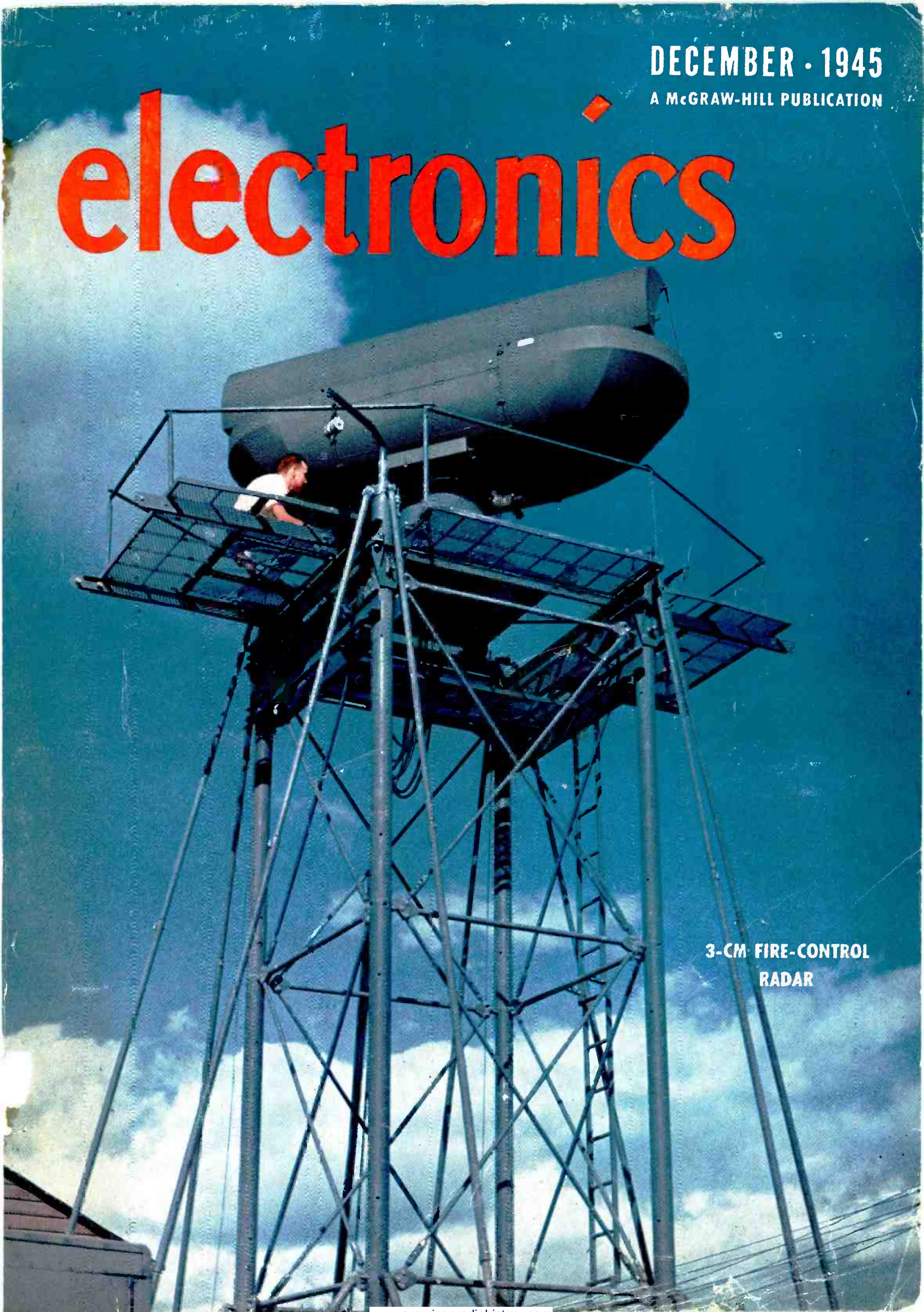
DECEMBER · 1945

A McGRAW-HILL PUBLICATION

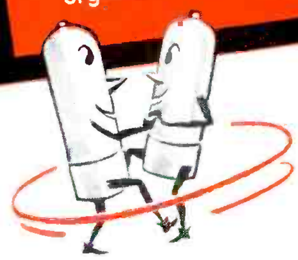
electronics



3-CM FIRE-CONTROL RADAR

THE AMPEREXTRA FACTOR in SOUND TRANSMISSION

The Amperextra Factors of dependability and longevity represent important operational and replacement savings in the sound transmission field. Even in wartime, orders from essential civilian users were filled with fairly consistent regularity. Now, with nothing ahead but peace, the Amperextra Factor of service takes on an entirely new meaning for broadcasting stations, amateur radio operators and communications organizations. Your inquiries are invited.



WHAT ONE USER SAYS...

. . . "the ease with which they can be driven to full output, the simplification of cooling arrangements, the relative immunity to heavy overloads, and the moderate plate voltages required result in a combination not easily surpassed."

AMPEREX INTERCHANGEABILITY

Amperex tubes will fit into all types of transmitters for which they are intended, and may be interchanged or used to replace tubes of other manufacture without need for circuit readjustment and without impairment of transmitter performance.

SPECIALLY PROCESSED GRAPHITE ANODES..

. . . in many of our exclusive designs make for more uniform temperature distribution, absence of change in characteristics with time, and a higher initial vacuum which keeps tubes harder and assures longer life.

AMPEREX

...THE HIGH PERFORMANCE TUBE

Many standard types of Amperex tubes are now available through leading radio equipment distributors. The Amperex Special Application Engineering Department will gladly work with you on the solution to your pressing problems.

Amperex Type ZB-120 Transmitting Tube. Filament voltage, 10-10.5 volts AC or DC. Filament current, 2 amperes. Amplification factor, 90. Grid-to-Plate Transconductance at 120 ma., 5000 micromhos. Direct Interelectrode Capacitances: grid-to-plate, 5.2 μμf; grid-to-filament, 5.3 μμf; plate-to-filament, 3.2 μμf.

Amperex Type HF-3000 Transmitting tube. Filament voltage, 21 to 22. Filament current, 40.5 amperes. Filament emission, 6 amperes. Amplification factor, 16. Grid-to-Plate Transconductance of plate current of 1 ampere, 6500 micromhos. Direct Interelectrode Capacitances: grid-to-plate, 10 μμf; grid-to-filament, 13 μμf; plate-to-filament, 4 μμf.

Amperex Type 891-R Transmitting Tube. Filament, two-unit type for single-phase or two-phase AC or DC operation—voltage per unit, 11; current per unit, 60 amperes; amplification factor, 8. Grid-to-Plate Transconductance at a plate current of 0.75 ampere, 4000 micromhos. Direct Interlectrode Capacitances: grid-to-plate, 30 μμf; grid-to-filament, 16 μμf; plate-to-filament, 3 μμf.

AMPEREX ELECTRONIC CORPORATION

25 Washington St., Brooklyn 1, N. Y., Export Division: 13 E. 40th St., New York 16, N. Y., Cables: "Arlab"

Canadian Distributor: Rogers Majestic Ltd. • 622 Fleet Street West, Toronto

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DECEMBER • 1945

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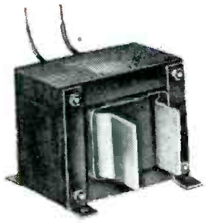
UNUSUAL DESIGNS AT UTC

RESONANT TRANSFORMERS

This high voltage application involved a minimum size requirement. For maximum compactness, the final transformer produced has a turns ratio of 115/5,800, but a voltage ratio due to resonance of 115/10,000 V.

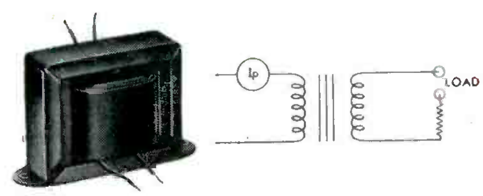
VARIABLE AC SATURATED INDUCTOR

This inductor is part of a voltage sensitive non-linear network. By adustment of the inductor with a specific capacitor, peak non-linearity can be adjusted over a substantial range in voltage.



CONDENSER – PULSE WELDING TRANSFORMER

This transformer is designed for a small precise spot welding set. For this type of application, design factors include High Q and maximum surge power transfer. The transformer shown is the equivalent of 100 VA in size, but handles 1,000 VA pulses.



SPECIAL CONTROL TRANSFORMER

In this odd application, the requirements were that the primary current go down with increase in load current. In actual practice, when normal load is placed on the secondary, the primary current drops 50%.

The UTC application engineering section is available for your problem.

United Transformer Corp.

