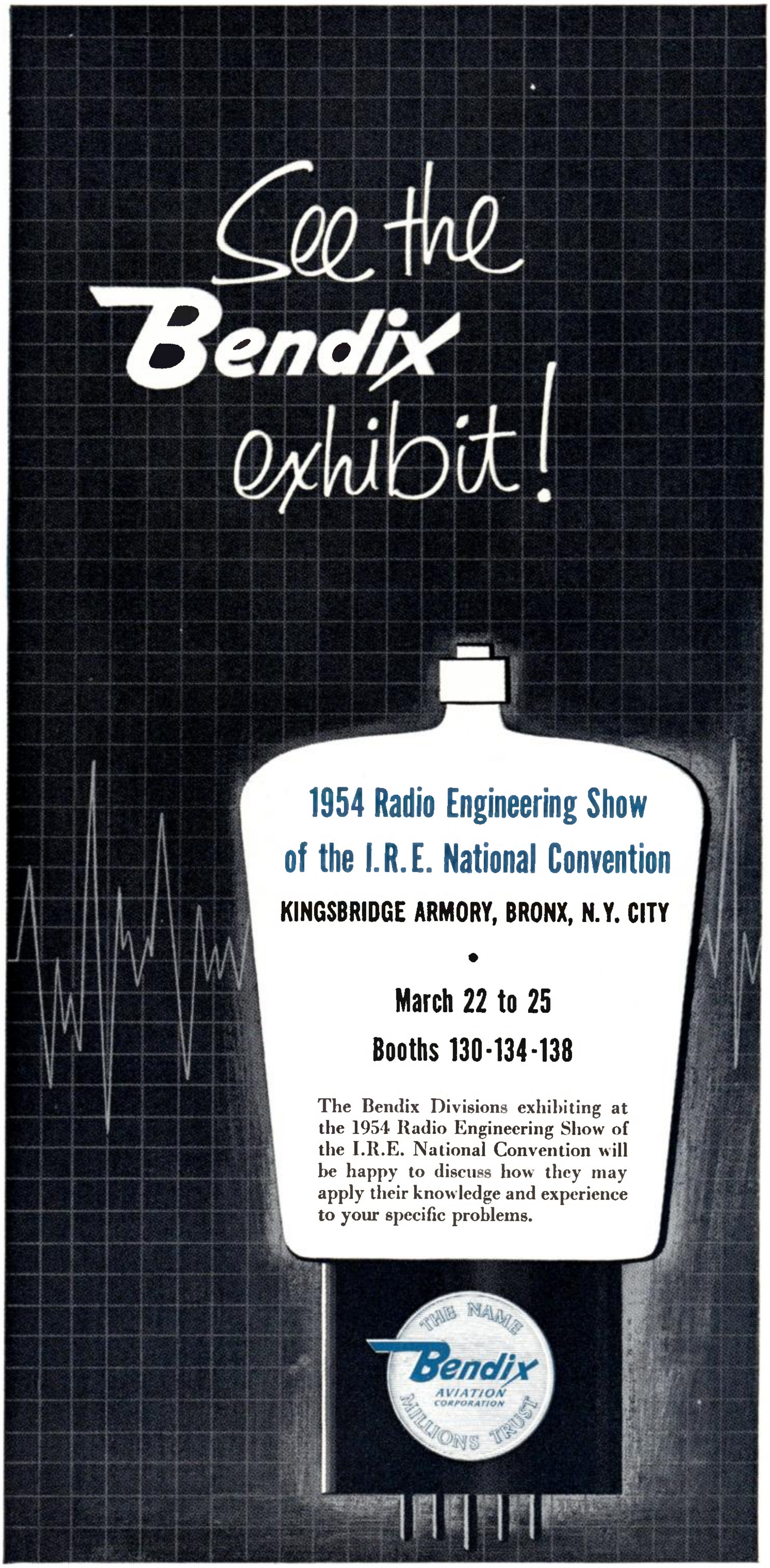

BENDIX RADIO DIVISION, TOWSON, MD.

The nation's airlines and more than 45 of the major railroads depend on Bendix* Radio for precision electronic equipment. In the field of radar, radio communications and navigation equipment, Bendix Radio enjoys a reputation second to none.

ECLIPSE-PIONEER DIVISION, TETERBORO, N. J.

Famous for over 30 years for the quality and design superiority of its tremendous variety of aviation instruments and accessories, Eclipse-Pioneer is today a major supplier of precision components for the electronic industry.

RED BANK DIVISION, EATONTOWN, N. J.

Specialists in extensive coverage of electronics. Units designed for durability to meet exacting requirements. Special-purpose tubes such as Klystron regulators and spark gaps are available for non-standard applications.

SCINTILLA DIVISION, SIDNEY, N.Y.

Bendix Scinflex Electrical Connectors are completely pressurized and are for all contact sizes and pin arrangements—full ACN approval. Bendix Ignition Analyzer checks efficiency of both ignition units and spark plugs, and detects incipient failures.

PACIFIC DIVISION, NORTH HOLLYWOOD, CALIFORNIA

This division has attained outstanding leadership in the field of sonar, telemetering, airborne radar, hydraulic servomechanisms and radio control—a striking example of Bendix talent in combining advance engineering design with modern production facilities.

*REG. U.S. PAT. OFF.

Industrial Engineering Notes

(Continued from page 150A)

tures, and an engineering handbook of the hand tool process (PB 111277) may be obtained through the Office of Technical Services, Department of Commerce, Washington 25, D. C. Also available through OTS is a summary of the entire project (PB 111275). . . . **Owing to the requirement of the Signal Corps' electronic and aviation activities for more experimental space than now is available at Fort Monmouth, N. J., the Department of the Army recently announced the establishment of the U. S. Army Electronic Proving Ground at Fort Huachuca, Ariz.** The major Signal Corps activities at Fort Monmouth, including research and development laboratories and the Signal Corps School, remain unaffected by the transfer, the Department of the Army announced.

Aeronautical and Navigational Electronics

The Professional Group on Aeronautical and Navigational Electronics met on December 3, 1953 at the Dayton Engineers' Club, Dayton, O., under the chairmanship of Maurice Jacobs. Carl G. Sontheimer, President of C. G. S. Laboratories of Stamford, Conn., presented a paper on "Saturating Reactors as Controlled Inductors." The use of new high permeability materials makes possible new fields of application for the saturable reactor. Variable inductance high "Q" units may be obtained through control ranges as high as 100 to 1. Present uses include a wide range sweep oscillator for television receiver alignment. Prospective uses in remote controlled continuously tunable radio receivers and as remote gain controlling elements were described. Methods of minimizing the hysteresis effect in the saturating circuit were also covered.

Audio

The Albuquerque-Los Alamos Chapter of the Professional Group on Audio met on November 12, 1953 at the Coronado Club, Sandia Base, Albuquerque, N. M. The Chairman of the meeting was A. M. Garblik, and Lt. Clifford Smith and George Reidel presented a paper entitled "Design and Construction of the R-J Speaker Enclosure." A demonstration was given of four different type R-J Enclosures.

The Cleveland Chapter of the Professional Group on Audio met on December 14, 1953 at Station WHK, Studio 3, Cleveland, O. The Interim Chairman was Herbert Heller, and Dr. Rudolph Ringwall, the Conductor of the Cleveland Orchestra presented a paper on "Subjective Listening." Dr. Ringwall discussed dynamic range, frequency range, and other aspects of music as heard in the concert hall and as compared with music electronically reproduced in the home. He illustrated the various results obtained with different microphone placements through tape-recorded orchestral excerpts. During the subsequent discussion period, S. J. Begun of Brush Electronics Co. presented the engineer's point of view of the

(Continued on page 154A)

Industrial Engineering Notes

(Continued from page 153A)

state of the art of recording and reproducing sound.

BROADCAST TRANSMISSION SYSTEMS

The Boston Chapter of the Professional Group on Broadcast Transmission Systems met on January 28, 1953 at the Massachusetts Institute of Technology, Cambridge, Mass. Commissioner G. E. Sterling of the Federal Communications Commission, and G. R. Townsend, Chief Engineer of WWLP, Springfield, Mass., presented "A Progress Report on UHF-TV Broadcasting—With Some Color." Mr. Sterling presented the Commission's viewpoint on progress in UHF-TV broadcasting to date, and Mr. Townsend gave a résume of UHF installation and transmission problems.

COMMUNICATIONS SYSTEMS

The Washington D. C. Chapter of the Professional Group on Communications Systems met on December 17, 1953 at the National Academy of Sciences Building, Washington, D. C., under the chairmanship of C. L. Engleman. The speakers were M. G. Crosby, President of the Crosby Laboratories, Inc., and W. S. Halstead, President of the Multiplex Development Corp. Messrs. Boese, Meisinger, Beville, Bose and others discussed the papers. W. H. Muench of the Bureau of Ships described certain tests of FM multiplex systems when used as a supplementary means of interconnecting Navy Communication Stations. Highly satisfactory results were indicated. Mr. Crosby described results of development in which additional channels are multiplexed on a standard FM Broadcast transmitter without interference to the program on the main channel. Circuit arrangements were shown for a multiplex system under Navy sponsorship in which three additional audio channels were added to the transmission of WTOP-FM and carried various types of program material for a period of a month without a report of interference on the main channel. The signal-to-noise ratio characteristics of the various types of multiplex systems were discussed. A multiplex system capable of adding a 15 kc audio channel for the transmission of binaural sound was described. Mr. Halstead reviewed the operational results obtained in a series of field tests of FM broadcast multiplex systems in a development program extending over a period of five years. Various potential applications of these systems in broadcast and general telecommunication services were discussed. Emphasis was placed on the public-service aspects of broadcast multiplex methods in achieving greater efficiency of utilization of the radio-frequency spectrum in providing on a non-interfering basis at existing FM broadcast stations additional transmission channels suitable for stereophonic sound, subscription radio services, or multiple channels for voice, facsimile and teletype.

ELECTRON DEVICES

The Philadelphia Chapter of the Pro-

(Continued on page 156A)

Make sure you are in the crowd around the Collins Radio Booth

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TVOR Terminal VHF Omni Range — For ground-installed guidance of aircraft. Available in either 50 or 200 watt versions. See a miniaturized system in operation at our booth during the show.

51X VHF Communications Receiver — 360 crystal-controlled frequencies in the 118 to 135.95 megacycle range. 50 kc channel separation without cross-channel interference.

17M VHF Airborne Transmitter — 360 crystal-controlled frequencies with 50 kc channel separation in the 118 to 135.95 megacycle range. 40 watts output to a 52 ohm aircraft antenna.

FD-103 Integrated Flight System — Greatly simplified instrumentation for assuring more consistent instrument landings with less scanning of the instrument panel.

32W1 Amateur Exciter — For AM, CW, or SSSC operation. Dual conversion with crystal-controlled high frequency oscillator and very stable low frequency VFO permitting dial calibration of one kilocycle per dial division on all bands.

75A-4 Amateur Receiver — All the features of the 75A-3 plus separate detectors for AM and single-sideband. AVC on SSSC. BFO is mechanically tracked with the main tuning dial to permit tuning out interference on CW and SSSC without affecting beat note or intelligibility of the desired signal.

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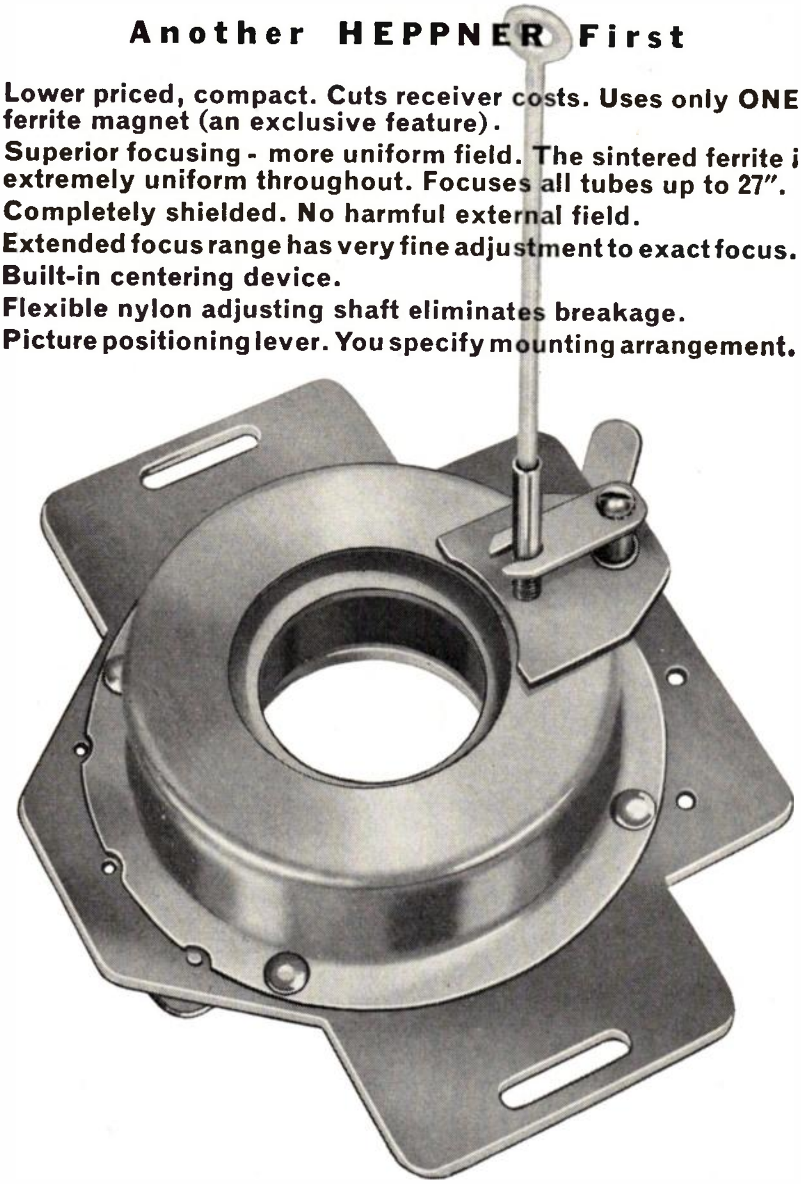

(Continued from page 154A)

fessional Group on Electron Devices met on November 30, 1953 at the University of Pennsylvania, Philadelphia. Pa., under the chairmanship of E. I. Hawthorne. J. R. Pierce, Director of Electronics Research of the Bell Telephone Laboratories, presented a paper on "Recent Advances in Microwave Tubes." The following officers for the 1954 year were elected: Chairman, E. I. Hawthorne, of the University of Pennsylvania; Vice-Chairman, W. Hasenberg, of RCA; and Secretary, N. A. Koss, of the General Electric Co.

Engineering Management

The Los Angeles Chapter of the Professional Group on Engineering Management met on December 16, 1953 at the IAS Building, Los Angeles, Calif., under the chairmanship of T. W. Jarmie. Max Clark of the Hughes Aircraft Co. presented a paper on "How to Determine an Engineer's Salary." Mr. Clark explained two evaluation methods: (1) classification according to jobs, and (2) evaluation of both the man and the job. When evaluating by job description, the importance of such requirements as experience, education, mental ability, supervision of others, and co-operation and contact with others are weighed and assigned point values. By plotting point values, other jobs are correlated with key jobs and a conversion line for job categories and salary is established. Minimum and maximum value curves are added to the chart to allow for differences in people's abilities to do the jobs. With the second method, maturation curves are prepared which evaluate the man for a job. Salary is plotted as a function of years of experience, according to rating values between 50 and 100 points. When on the job, a man's point status is obtained from rating sheets which are filled out at review periods. Comparisons with other companies, percentage acceptance of offers and turnover sometimes require revisions of certain areas of the chart. The paper was discussed by the audience.

Information Theory

The Los Angeles Chapter of the Professional Group on Information theory met on December 10, 1953 at the Institute for Numerical Analysis of the University of California at Los Angeles. J. B. Breakwell presented a paper entitled "Optimum Tests for Reliability," which discussed the setting up of statistical tests from the point of view of total risk. S. E. Bennesch presented a paper on "Foundations of Redundancy," which discussed the long-recognized need for an abstract formulation of redundancy.

Medical Electronics

The San Francisco Chapter of the Professional Group on Medical Electronics met on December 10, 1953 at Toland Hall, University of California Hospital, San Francisco, Calif., under the chairmanship of A. J. Morris. Richard Wexlar, Senior Electronic Technician of the Department

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Industrial Engineering Notes

(Continued from page 156A)

of Medicine, University of California Medical School, presented a paper on "Methodology in Recording Cardiovascular Phenomena." Dr. Sanford E. Leeds, Assistant Clinical Professor of Surgery at the University of California Medical School, presented a paper on "Electrical Characteristics of the Heart." The papers were discussed by R. S. Mackay of the Department of Electrical Engineering, University of California.

Nuclear Science

The Oak Ridge Chapter of the Professional Group on Nuclear Science met on December 16, 1953 at the Ridge Recreation Hall, Oak Ridge, Tenn., under the chairmanship of H. E. Banta. C. H. Johnson, physicist in the High Voltage Group of the Physics Division, O R National Laboratories, spoke on the "General Aspects of Van de Graff Accelerator Design and Operation." The paper was followed by an open discussion.

Vehicular Communications

The Chicago Chapter of the Professional Group on Vehicular Communications met on December 11, 1953 for a conducted tour through the communications and consumer production facilities of Motorola, Inc. At the November 20, 1953 meeting, the Group had heard Kenneth Bachman, senior development engineer of Motorola, Inc., speak on "6 to 12 Volt Conversion of Mobile Units."

The Group also met on February 19, 1953 to hear Col. Edwin L. White, Chief of the Safety and Special Services Bureau of the Federal Communications Commission, speak on the subject, "Can Mobile Radio Grow?"

What to See at the Radio Engineering Show

(Continued from page 87A)

Bendix Aviation Corp., Scintilla Div., 130-140 Military Ave.
*AN3057B waterproofing cable clamp. Type "E" environment resisting connector for high-altitude performance. *High-temperature connector to protect aircraft control circuits.

Berkeley Div. of Beckman Instruments, Inc. 752, 754 Airborne Ave.
Industrial control through application of electronic counter techniques; direct reading digital instruments for measuring time interval, frequency, pressure, flow, rpm, viscosity, velocity, etc. Problem solving and system simulation on the EASE analog computer. *Direct reading automatic frequency monitor and recorder. *1mc/1μs universal counter and timer.

Beta Electric Corp., 320 Computer Ave.
Featuring high voltage power supplies with *2-section construction and ranges particularly suited for testing color TV components.

James G. Biddle Co., 714 Airborne Ave.
Frahm Resonant Reed Frequency Sensitive Relays and Oscillator Controls together with MEGGER electrical resistance testing instruments.

*Indicates new product

(Continued on page 160A)

Automatic, maintenance-free, instantaneous voltage stabilization

Static-magnetic constant voltage transformers are a practical and efficient solution for controlling input voltage to voltage-sensitive electrical and electronic equipment.

Sola Constant Voltage Transformers are widely used both as built-in components and as accessory units. They differ from regulators which depend solely upon saturation of core materials for their regulating action, or electronic types employing tubes. Sola Constant Voltage Transformers have the following characteristics:

1. Regulation within ±1%, with primary voltage (transient or continuous) variations as great as 30%.
2. Response time less than 1½ cycles.
3. No moving or wearing mechanical parts, nor vacuum tubes; requires no manual adjustments.
4. Completely automatic, continuous regulation.
5. Self-protecting against short-circuits on output.
6. Current-limiting characteristics protects load equipment.
7. Can often be substituted in place of conventional non-regulating transformers.
8. Generally smaller than other types of regulators for similar duty.
9. Isolates the input and output circuits.

Forty-three Sola stock units are available in a wide variety of ratings, voltages and types. In addition, custom-designed units can be manufactured (in production quantities) to meet specific requirements.

The experience of the world's largest manufacturer of constant voltage transformers is available to you. We invite you to discuss your voltage stabilizing problems with a Sola Sales Engineer.

SOLA *Constant Voltage* **TRANSFORMERS**

See the complete line of Sola Constant Voltage Transformers demonstrated at the IRE Show in New York at Booths 537, 539 Components Ave., Kingsbridge Armory, March 22-25.

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PHILADELPHIA: Commercial Trust Bldg., RIttenhouse 6-4988 • BOSTON: 272 Centre St., Newton 58, Mass., BIgelow 4-3354
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What to See at the Radio Engineering Show

(Continued from page 158A)

J. F. Bingham Mfg. Co., 789 Airborne Ave.
Ferrous and non-ferrous precision sheet metal fabricators specializing in magnesium and aluminum cabinets, chassis, and components for the military services and civilian electronic industries.

Bird Electronic Corp., 254 Instruments Ave.
Thruline radio frequency wattmeters, termaline radio frequency wattmeters, termaline coaxial load resistors, coaxial switches, radio frequency filters.

Birklan Corporation, 708 Airborne Ave.
*High linearity potentiometers, their method of construction, and some testing methods.

Bliley Electric Co.
585 Components Ave.

Quartz crystals, crystal ovens, frequency standards, ultrasonic delay lines, custom assemblies. Miniature bantam crystal units. Standard Delay Lines for 1000 and 2000 yard markers, color TV crystals.

Bodnar Industries, Inc.
797 Broadcast Way

Mil-P-7788 (ANP89) plastic lighting panels and dials—illumination, gloss, contrast and abrasion testing equipment approved by BuAir and Bu Standards—consulting aid to project engineers.

Boeing Airplane Co., 332 Computer Ave.
Will exhibit the model 7000-B Analog Computer and latest components including pre-patch panel and electronic multiplier.

Boesch Mfg. Co., Inc., 705, 802 Production Rd.
*Model SM-A toroidal winder for sub-miniature sized coils. *Tape Winding Machine, "7" Shuttle assembly for stacked coils. Standard Automatic Toroidal Winder. Standard Semi-Automatic Toroidal Winder. All machines equipped with variable speed controls and electronic pre-set counters.

Bogart Mfg. Corp.
379 Microwave Ave.

Designers and producers of Electronic and Microwave components and assemblies. Items include *waveguide switches, *broadband rotating joints, *bifurcated balanced mixers, *dummy loads, *hybrid junctions.

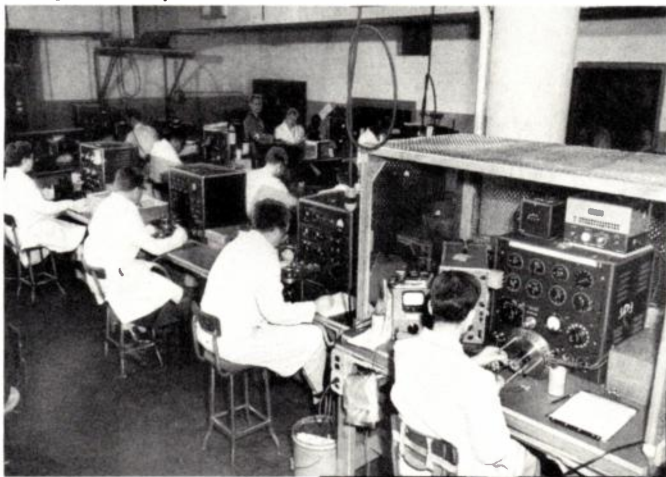
Bogue Electric Mfg. Co.
109, 111 Military Ave.

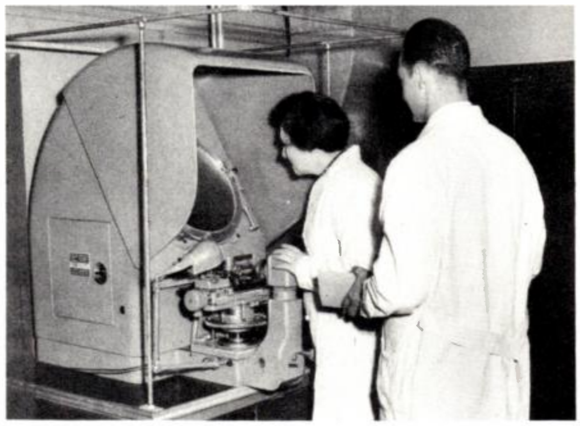
400 cycle motor-generators capable of delivering sine-wave power with total harmonics reduced as low as 0.1%. Also gene. .tors for any special power output.

*Indicates new product

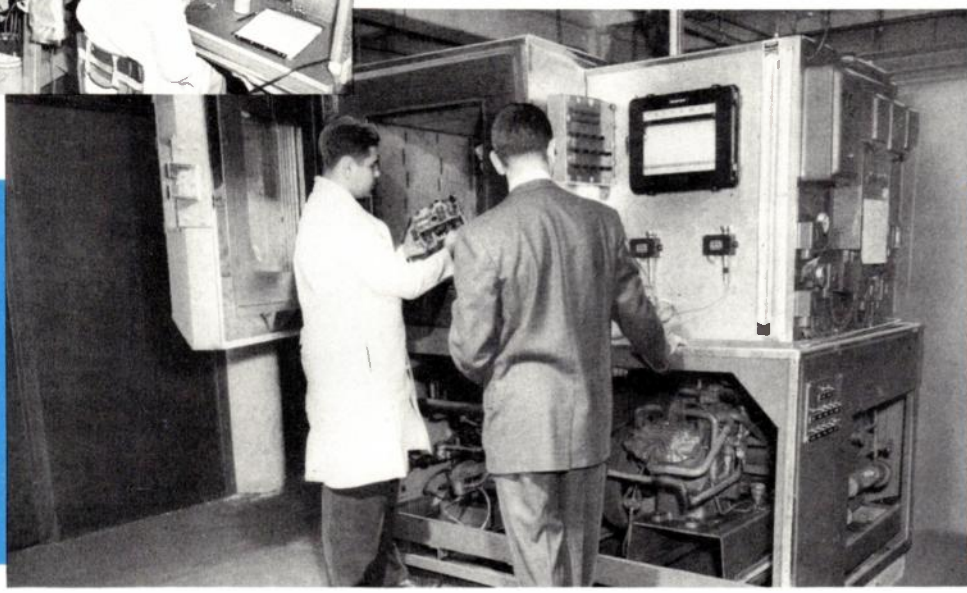
(Continued on page 164A)

Skilled technicians performing one of dozens of tests on size 23 Synchros. As design agent for Army Ordnance, Ketay designed all Synchros of this size.





Jones and Lamson optical comparator . . . one of hundreds of different methods (many of them original developments) used to insure precision.



Environmental test chamber can simulate altitudes up to 90,000 feet; produce temperatures to minus 100°F and controlled humidity to 98%. This chamber performs all environmental tests in accordance with MIL-E-5272.

EXPERIENCE + RESEARCH + PERFORMANCE = LEADERSHIP

The final test of leadership is the ability to deliver. Ketay offers:

> Original research to meet highly specialized requirements and rigorous operating conditions;
>
> Application of this research to the economical manufacture of high quality products;
>
> Volume production to comply with stringent delivery schedules.

By providing a complete range of sizes and types . . . originality of design . . . facilities for volume production . . . Ketay has established this kind of leadership.

Ketay's experience also includes: gyro components; automatic control devices for fire control and missile systems; computers and simulators; magnetic, resolver and synchro amplifiers; marine inter-communication equipment; ship's course, salinity and other remote indicators; and automatic control systems.

The Research and Development Division is staffed and equipped to participate in advanced studies during the design stage of applications involving Ketay electro-mechanical devices.

SYNCHROS
SERVO MOTORS
RESOLVERS
MAGNETIC AMPLIFIERS
AUTOMATIC CONTROL SYSTEMS

Booth 629-631—I.R.E. Show
Kingsbridge Armory
New York City, March 22-25

Ketay
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Executive Offices 555 Broadway, New York 12, N. Y.
Pacific Division, 12833 Simms Avenue, Hawthorne, California

New York Division • Kinetix Instrument Division • Pacific Division
Electronic Instrument Division • Research & Development Division

For further information or additional copies of this catalog sheet write directly to Ketay

Typical characteristics of some of the units

TWO PHASE SERVO MOTORS

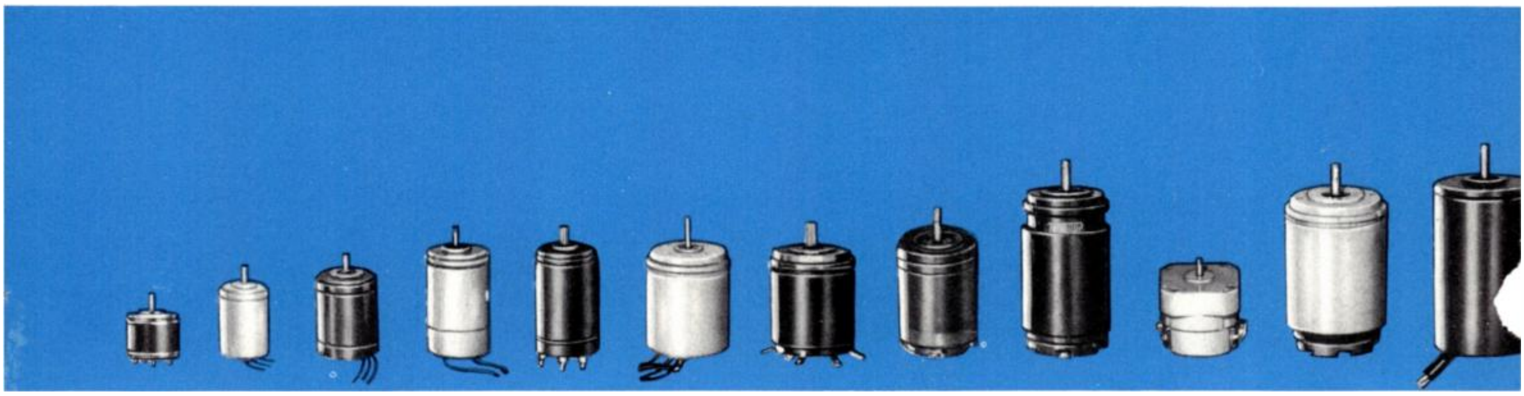
TYPE	FRAME SIZE	MK	MOD	MIN. TORQUE AT STALL (IN OZ.)	NO LOAD SPEED (MIN.)	POWER PHASE AT STALL (WATTS)	NO. OF POLES	OPERATING FREQUENCY	RATED VOLTAGE EXCITATION FIXED PHASE	CONTROL PHASE SERIES	CONTROL PHASE PARALLEL
K402350	10			.13	9600	1.5	4	400	18/18 *		
K402400	10			.13	9600	1.5	4	400	18/18 *		
K402390	10			.3	6200	2.7	6	400	26/26 *		
K402300	11	14	2	.63	6200	3.5	6	400	115	115	57.5
K402310	11			.35	6200		6	400	50/26 *		
K402290	11			.45	6200	3.5	6	400	115	115	57.5
K402380	15			1.45	3200	5.0	2	60	115	115	57.5
K402470	15			1.3	1600		4	60	24/24 *		
K101600-6	15	7	0	1.45	4800		8	400	115	115	57.5
K101650-5	15	7	2	1.45	4800	6.1	8	400	115	230	115
K101660	15	7	1	1.45	4800	6.1	8	400	115	115	57.5
K402410	15			.28	4800	6.1	8	400	40/50 *		
K402420	15			.28	4800		8	400	26/50 *		
K402430	15			.28	4800		8	400	50/26 *		
K402440	15			.28	4800		8	400	42/42 *		
K402150	15			1.3	6200	6.1	6	400	115/26 *		
K402550-1	18	8	0	2.35	4800	9.2	8	400	115	115	57.5
K402550-2	18	8	1	2.35	4800	9.2	8	400	115	115	57.5
K402560	18	8	2	2.35	4800	9.2	8	400	115	282	141
(1) 113E1Y	23			7.5	3500	14.0	2	60	115	115	57.5

(1) Also for 115 or 230 operation on control phase
*Denominator refers to control phase excitation

SYNCHRO CONTR…

TYPE	FRAME SIZE	MK	MOD	VC…
(1) K101530	10			
K101560	10			
11CT4a	11	24	1	
K101300	15			(3)
(2) K402100				
K101750	15			
15CT4a	15	14	1	
K101800	15			(3)
16CTB4a	16	21	1	
18CT4a	18	15	1	
18CT6a	18	25	0	
19CTB4a	19	22	1	
19CTB6a	19	27	0	
1HCT	1			
23CT4	23			
23CT6	23			

(1) High Impedance …
(2) Linear synchro
(3) When used as con…



1 2 3 4 5 6 7 8 9 10 11 12

SYNCHRO RESOLVERS

TYPE	FRAME SIZE	TOTAL NULL VOLTAGE MAX. AT TEST VOLTAGE	TEST VOLTAGE	INPUT IMPEDANCE Ohms	VOLTAGE RATING	ANGULAR DISTANCE BETWEEN NULL VOLTAGE	MAXIMUM ANGULAR ACCURACY	OPERATING FREQUENCY
K101580	10	200 MV	26/12	600	26/11.8 VAC	90° ± 5'	30'	400
(1) K101590	10	200 MV	26/12	2500	26/11.8 VAC	90° ± 5'	30'	400
101D2A	11	60 MV	26	1400/70°	26/22 VAC	90° ± 30'	± 10'	400
101D2C	11	60 MV	26	440/76°	26/11.8 VAC	90° ± 15'	± 10'	400
D13640	11	30 MV	26	1510/71°	26/22 VAC	90° ± 30'	± 10'	400
D13800	15	75 MV	50	2740/83°	50/50 VAC		±.3%	500
(2) 105D2A	15	30 MV	30	2730/80.5°	10/10 VAC	90° ± 5'	±.1%	400
105D2Z	15	40 MV	26	900	26/26 VAC	90° ± 20'	±.12%	400
(2) D13610	15	30 MV	24	(4)	(4)	90° ± 5'	±.2%	1000 (Test)
D11960	15	25 MV	26	585/81°	26/11.8 VAC	90° ± 5'	20' Spd	400
K101450	15	200 MV		1970/75°	26/18	Single phase	40'	400
				274/28°	1/2	Single phase	40'	30
D13310	15	30 MV	26	740/80°	26/26 VAC	90° ± 5'	±.10%	400
(2) D13820	15	15 MV	15	889/78°	26/26 VAC	90° ± 5'	±.10%	400
K101340	15	200 MV	26/12	440/75°	26/11.6 VAC	90° ± 5'	20' Spd	400
(2) D13320	23	30 MV	24	(4)	(4)	90° ± 5'	±.2%	1000 (Test)
D13600	23 (3)	50 MV	50	7000	50/50 VAC	90° ± 30'	± 5'	500
D13650	23	30 MV	30	3200/85.7°	30/30 VAC	90° ± 5'	±.15%	350
D13350	23	10 MV	8	975/86.4°	8/16 VAC	90° ± 5'	± 8'	400
D13810	23	30 MV	30	3200/85.7°	30/30 VAC	90° ± 5'	±.15%	350
23RS6B	23	15 MV	26	1000	26/26 VAC	90° ± 2.5'	±.1%	60
23RS6S	23	30 MV	24	480/78°	24/24 VAC	90° ± 5'	±.2%	60
D13440	23	90 MV	90	2700/73.8°	90/90 VAC	90° ± 5'	±.1%	400
23RS6	23	60 MV	60	585/61°	90/90 VAC	90° ± 5'	± .2%	60
23RS6A	23	30 MV	24	570/79°	45/45 VAC	90° ± 5'	± .2%	60
23RS4	23	60 MV	60	720/80°	90/90 VAC	90° ± 5'	± .2%	400
23RS4A	23	60 MV	60	234/83°	90/90 VAC	90° ± 5'	± .2%	400
23RS4B	23	20 MV	26	550/86°	26/26 VAC	90° ± 5'	± .10%	400
23RS4C	23	30 MV	60	3200/86°	90/90 VAC	90° ± 5'	± .10%	400
(2) 23RS4D	23	30 MV	60	3200/86°	90/90 VAC	90° ± 5'	± .10%	400

(1) High impedance unit
(2) Feedback Resolver
(3) Geared housing

(4) For these Sweep Resolvers input impedance is not considered. Instead, inductance at 1000 c.p.s. is important.

Inductance at 1000 c.p.s.	D13320	D13610
Rotor winding	17.7 Mh	27 Mh
Main Stator winding	16.2 Mh	24.6 Mh
Feedback Stator winding	16.2 Mh	24.6 Mh

INDUCTION …

TYPE	FRAME SIZE	DUTY	OPERATING VOLTAGE
D11940	18	Continuous	3 Phase 115 V
E11590	20	Intermittent	2 Phase 115/40
E11600	1	Intermittent	3 Phase 115 V

(1) SERVO MOTOR, Size 10 Frame, O.D. .937"
(2) SYNCHRO, Size 10 Frame, O.D. .937" (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)
(3) SERVO MOTOR, Size 10 Frame, O.D. .937"
(4) SYNCHRO, Size 11 Frame, O.D. 1.062" (Transmitter, Resolver, Control Transformer)
(5) SERVO MOTOR Mk 14, Size 11 Frame, O.D. 1.062"
(6) SYNCHRO, Size 15 Frame, O.D. 1.437" (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)
(7) SERVO MOTOR Mk 7, Size 15 Frame, O.D. 1.437"
(8) SYNCHRO, Size 15 Frame, O.D. 1.437" (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)
(9) SYNCHRO, Size 16 Frame, O.D. 1.537" (Transmitter, Receiver, Control Transformer)
(10) LINEAR TYPE CONTROL TRANSFORMER, O.D. 1.625"

in current volume production by Keta**y**

ƆL TRANSFORMERS

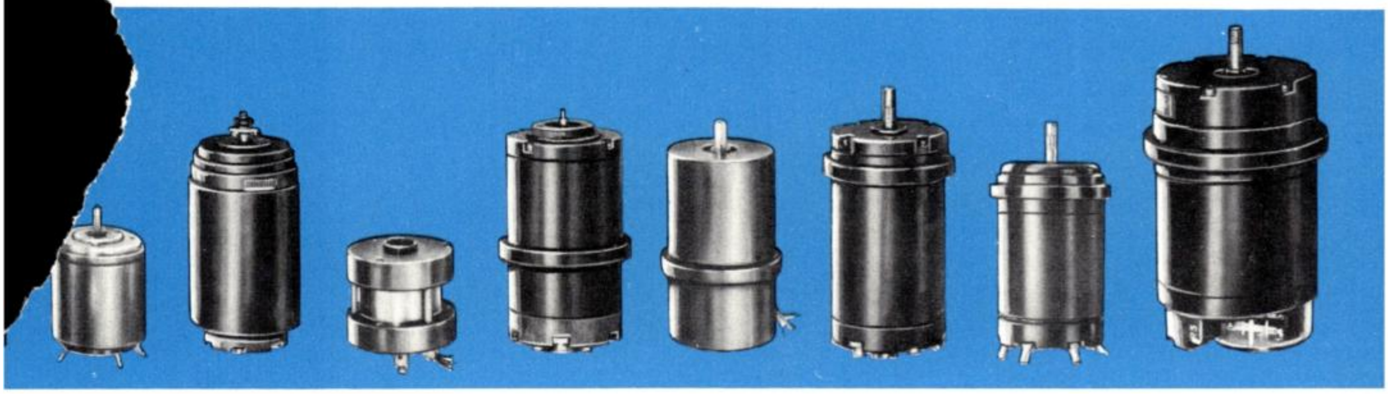
TAGE RATING	OPERATING FREQUENCY	ELECTRICAL ACCURACY MAX. ERROR
5/11.8 VAC	400	24' SPD.
5/11.8 VAC	400	30' SPD.
)/1V per deg	400	±7'
.8/22 VAC	400	20' SPD
) Volt Input	400	
.8/22 VAC	400	15' SPD.
)/1V per deg	400	±10'
1.8/22 VAC	400	20' SPD.
)/1V per deg	400	±10'
)/1V per deg	400	±8'
)/1V per deg	60	±8'
/1V per deg	400	±8'
V per deg	60	±8'
1V per deg	60	±18'
1V per deg	400	±6'
V per deg	60	±6'

mitter 26/11.8 VAC

SYNCHRO RECEIVERS

TYPE	FRAME SIZE	FUNCTION	MK	MOD	VOLTAGE RATING	OPERATING FREQUENCY	RECEIVER ERROR MAXIMUM
K101540	10	Torque Receiver			26/11.8 VAC	400	1.5°
K402020	15	Torque Receiver			115/18.2 VAC	400	.75°
K101430	15	Torque Receiver			26/11.8 VAC	400	.75°
15TR4A	15	Torque Receiver	16	1	115/90 VAC	400	1.0°
16TRB4	16	Torque Receiver			115/90 VAC	400	1.0°
18TR4A	18	Torque Receiver	15	1	115/90 VAC	400	1.0°
19TRB4A	19	Torque Receiver			115/90 VAC	400	1.0°
1F	1	Torque Receiver	8	8	115/90 VAC	60	1.5°
23TR4	23	Torque Receiver			115/90 VAC	400	1.0°
23TR6	23	Torque Receiver			115/90 VAC	60	1.0°
31TDR4	31	Torque Differential Rec.	19	1	90/90 VAC	400	48'
31TDR6S-1	31	Torque Differential Rec.			90/90 VAC	60	*(1)
31TDR6	31	Torque Differential Rec.			90/90 VAC	60	48'
31TR4A	31	Torque Receiver	18	1	115/90 VAC	400	48'
31TR6	31	Torque Receiver	22	0	115/90 VAC	60	48'

*(1) 31TDR6S1—Pigtail Unit, Sensitivity 10'



13 14 15 16 17 18 19 20

ƗOTORS

FREQUENCY	MINIMUM NO LOAD SPEED (RPM)	MINIMUM STALL TORQUE (OZ. IN.)
60	3000	3
60		.75 at { 115 MF 8V CF
60	3200	16

SYNCHRO TRANSMITTERS

TYPE	FRAME SIZE	FUNCTION	MK	MOD	VOLTAGE RATING	OPERATING FREQUENCY	ELECTRICAL ACCURACY MAX. ERROR
K101500	10	Control Transmitter			26/11.8 VAC	400	24' Spd
K101550	10	Control Transmitter			26/11.8 VAC	400	24' Spd
K101570	10	Control Differential Trans.			11.8/11.8 VAC	400	30' Spd
101B2J	10	Control Transmitter			26/11.8 VAC	400	20 Spd
11CX4a	11	Control Transmitter			115/90 VAC	400	±7'
K101350	15	Control Differential Trans.			11.8/11.8 VAC	400	20' Spd
K101400	15	Control Transmitter			26/11.8 VAC	400	20' Spd
K101420	15	Control Transmitter			26/11.8 VAC	400	20' Spd
K101480	15	Control Differential Trans.			11.8/11.8 VAC	400	20' Spd
15TDX4a	15	Torque Differential Trans.	28	1	90/90 VAC	400	±10'
15CDX4a	15	Control Differential Trans.	33	1	90/90 VAC	400	±10'
15CX4a	15	Control Transmitter	22	1	115/90 VAC	400	±12'
K101820	15	Control Differential Trans.			11.8/11.8 VAC	400	20' Spd
16 CXB4a	16	Control Transmitter		1	115/90 VAC	400	±12'
18CDX4a	18	Control Differential Trans.	34	1	90/90 VAC	400	±8'
18TDX4a	18	Torque Differential Trans.	29	1	90/90 VAC	400	±10'
18CX4a	18	Control Transmitter	32	1	115/90 VAC	400	±8'
18CX6a	18	Control Transmitter	46	0	115/90 VAC	60	±10'
18CDX6	18	Control Differential Trans.			90/90 VAC	60	±10'
19CXB4a	19	Control Transmitter	38	1	115/90 VAC	400	±8'
1HG	1	Torque Transmitter	14	8	115/90 VAC	60	±18'
23CX4	23	Control Transmitter			115/90 VAC	400	±8'
23CX6	23	Control Transmitter			115/90 VAC	60	±8'
23CDX4	23	Control Differential Trans.			90/90 VAC	400	±8'
23CDX6	23	Control Differential Trans.			90/90 VAC	60	±8'
23TX4	23	Torque Transmitter			115/90 VAC	400	±8'
23TX6	23	Torque Transmitter			115/90 VAC	60	±8'
23TDX4	23	Torque Differential Trans.			90/90 VAC	400	±8'
23TDX6	23	Torque Differential Trans.			90/90 VAC	60	±8'
31TDX4	31	Torque Differential Trans.	36	0	90/90 VAC	400	±8'
31TDX6	31	Torque Differential Trans.			90/90 VAC	60	±8'
31TX4a	31	Torque Transmitter	35	1	115/90 VAC	400	±8'
31TX6	31	Torque Transmitter	42	0	115/90 VAC	60	±8'

SYNCHRO, Size 18 Frame, O.D. 1.750" (Transmitter, Receiver, Differential Transmitter, Control Transformer)

INDUCTION MOTOR, Size 18 Frame, O.D. 1.750", 3 Phase, 2 Pole

) SERVO MOTOR Mk 8, Size 18 Frame, O.D. 1.75"

SYNCHRO, Size 19 Frame, O.D. 1.90" (Transmitter, Receiver, Control Transformer)

INDUCTION MOTOR, Size 20 Frame, O.D. 1.95"

) SYNCHRO, Type 1F, 1HCT, or 1HG, Size 1 Frame, O.D. 2.250" (Receiver, Transmitter, Control Transformer)

INDUCTION MOTOR, Size 1 Frame, O.D. 2.250"

SYNCHRO, Size 23 Frame, O.D. 2.250" (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)

SERVO MOTOR, Size 23 Frame, O.D. 2.250"

) SYNCHRO, Size 31 Frame, O.D. 3.10" (Transmitter, Receiver, Differential Receiver, Differential Transmitter)

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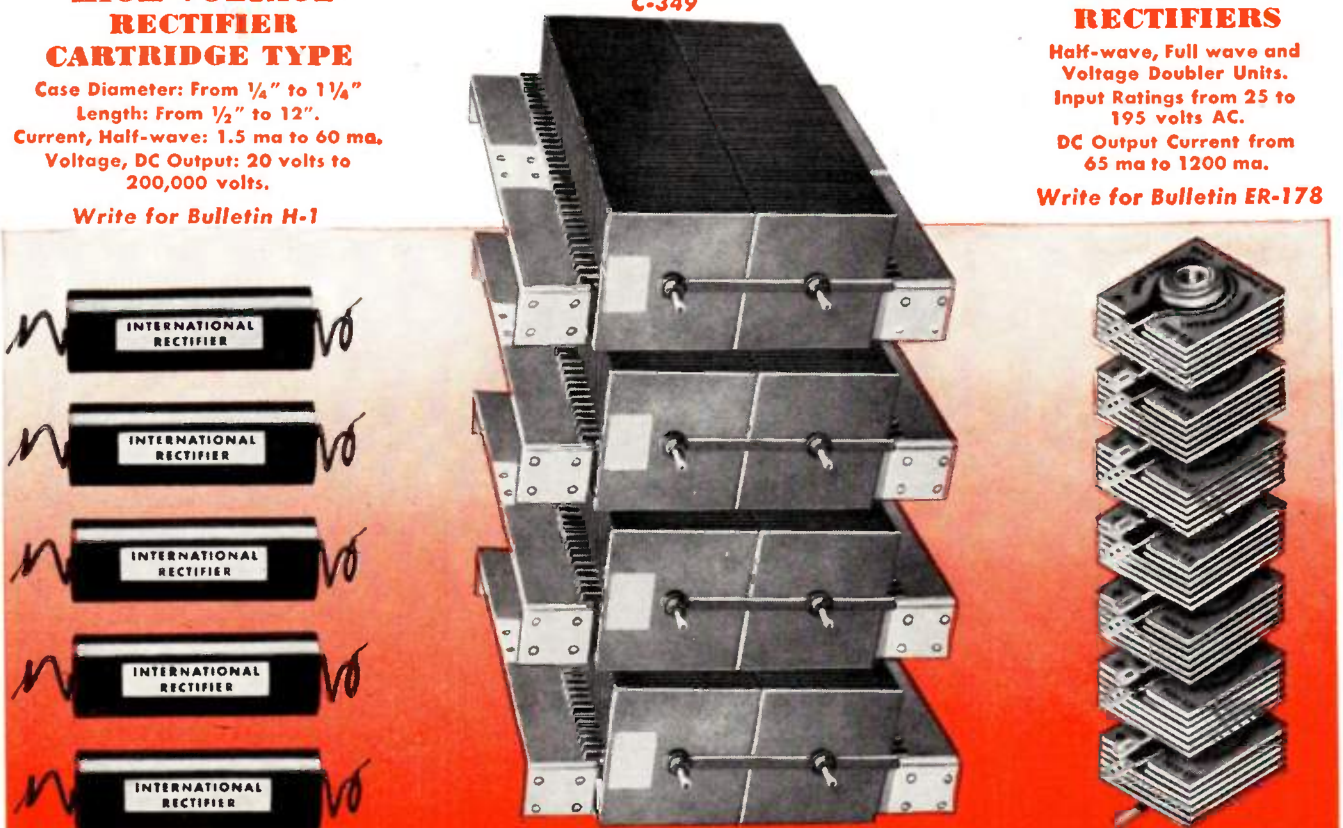
Half-wave, Full wave and Voltage Doubler Units.
Input Ratings from 25 to 195 volts AC.
DC Output Current from 65 ma to 1200 ma.

Write for Bulletin ER-178



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Professional Group on Medical Electronics

For centuries mankind has searched for a fuller knowledge of the workings of the human body and for improved means of diagnosing and curing bodily ailments. This noble task has been greatly aided in recent years by the application of electronics to medicine and related fields.

Electronics has provided the physician with the means for making better, more exact, more comprehensive measurements of countless parameters important to his work. As a result, he now knows a great deal more about the brain, heart, blood, respiratory system, tissue, muscle, and nervous system.

Having thus increased his knowledge, the doctor has turned to electronics also for assistance in the treatment of disease. Cancer therapy, the location of tumors, diathermy, and the treatment of heart diseases are but a few examples of the uses to which electronic equipment and techniques are being put.

To provide the medical field with the necessary electronic equipment, almost every branch of radio engineering has been called into play: from ultrasonics to X rays, from dc amplifiers to microwave apparatus, aids for the blind and aids for the deaf, electronic recording and mapping devices. Even television has supplied an important and useful tool, the television microscope.

However, the rapid development of medical electronic equipment has been hampered by a serious obstacle. For here was a situation which called for the combined knowledge of two highly skilled and hitherto unrelated fields. Either the doctor would have to become an engineer or vice-versa, unless some common meeting ground could be provided to enable an exchange of vitally needed information.

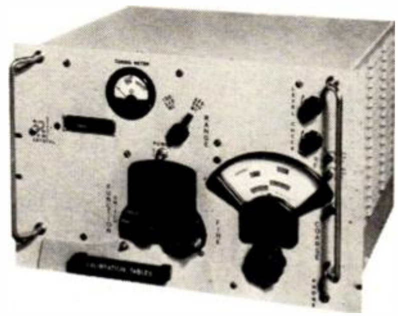
It was to meet this urgent need that the IRE Professional Group on Medical Electronics was recently formed. Already 700 strong, the Group is actively engaged in publishing valuable technical papers and sponsoring national meetings, thereby providing the only organized activity of its kind in this vital field.

W. R. G. Baker

Chairman, Professional Groups Committee

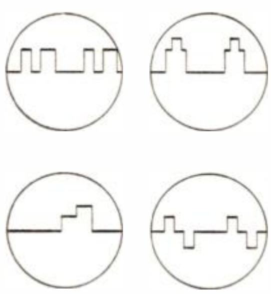
LAVOIE

FOR THE NEWEST and BEST in ELECTRONIC EQUIPMENT



FREQUENCY METERS

Three frequency meters accurate to 0.001% cover ranges from 10 to 2000 MC. Model LA-5 covers the 10 to 100 MC range, LA-6, 100 to 500 MC and LA-61 500 to 2000 MC.

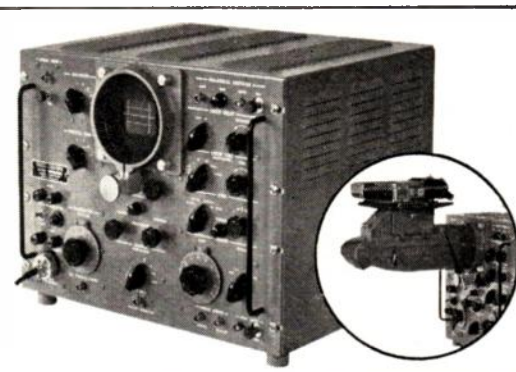


PULSE GENERATOR—MODEL LA-592D

A double-pulse generator with wide range control, excellent pulse shape. Eliminates necessity for many instruments usually required in an electronics laboratory.

OSCILLOSCOPE—MODEL LA-239C

The new and improved Lavoie oscilloscope offers wider frequency range, greater sensitivity and faster rise time. The Lavoie Camera Adapter may be added quickly and without modification.



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Maintains crystal temperature to within 0.025° C at normal room temperature—to within .15° C over outside range from -40° F to 150° F. Available for HC 6 or HC 13 crystal units.

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LOW LOSS... MINIMUM CREEPAGE

NEW TYPE 2C TAP SWITCHES

Designed and constructed for precision service, long operating life and rugged duty, Type 2C instrument switches are an advanced design of the proven Tech Laboratories Type 2A. Ceramic insulation and improved contacts greatly increase their efficiency. Low r.f. loss and sharp reduction of creepage, plus a *constant* contact resistance of only 1 or 2 milliohms, give these precision switches matchless performance records. *Write for full details.*

SPECIFICATIONS

Contact resistance: 1-2 milliohms

Contact material: Silver alloy

Contact design: Laminated wiper arm, self-cleaning, shorting or non-shorting

No. of contacts: 2 to 24 single pole, shorting or non-shorting
2 to 11 double pole, shorting or non-shorting
2 to 5 triple pole, shorting or non-shorting

Spacing: 15° or 20°, shorting or non-shorting

No. of poles per deck: 1 to 4

No. of decks: According to requirements

Life: 200,000 cycles, min.

Current carrying cap.: 3 amp.

Max. operating voltage: 120 V., a.c.

Mounting: Single hole, ⅜"-32 bushing, standard length for up to ¼" panel, special lengths to order

Size: 1¾" dia.

Detent: Ball and spring

Weight: Approx. 1 oz. per deck

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Manufacturers of Precision Electrical Resistance Instruments

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(Continued from page 160A)

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Microwave Ave.

Bond Electronics Corp., 363 Mobile Ave.
Precision Wire-wound Resistors, Coils, Coil Assemblies.

H. BRAUN Tool & Instrument Co., Inc.
140 FIFTH AVENUE
HAWTHORNE, NEW JERSEY
MANUFACTURERS
and HEAT TREATERS of
BERYLLIUM COPPER
Components for the Electronic Industry
BOOTH 417—Electronic Avenue

British Industries Corp., 453 Electronic Ave.
Ersin Multicore Solder, Douglas & Macadie Coil Winding Machinery, Widney-Dorlec Cabinets, "Expamet" expanded aluminum grille material, Genelex KT66, KT61, Z729 tubes.

See the NEW
Q STANDARD
Q Meters, RX Meter, QX Checkers, G Meter, FM-AM Signal Generators, Univerters, ILS Signal Generators
225-227 Instruments Ave.
BOONTON RADIO CORPORATION
Boonton, New Jersey

The New Standard for Multiturn Potentiometers
BORG MICROPOTS
THE GEORGE W. BORG CORP.
536 Components Avenue
1954 Radio Engineering Show
Kingsbridge Armory, New York

POTENTIOMETER INSTRUMENTS
Bourns LABORATORIES
RIVERSIDE, CALIFORNIA
Booth No. 788
Airborne Avenue

(Continued on page 166A)

What to See at the Radio Engineering Show

(Continued from page 164A)

W. H. Brady Co., 289 Instruments Ave.
Self-sticking wire markers, pipe & conduit markers, safety signs, write-on labels, printed roll tapes, pre-cut masking tape, insulators, gaskets, and pinstripe stencils.

Brooks & Perkins, Inc., 748, 750 Airborne Ave.
*Magnesium Communications equipment housings, radar plotting equipment, reflectors, radio chassis, consoles and cabinets. Look for the Magnesium missile and big radar reflector.

Brown Electro-Measurements, Inc.
See Electro-Measurements, Inc.

Browning Laboratories, Inc., 238, 240 Instruments Ave.
Scopes: ON-7 medium-priced for DC-5 MCS; OA-16, highly flexible for DC-5 MCS; OL-23, 10 MCS, Variable delay, plus the first binaural tuner, RJ-48.