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ALL PLANTS

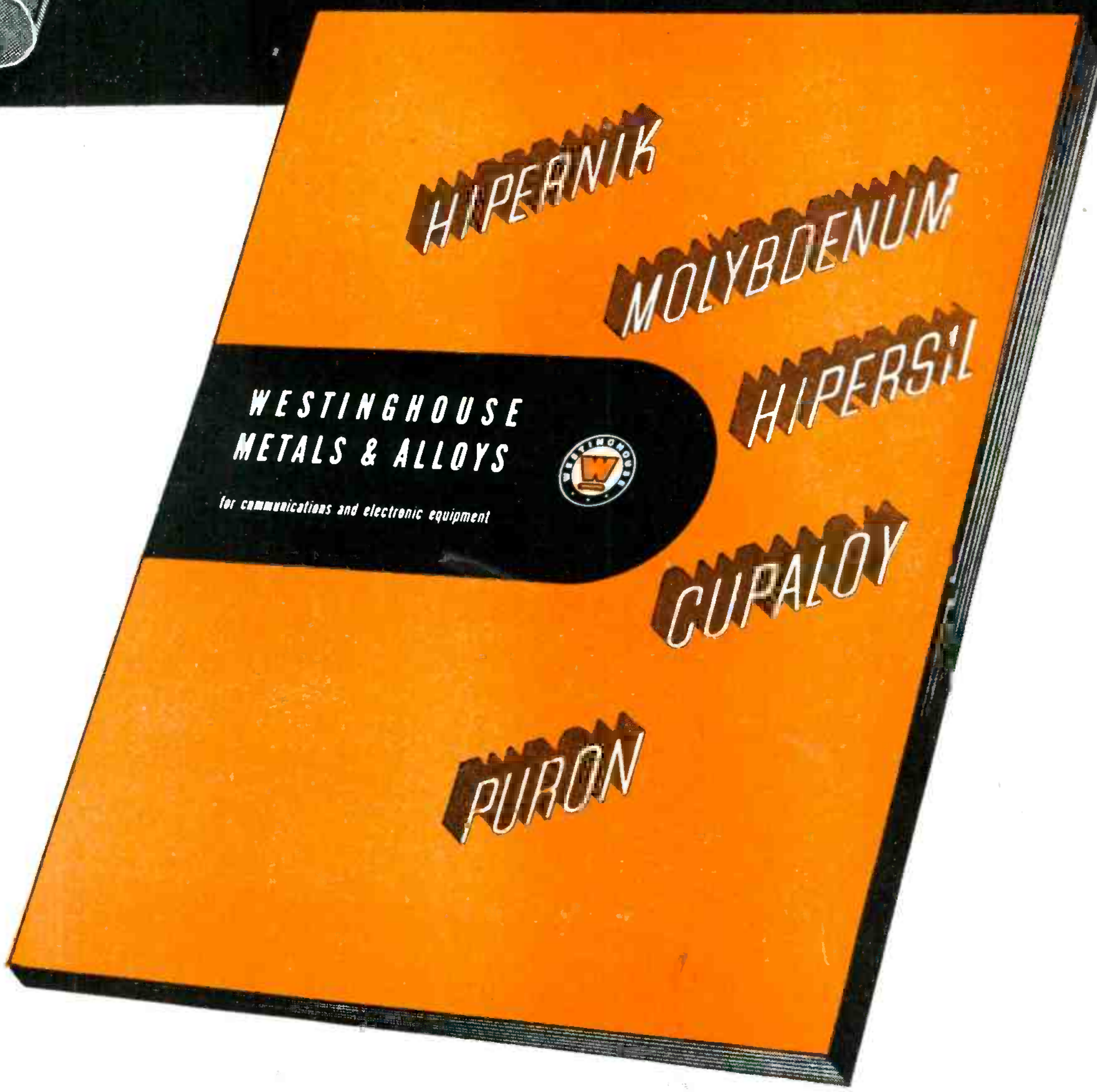
"Impossible" is a word that is not recognized by engineers. To dam a mighty river, tunnel under it or suspend a bridge across it—things such as these that once seemed pure imagination were made possible by instruments devised to refine and extend human faculties, to translate the precision of engineering thought into action.

Keuffel & Esser Co. is proud to have played so large a part in making such instruments widely available. In this way K & E equipment and materials have been partners of the engineer and draftsman for 78 years in shaping the modern world. So universally is this equipment used, it is self-evident that K & E have played a part in the completion of nearly every engineering project of any magnitude. Could you wish any surer guidance than this in the selection of your own "partners in creating"?

partners in creating

Not only for construction and building, but for setting up precision machine tools and long production lines, in the fabrication of large ships and aircraft, experienced engineers know that they can rely utterly on K & E transits and levels. Coated lenses for increased light transmission, precision-ground adjusting screws, chromium-coated inner center and draw tubes, completely enclosed leveling screws, improved achromatic telescopes—all these typify the advanced design of these instruments.

How many ways can this NEW BOOK help you?



Here's real help for communications and electronic equipment designers . . . a fact-packed, thoroughly-illustrated book on Westinghouse metals and alloys.

This new book includes complete data, performance characteristics and applications for more than a dozen Westinghouse metals and alloys in five major classes: magnetic; electrodes, filaments and contacts; sealing; joining; and high temperature. An extensive table permits a detailed comparison of Westinghouse and other metals and alloys.

Your nearest Westinghouse office can supply you with copies of this new, authoritative book and a Westinghouse engineer will be glad to help you find new ways to put these metals and alloys to work in your own product designs. Write today for your copy of B-3369. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

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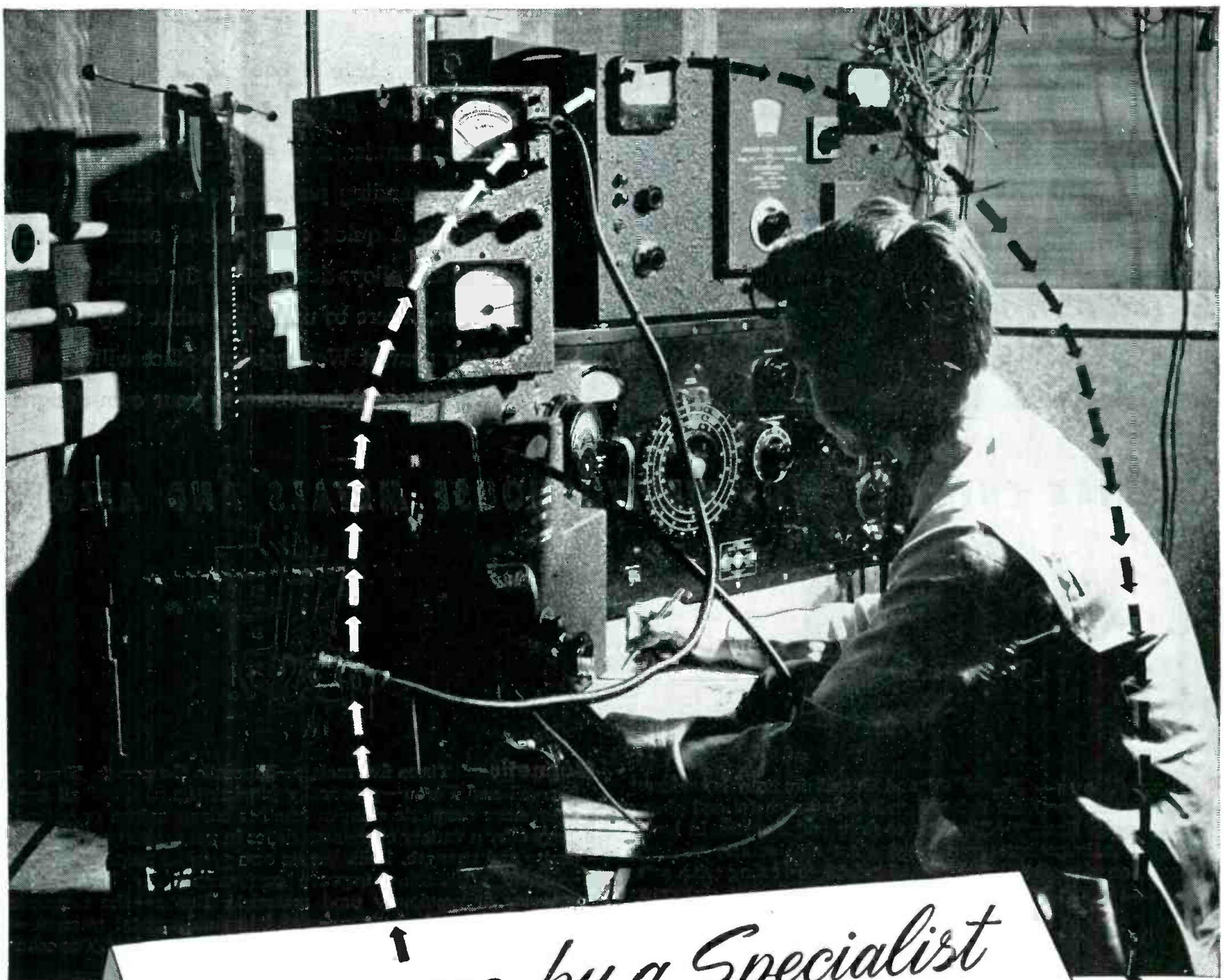
Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE



DIAGNOSIS *by a Specialist*

THE CURE OF RADIO NOISE is a highly specialized task that involves much more than simply "hooking a condenser across the line". It requires exact knowledge of the proper size and type of capacitor to use . . . of the correct place to add it to the noise-making circuit . . . of the necessary length or positioning of connecting leads . . . and of many other seemingly trivial, but actually vital, bits of information that cannot rightfully be expected of the electrical design engineer.

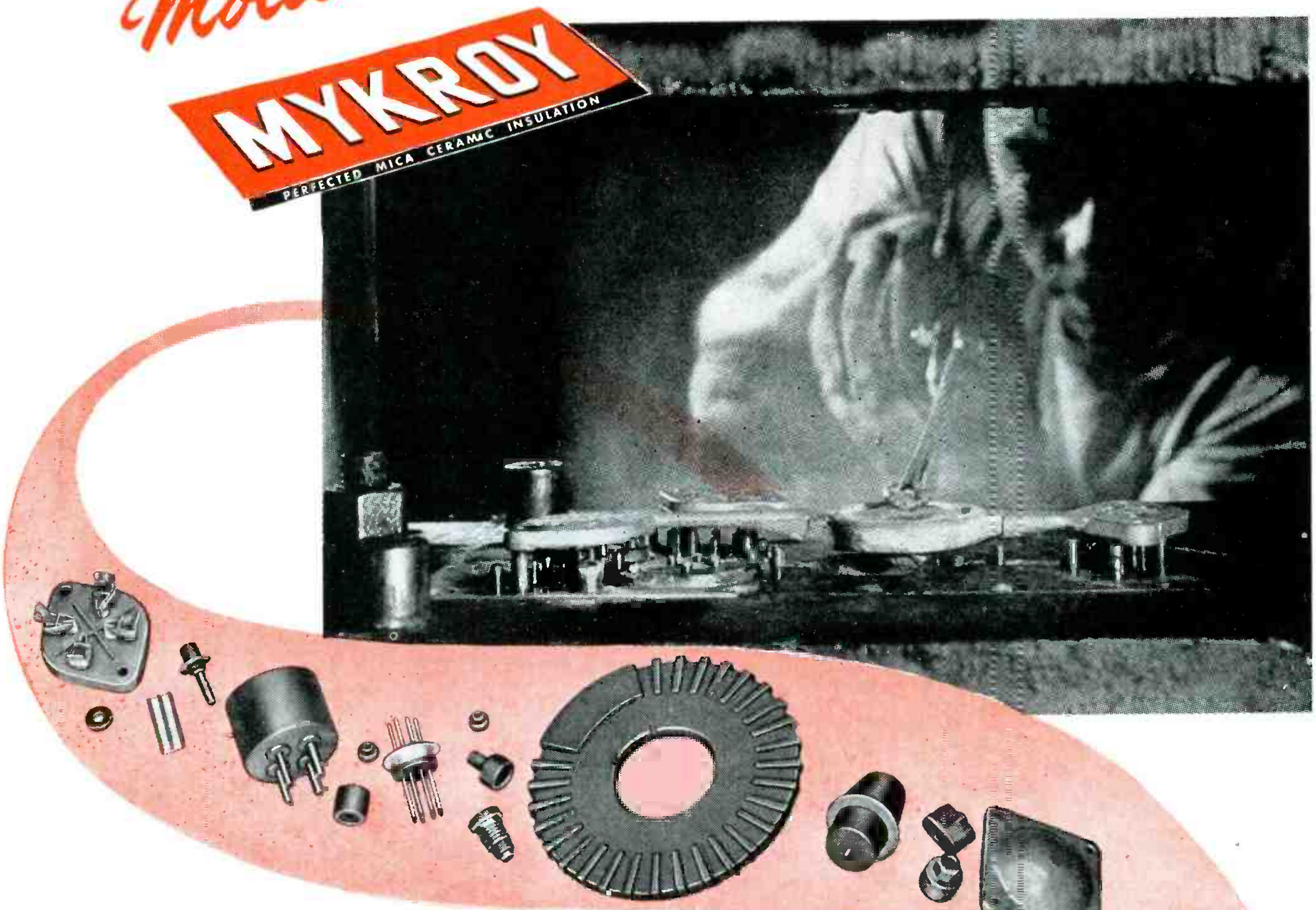
This exact knowledge is available to you when you must provide radio silence for electrical apparatus. Just send us the offending equipment and we will measure its radio noise output according to standard specifications, will design the most efficient Filterette to cure the noise, will specify the proper means of installing it, and, upon your adoption of our recommendations, will authorize your use of the FILTERIZED label that tells buyers your apparatus will not interfere with radio reception. This service is free to users of Tobe Filterettes . . . write for details.

SUPPRESS MAN-MADE RADIO STATIC
TOBE
FILTERIZED

TOBE DEUTSCHMANN CORPORATION-CANTON, MASSACHUSETTS

ORIGINATORS OF FILTERETTES . . . THE ACCEPTED CURE FOR RADIO NOISE

MICA CERAMIC INSULATION
Molded TO YOUR SPECIFICATIONS



Holds to Tolerances up to ±.001"

In part after part, and in any quantity, Mykroy molds and *holds* to critical tolerances. In this, the only ceramic which can be molded under heat and pressure to such close tolerances, are combined many other highly desirable properties that distinguish Mykroy from all other types of insulating materials.

Unique in the class of glass-bonded mica ceramics, Mykroy possesses *electrical characteristics of the highest order* which do not shift under any conditions short of actual destruction of the material itself. Furthermore it will not warp—is impervious to gas, oil and water—withstands heat up to 1000° F and will not char or carbonize.

Its mechanical strength is comparable to cast iron and because it bonds firmly to metals it is particularly suited to molding parts with metal inserts. Even where price is a factor it competes with many standard insulating materials of lower electrical properties.

For improved performance and better quality in your new products investigate the many advantages of Mykroy. Write for samples and full information.

10th ANNIVERSARY 1935 MYKROY 1945 ELECTRONIC MECHANICS INC.

MADE EXCLUSIVELY BY

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A-C's Electronic Heater Gives You

NEW A-C WAY

A-C's Electronic Heater cuts production corners with new service features, wide application range.

STURDY, Long-Life Oscillating Tubes — fully protected by overload relays, water filters and pressure switches.

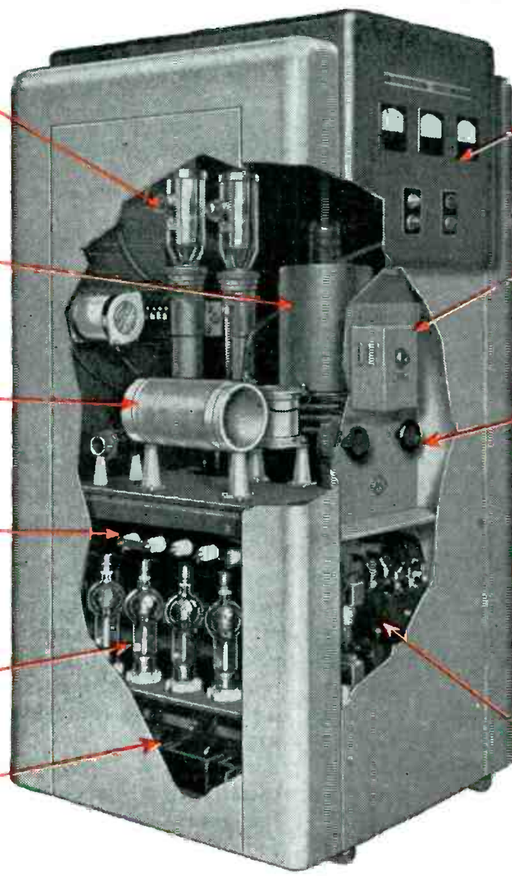
NEW Coupling System, developed by A-C, keeps losses low, permits adaptation to most applications without use of radio frequency transformers.