Brubaker Mfg. Co., Inc., 640 Circuits Ave.
Specialty components: Delay lines, video switching relays, equipment cabinet drawer slides, binary count rotary switches. Test equipment; precision marker-pulser generator for accurate timing measurements.

Brush Electronics Co.
869-875 Audio Ave.
Industrial and research instruments, magnetic components, piezoelectric crystals and ceramics, acoustic products. *Complete line of rack-mounted oscillographs and amplifiers. *Surfindicator—surface roughness measuring instrument.

Buchanan Electrical Products Corp., 912 Registration Row
"Pres-SURE-connectors" for wire splicing and terminating, Heavy Duty Molded Terminal Blocks, *Terminal-less wire-to-wire Buck-Block Terminal Strips.

Buckbee Mears Co., 721 Airborne Ave.
First to produce shadow masks—the precision heart of the tri-color kinescope. Pioneers in electro-formed and etched components for electronic discharge devices.

H. H. Buggie, Inc.
418, 420 Electronic Ave.
Many types of special and standard connectors, cable assemblies, and component parts. *Printed Circuit Connectors. *Miniature Cable Connectors. *Safety Interlock Switch. *TV Camera Connectors.

Burgess Battery Co., 762 Airborne Ave.
Complete line of Radio, Industrial and Electronic Batteries.

BURLINGAME ASSOCIATES
LABSCOPE precision equal-amplifier OSCILLOSCOPES
HYCOR Precision Resistors, Toroids, Potentiometers, Filters
NONLINEAR SYSTEMS, Inc. Digital Voltmeters
PERKIN ENG. CORP. Mag. Amp. Regulated D.C. Power Supplies
234-236 Instruments Ave.

*Indicates new product

(Continued on page 168A)

Visit us at
BOOTH 105,107
I.R.E. Show—March 22-25
Kingsbridge Armory,
New York City

DON'T MISS THE

Crucible magnet exhibit

AT THE I. R. E. SHOW

Here you'll see a complete line of Alnico magnets embracing virtually every electronic and industrial application.

And if you have a magnet problem, don't hesitate to bring it to us at booth 105,107. After all, our experience dates back to the beginning of Alnico permanent magnets. Since that time we've handled a lot of magnet applications, and we have a wealth of experience to draw upon. It's all yours for the asking.

So be sure and stop at the Crucible booth while you're at the show. The welcome mat is out.

CRUCIBLE first name in special purpose steels

54 *years of Fine steelmaking* **ALNICO PERMANENT MAGNETS**

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

STAINLESS • REX HIGH SPEED • TOOL • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS

What to See at the Radio Engineering Show

(Continued from page 166A)

BURLINGTON INSTRUMENT COMPANY
673 Circuits Ave.

AC and DC electrical indicating instruments including hermetically sealed ruggedized types. Also generator voltage regulators. Instruments built to your specifications.

Burnell & Company, 678 Circuits Ave.
Plug in decade inductors, miniaturized hermetically sealed telemetering filters & *subminiature H. F. toroidal coils.

Burroughs Corp., Electronic Instruments Div.
337, 339 Computer Ave.

*High speed magnetron type beam switching tubes. *Strip-wound magnetic-core pulse transformers, and shift registers. See pulse control equipment applied to actual pulse timing, gating, and distributing problems.

Bussmann Mfg. Co.
488 Electronic Ave.

Small dimension fuses of various types. Fusetron dual-element (slow blowing) fuses, fast acting fuses for instrument protection—and fuses of all types for the protection of television, radio, controls, avionics, and automobiles. Plus many kinds of fuse blocks, fuse clips and fuse holders.

CBS HYTRON DANVERS, MASS.
A Division of Columbia Broadcasting System, Inc.

Booths 588, 590, 592
Components Avenue

Will exhibit radio and television receiving tubes, television picture tubes, transmitting and special-purpose tubes, germanium and silicon diodes, and transistors. The CBS-Colortron, a television picture tube of advanced design, will be featured.

CEC Instruments, Inc.
See Consolidated Engineering Corp.

C. G. S. Laboratories, Inc., 666, 668 Circuits Ave.
*New line of INCREDUCTOR controllable inductors features high Q, improved temperature stability. Miniature S-band transmitter cavities ruggedized for 1000 G shock. New Antenna Polycoupler rf transformers.

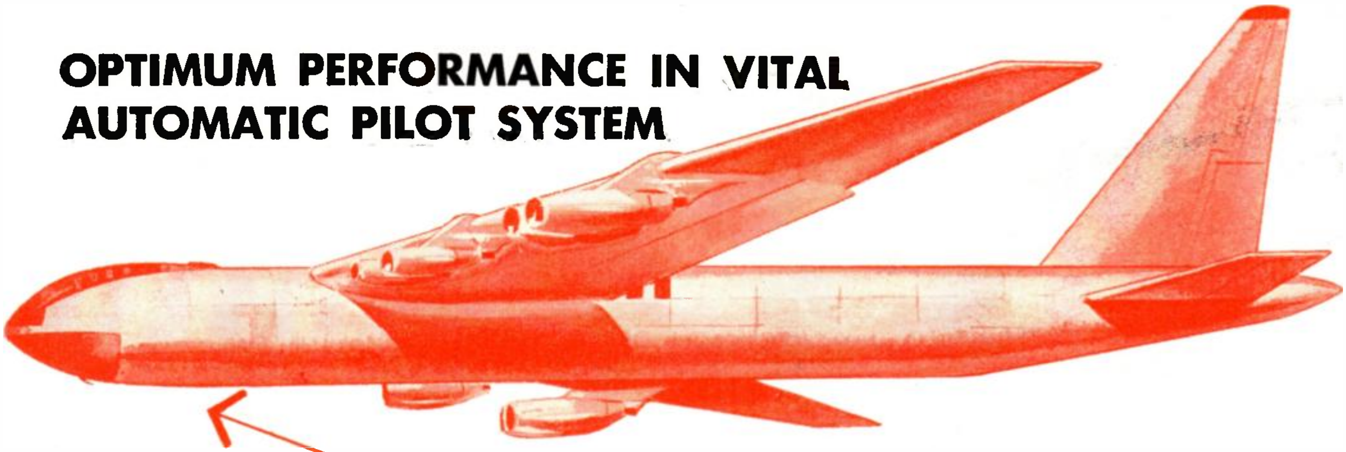
C & H Supply Company, 624 Circuits Ave.
METAL-CAL gives the first new concept to product identification by its adhesive application and its brilliant metallic colors anodically produced on 0.003 aluminum foil.

The Calidyne Company, 462, 464 Electronic Ave.
Vibration test equipment by Calidyne. High performance electro-dynamic Shaker Systems. Vibration pickup calibration systems. Accelerometer and *New Velocity type vibration pickups.

*Indicates new product

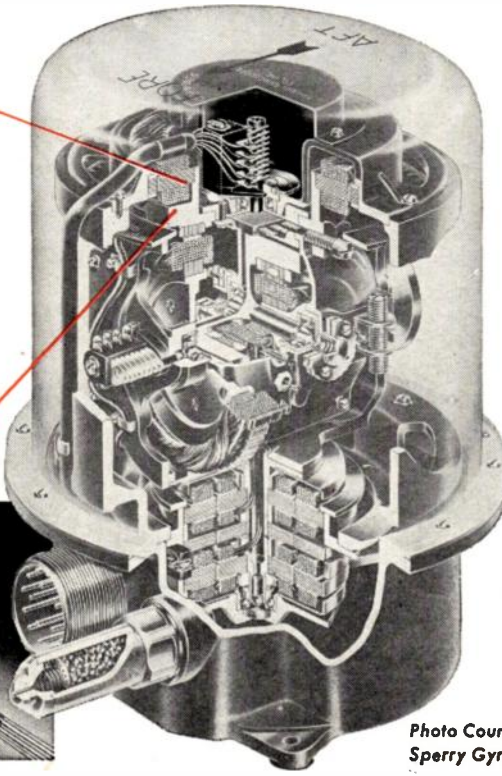
(Continued on page 172A)

OPTIMUM PERFORMANCE IN VITAL AUTOMATIC PILOT SYSTEM



ELECTRO TEC SLIP RING ASSEMBLIES

ONE PIECE UNIT REPLACES ASSEMBLY OF MULTIPLE COMPONENTS



The instrument shown is a Sperry "Gyrosyn"® compass which combines the advantages of gyroscopic stability and magnetic correction to provide an accurate directional reference.

Photo Courtesy Sperry Gyroscope Company

Offering Closer Tolerances, Absolute Uniformity and the Ultimate in Miniaturization:

- ONE PIECE, UNITIZED CONSTRUCTION
- ABSOLUTE MINIMUM FRICTION TORQUE
- DIAMETERS FROM .035" to 24.0"
- MINIMUM 1000 V.A.C. HI-POT INTER-CIRCUIT
- HARD SILVER RINGS PLATED TO PRECISELY MACHINED ONE-PIECE PLASTIC FORM
- SPECIAL SURFACE DEPOSITS PREVENT TARNISH, MINIMIZE FRICTION, BRUSH NOISE AND WEAR

—featuring SUPER DEPENDABILITY!

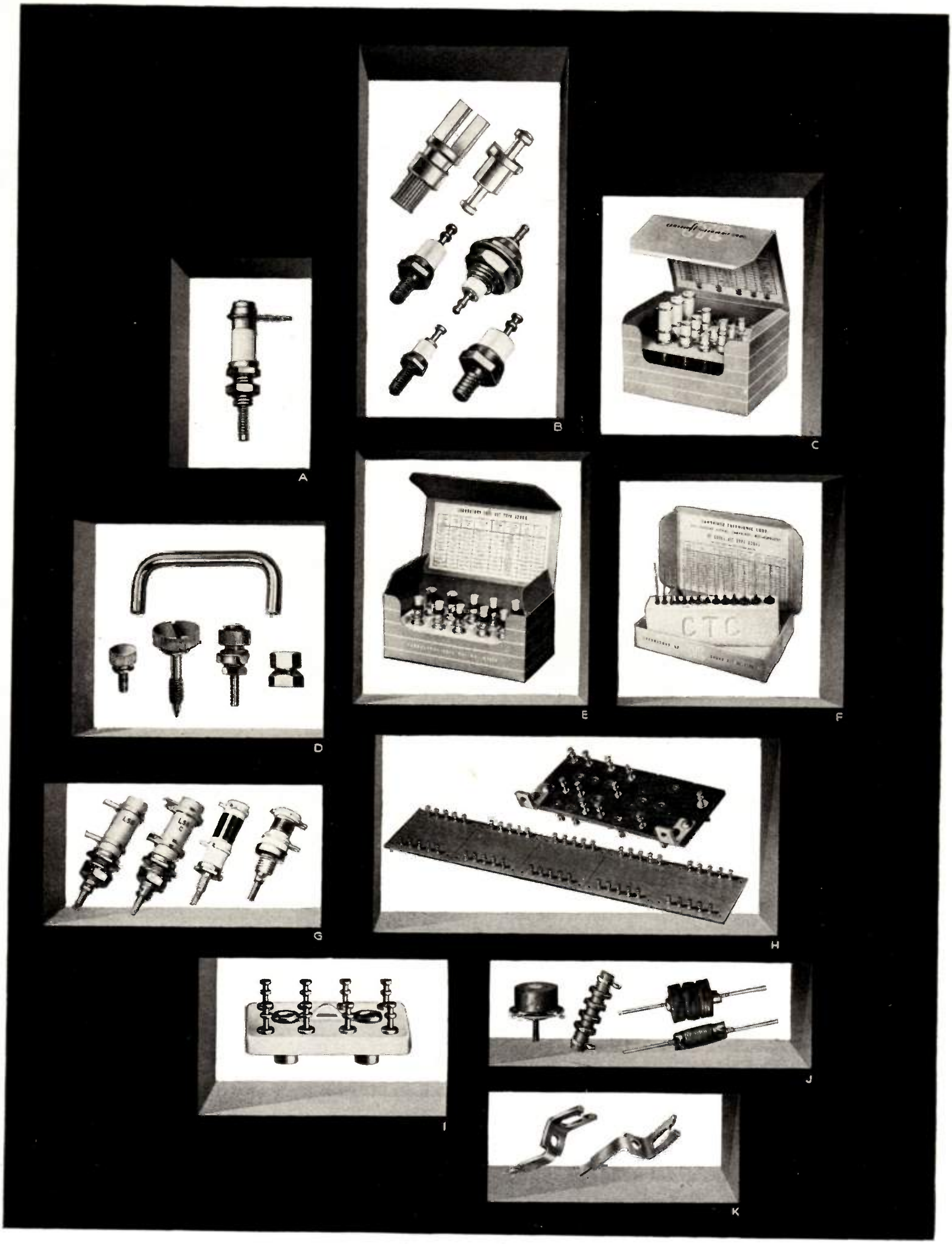
The Sperry "Gyrosyn" compass is an outstanding example of precision and dependability. Electro Tec is proud to furnish slip ring assemblies which are consistent with the high accuracy and unfailing performance of this instrument. In this application, as in hundreds of others, Electro Tec meets specifications with a degree of accuracy unattainable with built-up or molding methods of manufacture. This extreme precision plus the many other advantages that result from Electro Tec manufacturing techniques have resulted in leadership throughout the industry. For complete cooperation in applying Electro Tec "know-how" to specific problems call or write the Sales Engineering Department.

AT THE I. R. E. SHOW
A cordial welcome is extended to all to visit us at Booth 133, 135 MILITARY AVENUE, Kingsbridge Armory, New York City, March 22-25 Inclusive.

ELECTRO TEC CORPORATION
SOUTH HACKENSACK • NEW JERSEY

PRODUCTS OF PRECISION CRAFTSMANSHIP BY A NEW AND REVOLUTIONARY PROCESS *

* Patent Pending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What to See at the Radio Engineering Show

(Continued from page 168A)

Caltronics Corp., 906 Registration Row
The Supertester, an automatic production tester for quality control of electronic and electrical equipment. An X-Band Direct-Reading VSWR Indicator. Antenna pattern recording equipment.

Camloc Fastener Corp., 880 Audio Ave.
Quick operating fasteners. Radome latches. Push button access doors.

Canadian Radium & Uranium Corp., 414 Electronic Ave.
Luminous compounds for every industrial use. Manufacturing and finishing of dials, name-plates, panels and special applications to all government specifications. Design, research and development.

Capitol Radio Engineering Institute, Inc., 692 Circuits Ave.
CREI residence and/or home study courses in Practical Radio Engineering, Broadcast Radio Engineering, Television Engineering, Aeronautical Radio Engineering, Television, FM and Advanced Servicing.

Allen D. Cardwell Mfg. Corp., 710 Airborne Ave.
Will feature TV color grids, IF Decks, both black and white and color, printed circuitry and UHF Converters.

(Continued on page 176A)

EL-TRONICS

INCORPORATED

Fifth and Noble Sts., Phila. 23, Pa.

engineering release

ADVANCED DESIGN

De Luxe Wide Band Laboratory Oscilloscope

MODEL WBO-50

PRICE $395.
F.O.B. FACTORY

SPECIFICATIONS

VERTICAL AMPLIFIER

SENSITIVITY: 20 millivolts RMS per inch of deflection.

FREQUENCY RESPONSE: (Sine Wave) 20 cycles to 5 megacycles. Down 3DB at 5mc.

SQUARE WAVE RESPONSE: Excellent duplication of all square waves between 30 cycles and 1 megacycle. Maximum tilt of 50 cycle square wave 5%.

MAXIMUM INPUT POTENTIAL: 1000 volts peak to peak.

INPUT ATTENUATOR: X1 – X10 – X100 positions. X1 position useful up to 10 volts peak to peak input. Input attenuator is frequency compensated.

CALIBRATED GAIN CONTROL: Vertical amplifier gain is continuously variable by means of calibrated vertical gain control. Gain control is calibrated in peak to peak volts. Special circuit minimizes effect of gain control setting on frequency response.

INPUT IMPEDANCE: X1 position 3.5 megohms – 55mmfd
X10 position 1 megohm – 27mmfd
X100 position 1 megohm – 25mmfd

HORIZONTAL AMPLIFIER

SENSITIVITY: 0.3 volts RMS per inch of deflection.

FREQUENCY RESPONSE: (Sine Wave) flat to 300 KC.

RECURRENT SWEEP OSCILLATOR

FREQUENCY RANGE: 10 cycles to 150 kilocycles in 6 steps.

LINEARITY: Excellent linearity over entire range.

BLANKING & "Z" AXIS MODULATION

(control switch and terminals provides the following):

1. Provision for external intensity modulation.
2. Provision for external retrace blanking.
3. Provision for internal blanking pulse output for triggering purposes.
4. Internal retrace blanking amplifier incorporated for positive blanking.

CALIBRATED TEST SIGNAL

A built-in 2 volt peak to peak calibrated test signal source is brought out to front panel binding post.

REGULATED POWER SUPPLY

All voltages except heater and CR tube accelerating potential are fully regulated to minimize instability due to line voltage fluctuations.

Please see us at the
IRE Show-Space 338
Computer Ave.

CONSTRUCTION

Cabinet is 10½" wide x 13½" high x 15½" deep.

Finish is steel grey hammertone.

Finely perforated ports are provided for adequate ventilation.

Etched aluminum panel finished in semi-matte dark grey background to minimize glare. Panel markings are white.

WEIGHT

Approximately 35 lbs.

SPECIAL FEATURES

1. Full 4" vertical deflection without overload.
2. Vertical amplifier *NOT* overcompensated. Overshoot kept to a minimum. Frequency response drops off *gradually* beyond specified frequency range.
3. Rectangular light shield permits viewing of the *EFFECTIVE* cathode ray tube area 4" vertically and 4½" horizontally.
4. Green light filter reduces effect of external light interference, permitting excellent observation of test patterns in normal room light.
5. Special slotted design of light shield permits easy removal of graduated scale and light filter.
6. Cathode ray tube provided with MU-METAL shield for protection against external magnetic fields.
7. Continuously variable gain controls.
8. Vertical gain control calibrated in peak to peak volts.
9. Unusual chassis layout for maximum wiring efficiency and lowest interaction between H. and V. circuits.
10. High in quality – Low in price.

TUBE COMPLEMENT

(19 tubes)

VERTICAL AMPLIFIER: 6C4 cathode follower, 6AH6 amp., 6C4 phase splitter, PP 6AG7 deflection amplifiers.

HORIZONTAL AMPLIFIER: 6AB4 amp., PP 6C4 deflection amplifiers.

BLANKING AMPLIFIER: 12AT7.

SWEEP OSCILLATOR: 12AT7 multivibrator.

CR TUBE: Type 5UP1.

POWER SUPPLY: 5U4G, 5Y3GT, 3 OB2 regulators, 6AU6, 6AS7G.

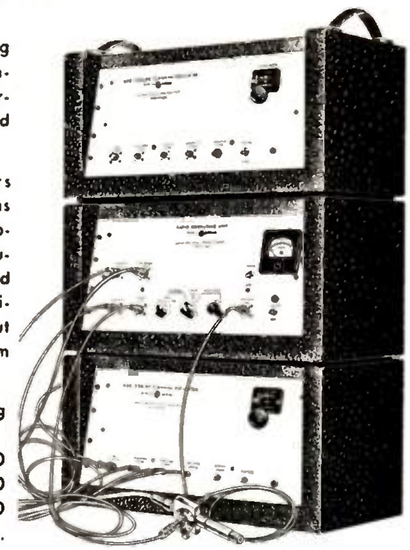
El-Tronics INC.

PRECISION ENGINEERING

THE TYPE 20 INSTANTANEOUS READING

BROAD-BAND SWR INDICATOR

The AIL type 20 SWR Indicator System consists of two separate Scanning Oscillators covering the 400-900 mc and 900-1350 mc bands, a Reflectometer with a standard matched 50-ohm load, a Ratio Measuring Unit, interconnecting and power cables. Frequency and SWR over the entire band are displayed on an oscilloscope (not supplied).



- Instantly measures standing wave ratio over the 400-900 mc and 900-1350 mc bands.
- Eliminates tedious point-by-point data taking.
- Adjust antennas, transmission systems, filters, networks, receivers while under test.
- The Scanning Oscillators may be used separately as sources of r-f power, automatically scanned or manually adjusted to the desired frequency, giving 200-milliwatt minimum power output over the band into a 50-ohm resistive load.

Type 20 SWR Indicator System, Complete with Interconnecting Cables less oscilloscope

Low Frequency System	$2,980
High Frequency System	2,980
Complete High and Low Frequency Systems	4,200

F.O.B. Mineola. Prices for individual units may be obtained upon request.

WIDE RANGE POWER OSCILLATOR

Continuous control within ranges from 300 to 900 mc and 900 to 2,500 mc

Separate output coupling control

More than 10 W to 1200 mc

More than 2.5 W to 2,500 mc

The AIL type 124A Oscillator consists of a grid-separation coaxial oscillator employing a 2C39A disc seal triode, an audio oscillator and a modulation section.

Write for a detailed description of its versatility and operating ease.

$2,285.00 F.O.B. Mineola

Airborne Instruments Laboratory is known the world over for its skill in electronic research and engineering development. More than eighty per cent of its business activity has been in assisting industry and government in improving the scope of electronic application and solving problems for producers and users of electronics.

Perhaps we can be of service to your organization. Your inquiry will receive prompt attention and will be handled in confidence.

Write for complete literature on these items, or AIL custom design and manufacturing service on other precision instruments and components.

Visit our booth
at the IRE Convention
No. 718
Airborne Avenue

CUSTOM MANUFACTURING

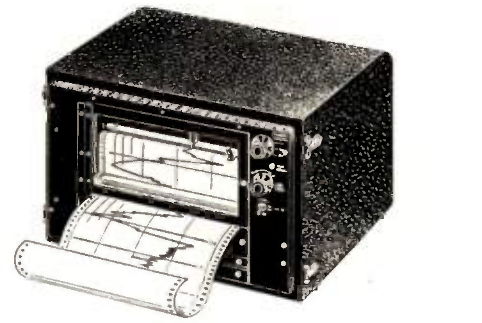
RECTANGULAR COORDINATE RECORDING SYSTEM

The AIL type 373A Rectangular Coordinate Recording System has the accuracy of a precision laboratory instrument, yet its rugged construction recommends it for field use. Fills a variety of recording needs where fast plotting and permanent records are required.

Radio and Radar	Antenna radiation patterns
Acoustics	Reverberation-time studies Directional characteristics of microphones and loud speakers Frequency response curves
Atomic Research	Counting rates Monitoring process control

Provides in rectangular coordinates a continuous inked plot of voltage, as a function of either angular position or time. Two-microvolt sensitivity.

Available to provide logarithmic or linear recording of input voltage.



Full scale (10 inches) pen deflection in one quarter second.

Paper speed up to 10 inches per second.

Write for information today.

$8,500.00 F.O.B. Mineola, N. Y.

MICROWAVE CRYSTAL TESTER

checks microwave crystals easily—accurately

Measures: Relative Noise Figure
Relative Sensitivity
Match of Crystal Pairs
Conversion Loss
Noise Temperature

Uses: Field test set to determine receiver sensitivity, as determined by crystal quality
Laboratory test set to choose representative and extreme crystals from a group
Crystal inspection test set

Tests crystals without removing them from the receiver

Accepts both ceramic cartridge and coaxial types, normal or reversed polarities

AIL Type 390A-3

Accurate

Portable

Self-Contained

$97.00

F.O.B. Mineola

AIRBORNE INSTRUMENTS LABORATORY

INCORPORATED

160 OLD COUNTRY ROAD, MINEOLA, L. I., N. Y.

What to See at the Radio Engineering Show

(Continued from page 172A)

NEW 6/12 v. DUOVOLT GENEMOTORS
NEW CHANGE-A-VOLT DYNAMOTORS
NEW DC to AC CUSTOM CONVERTERS
INDUCTOR ALTERNATORS
Booth 409 Electronics Ave.
Carter Motor Co.
2644 N. MAPLEWOOD AVE. CHICAGO 47

Cascade Research Corp.
779 Airborne Ave.

The *4,000 and 6,000 mcs communication band "Unilines" (microwave ferrite load isolator) and "Gyralines" (microwave ferrite amplitude modulator) are displayed with previously announced X-band units.

Centralab.
A Div. of Globe-Union Inc.
900 East Keefe Ave.
Milwaukee 1, Wisconsin
SINCE 1922
"First in Components Research"
920 REGISTRATION ROW
Opposite registration desk

Centronics Co., 617 Circuits Ave.
Printed Circuits, Hermetic Seals, *Printed Circuit Amplifiers, also a *Printed Circuit Intercom, and our newest engineering brochure.

Century Geophysical Corp., 274, 276 Instruments Ave.
Recording oscillographs, galvanometers, carrier and Linear-Integrate amplifiers, for recording and measurement of vibrations, stress, strain, pressure, etc. New multi-channel oscillographs, operable from either AC or DC without modification.

The Ceramaseal Co., 630 Circuits Ave.
*High temperature terminals, 350° C. and higher operating temperatures. Terminals consist of high-alumina ceramic to which is brazed metal parts, have extreme thermal shock resistance, may be brazed into equipment.

Chatham Electronics Corp.
474-478 Electronic Ave.

ELECTRONIC TUBES: Rectifiers, Current & Voltage Regulators, Hydrogen Thyratrons, Vacuum Switches and Relays, Cold Cathode Diodes and Triodes.
ELECTRONIC EQUIPMENT: Test Equipment, Radar Components, Regulated Power Supplies.
RADIATION MEASUREMENT INSTRUMENTS

*Indicates new product

(Continued on page 178A)

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

Millions in Use – Thousands Prefer

ILLINOIS ELECTROLYTIC CAPACITORS

...A COMPLETE CAPACITOR LINE OF TIME-TESTED QUALITY!

Customer acceptance of high quality Illinois electrolytic capacitors has made them world famous — and for good reason!

For more than 19 years, ILLINOIS CONDENSER COMPANY has lead the field in new developments, bringing even greater dependability and longer life to these capacitors of "Time Tested Quality".

There is an Illinois electrolytic capacitor for every application. Listed below are only a few of the more popular Illinois types. Write for new Illinois catalog — now!

IHT This popular pigtail type in aluminum can features internal riveted construction that assures immunity to shock and vibration. Available with or without outer cardboard insulating sleeve, with brass-tinned wire leads or solder lugs in capacity ranges from 1 to 2,000 MFD and from 3 to 700 W.V.D.C.

IHC Ideal for replacement or original equipment, this type has flexible wire leads, is sealed with high temperature compound, has electrolytic grade cardboard tubes and has radial or tangential clamps attached. Supplied in common negative, four section types or dual negatives with separate cathodes. Available in capacity ranges from 25 to 250 MFD and from 5 to 500 W.V.D.C.

LN Has screw neck type mounting, extruded aluminum cans and is available in 1" to 1½" diameters. Capacity ranges from 8 to 80 MFD and from 450 to 600 W.V.D.C.

BT (Bathtub) Developed for military, fixed and portable communication equipment. Has hermetically sealed, drawn metal case with corrosion resistant finish. Will stand shock and vibration. Fully meets government JAN specifications. Available in any capacity range required and from 25 to 600 W.V.D.C.

PE For use in all communication equipment, fixed and mobile. Plug-in octal base, hermetically sealed. Features new molded through pin design. Available in types to meet all government JAN specifications.

UMT Specifically designed for use in high quality equipment. Complete line meets all government JAN specifications. Hermetically sealed, shock resistant. Newly designed molded capacitor design and terminal construction.

UMS Inverted screw mounting, hermetically sealed. Entire line fully meets all government JAN specifications.

UMC Popular for use in telephone equipment, power factor correction voltage stabilization, high current energy sources, motor starting and other types of phase shifting networks. Available in capacity ranges up to 10,000 MFD and from 5 to 500 W.V.D.C.

UMP Ideal for communication, radio and TV. Standard twist prong mounting. Uses recently developed molded capacitor construction and will operate efficiently under wide temperature ranges. Remains stable under all operating conditions. Available in capacity ranges from 40 to 3,000 MFD and from 10 to 525 W.V.D.C.

ILLINOIS CONDENSER CO.
1616 N. THROOP ST., CHICAGO 20, ILLINOIS

EXPORT DEPT., 15 MOORE ST., NEW YORK 4, N. Y.
CABLE "MINTHORNE"

See our Exhibit Booth No. 408, Electronic Ave., Radio Engineering Show

What to See at the Radio Engineering Show

(Continued from page 176A)

Chester Cable Corp.
664 Circuits Ave.

Plasticord and plasticote wire and cable for every electronic and electrical application.

CHICAGO STANDARD TRANSFORMER CORP.
BOOTH #415
See the CHICAGO stock line of MILITARY STANDARD 400 CYCLE TRANSISTOR and other transformers for military and industrial applications.

415 Components Ave.

Chicago Telephone Supply Corp.
450 Electronic Ave.

*Complete Lines CTS. Composition and Wirewound Variable Resistors for Twist Ear Mounting. Variable Resistors for Printed Circuit Applications.

Many other CTS Commercial and Military Types will also be shown.

"FOR IDEAS IN THE MAKING"

See CIBA

FAMOUS ARALDITE EPOXIES

CIBA COMPANY INC.
658-660 CIRCUITS AVENUE

Cinch Mfg. Corp.
Howard B. Jones Div.
394, 396 Broadcast Way

Tube sockets and shields—micro-connectors—terminal strips—battery plugs & sockets—transistor sockets—strapnuts—tube holders—metal stampings.

Cinema Engineering Div., 548-552 Components Ave. See Aerovox Corp.

Circuitron, Inc., Div. La Pointe Plascomold, 285 Instruments Ave.
*Printed Circuit Chassis TV Set. *High Performance Printed Circuit IF Strip. Weather-Proof Cast P.C. Assemblies.

*Indicates new product

(Continued on page 180A)

What to See at the Radio Engineering Show

(Continued from page 178A)

CLARE RELAYS
C. P. Clare & Co • Chicago, Illinois
BOOTH 434
Electronics Avenue
Relays • Stepping Switches • Lever Keys
Push and Turn Keys
DON'T FAIL TO SEE NEW MODELS

Clarostat Mfg. Co., Inc.
725, 727 Airborne Ave.

*Two Watt Molded Element Composition Control. *Miniature Rotary Selector Switch. *Miniature Wire Wound and Composition Controls *with Switches.* *Plug-in Precision Ganged Potentiometers.

Cleveland Container Co.
519 Components Ave.
CLEVELITE phenolic tubing—various grades and fabrications—also "Torkrite" the answer to torque and stripping problems encountered in coil forms requiring the use of iron cores.

The Clough-Brengle Co.
838 Audio Ave.

Audio oscillators, beat frequency, RC and Audiomatic types; RF Signal Generators; IF sweep generator; Capacitance - Inductance - Resistance Bridge; Transmission Measuring sets.

COASTAL PUBLICATIONS
130 W. 42 ST., N. Y. C.
COMPLETE SERVICE FOR THE PREPARATION OF INSTRUCTION BOOKS
616 CIRCUITS AVENUE

Codetyper Laboratories, 810 Audio Ave.
*New model Electronic Brain Codetyper tube complement reduced to only 12 tubes. Will send Morse code by merely touching any letter on its typewriter-like keyboard.

*Indicates new product

(Continued on page 184A)

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

DESIGN AND DEVELOPMENT ENGINEERS!

HERE'S A SURE CURE FOR YOUR

Deep Drawn Instrument Case Problems!

kaupp

—facilities for

SPINNING, STAMPING, PUNCHING, DEEP DRAWING, HYDROFORMING, ANNEALING, SPOT WELDING, ASSEMBLING, TOOL MAKING

Kaupp can supply your instrument cases to exact specification quickly and economically. Special shapes and odd sizes are a specialty at Kaupp and, in most cases, can be turned out on reasonably short notice. Kaupp has the experience and the metal working facilities for precision forming of intricate shapes to close tolerances. Gauges .002 to 3/8 stock in stainless steel, Inconel, aluminum, cold rolled steel, brass and other alloys. Check with Kaupp on your metal parts needs, now!

C. B. KAUPP & SONS

NEWARK WAY • MAPLEWOOD • NEW JERSEY

Rx The new 16 page Kaupp Brochure with complete information on metal forming and sub-assembly facilities. Call or write for your copy, today!

PRODUCTION AND DEVELOPMENT METAL FORMING FOR ELECTRONICS, NUCLEONICS, AVIATION, MARINE AND GENERAL INDUSTRY

Be sure to visit our display at the I.R.E. SHOW BOOTH 720 AIRBORNE AVE.

NEW! FOR PRINTED

COMPLETE LINE

1 FOR AUTOMATION: EXCLUSIVE NEW Self-Supporting Snap-in Bracket Mounting. (See Type YGC-B45.)

2 NEW Twist-ear Mounting. (See Types XP45 and UPM45.)

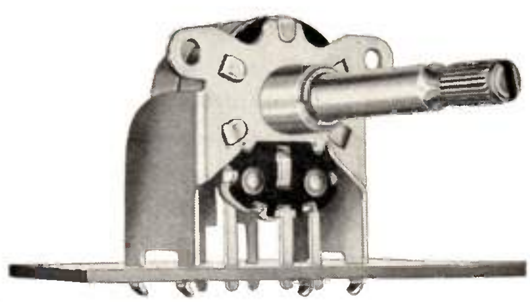
3 PLUG-IN BLADE-TYPE TERMINALS for vertical or horizontal mounting of control to printed circuit panel. (See all photos.)

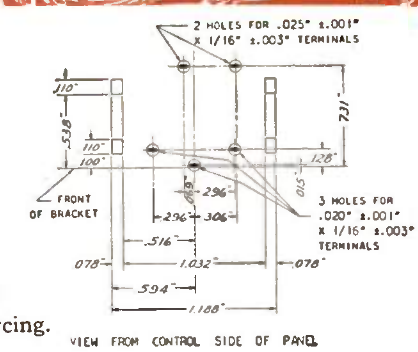
4 Threaded Bushing Mounting. (See Types XGC-45, GC-U45 and *miniaturized* U70.)

Consultation without obligation available on variable resistors for your printed circuit applications. Write today.

VERTICALLY MOUNTED to Printed Circuit Panel. Shaft above panel. (Types YGC-B45, XP45 and XGC-45.)

- NO shaft protection needed during soldering.
- PARALLEL terminals permit *small* round connecting holes instead of *large* elongated slots necessary for fan shaped terminals.
- Terminals available in 7/8″ or 1-1/32″ lengths from control's center.

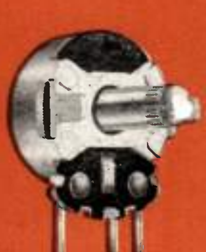


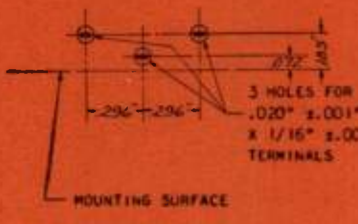


Suggested panel piercing.

Type YGC-B45 FOR AUTOMATION: *EXCLUSIVE NEW Self-Supporting Snap-in Bracket*

- Snaps instantly into place.
- Stays firmly put during soldering. Solder permanently anchors control to circuit panel.
- Terminal connections cannot loosen; bracket prevents mounting or operating strain on control or switch terminals.
- No mounting hardware, no separate supporting panel needed.
- No strain on printed circuit panel. Anchor tabs attach bracket to cabinet.
- Adequate clearance for circuit paths provided by ample spacing between terminals and by design of mounting lugs on bracket.

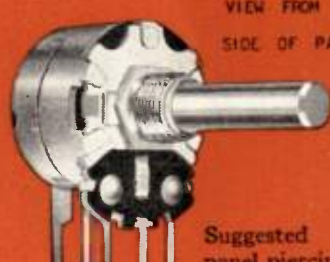


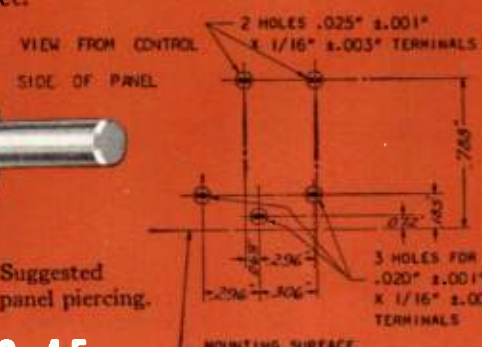


Suggested panel piercing.

Type XP45

For TV preset control applications using a mounting chassis to support printed circuit panel. Twisting 2 ears holds control rigidly to mounting chassis. Available in finger adjusted shaft lengths of 1/2″, 5/8″, 11/16″, 7/8″ and 1″ from control's mounting surface. Also available with recessed screw driver slotted shaft (Type XFM45).





Suggested panel piercing.

Type XGC-45

For applications using a mounting chassis to support printed circuit panel. Threaded bushing mounting.

All controls illustrated actual size.

CIRCUITS
OF VARIABLE RESISTORS

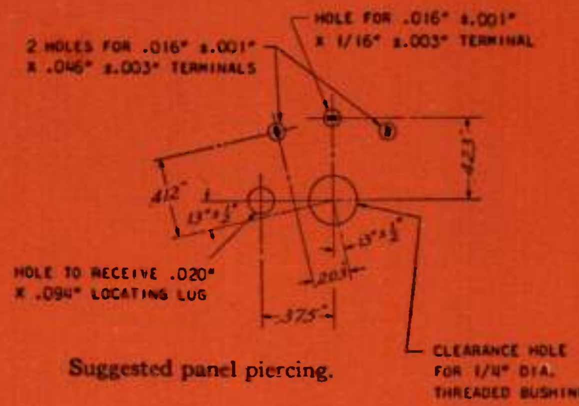
HORIZONTALLY MOUNTED

to Printed Circuit Panel. Shaft extends through panel. (Types U70, GC-U45 and UPM45.)

Type U70

(Miniaturized).

Threaded bushing mounting. Terminals extend perpendicularly 5/32" from control's mounting surface.



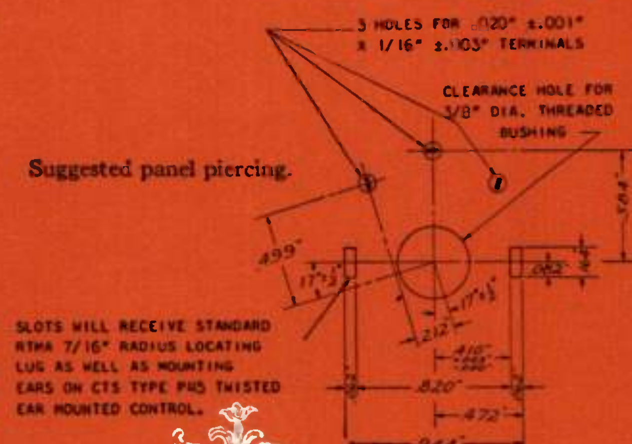
Suggested panel piercing.

Type GC-U45

Threaded bushing mounting. Terminals extend perpendicularly 7/32" from control's mounting surface. Available with or without associated switches.

Type UPM45

For TV preset control applications. Recessed screw-driver slotted shaft remains solder-free during panel dipping. Control may be held rigidly to panel before soldering by twisting 2 ears. If ears are left straight, the solder will permanently anchor control to circuit panel. Terminals extend perpendicularly 7/32" from control's mounting surface.



Suggested panel piercing.

Specialists in Precision Mass Production of Variable Resistors. Founded 1896.

REPRESENTATIVES

Henry E. Sanders, McClatchy Bldg., 69th & Market St., Upper Darby, Penna. Phone: Flanders 2-4420

W. S. Harmon Company, 1638 So. La Cienega Blvd., Los Angeles 35, California Phone: Bradshaw 2-3321

John A. Green Company, 6815 Oriole Drive, Dallas 9, Texas

CANADIAN MANUFACTURING AFFILIATE

C. C. Meredith & Co., Ltd., Streetsville, Ontario

SOUTH AMERICA

Jose Luis Pontet, Buenos Aires, Argentina
Montevideo, Uruguay · Rio de Janeiro, Brazil · Sao Paulo, Brazil

OTHER EXPORT

Sylvan Ginsbury, 8 West 40th Street, New York 18, N. Y.

CTS

CHICAGO TELEPHONE SUPPLY *Corporation*

ELKHART · INDIANA

General tolerance all decimal dimensions ±.005"

What to See at the Radio Engineering Show

(Continued from page 180A)

Sigmund Cohn Corp.
571, 670 Transistor Way

Base metals; Precious metals, Fine wire and ribbon, bare drawn, etched, electroplated, enamel insulated.

Coil Winding Equipment Co.
305, 402 Production Rd.

Coil winding, equipment for laboratory, schools, and production. Engineering help on special problems. Special designs for winding stator coils, self-supporting layer wound coils. Unique cam designs. Tensions for every wire size.

See Collins
Aviation
Broadcasting
Communications
and Amateur Equipment
496—594, 5, 6, 7—694
Broadcast Way

Color Television, Inc., 907 Registration Row

Colortone Electronics, Inc., Div. International Television Corp., 623 Circuits Ave.
Model TS 175 A/U Frequency Meter, a *portable frequency setting and determining instrument for general purpose use at frequencies of 85 to 1000 MC.

Columbia, See "C.B.S."

Comar Electric Co.
760 Airborne Ave.

Miniature, light, medium and heavy duty relays for commercial and military requirements. Solenoids, coils, switches, transformers, hermetic sealing.

Communication Accessories Company, Booth 465 Electronic Avenue
Electrical filters, Transformers, Toroidal Inductors.

*Indicates new product

(Continued on page 186A)

FREE BUSES
Every 10 minutes both to and from Waldorf-Astoria

How Lewyt research-development saved 2,000,000 pounds of critical materials

Soon after World War II, a problem arose when 24-volt electrical systems came into widespread use for Armed Forces vehicles.

The PE-237 Power Supply Unit for mobile radio sets was built to be used primarily with 6 and 12-volt systems. It could also be used with 24-volt systems, but did not perform efficiently at this higher voltage. *Needed* was a new power supply that would perform as well in 24-volt systems as it would in the 6 and 12.

. . . however, actual field experience with 24-volt systems was very limited!

. . . in addition, a power supply more compact than the existing PE-237 was desired — one lighter in weight, smaller in size and easier for the man in the field to service!

The Signal Corps Engineering Laboratory drew up specifications and a Research and Development Contract was awarded to Lewyt.

Working closely with Signal Corps Engineers, Lewyt developed the first prototype of the DY-88 Power Supply Unit in just 8 months. In 16 months — 8 months ahead of the allotted 24 — the DY-88 was accepted by SCEL engineers.

What were the results?

A smaller Power Supply Unit that performed equally well on 6, 12 or 24 volts!

A 90% decrease in wiring and soldered joints!

A 70% reduction in number of components!

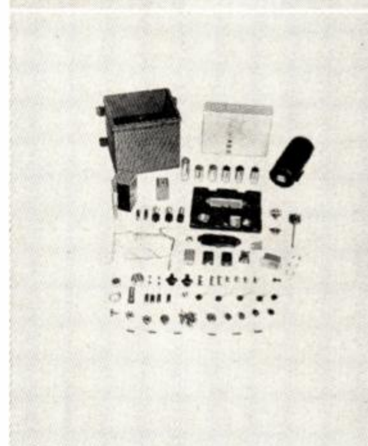
A weight of only 33 pounds compared to 89 — *a projected saving of 2,000,000 pounds of critical materials!*

Add them all up and they mean savings in production and material costs . . . easier, faster field maintenance . . . fewer spare parts . . . greater reliability of power supply . . . more room in combat vehicles!

Research and development is another way Lewyt helps America get more defense for the dollar. Lewyt stands ready with 1,800 trained workers at all times — producing for peace, geared for emergencies.

Visit us at
110
Military Ave.
Radio Engineering Show

Exploded view of formerly used Vibrator Power Supply PE-237 with its components.



Exploded view of Dynamotor Power Supply DY-88 (which supplants PE-237) with its components.

LEWYT

Manufacturers of Electronic and Electro-Mechanical Equipment Since 1888

LEWYT MANUFACTURING CORPORATION, BROOKLYN 11, NEW YORK

What to See at the Radio Engineering Show

(Continued from page 184A)

Communication Measurements Lab., Inc.
675 Circuits Ave.

Project Tinkertoy hand tools and modular design kit plus new VTVM and SSB transmitter are major items in CML Display. Don't miss introduction to automation.

Communication Products Co., Inc.
371 Mobile Ave.

Styroflex cable, a new aluminum coaxial cable with matched fittings to form an unbeatable team. A complete line of Lo-loss RF selector switches.

Compaignie Generale de Metrologie, Annecy, France, 785 Airborne Ave.
First time in U.S.A., *complete series of precision electronic measuring instruments: overload protected multimeters, TV and standard signal generators, tube analysers, impedance bridges.

Condenser Products Co.
423 Electronic Ave.

Original producers of all plastic film capacitors including glassmikes and plasticon. Produce HIVOLT power supplies and pulse forming networks. Manufacture capacitors to any specification.

Main Office: 140 Hamilton St., New Haven, Conn. Engineering: 7517 N. Clark St., Chicago, Ill.

Connecticut Telephone & Electric Corp.
366 Mobile Ave.

"Fleetway" Mobile Radio (450-470 mc) featuring revolutionary, patented "Lister" circuit; private line intercommunication systems; headsets; microphones; handsets; UHF Signal Generator 50-950 mc.

Consolidated Engineering Corp., 237, 239 Instrument Ave.
A *vibration meter, a *small laboratory oscillograph, a *50-channel flight-test recording oscillograph, and an *automtic oscillogram processor.

Consolidated Vacuum Corp., 233, 235 Instruments Ave.
*Rotary exhaust for miniature tubes—*TV aluminizer for B&W and color tubes—oil diffusion pumps—high vacuum valves & gauges—conversion type pump & port assemblies.

*Indicates new product

(Continued on page 188A)

Want to join the IRE? Come to IRE Room—to right of Lobby!

THE SYMBOL OF **Quality** IN TRANSFORMERS

dollars AND sense...

Triad quality costs no more, and those who buy Triad Transformers get what they pay for.

Superior design—finer materials—precise workmanship—distinctive appearance—continuous and unfailing service. All these contribute to the recognized value of Triad products.

Industry expects and gets—from Triad the finest transformers made.

Triad Transformers are sold by select jobbers in principal cities. Write for Catalog TR-53H.

TRIAD TRANSFORMER CORP.

4055 Redwood Ave., Venice, California

At the Show—428 Electronic Ave.

What to See at the Radio Engineering Show

(Continued from page 186A)

L. L. Constantin & Co.

Lodi, New Jersey

Booth 672, 674 Circuits Avenue

High Compression and Kovar Glass to Metal Vacuum Seals of all types including Headers, Single Terminals, Multi-pin Connector Plugs, Button Seals, Crystal Holders and Vacuum Coating Equipment.

Continental Carbon, Inc.
456 Electronic Ave.

"Nobleloy" metal film high stability resistors with improved features on the miniature style. Wire wound (low power) resistors, auto radio suppressors. Oil burner suppressors, composition resistors.

Continental Connectors — Long Island 1, New York

BOOTH 200 Production Road

World's most complete line of miniature precision connectors and terminal boards. Distributed and displayed at the IRE Show by DeJUR-Amsco Corporation.

Continental-Diamond Fibre Co., 665, 667 Circuits Ave.
Diamond Vulcanized Fibre & Vulcoid, Dilecto laminated plastics. Celoron molded products. Spiral tubing. Micabond, Teflon & Silicone tapes.

Contract and Special Products Div., American Machine & Foundry Co., 106, 108 Military Ave.
Demonstration of AMF's newly developed Dynamic Tube Comparator (indicates exactly operating characteristics of electronic tubes). Also see AMF developments in radar, bombardier training, electronic controls.

CORNELL-DUBILIER
ELECTRIC CORPORATION

294-296 BROADCAST WAY — SOUTH PLAINFIELD, NEW JERSEY

CAPACITORS • VIBRATORS • CONVERTERS
ANTENNAS • ROTORS

Corning Glass Works, 397-495 Broadcast Way.
Glass components for all electronic applications. TV black and white or color, Radio, Radar, Capacitors, Resistors, Trasistors, Diodes.

(Continued on page 190A)

FIRST AID ROOM

A nurse is in charge at all times. First Aid Room is the third room to left of Lobby directly off registration area.

Want to give your '54 electronic equipment greater utility at lower cost?

HERE ARE TECHNIQUES TO SIMPLIFY YOUR JOB

1 To solve problems of hi-voltage and corona suppression

To help you get on a commercial basis, new Alden techniques offer compact connectors that cost only pennies yet actually solve the problems of high voltage and corona suppression beter than the bulky, expensive connectors heretofore available. Ask about: A) New Alden 20-pin Picture Tube Connector; B) New Alden Hi-Voltage Disconnects; C) New Alden Hi-Voltage Tube Cap; D) New Alden Hi-Tension Disconnect—all using brand new molding technique providing sealed contacts and long leakage path in ultra-compact economy units.

2 To adapt present equipment to Plug-in Construction

Your "Black Box" units mounted in conventional ways can quickly be changed over to plug-ins using Alden's simple Adapter Kits. Ask about: 1) new Alden Back Connectors which unify all in-out connections into an orderly row that makes and breaks as the equipment plugs in or out, yet is beautifully accessible, spread out and color coded for easy tracing and servicing. 2) Alden Quick-Locking and Fastening Devices to pilot, draw in and eject your plug-in equipment with a turn of the wrist.

3 To design from the ground up with 100% Plug-in Unit Advantages

It's beautifully easy, with Alden's complete range of backbone, nerve and sensing elements, to build any equipment on unitized principles so trouble can be spotted instantly, and 30-second plug-in replacements permit operation to be restored on the spot by user's own personnel. Ask about the Alden Plug-in Packages and Basic Chasses for packages, Sensing Devices for tell-tales, and Back Connectors for making all circuitry clearly traceable units with dynamic color coding so simple it reads like a book.

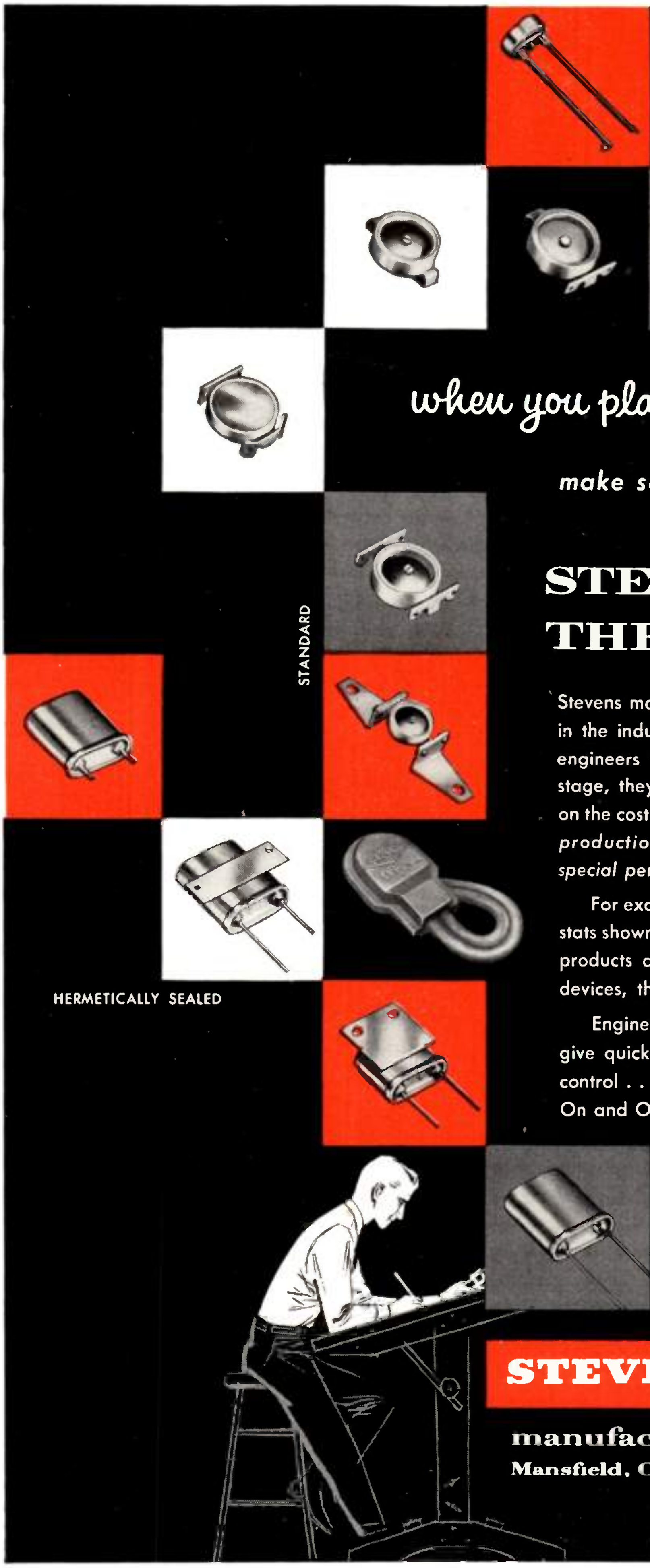
4 To put circuitry in low-cost, compact vertical planes

You may dream about new wrap-arounds and printed circuitry, but if you're really trying to save space and cut production costs NOW, you can put your circuitry in compact, vertical planes that can be in the low-cost or expendable class. Alden makes it possible with complete range of stock items for circuitry layout: Pre-punched Terminal Boards that take any layout of unique Ratchet-Slot Terminals requiring no pliering or wrap-around, and Card-Mounting Tube Sockets so that complete circuitry can be put on one board.

Send for complete story—get "What's New at Alden's"—make it a point to visit Alden Display at the IRE Show, Booths 185-7.

ALDEN PRODUCTS CO.

3121 N. Main St., Brockton 64, Mass.


STANDARD
HERMETICALLY SEALED

What to See at the Radio Engineering Show

(Continued from page 188A)

Cox & Co., Inc.
819 Audio Ave.

Overcoats for electrolytic condensers are a *Thermopatch heating element application. Cox Thermowire, Thermopatch and Thermosheet heating elements have government approval for over 300 applications.

Craig Machine, Inc., 909 Registration Row.
Transit cases for electronic components, instruments, and fragile equipment during field use and transportation.

R. W. Cramer Co., Inc., 587, 589 Components Ave.
*Synchronous Timing Motor, Interval Timers. *Time delay relay, cycle and percentage timers. Hermetically sealed time delay relays, reclosing relays, running time meters. Other timing devices.

Crosby Laboratories, Inc., 481 Electronic Ave.
*Single-sideband signal generators, *Single-sideband receivers, *Frequency-shift equipment, *Wide-band twin channel oscilloscope, multiplex equipment, exalted-carrier receivers.

Crucible Steel Company of America
Henry W. Oliver Building
Pittsburgh, Pa.
105, 107 Military Ave.

Crucible Permanent Alnico Magnets
Highest gap flux per unit of weight

CURTIS
Terminal Blocks

Better Connections
Economically—Quickly
A type for every purpose
644 Circuits Ave.

Dale Products, Inc., 769, 771 Airborne Ave.
*Deposited carbon resistor furnace in operation. Complete display of deposited carbon and wire-wound resistors, also *ruggedized and hermetically sealed resistors and high voltage resistors for color TV application.