CHOKE COIL protects rectifier tubes from damage by high-frequency radio currents.

HEAVY-DUTY Transformer for handling overloads, other extreme operating conditions.

3-PHASE Rectifying System obtains maximum power from electronic heater, prevents unbalanced load on power lines.

INDIVIDUAL Filament Transformer for each rectifier tube, easy to get at.



LARGE Indicator Panel for easy reading — shows at a glance when power is on, grid and plate currents, filament voltage.

AUTOMATIC Timer controls heat sequence from 2/10 seconds to 2 minutes, makes unit easy for unskilled operators to use.

ALL Controls on one panel for easy change in applications. No other internal adjustments needed. Protected from tampering by door and lock.

MODERN Industrial Cabinet encloses complete unit. All-Steel construction. Mounted on casters for mobility.

SAFETY FEATURES: Heavy-duty control, high water-temperature switch, fuses, interlocking switches on doors to protect operators.

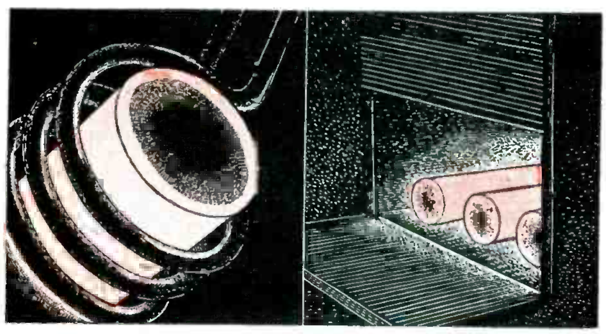
Pioneer Builders of Electronic Equipment for Industry.

Allis A-C

Fast, Uniform Production! Compare—

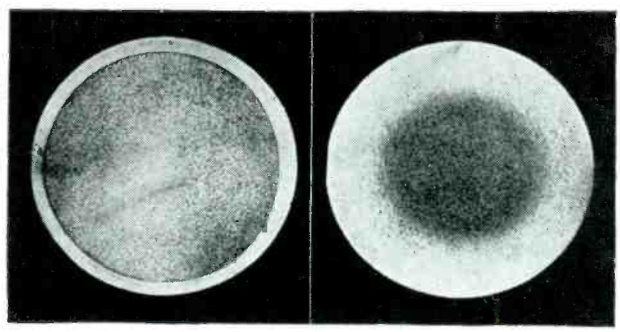
v. OLD WAY!

A-C's Electronic Heater is clean, automatic — easy to operate . . . increases output, cuts cost.



FAST **Electronic Heat** *v.* **SLOW** **Furnace Heat**

A-C's Electronic Heater doubles and redoubles output of hardened metal parts because entire heating operation can be completed in a matter of seconds! Compare this with slow heat, time-waste of conventional methods.



NEW **Controlled Heat** *v.* **OLD** **Uncontrolled Heat**

Compare ideal hard surface and tough core of metal at left as treated by Allis-Chalmers Electronic Heater . . . with deep, irregular hardening and brittle core of metal at right, as treated by conventional methods.

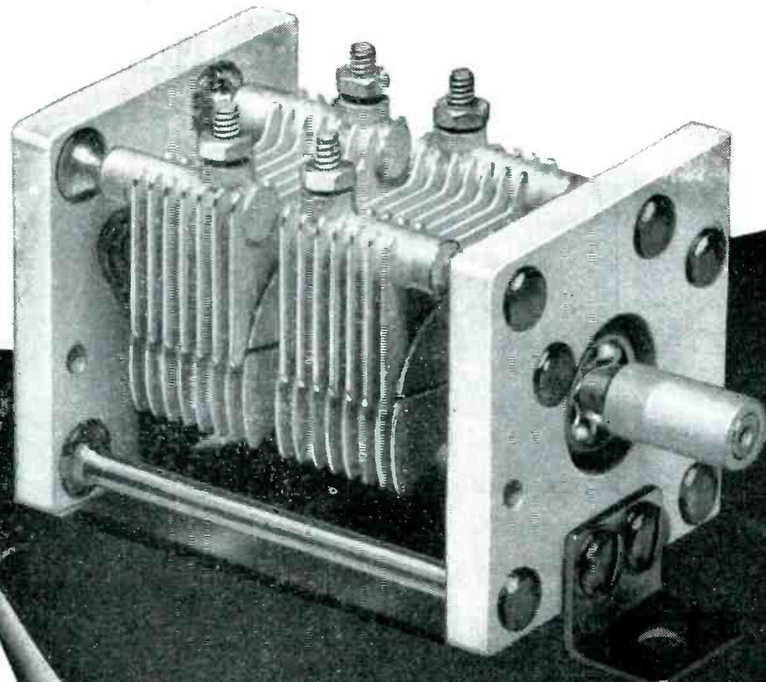
INDUCTION HEATING at its newest and finest — that's what Allis-Chalmers Electronic Heater offers you! This great, new all-in-one production tool gives you flexible, selective, controllable heat for brazing, annealing, forging — yet it's simple to operate, requires no special skills. Write for further details about this modern answer to many modern production problems, or send samples for free laboratory test. No obligation. ALLIS-CHALMERS, ELECTRONIC DEVICES SECTION, MILWAUKEE, WISCONSIN.

A 1972

HEAR THE BOSTON SYMPHONY: *Saturday, American Broadcasting Co.*

Chalmers MILWAUKEE WISCONSIN

new VHF-UHF CAPACITOR TECHNIQUE



Send card for mechanical and electrical specifications.

Here's the answer to your UHF design problems. Noiseless operation — no rotor contacts — symmetrical layout. The new "VU" type variable capacitors can be used in conventional tuned circuits at frequencies as high as 500 megacycles. Write for folder with full technical data.

THE SIGN OF QUALITY

ESTABLISHED 1910

HAMMARLUND

THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., NEW YORK 1, N.Y.

MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

High power output, long life, feature these transmitting tube stalwarts!

- **TYPE GL-892**
  Water-cooled . . . $170
- **TYPE GL-892-R**
  Forced-air-cooled . $345

HERE is *proved* power, dependability, and long service life for the large AM transmitter owner or the manufacturer using electronic heating. General Electric Types GL-892 and GL-892-R have demonstrated their reliability in broadcasting and industrial sockets operating 24 hours a day, 7 days a week. With broad applications as high-power amplifiers, modulators, and oscillators, Types GL-892 and GL-892-R also are adaptable as to filament supply, their 2-unit filament permitting operation from 2-phase or single-phase a-c, as well as from d-c. For complete data to supplement the basic ratings at the right, see your nearest G-E Office or distributor, or write *Electronics Department, General Electric Company, Schenectady, N. Y.*

Come to GENERAL ELECTRIC *with any special tube problems. A staff of experienced G-E tube engineers will work with you closely to meet your application or replacement needs.*

CHARACTERISTICS

Three-electrode high-vacuum power tubes for use as amplifiers and modulators in broadcasting and communications equipment—also oscillators in industrial electronic heating. Besides Types GL-892 and GL-892-R shown above, Types GL-891 and GL-891-R also are available at the same prices, and are similar in design characteristics except for the amplification factor, as given below.

Rating	GL-892	GL-892-R	GL-891	GL-891-R
Filament voltage	11 v	11v	11v	11 v
Filament current	60 amp	60 amp	60 amp	60 amp
Max plate voltage	15,000 v	12,500 v	12,000 v	10,000 v
Max plate current	2 amp	2 amp	2 amp	2 amp
Max plate input	30 kw	18 kw	18 kw	15 kw
Max plate dissipation	10 kw	4 kw	6 kw	4 kw
Amplification factor	50	50	8	8

Notes: (1) Filament voltage and current given above, are per unit of 2-unit filament. (2) Maximum frequency for all four tube types is 1.6 megacycles at max plate input; up to 20 megacycles at reduced ratings.

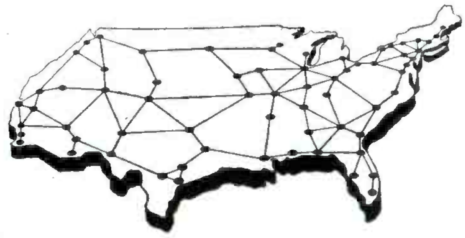
TRANSMITTING, RECEIVING, INDUSTRIAL, SPECIAL PURPOSE TUBES · VACUUM SWITCHES AND CAPACITORS

GENERAL ELECTRIC

161-D12-8850

MICRO-TEL RELAY

Television's first MICROWAVE *link*



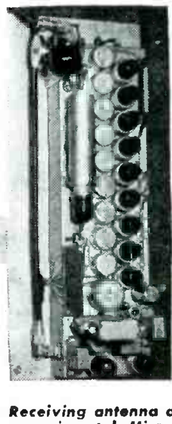
GENERAL ELECTRIC'S Micro-Tel relay—first 2000-megacycle radio relay in history—heralds a new era in network operation that will bring television and FM to more people at less cost.

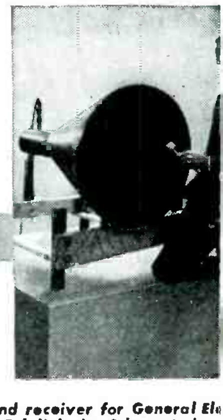
● This simple relay, which eliminates connecting wire lines and costly right-of-ways, consists of a low-power microwave FM transmitter, a microwave FM receiver, *and a highly directional transmitting and receiving antenna system which gives each watt of transmitter power the effectiveness of approximately one million watts.* The system is simple, economical and provides unattended operation.

● Today, General Electric is testing a Micro-Tel link between the studio and transmitter of its great television station WRGB in Schenectady —a distance of 12½ airline miles. Soon, the world's first television microwave relay — equipped by G. E. and operated by the International Business Machines Corp. — will be added. This relay will extend to New York, Philadelphia, Baltimore, and Washington. Additional links will follow . . . for television programs, full fidelity channels for network broadcasting, facsimile channels, and multiple business machine channels — simultaneously in both directions.

● Further expansion of this network and the establishment of others will bring television, broadcasting, and business machine services to smaller communities.

● Whether your requirements are for Micro-Tel relays, complete television broadcast stations, or Intra-Tel systems, look to General Electric for your equipment. Plan now to visit Schenectady to study G-E broadcast facilities. Wednesdays and Fridays are "open house" days. Write for the folder "How to Get To Schenectady," or ask your G-E broadcast equipment representative to help you plan your visit. *Electronics Dept., General Electric Company, Schenectady 5, N. Y.*





Receiving antenna and receiver for General El[...] experimental Micro-Tel link in Schenectady. [...] extreme simplicity of installation. The hor[...] antenna is only 2 feet in diameter.

Authentic Guide to Television Programming

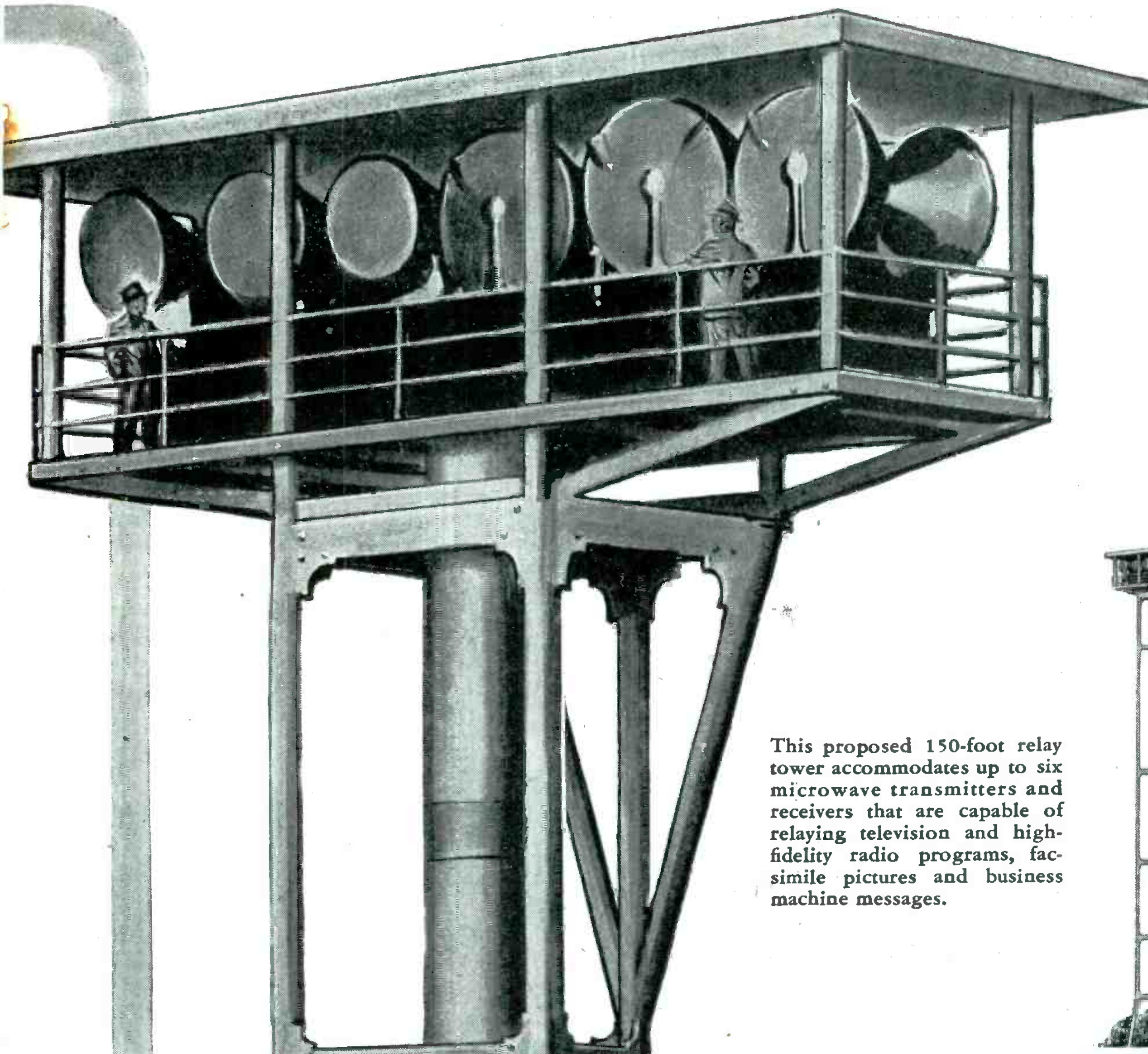
Write for the new book "Television Show Business," by Judy Dupuy. Published by General Electric. $2.50 per copy. Address: Electronics Department, General Electric Company, Schenectady 5, N. Y.

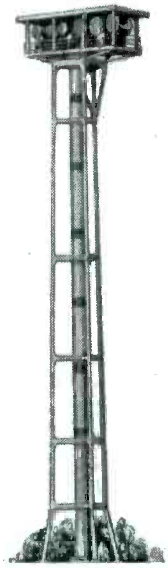
For earliest possible delivery of your broadcast equipment, place your order *now.*

STUDIO AND STATION EQUIPMENT • TRANSMITTERS

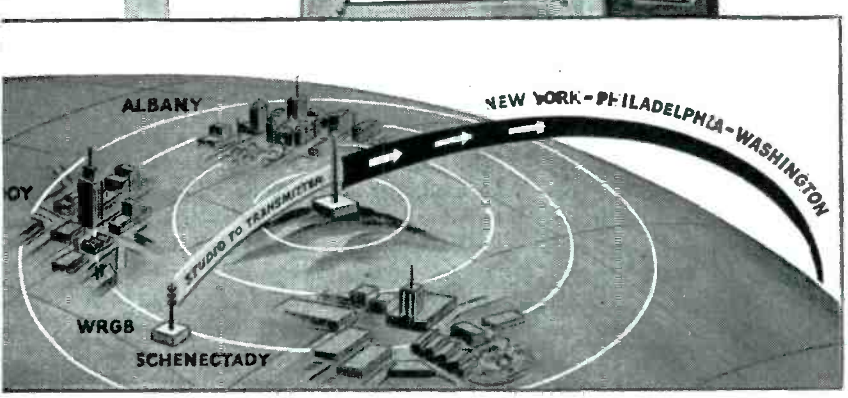
GENERAL ELECTRIC

156-D3-6912

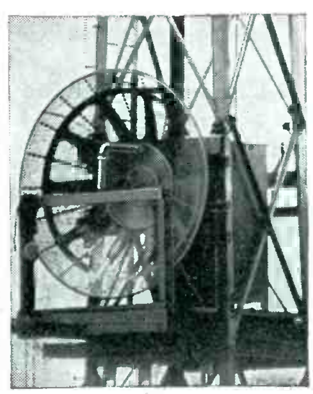


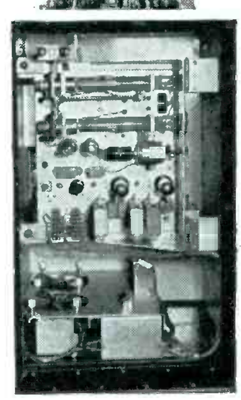


This proposed 150-foot relay tower accommodates up to six microwave transmitters and receivers that are capable of relaying television and high-fidelity radio programs, facsimile pictures and business machine messages.