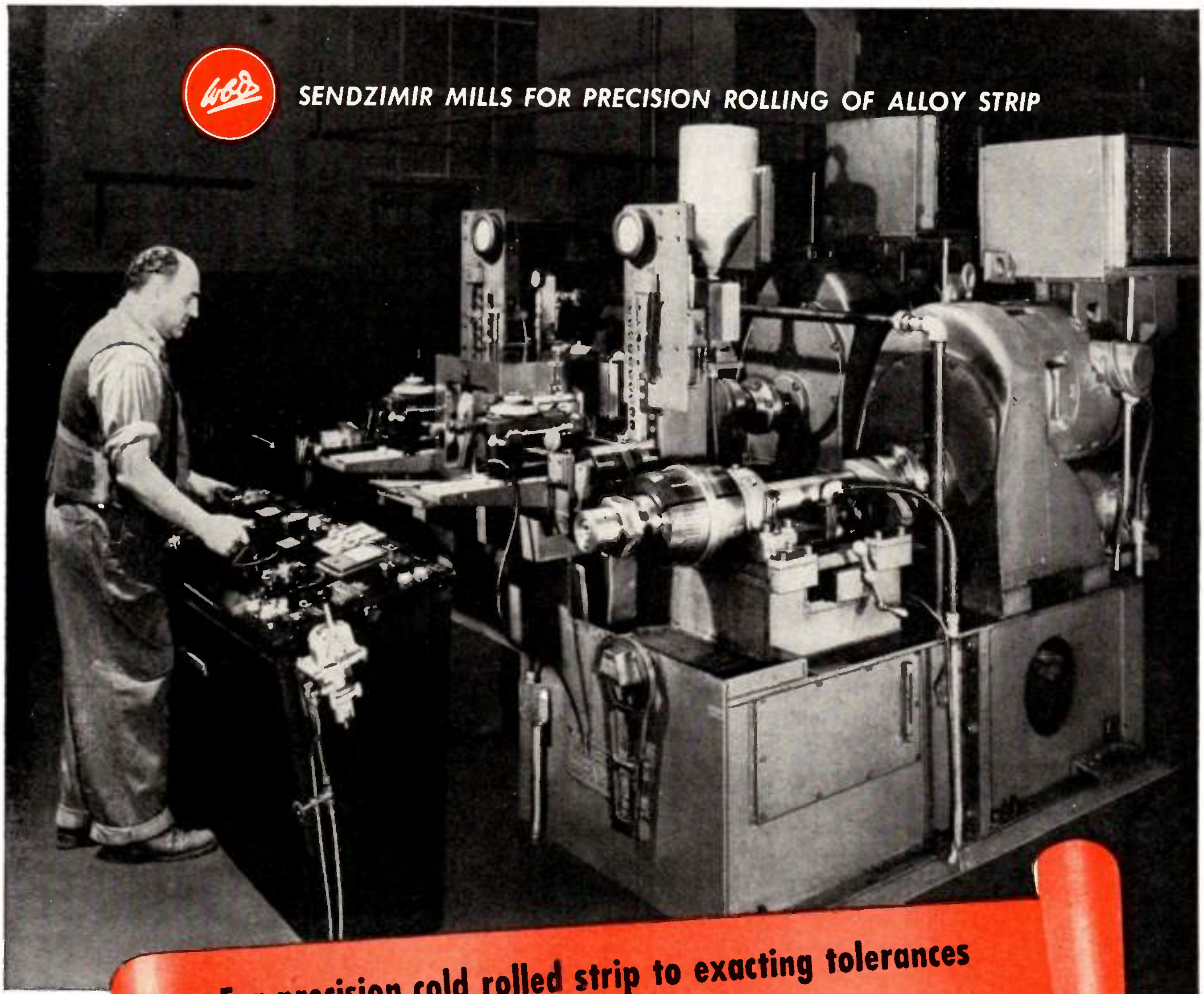
Danbury-Knudsen, Inc. 794, 796 Broadcast Way
See Industrial Products Co.

Davelle Laboratories, Inc.
804 Audio Ave.

Modern production miracles enable us to give you finest etched, printed, or stamped circuits at minimum cost and speediest deliveries. Contact us for your requirements.

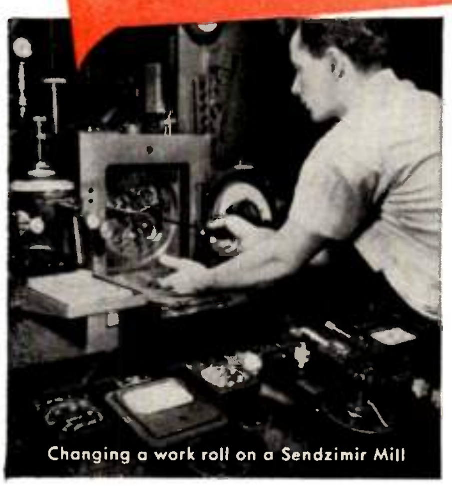
*Indicates new product

(Continued on page 192A)



For precision cold rolled strip to exacting tolerances

-specify W.B.D. Alloys


Changing a work roll on a Sendzimir Mill

-For electric, electronic, instrument and other critical applications

These Sendzimir mills represent the latest development in cold rolling technique and assure uniformity across the strip width. The expert operators are accustomed to close size tolerances and excellent finishes. A completely new and modern plant incorporates the latest production facilities. For resistance alloys, Rodar, Nickel, Beraloy, and custom alloys to specification, contact an experienced WILBUR B. DRIVER Sales Engineer.

WILBUR B. DRIVER CO.

NEWARK 4, NEW JERSEY

TOPHET

AT THE I.R.E. SHOW—BOOTHS 691-693 CIRCUITS AVENUE

What to See at the Radio Engineering Show

(Continued from page 190A)

The Daven Co.
543, 545 Components Ave.

Encapsulated precision wire wound resistors; audio, video, and rf attenuators; solenoid-operated rotary switches; transmission measuring sets for microwave relay systems; vacuum tube voltmeters.

The Davies Laboratories, Inc., 222 Instruments Ave.
Analog Computers, Data Recorder Telemetering, Vibration Analyzers.

Bryan Davis Publishing Co., Inc., 892 Audio Ave.
Annual IRE Radio Engineering Show number of SERVICE magazine.

Daystrom, Inc.
Instrument Div.
613 Circuits Ave.

Display will depict engineering, research and development and manufacturing services available. Will include samples of parts or products. Will demonstrate scope of physical facility.

Decade Instrument Co., Inc., 207 Instruments Ave.
Decaviders for increasing the frequency range of standard frequency counters; Decalators—direct reading decade switched precision oscillators; Deca-Sweeps—decade switched sweeping oscillators.

DeJUR-AMSCO CORPORATION
LONG ISLAND CITY 1, NEW YORK
BOOTH 200
Production Road
Featuring a complete line of precision potentiometers, rheostats, watertight and "Ruggedized" panel instruments, and Continental connectors and terminal boards.

Deltavis Co., 836 Audio Ave.
See Swiss Jewel Co.

Tobe Deutschmann Corp., 580 Components Ave.
*Capacitors, silicone and seal, metal tubulars, molded paper tubulars, Mylar high temperature, Polystyrene printed wiring, double-header metal tubulars, electrolytic, *flat molded paper with solid impregnant. FILTERS, *screen-booth line, miniaturized filter, *feed-thru capacitor line. Special Capacitors, *pulse capacitors and pulse forming networks.

Dialight Corp., 177, 179 Television Ave.
*sub-miniature indicator lights in non-dimmer, dimmer, polaroid, light shield and press-to-test types. Edge lighting assemblies with choice of colors. Pilot light assemblies for neon and incandescent lamps.

BOOTH 485 ELECTRONIC AVENUE
DICO
Standard and Special R. F. Connectors on Display. Sub-miniature Connectors will be shown.
DIAMOND MANUFACTURING CORPORATION
WAKEFIELD, MASSACHUSETTS

* Indicates new product.

(Continued on page 194A)

Available in quantity — NOW!

UNION TYPE M MINIATURE RELAYS

MEET ALL REQUIREMENTS OF MILITARY SPECIFICATIONS MIL-R-5757 A & B

TYPICAL PERFORMANCE DATA

Service Temperature	-65°C to 125°C	-55°C to 85°C
Style FM (6-pole)	303125	303085
Style FM (4-pole)	312570	
Coil Resistance	325 ohms	325 ohms
Nominal Voltage	26.5	26.5
Max. Pull-In Voltage at Max. Rated Temperature	18	18
Max. Drop-Out Voltage at Max. Rated Temperature	13	13

Service	Continuous
Shock	40 G's for 10 milliseconds
Vibration	10 to 55 cycles per sec.— 0.060 total excursion
Life Expectancy	1,000,000 operations minimum
Contact Rating	2 amps. at 26.5 Volts— Resistive Load
Breakdown Voltage at Sea Level	1000 volts a.c. between case and contacts or coil

Now, you can buy Union type M miniature relays *in quantity*. And due to our large production facilities, you can expect a delivery date that will meet your needs. Both 6-pole and 4-pole doublethrow models are available. They meet all requirements of Military Specifications MIL-R-5757 A & B.

Here are the facts: shock load rating for the Union type M relay is 40 G's for 10 milliseconds, and this figure is obtained with the relay deenergized. This is an important point to remember, because some relays are shock-rated with the relay energized, resulting in a stiffer assembly with a higher (and non-comparable) G rating.

Breakdown voltage at sea level is 1000 volts between case and coil *or* contacts, a figure unmatched by any known comparable relay. The low 18-volt pull-in voltage is given for *maximum* rated temperature. You do not have to allow for temperature rise when you use this design figure.

This relay, weighing only 3½ ounces, is hermetically sealed containing nitrogen under pressure.

General Apparatus Sales Department IR-67
Union Switch & Signal Division
Westinghouse Air Brake Company
Pittsburgh 18, Pa.

Please send additional information on Union type M relays.

Name .... Title............

Company ....

Address ....

City, Zone & State ....

GENERAL APPARATUS SALES

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18 PENNSYLVANIA

NEW YORK CHICAGO ST. LOUIS SAN FRANCISCO

Lewis M. Clement

These men promise you a great one-day meeting!

CINCINNATI

April 24

Eighth Spring Technical Conference

Lewis M. Clement, Papers Chairman

Lewis M. Clement graduated from the University of California in 1914. From 1914 to 1935 Mr. Clement was with the Marconi Wireless Telegraph in Honolulu; Western Electric, Bell Labs, Fada Radio and I.T.T. in this country and Europe. From 1935 to 1940, in charge of Research and Engineering at RCA, and since 1940 with Crosley and Avco, and is Technical Advisor to the General Maanger.

Mr. Clement is a Fellow of the IRE and has been the recipient of the following awards: Modern Pioneer Award 1940, National Association of Manufacturers; Naval Ordnance Development Award 1945, Bureau of Ordnance, U. S. Navy and A Pioneer in the Field of Aircraft Electronic Development 1950, Dayton Section, IRE.

Walter B. Shirk

Mr. Clement is active in RETMA as Chairman of the Executive Council and is Chairman of the Advisory Group on the Reliability of Electronic Equipment, Office of the Assistant Secretary of Defense for Research and Development.

Walter B. Shirk, Cincinnati Chairman

Walter B. Shirk was born in New Preston, Connecticut, in 1910. Following graduation from the University of Wisconsin in 1933 he was employed by the Midwest Radio Corp. in Cincinnati. During World War II he was in charge of production test equipment design on the proximity fuse project. Later, he became Chief Design Engineer of the Household Radio Department, responsible for all phases of activity in this division. Since 1952 he has been supervisor of production engineering on Navy shipboard radio equipment. Mr. Shirk has been active in local IRE affairs and is presently chairman of the Cincinnati Section.

Richard A. Maher, Morning Moderator

Born in Massachusetts, Mr. Maher graduated from Northeastern University in 1934. He was commissioned in the U. S. Navy in March 1942, where he served as Assistant Inspector of Naval Material, Radar Specialist on shipboard equipment, and Lieutenant in charge of Com Seron Sopac Radio Laboratory. His last post was as Lieutenant Commander, Electronics Officer for the South Pacific Area.

After his release from active duty, Mr. Maher was associated with the R.C.A. Laboratory Division as design and development engineer. Since 1948 he has been with the Crosley Division of Avco on new circuitry, a transistor research project, ultra high frequency development and color television.

Mr. Maher is an alternate on NTSC Panel 13 (Color Video Standards), and a member of Panels 14 and 16 (Color Synchronizing Standards and Field Testing). He is Vice-Chairman of the Cincinnati IRE Section.

Richard A. Maher

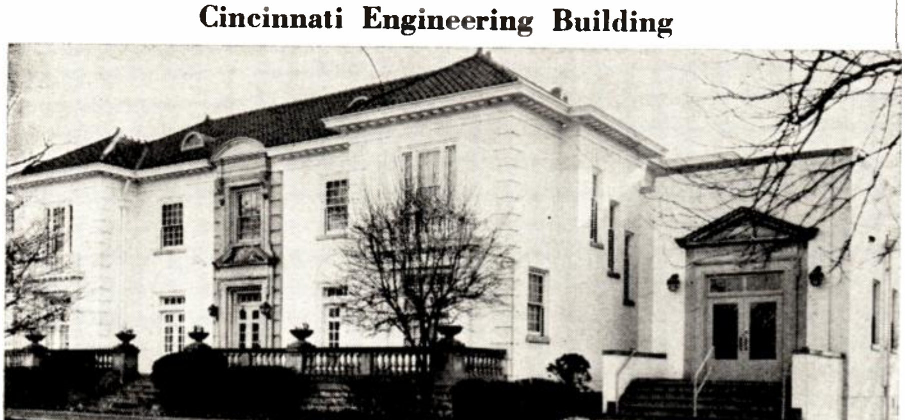
Dr. Daniel W. Martin, Afternoon Moderator

Daniel W. Martin, bo-n Nov. 18, 1918, Georgetown, Ky., A.B. 1937, Georgetown College, M.S., Ph.D. (physics) 1941, University of Illinois. Doctoral thesis "A Physical Investigation of the Performance of Brass Wind Instruments." Physics Assistant, University of Illinois 1937-41. Acoustical Engineer, RCA Victor Division, Radio Corporation of America, Indianapolis, 1941-46, Camden, N.J. 1946-49. Acoustical Consultant and Supervisor Acoustical Engineering, The Baldwin Piano Company, Cincinnati, 1949 to present.

Fellow, Acoustical Society of America, and Member, Committee on Music. Patent Reviewer, Journal of the Acoustical Society, contributor. Senior Member, Institute of Radio Engineers. Editor of TRANSACTIONS of the IRE Professional Group on Audio. Treasurer Cincinnati Section IRE. Chairman, Musical Acoustics Terminology Group, Z-24 Committee, American Standards Association.

Dr. Daniel W. Martin

Cincinnati Engineering Building



What to See at the Radio Engineering Show

(Continued from page 192A)

Digital Instrument Co., Inc.
340 Computer Ave.

*Two megacycle frequency counters featuring in-line indicators, time interval meters, industrial preset counters, recording attachments. Volkers & Schaffer ultra sensitive oscillograph 30μV per inch.

Douglas Microwave Co., Inc.
706 Airborne Ave.

Coaxial Line 1,000 to 40,000 mcs. Radar and microwave components.

Wilbur B. Driver Co.
691, 693 Circuits Ave.

Melters and manufacturers of alloys for the following electronic applications: 1-Filament; 2-Grid wire; 3-Carbonized nickel for anodes, wire and ribbon; 4-Resistors; 5-Glass-to-metal seals.

Driver-Harris Co., 607 Circuits Ave.
Nichrome ®, D-H radio, resistor and glass-to-metal sealing alloy including our new alloy, Therlo ® for commercial hard glass requirements (Corning 7052 and 7040).

Dumont Airplane & Marine Instruments, Inc., 432 Electronic Ave.
MILCAPS . . . Hermetically sealed subminiature capacitors which meet MIL—C—25A operating conditions.

Allen B. Du Mont Labs., Inc.
Communication Products Div.
165-171 Television Ave.

VHF-UHF Studio-Transmitter equipment; Flying Spot Scanner Systems for 16 mm. Film and Opaque Slide Pickup for Monochrome and Color; *Video Switcher; Mobile Communications equipment.

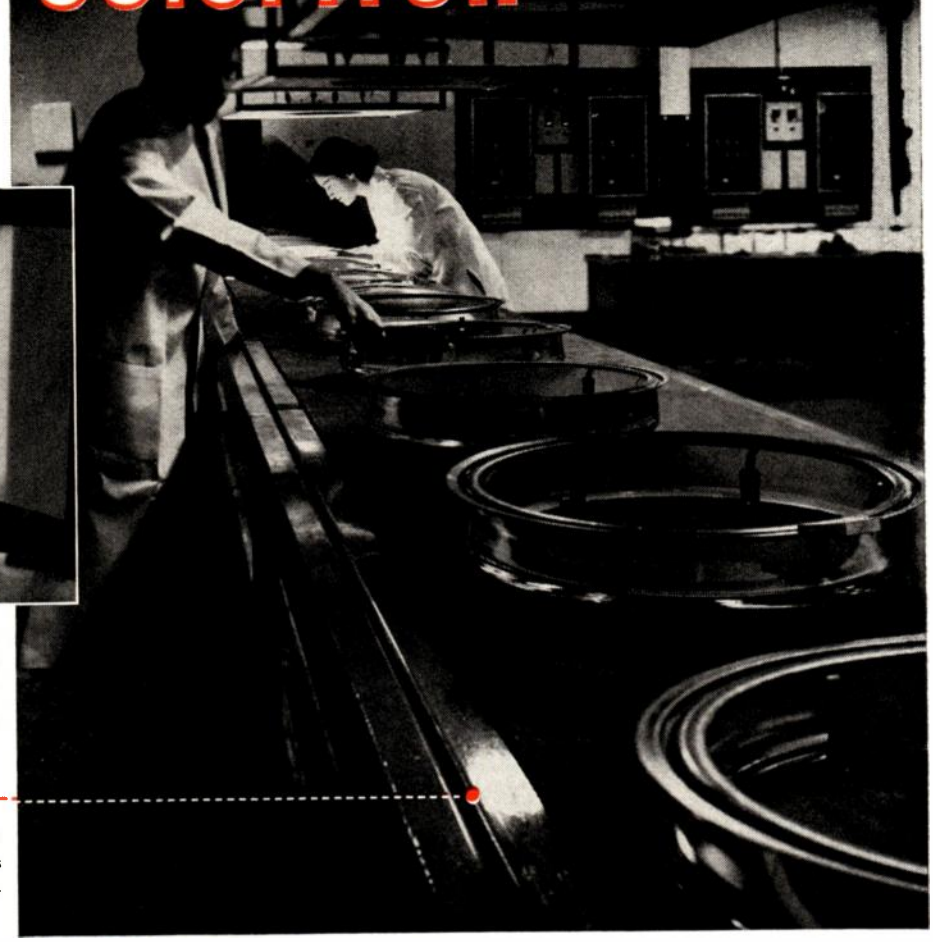
*Indicates new product

(Continued on page 196A)

New CBS-Colortron

NOW IN MASS PRODUCTION

Unique photographic process, like photoengraving, uses aperture masks as negatives to print consecutively the red, green, and blue phosphor dots (250,000 of each) on CBS-Colortron screens.



After tri-color screens are printed, aperture masks are temporarily removed and face plates move on to critical inspection for screen imperfections.

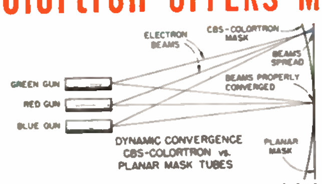
COLOR TV IS COMING . . . faster than you think. The revolutionary new CBS-Colortron . . . a practical color picture tube . . . hastens the day. Already it is in lower-cost, mass production . . . made possible by its simplified, advanced design.

As in black-and-white tubes, the CBS-Colortron's screen is deposited directly onto the inside of its face plate. A unique photographic technique makes this possible. Because each aperture mask serves as a negative to print its tri-color screen, perfect register of mask and screen is automatically achieved and maintained. The rugged, simple, light-weight mask sharply reduces assembly and exhaust problems. And the spherical design of mask and screen simplifies convergence circuitry and adjustment.

The CBS-Colortron is now a 15-inch, round tube. But, as soon as tooling is completed, it will be made in larger sizes. Watch for the new CBS-Colortrons. You'll see plenty of them soon. And you'll be sold on sight by their logical simplicity . . . their superior performance . . . their many advantages.

CBS-Colortron OFFERS MANY ADVANTAGES

Cross-section (face plate, aperture mask, funnel, tri-color electron gun) shows simplicity of CBS-Colortron and its adaptability to low-cost, mass production.



Spherical screen and aperture mask of CBS-Colortron simplify convergence and focus. Electron beams remain in focus over entire surface of screen.

Light-weight (6 oz.), rugged, simple aperture mask of CBS-Colortron minimizes problems of exhaust, handling, and assembly.

COMPLETE CBS-Colortron DATA *FREE!*

Take a look into the future. Write today for complete information on CBS-Colortron 15HP22: Construction . . . operation . . . application . . . installation and adjustment . . . electrical and mechanical data. Four packed pages . . . free!

CBS-HYTRON, Main Office: Danvers, Massachusetts

A Division of Columbia Broadcasting System, Inc.

Manufacturers of Receiving Tubes Since 1921

A member of the CBS family: CBS Radio • CBS Television • Columbia Records, Inc. • CBS Laboratories • CBS-Columbia • and CBS-Hytron

RECEIVING • TRANSMITTING • SPECIAL-PURPOSE • TV PICTURE TUBES • GERMANIUM DIODES AND TRANSISTORS

What to See at the Radio Engineering Show

(Continued from page 194A)

Allen B. Du Mont Labs., Inc., Instrument Div.
264-268 Instruments Ave.

*High frequency Type 323CRO with calibrated notch expansion; *type 301-A miniaturized high frequency CRO; type 322-A dual-beam CRO; *mono-accelerator cathode-ray tubes; *complete line of multiplier phototubes.

E. I. du Pont de Nemours & Co., Inc., 701 Production Road
"MYLAR" polyester film permits important electrical design improvements. This exhibit features applications which take advantage of the excellent electrical properties, tensile strength, temperature and moisture resisting properties of "MYLAR."

Dyna-Labs., Inc.
480 Electronic Ave.

Gaussmeter; miniature earphones and microphones; ultrasonic and underwater-sound transducers; sonar equipment; electronic vacuum tube voltmeters; noise generators; pulsers and visual display audio response tracers.

ESC Corporation, 684 Circuits Ave.
Delay Lines—lumped constant or distributed constant design—variable or fixed delays in accordance with military requirements. Can be supplied in sample or production quantities.

Eastern Air Devices, Inc., 783 Airborne Ave.
Complete line of fractional and sub-fractional induction motors, hysteresis synchronous motors, torque motors, gear motors, alternator tachometer generators, fans, vane axial fans, centrifugal blowers, specialty rotating electrical equipment.

Eastern Precision Resistor Corp., 686 Circuits Ave.
Introducing *"N-CAPS," a completely new approach to hermetically sealed precision wire wound resistors. Including a remarkable sub-miniature, measuring a mere ¼" by ¼". All units supersede MIL-R-93A specifications.

Hugh H. Eby, Inc.
577, 579 Components Ave.

Color TV components; Computer parts and components; UHF components; coil parts; intricate molded parts; printed wiring components and assemblies, designed for specific application.

Eclipse-Pioneer Div., 130-140 Military Ave.
See Bendix Aviation Corp.

Edin Company, Inc., 482 Electronic Ave.
*Reverted train multi-speed recording-chart drives with instantaneous shockless, radial shift. Extended frequency range Galvanometers; AC, DC and carrier amplifiers; and complete multi-channel Consollette graphic recording systems.

*Indicates new product

(Continued on page 198A)

Revolutionary! Lightweight Power

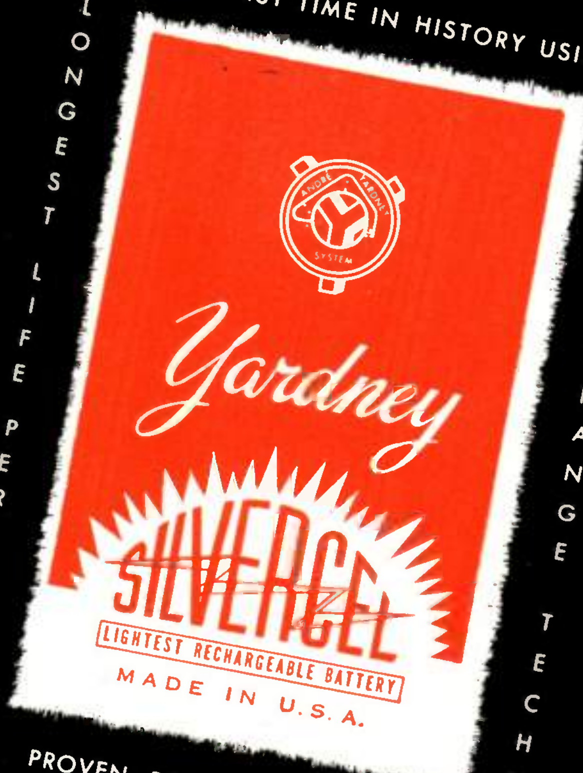
ONLY
ONLY
YARDNEY THE ONLY REVOLUTIONARY STOR-AGE STOR-AGE BATTERY
ONLY

FOR THE FIRST TIME IN HISTORY USING SILVER ZINC

ION EXCHANGE TECHNIQUES

SMALLEST SIZE & SMALLEST WEIGHT

LONGEST LIFE PER PERFORMANCE



PROVEN DEPENDABILITY UNDER MOST ADVERSE CONDITIONS OF MECHANICAL STRESS, AND OVER A WIDE TEMPERATURE RANGE DOWN TO —65°F.

GREATEST CONCENTRATION OF POWER

RECHARGEABLE

A FEW NAMES from our sales ledger

U. S. ARMY
U. S. NAVY
U. S. AIR FORCE
U. S. BUREAU OF STANDARDS
A.E.C.
AIR ASSOCIATES
AIRBORNE INSTRUMENTS
A.B.C.
BELL AIRCRAFT
BENDIX AVIATION
BENDIX RADIO
BOEING AIRPLANE
BRUSH DEVELOPMENT
C.B.S.
CHANCE VOUGHT
CONSOLIDATED VULTEE
CURTISS-WRIGHT
E. I. DU PONT
EASTMAN KODAK
GENERAL ELECTRIC
HUGHES AIRCRAFT
JOHNS HOPKINS
LOCKHEED AIRCRAFT
McDONNELL AIRCRAFT
MOVIETONE NEWS
NORTHROP AIRCRAFT
PHILCO
R.C.A.
RAYTHEON MFG.
TEMCO AIRCRAFT
VITRO CORP.
WESTINGHOUSE ELECTRIC

AND MANY MORE

SEE YOU AT THE I.R.E. SHOW!
BOOTH #765—AIRBORNE AVENUE

U. S. PATENTS GRANTED OR PENDING

YARDNEY ELECTRIC CORP.

105 CHAMBERS ST., NEW YORK 7, N. Y. WO 2-5500

Designed for

TELEVISION

Broadcasters

Type 524-D and Scope-Mobile

Sync Separator
Permits triggering from composite signal.

Delayed Sweeps
Zero to 25 milliseconds from start of field—triggered at any selected line.

Field Selector
Instant shift to opposite field.

New Sweep Magnifier
3x or 10x magnification — expands sweep to left and right of center.

Flat Faced CRT
4 kv accelerating potential.

Time Base Range
0.01 sec/cm to 0.1 μsec/cm continuously variable, accurate within 5%.

Transient Response
Risetime — 0.04 μsec.

Direct Coupled
Sensitivity dc to 10 mc — 0.15 v
to 50 v/cm . . . 2 cps
0.15 v/cm to 50

Signal

...utput
...erved are brightened
...or.

...Cycle Sweep
Separate phase and amplitude controls.

Regulation
All dc voltages electronically regulated.

For a true picture of circuit beh...
Type 524-D Televisio...
ment was designe...
tures you ne...
adjustm...
equip...
...a
...erimental
...direct coup-
...nt transient response,
...e base range in a portable
...-ray oscilloscope.

TO YOUR ADVANTAGE!

Yes, it will be to your definite advantage to attend the IRE Region 7 Technical Conference and Trade Show, Portland, Oregon. May 5—6—7

PAPERS BY NATIONALLY PROMINENT MEN!
COMBINE VACATION WITH CONFERENCE ATTENDANCE!
A "RADIO ENGINEERING SHOW" IN MINIATURE!
REMEMBER
PORTLAND, OREGON — — MAY 5-6-7

Type 524-D—$1180 f.o.b. Portland, Oregon

Pictured above with the Type 524-D, the TEKTRONIX Type 500 Scope-Mobile — $97.50 f.o.b. Portland, Oregon.

For complete specifications call your TEKTRONIX Field Engineer, or write to:

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P. O. Box 831B, Portland 7, Oregon • Cable: TEKTRONIX

Visit Us at Show Booths 129, 131 Military Avenue at the I.R.E. Show, March 22-25

What to See at the Radio Engineering Show

(Continued from page 196A)

Thomas A. Edison, Inc.
Instrument Div.
677 Circuits Ave.

*Ultra sensitive DC relay operates as null detector in bridge circuit or direct operation from photocell output. Thermal time delay relays and sealed thermostats for airborne communications equipment.

Eimac

20TH ANNIVERSARY DISPLAY

- new Klystron and ceramic developments.
- complete line of electron-power tubes.
- top management and engineering representatives present to discuss your tube applications.

EITEL-McCULLOUGH, INC.
Booths 549-551, Components Ave.

ELCO CORPORATION
2nd & GLENWOOD, PHILA. 40, PA.

America's Quality Line of Miniature & Subminiature Sockets, Shields and World-Famous "Varicon" Connectors

792 AIRBORNE AVE.

ELECTRA
Manufacturing Company
Kansas City, Missouri
477 Electronic Ave.

Manufacturers of precision deposited carbon resistors for your most exacting requirements.

Electric Regulator Corp., 627 Circuits Ave.
Regohm regulators for Servo, voltage, frequency, current and filament control. *High temperature potentiometers. *Magnetic amplifier controls. *A.C. line-load regulators. *Precision air-damped dashpots.

Electrical Industries
Div. of Amperex
Electronic Corp.
650, 652 Circuits Ave.

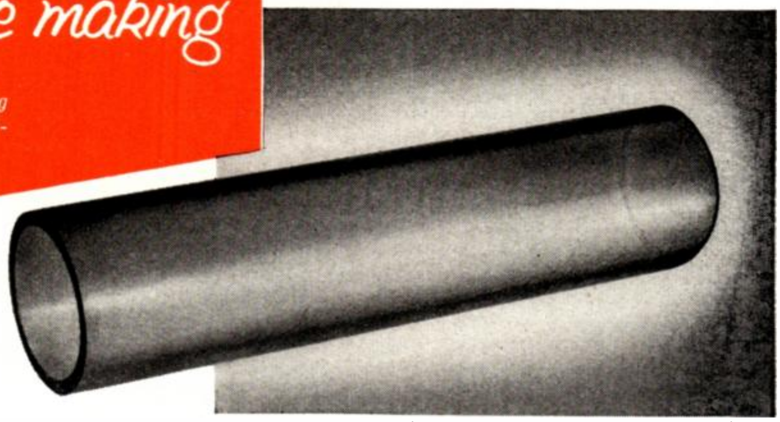
Hermetically sealed leads and multiple headers. New super-rugged compression types.

*Indicates new product

(Continued on page 200A)

IDEAS *in the making*

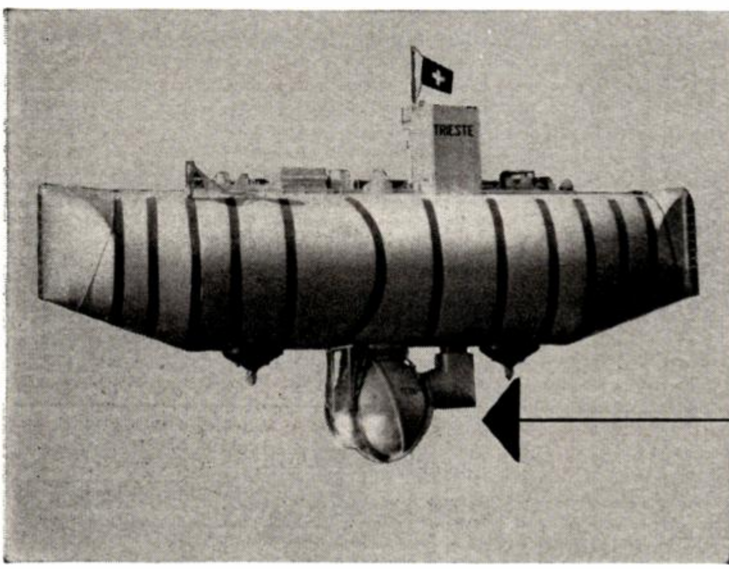
Araldite® Bonding, Casting, Coating and Laminating Resins developed by Ciba Research are simplifying manufacturing methods, improving product efficiency, and opening new fields of product development. You will want to know more about them.



(Photo courtesy of Resdel Corporation)

ARALDITE RESINS USED TO MAKE CENTRIFUGAL CAST PIPE WITH EXCEPTIONAL PROPERTIES

Araldite Resins of the "CN" series are formulated especially for casting, potting, impregnating and encapsulating uses. The pipe shown here is available in a wide range of gauges, diameters and lengths. In addition to exceptional toughness, impact and dielectric strength, it offers excellent resistance to chemical attack from circulating corrosive liquids. Araldite cast pipe of larger diameters with sealed ends is used for storage of chemicals as well. The strong clean pipe is also undergoing tests for supportive structural uses. Araldite Resins of this type achieve outstanding results in castings bonded to metal parts, impregnating of transformers, capacitators, coils, motor windings and other electrical apparatus.



POWER CABLE INSTALLATION PROBLEM SOLVED EFFECTIVELY WITH ARALDITE RESINS IN "BATHYSPHERE" FOR RECORD-SHATTERING DESCENT

On this newest "Bathysphere" the controls are connected by instrument and power cables which pass through the wall of the cabin to the apparatus located outside the cabin. In the previous "Bathysphere" all motors were controlled through relay circuits. The relays were installed outside the cabin and only small wires were able to pass through the walls. By sealing the openings with Araldite Resins it became possible to simplify the arrangement and put full-sized power cables carrying currents up to 200 amperes through the walls. The Araldite Resin used was simply poured into the space between the walls of the sphere and the cables, where it hardened and formed a seal capable of withstanding the tremendous pressure of the water at the great depth of more than 4,000 meters below the surface of the Mediterranean to which the "Bathysphere" recently descended.

SEND THIS COUPON...or write us on your company letterhead...for complete technical data on the physical properties and recommended procedures for the successful use of Araldite Resins for your fabricating needs.

CIBA

ARALDITE *Epoxies*

...FOR SUPERIOR BONDING, CASTING, COATING & LAMINATING RESULTS

IRE-1

CIBA COMPANY INC., PLASTICS DIVISION
627 Greenwich St., New York 14, N. Y.
(In Canada: Ciba Co. Ltd., Ciba Bldg., Montreal)

Please send me Ciba Plastics Technical Bulletins for

BONDING ☐ CASTING ☐ COATING ☐ LAMINATING ☐

*Name*________________________

*Company*____________ *Title*____________

*Address*________________________

What to See at the Radio Engineering Show

(Continued from page 198A)

Electro Impulse Laboratory, Inc., 384 Microwave Ave.
Dummy loads, power meters, frequency meters, spectrum analyzers, signal generators.

Electro-Mechanical Specialties Co., Inc., 609 Circuits Ave.
QUALITY Relays featuring a "Balanced Armature" that is practically IMMUNE to Vibration and exceeds present MIL specifications. The units are available to 4 PDT with contacts rated up to 5 amps. Coil resistances to 80,000 Ohms.

Electro-Motive Mfg. Co., 361 Mobile Ave.
See Arco Electronics, Inc.

Electro Precision Products, Inc., 137 Military Ave.
Coaxial connectors, RF fittings, small waveguide assemblies, small electronic devices.

*Indicates new product

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

(Continued on page 202A)

wherever a transistor is used . . .

in

- COMPUTERS • HEARING AIDS
- MINIATURE AIRBORNE EQUIPMENT
- POCKET RADIOS • F-M TRANCEIVERS
- TELEPHONE MESSAGE RECORDERS
- GUIDED MISSILES AND A HOST OF EXPERIMENTAL APPLICATIONS . . .

GRAMER TINYFORMER

OPEN TYPE (actual size)

GRAMER TINYFORMER

CLOSED TYPE (actual size)

THERE'S A JOB FOR GRAMER TRANSISTOR TRANSFORMER TINYFORMERS

★It is a fact . . . designers of miniature electronic equipment invariably associate Gramer TINYFORMERS with the Transistor. A strong linkage has been established between Gramer TINYFORMERS and the leading manufacturers of hearing aids, miniature electronic airborne equipment and comparable small electronic devices. Check the physical and electrical characteristics of the Standard Open-Type and Mu-Metal Shielded Gramer TINYFORMERS charted to the right. Note the varying range of match impedances from 200,000 to 50 ohms. Consider that Gramer TINYFORMERS have high permeability nickel-alloy cores and nylon bobbins. Their fine copper wire is coated with tough enamel and they are impregnated for moisture resistance. They utilize high temperature (+125°C) plastic flexible lead wire. You see . . . Gramer TINYFORMERS are not just better . . . they *far surpass* all other methods which justifies your selection of Gramer TINYFORMERS *wherever a transistor is used.*

Open Types or Sealed to Specifications

14 Tinyformers available for immediate delivery:

OPEN TYPE PART NO.	MU-METAL SHIELDED NO.	TYPE	MATCH. IMPEDANCE		D.C. RESISTANCE	
			PRI.	SEC.	PRI.	SEC.
M1	M1-S	Interstage	20,000	1,000	1,150	175
M2	M2-S	Interstage	20,000	1,000	930	95
M4	M4-S	Output	600	50	66	7.7
M5	M5-S	Output	400	50	70	9.3
M6	M6-S	Input	200,000	1,000	2,600	135
M7	M7-S	Output	1,000	50/60	160	9
M10	M10-S	Choke	12 Hy. O D.C.		830	

Open Type 1⅓₂" x ⅜" x ⅜"   Mu-Metal Shielded Type 1³⁄₃₂" x ²⁷⁄₆₄" x ²⁷⁄₆₄"

plus A COMPLETE LINE OF TRANSFORMERS FOR EVERY TYPE OF INDUSTRY

Hermetically Sealed

Meet MIL-T-27 Grade 1, Class A or B; and Grade 2, Class C Specifications.

Send your specifications now for cost-free recommendations

GRAMER TRANSFORMER CORPORATION

2734 NORTH PULASKI ROAD · CHICAGO 39, ILLINOIS

What to See at the Radio Engineering Show

(Continued from page 200A)

Electronic Associates, Inc.
329-333 Computer Ave.

Analog computer, computer components, Variplotter plotting boards, precision functional potentiometers.

Electronic Computer Div., Underwood Corp.
801, 803 Production Rd.

*General purpose electronic digital computer OPERATING. Schedule of interesting computing problems. Also, Delay lines: Unusual low attenuation; Compact; wide range of delays and impedances.

Electronic Instrument Co., Inc., 209, 211 Instruments Ave.
Electronic test instruments—kits or factory wired. VTVM's oscilloscopes tube testers, generators, VOM's signal tracers, decade boxes, battery eliminators, probes.

Electronic Mechanics, Inc., 633 Circuits Ave.
Mykroy, Teflon, Kel-F.

Electronic Research Assoc. Inc., 216 Instruments Ave.
Featuring complete *line of TRANSISTOR TEST EQUIPMENT and related equipment. *TRANSPAC MINIATURIZED POWER PACKS, *TRANSAMP MINIATURIZED TRANSISTOR AMPLIFIERS. Also transistorized circuitry.

Electronic Tube Corp.
241 Instruments Ave.

*DC to 10 Mc dual-beam oscilloscope, the Model H-25; ETC SIMUL-SCOPIC SYSTEM—two to eight electron guns in single ETC CRT. Multiple phenomena displayed simultaneously on single screen. Not an electronic switch or optical system. Special purpose CRT's. Request copy of "Oscillography. . . . Key To The Unknown."

Elgin Metal Formers Corp.
808 Audio Ave.

Avoid high-cost custom construction with the *EMCOR Modular Enclosure System. Every custom advantage—beauty, quality, accessibility, great strength—plus endless flexibility at low production prices.

Elly Electronics Corp., 890 Audio Ave.
The "SNAPPER" Thermal Time Delay Relay now features time delays as low as 2 seconds and as high as five minutes. Its single-pole double-throw feature is the only one in the market that is being used by more and more development engineers.

*Indicates new product

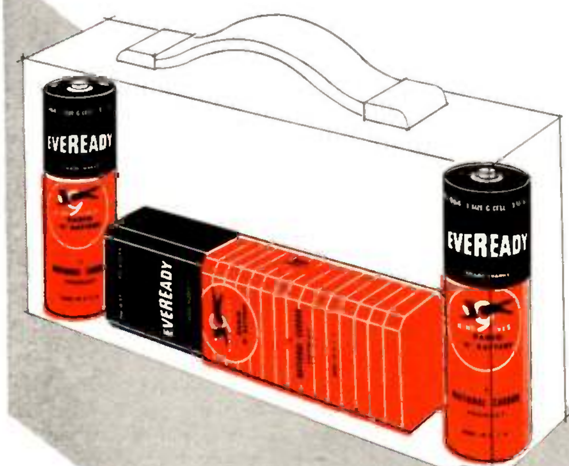
(Continued on page 205A)

Design Your New Personal Receivers for

BALANCED BATTERY LIFE

with **EVEREADY** TRADE-MARK

RADIO BATTERIES



No. 437-964 "Eveready" Battery Complement

This popular "Eveready" battery combination, for book-type "personal" radios, provides the economy and convenience of *balanced battery life* at the lowest cost per hour of listening of any battery its size.

No. 477-964 "Eveready" Battery Complement

Another popular "Eveready" battery complement, featuring longest life and lowest cost of operation in the services for which it is intended.

No. 415-635 "Eveready" Battery Complement

For that new pocket-size receiver, design around this combination and get minimum size, top economy and a near-perfect balance of battery life. Also used with a single No. 635 "A" battery, the "Eveready" No. 415 battery is the latest in sub-miniature power packages.

"EVEREADY" "NINE LIVES"

radio batteries offer you a *complete range* of standard types and sizes. You *start* with batteries and design around them . . . for *any* type or size of new-model receiver.

With "Eveready" batteries you are sure of better radio performance, longer, more *balanced* battery life and fewer replacements. Then, when replacements *are* necessary, nationally distributed "Eveready" batteries are available to the user everywhere.

Write to our Battery Engineering Department for full details and specifications of "Eveready" radio batteries.

See you at the RADIO ENGINEERING SHOW
Kingsbridge Armory • New York City
Booth Numbers 527, 529, 531

The terms "Eveready", "Nine Lives" and the Cat Symbol are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

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

What to See at the Radio Engineering Show

(Continued from page 202A)

El-Tronics, Inc.,
338 Computer Ave.

Introducing F.C.D.A. approved radiation survey meter for civilian defense applications. Electronic Instruments for detection and measurement of nuclear radiation. *Scintillation counters, decade scalers, rate meters, *portable Geiger counters. Also featuring *deluxe wide band oscilloscope for pulse and microwave work.

MANUFACTURERS OF
FIELD INTENSITY METERS
DISTORTION ANALYZERS
IMPULSE GENERATORS
COAXIAL ATTENUATORS
CRYSTAL MIXERS

Visit our Booth 252, on Instrument Ave.

edp **EMPIRE DEVICES PRODUCTS CORPORATION**
38-15 BELL BOULEVARD
BAYSIDE 61, NEW YORK

The Entron Co., 902 Registration Row. Community and Master Television Systems Equipment. The Entron ShuVee, the solderless connector for coaxial cable. The FasTee, the solderless coaxial "T" for service connections.

Erie Resistor Corp.
Erie, Pa.
538 Components Ave.

A Complete Line of
High Quality
Electronic Components

Essex Wire Corp., 614 Circuits Ave. Relays and controls for communication and electronic application—Wire assemblies for all types electronic units—Complete line of cord sets and special electronic power cords.

GUIDED MISSILE MICROWAVE PLUMBING
ANTENNA PATTERN ANALYZERS
HIGH POWER MAGNETRON MODULATORS
PRECISION MICROWAVE TEST EQUIPMENT
Slotted Sections • Probes
VSWR Amplifier • Spectrum Analyzers
FXR #387 MICROWAVE AVENUE
Electronics & X-Ray Division
F-R MACHINE WORKS, Inc.
44-14 ASTORIA BOULEVARD LONG ISLAND CITY 3, N. Y.

Potentiometer Division
FAIRCHILD CAMERA & INSTRUMENT CORPORATION
HICKSVILLE, L. I., NEW YORK
Presents
FIVE NEW Potentiometers
"See the FAIRCHILD FilmPot"
Booth 648 Radio Road & Circuits Ave.

*Indicates new product

(Continued on page 207A)

What to See at the Radio Engineering Show

(Continued from page 205A)

Fairchild Recording Equipment Corp., 831, 833 Audio Ave.
Quality playback equipment for the professional field and high fidelity consumer market. The only integrally built 3-speed synchronous transcription table. *New arms and a balanced-bar control pre-amplifier-equalizer.

Falstrom Co.
766, 768 Airborne Ave.

*Aluminum cabinets, *aluminum frames, *aluminum weldments, Instrument and control panels and consoles, *Transmitter & power supply housings, *Custom-built quality metal fabrication up to ⅝″ plate.

Federal Shock Mount Corp., 778 Airborne Ave.
Designers and manufacturers of vibration isolators and shock mounts for airborne electronic equipment. Engineered mounting bases for special requirements to applicable government specifications.

Federal Telecommunication Labs., Div. I. T. & T., 877-883 Audio Ave.
Communications and air navigation equipment and components.

Federal Telephone & Radio Co.
Div. of I T & T
885-893 Audio Ave.

Selenium Rectifier Stacks and equipment, High Frequency Cable, Pulse Time Modulation Microwave System, Transmitting and Industrial Vacuum Tubes, Mobile Radio, Closed Circuit Television, Germanium Diodes.

SEE MICROSCOPIC WELDINGS
TWEEZER-WELD
BOOTH 791, AIRBORNE AVE.
FEDERAL TOOL ENGINEERING CO.
Box 26, CEDAR GROVE, N. J.

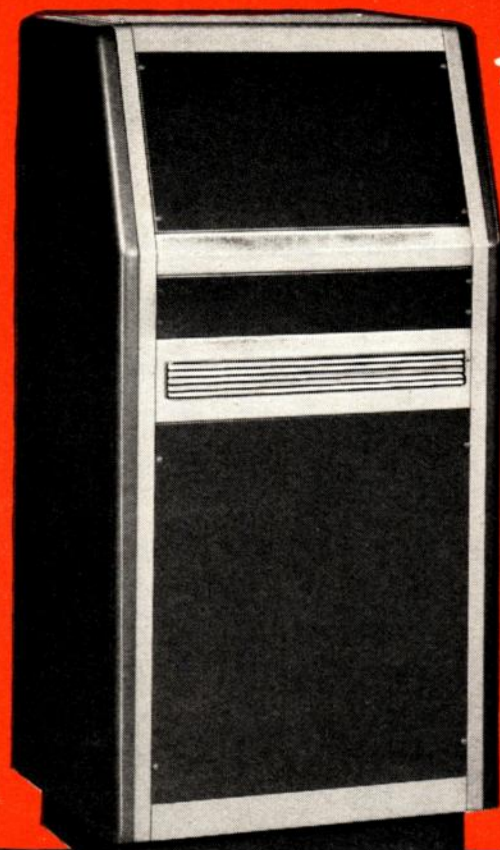
Felts Corporation, 679 Circuits Ave.
See Microdot Div.

Ferris Instrument Co., 265–271 Instruments Ave.
*Hinge Type Ultra High Frequency Tuner. Battery Powered Field Strength Generator for Checking Loop Receivers and Field Strength Meters.

filtered by
FILTRON
FLUSHING, L. I., N. Y.
BOOTH 649
CIRCUITS AVE.
RF INTERFERENCE FILTERS

*Indicates new product

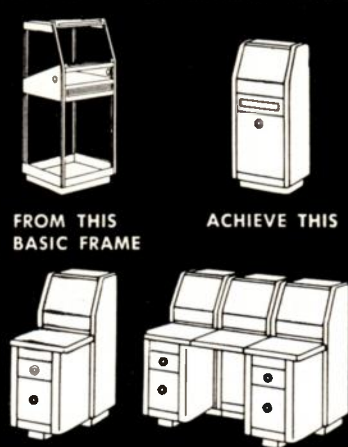
(Continued on page 208A)



* avoid high-cost custom construction with the NEW...

EMCOR

MODULAR ENCLOSURE SYSTEM



NOW, every custom construction advantage — beauty, quality, accessibility, great strength — plus endless flexibility — is yours in the EMCOR Modular Enclosure System — *at new* low production prices* — up to 80% less than custom construction! Units are assembled in only a few minutes with TINNERMAN *Speed Nuts* and hardened *Phillips Head Screws* — all furnished — even the screwdriver.

For full information on the EMCOR System, EMCOR Stacking and Instrument Cabinets, as well as other EMCOR products write:

EMCOR Quality PRODUCTS

Nothing rivals the beauty of an EMCOR installation.

EMCOR
ELGIN METALFORMERS CORPORATION
902 NO. LIBERTY ST. • ELGIN, ILLINOIS
PHONE ELGIN 7225

SEE EMCOR DISPLAY • BOOTH 808 • I.R.E. SHOW • N.Y.

What to See at the Radio Engineering Show

(Continued from page 207A)

T. R. Finn & Co., Inc., 421 Electronic Ave.
Vibration and shock control equipment—aluminum mounting bases for airborne electronic equipment—fire control shock mounts. Signal Corps shock mounts.

FORD INSTRUMENT COMPANY
Division of The Sperry Corp.
LONG ISLAND CITY 1, N. Y.
503-505 Components Ave. at Production Rd.
Control systems and computers for the military and industry—plus servos, synchros, computing cams, integrators, resolvers, and other precision components.

Formica
Booth 835-837 Audio Avenue
Productive FORMICA Pays in Performance
ENGINEERED laminated plastics

Freed Transformer Co., Inc.
522, 524 Components Ave.
Power and Communications Components for Military and Commercial Applications. Precision Laboratory and Production Test Equipment. Pulse Transformers. Magnetic Amplifiers, High "Q" Toroidal Inductors. Filters and Discriminators.

Frequency Standards
Asbury Park, New Jersey
732 Airborne Ave.
Microwave Frequency Meters
Field and Laboratory Frequency Meters
Precision-Built Micrometer Heads

Furst Electronics
Chicago 25, Ill.
416 Electronic Ave.
Klystron Power Supplies, Wide-band DC Amplifiers, Wow Meter, & Laboratory Power Supplies.

(Continued on page 210A)

Announcing...

POWERSTAT

VARIABLE TRANSFORMERS

TYPE 136 and 236

TYPE 136

- **Higher Ratings** — to meet the demand for POWERSTATS with 20 ampere capacity.
- **Small Size** — "pancake" coil design provides a compact assembly for panel or bench mounting.
- **Easy, Versatile Installation** — 3 sets of mounting holes to suit all needs — simple to change from bench to panel mounting — binding post type terminals provide for any method of connection.
- **Smoother Operation** — self-lubricating nylon bearing shaft support — hand fitted knob.
- **Easy Service** — simply remove plate block for easy access to brush assembly.
- **Rhodium Plated Commutator** assures smoother performance — longer life — contact surface forever free of oxides — uniform contact drop maintained — corrosion reduced — allows greater overload characteristics.

The complete line of POWERSTATS type 136 and 236 will be on display at the 1954 Radio Engineering Show to be held March 22-25 at the Kingsbridge Armory in New York. Visit The Superior Electric Company's exhibit in Booths 100, 101, 102, 103, 104.

SEE OTHER SIDE FOR MORE FACTS

What to See at the Radio Engineering Show

(Continued from page 208A)

The Fusite Corp.
824 Audio Ave.

Glass-to-steel hermetic terminals, as used for hermetic relays, transformers, switches, capacitors and various electronic components.

Gabriel Electronics Division
Formerly Workshop Associates Div.
The Gabriel Company
193, 195 Television Ave.

• *Microwave Passive Reflectors • *2000 mc Parabolic Antenna Feed • *Parabolic Offset Feed Mount • Complete line of Microwave Antennas UHF Broadcast Antenna • Complete Line of Mobile Communications Antennas • High Gain Beacon Antennas • Aircraft and Naval Blade Antennas.

The Gamewell Company, 716 Airborne Ave.
98 years of service in the electrical manufacturing business. Largest fire alarm and police signaling systems company in the U.S.A. now manufactures precision variable wire-wound resistors, standard models and custom made.

Gates Radio Co., 155-163 Television Ave.
*1 kw UHF Television Transmitter, *complete remote control system, *250 watt auxiliary or standby AM Transmitter *CCl Audio Console. *Compact 4-channel remote amplifier and other apparatus for broadcasting and communications.

General Ceramics & Steatite Corp.
566, 568 Components Ave.

*Ferrite materials exhibiting extremely low losses at high frequencies. Additional square hysteresis-loop magnetic-core ferrites. *Completely new standard line of solderseal terminal bushings and several new product lines.

General Communication Co., 724 Airborne Ave.
Offering a complete line of COAXIAL SWITCHES, headed by the *110 volt A.C. series. The latest Signal Generators and miniaturized Radar Beacons available for close inspection

General Electric Co.,
Apparatus Dept.
174-180 Television Ave.

Control relays, rectifiers, capacitors, inductrols, Amplistats, soldering irons, radar transformers, cast permafic transformers, thyrite varistors, glass bushings, molecular vacuum gage, thermocouple vacuum gage.

*Indicates new product

(Continued on page 214A)

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

on display . . . and at work . . . demonstrating instruments designed to save money by saving time

the pioneer is the leader

spotlighting the NEW . . . at the I.R.E. show—Booth 230, 232

PANORAMIC THE PIONEER demonstrates the complete line-up of standard Panoramic Equipment—*and introduces new Panoramic Instruments of interest and importance to the electronic field.*
Introduction of these new units broadens the already wide range of Panoramic high speed spectrum and waveform analyzers and sweep generators—demonstrating once again that *the pioneer is the leader.*

AT WORK ON YOUR PROBLEMS . . .

PANORAMIC THE PIONEER provides instruments of unsurpassed excellence. Panoramic's specialized models covering audio to microwave frequencies speed and simplify analysis of waveform distortions, sounds, vibrations, spurious oscillations or modulation, response characteristics of filters or transmission lines, characteristics of AM, FM or pulsed signals, or monitoring many frequency channels simultaneously.

A Panoramic Analyzer can provide the answer to your problems. Partial list of organizations whose choice of Panoramic Equipment is a continuing demonstration that *the pioneer is the leader.*

Civil Aeronautics Authority
National Bureau of Standards
Naval Ordnance
Aerojet Engineering Corp.
Allison Division, General Motors Corp.
U. S. Atomic Energy Comm.
Bell Telephone Laboratory
Bendix Aviation Corp.
Canadian National Railway Co.
Collins Radio Company
A. V. Roe, Canada, Ltd.
California Institute of Technology
Chance Vought Aircraft
Douglas Aircraft Co.
Eastman Kodak Co.—Navy Ordnance Division
Fairchild Camera & Instrument Corp.
General Motors Corp.
The Hallicrafters Co.
Hughes Aircraft Company
Kimberly-Clark Corp.
Lockheed Aircraft Corp.
North American Aviation
Northrup Aircraft Inc.
Pratt & Whitney Aircraft
Radio Corporation of America
Raytheon Mfg. Co.
Stromberg-Carlson Co.
Underwood Corp.
Western Electric Company

If you cannot attend the show, write for information on Panoramic's *new* and important Instruments.

Inquiries invited on Panoramic Spectrum Analyzers for Special Problems.

PANORAMIC RADIO PRODUCTS, INC.

12 South Second Avenue, Mount Vernon, N.Y.
MOunt Vernon 4-3970

What to See at the Radio Engineering Show

(Continued from page 212A)

General Electric Co., Electronics Dept. 184-196 Television Ave.

*Color receiving tubes and color picture tubes, *Five-star reliable tubes, *Low-noise triode, *Ceramic version GL2C39-A, I-M-F picture tubes. Multiple advantage "print wire" circuit boards, distributed constant delay lines, "KOR-LES" power resistors and precision formed and stamped metal parts. Transistors, rectifiers, diodes, blocking, switching, relaying circuit diagrams. Transistor tester, oscilloscopes, sweep generator, marker generator, diode tester, power supplies.

General Electric Co., Chemical Dept., 182 Television Ave.
Industrial laminated plastics for use in electrical and electronic applications; *Foil clad laminates now available for manufacture of etched circuits; silicone rubber fabricated parts; mycalex.

General Instrument Corp. 362 Mobile Ave.

*V/U Combination tuners. *VHF Tuners. *UHF Tuners and converters and variable capacitors.

General Precision Laboratory, Inc. 154, 156 Television Ave.
*Newest industrial TV, exceptionally flexible with complete remote control. Precision microwave components. Super-range variable focal length lenses.

GENERAL RADIO CO. CAMBRIDGE, MASS. 251-255 Instruments Ave.