The G-E microwave television link. With the Micro-Tel relay, G.E. contributes another major development in television and broadcasting.





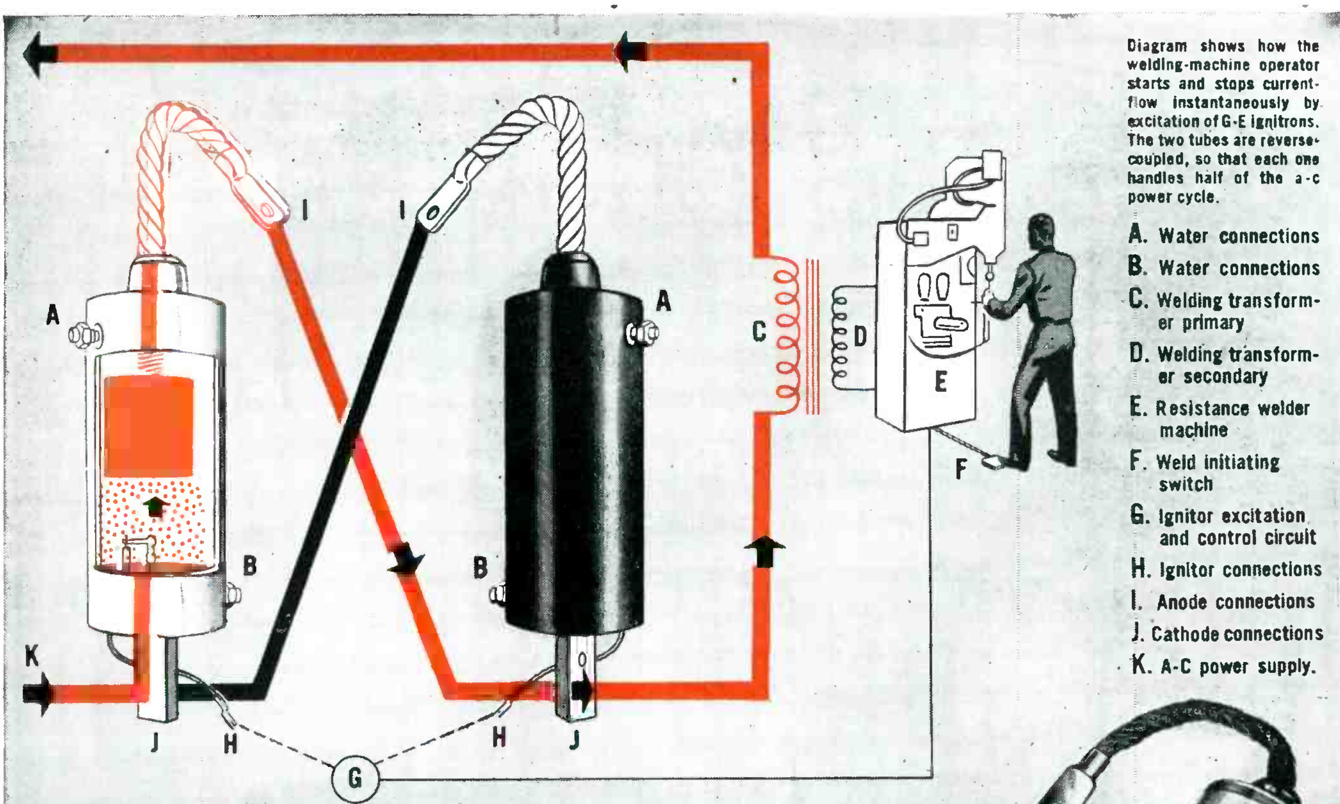
Micro-Tel link transmitter and antenna with highly directional reflector atop mast at WRGB. This system gives each transmitted watt of output the effectiveness of approximately 1,000 watts.

Lighthouse tubes make television microwave relaying possible. For maximum station dependability and performance, use G-E electronic tubes.

ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

AM • TELEVISION • FM

See G.E. for all three!



IGNITRONS "trigger" the heavy currents for resistance welding

AN important use of G-E ignitron tubes is shown above—controlling the primary current of resistance welders. The same benefits of split-second, positive "valve" action, with no mechanical linkage and no arcing between movable contacts, are provided by G-E ignitrons for other control circuits—furnace, motor, etc.—involving heavy electrical currents.

● Current control is but one of this tube's functions in industry. Another is current conversion—a-c to d-c. Here ignitrons offer the advantages of silent operation, no rotating parts, no need for lubrication, no mechanical upkeep.

● Steel-jacket construction and mercury-pool type cathode, among other features, make the G-E ignitron sturdy, dependable, and long-lived. Learn more about this versatile electronic tube from G. E.'s new Booklet ETI-21, "Ignitron Tubes and How They Are Used." Its 24 profusely illustrated pages, complete with selected circuits, tell the full story of ignitrons and how they serve industrially. Telephone your nearest G-E office or distributor, or write *Electronics Department, General Electric Company, Schenectady 5, New York.*

IGNITRON FG-235-A . . . $75.

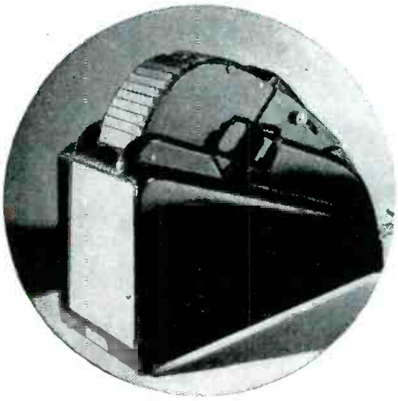
This tube is one of the most widely used G-E ignitrons. It is a steel-jacketed, water-cooled, gas-filled triode with mercury-pool cathode, used for welder and other heavy current controls, and as a low-power current converter. For welder-control service, ratings are: max kva demand 1,200, with corresponding avg anode current 75.6 amp—max avg anode current 140 amp, with corresponding kva demand 400. (These ratings are for voltages of 600 v rms and below.) Ignitor requirements are 200 v and 30 amp. . . . Ratings for current conversion will be supplied on request, in which case please include a brief description of the application or circuit.

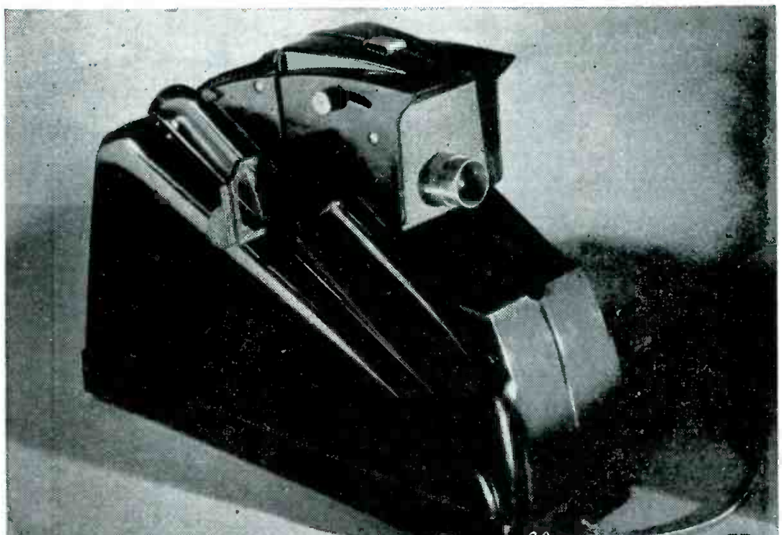
G. E. HAS MADE MORE BASIC ELECTRONIC TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

162-D12-8850

TRANSMITTING, RECEIVING, INDUSTRIAL, SPECIAL PURPOSE TUBES ★ VACUUM SWITCHES AND CAPACITORS





Phenolics featured in Postwar Plastics "Picture"

The phenolics are the most versatile of all plastics. Naturally, this makes their use practically universal throughout industry. In the electrical manufacturing field, for example, you will find phenolic molding compounds being used for literally thousands upon thousands of vital parts The Novex Combination Projector Viewer shown above serves as an excellent illustration of this point. Its sturdy heat-resistant plastic housing was molded from a Durez phenolic compound.

This Novex Combination Projector Viewer effectively demonstrates the practical, sales-stimulating use to which Durez phenolic molding compounds can be put. Its durable, eye-appealing 14"-long body is molded in one piece. The complete unit embodies several molded Durez parts. With molded-in inserts, these, naturally, help to make assembly a simple process and keep production costs at a minimum.