Since 1915—Manufacturers of Electronic Apparatus for Science and Industry

See over 50 instruments including the NEW Laboratory I-F Amplifier, Pulser, Decade Voltage Divider, Beat-Frequency Oscillator, Line-Voltage Regulator, High-Frequency Variacs®, and Transistor Oscillator.

General Transformer Corp. 359 Mobile Ave.

*Hi-quality, Hi-fidelity audio output transformers and transformers of unusual applications. Display will show transformers for television, radio, electric fence units, tape recorders and for various other applications.

Germanium Products Corp., 419 Electronic Ave.
Grown Junction Tetrode and Power Transistors, Transistorized test equipment, such as Alpha cut-off measuring. High frequency transistors, junction type.

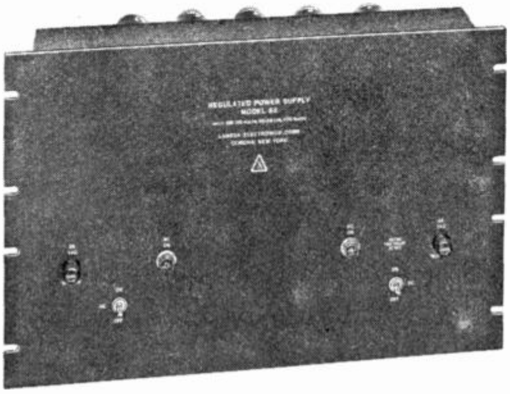
*Indicates new product

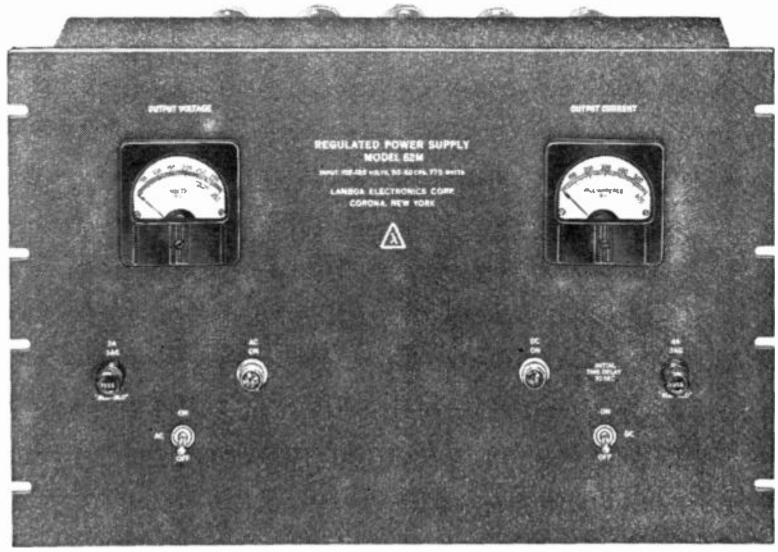
(Continued on page 216A)

LAMBDA'S NEW "600 MA" SERIES

OF HEAVY DUTY, PRECISION REGULATED POWER SUPPLIES

FOUR VOLTAGE RANGES...WITH AND WITHOUT METERS





Rack Model 62 (without meters) $239.50
(Also illustrates Models 63, 64 and 65)

Rack Model 62M (with meters) $269.50
(Also illustrates Models 63M, 64M and 65M)

These new, compactly engineered LAMBDA models supply load currents up to 600 MA in the following voltage ranges:

Model 62 and 62M	**245-305 VDC @**	**0-600 MA, regulated**
Model 63 and 63M	**195-255 VDC @**	**0-600 MA, regulated**
Model 64 and 64M	**100-200 VDC @**	**0-600 MA, regulated**
Model 65 and 65M	**0-100 VDC @**	**50-600 MA, regulated**

Equipment in the "600 MA" series is designed for standard 19" rack mounting. Efficient design has made possible a panel height of only 12¼" with a depth behind panel of only 9". Intended primarily for fixed voltage use, these models are adjustable over the voltage ranges indicated.

Models 62, 63, 64 and 65 are excellent sources of power for racks of equipment. Representative applications are for television studio and transmitter equipment, tube ageing apparatus, computer installations, and multi-channel equipment. These models are well suited to all installations where comparatively large amounts of power are required. They are rated for industrial applications, based on continuous-duty operation at maximum ratings.

SCHEDULE OF PRICES

Model 62	$239.50	Model 64	$244.50
Model 62M	269.50	Model 64M	274.50
Model 63	239.50	Model 65	249.50
Model 63M	269.50	Model 65M	279.50

Available for immediate delivery. Prices F.O.B. factory, Corona, N.Y.

SPECIFICATIONS FOR "600 MA" SERIES

Input:
105-125VAC, 50-60C, 775W (Model 62); 715W (Model 63); 675W (Model 64); 585W (Model 65)

DC Output (regulated)
Voltage and currents:

Models	Voltage range*	Current range**
62 & 62M	245-305VDC	0-600MA
63 & 63M	195-255VDC	0-600MA
64 & 64M	100-200VDC	0-600MA
65 & 65M	0-100VDC	50-600MA

**Voltage range for any given model is completely covered in four continuously variable bands.*
***Current rating applies over entire voltage range.*

Regulation (line) .... Better than 0.15% or 0.3V
Regulation (load) .... Better than 0.25% or 0.3V
Impedance .... Less than 2 ohms
Ripple and Noise .... Less than 5 millivolts rms
Polarity ..... Either positive or negative may be grounded

AC Output (unregulated):
6.5VAC at 20A (at 115VAC input). Allows for voltage drop in connecting leads. Isolated and ungrounded.

Ambient Temperature and Duty Cycle:
Continuous duty at full load up to 50°C (122°F) ambient.

Controls, Terminals and Overload Protection:

DC output controls:	Band-switches and screw-driver adjusting vernier-control, rear of chassis
AC and DC switches:	Front panel
External overload protection:	AC and DC fuses, front panel
Internal failure protection:	Fuses, rear of chassis
Input and output terminals:	Barrier terminal block, rear of chassis

Meters:
3½" rectangular voltmeter and milliameter (Models 62M, 63M, 64M and 65M only).

Voltage Reference Tube:
A stable 5651 voltage reference tube is used to obtain superior long-time voltage stability.

Time-Delay Relay Circuit:
A 30-second time-delay relay circuit is provided to allow tube heaters to come to proper operating temperatures before high-voltage can be applied.

Size, Weight, Panel Finish:
Size: Standard 19" relay-rack mounting
12¼" H x 19" W x 9" D
Weight: 70 lb. net; 140 lb., shipping
Panel Finish: Black ripple enamel (standard)

LAMBDA λ ELECTRONICS CORP.

103-02 NORTHERN BOULEVARD CORONA 68, NEW YORK

VISIT THE LAMBDA BOOTHS, 467-469 AT THE I.R.E. SHOW IN NEW YORK

What to See at the Radio Engineering Show

(Continued from page 214A)

Gertsch Products, Inc.
204 Instruments Ave.

*Accurate microwave frequency multiplier, *short duty cycle pulse peak reading VTVM, VHF frequency meter, standard ratio transformer, VHF interpolator, half octave filters.

G. M. Giannini & Co., Inc., 117, 119 Military Ave.
Pressure switches, pressure transmitters, precision potentiometers, commutators, gyros, accelerometers, *resolvers, *hysteresis & salient pole motors, digital recording computer, *Magseal relays.

Glenco Corporation
850 Audio Ave.

***Glennite Non-Linear Dielectrics**

For application in dielectric amplifiers, memory devices, modulation, voltage tuning, frequency doubling, sweep circuits and variable filters.

Globe Industries, Inc.
612 Circuits Ave.

Sub-miniature fractional HP permanent magnet DC motors, 400 cycle AC motors and motor products (generators, concentric gear reducers, planetaries, vibrators, blowers, switches, gyros, actuators).

John Gombos Co., Inc.
573, 575 Components Ave.

Precision electronic assemblies; cross-bar contact switches; buttontype capacity filters; dial light sockets; connectors; high frequency and ultra-high frequency connectors; Jack assemblies and crystal converters; microwave components.

Goodyear Aircraft Corp., 316, 318 Computer Ave.
Geda Line of Analog Computing Equipment.

Grant Pulley & Hardware Corp.
301, 303 Production Rd.

Electronic equipment and industrial slides, featuring *"standard" slides of stock sizes. Custom and general material for all sliding applications.

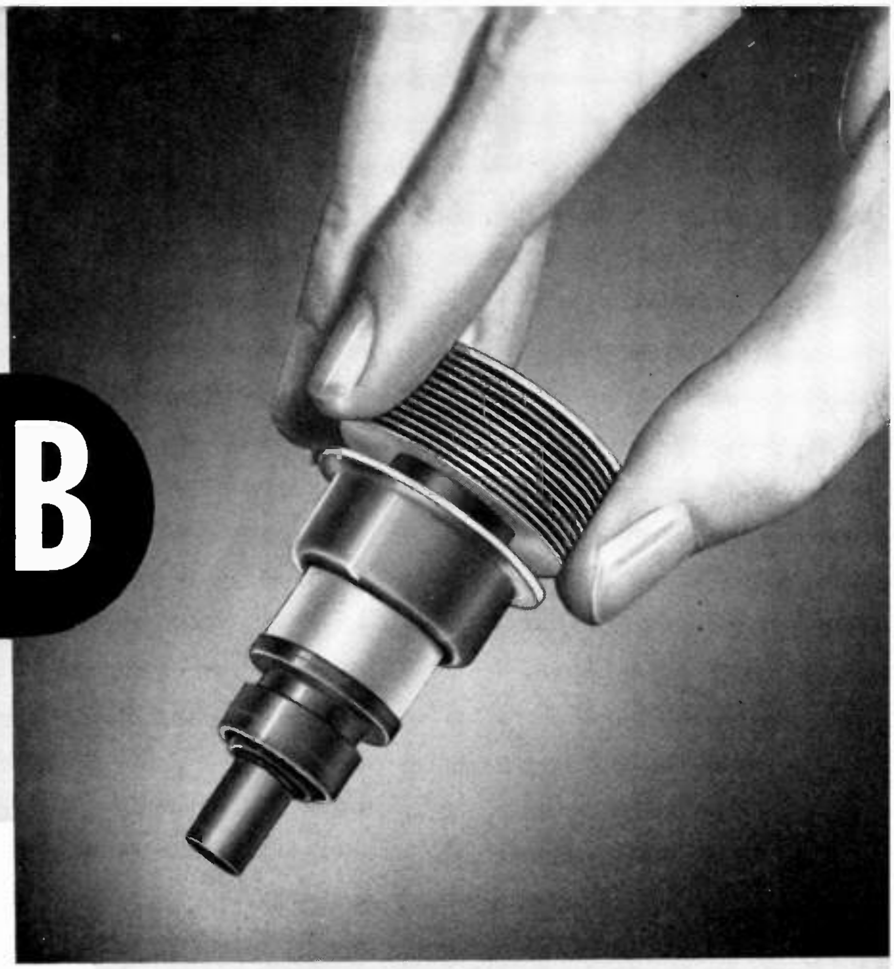
*Indicates new product

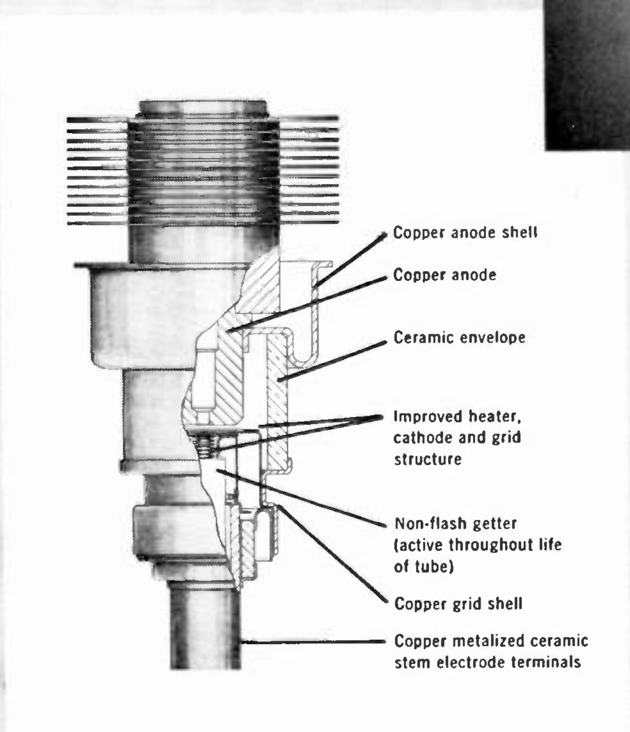
(Continued on page 218A)

EIMAC announces

the 2C 39B

- Ruggedness of ceramic
- High conductivity of copper





The Eimac 2C 39B, unilaterally interchangeable with the 2C 39A, is a new tube type with advancements that provide longer life, more useful power output, efficiency and stability, and greater immunity to thermal and physical shock. Rugged, low loss ceramic replaces glass throughout the Eimac 2C 39B and highly conductive, heat dissipating copper is utilized in the anode, anode shell and grid shell. Use of ceramic and copper, an exclusive Eimac feature, allows higher operating temperatures and minimizes RF losses. Electrode terminals are formed in the stem by copper metalizing the ceramic stem surface. All external contact surfaces are silver-plated. New heater, cathode and grid structures, plus a non-flash active getter, add to long life and stability. These features, born out of Eimac experience over the past few years in research and production of glass and ceramic 2C 39As, make the Eimac 2C 39B an incomparable planar-type 100 watt triode for UHF operation through 2500mc.

● *Eimac, one of the world's largest designers and manufacturers of electron-power tubes, presents its 20th Anniversary display at the March IRE show—booths 549-551*

TYPICAL OPERATION

(RF Oscillator 2500mc)

D-C Plate Voltage	900v
D-C Grid Voltage	-22v
D-C Plate Current	90ma
D-C Grid Current	27ma
Useful Power Output	15w

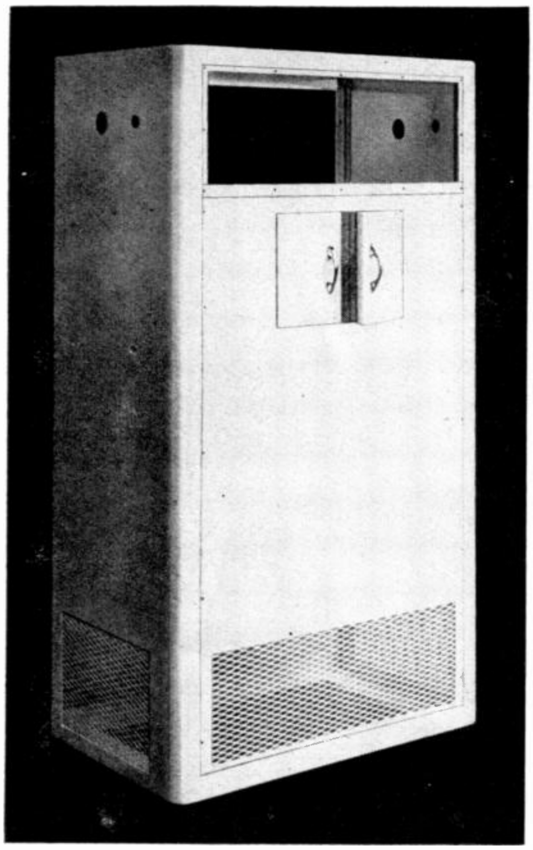
EITEL-McCULLOUGH, INC.

SAN BRUNO • CALIFORNIA

Eimac

MARK OF EXCELLENCE IN ELECTRON-POWER TUBES

Want a "QUIRK" in Your Cabinets?



SEE US at the SHOW Booth 354 Mobile Ave.

Check with R & T for Details On Quality Sheet Metal Products

When the housing of your product is a problem—of intricate design, complex shape, extra detail or improved appearance—our *specialized* service is your answer. As both designers and fabricators, we have satisfied thousands of industrial users with better quality cabinets—and with production economies made possible by our complete, modern plant and 50 years of know-how. Your problem or blueprints, submitted now will bring a prompt quotation.

- Aluminum Spot Welding
- Heliarc Aluminum Welding

REPRESENTATIVES

Frank W. Taylor Co.
P.O. Box 316, DeWitt, N.Y.

Paul R. Sturgeon
25 Huntington Ave., Boston 16, Mass.

Kenneth E. Hughes Co.
4808 Bergenline Ave., Union City, N.J.

Samuel K. Macdonald, Inc.
1531 Spruce St., Philadelphia 2, Pa.

William E. McFadden
150 Broad St., Columbus 15, Ohio

Southeastern Sales Co.
Georgia Savings Bank Bldg., Atlanta, Ga.

MANUFACTURERS
Special Steel Equipment
Metal Cases – Cabinets
CONTRACTORS
Sheet Metal
Building Products
VENTILATION, AIR CONDITIONING

THE RIESTER & THESMACHER COMPANY
1526 W. 25TH ST. CHerry 1-0154
CLEVELAND, OHIO

What to See at the Radio Engineering Show

(Continued from page 216A)

Gray Manufacturing Co., 297 Broadcast Way
See Gray Research & Dev. Co.

Gray Research & Development Co., Inc., 297 Broadcast Way
*3b Monolens Telojector (Complete), Fixed Mirror Multiplexer, 109 Tone Arm. Amazing Gray Telop II with Multiplexers—four way and moving mirrors. Camera Turret Gray Audograph.

Grayhill, 639 Circuits Ave.
Miniature switches; tap, snap action and push button, test clips—fully insulated alligator and panel mount. *plug-in test clip board. Miniature electronic components.

Green Instrument Co., Inc., 243 Instruments Ave.
GREEN (Pantograph) ENGRAVER for all metals and plastics. *New IDEAS and SPECIAL FIXTURES for production engraving.

Greibach Instruments Corp.
850 Audio Ave.
THE FIRST MAJOR IMPROVEMENT IN METERS IN THE LAST FIFTY YEARS! Revolutionary friction-free movement withstands 500 g's and overloads to over 100,000%.

Guardian Electric Manufacturing Co.
582 · 584 COMPONENTS AVENUE
The Latest in Relays, Solenoids, Hermetically Sealed Controls, Electromagnetic Developments.

Gudebrod Bros. Silk Co., Inc.
737 Airborne Ave.
Two fungus-resistant nylon flat-braided lacing tapes: *GUDELACE, the nylon tape with *wax* finish and *GUDE-NYLACE, the all nylon tape which is wax free.

The Gudeman Company, 407 Electronic Ave.
Miniature paper-dielectric capacitors, dry electrolytic capacitors, metallized paper, *plastic film dielectric capacitors, filters.

Gulton Manufacturing Corp.
850 Audio Ave.
GLENNITE piezoelectric transducers; piezoelectric and self-recording accelerometers; instrumentation for shock, vibration, blast studies; high dielectric ceramic capacitors; printed circuits. *Ultrasonic devices, ultrasensitive Greibach meters.

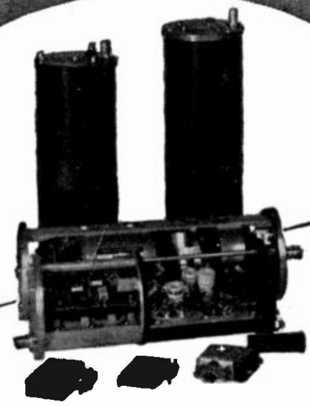
*Indicates new product

(Continued on page 220A)

ASCOP

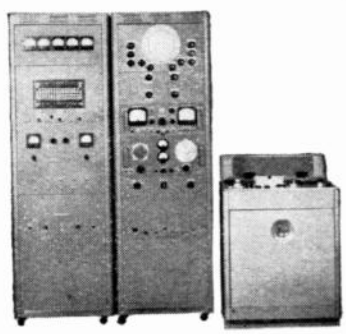
Now Available!

Complete Time Division Multiplex Data Systems



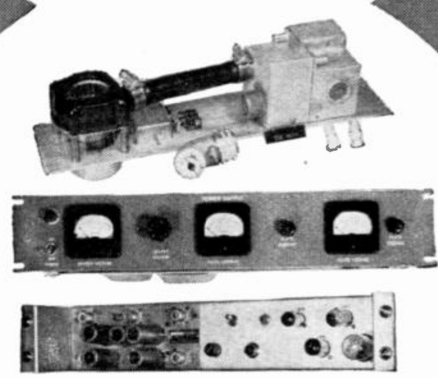
MODEL TK-M4/DC-M4 PW/FM AIRBORNE SET

Uses a 30 RPS commutator to sample 28 data sources in the 0 to +5 volt range. 4 to 5 watt crystal-controlled RF transmitter is frequency modulated. Equipment is sealed and pressurized for high altitude operation, and withstands ambient temperatures from −40°F to +140°F, 100g shock, and 12g vibration. Transmitting equipment is also available with other sampling rates and numbers of channels and in different packages for separate applications. Bulletin FBA-1.



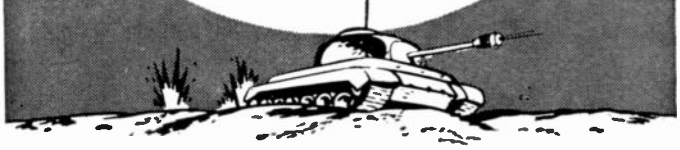
M SERIES PW GROUND STATION

Separates and reduces all data channels in real time. Operates on signals from standard airborne set, from FM/FM sub-carrier, or from magnetic tape recorder. Bulletin M-4



MODELS APA-1 RF PREAMPLIFIER AND AMC-1 MULTICOUPLER

Increase receiving gain and reduce noise figure for longer range RF link operation without increasing transmitter power. Permit connection of up to 4 receivers, tuned to different frequencies, to the same antenna. Bulletin APA-1.

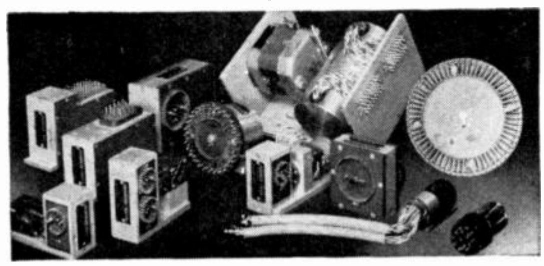


Standardized equipment is now available for complete systems for multichannel data transmission over a single radio link or recording on a single magnetic tape track, using time-division multiplexing and pulse width coding.

ASCOP systems engineers can now choose from a complete line of units for sampling, coding, transmitting, receiving, monitoring, separating, reducing, and recording to assemble systems to meet your data transmission or recording problems.

Pulse width data systems provide, through time division multiplexing, a large number of identical data channels of moderate frequency response. The handling of information in the form of time rather than amplitude allows accurate operation independent of the characteristics of the transmitting or recording medium. Utilization of zero and sensitivity reference channels affords continuous automatic system calibration and avoids the need for frequent manual adjustment.

A typical standard ASCOP PW system handles 26 separate data channels with 5 CPS response per channel with overall system accuracy, from original data source to final reduced output record, of better than 1%. Real time output of each channel is available as a meter reading and as continuous record from a direct-writing recorder.



ROTARY SAMPLING SWITCHES

Over 40 models, single and multi-pole, with up to 180 contacts per pole and speeds up to 100 RPS. For all applications requiring high quality switching of low level signals. Bulletin 521-R.

ASCOP

WE PROVIDE THE LEVER • YOU MOVE THE WORLD

Your inquiries are invited. Phone, wire or write to the nearest office, advising us of your requirements

Applied Science Corp. of Princeton

P.O. Box 44 Princeton, N. J. • Plainsboro 3-4141
1641 S. LaCienega Boulevard, Los Angeles 35, Calif. Crestview 1-8870

See Us at the I.R.E. Show • 206-208 Instruments Ave.

What to See at the Radio Engineering Show

(Continued from page 218A)

The Hallicrafters Co., 812 Audio Ave.
Communications receivers, communications transmitters, two-way portable radios, two-way central station radios, high fidelity tuners, high fidelity amplifiers.

Hammarlund Mfg. Co., Inc., 411, 413 Electronic Ave.
*Amateur and professional communications receiver. *Industrial remote control system. Additional improved signaling and control equipment. *HQ and *super-Pro receivers as well as standard and special variable capacitors.

Hastings Instrument Co., 410 Electronic Ave.
*Raydist, radio location system which tracks with accuracy of 1 foot in a mile. *Vacuum Controller-Indicator, which automatically controls vacuum level, operates alarm, etc. Manometer-Flowmeter. Air Meters. Electronic Standard Cells.

Hayden Publishing Co., 872 Audio Ave.
Typical monthly electronic processing of 25,000 inquiries from the readers of Electronic Design.

A. W. Hayden Co., 570, 572 Components Ave.
*Miniature Hermetically Sealed Repeat Cycle Timers and Time Delay Relays—*Adjustable Hermetically Sealed Time Delay Relays—*Precision Adjustable Round Time Delay Relays.

Haydu Brothers, Special Products Dept., 628 Circuits Ave.
Cathode-Ray Tubes, Power Tubes, Receiving Tubes, High Precision Formed Wire Parts, Precision Stampings and Machined Parts for Electronic Industry. Glass Working Equipment.

Heiland Research Corp.
290 Instruments Ave.

Recording oscillographs, models 401, 500, 700; amplifier system, model 119; bridge balance, model 82-6; and *sub-miniature oscillograph and sub-miniature galvanometers. Galvanometers are most sensitive yet most stable ever produced.

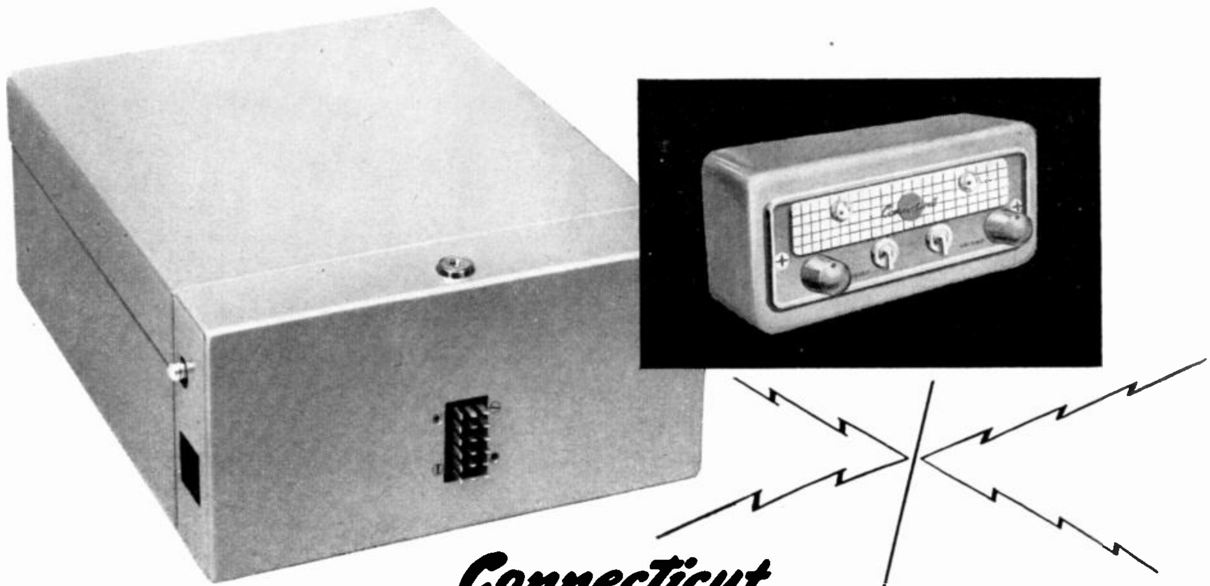
Heinemann Electric Co.
365 Mobile Ave.

*400-cycle circuit breakers in single-pole and multi-pole units; *plug-in Silic-O-netic time delay relays; complete line of circuit breakers for electronic applications.

*Indicates new product

(Continued on page 222A)

New 75 Mc crystal circuitry obsoletes conventional UHF 2-Way Radio design

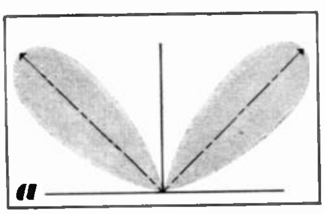


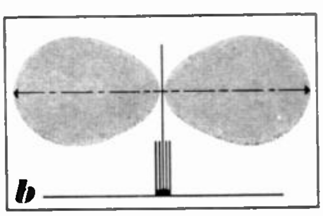
Connecticut

FLEETWAY

FIRST FM 2-WAY RADIO

UNIQUE CONN-TENNA DESIGN BEAMS STRONG HORIZONTAL SIGNAL





More evidence of FLEETWAY's radical design is found in its new Conn-tenna. Sketch *A* shows how conventional monopole antenna dissipates much of its signal at 45° upward angle. Sketch *B* shows how multipole *Conn-tenna* concentrates radiation along a horizontal plane, transmitting a stronger signal with lower power requirement.

HIGHER OVERTONE • The patented Lister circuit uses a starting frequency of 75 Mc instead of the usual 6 Mc. Low 6-time frequency multiplication required to reach 450 Mc contrasts with 24-times or more in other types of equipment.

GREATER STABILITY • Direct circuitry and fewer components permit better control of signal output, greatly minimize drift and spurious radiation. Result is greater stability requiring minimum maintenance, producing clearest signal ever attained in mobile radio.

'FM' CLARITY MINUS NOISE • True frequency modulation — for the first time in mobile radio — produces noise-free, natural tone quality, and eliminates distortion so common in conventional equipment. *This is true FM, not commonly used phase modulation (PM).*

LOWER OPERATING COST • Simplified FLEETWAY circuitry requires fewer tubes and parts — uses standard, lower cost crystals and tubes, needs less servicing.

NEW 450-470 Mc BAND OPENS 2-WAY RADIO TO EVERY CITIZEN AND COMPANY • Even if you have not been able to obtain a license for 2-way radio for yourself or your business, the chances are you can now get an immediate assignment in the recently opened 450-460 commercial fleet band or in the 460-470 citizens' band. These new bands offer easy licensing requirements for anyone who does not qualify in one of the older channels. You can now enjoy the advantages of FLEETWAY mobile radio for business or private use.

***HEAR IT!* Visit the "Connecticut" booth No. 366 at the IRE show — March 22 through 25. Hear paper on "New Approach to 450-470 Mc Equipment" by Richard Tuttle, March 22 at Waldorf Astoria. If unable to attend, write for specification data.**

Connecticut

CONNECTICUT TELEPHONE & ELECTRIC CORP. 96 BRITANNIA ST. MERIDEN, CONN.

What to See at the Radio Engineering Show

(Continued from page 220A)

The Helipot Corp., Div. of Beckman Instruments, Inc.
756, 758 Airborne Ave.

Single-turn and multi-turn, linear and non-linear (functional) precision potentiometers; turns-counting Duodials; *variable delay lines; *analog-to-digital output transducers.

Heminway & Bartlett Mfg. Co., 888 Audio Ave.
Nylon Lacing Cords and Flat Braided Tapes. 100% fungus-proof. Lace faster and tighter with less pull. High abrasion resistance, low moisture absorption. Retain desirable malleability of wax and yet have melting point of over 190° F. Non-toxic to humans. Meet Army, Navy and civilian "specs."

Henry and Miller Industries, Inc., 307 Computer Ave.
Specialists in producing pressurized cases for sealing electronic systems. ELECTRONIC AND METAL FABRICATORS, MACHINISTS, WELDERS, ANODIZERS AND PLATERS.

Heppner Mfg. Co.
854 Audio Ave.

*Lower priced focomag with single ferrite magnet. *color TV flybacks, Ion traps, Ferrite rod antennas, loudspeakers, Centering devices and correcting magnets.

Hermetic Seal Products, Co.
199 Broadcast Way

Hermetic Seals, glass-metal hermetically sealed terminals; bushings; headers; plugs and bases in single terminals or multi-headers for the electronics industry.

Hetherington, Inc., 736 Airborne Ave.
Push-button, snap-action switches, toggle and rotary switches. *Mil-S-6743 approved push-buttons. *Shock-vibration resistant relay. *Subminiature indicator light.

Hewlett-Packard Company

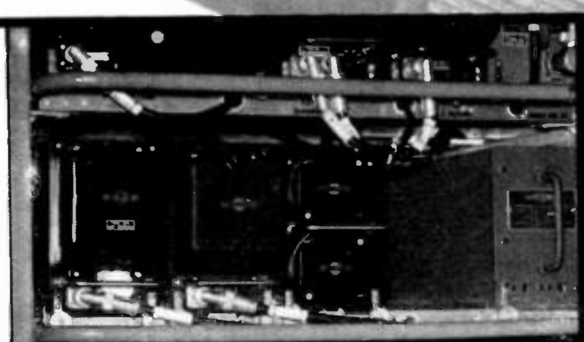
BOOTHS **248-250** CORNER **RADIO ROAD** AND **INSTRUMENTS AVE.**

The John Hewson Co., 374 Microwave Ave.
Will exhibit our TAKK high-voltage DC insulation testers, TAKK high-speed static control systems and STATICATOR—master static alarm systems

*Indicates new product

(Continued on page 224A)

THE NEW DOUGLAS *DC-7*



Diamond Connectors at work in DC-7 radio equipment, helping to insure reliable communication.

Depends on

DIAMOND CO-AXIAL CABLE CONNECTORS

As dependability in electronic circuits becomes more critical, coordinated engineering and manufacturing effort of a highly refined degree becomes an unqualified "must".

This Company is proud that its product has been selected for use in THE NEW DOUGLAS DC-7.

DICO

DIAMOND MANUFACTURING CORPORATION

7 North Avenue, Wakefield, Massachusetts

What to See at the Radio Engineering Show

(Continued from page 222A)

Hickok Electrical Instrument Co.
458, 460 Electronic Ave.
*Marker Calibrator Generator, *Heterodyned Marker Adder, *Sweep Generator, *UHF Sweep Alignment Generator, *Television Video Generator for Color and Black and White, *Sine Square Wave Generator, *Noise Generator, *Electronic VTVM with 9" meter, *Laboratory Scope, *Laboratory Dynamic Mutual Conductance Tube Tester.

High Vacuum Equipment Corp., 310 Computer Ave.
*Shorter diffusion pumps; vacuum seals, gauges, gauge controls, pneumatically-operated valves, vacuum soldering and brazing units, metallizing units and exhaust equipment.

Hi-Q Division, 548-552 Components Ave.
See Aerovox Corp.

Hitemp Wires, Inc., 911 Registration Row
*Hitemperature wire and cable products. Teflon magnetic wire. Silicone magnet wire. Teflon hook-up wire. Teflon-glass fibre lead wires, miniature coaxial and low noise cable.

Honeycomb Co. of America, Inc., 604 Circuits Ave.
Manufacturers of Radar Reflectors, Radomes, Dielectric Windows, Laminated Fibre-glass Pipe, Aluminum & Cotton Honeycomb, and Honeycomb structures utilizing Paper, Cotton or Aluminum Cores; also adhesives.

Harvey Hubbell, Inc., 406 Electronic Ave.
*Hubbell Interlock type "C" sub-miniature connector with Automatic Lock-Quick Disconnect, Low Contact Resistance features. Ideal for printed circuit use. This connector can also be seen at Photocircuits, Inc. booth.

Hudson Tool & Die Co.
472 Electronic Ave.
Standard Cases and Covers. . . .
Quality Metal Stampings.

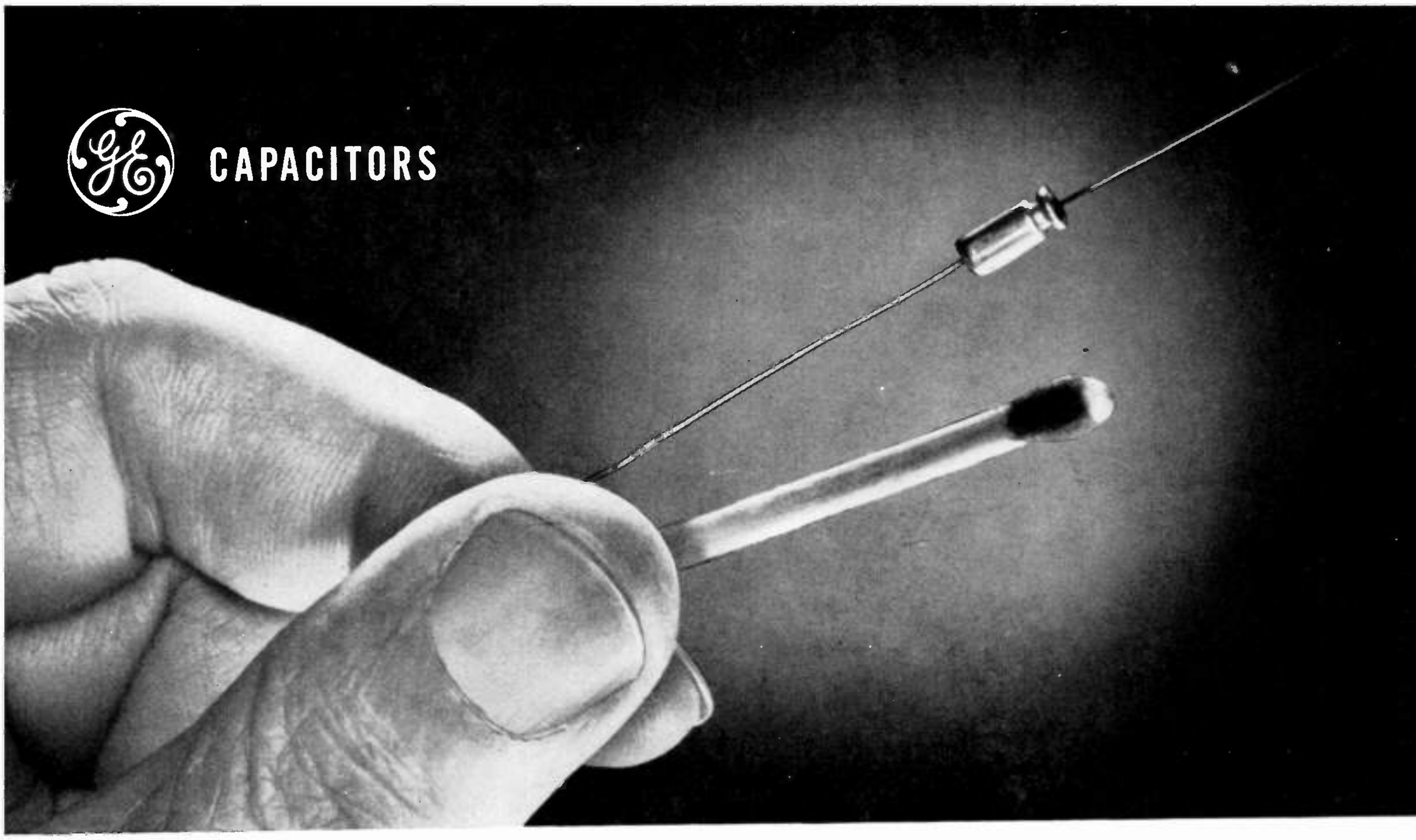
A HUGHES DIODE actual size
SEE THE HUGHES EXHIBIT
753-757 Airborne Ave.

Hytron Radio & Electronics Co., 588-592 Components Ave.
See Columbia Broadcasting System

*Indicates new product

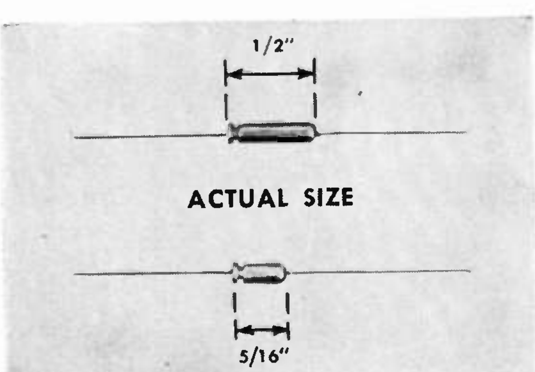
(Continued on page 228A)

FREE BUSES
Every 10 minutes both to and from Waldorf-Astoria



THIS 8-MICROFARAD, 4-VOLT UNIT IS NOW AVAILABLE WITH −0% TO +100% CAPACITANCE TOLERANCE.

Announcing HIGHER RATINGS for Micro-miniature Tantalytic Capacitors



LARGE CAPACITANCE and small size make Micro-miniature Tantalytics valuable where space is at a premium. Diameters are .125 inches.

We can now supply up to 20 volts, or, up to 8 microfarads in the $\frac{5}{16}$" case size, higher capacitance in the ½" case size . . . and with −0% to +100% capacitance tolerance!

SEE THESE CAPACITORS IN OUR BOOTH AT THE NEW YORK IRE SHOW.

Higher ratings are now available in General Electric's new *Micro-miniature* Tantalytic capacitor line. Eight microfarads at four volts can now be obtained in the $\frac{5}{16}$ inch unit, higher capacitance in the ½ inch unit. Designed for low-voltage d-c circuits, they are particularly adaptable to transistorized subminiature assemblies, where space is at a premium, such as hearing aids.

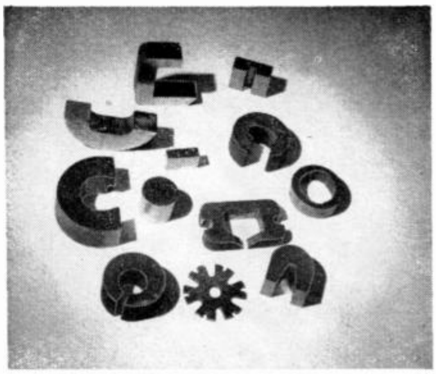
SUPERIOR PERFORMANCE. *Micro-miniature* Tantalytic capacitors outperform aluminum electrolytics in electrical stability, operating and shelf life, because of the inert characteristics of tantalum metal and the stability of its oxide. They gain added reliability from the use of silver cases, a non-acid electrolyte, and complete sealing that prevents leaking and contamination of the interior.

WIDE TEMPERATURE RANGE. *Micro-miniature* Tantalytics can operate over a −20 C to +50 C range—may be stored at −65 C. With some capacitance derating, they can operate well below −20 C. They also perform above +50 C with some life limitations.

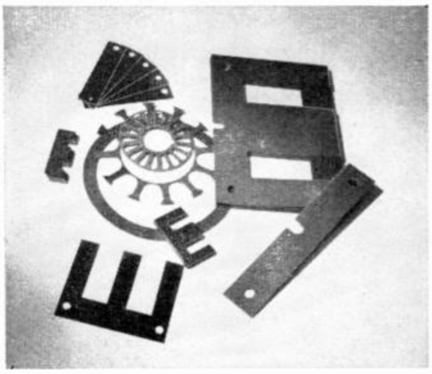
AVAILABILITY. Designed especially for non-resonant, non-critical applications such as coupling, by-pass and filtering, *Micro-miniature* Tantalytics can be obtained in sample lots in 2 to 3 weeks, production lots can be shipped in 6 to 8 weeks. For more information, see your G-E Apparatus Sales Representative or write for bulletin GEA-6065 to General Electric Company, Section A442-14, Schenectady 5, New York.

Progress is our most important product

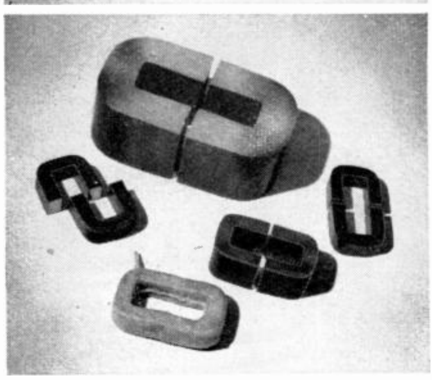
GENERAL ELECTRIC



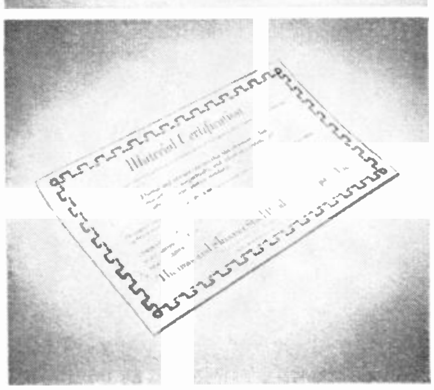
PERMANENT MAGNETS Whatever your needs — Alnico, cobalt, chromium—Thomas & Skinner can meet your specifications for either standard designs or special shapes. Typical of T&S advanced materials is Alnico 5Cb, offering an energy product of 5.70 million *nominal.* And typical of T&S advanced techniques is shell-molding, offering intricate shapes with tolerances as close as ± .005″ without grinding or finishing.



ELECTRICAL LAMINATIONS Geared to high volume production, T&S uses the most modern equipment available to produce high quality laminations in quantity at the lowest prices possible. Rigid quality control is maintained through each phase of production—stamping—atmosphere annealing— every vital step in producing top quality laminations. For every type application, T&S can provide all grades, all gauges to meet your demands for standard or special laminations. T&S's OrthoSil is also available for applications requiring directional electrical characteristics with extreme high permeability and low core loss.



WOUND CORES You can save on both assembly costs and time —and reduce both size and finished weight—with "C" Type and Toroidal Wound Cores made from T&S OrthoSil. The directional magnetic characteristics and extremely rectangular hysteresis loop of oriented OrthoSil have proved advantageous on hundreds of applications, particularly in 400 cycle equipment at flux densities of 15,000 gauss and over.



Did you know... that you can now buy electrical laminations that are pre-tested with the certified reports sent to you with each shipment. Yes, Thomas & Skinner certifies that each order of laminations is tested and meets the most rigid specifications . . . you receive test figures for both core loss and exciting current *at* 10M gauss on each heat annealed. This means an additional savings to you since it eliminates the need for retesting on your part. Many of the leading transformer manufacturers specify T&S CERTIFIED LAMINATIONS. Perhaps you should too!

write today for free catalogs!

Thomas & Skinner
STEEL PRODUCTS COMPANY, INC.
1125 EAST 23RD STREET
INDIANAPOLIS, INDIANA

UHF ATTENUATORS

UHF ATTENUATORS, MODELS AT-50, AT-60

50 ohm resistive T-networks of concentric line construction.

FREQUENCY RANGE: AT-50: DC to 4000 MC.
AT-60: DC to 3000 MC.

VSWR: Better than 1.1 at all frequencies.

ACCURACY: ±½DB.

RATED POWER: AT-50: 1W continuous • 1KW peak
AT-60: 2W continuous • 2KW peak

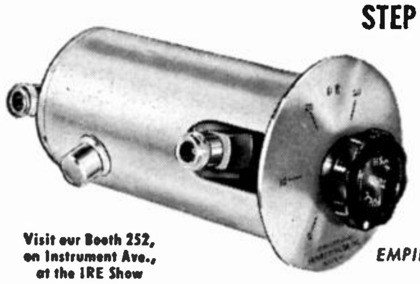
ATTENUATION: Standard: 3, 6, 10, 20, 40 or 60 DB.

AT-50

AT-60

SPECIAL VALUES UPON REQUEST

STEP ATTENUATOR MODEL AT-101



Uses AT-50 pads in multiple step coaxial turret arrangement.

AT-101A, ATTENUATION: 0, 10, 20, 30, 40, 50 DB.

AT-101B, ATTENUATION: 0, 20, 40, 60 DB.

Visit our Booth 252, on Instrument Ave., at the IRE Show

EMPIRE DEVICES' expert engineering staff is available to give careful attention to your inquiries.

edp | EMPIRE DEVICES PRODUCTS CORPORATION

38-15 BELL BOULEVARD • BAYSIDE 61, NEW YORK

MANUFACTURERS OF

FIELD INTENSITY METERS • DISTORTION ANALYZERS • IMPULSE GENERATORS • COAXIAL ATTENUATORS • CRYSTAL MIXERS

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now... RESINITE brings you the HIGHEST RESISTIVITY of any RESINATED PRODUCT

Resinite Coil Forms are laboratory tested and field proven. Their operating characteristics—volume resistivity . . . power factor . . . thermal properties . . . low moisture absorption . . . and resistance to voltage breakdown — represent a new achievement in basic components for electronic application.

Resinite Coil Forms are available with inside or outside threads, slotted, punched or embossed. Axial pressure in excess of 25 lbs. is accomplished through a special three-row threaded design. Torque can be controlled to + or —1 in. oz.

RESINITE 8104: for coil forms requiring very high dielectric properties under extreme humidity.

RESINITE "AC": for applications requiring very high dielectric strength. ELECTROLYTIC CORROSION IS IMPOSSIBLE.

RESINITE 104: for stapling, severe forming, fabricating.

Send today for full details and technical information.

RESINITE CORPORATION

DIVISION OF PRECISION PAPER TUBE

2035G W. Charleston St., Chicago 47, Ill.
79 Chapel St., Hartford, Conn.

What to See at the Radio Engineering Show

(*Continued from page 224A*)

HYCOR

Precision Resistors
Potentiometers
Toroids
Filters

BURLINGAME ASSOCIATES
234-236 Instruments Ave.

I-T-E CIRCUIT BREAKER CO.
Resistor Division
PHILADELPHIA 30, PA.

719 AIRBORNE AVENUE

Power, Precision and Specialty resistors, Potted Resistor Networks, TV Deflection Yokes, Focus Coils, IF and RF Transformers and Coil assemblies, RF Chokes, RF Output Transformers, Antenna Transformers, buffers, doublers, mixers, linearity and peaking coils, any stage tuners and other specialty wire-wound electronic products.

Illinois Condenser Co.
408 Electronic Ave.

Manufacturers of electrolytic and motor-starting capacitors, engineered to meet rigid requirements of industry. Highest quality, fully guaranteed.

Illinois Tool Works, Shakeproof Div., 739 Airborne Ave.
Applications for demonstrations of SHAKEPROOF fastenings used by the radio industry: *Plasti-Grommets, Plasti-Rivets, Lock Washers, Stamped Gears, Terminals, Sems, and special fastenings.

The Indiana Steel Products Co.
523 Components Ave.

"Permanent Magnet Engineering Service" is featured. Magnets of all types are on display: Hyflux Alnico V; Indox 1—a new ceramic magnet; Cunife; loudspeaker and magnetron magnets; etc.

Induction Motors Corp.

WESTBURY LONG ISLAND

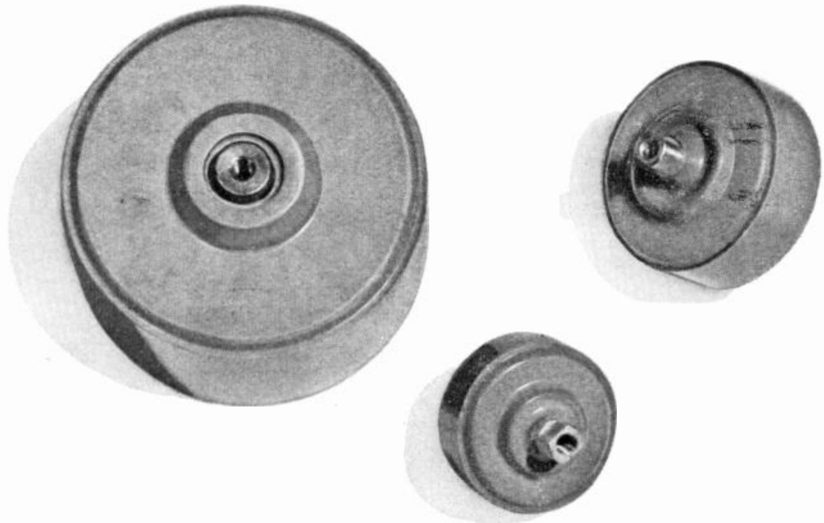
734 AIRBORNE AVENUE

Servo, Gear, Blower, Actuator and Torque Motors: synchronous and non-synchronous in ratings from 1/1000 to 1/10 horsepower.

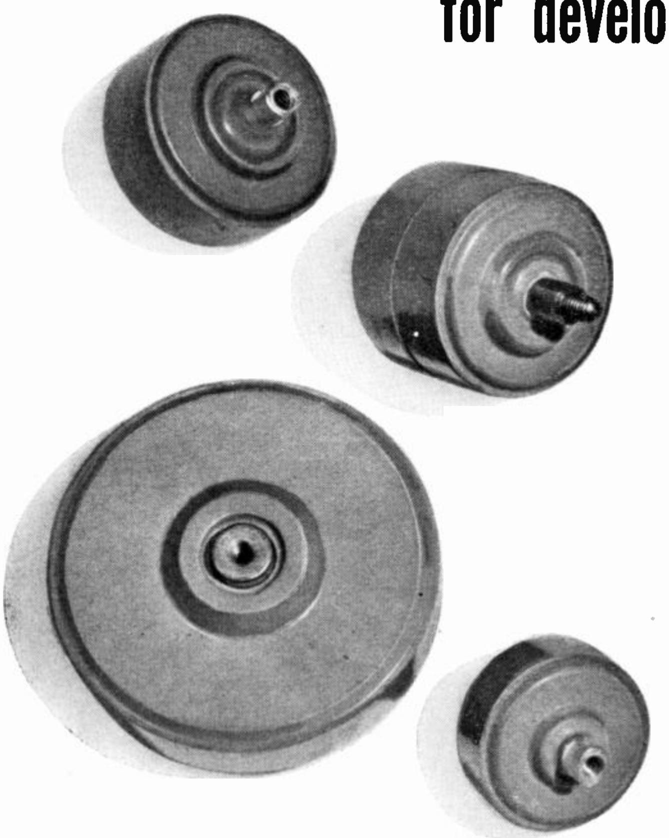
*Indicates new product

(*Continued on page 230A*)

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM



Need a complete complement* of High Voltage Capacitors for developmental color TV?



Leaders for over two years in experimentation with component parts for color TV, Jeffers Electronics has developed this first complete complement of high-voltage capacitors.

Each set includes the following units:

No. per kit	Capacity	Voltage Rating
1	10,000 MMFD	6KV
1	2,000 MMFD	30KV
1	500 MMFD	30KV
2	1,000 MMFD	10KV
3	1,200 MMFD	15KV

**Typical quantities proposed*

Drawings and additional technical information furnished on request. Complete kits of above high-voltage capacitors available at nominal cost.

Look to Jeffers for leadership in color TV components. In the past 5 years alone, Jeffers has produced over 7 million high-voltage capacitors.

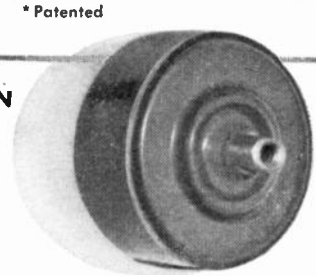
OTHER JEFFERS PRODUCTS

ceramic capacitors • disc capacitors • capristors
R.F. choke coils • high voltage condensers

OTHER SPEER PRODUCTS FOR THE ELECTRONICS INDUSTRY

anodes • contacts • resistors • iron cores
discs • brushes • molded notched* coil forms
battery carbon • graphite plates and rods

* Patented



JEFFERS ELECTRONICS DIVISION
SPEER CARBON COMPANY
Du Bois, Pennsylvania

JEFFERS ELECTRONICS

Other Divisions: Speer Resistor, International Graphite & Electrode

What to See at the Radio Engineering Show

(Continued from page 228A)

Industrial Hardware Mfg. Co., Inc.
579 Components Ave.

Laminated tube sockets, Half-moon duodecal sockets, Anode, connectors, Interlock plugs, Terminal strips, Wired assemblies, Metal or bakelite stampings, Terminal board assemblies, Tuner strips, sockets and brackets for UHF.

Industrial Instruments, Inc., 637 Circuits Ave.
High-speed automatic capacitance & resistance sorter. Variable high voltage breakdown tester. AC Wheatstone Bridge. Latest model Wheatstone Bridge. Potentiometer noise and taper checker.

Industrial Laboratories Pub. Co., 322 Computer Ave.
New communication medium between industry and all graduate students working for engineering and industrial science degrees in all universities and colleges in U.S. and Canada.

Industrial Products Co., Div. of Danbury-Knudsen, Inc., 794, 796 Broadcast Way.
R F Components—Connectors.

"The Manufacturer's Manufacturer"
Industrial Television, Inc.
221 Instruments Ave.

Oscilloscope OS-4A/AP, Color Monitors, Black & White Monitors, UHF Boosters, UHF-VHF Field Strength Meters, Television Couplers, Accessories.

PHAZOR **BOOTH NO. 309 COMPUTER AVE.**

Features the new in Phase Meters, Null Meters, Impedance Comparators, Power Oscillators and other Electronic Test Equipment.

Industrial Test Equipment Co.
NEW YORK, N. Y.

Instrument Specialties Co., Inc.
867 Audio Ave.

Assorted styles of beryllium copper finger stock for grounding and bonding strips. Beryllium copper contact rings of various diameters. Available from stock.

(Continued on page 232A)

FIRST AID ROOM

A nurse is in charge at all times. First Aid Room is the third room to left of Lobby directly off registration area.

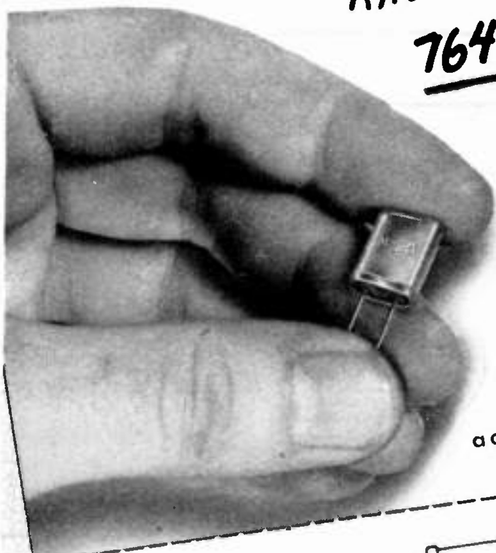
REMINDER!

BE SURE TO SEE THESE AT McCOY BOOTH

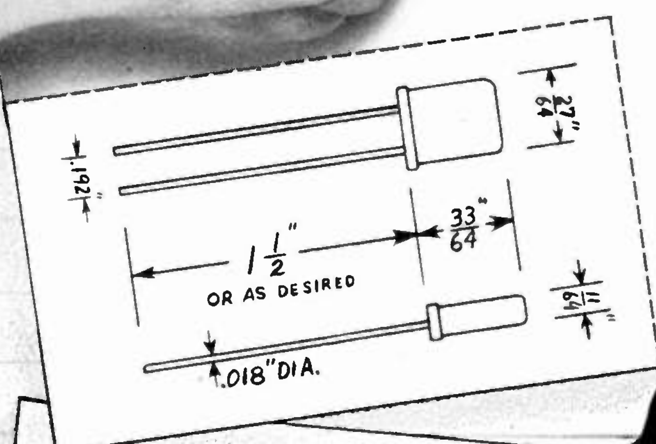
RADIO ENGINEER'S SHOW

764 AIRBORNE AVE.

McCOY M-20 "McMITE" SUB-MINIATURE CRYSTAL



(shown actual size)



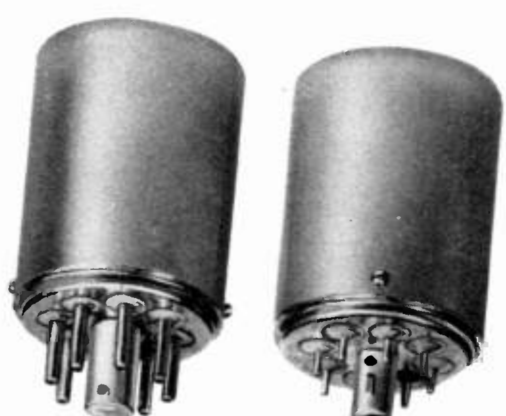
The McCoy M-20 "McMite" is a Subminiature hermetically sealed unit which delivers the same performance as a regular sized crystal, yet takes up just *one-fifth* the space formerly required.

The M-20 "McMite" Subminiature crystal meets Military characteristics and performance requirements for fundamental operation above 10 mc and overtone operation above 15 mc without any sacrifice of stability or dependability.

Now available for engineering and production quantities.

FREQUENCY RANGE
10.0 mc to 110 mc

McCOY MO-1 (OCTAL) MO-1L (LOCTAL) CRYSTAL OVENS



MO-1 (OCTAL) MO-1L (LOCTAL)

MO-1 (OCTAL)
Hermetic or gasket seal.
Holds 1 or 2 McCoy M-1 (HC-6/U) crystal units.

Temperature	65°C to 85°C (adjustable)
Stability	± 5°C from nominal
Ambient Ranges	— 55° C to 5° C below nominal

Power: less than 6 watts. 6, 12 or 24 volt operation.

MO-1L (LOCTAL) see description MO-1

One or the other of these McCoy Ovens is the answer to the problem of maintaining close temperature control in all transmitting and receiving equipment—moble, railway, marine and aircraft.

If you can't make the show, write, wire or call us for full information on these or any other of your crystal requirements.

McCoy
ELECTRONICS COMPANY
MT. HOLLY SPRINGS, PA.

What to See at the Radio Engineering Show

(Continued from page 230A)

Instruments for Industries, Inc., 717 Airborne Ave.
Unique packaged r-f and i-f amplifiers, low noise, very wide bandwidth, flat response, high gain. Also novel motor control providing smooth operation, large torque at extremely low speeds.

Instruments Publishing Co., Inc., 218 Instruments Ave.
Magazines and books on instrumentation, automation, research.

Insuline Corp. of America
430 Electronic Ave.
Electronic Housings and components.

International Electronic Research Corp. (of Calif.) 813 Audio Ave.
Tube shields for miniature and subminiature vacuum tubes.

International Instruments, Inc., 763 Airborne Ave.
*Miniature side Reading Indicator, Model 1120. Complete Line miniature and sub-miniature electrical measuring instruments for Government or commercial electronic and audio equipment.

International Nickel Co., Inc., 173, 270 Transistor Way
*Ultrasonic tool cuts hardest materials; *Ultrasonic burglar, fire alarm; parts, new Sperry tuning-fork type gyroscope; *color TV mask; self-powered telephone.

International Pump & Machine Works
784 Airborne Ave.
International vacuum pump #106, Mobile exhaust unit. Featuring: Ionization gauge, absolute pressure gauge, three-stage diffusion pump, flow switch, vacuum shut-off valve 0.1 Micron.

International Radiant Corp., 903 Registration Row.
Be sure to obtain the new information on the fan and dust unit capable of meeting all government specifications. Manufacturers of low and high temperature chambers, altitude, humidity, explosion and walk-in chambers.

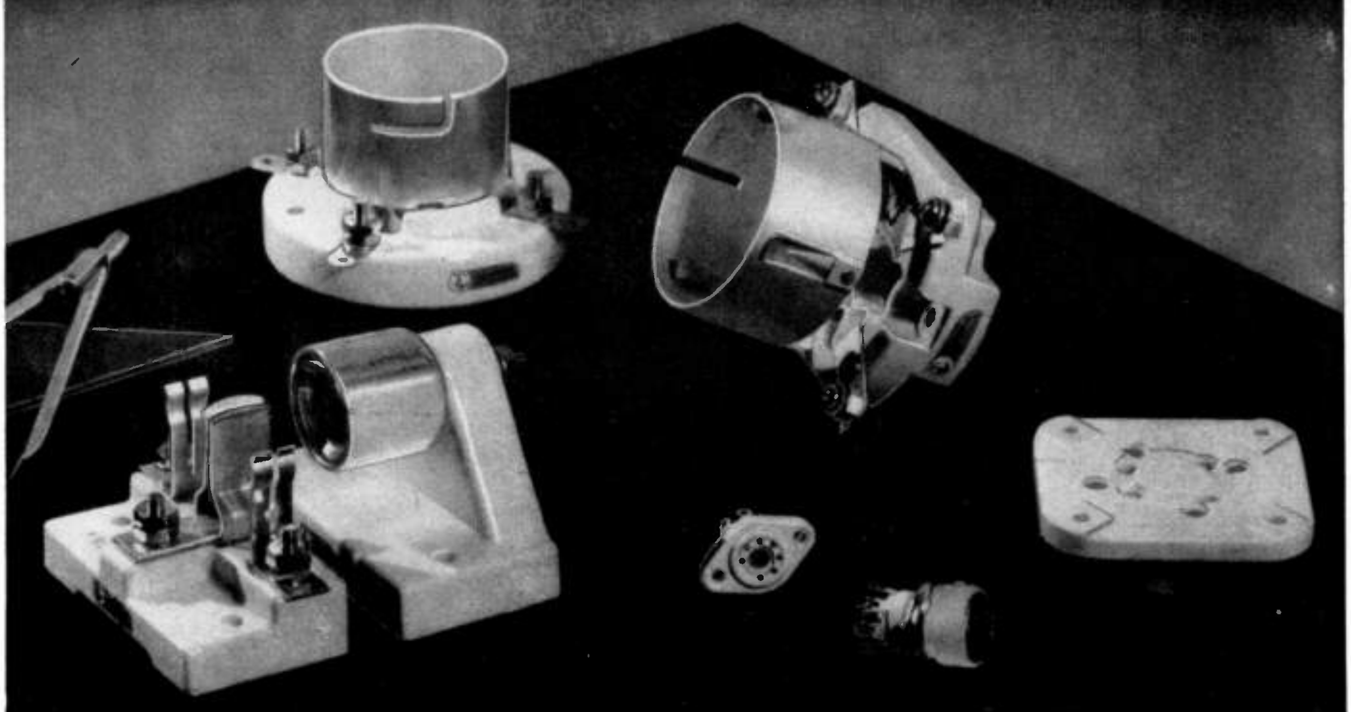
IRC INTERNATIONAL RESISTANCE CO.
Phila., Pa.
553 and 555 Components Ave.
Boron and Deposited Carbon Precistors • Insulated Composition Resistors • Low Wattage Wire Wounds • Power Resistors • Voltmeter Multipliers • Volume Controls • Insulated Chokes • Precision Wire Wounds • Ultra HF and Hi-Voltage Resistors • Hermetic Sealing Terminals

*Indicates new product

(Continued on page 236A)

Want to join the IRE? Come to IRE Room—to right of Lobby!

Announcement to the industry...



WHY TUBE SOCKET STANDARDIZATION?

A message from the E. F. Johnson Company

Standardization means different things to different people. To you—the design engineer or manufacturer specifying or purchasing tube sockets, Johnson's new standardization program offers *three* definite advantages.

1. Simplified selection of components.
2. Shorter delivery cycles.
3. Superior sockets at the same or lower cost, due to the elimination of special set-up and tooling charges.

In the past, selection of materials for commercial, industrial, and military sockets resulted in anywhere from 15 to 50 variations of each socket. This program permits the maintenance of stock on industrial and military types as well as standard commercial models. Immediate shipment of small quantities is hereby made possible for development or pre-production runs. Small run set-up charges will thus be eliminated, and manufacturers ordering sockets to their specification will receive equal or superior quality sockets, in most cases at a lower cost.

STANDARD—A standard grade commercial socket for all general requirement,. Grade L4 steatite bases, Dow Corning 200 impregnated or white glazed porcelain. Phenolic washers are fungus resistant, glass base melamine. Contact materials vary with tube socket types.

INDUSTRIAL—A higher quality socket incorporating such features as DC 200 impregnated glazed steatite bases and .0005 silver plated contacts with phosphor bronze clips and beryllium copper springs. Aluminum shields on shield base types are irridite No. 14 treated to prevent corrosion.

MILITARY—A top quality socket designed to meet all military requirements. Incorporating the finest materials and plating, glazed steatite bases are DC 200 treated—grade L4 or better. Contacts have phosphor bronze clips and beryllium copper springs, both heavily silver plated. Fungus resistant cushion washers are of glass base melamine. All solder terminal ends—hot tin dipped. Bayonet shield base types have brass shells, .0003 nickel plated. Threaded hardware, .0002 nickel plated—unthreaded hardware, .0003 nickel plated. Entire socket fully protected to meet 200 hour salt spray requirements.

E. F. JOHNSON COMPANY

2110 Second Avenue Southwest • Waseca, Minnesota

CAPACITORS • INDUCTORS • SOCKETS • INSULATORS • PLUGS • JACKS • KNOBS • DIALS AND PILOT LIGHTS

1954 NEW! advances in communication continue to be foremost in

NEW! TWINPLEX COMMUNICATION UNITS

• provide 2 channels of FS communication with existing single channel transmitter and receiving facilities—with performance comparable to the existing single channel system

This Twinplex communication system makes possible a 2-channel radio circuit whereby 2 non-synchronous or synchronous telegraph transmissions modulate a single radio carrier wave by causing the carrier to assume one of four specific frequencies with 400 cps separations.

The transmitting equipment consists of the Twinplex Combiner Type 177 Model 1 and an RF Frequency Shift Keyer such as the Northern Radio Type 105 Model 4. The Combiner converts the four possible conditions of two telegraph signals (M1-M2, M1-S2, S1-M2, S1-S2) respectively into one of four voltages related in a 0-1-2-3 manner. The Combiner output voltage modulates the FS Keyer.

The receiving equipment consists of the Twinplex Converter Type 178 Model 1 and a single or diversity receiver such as the Northern Radio Type 110 Dual Diversity Receiving System. The Converter demodulates and separates the four audio tones from the radio receiver(s) into two channels each carrying the originally transmitted intelligence. The Twinplex Converter replaces the standard FS Converter for this purpose.

The two telegraph channels provide the same operational flexibility as that of two separate single channel FS systems. One can, for example, simultaneously use channel #1 on 60 wpm teletype and channel #2 on high-speed Morse or Time Division Multiplex. It further permits the reception of channel #1 signals on all standard FS converters (tunable to 400 cps shift) without need for a Twinplex Converter: this is valuable for "Forked Circuit Operation" where the intelligence of channel #1 is intended for pick-up by other receiving stations which are not equipped for Twinplex Reception in addition to the main receiving stations which are so equipped. Reception of channel #2 (or of both channels) requires the receiving end to be equipped with a Twinplex Converter.

Write for complete information.

- Frequency Shift Keyers
- Master Oscillators
- Diversity Receivers
- Frequency Shift Converters
- Multi-Channel Tone Systems
- Tone Keyers
- Demodulators
- Monitors
- Radio Multiplex Systems
- Tone Filters
- Line Amplifiers
- Twinplex Equipment

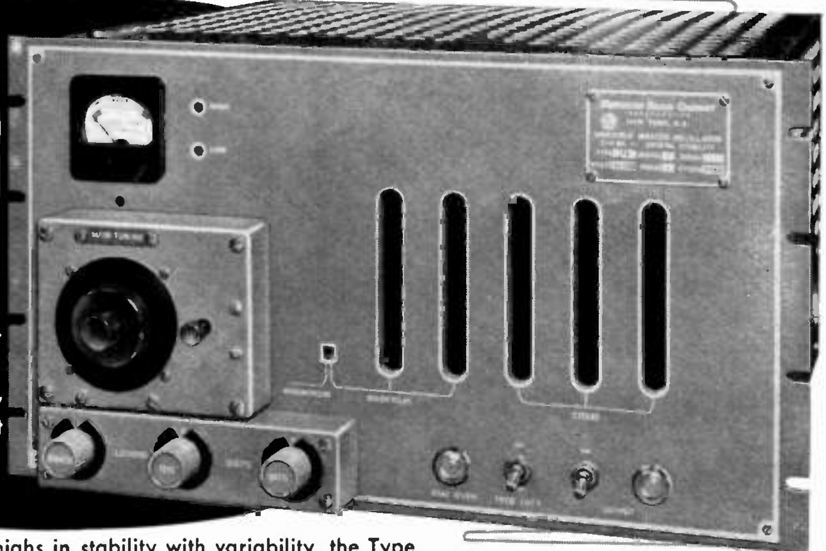
SEE OUR IRE EXHIBIT BOOTH #197,198

NORTHERN RADIO equipment

accuracy, stability and versatility

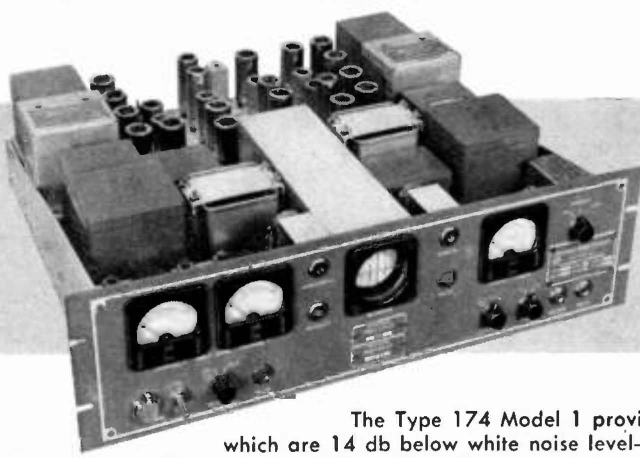
NEW! VARIABLE MASTER OSCILLATOR

- Long-time stability 1 cycle per megacycle
- Variable to ANY frequency from 2 to 4 mc within 1 part per million



In addition to accomplishing these new highs in stability with variability, the Type 173 Model 1 is so easy to operate that it can be handled by completely unskilled personnel: frequency is continuously displayed.

It is excellent as the basic control oscillator for diversity receivers, HF transmitters, and other communication devices, or as a laboratory standard. It also provides both a crystal-controlled BFO and a time base 100 kc crystal oscillator as a secondary standard; stability of the latter is 1 part in 5 million. The power supply for this model is housed in a separate panel.



NEW! FREQUENCY SHIFT DIVERSITY CONVERTER

- for use with *either* single-receiver frequency diversity systems or two-receiver space diversity systems

The Type 174 Model 1 provides solid copy of signals which are 14 db below white noise level—making it the outstanding unit of today. By means of plug-in units, any reasonable number of channels is available between the frequencies of 425 and 3315 cps for either frequency or space diversity operation. For standard FS operation, the plug-in networks provide shift adjustments from 100 to 1000 cps shift.

NORTHERN RADIO COMPANY, inc.
147 WEST 22nd ST., NEW YORK 11, NEW YORK
Pace-Setters in Quality Communication Equipment

SEE OUR IRE EXHIBIT BOOTH #197,198

What to See at the Radio Engineering Show

(Continued from page 232A)

J-B-T Instruments, Inc., 205 Instruments Ave.
Vibrating Reed Frequency Meters; Elapsed Time Meters; *Toggle Switches, JAN-S-23 quality; Lever Action Switches, 3, 4, and *enclosed 5 position type; Rotary Selector Switches; Switch Kits; Pyrometers; 2" Electrical Instruments, Shorite panel and pocket AC & DC voltmeters, ammeters, and milliammeters.

JFD Electronics

JFD MFG. Co. Inc.
Brooklyn 4, New York
Booth 123, Military Ave.
Piston Capacitors, Military Communication Equipment, TV Antennas and Accessories.

Jennings Radio Mfg. Corp.
436 Electronic Ave.

Vacuum capacitors—*fixed and variable types. Vacuum relays—*coaxial, overload and multiple pole units. Vacuum capacitor voltage divider and *high voltage voltmeter.

Jerrold Electronics Corp., 139 Military Ave.
Color-tested Television Master Antenna Systems for apartments, hotels, schools, institutions. Closed circuit community television systems. Television field strength meter; rf preamplifier and fixed frequency UHF converter.

Howard B. Jones Div.
Cinch Mfg. Co.
394-396 Broadcast Way

Multi-contact plugs and sockets—barrier terminal strips—fanning strips—terminal panels—fuse mounts.

M. C. Jones Electronics Co., Inc., 685 Circuits Ave.
MicroMatch Standing Wave Ratio and RF Power Measuring Equipment—RF Absorption Type Wattmeters—Dummy Load Resistors—and *additions to a Series of Directional Couplers.

Kaiser Electronics Div. of Willys Motors, Inc., 704 Airborne Ave.

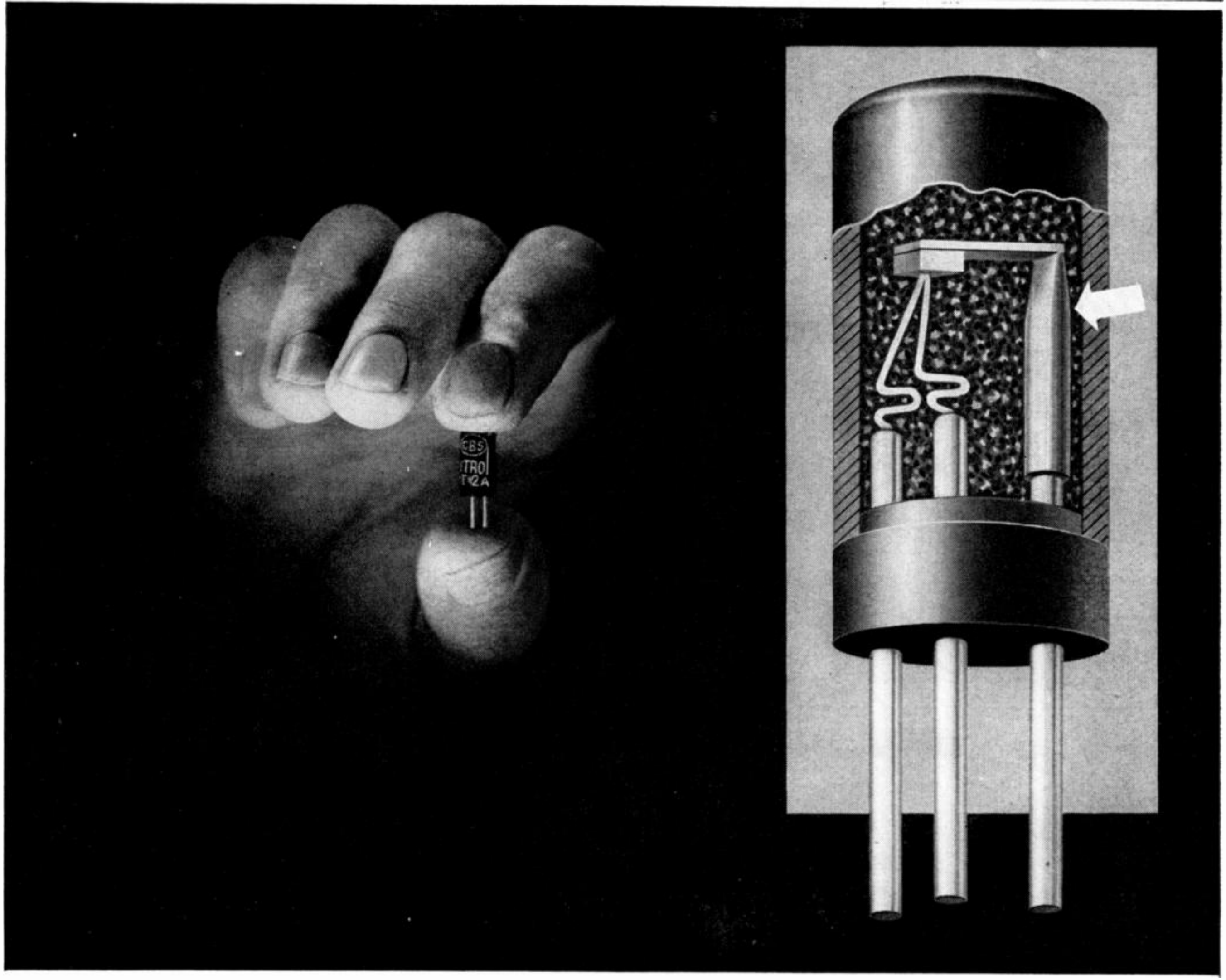
Karp Metal Products Co., Inc.
349 Computer Ave.

Cabinets, chassis, housings, racks and enclosures especially fabricated for the electronics industry. Exhibit shows complex units produced entirely with stock tooling; examples of advanced welding and finishing techniques; shows how enclosures can be made attractive and functional at low cost.

*Indicates new product

(Continued on page 238A)

Look what's happened to the "cat's whiskers"

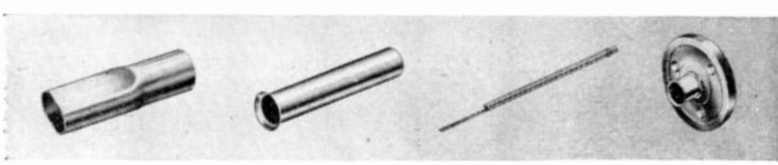


A miracle that can hide behind your thumb-nail is the hottest electronics news in years. Modernized descendant of the Twenties' crystal diode with its cat's whisker, the transistor threatens to send many vacuum tubes the way of old head sets.

No matter which ultimately gets the nod—tube or transistor—Superior will be in there pitching. Superior seamless and Lockseam* nickel cathodes, anodes and grid cups are familiar to you in vacuum tubes. Now Superior tubing is going into transistors.

CBS-Hytron, a division of Columbia Broadcasting System, Inc., uses Superior tubing for the L-shaped bracket that holds the germanium crystal in their PT-2A point-contact transistor. For this purpose they purchase tiny tubes—.032″ I.D. x .003″ wall. .193″ long, drawn from seamless nickel. Added to the good welding, soldering and formability characteristics of the metal. Superior manufactures the brackets to the close tolerances CBS-Hytron must have.

Whether you are for the old or new order in electronics, if you need an idea or an analysis in small tubing, Superior is the first place to look. Superior Tube Company, Electronics Division. 2506 Germantown Ave., Norristown, Pa.



Superior
THE BIG NAME IN SMALL TUBING

All analyses .010″ to ⅝″ O.D.
Certain analyses in Light Walls up to 2½″ O.D.

SeamlessNickelAnode. Flattened one end. .500″ O.D. x .025″ Wall x 1.625″ long.

Seamless Nickel Cathode. Round, flanged one end, .070″/.072″ I.D. x .0025″ Wall. .295″ long.

Lockseam* Nickel Cathode. Round, tabbed, single bead, .045″ O.D. x .0021″ Wall. 27 mm long.

Disc Cathode .121″ O.D. .312″ long.

Many types of nickel cathodes—made in Seamless and Lockseam* from nickel strip, disc cathodes, and a wide variety of anodes, grid cups and other tubular fabricated parts are available from Superior. For information and Free Bulletin, address Superior Tube Company, Electronics Division, 2500 Germantown Avenue, Norristown, Pa.

***Manufactured under U.S. Patents.**

What to See at the Radio Engineering Show

(Continued from page 236A)

C. B. Kaupp & Sons
720 Airborne Ave.

Precision formed metal components for production. . . . Economical "Hydroformed" parts for development.

Kay Electric Co.
242-246 Instruments Ave.

*Complete radar noise figure measuring equipment, *transistor curve plotters, *precision x-band tunable CW signal sources, *receivers for low level microwave measurements, *K-band random noise sources, *precision decade switched oscillators, *color, UHF and VHF TV test equipment.

Kay-Lab. (Kalbfell Laboratories, Inc.), 263 Instruments Ave.
*Television Camera Systems featuring a high degree of flexibility and features of interest to both broadcasters and industrial users. *Super-Regulated and Absolute DC Power Supplies. An expanded line of *Meter Calibrators.

Kearfott Company, Inc.
Little Falls, N. J.

722 Airborne Ave. 154 Television Ave.

AIRCRAFT NAVIGATION SYSTEMS
AIRCRAFT INSTRUMENTS • SYNCHROS
SERVO MOTORS • TACHOMETER
GENERATORS • GYROS (FREE, RATE, VERTICAL) • MAGNETIC AND SERVO AMPLIFIERS • HERMEFLEX • ANGLE COUNTERS • INDUSTRIAL SERVO SYSTEMS

Kemtron Electron Products, Inc., 313 Computer Ave.
Diodes (germanium and silicon). Transistors and circuit applications.

F. C. Kent Company, 790 Airborne Ave.
Precision bending and forming of waveguide and round tubing in brass, aluminum, magnesium, steel, in all sizes.

The latest in transformers
Miniature, Molded,
Cased, Oil Filled, T-Line,
Toroids, at Booth 541.

KENYON TRANSFORMER CO., Inc.
840 Barry St., New York 59

Kepco Laboratories
342, 344 Computer Ave.

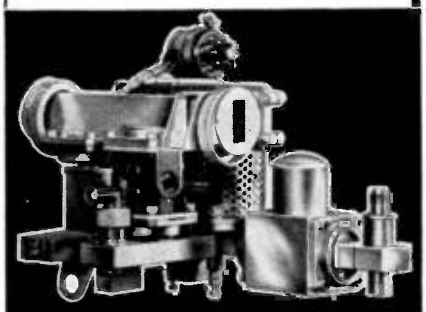
Super voltage-regulated power supply (DC voltage regulated to 0.01%). Will show 16 of 30 standard DC voltage-regulated power supplies. Low voltage, high and low current; medium voltage, high and low current; high voltage, high and low current.

*Indicates new product

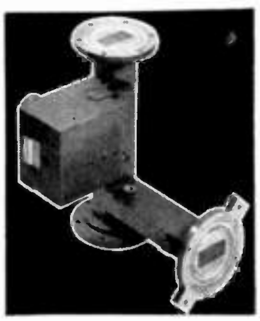
(Continued on page 240A)

The
WAVEGUIDE
House

Under our roof are all facilities needed for high quality production of microwave components, supervised by a top-flight engineering staff—quality is controlled every step of the way—



For components from mixer-duplexer combinations to low-cost, high quality link wave-guides, consult us!



Look us up at
I.R.E. Convention
Kingsbridge Armory, N.Y.C.
Booth: 723 Airborne Ave.

Brochure on request

PRECISION IS PREMIER

TRADE MARK

PREMIER
INSTRUMENT CORP.
52 West Houston Street
New York 12, N. Y.

NOW

NEW YORK—
73 RUTLEDGE ST., BROOKLYN 11, N. Y.

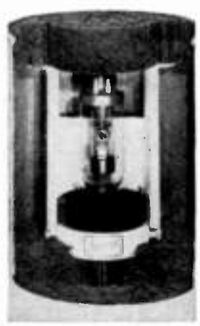
CARGO PACKERS
EAST & WEST COAST
PACKAGING SERVICE!

CALIFORNIA—
2050 BROADWAY, SANTA MONICA

Individually-engineered
CLIMATE-PROOF, SHOCK-PROOF PACKAGING

To meet the increased, country-wide demands of the electronics industry. Cargo Packers has now inaugurated complete facilities in the West Coast area also, for packaging protection of delicate instruments, equipment and components, including

- **Special Assembly Equipment**
- **Experts in Military Specifications**
- **Economical Production line methods**
- **Full Compliance in Every Detail**
- **Competent Consulting Service**



12-PAGE BROCHURE tells how to avoid the pitfalls, gives complete detailed information on C-P methods of protective packaging.

Whether in storage or in transit anywhere, absolute protection against strain, stress, shock, vibration, temperature or humidity fluctuations, moisture—or even skin damage—is assured by Cargo Packers' individual attention to every job. For recommendations on specific packaging problems, call or write our Sales-Engineering Department today.

CARGO PACKERS
INCORPORATED
New York—73 RUTLEDGE ST., BROOKLYN 11, N. Y.
California—2050 BROADWAY, SANTA MONICA

CLIMATE-PROOF PACKAGING

SPECIALISTS IN
CLIMATE-PROOF, SHOCK-PROOF
PACKAGING FOR ORDNANCE AND INDUSTRY

VISIT US AT THE I.R.E. SHOW—BOOTH 141 MILITARY AVENUE

What to See at the Radio Engineering Show

(Continued from page 238A)

Kester Solder Co.
521 Components Ave.

*Very latest development in Kester "Solderforms" (Preformed Solder) Nothing like it before! Washers, Discs, and Special Stampings of Solder that are FLUX-FILLED! NO Other Flux Needed.

Ketay MANUFACTURING CORP.
555 Broadway, New York 12, N. Y.
Booths 629-631 Circuits Ave. at Radar Rd.
Synchros · Resolvers
Servo Motors · Magnetic Amplifiers
Induction Motors · Overload Transformers
Automatic Control Equipment
NEW YORK, N. Y. · HAWTHORNE, CALIF.

Kimble Glass Co., 142, 146 Military Ave.
Glassware including television bulbs and a variety of electronic glassware for industry.

KINETIX INSTRUMENT DIVISION
Ketay MANUFACTURING CORP.
902 Broadway, New York 10, N. Y.
Booths 629-631 Circuits Ave. at Radar Rd.
Synchros · Resolvers
Servo Motors · Gyro Components
Electronic Equipment
NEW YORK, N. Y. · COMMACK, LONG ISLAND

Kings Electronics Co.
506, 508 Components Ave.

Coaxial connectors, RF fittings, microwave assemblies, waveguide components, antennas, test sets, cable assemblies, mounts.

The James Knights Co.
516 Components Ave.

Crystals for the Critical

Quartz crystals and holders; Quartz oscillator plate; Filter and ultrasonic crystals; Phenolic, Hermetic-sealed holders; Ovens of all sizes and capacities; Tourmaline and Quartz crystals.

Kotron Rectifier Corp., 744 Airborne Ave.
Selenium Rectifiers.

*Indicates new product

(Continued on page 242A)

Show Hours:
Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

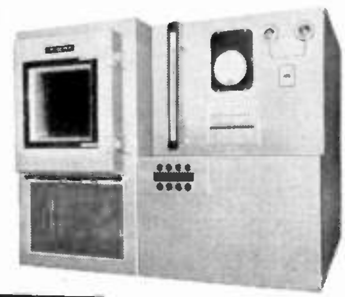
temperatures! atmospheres! pressures!

FOR ACCURACY TEST WITH Tenney

For Tenney Test Chambers are precision-engineered for maximum efficiency and can be designed to simulate the complete range of temperature, atmospheric or pressure conditions found anywhere on earth—or above it to altitudes of 120,000 ft. plus! They attain sub-zero temperatures quickly, maintain them efficiently and provide full instrumentation for accurate evaluation of complete test data.

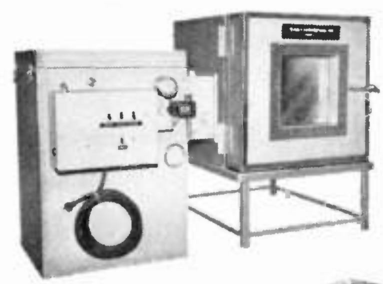
TENNEYZPHERE ALTITUDE CHAMBERS

Designed to withstand atmospheric pressure and to simulate global conditions of pressures, temperatures and humidities. Altitudes from sea level to approx. 80,000 ft. Temperature range from plus 200°F to minus 100°F. Also simulates desired (20% to 95%) relative humidity.



TENNEY SERVO UNIT

Portable air conditioning unit which may easily be attached to various types of laboratory enclosures —impact machines; tension machines; torsion testers; cold boxes and similar equipment. Through its use, articles undergoing testing, aging or weathering can be subjected to wide variations of humidity, heat and cold. Photo shows servo attached to companion chamber.



TENNEY TEMPERATURE AND HUMIDITY CHAMBERS

These chambers provide positive control of wet- and dry-bulb temperatures, humidity, and air circulation; and are designed for research and production testing of physical quality, fragility, tension, and all other pertinent factors, at constant conditions or on planned program cycles.

Model TR—Precision recorder controllers permit accurate simulation and check of temperatures to +200°F. Meets all Mil and JAN specifications for low- and high-temperature requirements by incorporation of temperatures down to −100°F. Humidities within 20%-95% range. Built in a variety of standard sizes.

Model TH—Specifically designed for a temperature range of +35°F to +180°F, and a humidity range of 20%-95%. Accurately simulates, controls, and checks all above-freezing temperatures. Can incorporate program control for meeting a wide variety of Mil specifications if desired. Manufactured in many standard sizes.

TENNEY SUB-ARCTIC INDUSTRIAL CABINETS

Designed for low-temperature testing of metals, radios, instruments, plastics, liquids, chemicals and pharmaceuticals. Ranges of −40°, −80°, −100°, −120°, −150° and −170°F, are standard for each size.

Tenney ENGINEERING, INC.

1090 SPRINGFIELD ROAD, UNION, N. J.

Plants: Union, N. J., Newark, N. J., Baltimore, Md.

Los Angeles Representative: GEORGE THORSON & CO.

For further information on these and other Tenney test equipment, write to Tenney Engineering, Inc., 1090 Springfield Road, Union, N. J.

Engineers and Manufacturers of Automatic Environmental Test Equipment

3531

Visit our Booth, 713 Airborne Ave., IRE Show

What to See at the Radio Engineering Show

(Continued from page 240A)

Krohn-Hite Instrument Co.
201 Production Rd.

*Ultra-low distortion amplifier—the ultimate in power amplification. *Ultra-high regulation power supplies—ideal for transistor research. Variable electronic filters. Ultra-wide range oscillators—0.001 to 100,000 cps.

Kulka Electric Mfg. Co., Inc., 425 Electronic Ave. Sub-miniature terminal blocks; molded convenience outlets; Kulka interlock and standard barrier type terminal blocks. DC bayonet sockets. JAN type switches, receptacles, candelabra, intermediate and medium base sockets.

Kupfrian Mfg. Co., 470 Electronic Ave. Flexible shaft couplings, and flexible shaft assemblies for remote control of potentiometers, tuners, switches, repeaters, revolution counters, and other instruments and components. Also electrostatic wire shielding, push-pull controls, universal joints, and portable motor generators.

Kuthe Laboratories, Inc.
905 Registration Row

Hydrogen thyratron tubes for discharging pulse-forming networks in high-power, high-voltage, pulse generator application.

LABSCOPE, INC.
precision
equal-amplifier
OSCILLOSCOPES
BURLINGAME ASSOCIATES
234-236 Instruments Ave.

Laboratory for Electronics, Inc.
Boston 14, Mass.
229,231 Instruments Ave.
326,328 Computer Ave.
L/E
Precision Electronic Equipment
Oscilloscopes
Magnetometers
Computers
Solid Delay Lines

*Indicates new product

(Continued on page 244A)

FIRST AID ROOM

A nurse is in charge at all times. First Aid Room is the third room to left of Lobby directly off registration area.

VOLTAGE REGULATED POWER SUPPLY

Model 2400

MULTIPLE POWER SUPPLY

OUTPUT	VOLTS	CURRENT	REGULATION	RIPPLE
1	0-150 Bias	0-5 Ma.	*	5 Mv.
2	0-400	0-150 Ma.	0.5%	5 Mv.
3	0-400	0-150 Ma.	0.5%	5 Mv.
2 & 3 Parallel	0-400	0-300 Ma.	0.5%	5 Mv.
2 & 3 Series	0-800	0-150 Ma.	0.5%	5 Mv.
4	6.3 AC	10 Amp.	★	
5	6.3 AC	10 Amp.	★	

REGULATION: As shown in table for both line fluctuations from 105-125 volts and load variation from minimum to maximum current.

*Regulation Bias Supplies: 10 millivolts for line 105-125 volts. ½% for load at 150 volts.

★All AC Voltages are unregulated.

KEPCO LABORATORIES

131-38 SANFORD AVENUE • FLUSHING 55, N. Y.

INDEPENDENCE 1-7000

VISIT OUR BOOTHS AT I.R.E. SHOW — #342-344 COMPUTER AVENUE

What to See at the Radio Engineering Show

(Continued from page 242A)

Lambda-Pacific Engineering, Inc., 910 Registration Row.
*A 6-7 KMc microwave link for TV and industry, featuring one watt power output, Co-Axial wavemeters, minimum phase shift, and "off the air" monitoring.

LaPointe Electronics, Inc., 285 Instruments Ave.
Television Antennas and Accessories.

Leland Electric Co., 106, 108 Military Ave.
A subsidiary of American Machine & Foundry Co. Demonstration of compact, lightweight inverters offering dependable regulation of voltage and frequency; with complete filtering; meeting AC requirements of aircraft and special applications

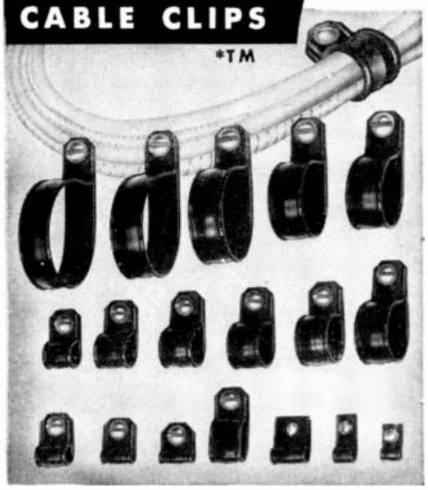
*Indicates new product

(Continued on page 246A)

Show Hours:
Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

NyGrip* CABLE CLIPS

*TM



Hold that wiring with these all Nylon cable clips

- ✶ Lightweight ✶ Tough ✶ Strong
- ✶ Chemically resistant
- ✶ No metal to corrode or cause short circuits
- ✶ Easy to apply ✶ No sharp edges
- ✶ May be used from – 60° to 250° F.

Send for samples and literature

WECKESSER COMPANY

5269 N. Avondale Ave., Chicago 30, Ill.

NEW Product Improvement at LOWER COST

Photocircuits

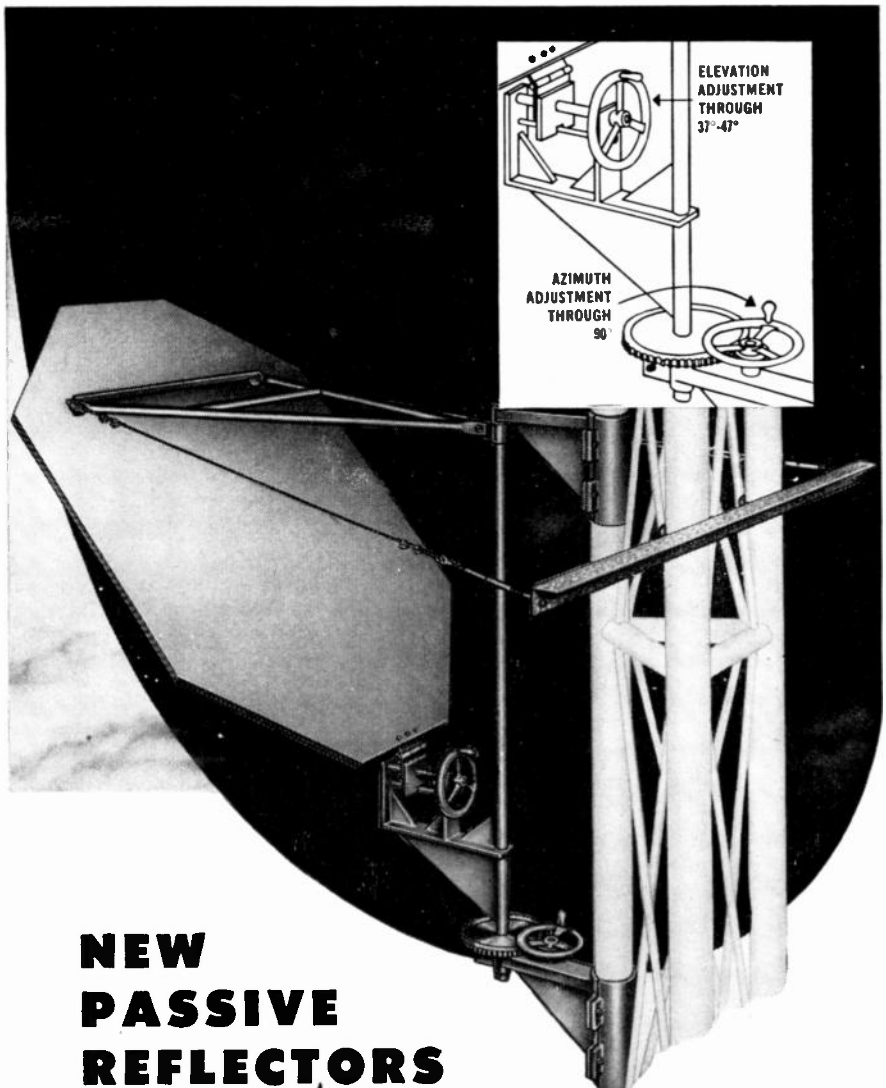
PRINTED CIRCUIT PANELS
DIP SOLDERED
Electronic SUB-ASSEMBLIES
with *PLATED-THRU HOLES*

Printed Circuit
SWITCH PLATES
COMMUTATOR DISCS
and associated
ELECTRO-MECHANICAL ASSEMBLIES

See examples of these at the
RADIO ENGINEERING SHOW
661-663 CIRCUITS AVE.
Literature on request!

Photocircuits CORPORATION

Dept. IRE-3, GLEN COVE, NEW YORK



NEW PASSIVE REFLECTORS

cut microwave relay costs

Total costs come down—each time a Gabriel Passive Reflector goes up. Mark these savings in time, manpower, and overall costs of tower installation with this new Gabriel design.

- **Save man hours**—a smaller crew spends less time on each installation. The all-aluminum, heliarc welded unit is easily hoisted into position where adjustable U-clamps have been set at required tower height.
- **Reflector adjustment is fast and precise.** Easily reached hand-crank and gear system gives exact station-to-station directivity through 90° in azimuth, through ±5° from 42° in elevation. Turnbuckled guy wires rigidly fix mount and reflector against heavy wind pressures.

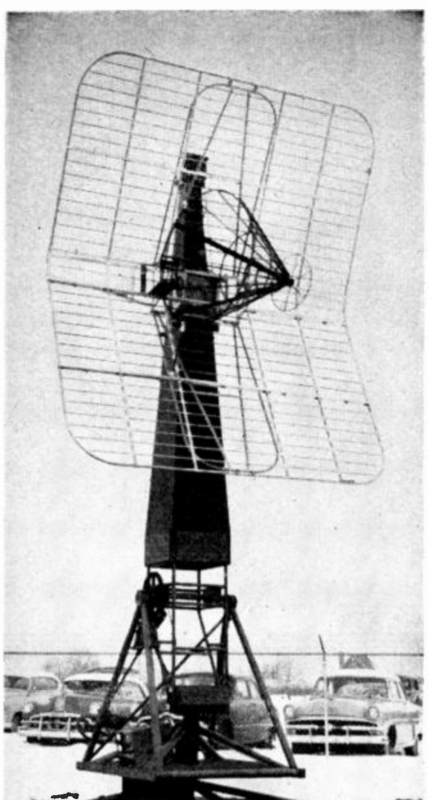
New research by our affiliate, The Gabriel Laboratories, has determined optimum reflector size, contour, and shape for greater gain characteristics with specific tower heights and antenna diameters. Reflectors are "sandwich" type, of aluminum sheets and honeycomb core bonded and sealed at edges.

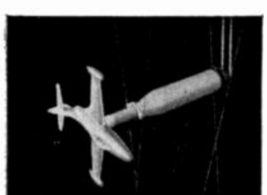
Write for mechanical specifications and specific systems application data. On Display at Booth 193-195 I.R.E. Show.

GABRIEL *electronics division*

FORMERLY WORKSHOP ASSOCIATES DIVISION
THE GABRIEL COMPANY, 210 ENDICOTT STREET, NORWOOD, MASS.

A GABRIEL PRODUCT





What to See at the Radio Engineering Show

(Continued from page 244A)

110 Military Ave.

Librascope, Incorporated
1607 Flower Street
Glendale 1, California
154, 156 Television Ave.

X-Y Plotter and Recorder operating from punched cards, key boards, and analog inputs. Analog-digital converter and analog computer components.

Lieco, Inc., 380 Microwave Ave.
New and improved types of High and Low Power Waveguide Dummy Loads, Waveguide Flanges, Broadband Waveguide Mitre Corners, All Types of Directional Couplers, Waveguide-to-Coaxial Adapters, and Engineering and Development Services.

Linde Air Products Co., Div. Union Carbide & Carbon Corp., 527 Components Ave.
Xenon, Krypton, Argon, Helium, Neon, and Rare Gas Mixtures as well as Synthetic Sapphire Boules, Rods and Balls.

Linear Equipment Laboratories, 786 Airborne Ave.
*Test equipment and laboratory accessories for use in UHF and color TV development. *Grid-Dip Oscillator, Wavemeter, Transformer-Balun; Lo-C Oscilloprobe and Square Wave Generator.

Littelfuse, Inc., 525 Components Ave.
Exhibiting small glass enclosed cartridge fuses, enclosed fuse holders, open style fuse holders, indicating type fuse holders, low voltage circuit breakers, custom designed fuse panels.

Little Falls Alloys, Inc., 682 Circuits Ave.
Non-ferrous Speciality Wires (not insulated) of *Titanium, Beryllium copper, Bronzes, Silver Plated Wires and Aluminum, used for Springs, Transistors, Grid Construction and other Electronic uses.

Lowell Mfg. Co., 858 Audio Ave.
Aluminum ceiling type speaker baffles, and back protective loudspeaker enclosures for low level sound distribution. Steel boxes and stampings for intercom in the home, hospitals, and industry.

*Indicates new product

(Continued on page 248A)

What to See at the Radio Engineering Show

(Continued from page 246A)

McMillen Laboratory, Inc., 814 Audio Ave.
Research, Development and Manufacturing in Microwave Optics, Radomes, Reinforced Plastics, Materials for wave traps and free space antenna test room, RF loads and low loss dielectrics, Electronic gas tubes, Geophysics.

M B Manufacturing Co., Inc., 120, 122 Military Ave.
*10,000 cps Calibrator-Tube Tester, M-6 Meter with filters, Automatic Cycling System, 3500 lb. force shaker. Standard products for vibration control, measurement, and reproduction.

Machlett Laboratories, Inc., 567, 569 Components Ave.
*Kilowatt range triodes and tetrodes with coaxial terminal ring seals and thoriated tungsten filaments for industry and broadcasting, AM, FM & TV. Heavy wall anode triodes for industrial service; broadcast types for FM, AM & TV. Water cooled and forced air types; accessories.

Maclen Corporation, 859, 861 Audio Ave.
Schuttig Remote Transmitter Control Equipment. C & C Regulated Low Voltage Rectifier Power Supply. MGC 400-cycle Frequency Changer.

MacLeod & Hanopol, Inc., 287 Instruments Ave.
Vacuum tube test equipment, capacity meter, megohm meter, shorts indicator, capacity standards for use with inter-electrode capacity meters & bridges. Pilot runs and custom manufacturing of instruments.

Magnecord, Inc., 809 Audio Ave.
Complete line of professional tape recording equipment and accessories including binaural recorders and amplifiers. *New M80 series. Portable Magnecordette, Magnecordette, Contiouous Tape Player and others.

Magnecraft Electric Co., 676 Circuits Ave.
Relays—Telephone type AC or DC open and hermetically sealed; Aircraft and AN types as well as commercial types—Engineered for adaptability, reliability, small size and long-life. Also, see new subminiature relay, hermetically sealed or open.

Magne-Pulse Corp., 314 Computer Ave.
Demonstration of new Type 104 Transient Recorder showing recording, display, and frequency analysis of as many as four transients. Demonstration of *Type 202 Intermittent Recorder to localize and record intermittents.

*Indicates new product

(Continued on page 250A)

25 cycles to
5 megacycles.

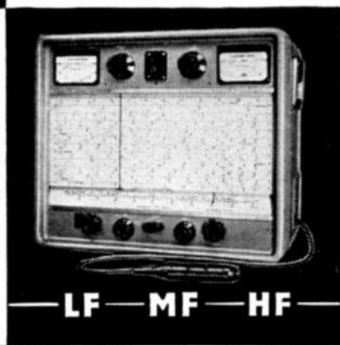
VIDEO OSCILLATOR
Type TF 885A

2.5 to 10 megacycles
and 20 to 100 megacycles.

CARRIER DEVIATION METER
Type TF 934

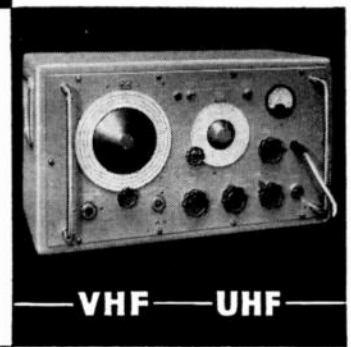
15 kilocycles to
30 megacycles.

STANDARD SIGNAL GENERATOR
Type TF 867



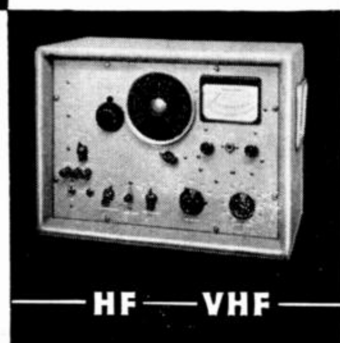
300 to 600 megacycles
or 200 to 400 megacycles
or 450 to 900 megacycles.

SIGNAL GENERATOR
Type TF 762C (series)



1,000 cycles, Inductance
and Capacitance;
Resistance at D.C.

UNIVERSAL BRIDGE
Type TF 868

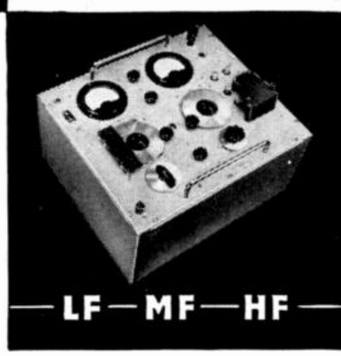


13.5 to
216 megacycles.

FM/AM SIGNAL GENERATOR
Type TF 995

50 kilocycles to
50 megacycles.

CIRCUIT MAGNIFICATION METER
Type TF 329G



250 to
4,000 megacycles.

PORTABLE FREQUENCY METERS
Type TF 1026 (series)

← Covering the whole radio spectrum →

A few examples of telecommunications test equipment, representative of the quality, reliability and precision workmanship of the wide range manufactured by

MARCONI INSTRUMENTS

VACUUM TUBE VOLTMETERS · FREQUENCY STANDARDS · OUTPUT METERS
WAVE METERS · WAVE ANALYSERS · Q METERS · BEAT FREQUENCY OSCILLATORS

23-25 BEAVER STREET • NEW YORK 4

CANADA: CANADIAN MARCONI CO., MARCONI BUILDING, 2442 TRENTON AVENUE, MONTREAL
ENGLAND: Head Office: MARCONI INSTRUMENTS LIMITED, ST. ALBANS, HERTFORDSHIRE

Managing Agents in Export: MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

See Us in Booths 260, 262 Instruments Avenue at the Radio Engineering Show

Keeping Communications on the G-O!

B&W COMPLETE SYSTEMS FOR

- Frequency-Shift Radio Teletype and Telephone Mobile or Point-to-Point
- V-H-F Radio Relay
- Radio, Radar, Microwave, and Direction Finding

For dependable radio communications . . . linking stations that are fixed or mobile . . . with conventional radio gear or high speed teletype and telephone . . . B&W offers a line of complete systems and special equipment that has been proved and approved by both industry and military.

For example, in the time-tested Mobile Frequency-Shift Radio Teletype Unit illustrated above, B&W has designed and built, from the drawing board up, the necessary:

- Dual Diversity Receivers and Converters
- Frequency-Shift Exciters
- Transmitters
- High Power R-F Amplifiers
- Speech Amplifiers
- Frequency Meters
- Control Units

Once assembled, these units are installed in shelters with all associated equipment, ready for immediate use.

If you have a problem concerning the design or construction of radio communications systems, B&W engineers would like you to take advantage of the same facility. Write for details.

B&W BARKER & WILLIAMSON, Inc.

237 Fairfield Ave., Upper Darby, Pa.

Visit Our Booth at the I.R.E. Show—202 Instruments Ave.

What to See at the Radio Engineering Show

(Continued from page 248A)

Magnetic Amplifiers, Inc., 564 Components Ave.
Tubeless high performance servo system. Tubeless motor-generator voltage regulator. Transistor curve tracer.

To See Performance-Guaranteed
Tape Wound Cores · Magnetic Laminations
MAGNETICS inc.
Booth 795 AIRBORNE AVE.

Magnetics Research Co., 908 Registration Row.
An operating demonstration of magnetic shift registers and magnetic logical elements for computers. Pulse transformers and magnetic amplifiers.

D. E. Makepeace Co., Div. of Union Plate & Wire Co., 403, 405 Electronic Ave.
*Miniature and Multi-Circuit slip ring and Brush assemblies. Precision wave guide and wave guide assemblies. Laminated precious metals.

P. R. Mallory & Co., Inc.
348 Mobile Ave.
*Mallory Mercury Batteries and Silverlytic capacitors designed especially for transistor circuits. *Mallory selenium rectifiers. Also contacts, resistors, rheostats, switches, vibrators, tuners and controls.

Marconi Instruments Ltd.
260, 262 Instruments Ave.
will be showing for the first time *signal generators, a vacuum tube voltmeter, Nyquist Diagram Plotter, and a *series of bridges.
Demonstrations

Marion Electrical Instrument Co., 556 Components Ave.
Marion Aircraft Panel Instruments, lighter weight, more compact, and hermetically sealed. Marion coaxial meter movements, adaptable to many new applications. Ruggedized, hermetically sealed and standard panel instruments. Marion M2 meter-tester and Model PM1 Induction Heating Unit and related products.