Heat-Resistant Housing

By molding the housing for this Combination Projector Viewer of Durez, the manufacturers gain the heat-resisting and heat-insulating characteristics so necessary for the efficient operation of a machine of this type. Furthermore, a rugged yet lightweight construction results.

Properties of the Phenolics

Just as the Novex Corporation found a Durez phenolic plastic that fitted their job, so have many other manufacturers. Such desirable properties as heat and moisture resistance and dielectric strength make Durez compounds of unusual value to electrical manufacturers. Additional inherent characteristics such as highest dimensional stability at temperature extremes, excellent moldability, and impact strength make them extremely useful to the automotive industry. Closure manufacturers find the eye-appealing, non-bleeding finish of molded Durez to be the answer to their materials problems. Time and again the versatility of the more than 300 Durez phenolic molding compounds has provided the solution to the materials problems of the imaginative design engineer.

Competent Assistance Available

The Durez laboratory technician is an experienced man. Years of successful development work and the continuing leadership of Durez phenolic plastics attest this. Your custom molder is also an experienced man. Many new molding methods and processes make his service even more valuable than before. Put these two men together and you'll stand an excellent chance of coming up with the answer to any practical plastic materials problem which you may have. The services of the Durez staff are available at all times to you and your custom molder. Durez Plastics & Chemicals, Inc., 3212 Walck Road, North Tonawanda, N. Y. *Export Agents: Omni Products Corporation, 40 East 34th Street, New York 16, N. Y.*

DUREZ

PHENOLIC RESINS

MOLDING COMPOUNDS

INDUSTRIAL RESINS

OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB

9 NEW RCA MINIATURES!

INCLUDES NEW COMPACT TYPES FOR AM, FM, AND TELEVISION RECEIVERS

• Here it is—that latest addition to the peacetime line of miniatures . . . 5 new miniature types that provide performance equivalents for the popular prewar kit 12SA7, 12SQ7, 12SK7 (or 12SG7), 35Z5GT/G, and 50L6GT—and 4 other tubes introduced as performance equivalents to the 6SA7, 6SG7, 6SQ7, and 6SH7.

These 9 new RCA miniatures bring to 35 the total number of tubes in the RCA miniature line—*and all but 2 were developed by RCA engineers.*

Such RCA pioneering means two important things to you:

1. That RCA knows your needs—keeps an eye on the industry—is ever striving to give you the tubes you want when you want them.
2. As the originator of miniatures and as the largest producer of them ever since their introduction, RCA can assure you of superior tube quality and uniformity at prices that are right.

For data on these 9 new tubes, send coupon.

If you are designing radio equipment and need tube-application assistance, don't forget that the RCA application-engineering staff is always at your service for consultation. A telephone call to our nearest office, or a letter stating your problem, will do the trick. Address: Radio Corporation of America, Tube Division, Commercial Engineering Department, Section 62-41E, Harrison, N. J.

In Metals, Miniatures, or Glass Types . . .

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

MAIL THIS TODAY FOR FREE DATA SHEETS

RCA, Commercial Engineering Department,
Section 62-41E, Harrison, N. J.

I'd like all the data available on the 9 new RCA miniatures announced in your December advertisement. Please rush me a complete set of data sheets, including ratings, curves, drawings, etc.

Name..........

Position..........

Company..........

Address..........

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

AND HERE THEY ARE!

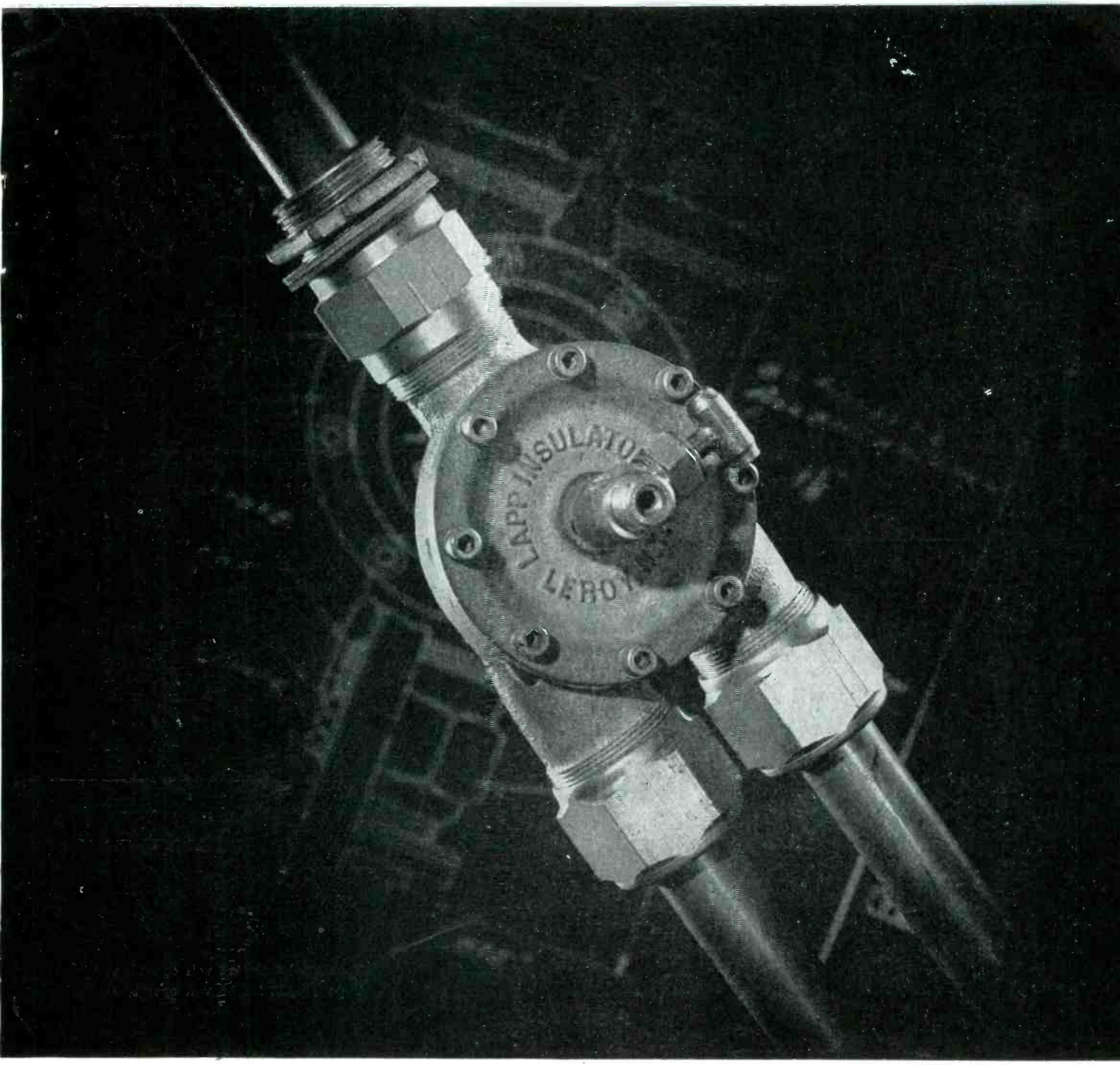
	Miniatures New Types	DESCRIPTION	Performance Equivalent
★	6AT6	Duplex-Diode High-Mu Triode	6SQ7
★	6AU6	RF Amplifier Pentode with Sharp Cutoff	6SH7
★	6BA6	RF Amplifier Pentode with Remote Cutoff	6SG7
★	6BE6	Pentagrid Converter	6SA7
★	12AT6	Duplex-Diode High-Mu Triode	12SQ7
★	12BA6	RF Amplifier Pentode with Remote Cutoff	12SG7 (or 12SK7)
★	12BE6	Pentagrid Converter	12SA7
★	35W4	Half-wave High-Vacuum Rectifier	35Z5GT/G
★	50B5	Beam-Power Amplifier	50L6GT

RCA

62-6136-41

RADIO CORPORATION OF AMERICA

TUBE DIVISION • HARRISON, N. J.



ENGINEERING AND PRODUCTION

The gadget above is a junction box for a co-axial gas-filled transmission line. It is one of a series of coupling units, end seals and other fittings for high-frequency transmission—designed and built by Lapp.

To this type of construction, Lapp brings several innovations and improvements. For example, such a line from Lapp parts is genuinely leak-proof. Every gasket is under spring loading, so there's no leakage created by vibration or thermal change.