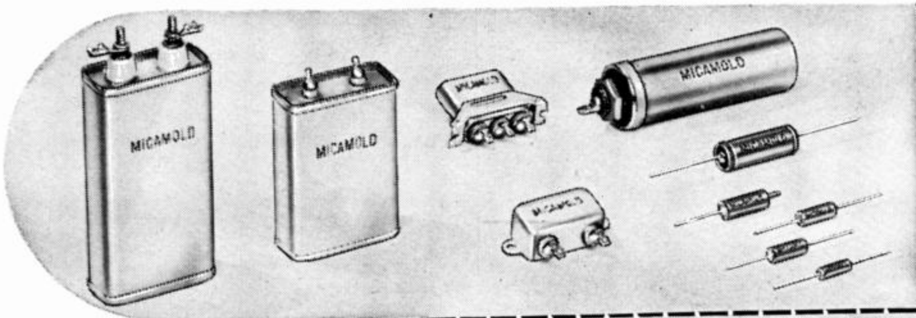
Markem Machine Co., 306 Computer Ave.
*Model 45AF machine for automatically marking cylindrical wire lead items such as resistors, condensers, capacitors, diodes, triodes, transistors, sub-miniature radio-electronic tubes.

*Indicates new product

(Continued on page 252A)

30 YEARS OF CAPACITOR EXPERIENCE

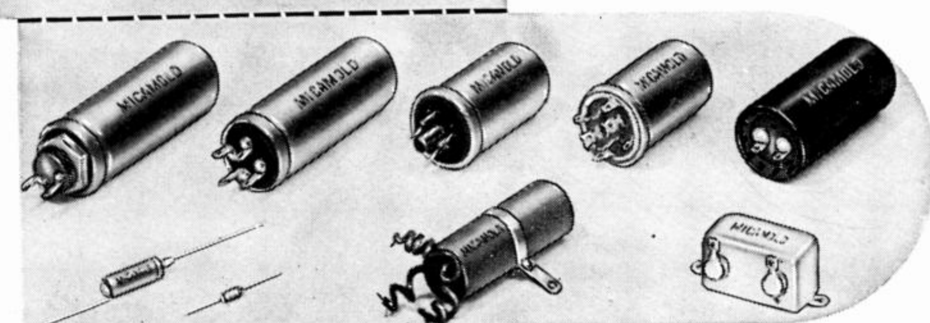
MICAMOLD pioneered the development, design and manufacture of capacitors — and is still producing under the original management.

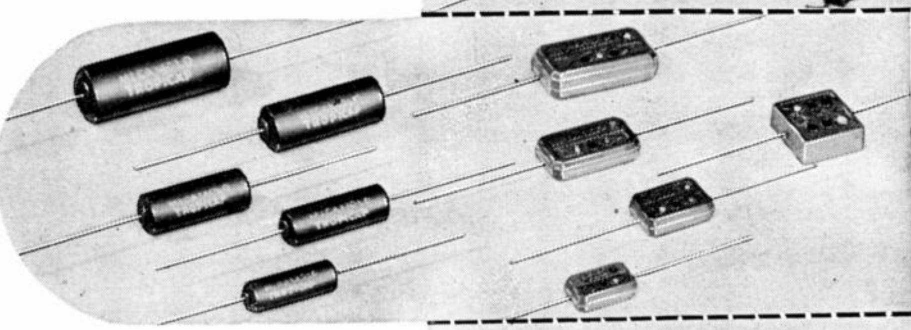


MICAMOLD METAL ENCASED PAPER CAPACITORS — hermetically sealed, are available in all the Military Standard styles and many special designs. Micamold also manufactures complete lines of oil filled capacitors for industrial applications. Another Micamold first — the exclusive Ambirite line — the only paper capacitors for operation at 150°C.

MICAMOLD ELECTROLYTIC CAPACITORS are manufactured in all Military Standard styles, and types for radio, television and industrial applications. The Motorlytics are for capacitor motor starting.

MICAMOLD's exclusive 'lytics include: Thermalytics, the only capacitors capable of operation up to 100°C, and Chromalytics that work at voltage ratings up to 700VDC.

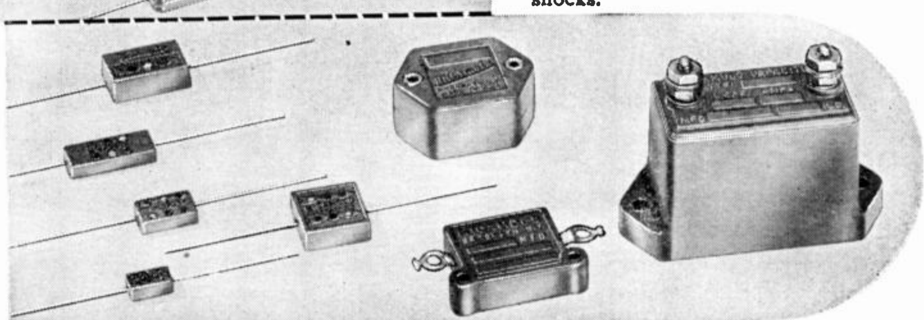




MICAMOLD MOLDED PAPER CAPACITORS, hermetically sealed in rectangular cases are the only complete line of Military Standard styles. A commercial line is manufactured in the same case sizes for industrial applications.

MICAMOLD TROPICAPS are molded tubular capacitors that afford protection from exposure to high humidity or even total immersion. The case is non-flammable and not injured by severe mechanical and thermal shocks.

MICAMOLD originated and introduced the first **MOLDED MICA CAPACITORS** thirty years ago. The company manufactures Military Standard styles from CM15 through CM70, and also makes the same types for industrial uses. Another Micamold first — the development and manufacture of high temperature types AO, AW and AV for operation to 150°C.



Micamold

MICAMOLD manufactures all types of Paper, Electrolytic and Mica Capacitors, Radio Frequency Interference Filters, Pulse Networks and Delay Lines.

The Micamold Catalog giving complete specifications is available upon request.

Visit our Booth Number 618 on Circuits Ave. at the IRE Show

MICAMOLD RADIO CORPORATION

1087 FLUSHING AVENUE, BROOKLYN 37, N. Y.

What to See at the Radio Engineering Show

(Continued from page 250A)

Maryland Etching Co., 774 Airborne Ave.
Etched metal nameplates and etched metal panels, as well as edge-lighted plastic panels.

Metal Powder Association, Electronic Core Div., 483 Electronic Ave.
Materials and methods of manufacture of powdered iron cores. Demonstration of measurement of "Q" value. Cores in live circuit.

Metal Textile Corp., 745 Airborne Ave.
SHIELDING MATERIALS for military specifications, FCC regulations (i.e., color oscillator radiation), and other RF leakage problems. METEX TVI-20-S for ham TVI problems. METEX ELECTRONIC WEATHERSTRIPS. Demonstration with high level broad band noise source.

Metrix, 785 Airborne Ave.
See Compagnie Generale de Metrologie.

*Indicates new product

(Continued on page 254A)

What to See at the Radio Engineering Show

(Continued from page 252)

Mica Fabricators Association, 324 Computer Ave.
Mica films, tube spacers, television tube bridges and various types of mica parts for the electronics and appliance industries.

Microdot Div., Felts Corp.
679 Circuits Ave.
"Microminiature" components featuring *Microdot gold-plated miniature coaxial connectors—miniature coaxial cable with Teflon dielectric—miniature "Mininoise" cable—assemblies, harnesses, assembly kits, hand tools.

Micro Switch Div., Minneapolis-Honeywell Regulator Co., 574, 576 Components Ave.
Sealed subminiature switches. Panel sealed push button and slide switches. *The first rotary selector switch with seal elements. All specially designed for the electronics field.

Microtran Co.
634 Circuits Ave.
Transformers—Transistor and miniature types. Audio Power and Pulse. Hermetically sealed, Encapsulated and Molded construction. MIL-T-27 types.

Microwave Associates, Inc., 392 Microwave Ave.
*Low noise silicon diodes for 5400-7400 mcs. 4J52 magnetrons with ceramic-to-metal seals. Miniature X-band CW magnetron. TR and ATR tubes. Millimeter components.

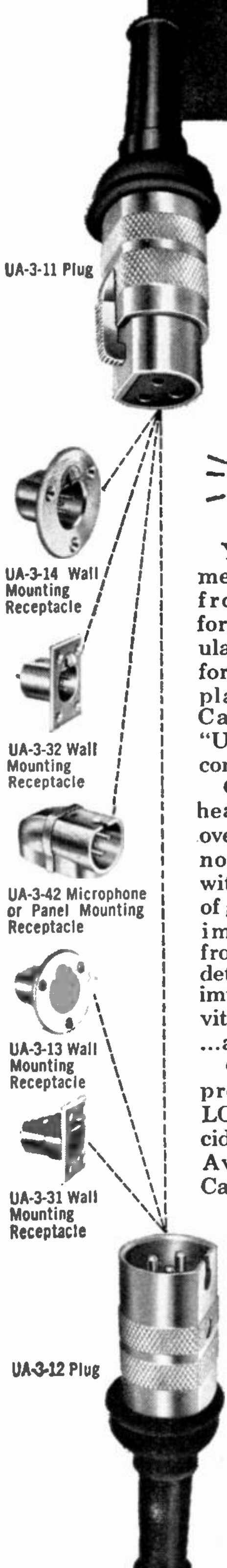
Microwave Development Labs., Inc.
377 Microwave Ave.
Waveguide circuit components, hybrid junctions, balanced mixers, balanced duplexers, compensated Invar reference cavities, rotary joints, precision cast E and H bends, precision directional couplers and custom waveguide assemblies.

*Indicates new product

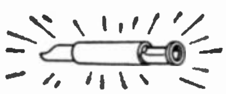
(Continued on page 257A)

MORE DATA
Exhibitors listed in display type, cuts and borders have more data for you in their ads in the March issue of "Proceedings of the I.R.E."

In **CANNON "UA" Audio PLUGS**



gold-plated contacts really pan out!



Yes! You get immense satisfaction from gold in any form... and particularly from the performance of the gold-plated contacts in Cannon's modern "UA" audio Series connectors.

Contacts are heavily gold-plated over silver plate... not just "flashed" with a light coating of gold. You get maximum protection from oxidation and deterioration... maximum protection to vital audio circuits ...absolute reliability.

Cannon's thumb-pressure LATCH-LOCK prevents accidental disconnect. Available through Cannon distributors.

WRITE FOR RJC BULLETIN!

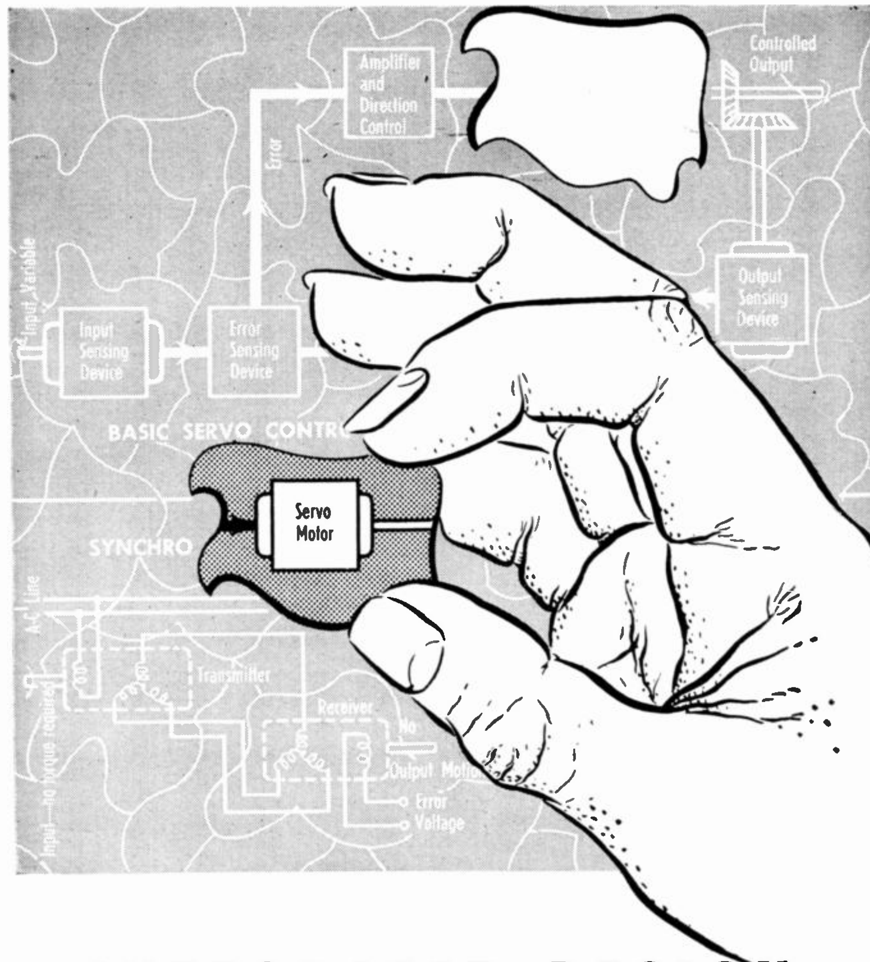
Refer to Dept. 377

CANNON ELECTRIC COMPANY, 3209 Humboldt St., Los Angeles 31, Calif. Factories in Los Angeles; New Haven; Toronto, Canada; London, England. Representatives and distributors in all principal cities.

I.R.E. Show Booth 546

CANNON ELECTRIC

Since 1915



INTEGRATED DESIGN

...FOR COMPLETE SERVO SYSTEMS!

Like pieces in a jig-saw puzzle, all components in a Transicoil servo system are designed to fit each other . . . coordinating to form the complete picture. Systems made by piecing together unmatched components usually spoil the picture by limiting the final efficiency of the entire system.

But if building your own system seems desirable, you'll find that individual Transicoil components offer the best performance in the job each is required to do. Built to your exact specifications, ready for immediate application, their ability to fit into the picture of your system is limited only by the restrictions you place upon them.

Details covering Transicoil Servo Systems, or components are available upon request to . . .

TRANSICOIL CORPORATION

107 GRAND STREET NEW YORK 13, N.Y.

What to See at the Radio Engineering Show

(Continued from page 254A)

Midland Manufacturing Co., Inc.
143 Military Ave.

*Color TV crystal developed by Midland is now being produced for major set manufacturers. Designed for either ringing or reactance tube applications.

Midwestern Geophysical Lab., 369 Mobile Ave.
Oscillographs, both laboratory and flight test, magnetic structures, galvanometers, amplifiers, and servo components (servovalves and torque motor).

James Millen Mfg. Co., Inc.
557 Components Ave.

GridDip Meters; Radar, Radio & Electronic equipment and components, Magnetic Metal Shields; *Delay lines, Delay line Kits; *Complete line subminiature parts; *1" instrumentation oscilloscope.

Miller Dial & Name Plate Co., 357 Mobile Ave.
The *FOILCAL Rivet-less nameplate and complete line of etching, lithographing, engraving & silk screen facilities including etched circuits, edge-lighted panels, dials, scales, instrument panels and radium and fluorescent applications.

William Miller Instruments, Inc., 821 Audio Ave.
*High gain-wide band DC amplifier, arbitrary function generator, recording oscillographs, transformers, and transductors.

Millivac Instrument Corp., 281, 283 Instruments Ave.
Dynamically compensated regulated DC Power Supplies having negative impedance, completely new line of sensitive VTVM's for DC, AC and RF. Sensitive 4-Diode RF Probe.

Milwaukee Electronic Corp., 433 Electronic Ave.
See: Milwaukee Transformer Co.

Milwaukee Gas Specialty Co., 738 Airborne Ave.
Hermetically Sealed Sensitive Relay.

Milwaukee Transformer Co., 433 Electronic Ave.
Various types of transformers and reactors used for military and commercial applications. Booth will be shared by Milwaukee Electronic Corp. showing a new high voltage tester.

Minneapolis-Honeywell Regulator Co., Aeronautical Div., 741, 743 Airborne Ave.
Will feature highly accurate, rugged, fully-floated RATE INTEGRATING GYROS (previously veiled by security), *electro hydraulic coordinated, JET ENGINE CONTROL *TRANSISTORIZED FUEL GAGES and miniaturized, long life CHOPPERS (vibrators), SERVOS and AMPLIFIERS.
*Indicates new product

FIRST AID ROOM

A nurse is in charge at all times. First Aid Room is the third room to left of Lobby directly off registration area.

(Continued on page 274A)

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.

PATENT ENGINEER

B.E.E., M.S.E.E., 4 years tube and transistor circuit research, design, development experience; attending (evening) law school, 50% completed. Desires electronics patent work. Location: permitting convenient continuation of law study. Box 694 W.

ELECTRONICS SCIENTIST

B.S.E.E. 1926, Stanford University. Broad background in electronics and radio communications, including radio noise, propagation, equipment and instrumentation development. Desire

(Continued on page 260A)

Positions Wanted

(Continued from page 258A)

to continue past research in LF and VLF propagation, including storm tracking; or electromagnetic aspects of nuclear development. Prefer west coast or western U.S. Box 695 W.

ELECTRONIC ENGINEER

B.E.E. 1950; Tau Beta Pi; Eta Kappa Nu. Age 29, married. 3½ years design and development experience in pulse circuitry, communication equipment and radar. Desires permanent position with future. Will locate anywhere. Box 698 W.

ENGINEER—PRACTICAL SALES

Outstanding, electronic background. Supervisor leading TV field engineering dept., 3 years sales engineer, 6 years TV instructor, 2 years broadcast engineer, trades editor, 4 years supervisor military communications; F.C.C. licenses—1st radio telephone, 2nd radio telegraphs, ham operator. Single, age 31. Prefer sales. Box 699 W.

ENGINEER

B.E.E., age 29, looking for a career position preferably in sales or administrative engineering. Experience includes research and development, test and field engineering. Desire metropolitan New York location. Box 700 W.

ENGINEER

B.E.E. Manhattan College 1952. 1 year experience instructor (lab. & lecture). Electronic and radio Manhattan College. Age 26, single. Desirous of obtaining employment in industry research or development. Metropolitan area only. Box 701 W.

TRANSLATOR

B.S.E.E. University of California 1950, age 25, excellent knowledge of Russian; 2 years teaching experience signal corps; 7 mos. radio and electrical engineer, currently graduate student desiring some free lance work translating technical Russian literature. Box 708 W.

ENGINEER

B.S.E. 1951. Age 26, one child. 2½ years experience in Airborne navigation systems. Desires foreign assignment with suitable living conditions for family. Box 710 W.

ENGINEER—EXECUTIVE

B.E.E., M.E.E., B.B.A.; 15 years comprehensive experience planning, development, application of electronic automatic control systems involving radar, computers, data handling, displays; creative and administrative ability; seeks non-defense management opportunity. Box 711 W.

ELECTRONIC ENGINEER

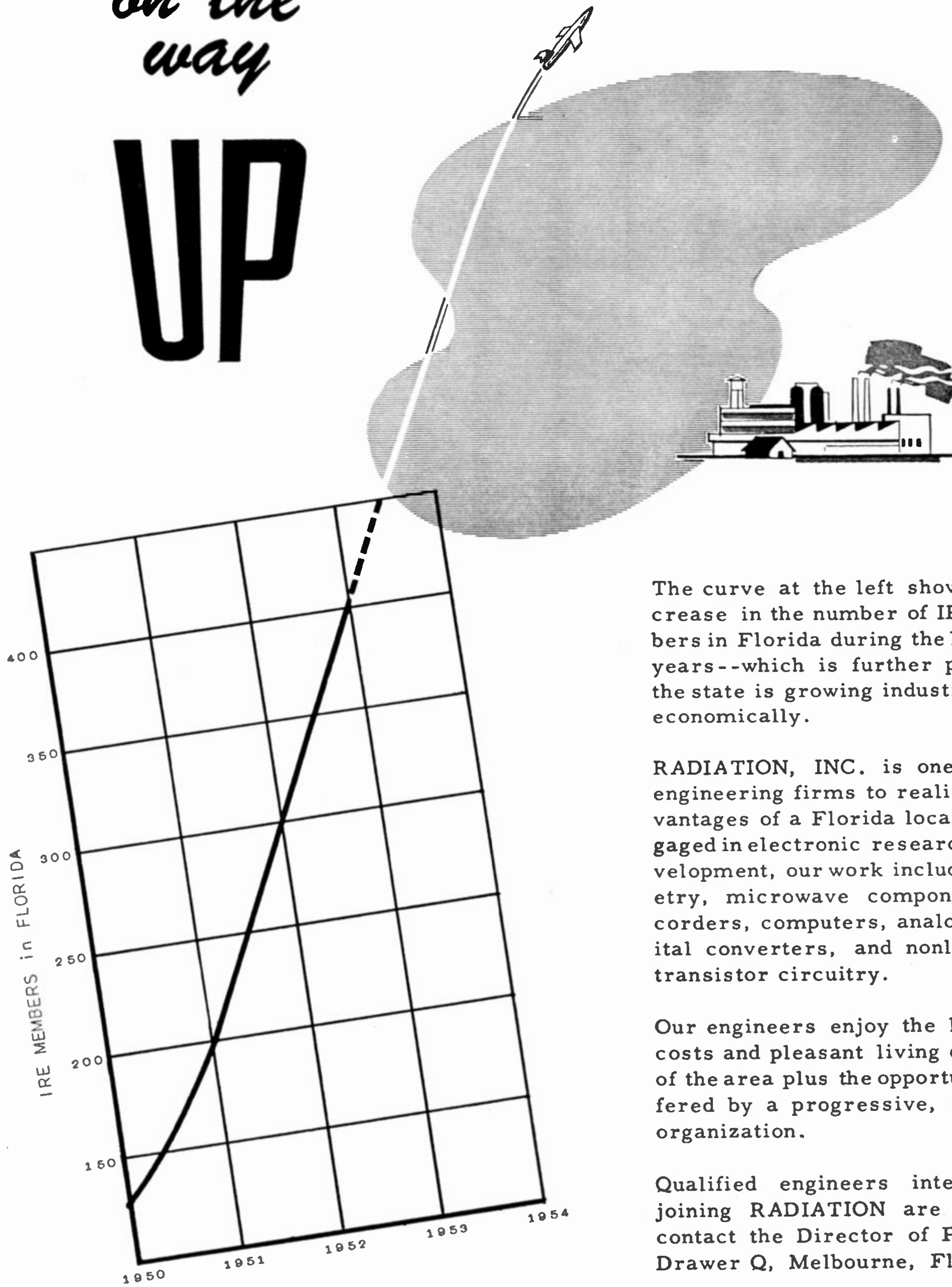
B.E.E. June 1951. Age 26, married. 2 years Navy ETM2/c. 2½ years field engineering with leading business machine manufacturer. Attending evening graduate school. Desires challenging position in design or electronic research and development. Metropolitan area. Will accept trainee position in this field. Avaiable immediately. Resume on request. Box 712 W.

ELECTRONICS RESEARCH

B.E.E. 1946, M.E.E. 1950 electronics. Age 28, married, one child. Three years experience radio navigation systems research, creative design, construction, analysis, laboratory and field evaluation. Officer Naval Reserve. Presently employed government research activity. Desire similar position with advancement opportunity industry or university research program. Box 713 W.

(Continued on page 262A)

on the way UP



The curve at the left shows the increase in the number of IRE members in Florida during the last three years--which is further proof that the state is growing industrially and economically.

RADIATION, INC. is one of many engineering firms to realize the advantages of a Florida location. Engaged in electronic research and development, our work includes telemetry, microwave components, recorders, computers, analog-to-digital converters, and nonlinear and transistor circuitry.

Our engineers enjoy the low living costs and pleasant living conditions of the area plus the opportunities offered by a progressive, expanding organization.

Qualified engineers interested in joining RADIATION are invited to contact the Director of Personnel, Drawer Q, Melbourne, Florida.

RADIATION Inc. Melbourne, Fla. Orlando, Fla.
Electronic RESEARCH · DEVELOPMENT · PRODUCTION

Positions Wanted

(Continued from page 260A)

ENGINEER

Competent engineering group, experienced in radar, instrumentation and data reduction systems; wishes to contact persons interested in backing an elecronics engineering company in Southern California. Box 714 W.

ENGINEER

S.B. and S.M. EE., Mass. Inst. of Tech. 1950, 1951. Member of Eta Kappa Nu, Tau Beta Pi, Sigma Xi. Two years development experience in analogue computers, servomechanisms and relay switching circuits. Age 27. Desires position with future. Anywhere in U.S.A. Will not consider classified work. Box 715 W.

ENGINEER

B.E.E. Rensselaer Polytechnic Inst. 1942. Graduate work in Physics, seeks management opportunity with progressive New England firm. Broad and practical experience in project direction including present position as Chief Engineer. Specialist in electromagnetic engineering and microwave circuits. Box 716 W.

ELECTRONIC ENGINEER

B.E.E. 1946, graduate work in E.E. Married, age 31. Experience in commercial TV; 3 years in application and test of electronic components used in airborne gear to government specifications. Desire position on government contract work in New York metropolitan area. Box 717 W.

PHYSICIST—ELECTRONIC SCIENTIST

Single—Age 25—Veteran. B.S. in Engineering Physics 1951 NYU. Desires position in either research and development or overseas field engineering. Experienced in Commercial and Military Microwave Communications Systems, also has experience in Transistor Theory and Application. Box 718 W.

ENGINEER—PHYSICIST

Physics Graduate, 2 years graduate work strong mathematics. Two years experience on digital computer design and development. Two years general experience involving information theory, instrumentation, telemetering, technical writing. Eight years Navy Radar experience including time as instructor. Desire position with small organization. New England location outside of metropolitan areas preferred. Box 719 W.

ENGINEER

B. Engr. mechanical and electrical major Feb. 1950. Age 32, married. 3½ years Navy instrument electrician. Experience product engr., A.S.M.E. & A.S.T.M. inspection. Desires quality control, plant maintenance or related sales position, Indiana, Michigan or Ohio preferred. Box 720 W.

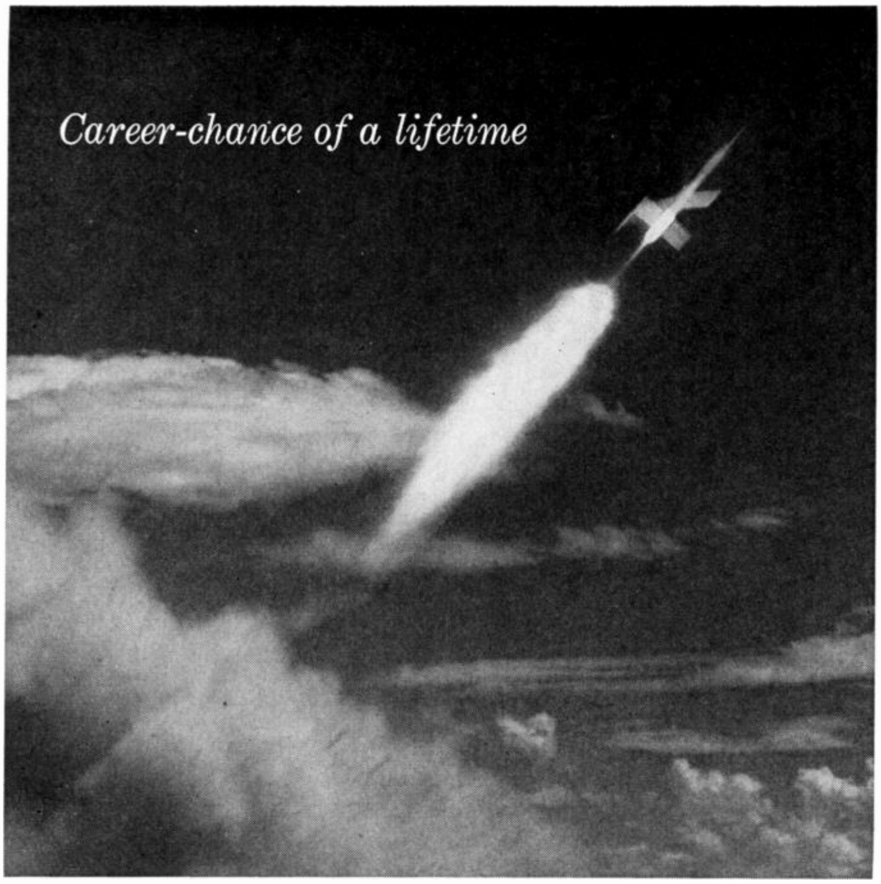
DIRECTOR OF ENGINEERING

M.S. in E.E. 1938. Fifteen years responsible engineering in Government and industry. Technical direction of 400 professional men in digital computer and electromechanics. Sales and contract experience. Capable to start, build and operate engineering group. Box 721 W.

ENGINEER

B.E.E., Over twelve years varied experience, including radar, circuits, aircraft instruments, optics, special electronic devices, supervision and report writing. Several patents. Desires creative responsible position. Box 722 W.

(Continued on page 264A)



ELECTRONIC ENGINEERS AND ELECTRO-MECHANICAL ENGINEERS

for Lockheed's expanding Missile Systems Division

Recently formed from other Lockheed Engineering organizations to prepare for the era of automatic flight, the Missile Systems Division deals exclusively with missiles and their electro-mechanical systems.

Its expansion has created "ground-floor" openings for

Electronics Engineers experienced in any or all of the following fields:

- **Micro-wave techniques**
- **Electronic components**
- **Circuit design**
- **Flight instrumentation**

Electro-Mechanical Engineers with circuit or servomechanisms experience (aircraft or missile experience preferred)

In addition to outstanding career opportunities, the Lockheed Missile Systems Division offers you high salaries commensurate with your experience, generous travel and moving allowances, and a better life for you and your family in Southern California.

Address inquiries to L. R. Osgood, Dept. IRE-M-3, Lockheed Missile Systems Division, 7701 Woodley Avenue, Van Nuys, California.

LOCKHEED MISSILE SYSTEMS DIVISION

VAN NUYS, CALIFORNIA

Positions Wanted

(Continued from page 262A)

PATENT ATTORNEY

Electronics field, 28 years old. B.S.E.E. (communications), L.L.B., state bar. High scholastically. About 2 years corporate patent experience, and 4½ years engineering. Seeks position within commuting distance of New York City. Box 731 W.

ENGINEER

B.S.E.E., M.S.E.E. 1955. E.T.M., Navy W.W. II. 5 years diversified experience in electronics elect. plant layout, research & dev. in semiconductivity, piezoelectricity. Age 27, married, family. Prof. Eng. (Ohio) momentarily, Tau Beta Pi, Eta Kappa Nu, IRE, AIEE. Prefer Cleveland area. Box 732 W.

ENGINEER—INSTRUCTOR

M.Sc. degree 1948. Electronics major. Age 28, married. Five years experience teaching electronics and power courses in mid-west and eastern universities. Three years vacuum tube research. Member Sigma Xi, Eta Kappa Nu, ASEE. Navy Supply Corps experience. Desires either a teaching position or one with supervisory responsibilities in production or development. Box 733 W.

INDUSTRIAL ELECTRONIC ENGINEER

Automatic controls, HF heating, Ultrasonics in 3½ years consulting, 5 years industrial development. Non-graduate, Math. background, prec. gaging. Location Midwest. Minn. $8,000. Box 734 W.

(Continued on page 266A)

WANTED

ENGINEER WITH EXPERIENCE IN VHF OR UHF

Interesting creative work with the most resourceful and progressive firm in the field of television equipment.

This position is permanent. It will offer every opportunity for unlimited advancement and for developing a successful career. The plant is now housed in a newly-acquired larger building, only 22 miles from downtown New York City. The surroundings and atmosphere are stimulating and congenial.

Attractive Salary

Write stating qualifications.

BLONDER-TONGUE LABORATORIES
526-536 NORTH AVENUE
WESTFIELD, NEW JERSEY

VACUUM TUBE TECHNICIANS AND/OR FOREMEN

Must be familiar with all phases of magnetron or transmitting tube assembly. Must be experienced.

●

ENGINEER QUALITY CONTROL

Must be familiar with all phases of power tube production such as magnetron, transmitting and X-ray tubes. Must have previous experience in all phases of inspection and test as well as assembly and processing of tubes.

●

ENGINEERS ELECTRONIC MAGNETRON DESIGN

Experienced in the design and development of magnetrons.

MICROWAVE MEASUREMENTS

Experienced in analysis and measurements of the microwave field.

●

—SUBURBAN LAB—
—EXCELLENT OPPORTUNITIES—
—MANY COMPANY BENEFITS—
—NEW YORK AREA—

MR. WOLFERT
Will interview all day
Monday, Tuesday and Wednesday,
March 22, 23 and 24.

Call PEnnsylvania 6-5700
for appointment.

Positions Wanted

(Continued from page 264A)

ENGINEER

B.S. in Radio Engineering 1943. Experienced in Communication, Industrial Electronics and Radar. Have supervisory and creative abilities. At present employed as a Field Engineer in the Arctic. Age 31 years, single. Wish to work in any of the Latin American countries. Box 735 W.

ENGINEER

Age 25. B.E.E. June 1951. Two years experience as electronic engineer—research and development of varied classified electronic circuits and systems. Desire: circuit development with company producing commercial equipment. Box 736 W.

DIGITAL COMPUTER ENGINEER

Five years experience; logical design, component development, input-output equipment, system testing; present on supervisory staff of general purpose machine; seeking affiliation with group requiring above experience in high level position. Box 737 W.

MATHEMATICAL STATISTICIAN

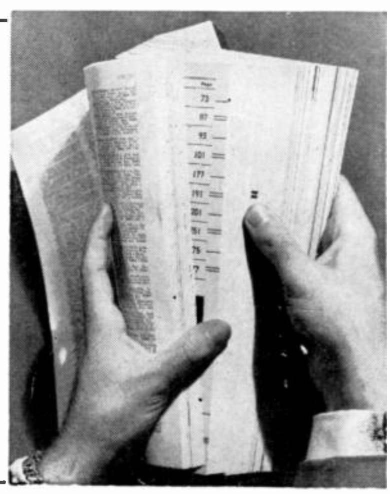
Strictly non-military work wanted by man with excellent background in evaluation of military electronic systems such as radar, missile guidance, radio-location, fire control. Well qualified in error analysis, statistical planning of experiments and related publications work. Box 738 W.

(Continued on page 268A)

30,000 Member Engineers

find IRE DIRECTORY is USEFUL every day!

- It lists 30,000 Members.
- Directory of 2550 Firms.
- Index to over 500 Electronic Products in 10 basic fields.



HIGHLY QUALIFIED ENGINEERS DESIRED BY DIGITAL COMPUTER LABORATORY AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY

to design and develop high-speed electronic digital equipment involving vacuum-tube and magnetic-core circuitry.

Openings are also available for outstanding candidates to work on use of high-speed digital computers to control large physical systems. This involves study of control requirements of the whole system, reduction of them to a simple pattern of control instructions, and translation of the pattern into computer code. Position requires appreciation for physical systems, ingenuity, and imagination. Training in computer principles provided as necessary.

Persons from other fields wishing experience in digital computers for engineering and military uses are encouraged to apply. Positions carry opportunity for advancement. Salary appropriate to candidate's experience and training. Address:

DIGITAL COMPUTER LABORATORY, MIT, 211 Massachusetts Avenue,
Cambridge 39, Massachusetts

NORDEN

OFFERS UNUSUAL OPPORTUNITIES FOR COMPETENT ENGINEERS

Electronic
Mechanical
Electro-Mechanical

FOR RESEARCH AND DEVELOPMENT WORK ON

Servo Mechanisms
Microwave Equipment
Antennas
Infrared Equipment
Communications Equipment
Computers
Gyroscopes
Radar

- Liberal Hospitalization Plan
- Merit Salary Reviews
- Excellent Working Conditions
- Ideally located in Westchester County

●

Please telephone or send resume and salary requirements to the Personnel Department. All inquiries will be handled in confidence.

●

THE NORDEN LABORATORIES CORPORATION

121 Westmoreland Avenue
White Plains, New York
White Plains 6-4300

An assurance is required that the relocation of an applicant will not cause disruption of an urgent military project.

POSITIONS OPEN

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. ....

The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

PROCEEDINGS of the I.R.E.
1 East 79th St., New York 21, N.Y.

ELECTRONIC ENGINEER AND ENGINEERING DRAFTSMAN

The Special Devices Center has several critical vacancies for the following: Electronic Engineer at $5060 per year—B.E.E. degree plus 18 months professional experience in electronics. Engineering Draftsman at $4205 per year—five years experience in engineering drafting. Apply—Industrial Relations Officer, Special Devices Center, Port Washington, New York.

SPECTROSCOPIST—PHYSICIST—ION OPTICS

Our expansion of firm commercial business or building some of the world's finest scientific instruments can assure you of a secure future. If the positions above fit your interest and abilities, communicate with our Technical Employment Manager, Beckman Instruments, Inc., 1001 El Centro, So. Pasadena 6, Calif.

(Continued on page 270A)

POSITIONS OPEN

(Continued from page 268A)

ELECTRONIC ENGINEERS

1. Chief Test Engineer for a project engaged in the manufacture of a complex electronic product. 2. Instrumentation Engineer who will be engaged in problems involving measurement in the general field of engineering. Positions require electronic engineers or the equivalent with at least four years experience and active in the field of electronics. Salaries approx. $6000 per year. Write to Naval Inspector of Ordnance, Rochester, New York for information or to make application.

PHYSICIST

Specializing in antenna design and analysis. Writing ability desirable. Permanent position in excellent location. Advancement commensurate with ability and results. State qualifications, salary desired and availability in first letter. Telrex, Inc., Box 879, Asbury Park, New Jersey.

ELECTRONICS ENGINEER—INSTRUMENTS

Junior engineer (B.S.E.E.) for development of precision gaging instruments with well established company. Design and construction of experimental units involving both mechanical and electrical components. Opportunity to exercise initiative and ability. Located within 100 miles of New York City. Box 756.

RESEARCH ASSISTANT

Research assistant trained and experienced in electronics, sound recording and reproduction, New York area. Salary commensurate. Give full particulars of education and experience. Box 757.

(Continued on page 272A)

POSITIONS OPEN

(Continued from page 270A)

ENGINEERS

1. Chief Development Engineer: Minimum M.S. degree in engineering or physics plus five years progressive experience. Must have two years general electronic design, development, or research experience. 2. Engineers: All levels. Education B.S. to Ph.D. Experience in one or more of following: general circuit design, telemetering, radar, instrumentation, packaging, subminiaturization, testing or research. Test Engineers: All levels. B.S. to Ph.D. Applied, experimental and theoretical. Experience in one or more of following: general physical testing, guided missiles, ordnance, electrical and electronics. Salary and age open. Location Michigan. Box 758.

ELECTRONICS ENGINEERS

Denver Research Institute of the University of Denver has openings in the fields of computer development, pulse circuitry, electro-optical devices, radio communication systems, and electronic instrumentation. Close liaison between Institute staff and University faculty combined advantages of industrial methods with academic environment. Reply to Mr. C. A. Hedberg, Denver Research Institute, University of Denver, Denver 10, Colorado.

INSTRUMENT SERVO ENGINEER

Senior responsible position on a new government project for a capable electronics engineer having 3-5 years experience in instrument servo field, including analog computer design. Digital experience in addition would be helpful. Submit resume or letter outlining education and industrial experience to: Engineering Employee Relation Manager, Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York 11, New York.

ASSISTANT PROFESSOR

Assistant Professor—Dept. of Electrical Engineering, Univ. of British Columbia, Vancouver, Canada. Experience—post-graduate training preferably at the Doctor's level in Electronics and Servo-mechanisms. Duties—teaching undergraduate courses in Electrical Engineering and postgraduate studies in some phase of Servo-mechanisms or Electronics. Starting salary $4500 to $5000 per year. Date of appointment July 1, 1954. Further information may be obtained by writing to Head of the Dept.

SENIOR ENGINEER

A well known metropolitan New York manufacturer has an opening for a senior engineer with broad experience in the design, development and problems of production of high-fidelity AM-FM Tuners and Audio Amplifiers. Must be able to supervise and direct the activities of a complete commercial engineering group. Submit resume and salary desired. Box 759.

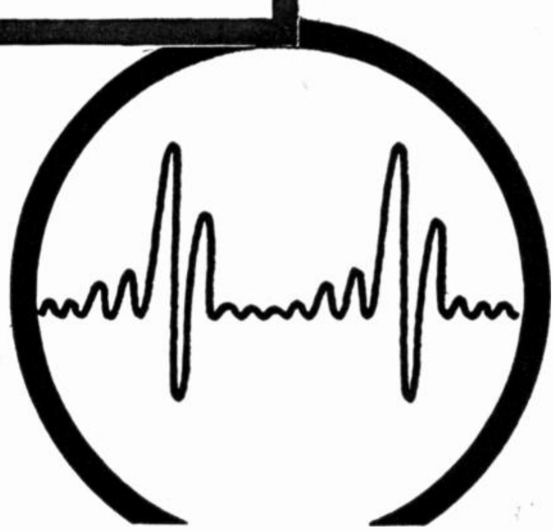
ELECTRONIC ENGINEER

Nationally-known and well established midwest manufacturer of microwave components desires the services of electronic engineer to organize and head group to perform component design and development work. Antenna experience desirable. Attractive salary. Policy level position. Full benefits. Please send resume to Box 760.

ELECTRONICS ENGINEER

For Laboratory instructorship: maintain and operate CRC 102A digital computer. Opportunity for graduate study. Dept. of Math. & Mech., U.S. Naval Postgraduate School, Monterey, Calif.

(Continued on page 327A)



What to See at the Radio Engineering Show

(Continued from page 257A)

Model Engineering & Mfg. Co.
Tru-Ohm Products Div.
444 Electronic Ave.

*New style Econohm resistors.
*25 watt power rheostat.

Moloney Electric Co., 680 Circuits Ave.
See: Pacent Engineering Corp.

F. L. Moseley Co.
315 Computer Ave.

"Autograf" Two axis recorder, curve follower, servo operated DC Voltmeter (Digital Output). *Key Board point plotter model of Autograf.

J. Frank Motson Co., 606 Circuits Ave.
Printing on electronic and industrial parts; plastics, metals, glass; dials, terminal boards, chasses, shields, etc.; *New development of direct printing of solderable conductive silver circuits.

Mucon Corporation, 442 Electronic Ave.
Subminiature ceramic capacitors for coupling, by-pass, temperature compensation. Ultra-high-frequency standoff and ribbon lead capacitors with minimum series inductance, *voltage-sensitive capacitors.

Multi-Metal Wire Cloth Co., Inc., 125, 127 Military Ave.
*Magnetic shields for tricolor kinescopes, standard magnetic shields for popular 2", 3" and 5" tube sizes, custom-built shields, cabinets, chasses, dial plates, panels and racks.

MURPHY & MILLER LO-TEMPERATURE

MURPHY & MILLER
Environmental Test Units
BOOTH 288
INSTRUMENTS AVENUE

MYCALEX CORPORATION OF AMERICA
Executive Offices:
30 Rockefeller Plaza, New York 20, N.Y.
General Offices and Plant:
Clifton Boulevard, Clifton, New Jersey
MYCALEX† glass-bonded mica
The World's Most Nearly Perfect Insulation
651, 655 Circuits Ave.
†Trade-Mark Reg. U. S. Pat. Off.

*Indicates new product

(Continued on page 276A)

AMPEX

MAGNETIC RECORDERS

The most complete line of data tape recorders

AMPEX has applied magnetic tape recording to more varied problems in research, testing and control than any other manufacturer of tape equipment. To meet specific demands for broad frequency response, precise timing, extreme tape stability, high shock resistance and reliable transient accuracy, Ampex has built machines of a wide variety of designs. And from this experience has come this line of proven magnetic recorders:

F-M CARRIER TYPE RECORDER — MODEL 306

Explosions, shock waves, geophysical data and other highly transient phenomena can be recorded on the Model 306 with excellent "instantaneous" accuracy. Because the machine uses an fm carrier to modulate the signal, the accuracy of the recording is unaffected by minor tape imperfections.

Also, the Model 306 is able to record the vast majority of all mechanical occurrence, since it covers the extremely useful frequency range from 5000 cycles/sec. down to zero (D.C.).

OPTIONS: *One to 14 tracks*
Rack, console or combination mounting
Record and playback, record only or playback only

WIDE RANGE DIRECT RECORDER — MODEL 307

With a frequency response from 100 to 100,000 cycles per second, the Model 307 is particularly suited to steady state data occurring over a wide range of frequencies. The 307 has had extensive application in fm-fm telemetering, sharing this field with the Model 500 described below.

OPTIONS: *Same as Model 306*

PULSE WIDTH RECORDER — MODEL 303

This model can record any type of phenomena that lends itself to pulse width coding. Pulses can range from 60 to 1000 microseconds and will be accurate in duration to closer than 2 microseconds. Since each track on the machine may record commutated data consisting of many channels, it is possible to record hundreds of parallel data channels on one tape on a Model 303 machine.

OPTIONS: *Same as Model 306*

COMBINATION RECORDERS — MODELS 309, 311, etc.

Special Ampex Data Recorders can incorporate combinations of the heads and electronic circuitry of the 303, 306 and 307. Thus the parallel tracks on the same combination recorder might have the widely differing characteristics of each of those models. For example, on its parallel channels such a recorder might have an overall frequency response of 0 to 100,000 cycles/sec.

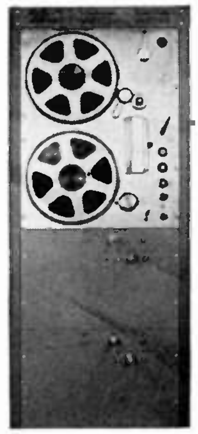
OPTIONS: *Same as Model 306 (but 2 or more tracks)*

"LOW FLUTTER" WIDE RANGE RECORDER — MODEL 500

The Model 500 is a four-track, two-speed magnetic tape recorder designed to achieve extreme stability of tape motion while recording information in the frequency range between 100 and 100,000 cycles. Thus it is able to record fm-fm telemetering data without introducing any objectionable data error from small variations in tape speed. It has the lowest known flutter and wow characteristics of any tape recorder — less than 0.1% peak-to-peak by RDB standards.

Console mounting only
Four tracks only

For specifications and other information, write Dept. G-1535A



Series 300 data recorder in rack mounting.

Series 300 data recorder in console mounting.
Rack mounting of portions of the electronic components may be necessary on multi-track console mounted recorders.

Ampex Model 500 Recorder

AMPEX CORPORATION
934 Charter St., Redwood City, California

BRANCH OFFICES:
New York, Chicago, Atlanta, San Francisco and College Park, Maryland (Washington, D.C., area)

DISTRIBUTORS:
Radio Shack, Boston; Bing Crosby Enterprises, Los Angeles; Southwestern Engineering & Equipment, Dallas and Houston; Canadian General Electric Company in Canada.

AMPEX

MAGNETIC RECORDERS

What to See at the Radio Engineering Show

(Continued from page 274A)

Nassau Research & Development Associates, Inc., 378 Microwave Ave.
See: NARDA.

**National Carbon Co.
Div. of Union Carbide & Carbon Corp.
529, 531 Components Ave.**
"Eveready" battery line: pocket radio, personal radio, portable radio, home radio, radiation detectors, hearing aid, and photoflash. *Compact No. 964-437 balanced life complement, *635-415 pocket radio battery complement, plus the *491 and *497 high voltage batteries.

National Co., Inc., 848 Audio Ave.
Engineers and manufacturers of precision electronic equipment and components for government and commercial use. Exhibit to include introduction of the market's lowest priced crystal filter communications receiver.

**National Research Corp.,
Equipment Div.
224 Instruments Ave.**

High vacuum production equipment: *2" booster pump for receiving tube manufacture; *1" booster pump with new sight glass; *pump-and-head assembly for TV tube exhaust. *Pirani vacuum gage.

National Vulcanized Fibre Co., 777 Airborne Ave.
Copper-clad Phenolite, laminated plastic, for use in printed or etched circuits. Laminated plastics of glass, cloth and paper combined with phenolics, melamines, polyesters, and silicone resins.

*Indicates new product

FIRST AID ROOM

A nurse is in charge at all times. First Aid Room is the third room to left of Lobby directly off registration area.

(Continued on page 278A)

4 mmf/ft

AIR-SPACED ARTICULATED

CO-AX
CABLES

offer a unique combination of

- ✔ FRACTIONAL CAPACITANCE
- ✔ HIGH IMPEDANCE
- ✔ MINIMUM ATTENUATION

ALONG WITH

- ✔ EXCEPTIONAL FLEXIBILITY
- ✔ LIGHT WEIGHT

38 STOCK TYPES

FOR ANY OF YOUR STANDARD OR SPECIAL APPLICATIONS

A few of the very low capacitance types are:

Type No.	*Capacitance μμ F/ft.*	*Impedance ohms*	O.D.
C.44	4.1	252	1.03″
C.4	4.6	229	1.03″
C.33	4.8	220	0.64″
C.3	5.4	197	0.64″
C.22	5.5	184	0.44″
C.2	6.3	171	0.44″
C.11	6.3	173	0.36″
C.1	7.3	150	0.36″

WE ARE SPECIALLY ORGANIZED TO HANDLE DIRECT ORDERS OR ENQUIRIES FROM OVERSEAS

SPOT DELIVERIES FOR U.S.

BILLED IN DOLLARS—SETTLEMENT BY YOUR CHECK

CABLE OR AIRMAIL TODAY

TRANSRADIO LTD.

CONTRACTORS TO H.M. GOVERNMENT

138A CROMWELL RD., LONDON, S.W.7 ENGLAND

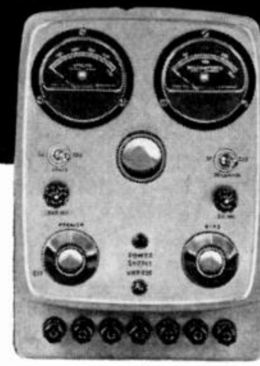
CABLES: TRANSRAD LONDON

THE **krohn-hite**

new **UHR*** *series*

POWER SUPPLIES

extremely low dc and ac impedance . . . ruggedized meters



UHR-220 is ideal for **TRANSISTOR** RESEARCH

* Ultra High Regulation over the entire operating range

MODEL UHR-220

POSITIVE SUPPLY
0-500 volts, 0-200 ma
Regulation..............0.001%
Ripple............100 microvolts
Impedance at Any Load .. dc 0.01 ohms, ac 0.1 ohms in series with 0.1 microhenry (4″ of wire)
Transient Response 0.01 millisecond

NEGATIVE SUPPLY
0-150 volts, 0-5 ma
Ripple..............2 millivolts

FILAMENT SUPPLY
12.6 volts ac at 4 amps CT

METERS........2 ranges, 0-50 and 0-500 volts. 0-20 and 0-200 ma

PRICE....$350.00

MODEL UHR-225

POSITIVE SUPPLY
150-500 volts, 0-200 ma
Regulation..............0.002%
Ripple............100 microvolts
Impedance at Any Load .. dc 0.01 ohms, ac 0.1 ohms in series with 0.1 microhenry (4″ of wire)
Transient Response 0.01 millisecond

FILAMENT SUPPLY
12.6 volts ac at 4 amps CT

METERS.....Voltmeter, 0-500 volts Ammeter, 0-200 ma

PRICE....$300.00

MODEL UHR-240

POSITIVE SUPPLY
0-500 volts, 0-500 ma
Regulation..............0.001%
Ripple............100 microvolts
Impedance at Any Load . . . dc 0.005 ohms, ac 0.05 ohms in series with 0.1 microhenry (4″ of wire)
Transient Response 0.01 millisecond

NEGATIVE SUPPLY
0-150 volts, 0-5 ma
Ripple..............2 millivolts

FILAMENT SUPPLY
12.6 volts dc at 5 amps
Ripple.............50 millivolts

METERS.....Voltmeter, 0-500 volts Ammeter, 0-500 ma

PRICE....$550.00

MODEL UHR-245

POSITIVE SUPPLY
150-500 volts, 0-500 ma
Regulation..............0.002%
Ripple............100 microvolts
Impedance at Any Load . . . dc 0.005 ohms, ac 0.05 ohms in series with 0.1 microhenry (4″ of wire)
Transient Response 0.01 millisecond

FILAMENT SUPPLY
12.6 volts ac at 10 amps CT

METERS.....Voltmeter, 0-500 volts Ammeter, 0-500 ma

PRICE....$450.00

See us at I.R.E. Show Booth 201

KH

write for free ***NEW CATALOG!***

krohn-hite INSTRUMENT COMPANY
580 MASS. AVE., CAMBRIDGE 39, MASS.

YOU CAN ALWAYS RELY ON EDISON COMPONENTS

for Electronic and Communications Equipment

Because of:

HERMETICAL SEALING in rigid glass.

TAMPER-PROOF stability that defies time and abuse.

ACCURACY. Patented feature permits calibration *after* sealing.

THERMAL TIME DELAY RELAYS

Cathode and filament protection • Gyro Erection • Prevent surges and false starts in sensitive auxiliary equipment • Miscellaneous circuit switching

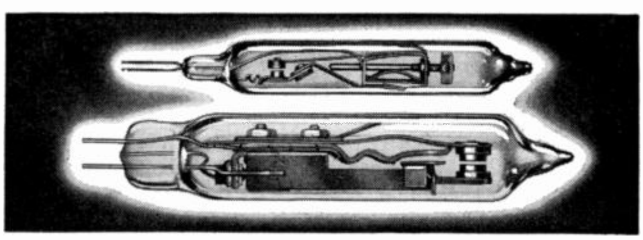
SPECIFICATIONS

Standard Octal Base

Delays . . . 2 seconds to 5 minutes
Heater . . . 5 watts nominal, continuous operation
Voltages: 6.3, 26.5 and 117
Contacts . . . 6 amps maximum, 3 amps to 450 volts a.c. or d.c.
Vibration . . . 1/16" amplitude at 55 cps. 50g shock.
Ambient . . . −60 to +85°C **Seated Height** . . . 3¼ max.

Miniature 7-Pin Base

Delays . . . 5 seconds to 75 seconds
Heater . . . 2.5 watts nominal, continuous operation
Voltages: 6.3 and 27.5
Contacts . . . 2.5 amps max. 1 amp at 125 volts d.c.
Vibration . . . 1/16" amplitude at 55 cps. 50g shock.
Ambient . . . −60 to +85°C **Seated Height** . . . 2¼ max.



SEALED THERMOSTATS

Ambient protection for frequency standards • Precision heat control for electronic laboratory instruments • Overheat detection and fire alarm

SPECIFICATIONS

Heavy duty—type D8

Max. temp. . . . . 320°C
Max. watts . . . 1000
Max. amps. . . . . 8.0 d.c.
Calibration tolerance . . . ±2.5°C
Length, 2¾"; **dia.,** 9/16" (approx.)

Precision control—type S1

Max. temp. . . . . 190°C
Max. watts . . . 150
Max. amps 1.0
Control differential at ¼ amp = 0.1°F
Length, 2½"; **dia.,** ⅜" (approx.)

Write for free bulletins and application data to:

Thomas A. Edison
INCORPORATED
Instrument Division
DEPT. 62, WEST ORANGE, NEW JERSEY

YOU CAN ALWAYS RELY ON EDISON

See Us at Booth 677, Circuits Avenue, I.R.E. Show, March 22-25

What to See at the Radio Engineering Show

(Continued from page 276A)

Neomatic, Inc.
335 Computer Avenue

Relays, sub-miniature, environmentally stable for hi-vibration, shock, temperature —65° to 200° C.

Wide section types including sensitive (10 MW UP) voltage, current, hi-speed, time delay, frequency tuned.

Network Mfg. Corp., 782 Airborne Ave. Toggle switches which comply with specs JAN-S-23 and MIL-S-6745. Available with accessories for hermetic sealing, splash and dust proofing. Applicable for commercial and military use.

New Hermes Engraving Machine Corp., 468 Electronic Ave. Engrave 15 different sizes from ONE master template. Engravographs cover a larger engraving area in one set-up than any other portable of its kind: engrave panels of unlimited dimensions, nameplates, dials, scales, stencils, dies, etc. Profiling and milling on all metals and plastics.

New London Instrument Co.
New London, Conn.
166 Television Ave.

Precision Electronic Measuring Equipment • FM Signal Generator • UHF Noise Source • UHF Sweep Generator • Grid Dip Oscillator

The J. M. Ney Co.
291 Instruments Ave.

Precious metal products including contacts, contact assemblies, sliprings and assemblies, precious metal resistance wire for precision potentiometers. *Sliding contacts for printed circuit applications.

NONLINEAR SYSTEMS, Inc.

Digital Voltmeters

BURLINGAME ASSOCIATES
234-236 Instruments Ave.

Northeast Scientific Co.
904 Registration Row

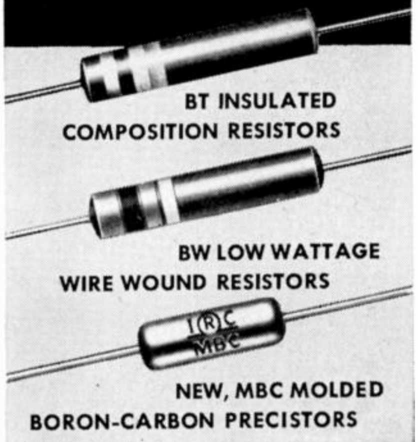
New Regulated High Voltage Supply Voltage range 700-2000, 0.0002% stability, under ½ ohm impedance, and less than ½ millivolt peak-to-peak ripple.

Northeast Scientific Co.
1 Gray St., Cambridge, Mass.

*Indicates new product

(Continued on page 280A)

IRC DISTRIBUTORS OFFER YOU FASTER, BETTER SERVICE on...



NEW IRC
INDUSTRIAL SERVICE PLAN

Independent IRC Electronic Parts Distributors can now give you the benefit of fast, local service on a greater share of your requirements. IRC's Distributor policies and prices have been adjusted to provide for larger quantities; certified quality; and new, insulated, close-tolerance resistors.

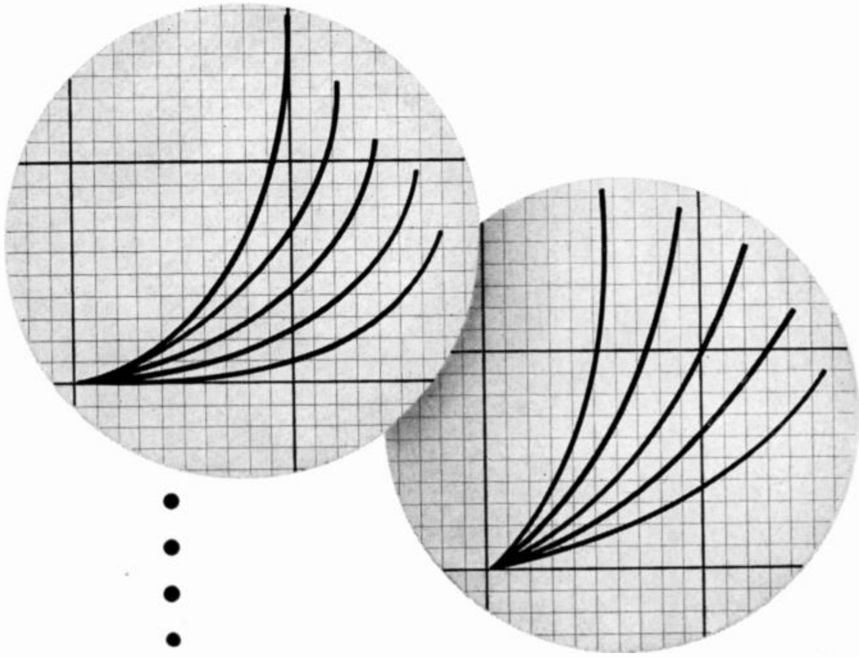
BONDED STOCK PROTECTION

Types BT and BW Resistors in quantities of 500 and over, and Type MBC in quantities of 100 and over are supplied by Distributors in FACTORY-SEALED BOXES. Sealing tape bears IRC's certification of the contents. Resistor type, wattage, value and tolerance are clearly identified. Applicable JAN or MIL Specifications are shown. You are assured fresh resistors, dependable quality and adherence to specifications.

LOCAL PROCUREMENT saves you delivery time and shipping charges. Your nearby IRC Distributor is well qualified to serve you. Call him and he'll prove it.

IRC

INTERNATIONAL RESISTANCE CO.
405 N. Broad St., Philadelphia 8, Pa.
In Canada:
International Resistance Co., Ltd., Toronto, Licensee



New: a versatile dynamic tube comparator

Here's the latest engineering development from AMF—a *dynamic* tube comparator for use in laboratories, pre-testing tubes for production, quality-control.

- **Compact and portable—affords quick, mobile testing**
- **Dynamic, versatile—tests *all* receiving-type tubes with simultaneous display of characteristics**
- **Compares sections of double-element tubes**
- **Facilitates circuit design**
- **Ideal for classroom demonstrations**

See it in operation at the I.R.E. Show
Booths 106-108 on Military Avenue

AMF

AMERICAN MACHINE & FOUNDRY COMPANY
1085 Commonwealth Avenue, Boston 15, Massachusetts

What to See at the Radio Engineering Show

(Continued from page 278A)

North Electric Mfg. Co., 375 Microwave Ave.
Hermetically sealed and unsealed relays for application in: airborne equipment, computer switching, control circuits. Rotary switches, telephone carrier equipment, & audio frequency signalling equipment.

North Shore Nameplate Co.
844 Audio Ave.

SPEEDY-CAL—Revolutionary nameplate; first improvement in over 100 years. Anodized, etched, pressure sensitive, permanent, inexpensive, meets Specs.

SPEEDY-MARX—World's fastest adhesive Wire Code Marker.

Northern Radio Co.
197, 198 Broadcast Wax

See a demonstration of the *Northern Radio TwinPlex communication system and the Variable Master Oscillator Type 173 Model #1.
See also the * Frequency Shift Diversity Converter Type 174 Model #1.

Oak Mfg. Co., 641 Circuits Ave.
Rotary, pushbutton and slide switches; VHF, UHF television tuners, choppers, vibrators and power supplies; Ledex rotary solenoids and other special electro-mechanical assemblies. Development and production for manufacturers only.

Be Right with OHMITE

Rheostats • Resistors
Tap Switches
RF Chokes

OHMITE MFG. CO.
554 Components Ave.

Olympic Metal Products, Inc.
336 Computer Ave.

Metal stampings and stamped products for the electronic industry, cans, covers, cases, brackets and small assemblies.

Optical Film Engineering Co. of Philadelphia
865 Audio Ave.

For the very latest in color television tube aluminizers, high vacuum evaporators and ultra efficient dichroic mirrors—Evaporated films of metals and dielectrics for various electrical and optical purposes.

*Indicates new product

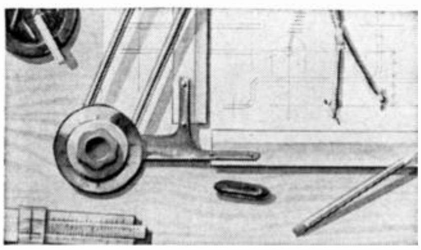
(Continued on page 282A)

One or a Million...

How expensive are your design ideas?
How accurate are your prototypes?
How quickly can you swing from pilot to production?

Do your design changes run up cost because of prototype "unreliability"? In orders of one or one million, I-S BeCu^mp springs measure up to one single standard of performance. This allows you to check your design against production tolerances and tests — without the expense of ordering production quantities. Our "Short-Run" department was set up expressly to handle pilot runs and small production requirements as regular output — instead of treating them as costly "special orders".

I-S Short-Run = Same High Performance – Lower Cost



Two Other Important Advantages

(1) Our ability to produce a better spring faster and usually at a lower cost.

(2) The specialized ability of our engineers to cooperate with your designers in developing your "problem" springs.

Like many other leading manufacturers, you will find that these I-S facilities can make significant improvements in your manufacturing processes and in your product. And they most likely will save you money! One thing is certain . . . it costs nothing to compare — it may cost considerable, *not to!*

The design stage normally poses the basic problems of time and unit costs—plus the uncertainties of performance. By utilizing I-S engineering research and advanced spring-making techniques, you save in testing time and development—as well as in elimination of regular production waste. In addition, you are ready to go into million-plus production, without time-consuming engineering usually involved in the transition from bench-made prototypes to full line production.

For more information on BeCu^mp Springs, write today to reserve your copy of our newest catalog—No. 8; for Electronic Components, ask for No. 8-A.

Instrument Specialties Co. Inc.

232 BERGEN BOULEVARD, LITTLE FALLS, NEW JERSEY
Telephone Little Falls 4-0280
BeCu^mp = Beryllium Copper, Micro-Processed

See us at Booth 867 Audio Avenue, I.R.E. Show

What to See at the Radio Engineering Show

(Continued from page 280A)

John Oster Mfg. Co.
747 Airborne Ave.

Instrument control motors—servos, synchros, resolvers; Tachometer generators; Servo Torque units; AC-DC drive motors; AC-DC blower and fan motors; Rotary and linear actuators.

PM Industries, Inc.

Booth 610 — Circuits Avenue

Slip ring assemblies designed and manufactured by molded, plated, built-up techniques. New brush and ring designs to handle RF, low noise, high voltage corona free circuitry.

PM Industries, Inc., Stamford, Conn.

PSC Applied Research, Ltd., 733 Airborne Ave.
*The world's first fully automatic electrical de-icing control system as installed in the AVRO CF-100 MK 4.

Pace Electrical Instrument Co., Inc., 438 Electronic Ave.
See: Precision Apparatus Co.

Pacent Engineering Corp., 680 Circuits Ave.
Representing: Moloney Electric Co.: Electronic transformers, Hipercore cores. Van Dyke Textigraph Co., Inc.: Helical potentiometers. T. L. G. Electric Corp.: Cable clamps, Pilot light dimmers, flux meters. Roller-Smith Corp.: Aircraft & Ruggedized Meters, Precision Balances.

Pacific Div., 130-140 Military Ave.
See: Bendix Aviation Corp.

Panelyte Division
St. Regis Paper Co.

Laminated resinous plastics—sheets, rods, tubes, fabricated parts, molded specialties in paper, fabric, glass, nylon base; with phenolic, melamine and silicone resins. Injection molded parts. Metal clad laminates for printed circuits. High strength, high heat-resisting laminates.

116-118 Military Ave.

Panoramic Radio Products, Inc.
230, 232 Instruments Ave.

*TM-1 consisting of Panoramic Indicator, Subcarrier deviation calibrator and three point frequency calibrator for FM/FM telemetry systems. *Sweep Generator (0 to 20kc, 0 to 200kc). *Triangular waveform generator. *Spectrum Analyzers, 50MC-950MC. *Distributed amplifier. *Signal Memorizer, SM-1. *Portable FM deviation monitor. *New low priced Panadaptor.

Paramount Paper Tube Corp.
385 Microwave Ave.

"Paraformed" or "Regular" type coil forms. Better quality square & rectangular paper tubing for winding better coils and transformers. Check our prices.

*Indicates new product

(Continued on page 284A)

What to See at the Radio Engineering Show

(Continued from page 282A)

Penta Laboratories, Inc., 367 Mobile Ave.
High-vacuum transmitting tubes of internal anode radiation-cooled and external anode air-cooled types. Traveling wave tubes, hydrogen thyratrons, and high-voltage vacuum switches.

Permacel Tape Corp., 605 Circuits Ave.
Pressure Sensitive Electrical Tapes.

Phalo Plastics Corp., 601 Production Road
Power Supply Cords. Cord Sets. Hook-up Wire. Cables. Wiring Harnesses. Transmission Lines. Molded-on Plugs and Connectors and miscellaneous assemblies.

Philamon Labs., Inc., 611 Circuits Ave.
An oscilloscope will show dynamically and visually the stability and accuracy between two tuning fork frequency standards in comparison to each other.

Philco Corp., Government & Industrial Div., 489-493 Electronic Ave.
See the amazing "Surface-Barrier" transistor, color TV slide and film equipment. Color TV test equipment, *television and communication microwave relay equipment.

*Indicates new product

(Continued on page 286A)

What to See at the Radio Engineering Show

(Continued from page 284A)

Phillips Control Corp., 735 Airborne Ave.
See the latest custom-engineered relays and solenoids, including type 8 relay with twin contacts anl type 51 actuator for automatic bowling-pin spotter.

Plastoid Corp., 162 Television Ave.
A representative line of pastic insulated wire and cable constructions.

The Polymer Corp. of Pa., 811 Audio Ave.
Polypenco nylon, Teflon and the *Polypenco Q-200.5 cross-linked Styrene material. Stock shapes and fabricated parts. Materials engineered for electrical insulators or mechanical parts.

Polyphase Instrument Co., 767 Airborne Ave.
*Line of transistor analyzers which measure and display current gain, negative resistance, noise, characteristic families & frequency characteristics. Pulse transformers, transistor transformers, low pass filters, strain measuring instruments.

*Indicates new product

(Continued on page 288A)

What to See at the Radio Engineering Show

(Continued from page 286A)

Polytechnic Research & Dev. Co., Inc.
293, 295 Instruments Ave.
Precision Microwave Test Equipment and Components to 75 kmc. VHF-UHF Noise Generator, Marker and Sweep Generator. Highest Gain VSWR and Magnetic Amplifiers. Low and High Voltage Power Supplies.

Popper & Sons, Inc., 437 Electronic Ave.
Marking Equipment to print on capacitors, resistors, rectifiers, cores, coils, cans, tubes, tube bases, relays, fuses; hand-operated and automatic.

Potter & Brumfield
Princeton, Ind.
Booth 520
Components Ave.
Featuring the new "PW", industry's most talked about miniature relay! Leading relay supplier to government and industry. Standard and special types, open and hermetically sealed. Wide variety of contact arrangements, mountings, enclosures, solder terminal and plug-in headers. Bring us your problems.

Potter Instrument Co., Inc.
346 Computer Avenue
*High-Speed Digital Magnetic Handler, Flying Typewriter, Magnetic Core Storage, Counter Translation Matrix and Teledeltos Printer, Frequency-Time Counters, Multiple-Sequence Predetermined Counters, 8-MC Counter Chronograph, Totalizing Scalers, Data-Handling Equipment, Plug-In Decades, Shift Registers, Frequency Dividers.

Power Designs, Inc., 308 Computer Ave.
Standard and custom fabrication. Electronically stabilized DC voltage and current regulated power supplies, designed for maximum reliability under continuous service conditions consistent with economy pricing. Special display of custom supplies.

Precise Development Corp., 282, 284 Instruments Ave.
*TV & Radio test equipment in kit & wired form. Including *8½" wide band oscilloscope; GmEm tube tester; voltage-regulated power supply, etc.

PRECISION
APPARATUS COMPANY INC.
Elmhurst, Long Island, N. Y.
438 ELECTRONIC AVENUE
High quality electrical indicating instruments; meters, electronic test and measuring instruments and accessories. Cathode-ray oscillographs, vacuum tube voltmeters, cathode-ray testers, vacuum tube testers, AM signal generators, sweep signal generators, volt-ohm milliameters, etc.

Precision Marking Co., 730 Airborne Ave.
*Photo-Mark® process for the manufacture of all kinds of instrument dials, scales, front-panels, placards, nameplates, circuit diagrams, military and commercial; on metals, glass, plastic, etc.

*Indicates new product

(Continued on page 290A)

What to See at the Radio Engineering Show

(Continued from page 288A)

Premier Instrument Corp.
The WAVEGUIDE House
52 West Houston St.,
New York 12, N.Y.
723 Airborne Ave.

Tees • Bends • Mixers • Ratraces • Duplexers • Cavities • Rotating Joints • Pads • Filters • Phasers . Attenuators • Flanges • Electronic Assemblies • Special Purpose Components.

Presto Recording Corp.
Theatre #2

Largest assortment ever of tape recording and reproducing equipment, disc recording and reproducing equipment, blank recording discs. Long playing slow speed tape mechanisms for entertainment and background music, for land installations and for all mobile use including aircraft.

Price Electric Corp.
793 Airborne Ave.

Husky relays and controls for military and commercial uses. Time delay relays, program timers, coaxial relays, rotary relays, hermetically sealed relays and numerous other types.

Prodelin, Inc.
395 Microwave Ave.

*UHF-TV waveguide with latest flange developments. *Semi-portable aluminum towers for communications. UHF, VHF-TV and microwave coaxial transmission lines and antennas.

FREE BUSES

Every 10 minutes both to and from Waldorf-Astoria

*Indicates new product

(Continued on page 291A)

What to See at the Radio Engineering Show

(Continued from page 290A)

Pyramid Electric Co.
586 Components Ave.

*Hermetically sealed dry electrolytics, 100°C low voltage dry electrolytics, AC motor starting, government specification types, and "Glasseal" subminiature capacitors.

RBM Division, 614 Circuits Ave.
See: Essex Wire Corp.

REF Manufacturing Corp., 459, 461 Electronic Ave.
Presents display of electronic cabinets and enclosures, showing the acme of perfection in welding, fabrication, assembly and engineering "Know How" unsurpassed in the metal industry.

Racon Electric Co., Inc., 830 Audio Ave.
*25-watt weatherproof re-entrant paging speaker with built-in transformer, which will provide levels of 16, 8, 4, 2, 1.3, 1.0, 0.7, 0.5, 0.34 and 0.17 watts based on a 70-volt line.

Radell Corp., 620 Circuits Ave.
MIL-Line Precision deposited carbon resistors designed to conform with exacting military specifications. Also a *companion line called INDUSTRIAL-Line for precision instrument applications.

Radio & Television News, 839 Audio Ave.
See: Radio-Electronic Engineering.

RADIO-TELEVISION-ELECTRONIC
Test Equipment
RCP
Specialists in Test Equipment for Printed Circuitry
RADIO CITY PRODUCTS CO., INC.
BOOTH #220 - INSTRUMENTS AVENUE

Radio Condenser Co., 780 Airborne Ave.
Television Tuners—V. H. F. and U. H. F. Automatic Radio Tuners—Home Radio. Variable Air Capacitors—Special. Applications Variable Air Capacitors. Custom-Built Tuning Devices—Electro-Mechanical Assemblies—Coil Products.

Radio Corp. of America
Engineering Products Dept.
151-153 Television Ave.

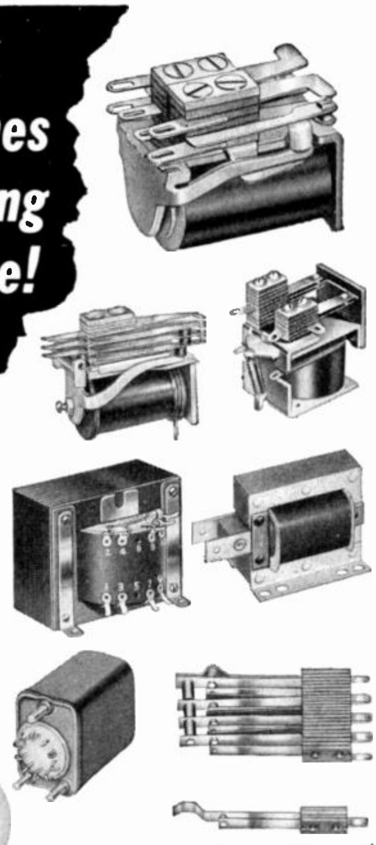
Testing and measuring equipment. Components. Dry batteries.

MORE DATA

Exhibitors listed in display type, cuts and borders have more data for you in their ads in the March issue of "Proceedings of the I.R.E."

*Indicates new product

(Continued on page 292A)



What to See at the Radio Engineering Show

(Continued from page 291A)

Radio Corp. of America, Tube Dept.
151, 153 Television Ave.

Emphasis is on color TV—*RCA color receiver dynamic demonstrator, *tricolor kinescope, deflection components, receiving tubes and test equipment developed for color *image orthicon for color. Exhibit also includes transistors, diodes, batteries, and *industrial tubes including a *40-ampere Xenon thyratron.

Radio Electronic Engineering, 839 Audio Ave.
A technical magazine for engineers and executives in all branches of the electronics industry. Presents essential, usable information on important engineering, research and development activities.

Radio-Electronics
452 Electronic Ave.

Covers TV, radio, audio-high fidelity and electronics with special emphasis on servicing. Also GERNSBACK LIBRARY of low cost technical books on electronics at the service technician level.

Radio Magazines, Inc., 852 Audio Ave.
Audio Engineering-monthly publication devoted solely to the science of reproduced sound. Audio Anthology and 2nd Audio Anthology containing reprints from Audio Engineering.

Radio Materials Corp.
518 Components Ave.

R.C.M. "DISCAP" ceramic capacitors, by-pass and temperature compensating disc types, special purpose and special voltage types.

Raleigh Engineering Div. of American Machine & Foundry Co., 106, 108 Military Ave.
Electronic Cigarette Machine Simulator with Beta gage. Microfeed Regulator provides electronic control; automatic inspection for high speed production processes. Plus a display of special purpose batteries.

Rawson Electrical Instr. Co., Inc., 210 Instruments Ave.
Laboratory meters for AC or DC featuring high sensitivity and high accuracy. Electrostatic voltmeters for zero current drain. Fluxmeters and rotating-coil gaussmeters for magnetic measurements.

(Continued on page 294A)

NOW-
available to you The finest *precision electronic test equipment*

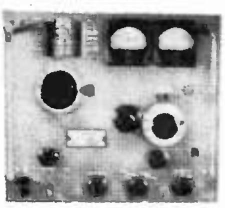
from A.R.F. Products, Inc.

A prime development and production source of communication and test equipment for the

U. S. Armed Forces

MODEL AR-1

FM Demodulator and Deviation Meter—Low distortion capable of accurately measuring FM deviation up to 1 MC over audio frequency range of 100 to 85,000 cycles with distortion below 0.5% for 100 KC deviation.



MODEL ASG-1

FM Signal Generator—covering 20 to 100 MC—For communication receivers and radio relay sets—featuring built-in crystal controlled frequency calibrator, precision indication of deviation and output levels and extremely low hum level.

Dual channel Audio amplifier—for Laboratory use with oscilloscopes, metering circuits, transmitter modulators and line amplifiers—featuring low distortion (BELOW 0.3%) and wide frequency response, (7 cps to 200,000 cps).

MODEL AAM-1

Crystal Calibrator and Sampler — Provides audio or oscilloscope frequency marks at intervals of 200 KC, 1 MC, 5 MC, 20 MC over a frequency band up to 400 MC — designed for use without interruption of the tested circuit.

MODEL AFR-1

Write Dep't. I.R.E. 354 today for literature and prices

A.R.F. PRODUCTS, INC.

Engineers and Manufacturers of Precision Electronic Products

7627 Lake St., River Forest, Ill.

NTSC
COLOR EQUIPMENT

PRICED RIGHT • *BUILT RIGHT* by

Tel-Instrument

A COMPLETE NTSC COLOR EQUIPMENT PACKAGE FOR LESS THAN $15,000!

Consists of the following:

Type 2600	Color Sync and Waveform Generator.
Type 2610	Matrixer and Encoder.
Type 2303	Color Monoscope.
Type 2120-A	Color Transmitter.
Type 2700	Equalizing Filter.
Type 2401	Color Picture Monitor.

Above equipment includes all power supplies which are of basically new design.

Tel-Instrument the world's leading manufacturer of TV Production and Laboratory Test Equipment, now makes available to the TV industry the first complete NTSC *COLOR* package based on completely new and integrated circuitry. This equipment is not to be confused with any presently available which is essentially a modification or adaptation of obsolete black and white equipment

This new approach enables *Tel-Instrument* to realize radical economies in manufacture, and still maintain the highest degree of electrical and mechanical standards.

We welcome the opportunity to further acquaint you with complete details concerning our NTSC color package.

Manufacturers of a Complete Line of TV Test Equipment

TIC Tel-Instrument Co. Inc.

728 GARDEN STREET • CARLSTADT, N. J.

Visit Us at Booths 256-258 Radio Engineering Show

What to See at the Radio Engineering Show

(Continued from page 292A)

Raymond Engineering Lab., Inc., 113 Military Ave.
Single magnetic fluid clutches-reversing magnetic fluid clutches, complete servo actuators, miniature solenoid type clutches, single and reversing.

Raytheon Mfg. Co.
145-149 Military Ave.

Miniature Radar, Table Model "Radarange," Computer Components, latest Developments in Transistors, *New Designs of Magnetrons, Servo-Mechanisms, Magnetic Amplifiers, Ultra-Sonic Devices, Radar and Missile Components, *Transistor Products, Vacuum Tubes.

Red Bank Div., 130-140 Military Ave.
See: Bendix Aviation Corp.

Reeves Instrument Corp., 341-347 Computer Ave.
*Portable and other REAC analog computers; Standard (¼") and *miniature (⅛") breadboard parts with working models of resolvers, magnetic clutches and gyros.

Remington-Rand, Inc., Electronic Computer Div., 356-360 Mobile Ave.
Univac General Purpose and E. R. A. Special Purpose Electronic Computers, Electronic Training Course.

Remler Company, Ltd.
364 Mobile Ave.

*Transluctance Microphone, with integral transistor pre-amplifier, *Marine Order System, *Induction Communication Announcing System—magnetic induction to individual receiver units, Marine General Announcing Equipment, Representative types of Air Force & Signal Corps equipment, Comprehensive historical radio exhibit of Remler products since 1918.

Reon Resistor Corp., 632 Circuits Ave.
Precision Wirewound resistors, MIL-R-93A, Commercial, Miniature, Sub-miniature, and Central Axial; also *encapsulated resistors for salt water specification (JAN-R-93A); Vitreous enamel power MIL-R-26B and commercial versions.

The Rex Corp., 515, 517 Components Ave.
*Spiral striped Kel-F insulated wire, copper clad Rexolite for UHF printed circuits, Fibre Glass reinforced Rexolite, miniature hook-up wire, multiple conductor cables.

FIRST AID ROOM

A nurse is in charge at all times. First Aid Room is the third room to left of Lobby directly off registration area.

(Continued on page 296A)

YOURS
for the asking

packed with the latest and most complete information on

performance guaranteed

TAPE WOUND CORES

- 12 Pages of Performance Curves
- Tables of Guaranteed Performance
- Description of Core Matching Service
- Applications – Constructions

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For your copy of the "Performance-Guaranteed" Tape Wound Core Catalog

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BOX I-1

MAGNETICS, inc.
Specializing in High Permeability Magnetics
BUTLER, PA.

Visit Booth 795, Airborne Ave., IRE Show.

"Nobleloy" METAL FILM RESISTORS

TRADE MARK REG

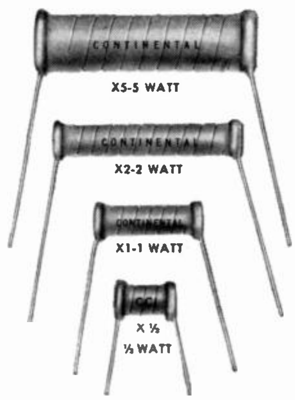
FOR APPLICATION WHEN PERMANENCY AND HIGH TEMPERATURE STABILITY —ARE A MUST

Efficient manufacturing methods and adequate plant equipment combined with our research facilities maintains our pace with electronic progress to economically provide dependable, high quality resistors. The Nobleloy metal film resistor is our tribute to the electronic industry for a fixed resistor that assures initial accuracy and high stability.

NOBLELOY TYPE NF

½ WATT

A metal film miniature precision resistor with a metallic resistance element deposited on a low loss ceramic carrier and axial leads firmly fastened to silver contact bands. A layer of vitreous enamel protects metal film against unusual atmosphere conditions. Primarily designed to meet MIL-R-10509A specifications.



NOBLELOY TYPE X

A metal film resistor with radial leads firmly fastened to extremely low resistance metal contact films to reduce contact resistance. It has a hollow center that permits greater heat radiation to withstand overloads, and possesses excellent resistance stability under adverse operating conditions. Each unit marked with resistance and tolerance.

NOBLELOY TYPE PX

A metal film resistor identical in construction as type X. A different improved alloy resistance film is used to allow for better temperature coefficient. Each unit marked with resistance and tolerance.

WM WIRE WOUND RESISTORS

Composed with a minimum of .0015 inch wire that is wound automatically for true parallel winding to prevent shorting at turns. Terminals are securely bonded for permanent connections to the winding. They are moisture resistant and recommended for circuits requiring very low resistance which is not ordinarily available in the carbon style.

WM1 • 1 WATT

WM½ • ½ WATT

WM⅓ • ⅓ WATT

Technical Data Furnished on Request

CONTINENTAL CARBON, INC.
13900 LORAIN AVE. CLEVELAND 11, OHIO CLEARWATER 1-6500

What to See at the Radio Engineering Show

(Continued from page 294A)

Booth, 751 Airborne Ave.

All-metal (MET-L-FLEX) vibration and shock mounts and engineered mounting systems.

PIONEERS IN AIRBORNE, SHIPBOARD, MOBILE, INDUSTRIAL AND PACKAGING MOUNTINGS

Rockbar Corp., See Welwyn.

702 AIRBORNE AVENUE

Ruggedized and Hermetically Sealed Instruments, JAN type Instruments, Switchboard and Portable Instruments, Indicating Relays, Rotary Switches, Precision Balances.

Rotron Mfg. Co., Inc., 581, 583 Components Ave.
Hi-Altitude Blowers and Fans, Multistage Air Turbines, Activated Carbon Filters, Utility Blowers, Inverted Blowers, Transmitting Tube Supports, Airflow Determinator Kit

Rutherford Electronics Co.

424 Electronic Ave.

*Model A-5 time delay generator and E-2 range sweep generator together with a line of precision pulse generators and timing instruments.

St. Regis Paper Co., Panelyte Division, 116, 118 Military Ave.
See: Panelyte.

SANBORN COMPANY
Cambridge 39, Mass.
455–457

The new Sanborn 150 Series direct writing oscillographic recording systems—a new design concept that brings even greater versatility to industrial oscillographic recording.

(Continued on page 298A)

What to See at the Radio Engineering Show

(Continued from page 296A)

Sanders Associates, Inc., 703 Production Rd.
*Modular Electronic Design (Project TINKERTOY) with ceramic modules; components; semi-mechanized modular production programs and engineering service "know how."

San Fernando Electric Mfg. Co., 619 Circuits Ave.
Hermetically sealed paper-dielectric capacitors to your commercial and military specifications.

Sangamo Electric Co.
Capacitor Div.
490 Electronic Ave.

Fixed Mica, Paper and Electrolytic Capacitors.

Carl W. Schutter Mfg. Co., 563, 565 Components Ave.
Components for pressurizable bead supported 3⅛" coaxial line (175 OHM) usable to 2300 Mc (VSWR of 1.05, loss of 0.1 db/100 ft. Voltage breakdown above 26,000 pk.).

Scintilla Div., 130-140 Military Ave.
See: Bendix Aviation Corp.

Sealtron Corp.
827 Audio Ave.

Complete line of hermetic glass-to-metal seals. *"Royal Blue" *Bonded* Compression Seals. Seal Assembly Service to solder seals into *your* units with guaranteed hermetic perfection.

SENSITIVE RESEARCH INSTRUMENT CORPORATION
MOUNT VERNON, N.Y.
BOOTH 386
Microwave Ave.
PRECISION ELECTRICAL MEASURING INSTRUMENTS
LABORATORY STANDARDS & SUB STANDARDS
Symbol of Quality

Servo Corp. of America
203, 300 Production Rd.

*1360A Pyrometer, *VHF Receiver, *Receiver Converter, *HV Power Supply, Servoscope, Servoboard, Signal Generator, Infrared Equipment, Servofrax glass, Direction Finders, Pyrometers, Communications test equipment, servo test and analysis equipment.

*Indicates new product

Want to join the IRE? Come to IRE Room—to right of Lobby!

(Continued on page 300A)

What to See at the Radio Engineering Show

(Continued from page 298A)

Servomechanisms, Inc.
740, 742 Airborne Ave.

Servo Amplifiers, Power Supplies, Servo Motors, Mechanical Development Apparatus, Pressure Transducers, Positioning Mechanisms, Film Potentiometers, Magnetic Amplifiers, Relative Wind Transducers, Accelerometers, Analog Computers, 60 to 400 cycle plug-in Components and Systems.

Servo-Tek Products Co., Inc.
816 Audio Ave.

Introducing a line of electronic adjustable-speed motor drives and servo systems, utilizing *Servo-Tek rate generators, motors, amplifiers, and a *constant reference voltage supply.

The Sessions Clock Co., 510, 512 Components Ave.
Clock Timers for Clock Radios. Snap-Action Switches. Timing Motors, Movements and Switches for Industrial Applications.

Shakeproof Div., 739 Airborne Ave.
See: Illinois Tool Works.

SHALLCROSS
Mfg. Co.
559, 561 Components Ave.

*Encapsulated "P" Type Resistors · Adjustable stop switches · Shielded decade boxes · Decade Delay Lines · Push-button rf attenuators · Miniature 20-step attenuators · Boro-carbon resistors.

Shasta Div., 752, 754 Airborne Ave.
See: Berkeley, Div. Beckman Instruments.

MULTI-CELL® SHIELDING ENCLOSURES
SCREEN ROOMS featuring the new type enclosure built in accordance with MILITARY SPECIFICATIONS . . . **MIL-S-4957**
BOOTH 895 BROADCAST WAY
New MODULAR TYPE standard enclosures suitable for use with various types of shielding materials.
SHIELDING, INC., RIVERSIDE, N. J.

F. W. Sickles Div., General Instrument Corp., 362 Mobile Ave.
New Color Deflection System, 70° and 90° Deflection Systems, Printed Circuits, IF Strips and S-Trans.
*Indicates new product

FREE BUSES
Every 10 minutes both to and from Waldorf-Astoria

(Continued on page 302A)

What to See at the Radio Engineering Show

(Continued from page 300A)

Sigma Instruments, Inc., 636, 638 Circuits Ave.
Featuring a *250 page Relay Engineering Manual a "must" for the user of sensitive relays! Three *sensitive polarized relay types. Standard line of quality, sensitive relays for industry.

Simberkoff Sales Co., 774 Airborne Ave.
Representing Maryland Etching Co. and U. S. Engineering Co.

Herman H. Smith, Inc., 578 Components Ave.
*Vibres Expanding Panel Fasteners—A radically new device which combines a fastening and a shock and vibration absorption in one fastner. Phone tip and banana plug with molded plastic handles and various types phone tip banana jacks.

*Indicates new product

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

(Continued on page 304A)

What to See at the Radio Engineering Show

(Continued from page 302A)

Southern Electronics Co.
715 Airborne Ave.

Precision Polystyrene Capacitors made to 0.1% Tolerance. "Mylar"† Capacitors to 1% Tolerance in very small package. Capacitance Decades to 1% Tolerance in both Polystyrene and "Mylar"† RC Filters for Band Pass and Band Rejection.

† Product of E. I. du Pont de Nemours & Co.

Southwestern Industrial Electronics Co.
213, 215 Instruments Ave.

*Versatile resistance meters; *Stable DC amplifier; *Portable transducer simulator and the famous SIE wide-range oscillators and laboratory-quality voltmeters.

Spencer-Kennedy Labs., Inc.
257, 259 Instruments Ave.

Be sure to see our *Series 600 High Speed Oscilloscope, Model 504 Square Wave Generator as well as many *TV Master Antenna System developments.

Sperry Gyroscope Co.
351, 353 Mobile Ave.

*First 5-Kilowatt Travelling Wave Amplifier Tube; *Gyrotron® Vibratory Gyroscope; and *field test equipment for microwave radar systems. Klystrons for medium and high power amplification, millimeter bench oscillators, STL and communications links. Latest designs of microwave measuring instruments.

Sperry Products, Inc., 286 Instruments Ave. (Danbury, Conn.)
Ultrasonic test instruments, Avionic amplifiers, Precision mechanical gear assemblies, Hermetically sealed transformers and magnetic amplifiers, Self-sealing couplings, Hydraulic remote controls, Chasis and sheet-metal work.

Sponge Rubber Products Co., 382 Microwave Ave.
Exhibit features actual demonstration of Microwave power absorption for three new absorbents: 500 mc and 2500 mc types, also a series of variable dielectric materials made of cellular rubber.

Sprague Electric Co.
247, 249 Instruments Ave.

*High Reliability Molded Borocarbon Resistors—*High Reliability Metallized Paper Capacitors—*Vitamin Q-M 125°C Subminiature Paper Capacitors—*Subminiature Pulse Transformers—*Miniaturized Blue Jacket Power Wire-Wound Resistors.

*Indicates new product

(Continued on page 306A)

What to See at the Radio Engineering Show

(Continued from page 304A)

Square Root Mfg. Corp., 440, 442 Electronic Ave.
Manufacturers of Electronic Equipment Consisting of: Toroids, Filters, Magnetic Amplifiers, Transformers: RF and Power, Phase Convertors, Amplifiers, Speed Controls, Direction Finder Antennas, Record Players, and Automatic Pilot Components.

Standard Pressed Steel Co., 115 Military Ave.
*"Micro" socket screws, self-locking spring pins. Also locknuts, clinch nuts, flat and button head socket screws, steel work benches, stools, cabinets and other shop equipment.

Stelma, Inc., 690 Circuits Ave.
*A portable telegraph distortion analyzer. Teletypewriter Regenerative Repeaters. Bias Test Sets. Receiver Carrier Telegraph. Electronic Ry Generator. Radio teletype telegraph monitor. Teletype communications equipment.

Sterling Engineering Co., Inc., 106, 108 Military Ave.
A subsidiary of American Machine & Foundry Co. Custom-made and standard relays designed to meet quantity production for unusual applications. Special application in radiosonde equipment.

Stevens-Arnold, Inc.
713 Airborne Ave.
Most diversified line of DC-AC Choppers, ultra-high-speed relays, and frequency sensitive relays. *Also first showing of complete line 60 cycle choppers.

Stevens Mfg. Co., Inc.
662 Circuits Ave.
Coil winding equipment for winding Armatures, Bobbins, Chokes, Progressive Universal Types, Universal Types, Resistors-solenoids, Transformers.

George Stevens Mfg. Co.
600 Production Rd.
All types of coil winding equipment —featuring *MODEL #319-AM with built in adjustable width control *MODEL #36-MA Armature winder, designed specifically for instrument and servomechanism.

*Indicates new product

(Continued on page 308A)

AKRON

"Project Tinkertoy," by C. C. Rayburn, National Bureau of Standards; November 19, 1953.

Tour of WAKR-TV facilities conducted by I. K. Knopp, Chief Engineer, WAKR-TV; December 17, 1953.

ATLANTA

"Phonetics and Communications," by Dr. B. J. Dasher, Faculty, Georgia Institute of Technology; December 18, 1953.

BALTIMORE

"Project Tinkertoy," by Cmdr. C. N. Quinland, USNR; December 9, 1953.

BINGHAMTON

"Digital Computers," by P. A. Perrone, International Business Machines; January 11, 1954.

BOSTON

"Some Recent Developments in Automatic Control Systems in Great Britain," by Prof. Arnold Tustin, University of Birmingham, England; December 10, 1953.

"NTSC Color Television," by R. P. Burr, Hazeltine Corporation; January 12, 1954.

BUFFALO-NIAGARA

"Analog Computers," by D. R. Allen, Bell Aircraft Corp.; January 20, 1954.

CEDAR RAPIDS

"Recording and Automatic Analysis in Atmospheric Studies," by Dr. A. R. Kassander and R. M. Stewart, Iowa State College; October 21, 1953.

"Cosmic Ray Measurements in Rockets at Far Northern Latitudes," by Dr. M. B. Gottlieb; and film, "Highlights of Farnborough 1952"; November 16, 1953.

Inspection trip of KCRI-TV and WMT-TV; December 16, 1953.

CENTRAL FLORIDA

"Automatic Controls for Aerial Photography," by Dr. George Bruck, Radiations, Inc.; December 15, 1953.

CHICAGO

"The Surface of the Moon," by Dr. Harold C. Urey, University of Chicago; January 15, 1954.

CLEVELAND

"Expanding Technology," by Dr. J. W. McRae, Bell Telephone Labs.; December 17, 1953.

COLUMBUS

"Binaural or Stereophonic Sound," by J. W. Hines, Magnecord, Inc., assisted by H. J. Schroeder, Neal Bear Corp.; December 15, 1953.

DAYTON

"Winds in the Upper Atmosphere by Meteors, Radio and Rockets," by Dr. F. L. Whipple, Harvard University; December 10, 1953.

DETROIT

"Color Television" (lecture and demonstration) by C. N. Hoyler, David Sarnoff Research Center of R.C.A.; November 20, 1953.

Demonstration of Wayne University's large digital computer by Dr. A. W. Jacobson and Dr. E. P. Little, both of Wayne University Computation Lab.; December 18, 1953.

EMPORIUM

Demonstration of binaural sound, by Norman Jarosic and Victor Fryling, Sylvania Electric; December 8, 1953.

(Continued on page 315A)

What to See at the Radio Engineering Show

(Continued from page 306A)

Stewart Stamping Co., 615 Circuits Ave. Metal stampings & wire forming, specializing in automatic, low-cost, high-speed volume production. Standard and specially designed parts for the electronic and electrical industry.

Stupakoff Ceramic & Mfg. Co.
866, 868 Audio Ave.

Ceramics including Alumina, Cordierite, Titanates, Steatite, Porcelain, Zircon for all Temperatures, Voltages and Frequencies. Negative Temperature Sensitive Resistors. Metallized Ceramics and Assemblies, Kovar Metal, Glass-to-Metal Seals and Sub-Assemblies, High Dielectric Materials, Printed Electronic Circuits, Insulcon and Stupalith.

The Superior Electric Co.
100-104 Military Ave.

Complete standard line of POWERSTAT Variable Transformers; STABLINE Automatic Voltage Regulators; VARICELL DC Power Supplies; VOLTBOX AC Power Supplies, and 5 WAY Binding Posts. *POWERSTAT types 136 and 236 featuring higher ratings, new design and rhodium-plated computator.

Surprenant Mfg. Co.
729, 731 Airborne Ave

*Miniature teflon coaxial cables. *Low temperature tubing and jackets. *Light weight aircraft constructions. *High temperature hookup wires. *Wires for miniaturization.

Extruded teflon and Kel-F wire. Many types of wires and cables with broad temperature ranges and excellent electrical properties, in standard construction or custom engineered.

Sutton Publishing Co., Inc., 864 Audio Ave. March issue of "Electronic Equipment" in new king-size format with expanded editorial content including industrial electronic applications and new product information.

Wally B. Swank, 639 Circuits Ave. Representative for Grayhill Switches, Special molded parts.

Swiss Jewel Co., 836 Audio Ave. Jewel Bearings. Sapphire Products. Precision Screw Machine Products. All made to your specifications.

Switchcraft, Inc.
435 Electronic Ave.

*Miniature audio mixers: Complete line telephone jacks and plugs; Switches—Lever, push button and lever action types; Multiple switch assemblies; Cable assemblies.

*Indicates new product

FIRST AID ROOM

A nurse is in charge at all times. First Aid Room is the third room to left of Lobby directly off registration area.

(Continued on page 310A)

What to See at the Radio Engineering Show

(Continued from page 308A)

Syntronic Instruments, Inc., 621 Circuits Ave.
*Rotating deflection coil and complete line of deflection yokes for TV, Radar, Computer and Special Applications. Also associated transformers, focus coils and centering devices.

T.L.G. Electric Corp., 680 Circuits Ave.
See: Pacent Engineering Corp.

The Technical Materiel Corp., 449, 451 Electronic Ave.
Receivers, Communications; fixed frequency, diversity and remote control. Frequency Shift Exciters & Converters. Variable Oscillators. Voice Frequency Telegraph. Rhombic, Beverage & Dipole Antenna Couplers. Regenerative Repeaters. Locator Beacons.

*Indicates new product

(Continued on page 312A)

What to See at the Radio Engineering Show

(Continued from page 310A)

Technitrol Engineering Co.
330 Computer Ave.

Pulse transformers: Variable width pulse generator; *Compact, wide band delay lines for pulse and color TV; *quartz memory package.

TECHNOLOGY INSTRUMENT CORP.
Acton, Mass. 226-228 Instruments Ave.

Presents NEW Phase Measuring Devices, Primary and Secondary Phase Standards. NEW Power and Compressor Amplifiers. NEW Metlfilm Potentiometers. Ball bearing, Plug-in, Miniature and Standard Linear and Non-linear Potentiometers. Signal Generators, Z-Angle Meters, Wide Band Decade Amplifiers, Complex Plane Analysers, Potentiometer Noise Analysers — all on display.

Telechrome Inc., 181, 183 Television Ave. Complete color TV broadcasting and Receiving facilities. Now color monitoring and test equipment. Pictures will be sent in color throughout show.

Telechron Dept., 446 Electronic Ave. *Clock radio timer to permit larger clock dials and greater flexibility in styling. Called the in-line 99, this unit will be featured in the exhibit.

Telecomputing Corp., 319, 321 Computer Ave. Data reduction equipment, including the Contact Telereader and Teleducer.

Tele-Tech & Electronic Industries, 642 Circuits Ave. This TV-electronic engineering magazine published by Caldwell-Clements, Inc., is exhibited in blown-up form in a display which also includes Tele-Tech supplements, maps, charts, directories, etc.

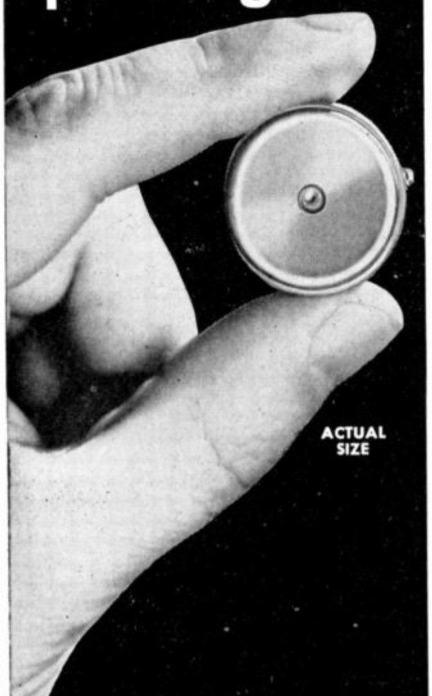
Teletronics Lab., Inc.
302 Computer Ave.

Pulse Generators—Single and Double Pulses, Sweep Calibrators, Precision Marker Generators, Diode Test Instruments, Constant Current-Voltage Power Supplies, Push-Button Test Oscillators, Secondary Frequency Standards.

*Indicates new product

(Continued on page 314A)

Worth planning for!



new SHURE series of 1-inch "Controlled Reluctance" Microphones

These Rugged Microphones Make Ideal Components for Small, Compact Equipment

• The new Shure MC Series of 1-Inch "Controlled Reluctance" Microphones were specially designed for use with transistor circuits—and they are highly recommended for use in transistor-type hearing aids. These 1-Inch Microphones are also ideally suited for use in vacuum tube devices such as small, compact Amplifiers, Transmitters, Dictating Equipment—wherever size and weight are factors, and portability is extremely important. The MC Series Microphones normally are furnished with impedance of 1000 ohms (other impedances are available).

The MC Series Microphones are rugged magnetic units, relatively *immune to mechanical shock and to varying conditions of heat and humidity.*

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AMAZINGLY VERSATILE ASSISTANTS SEEK EMPLOYERS WITH IMAGINATION

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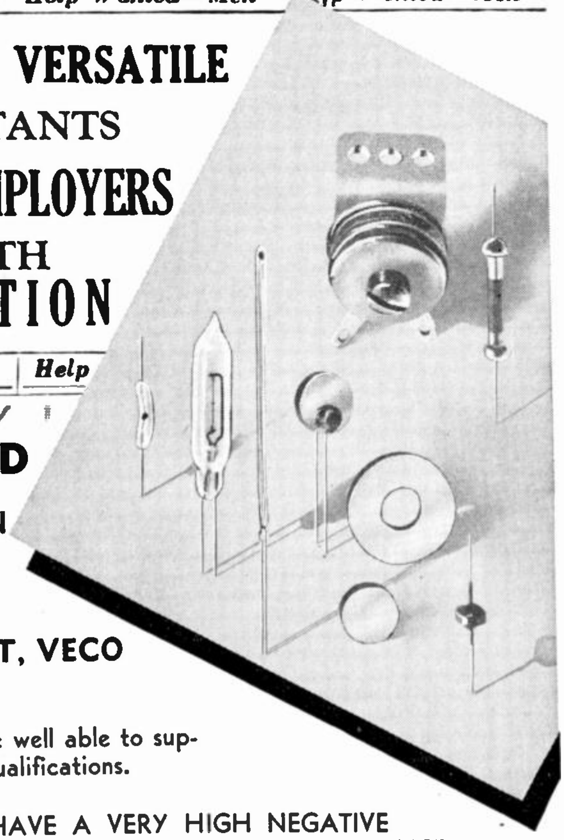
FACTORY



IF THEY COULD WRITE THEIR OWN APPLICATION FOR EMPLOYMENT, VECO

THERMISTORS would be well able to support such extraordinary qualifications.

VECO THERMISTORS HAVE A VERY HIGH NEGATIVE TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTANCE. Their SMALL SIZE and EXTREME SENSITIVITY to THERMAL CHANGES offer engineers a circuit element which can be utilized in new designs, and in improving old equipment.

VECO THERMISTORS have HIGH STABILITY, UNLIMITED LIFE when operated within their temperature ratings, and NO HYSTERESIS effects. These COMPACT, SHOCK-RESISTANT, semi-conductors are STOCKED in a WIDE RANGE of temperature vs. resistance characteristics—can also be produced to YOUR SPECIFICATIONS. Types of construction include RODS, DISCS, WASHERS, and BEADS, in a VARIETY of SIZES and MOUNTINGS.

A FEW PRESENT USES: Time delay • Gas analysis • Volume limiting • Surge protection • Vacuum manometry • Flow measurement • Temperature control • Temperature measurement • Radar power measurement • Temperature compensation • Oscillator stabilization • Additional applications being developed every day.

Have you considered all the possibilities of SIMPLIFYING YOUR CIRCUITRY—of designing for COMPACTNESS and INCREASED SENSITIVITY? A request on your business stationery will bring the VECO DATA BOOK, which contains specific technical information, characteristics, and applications of VECO THERMISTORS.

Visit Victory at the IRE Show, Booths 657, 659 Circuits Avenue.

$5.00 cash or money order, plus postage, will bring you the VECO Experimental THERMISTOR-VARISTOR package, No. 168—7 items and application circuitry—over a $15.00 value!

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ELECTRONIC AND THERMAL CONTROL INSTRUMENTS

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VECO

Victory
ENGINEERING CORPORATION
Springfield Road, Union, N. J.

What to See at the Radio Engineering Show

(Continued from page 312A)

Tetrad Company, Inc., 807 Audio Ave.
Diamond phonograph needles. Microscopic examination of customers' worn stylii.

Thomas Electronics, Inc., 773, 775 Airborne Ave.
Colortronic Picture Tubes—Single Gun "Lawrence" and "Shadow Mask" 3-Gun types. Complete line black and white, aluminized, and non-aluminized, including *90° deflected 21 inch.

Thompson-Bremer & Co., 106, 108 Military Ave.
A subsidiary of American Machine & Foundry Co. See the exclusive design features of "Everlock" lightweight, low-cost locknuts, terminals, lockwashers. . . providing vibration-proof, stronger, positive grip. Standard and special order units.

*Indicates new product

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

(Continued on page 316A)

SECTION MEETINGS

(Continued from page 307A)

Fort Wayne

"Transistor Applications," by R. D. Lohman, RCA Labs.; January 7, 1954.

Hamilton

"Application of Transistors," by Malcolm Gullen, CSRDE; December 14, 1953.

Hawaii

Description and inspection of the new KGMB-TV conducted by Dan Hunter, Hawaiian Broadcasting System Ltd.; December 9, 1953.

"Application of Radar to Cloud Physics Research," by D. S. Johnson, Pineapple Research Institute; January 14, 1954.

Houston

"Magnetic Tape Recording for Seismic and other Specialized Applications," by Fred Harmon, Southwestern Engineering and Equipment Company; December 15, 1953.

Huntsville

"The Logical Design of a Precision Data Processing System," by H. E. Burke, Jr.; Consolidated Engineering Corporation; December 15, 1953.

Indianapolis

"New Advances in Electronic Analog Computation," by J. R. Judkins, Naval Ordnance Plant; December 11, 1953.

Inyokern

"Electron Tube Design and Application (with particular emphasis on the Arinc and Subminiature Tubes)" by Messrs. Hass, Summerville and Millas, all of General Electric Company; December 14, 1953.

"Electronic Instrument Transformers," by John Jauch, Thermador Electrical Manufacturing Company; January 11, 1954.

Little Rock

"Industrial Electronics," by Floyd Wilson, U. S. Time Corp.; and film "The Telephone Cable to Cuba," furnished by A.T. & T.; January 19, 1954.

London

"The Future of Television as I See It," by Dr. Allen B. DuMont; December 11, 1953.

Long Island

"Definition of Images," by G. C. Higgins, Eastman Kodak Research Laboratory; December 8, 1953.

"A Modern View of Filtering Theory," by Dr. L. A. Zadeh, Faculty, Columbia University; January 12, 1954.

Los Angeles

"Things We Can Learn from the European Electronics Industry," by Burgess Dempster, Electronic Engineering Company; "Method of Specifying Transistor Performance," by W. R. Sittner, Hughes Aircraft Company, and dinner speaker: "Applied Psychology in Professional Development—or—What Every Engineer Should Know," by F. L. Graham; December 1, 1953.

Miami

"Acoustics in Radio and Engineering," by A. C. Wylly, Acousti Insulation Company, and "Unusual Electronic Industries in Florida," by Robert Newman, Student, University of Miami; November 27, 1953.

"A Punched Card Controlled Airborne Navigation Computer," by E. B. Thornley, Collins Radio Company; December 18, 1953.

(Continued on page 334A)

What to See at the Radio Engineering Show

(Continued from page 314A)

Tinnerman Products, Inc., 643, 645 Circuits Ave.
Engineered fasteners for the electronics industry. "Spotlighting the New" with recently developed *fasteners for printed circuits.

Tracerlab, Inc., 317 Computer Ave.
First commercially practicable automatic flow counter, a *scintillation counter, a *new model of the Autoscaler, and the Superscaler—a counter which features plug-in units. A complete line of accessory products and radiochemicals.

Transformer & Electronic Specialties Co. (Tresco), 654 Circuits Ave.
Transformers and Electronic Assemblies. Canned Transformer per MIL-T-27, Magnetic Amplifiers, Specialized Electronic Assemblies, Canned and Potted Standard Commercial Types of Transformers.

Transformer Engineers, 821 Audio Ave.
See: William Miller Instruments, Inc.

Transitron Electronic Corp., 681 Circuits Ave.
Gold-bonded germanium diodes featuring high back resistance, high forward conductance, short recovery time. Bonded silicon diodes for high temperature, high frequency operation.

*Indicates new product

(Continued on page 318A)

MICROWAVE

FREQUENCY METER 810
8,200 mc to 12,400 mc

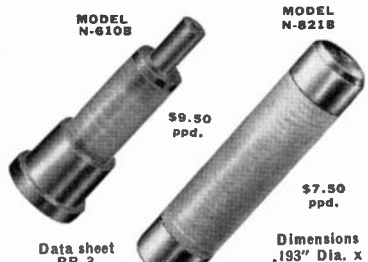
The NARDA model 810 Frequency Meter is a cylindrical cavity type resonator mounted on a section of 1 x ½ waveguide · The cavity is tuned over the complete range by a precision micrometer drive with a vernier which may be read to 0.0001 inch · A calibration table is mounted on the cavity · A reactive dip of at least 10% is obtained at all frequencies in the range · There are no spurious responses or other ambiguities.

SPECIFICATIONS:

Accuracy:	0.1%	
Precision:	0.02%	$110.00
Loaded Q:	7000	FOB.
Reactive dip:	10% min.	

Detailed catalog sheet RA-3 on request

NEW IMPROVED BOLOMETERS



Data sheet RB-3 on request

Dimensions .193" Dia. x .812" Long

APPLICATIONS:
Microwave power measurement · Square Law detection · VSWR detection · Attenuator calibration.

FEATURES:
N-610B INTERCHANGEABLE with 1N21 and 1N23 crystals in all tuneable probes, waveguide and coaxial crystal detectors.
STANDARDIZED BIAS—8.75 ma. for 200 ohms.
HIGHER BURNOUT RATING—15 mw of rf at rated bias.
RUGGEDIZED—soldered contacts and improved construction.
N-821B INTERCHANGEABLE in all barretter mounts.
RUGGEDIZED CONSTRUCTION.
Silver contacts and continuous copolymerstyrene sleeve.
STANDARDIZED BIAS—8.75 ma for 200 ohms.

Write for NARDA Catalog RC-3—a COMPLETE line of microwave test equipment.

NARDA NASSAU RESEARCH & DEVELOPMENT ASSOCIATES INCORPORATED
66 MAIN STREET · MINEOLA, NEW YORK · GARDEN CITY 3-3570

SWITCHCRAFT® INC. INTRODUCES ANOTHER MINIATURE 2-INPUT AUDIO MIXER

"MINI-MIX"

FOR USE WITH RECORDERS AND AMPLIFIERS USING JONES TYPE CONNECTORS

Made to fit recessed connections such as used by Webcor tape recorders.

Part No. 325 "MINI-MIX"

THESE FEATURES HAVE MADE "MINI-MIX" THE POPULAR MIXER

- Ideal for use with Tape, Wire or Disc Recorders; Amplifiers, Musical instruments, etc.
- Weighs only 3 ounces—small size.
- Connects directly to equipment.
- Minimum lead lengths inside shielded housing minimizes "stray pick-ups."
- Gain control knobs recessed inside housing—no bothersome projections.
- Gain control knobs located directly "in line" with inputs eliminate confusion in selection.
- Attractive brown finished case—nickel plated accessories.

Part No. 320 "MINI-MIX"
Microphone connector input and output mating with standard mic connectors.

Part No. 310 "MINI-MIX"
Phone Jack inputs with Phone Plug output fitting standard jacks.

SEE THESE AND OTHER NEW COMPONENTS
Booth No. 435
IRE RADIO ENGINEERING SHOW

SWITCHCRAFT INC.
1332 N. Halsted St., Chicago 22, Ill.
Canadian Representative
ATLAS RADIO CORP. LTD.
560 King St., W. Toronto 2B, Canada
Phone: Waverly 4761

AVAILABLE AT ALL LEADING RADIO PARTS JOBBERS •

What to See at the Radio Engineering Show

(Continued from page 316A)

Transradio, Ltd.
390 Microwave Ave.
CO-AX Air-Spaced Very Low Capacitance Cables. Magiflex Television Cables. Microdual Two-Speed Precision Drives. SM Subminiature Screened Connectors.

Travco Engineering Co., 728 Airborne Ave.
Aircraft and Missile Miniature Motors, High Frequency Power Supplies, Precision Instruments (Resolvers, Potentiometers, Servo Motors), *Radar Scan Drive.

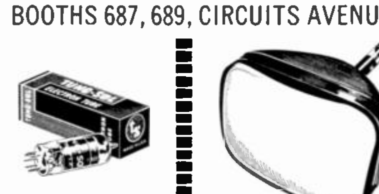
Triad Transformer Corp.
428 Electronic Ave.
Triad firsts from laboratory to production to the customer include widest-range *audio transformers, catalog stock MIL-T-27 transformers, transistor to radar pulse types, outstanding quality.

Triplett Electrical Instrument Co.
217, 219 Instruments Ave.
Electrical measuring & indicating instruments. Test equipment.

Tru-Ohm Products Div., 444 Electronic Ave.
See: Model Engineering & Mfg. Co., Inc.

Truscon Steel Div., Republic Steel Corp.
327 Computer Ave.
TOWERS
—any height—none too high for us—AM, FM, TV and for Microwave—
GROUND SCREEN
—Copper mesh type—surpassed by none—

BOOTHS 687, 689, CIRCUITS AVENUE



TUNG-SOL ELECTRIC INC., Newark 4, N. J.
ELECTRON TUBES. CRYSTAL PRODUCTS. MINIATURE (DIAL) LAMPS. FLASHERS.

Tweezer-Weld, 791 Airborne Ave.

*Indicates new product

(Continued on page 320A)

What to See at the Radio Engineering Show

(Continued on page 318A)

George Ulanet Co.
834 Audio Ave.

Miniature thermostats for precision control of electronic circuits and as thermal sensing units. Also large line of thermal timing units.

Ultrasonic Corp., 826, 828 Audio Ave.
*Expanded scale tape, *tape indicator assembly, *subminiaturized components, *magnetic amplifier, *RF wattmeter, *10-channel strain display, *antenna transfer switch, *sonar transducers, *"Ultraclean" parts cleaner.

Underwood Corp., 801, 803 Production Rd.
See: Electronic Computer Div.

Union Carbide & Carbon Corp., 529, 531 Components Ave.

Union Switch & Signal Div.
Westinghouse Air Brake Co.
112 Military Ave.

Traffic Control Equipment for Air, Rail, Highway, and Pipeline Traffic; Digital Read-out Indicator; Inductive Telecommunications Equipment; and special purpose, high performance Relays.

Unisco, Inc., 357 Mobile Ave.

United Catalog Publishers, Inc., 842 Audio Ave.
1954 Radio's Master (18th edition) 1370-page, 18-section, official buying guide of the industry. UCP pricing, service and United File-o-matic perpetual counter catalog service.

U. S. Components, Inc.
625 Circuits Ave.

Precision multi-contact, pressurized, co-ax connectors, printed circuits and card receptacles. Cable clamps, custom built assemblies.

U. S. Engineering Co., 774 Airborne Ave.
Terminals, Terminal Boards and Electronic Hardware.

QUALITY CONTROLLED FLUOROCARBON PRODUCTS

Booth 466—Electronic Ave., TEFLON and KEL-F insulating materials, electronic components, special fabricated parts and sub-assemblies.

Of unusual interest—specialized techniques in handling metal inserts, molding around metal structures and cementing to TEFLON.

UNITED STATES GASKET CO.
Fluorocarbon Products Inc. Div.
Camden 1, New Jersey

*Indicates new product

(Continued on page 321A)

What to See at the Radio Engineering Show

(Continued from page 320A)

United States Radium Corp., 806 Audio Ave.
Edge-lighted panels, dials, name plates, etched products, television phosphors, beta thickness gauge and liquid level device sources, static eliminators, radioactive radiation and light sources and standards.

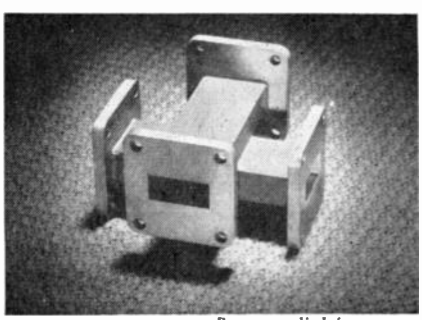
United States Time Corp., 709 Airborne Ave.
Sub-miniature precision rate gyroscopes—Developed by Sanders Associates—World's smallest, lightest, most rugged. Fast starting, excellent resolution and linearity. Unusually insensitive to shock and vibration.

United Transformer Co.
NEW YORK 13, N.Y.
547 Components Ave.
Corner of RADIO ROW
AUDIO, POWER TRANSFORMERS; FILTERS; MAGNETIC AMPLIFIERS; HIGH PASS, BAND PASS, LOW PASS, FILTERS; PULSE TRANSFORMERS; MILITARY and AIRCRAFT TRANSFORMERS.

Show Hours: Monday 10 AM–10 PM
Tuesday 10 AM–10 PM
Wednesday 10 AM– 5 PM
Thursday 10 AM–10 PM

(Continued on page 322A)

—NEW IDEA—
in cross guide couplers



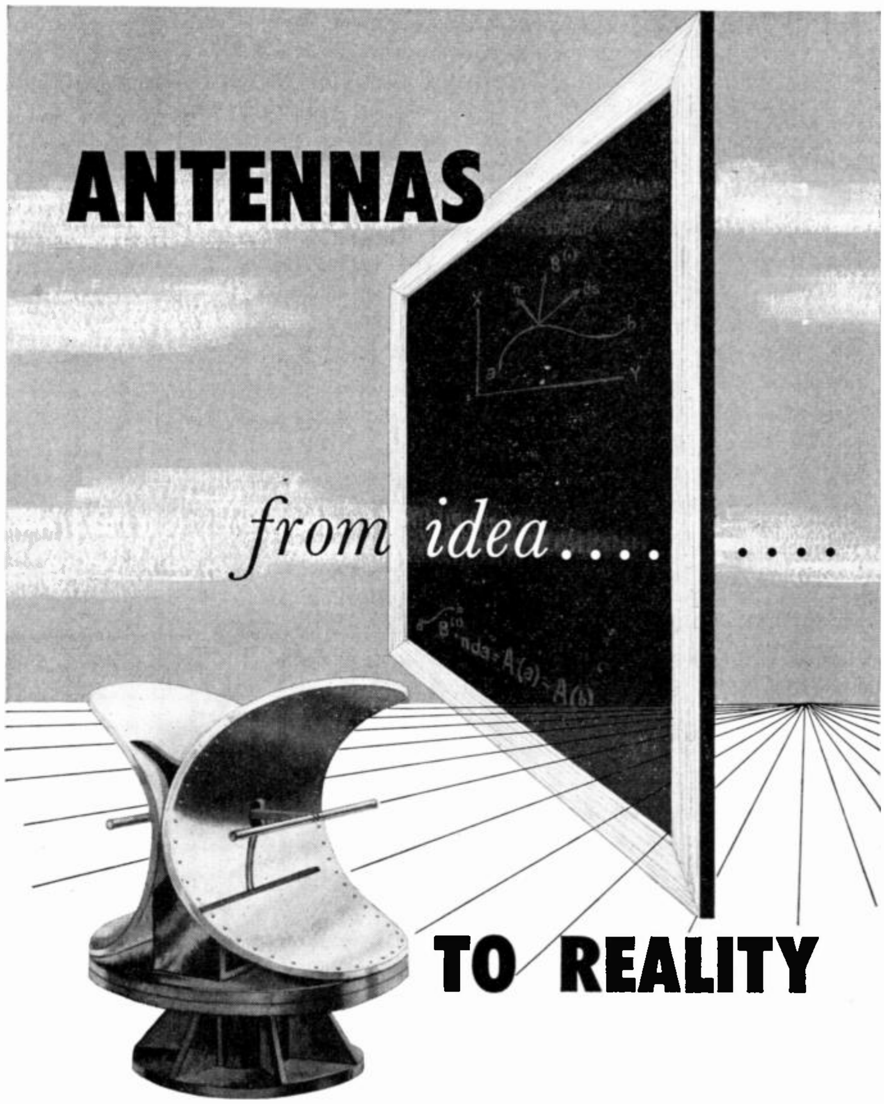
Patent applied for

Microwave Development Laboratories announces the first of a series of cross guide couplers having a new design concept which permits (1) higher minimum directivity over the waveguide band, (2) less coupling variation with frequency, (3) higher breakdown power.

SPECIFICATIONS: Directivity: approximately 22 db or more. Coupling accuracy: mean coupling level is within .4 db of 30 db. Coupling variation: less than ±.6 db over the frequency range.

See this new development at Booth No. 377, the IRE Show or write for full technical information.

MICROWAVE Development Laboratories, Inc.
220 Grove St., Waltham 54, Mass.
design • development • fabrication

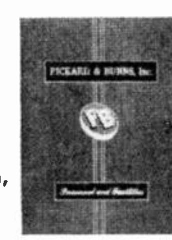


The keynote of superior systems planning is careful unit design. The Antenna, a vital link in many systems, requires a combination of creative genius and practical design talent.

Pickard & Burns, Inc. offers an antenna service unique in its completeness. Experienced engineers transform performance requirements into a design concept, then to physical reality which often involves not only laboratory models but pilot or full scale production.

From VLF through the millimeter region, the well-equipped laboratories of P & B are constantly serving the requirements of industry and the military for new and challenging antenna design.

Without obligation you are cordially invited to visit our facilities, and we would welcome an opportunity to discuss any antenna problem you may have.



For further information concerning our organization, its services and products, write for our brochure.

PICKARD & BURNS
INCORPORATED
240 Highland Avenue, Needham 94, Mass.

VISIT OUR BOOTH 626 AT THE I.R.E. SHOW

What to See at the Radio Engineering Show

(Continued from page 321A)

Universal Winding Co., 560, 562 Components Ave.
Coil Winding Machines *with new features. No. 108 with quick set-up and direct drive from adjustable speed motor. No. 107 fully automatic with Thymotrol drive.

University Loudspeakers, Inc., 846 Audio Ave.
Commercial, Industrial, High Fidelity and Military loudspeakers. *"Companion" Tri-phonic Sound System for minimum roomage—"Classic" Hi-Boy, Lo-Boy: "Dean" Cornerless Corner DeLuxe Tri-phonic Sound Systems.

Vacuum-Electronic Engineering Co., 280 Instruments Ave.
*Research vacuum system suitable for work in metal evaporation, metallurgy, vacuum tubes, etc.; also a new model leak detector and general line of vacuum valves.

Vacuum Metals Corp., 224 Instruments Ave.

Van Dyke Textigraph Co., 680 Circuits Ave.
See: Pacent Engineering Corp.

Varian Associates
542, 544 Components Ave.

Klystrons, including air-borne radar, missiles, beacons, *relay systems, laboratory measurements, *coherent transmitters, and high power UHF-TV. Special products including high power water-loads, klystron power supplies, RF Spectroscopy equipment and *electro magnets.

Vari-L Company, Inc., 712 Airborne Ave.
Electrically variable inductors with permanent magnet bias. Operating display showing typical application in Branson "Vidigage" ultrasonic thickness tester. Audio FM and sweep displays.

Vector Electronic Co., 602 Circuits Ave.
*Socket-strips for unitized construction; turret sockets; *plug-in enclosures; *switching test adapters with probe units; *taped & stitched wiring method.

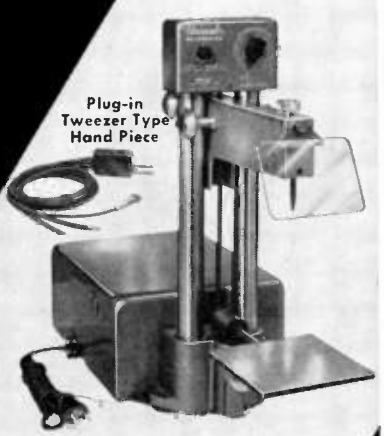
*Indicates new product

(Continued on page 324A)

NEW STORED-ENERGY WELDING METHOD SPEEDS PRODUCTION

Precision capacitor-discharge welder joins all metals (copper to steel, silver to iron, etc.) accurately and reliably. Supplants soldering, brazing, riveting & staking.

Model 1015



Unimatic Weldmaster

A versatile, bench-type unit for electronics and precision instrument industries. Welds all materials from ultra-fine wires to 20 gauge sheet metal.

FEATURES

SIMPLE TO INSTALL: self-contained, portable; 115 VAC, plug-in (5 amps).

EASY TO OPERATE: automatic timing, footpedal actuation, no operator training.

ONE-MINUTE SETUP: only two stepless controls, quick-change electrodes.

LOW MAINTENANCE: three receiving tubes, no special components.

UNIFORM RESULTS: high-strength welds; no discoloration or deformation.

write for descriptive brochure

Unitek CORPORATION

273 North Halstead Avenue
Pasadena 8 California

MO-BRAZE

A high temperature brazing powder
for rapid formation of strong joints

molybdenum to molybdenum
molybdenum to tungsten
tungsten to tungsten

No volatilization in hydrogen or high vacuum

For full information
Write or phone

BOROLITE CORPORATION

320 Yonkers Ave. Yonkers, N.Y.
YOnkers 8-2211

Increased Insulation

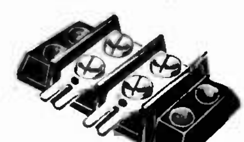
BETTER CONNECTIONS

JONES BARRIER TERMINAL STRIPS

Leakage path is increased—direct shorts from frayed terminal wires prevented by bakelite barriers placed between terminals. Binder screws and terminals brass, nickel-plated. Insulation, black molded bakelite. Finest construction. Add much to equipment's effect.

Jones Means Proven Quality

No. 2-142



No. 2-142-¾ W

No. 2-142-Y

Illustrated: Screw Terminals—Screw and Solder Terminals—Screw Terminal above Panel with Solder Terminal below. Every type of connection.

Six series meet every requirement: No. 140, 5-40 screws; No. 141, 6-32 screws; No. 142, 8-32 screws; No. 150, 10-32 screws; No. 151, 12-32 screws; No. 152, ¼-28 screws.

Catalog No. 18 lists complete line of Barrier Strips, and other Jones Electrical Connecting Devices. Send for your copy.

Jones

HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

What to See at the Radio Engineering Show

(Continued from page 322A)

Vibro-Ceramics Corp.
850 Audio Ave.

ULTRASONIC VIBRATIONS CHECK MATERIALS UNIFORMITY. *A new, versatile and accurate method for determining physical properties of alloys, ceramics, sintered metal carbides and other materials.

Victoreen Instrument Co.
484, 486 Electronic Ave.

Series of voltage regulators and hermetically sealed resistors developed for Color Television. Complete line of sub-miniature tubes, power supplies and radiation measuring instruments.

Victory
ENGINEERING CORPORATION
Springfield Road, Union, New Jersey
VECO THERMISTORS
657, 659 CIRCUITS AVE.
Exhibits include: ACTUAL PRODUCTION of Veco THERMISTOR Bead, the most VERSATILE CIRCUIT ELEMENT ever produced — THERMISTORS in ACTION, many applications: Surge Protection . Voltage Regulation . Air Flow Measurement . Time Delay . Oscillator Stabilization, etc. — EXPERIMENTORS' THERMISTOR-VARISTOR KIT, No. 168 (7 items and APPLICATION CIRCUITRY) — COMBUSTION ANALYZERS. Technical literature available.

Vitramon
CAPACITORS
Miniaturized fused-porcelain components with phenomenal stability, low loss, wide temperature range.
Booth 886—Audio Avenue
VITRAMON, INCORPORATED
Box 544, Bridgeport 1, Conn.

Waldes Kohinoor, Inc., 746 Airborne Ave.
An improved *jam-proof dispenser for Waldes Truarc crescent and "E" retaining rings. Complete Truarc line, retaining rings (*several new types) grooving tools, pliers, dispensers.

P. Wall Manufacturing Co., 820, 822 Audio Ave.
Electric soldering irons and miscellaneous soldering products.

Ward Leonard Electric Co., 870 Audio Ave.
*300 watt Vitrohm ring rheostat. World's largest selection of stock power resistors. Complete MIL-R-26B resistor line, AC and DC magnetic relays.

Warren Wire Co., 860 Audio Ave.
*Extruded Teflon Lead Wire. *Teflon Impregnated Glass Insulations. *Silicon Magnet Wire. *Special Teflon Cables. Magnet, Tinned and Bare Copper Wire Products.

*Indicates new products

See Floor Plan on Page 143A

(Continued on page 326A)

What to See at the Radio Engineering Show

(Continued from page 324A)

Waveforms, Inc., 832 Audio Ave. Miniature Precision Instruments: Extended Range Audio Oscillator (18 cps to 1.2 mc, low distortion); Sensitive Voltmeter (1 mv full scale, 10 cps to 2 mc); Precision Crystal Calibrator with heterodyne mixer; Audio Curve Tracer; High Quality Audio Amplifiers; AM-FM Signal Generator (100kc-170mc).

Webber Mfg. Co., Inc., 787 Airborne Ave. Environmental test equipment, new bench type model, designed to test small components at temperatures as low as —100° F. and as high as +200° F.

W. M. Welch Scientific Co., 223 Instruments Ave. Complete line of duo seal vacuum pumps, including *5 cubic foot size #1402—Also vacuum gauges and accessories.

Western Lithograph Co., 805 Audio Ave. Adhesive Labels, E-Z Code wire identification markers, N.E.M.A. color code markers, TEL-A-PIPE cable, conduit, and pipe markers, Westline contact labels, Breakaway labels.

West Instrument Corp., 608 Circuits Ave. *Pyrometers, stepless control instrument using no relay—featuring power output by saturable reactor; *pyrometer program controller; Industrial pyrometric temperature control instruments, ON, OFF Proportioning, etc.

*Indicates new product

See Floor Plan on Page 143A

(Continued on page 328A)

POSITIONS OPEN

(Continued from page 272A)

ELECTRONIC ENGINEERS

There are available for two senior engineers with advanced degrees or industrial experience: One position is in the communications field, including high performance networks and special equipment in the frequency range of 100 kc to 250 mc. Work will include circuit and component design, followed by laboratory measurements and tests. 2nd position is in microwave engineering, including antenna design, systems and component design in the c-w radar field. These jobs offer excellent opportunities with a small company located in suburban Boston. Reply to Robert L. Blanchard, Chief Research Engineer, Trans-Sonics, Inc., Bedford, Mass.

PRODUCTION MANAGER

An outstanding opportunity in the rapidly growing field of electronic instrumentation. The leading young company in the manufacture of nuclear measurement and control instruments needs an engineer with good line experience in electronic and mechanical production. Should know production planning, scheduling and control. Will have full charge of all production functions and be at top management level. Plant located in Columbus. Send resume to Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio.

TRANSFORMER ENGINEER

Large New England electronics manufacturer has opportunities in Transformer Division for electrical engineers interested in design of specialized transformers or in development of equipment using magnetic circuits such as filters, voltage regulators, etc. There are presently openings for both experienced and inexperienced people. Graduate study opportunities available under complete tuition refund plan. Send resume of background and experience to L. B. Landall, Raytheon Manufacturing Co., 190 Willow Street, Waltham, Mass.

TRANSFORMER ENGINEER

Established manufacturer of small transformers for radio and TV industry require experienced engineer to design transformers to customer's specifications, supervise the building of samples, also to design production test equipment. Only those with at least five years experience, able to furnish references, need apply. Generous salary. Box 761.

TELEVISION BROADCAST TECHNICIANS

CBS Television Network has openings for Assistant Technicians ($72.50 per week) and full Technicians ($76.50 to $150 per week) in all branches of television operations, maintenance and construction. Engineering background, radio knowledge, aptitude, and ability to work with others are more important than past television experience. Apply CBS Television Technical Operations, 524 West 57th Street, New York, N.Y.

PROJECT ENGINEER

Project Engineer (Loudspeakers) for acoustic and audio development. Must have good background in loudspeakers, microphones and physics of moving systems as pertains to audio frequency transducers. Challenging opportunity; salary commensurate with experience. Progressive manufacturer located in New York suburban area. Box 762.

(Continued on page 328A)

POSITIONS OPEN

(Continued from page 327A)

INSTRUMENTATION ENGINEER

Graduate E.E. with industrial instrumentation design experience for development laboratory of old established company in Mid-West. Servomechanism experience necessary. Bowser, Inc., Fort Wayne 2, Indiana.

ENGINEERING POSITIONS WITH ELECTRONIC MANUFACTURER

M.E. Minimum of 10 years experience in Electronics, must have been chief or assistant chief mechanical engineer for electronic firm. 1. Flyback Transformer Engineer experienced in design of horizontal deflection circuits and yolkes. 2. Capacitor Engineer experienced in electrical phases of Ceramic and Mica Capacitor Design. Administrative Coil Engineer with heavy experience in circuitry and Coil Design. Mail resumes to Personnel Director, Automatic Manufacturing Corp., 256 Passaic St., Newark, New Jersey.

What to See at the Radio Engineering Show

(Continued from page 326A)

Westinghouse Electric Corp.
843-855 Audio Ave.

*Color & Black & White TV Receiver tubes; Electronic Fire Control; Microwave; transistors; hermetically sealed diodes; AB circuit breakers; starters; electrical instruments for testing and measuring; specialty transformers; Hypersil cores; Magamps.

Weston Electrical Instrument Corp.
533, 535 Components Ave.

Service instruments for Television, Radio and Industrial Maintenance, Panel Instruments for Electronic Equipment, AC and DC Ruggedized Instruments, Sensitive Relays, DC Amplifier, Portable AC and DC instruments. *Proportional Mutual Conductance Tubechecker featuring meter measurement of high leakage resistance as high as 5 megohms.

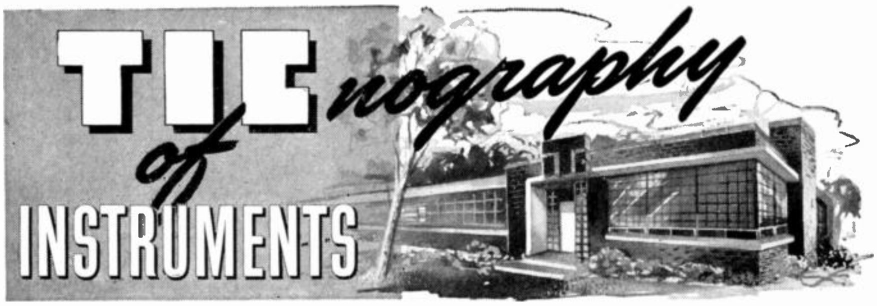
S. S. White Dental Mfg. Co.
707 Airborne Ave.

Featuring the "Airbrasive" Unit for fast, precise cutting of hard, brittle materials and for removal of deposited surface coatings. Used for producing printed circuits, film-type resistors, transistors, etc.

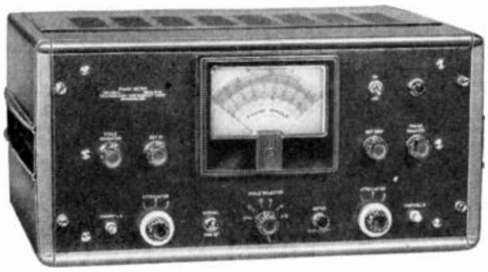
*Indicates new product

See Floor Plan on Page 143A

(Continued on page 335A)



NEWEST in the ITC line of QUALITY INSTRUMENTS

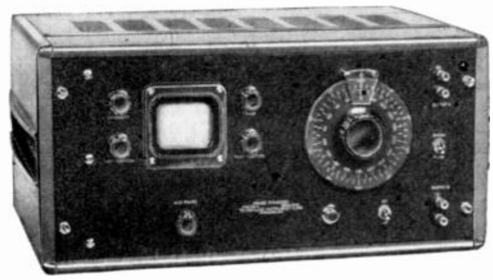


TYPE 324-A PHASE METER

- WIDE FREQUENCY RANGE
- HIGH ACCURACY
- DIRECT READINGS

. . . for measurement of phase response in video amplifiers since uniform time delay is achieved when curve of phase shift vs. frequency is linear. Frequency range is 20 kc. to 4.5 mc. Input range is 2-300 v. peak. Angular range is 0-360° with individual quadrant metering. Accuracy is ±4° on quadrant scales.

TYPE 706-A PHASE STANDARD



- HIGH PRECISION
- EXCELLENT STABILITY
- SIMPLICITY OF OPERATION

. . . generates two voltage signals whose phase difference is known to ±0.1°. Multiple frequency Lissajous pattern is used to indicate angles established. Phase shift is achieved by means of a precise, stable, and continuously variable electronic phase shifter. Operation is at single pre-determined frequency specified by customer.

TYPE 511-A POWER AMPLIFIER

- PHASE SHIFT COMPENSATION
- NEGLIGIBLE DISTORTION
- HIGH VOLTAGE OUTPUT LEVEL

. . . a general purpose laboratory power amplifier featuring low distortion, low noise and excellent phase characteristics throughout the frequency range from 50 cps. to 50 kc. A choice of four outputs available to match various loads (5, 25, 200 or 1200 ohms). At rated frequencies and gain settings the overall phase shift is small. A special feature is the phase compensation circuit which permits the overall phase shift to be maintained at a constant value with varying gain. Harmonic distortion and intermodulation distortion are low. Output voltage up to 120 volts into a 1200 ohm load. Operates into loads varying from pure resistance to pure reactance.

TYPE 501-A COMPRESSOR AMPLIFIER

- WIDE INPUT RANGE
- UNIFORM OUTPUT
- NEGLIGIBLE DISTORTION

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Bloom, L. R., Physics Research Laboratories, Sylvania Electric Products, Inc., Bayside, L. I., N. Y.
Briscoe, W. L., 2141-B—45 St., Los Alamos, N. Mex.
Bush, R. S., 3818 Alberta Ave., Houston 21, Tex.
Cherry, L. B., 1418 Central Dr., Beaumont, Tex.
Chrisman, D. W., 223 Rodgers Forge Rd., Baltimore 12, Md.
Dallas, W. K., 1585 S.W. Hyland Pkwy., Portland 14, Ore.
Farber, R. J., 188-04—64 Ave., Fresh Meadows 65, L. I., N. Y.
French, D. E., 1403 E. Clinton Ave., Huntsville, Ala.
Gulland, G. R., Weed Ave., Norwalk, Conn.
Hancock, H. E., Box 174, R.F.D. 2, Branch Hill, Loveland, Ohio
Himmer, F., 16 Johns Rd., Cheltenham, Pa.
King, F. W., 6249 Banning Rd., Cincinnati 24, Ohio
Knoblaugh, A. F., 6408 Cary Ave., Cincinnati 2, Ohio
Mann, D. O., 22021 Martinez St., Woodland Hills, Calif.
Marks, R. L., 18 Old Short Hills Rd., Millburn, N. J.
Marsten, R. B., 451-10 Heath Pl., Hackensack, N. J.
McCroskey, A. A., Naval Ordnance Laboratory, Corona, Calif.
McQuiston, W. R., 618 E. Clara St., Port Hueneme, Calif.
Moore, F. H., Wood Rd., Sands Point, Harbor Acres, L. I., N. Y.
Newman, H. L., 311 Capen Blvd., Buffalo 23, N. Y.
Niederman, B., 1651 W. 63 St., Chicago 36, Ill.
Palmer, G., Jr., 412 Harrington Rd., Havertown, Pa.
Petrides, T., 330 Haven Ave., New York 33, N. Y.
Quitter, J. P., The Baldwin Co., Cincinnati 2, Ohio
Ricketts, P. E., c/o Pellam, R.F.D. 3, Rome, N. Y.
Van Iderstine, A., 82 Burnham Rd., Morris Plains, N. J.
Weber, M., 3136—39 Pl., Sandia Base, Albuquerque, N. Mex.
Webster, W. M., Cherry Valley Rd., Princeton, N. J.
Wetz, R. H., 3259 Brotherton Rd., Cincinnati 9, Ohio

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Ewen, H. I., Ewen Knight Corp., 698 Massachusetts Ave., Cambridge 39, Mass.
Fox, B., 21-36—33 Rd., Long Island City 6, L. I., N. Y.
Goodman, G. H., 102 E. High St., Haddon Heights, N. J.
Harvey, J. R., 20 St. Edmunds Dr., Stanmore, Midax., England
Jerrems, A. S., Hughes Aircraft Co., Culver City, Calif.
Keene, L. C., 128 Via Las Vegas, Palos Verdes Estates, Calif.
King, E J., Jr., Communication Accessories Co., Hickman Mills, Mo.
Kuhn, H. G., 42 McFarland Ave., Toronto 10, Ont., Canada
Lanford, H. W., Jr., Box 459, R.F.D. 1, Edgewater, Md.

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MEMBERSHIP

(Continued from page 330A)

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Mann, R. W., 5564 Aspen St., Bellaire, Tex.
Miner, W. A., Jr., 65-21A—22 St., Bayside 64, L. I., N. Y.
Norton, E. L., 463 West St., New York 14, N. Y.
Snyder, R. F., Woodland Dr., Princeton, N. J.
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Star, J., 186 Parkway Dr., Roslyn Heights, L. I., N. Y.
Thompson, J. H., Jr., Texas Instruments, Inc., 6000 Lemmon Ave., Dallas, Tex.
Townsend, M. A., Bell Telephone Laboratories, Murray Hill, N. J.
Volkers, W. K., 519 Glen Ave., Scotia, N. Y.
Williams, N. A., Electrical Engineering Department, University of Manitoba, Winnipeg, Man., Canada
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Browde, A., 1911 Maltravers Rd., Glen Burnie, Md.
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Scott, V. J., Jr., 7021 Noble Ave., Cincinnati 24, Ohio
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Taffel, B. R., Haselton Branch, Rome, N. Y.
Westcott, J. L., 616—31 St., S.E., Cedar Rapids, Iowa

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(Continued from page 331A)

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White, M. A., 1231 W. Seventh St., Pomona, Calif.
Wilson, E. F., 38 Hillcroft Rd., Waltham 54, Mass.
Yockel, A. P., 396 Columbia Blvd., Wood Ridge, N. J.

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Piel, G., 39, Blvd. Beaumarchais, Paris 3, France
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Riemenschneider, N. L., 11 Glenview Dr., West Orange, N. J.
Rolf, T. E., 164 Hampshire Ave., Audubon 6, N. J.
Rosato, F. J., 22 Curtis St., Medford 55, Mass.
Schwartz, N. A., 239 W. Orange Grove Ave., Burbank, Calif.
Seidman, J. J., 7407 W. 91 St., Los Angeles 45, Calif.
Smith, H. N., 460 W. Glendale Rd., Webster Groves 19, Mo.
Sparling, W. N., 6825 Calder Dr., Glendora, Calif.
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Stone, K. A., 3707 W. Cold Spring La., Baltimore 15, Md.
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Whalen, J. F., Fournier Institute of Technology, Lemont, Ill.
Whittaker, B. H., 20231 Hillcrest Dr., Cleveland 17, Ohio
Wiegerinck, H. T. J., 3, The Towers, London Road South, Lowestoft, Suffolk, England
Williamson, J. H., Bendix Radio, Department 70, Towson 4, Md.
Wyke, A. A., 122 Gay St., Needham 92, Mass.

The following elections to the Associate grade were approved to be effective as of February 1, 1954:

Anderson, A. F., 1508 Midland Ave., Syracuse 5, N. Y.
Aram, R. A., New York Telephone Co., 140 West St., New York 7, N. Y.
Atkins, R. E., c/o Radio Officers Union, Rm. 408, Baronne Bldg., New Orleans, La.
Auld, J. S., 55 Violet Ave., Mineola, L. I., N. Y.
Bacquet, E. H., 1 Bis, Rue Daumesnil, Vincennes, Seine, France
Bahrs, R. D., 104 Rutgers St., Maplewood, N. J.
Bankowski, V. C., 313 Ridgecrest St., Huntsville, Ala.
Barkow, W. H., 7235 Githens Ave., Pensauken, Merchantville 8, N. J.
Barrila, F. L., Box 1, R.F.D., Waterford, Quaker Hill, Conn.
Bartling, M. H., 14513 Purche Ave., Gardena, Calif.
Bass, S., 16 Elliott Ave., New London, Conn.
Bassett, J. E., Jr., 17 Bank St., Mystic, Conn.
Beaudoin, L. W., 8822 W. Morgan Ave., Milwaukee 14, Wis.
Bernard, E. L., 101-37—116 St., Richmond Hill 19, L. I., N. Y.
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(Continued on page 333A)

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(Continued from page 332A)

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Castro, C. J. E., Apartado No. 132, Havana, Cuba
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Clark, V. C., Box 73, Annandale, Va.
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Cross, R. W., 224—16 Ave., S.W., Rochester, Minn.
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Dasko, G. J., 3841 Barclay Ave., Montreal, Que., Canada
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Davidson, D. S., 107 Golf St., Newington, Conn.
Davis, P. R., 211 Parklane Ave., Huntsville, Ala.
DeHaan, R. F., 3606 Cumberland Rd., Berkeley, Mich.
Digiulio, E. M., 2178 E. Second St., Brooklyn 23, N. Y.
Dixon, W. E., Box 1153, Charleston 24, W. Va.
Dreiman, L. W., U.S.S. Hector AR-7, Ninth Division, c/o FPO, San Francisco, Calif.
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DuMay, E. C., 6783 N. Ionia Ave., Chicago 30, Ill.
Dunckel, P. B., 955 Park Ave., New York 28, N. Y.
Dunkel, J. R., Jr., 8061 Garland Dr., Houston 17, Tex.
Eiter, W. F., 2123 Arlington Ave., Pittsburgh 10, Pa.
Ellstrom, R. V., 918 Southerly Rd., Towson 4, Md.
Falck, F. W., Jr., 2435 N. Naomi St., Burbank, Calif.
Falck, J. W., 2435 N. Naomi St., Burbank, Calif.
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Forgione, E. A., 107 Higgins Rd., Framingham, Mass.
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Fuller, E. J., 8 Terrace Cir., Great Neck, L. I., N. Y.
Gagliano, A. F., 18 Third St., Brooklyn 31, N. Y.
Gans, J. S., 217 E. Ninth St., Hazleton, Pa.

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SECTION MEETINGS

(Continued from page 315A)

Montreal

"Ears for Electronic Brains," by Dr. E. E. David, Jr., Bell Telephone Labs.; January 13, 1954.

New Orleans

"Principles of Sonar," by George W. Wood, Faculty, Tulane University; January 15, 1954.

Omaha-Lincoln

"Microwave Facilities of the A.T. & T. and NW Bell System," by Messrs. M. W. Berry, John Conway, J. W. Beterman, George Anderson and Franz Wille, A.T. & T. and NW Bell Engineers; December 17, 1953.

Philadelphia

"GE House of Magic" (exhibit) by Mr. O'Keefe, General Electric Company; and "High-Retentivity and Bistable Dielectrics as Information Storage Media," by Dr. C. F. Pulvari, Catholic University of America; January 7, 1954.

Pittsburgh

General Electric Company tapescript: "Germanium, The Magic Metal." Discussed by Dr. Paul N. Bossart, Union Switch and Signal Company; January 11, 1954.

Princeton

"Compatible Color Television and Its Relationship to the Broadcaster," by Dr. G. H. Brown, RCA Laboratories; December 10, 1953.

Rochester

"Peace on Earth," by Rev. G. L. Cadigan, St. Paul's Episcopal Church; December 15, 1953.

Rome-Utica

"Color Television," by I. C. Abrahams, General Electric Company; and "Human Engineering," by Maj. L. R. Wilcox, Rome Air Development Center; January 5, 1954.

Sacramento

Tour of transcontinental microwave installation at Pacific Telephone and Telegraph Co. Bldg.; January 15, 1954.

San Antonio

"Selected Topics on Explosion Damage," by Dr. A. F. Wittenborn, University of Texas; December 17, 1953.

"RC Filters," by Gifford White, White Instrument Labs.; January 14–15, 1954.

San Diego

"Industrial TV Systems," by Richard Silberman, Kalbfell Labs. Inc., and election of Officers; January 5, 1954.

Schenectady

"VHF and UHF Television," by Dr. A. B. Glenn, General Electric Company; December 14, 1953.

Demonstration in Microwave Optics by Dr. C. L. Andrews, New York State College for Teachers; January 11, 1954.

Syracuse

"The Next Decade in Air Navigation," by Harry Davis, Rome Air Center; January 7, 1954.

Tulsa

"Analysis of Relay Controlled Pre-set Systems," by N. L. Jochem, Gates Radio Company; December 17, 1953.

Twin Cities

"Design Features of Remington Rand Speed-Tally," by J. L. Hill, Remington Rand, Inc.; January 12, 1954.

Vancouver

"Theory and Application of Compandors," by J. A. Stewart, Lenkurt Elect. Co. of Canada; December 14, 1953.

SUBSECTIONS

Ithaca

"Digital Computers and Some of Their Applications," by C. R. Wayne, General Electric Company; November 20, 1953.

Lancaster

"Characteristics of the Common Systems of Air Navigation," by B. E. Montgomery, Civil Aeronautics Administration; January 12, 1954.

Orange Belt

Symposium: "An Evening with Transistors." Speakers: John Gettinger, N. J. Krilanovich, R. B. Hurley, Dean W. Slaughter and Dr. H. E. Holloman; December 9, 1953.

U.S.A.F.I.T.

"Analogue Computers," by Capt. C. J. Johnson, USAFIT; December 11, 1953

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(Continued from page 328A)

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Lynch, J. B., Phelps Dodge Copper Products Corp., 40 Wall St., New York, N. Y.
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Marsh, J. H., Jr., 510 Garfield Ave., Milford, Ohio
Marshall, M. R., Sylvania Electric Products, Inc., Eelectronics Division, Ipswich, Mass.
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McKeehan, W. F., Electronics Division, 601 E. Third St., Dayton 2, Ohio
McLaughlin, W. J., Sec. 710, Officer's Mail Room, Fort Monmouth, N. J.
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McParland, F. H., 38 Laurel St., Lowell, Mass.
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Mears, W. E., 1945-3 AACS Det., APO 742, c/o Postmaster, New York, N. Y.
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Pandey, G. C., L-156 Vinay Nagar, New Delhi 3, India
Park, J. R., Navy 230, Box 10, Third Division, c/o Postmaster, Seattle, Wash.
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Roman, R., Box 9, Bldg. 142, N.N.B., Norfolk, Va.
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(Continued on page 338A)

COMMUNICATIONS EQUIPMENT CO.

MICROWAVE COMPONENTS

"S Band," RG48/U Waveguide

POWER SPLITTER for use with type 726 or any 10 CM Shepherd Klystron. Energy is fed from Klystron antenna through dual pick-up system to 2 type "N" connectors..$22.50 EACH

DIRECTIONAL COUPLER. Broadband type "N" Coupling, 20 db. with std. flanges, Navy #CABV47AAN-2 (as shown) $37.50

LHTR, LIGHTHOUSE ASSEMBLY. Part of RT39 APG 5 & APG 15. Receiver and Trans. Cavities w/assoc Tr. Cavity and Type N CPLG. To Recvr. Uses 2C40, 2C43, 1B27. Tunable APX 2400-2700 MCS. Silver Plated $49.50

BEACON LIGHTHOUSE cavity p/o UPN-2 Beacon 10 cm. Mfg. Bernard Rice, each $47.50

MAGNETRON TO WAVEGUIDE Coupler with 721-A Duplexer Cavity, gold plated $45.00

RT-30 APG-5 10 cm. lighthouse RF head c/o Xmtr.-Recvr-TR, cavity compl. recvr. & 30 MC IF strip using 60K5 (2C40, 2C43, 1B27 lineup) w/Tubes.

721A TR BOX complete with tube and tuning plungers $12.50

McNALLY KLYSTRON CAVITIES for 707B or 2K28 ....$4.00

WAVEGUIDE TO 7/8" RIGID COAX "DOORKNOB" ADAPTER CHOKE FLANGE, SILVER PLATED BROAD BAND $32.50

AS14A AP-10 CM Pick up Dipole with "N" Cables $4.50

OAJ ECHO BOX, 10 CM TUNABLE $22.50

HOLMDELL-TO-TYPE "N" Male Adapters, W.E. #D167284 ....$2.75

I.F. AMP. STRIP: 30 MC, 30 d.b. gain, 4 MC Bandwidth, uses 6AC7's—with video detector. A.F.C. less tubes $24.50

BEACON ANTENNA, AS31/APN-7 in Lucite Ball. Type "N" feed $22.50

ANTENNA, AT49A/APR: Broadband Conical, 300-3300 MC Type "N" Feed $12.50

"E" or "H" PLANE BENDS, 90 deg. less flanges $7.50

X Band— RG 52/U WAVEGUIDE

VSWR Measuring Section. Consisting of 6" straight section, with 2 pick-up, Type "N" Output Jacks, Mounted ¼ Wave apart $8.50

1" x ½" waveguide in 5' lengths, UG 39 flanges to UG40 cover ....per length $7.50

Rotating-joints supplied either with or without deck mounting. With UG40 flanges .each, $17.50

Bulkhead Feed-thru Assembly $15.00

Pressure Gauge Section 15 lb. gauge and press nipple $10.00

Pressure Gauge, 15 lbs. $2.50

Directional Coupler, UG-40/U Take off 20db $17.50

TR-ATR Duplexer section for above $8.50

Waveguide Section 12" long choke to cover 45 deg. twist & 2½" radius, 90 deg. bend $4.50

Waveguide Section 3 ft. long silver plated with choke flange $5.75

Rotary joint choke to choke with deck mounting $17.50

90 degree elbows, "E" plane 2½" radius ..$12.50

Microwave Receiver, 3 CM. Sensitivity: 10-13μ Watts. Complete with L.O. and AFC Mixer and Waveguide Input Circuits. 6 I.F. Stages give approximately 120 DV gain at a bandwidth of 1.7 MC. Video Bandwidth: 2 MC. Uses latest type AFC circuit. Complete with all tubes, including 723A/B Local Oscillator $175.00

ADAPTER, waveguide to type "N", UG 81/U, p/o TS 12, TS-13, Etc. $27.50

ADAPTER, UG-163/U round cover to special btl. Flange for TS-45, etc. ....$2.50 ea.

K Band—½" x ¼" W.G. 1.25 CM.

APS-34 Rotating Joint $49.50

Right Angle Bend E or H Plane, specify combination of couplings desired $12.00

45° Bend E or H Plane, choke to cover $12.00

Mitered Elbow, cover to cover $4.00

TR-ATR-Section, Choke to cover $4.00

Flexible Section 1" choke to choke $5.00

"S" Curve Choke to cover $4.50

Adapter, round to square cover $5.00

Feedback to Parabola Horn with pressurized window $27.50

90° Twist $10.00

JAN WAVEGUIDE FLANGES

UG 39/U	$1.10	UG 51/U	$1.65
UG 40/U	$1.25	UG 52/U	$3.40
UG 40A/U	$1.65	UG 52A/U	$3.40

MAGNETRONS

Type	Freq. Range(MC)	Peak Power Out (KW)	Duty Ratio	Price
2J21A	9345-9405	50		$8.75
2J22	3267-3333	265		7.50
2J27	2965-2992	275	.002	19.95
2J31	2820-2860	285	.002	24.50
2J32	2780-2820	285	.002	28.50
2J38*	3249-3263	5		16.50
2J39*	3267-3333	8.7		24.50
2J48	9310-9320	50	.001	24.50
2J49	9000-9160	50	.001	59.50
2J56*	9215-9275	50	.001	132.50
2J61†	3000-3100	35	.002	34.50
2J62†	2914-3010	35	.002	34.50
700B	690-700	40	.002	22.50
700D	710-720	40	.002	39.75
706EY	3038-3069	200	.001	32.50
706CY	2976-3007	200	.001	32.50
725-A	9345-9405	50	.001	Write
730-A	9345-9405	50	.001	24.50
4J38	3550-3600	750	.001	169.45

*—Packaged with magnet.
†—Tunable over indicated range.

5J23 ....$49 | QK-253 ..$249
4J34 ....$125 | 3J3J $85

70 WATT C. W. MAGNETRONS*

QK-60 ....2800-3025 MC. QK-62 ....3150-3375 MC.
QK-61 ....2975-3200 MC. PRICE ....$85 Ea.

*Tunable, and packaged with magnet.

—IN STOCK—

AIA	ASH	SO-8
APA-9	BG	SG-1
APA-10	DAS†	SJ-1
APN-3	DBS†	TAJ
APN-7	APT-2	TBK
APN-9*	APT-4	TBL
APS-2	MKIV	SCR520*
APS-3	MKX	SCR521
APS-4	RC145	SCR518
APS-6	RC148	
ASD	SO-1	

* COMPONENTS. † LORAN EQUIPMENT

—TEST SETS—

TS-10	TS-12	TS-159
TS-36	TS-56	TS-268
TS-47	TS-34	TS-270

I. F. AMPLIFIER STRIPS

MODEL SO: 30 McGain figure is 120 db. Bandwidth: 2Mc. Uses 6 stages of 6AC7 Plus one video detector. Less Tubes $24.50

Model 15: 30 Mc center frequency. Bandwidth 2.5 Mc. gain figure: 65 db. Uses 5 stages of 6AC7's. Has D. C. Restorer and Video Detector. A.F.C. Strip included. Input impedance: 50 Ohms. Less tubes $27.50

Model APS-4: Miniature IF strip, using 6AK5's 60 Mc center Freq. Gain: 95db at Bandwidth of 2.7 Mc. Less tubes $45.00

THERMISTORS

D-164699 Bead Type DCR: 1525-2550 Ohms @ 75 Deg. F. Coefficient: 2% Per Deg. Fahr. Max. Current 25 MA AC/DC $2.50

D-167332 Bead Type. DCR is 1525-2550 Ohms. Rated 25 MA at .825-1.175 VDC $1.35

D-167613 Disk Type DCR: 355 Ohms @ 75 Deg. F.P.M. 2.5%, 1 Watt $1.35

D-166228 Disk Type 7120 Ohms @ 60°F. 4220 Ohms @ 80°F. 2590 Ohms @ 100°F.. 1640 Ohms @ 120°F. $1.35

PULSE NETWORKS

15A—1-400-50: 15 KV. "A" CKT. 1 microsec. 400 PPS. 50 ohms imp. $37.50

G.E. #3E (3-84-810) 8-2.24-405) 50P4T ; 3KV "E" CKT Dual Unit; Unit 1, 3 sections, 0.84 Microsec. 810 PPS, 50 ohms imp.; Unit 2, 8 Sections, 2.24 microsec. 405 PPS 50 ohms imp. $6.50

7-5E3-1-200-67P. 7.5 KV "E" Circuit, 1 microsec. 200 PPS, 67 ohms impedance 3 sections $7.50

7-5E4-16-60, 67P. 7.5 KV "E" Circuit, 4 sections 16 microsec. 60 PPS, 67 ohms impedance $15.00

7-5E3-3-200-67P. 7.5 KV, "E" Circuit, 3 microsec. 200 PPS, ohms imp. 3 sections $12.50

#755: 10KV. 2.2usec., 375 PPS, 50 ohms imp. ...$27.50

#754: 10KV. 0.85usec., 750 PPS, 50 ohms imp. .. $7.50

KS8865 CHARGING CHOKE: 115-150 H @ .02A, 32—40H @ .08A, 30,700V Corona Test, 21KV Test $37.50

G.E. 25E5-1-350-50 P2T. "E" SKT, 1 Microsec. Pulse @ 350 PPS, 50 OHMS Impedance $69.50

KS9623 CHARGING CHOKE: 16H @ 75 MA, 380 Ohms DCR, 9000 Vac test $14.95

G.E. 6E3-.5-2000 50 P2T: 6 KV., "E" Circuit 0.5 usec /2000 PPS/50 ohms/2 sections $7.50

PULSE EQUIPMENT

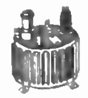
MIT. MOD. 3 HARD TUBE PULSER: Output Pulse Power 144 KW (12 KV at 12 Amp). Duty Ratio: .001 max. Pulse duration: 5, 1.0, 2.0 microsec. Input voltage: 115 v 400 to 2400 cps. Uses: 1-71B, 4-89-B 3-'72's, 1-'73. New ....Less Cover—$135

TPS-3 PULSE MODULATOR. Pk. power 50 amp 24 KW (1200 KW pk): pulse rate 200 PPS. 1.5 microsec. pulse line impedance 50 ohms. Circuit series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New with all tubes $49.50

PULSE TRANSFORMERS

RAYTHEON WX 4298E: Primary 4KV., 1.0 USEC. SEC: 16KV-16 AMP DUTY RATIO: .001 400 CYCLE FIL. TRANS. "BUILT-IN" $42.50

WECO: KS 9948: Primary 700 ohms: Sec: 50 ohms. Plate Voltage: 18 KV. Part of APQ-13 ....$12.50



GE #K-2449A
Primary: 9.33 KV, 50 ohms Imp.
Secondary: 28 KV, 450 ohms.
Pulse length: 1.0/5 usec @ 635/120 PPS, Pk Power Out: 1,740 KW
Bifilar: 1.5 amps (as shown) ...$62.50

GE #K-2748-A. 0.5 usec @ 2000 Pps. Pk. Pwr. out is 32 KW impedance 40:100 ohm output. Pri. volts 2.3 KV Pk. Sec. volts 11.5 KV Pk. Bifilar rated at 1.3 Amp. Fitted with magnetron well $39.50

K-2745 Primary: 3.1/2.8 KV, 50 ohms Z. Secondary: 14/12.6 KV 1025 ohms Z. Pulse Length: 0.25/1.0 usec @ 600/600 PPS. Pk. Power 200/150 KW. Bifilar: 1.3 Amp. Has "built-in" magnetron well $42.50

K-2461-A. Primary: 3.1/2.6 KV—50 ohms (line). Secondary 14/11.5 KV—1000 ohms Z. Pulse Length: 1 usec @ 600 PPS. Pk. Power Out: 200/130 KW. Bifilar: 1.3 Amp. Fitted with magnetron well .$39.75

UTAH X-151T-1: Dual Transformer, 2 Wdgs. per section 1:1 Ratio per sec 13 MH inductance 30 ohms DCR $7.50

UTAH X-150T-1: Two sections, 3 Wdgs. per section. 1:1:1 Ratio, 3 MH, 6 ohms DCR per Wdg. $7.50

68G711: Ratio: 4:1 Pri: 200V, Sec. 53V, 1.0 usec Pulse @ 2000 PPS, 0.016 KVA $4.50

TR1049 Ratio: 2:1 Pri, 220 MH, 50 Ohms, sec. 0.75 H. DCR 100 Ohms $6.75

K-904695-501: Ratio 1:1, Pri. Imp. 40 Ohm, Sec. Imp. 40 Ohms. Passes pulse 0.6 usec with 0.05 usec rise $8.95

Ray UX 7896—Pulse Output Pri, 5v sec. 41v $7.50

Ray UX 8442—Pulse inversion—40v + 40v $7.50

PHILCO 352-7250, 352-7251, 352-7287
RAYTHEON: UX8693, UX5986 ....$5 ea.
W.E.: D-166310, D-166638, KS9800, KS9948.

UTAH #9262, with Cracked Beads, but will operate at full rated capacity $5.00

UX 8693 (SCS #2Z9627-54): 3 Wdgs, 32 turns #18 wire, DCR is: 362/.372/.4 ohms. Total voltage 2500 vdc. $5.00

D-166173: Input: 50 ohms Z. Output: 900 ohms 3 Wdgs. Freq range 10 kc-2mc. P/O AN/APQ*-13 $12.50

K-2450: Pulse-inversion auto-transformer: primary 13 kv, 4 usec. Output: 14 kv @ 100 kw peak $34.50

MICROWAVE ANTENNAS

AT49/APR—Broadband Conical, 300-3300 MC. Type N Feed $8.95

AS-31/APN-7: 10 cm Polyrod in Lucite Ball. Type N Fitting Coax Feed $22.50

Relay System Parabolic reflectors approx. range 2000 to 6000 Mc. Dimensions 4½" x 3'. New $100.00

Dipole for above $12.00

Parabolic Peel. Radiation pattern approx. 25 deg. in horizontal 33 deg. in vertical planes $35.00

Cone Antenna. AS 125 APR, 1000-3200 mc. Stub supported with type "N" connector $14.50

AS14A/AP, 10 CM pick up dipole assy. complete w/length of coax and "N" connectors $4.50

AS46A/APG-4 Yagi Antenna, 5 element array ..$22.50

30" Parabolic Reflector Spun Aluminum dish $485

APS-34 Pillbox Antenna, waveguide input: 24,000-27,000 MC $22.50

SCR 584, Dishes Perforated, Metal Construction $185.00

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(Continued from page 336A)

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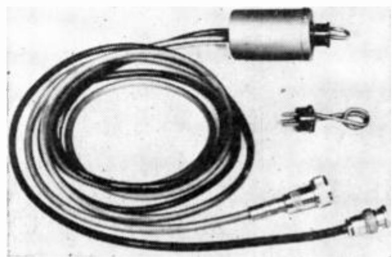
CORRECTION NOTICE

Resonance Indicator



A new Resonance Indicator, Model 60, manufactured by **Dynamic Electronics-New York, Inc.,** 73-39 Woodhaven Blvd., Box 188, Forest Hills, N. Y., is a unit which measures the parallel-resonant frequency of circuits from below 10 mc to above 1000 mc. Because of the small probe size passive, unenergized circuits hitherto inaccessible, may be checked and isolation of the desired circuit can be assured. This instrument will permit a wide range of applications in development, production and trouble-shooting work. It can be used to measure self-resonance of rf coils, to search for parasitic resonances, to pretune rf and IF circuits, to provide quick checks for shorted turns and Q of coils, and so forth.

This Resonance Indicator uses as accessories, signal generators and a microammeter. No additional accessories are required. Price is $29.75.

News—New Products

(Continued from page 80A)

Ceramic Insulators

Western Gold & Platinum Works, 589 Bryant St., San Francisco 7, Calif., has issued a 4 page brochure covering two of their alumina ceramic bodies and their usage in the electronic industry.

Wesgo "AL-1009" is a high purity (99.85 per cent minimum Al_2O_3) recrystallized alumina body which is free from any readily reduced impurities, and has a high melting point (over 2000°C). It is used in such applications as cathode heater insulators. Emitter poisoning due to "gassing" of ceramic is eliminated.

Wesgo "AL-300" is a high strength, vacuum tight, non "gassing" low loss 97 per cent alumina content ceramic. The material will withstand temperatures up to 1600°C without deformation or deterioration. The "AL-300" body is used for vacuum tube insulators, rf "windows" and various other shapes for high frequency applications.

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