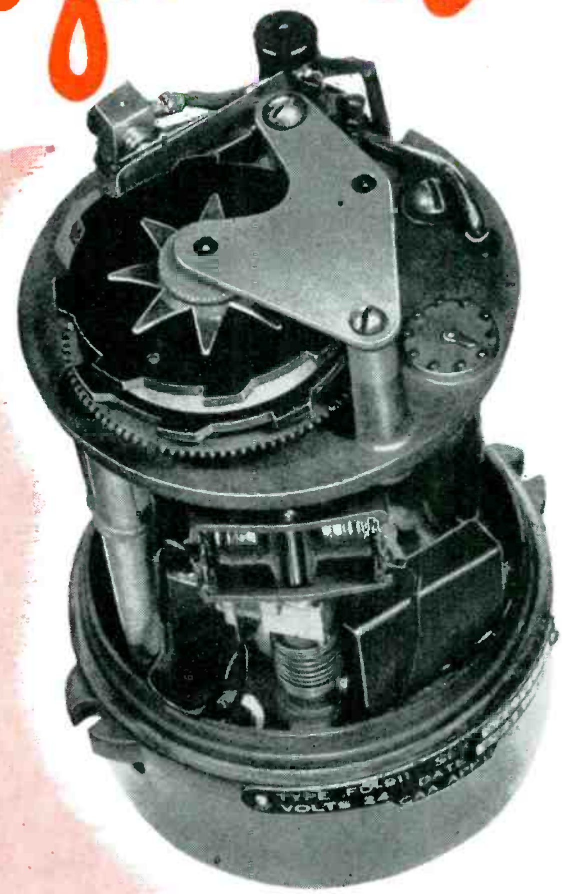
Whether or not you're interested in gas-filled transmission lines, you ought to know about Lapp. Here is an organization of engineers and manufacturers with broad basic knowledge of ceramics and their application. With experience in hundreds upon hundreds of special-purpose electronic parts, we have been able countless times to improve performance, or reduce costs, or cut production time through the application of our specialized skills to design and manufacture of parts involving porcelain or steatite and associated metal parts.

For quick and efficient assistance on a war production subcontract—or for the competitive advantage Lapp-designed and Lapp-built parts will give to you in the postwar battle—an inquiry to Lapp now may pay you dividends. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp

SPLITS SECONDS "just so"

THE W&T CONSTANT SPEED MOTOR MECHANISM meets precision standards



Type FA-121 for 12 volt operation
Type FA-122 for 24 volt operation

FOR coding, keying, monitoring, programming, or other timing applications this instrument, operating at a constant speed, regardless of voltage variations as great as ±20%, permits accurate timing to hundredths of a second.

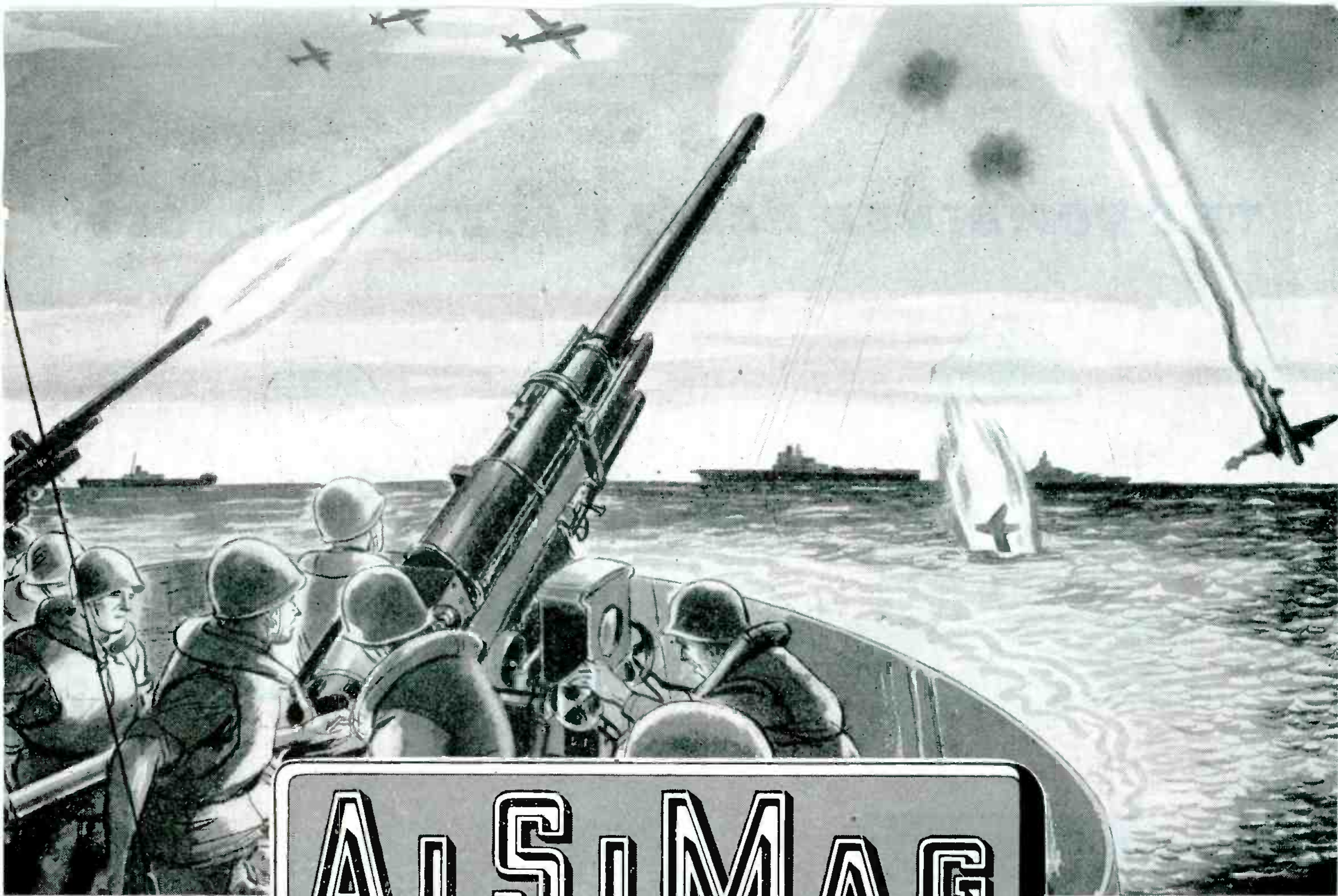
With a current input of only 0.003 milliamperes, the motor delivers 1800 gram inches per minute, a feature of especial importance in battery powered systems.

Interchangeable cams permit the use of any desired timing characteristic for two or more separate circuits.

Write for Technical Publication 234

WALLACE & TIERNAN
PRODUCTS, INC.
BELLEVILLE 9 • NEW JERSEY

A-55



ALSIMAG

TRADE MARK REGISTERED U. S. PATENT OFFICE

CERAMICS SO RUGGED THEY COULD WITHSTAND THE SHOCK OF BEING FIRED FROM A GUN WITH A FORCE OF 20,000g in the 'RADIO PROXIMITY FUSE'

War's Number 2 Scientific Development

ALSIMAG Ceramic Insulators were extensively used in condensers for the 'Radio Proximity Fuse' described by high Navy officials as second only to the atomic bomb among the greatest scientific developments of the war.

Development of the fuse required production of electronic parts so rugged they could withstand the shock of being fired from a gun with a force 20,000 times that of gravity. The components had to be so small that a complete unit could be installed in the nose of a projectile.

The fuse, developed at a cost of $800,000,000 is an extremely rugged, five tube radio sending and receiving station which fits into the nose of a projectile. Reflected impulses explode the projectile when it passes within 70 feet of enemy planes.

The 'Radio Proximity Fuse' was the effective answer to Japanese suicide plane attacks, as well as buzz bomb attacks on London.

American Lava Corporation is justly proud of the fact that it was able to provide the Ceramic Insulators capable of withstanding the tremendous shock of being fired from a gun in the 'Radio Proximity Fuse.'

Whatever you are planning in the field of electronics, we believe our specialized knowledge, research and production facilities will prove helpful. Let's work together.

ALCO has been awarded for the fifth time the Army-Navy "E" Award for continued excellence in quantity and quality of essential war production.

AMERICAN LAVA CORPORATION
CHATTANOOGA 5, TENNESSEE

43RD YEAR OF CERAMIC LEADERSHIP

THE COMBINED RESULT IS EXCELLENCE . . .

SANGAMO ELECTRIC

ESTABLISHED 1898 . . . MICA CAPACITORS . . .

• IN *Sangamo*

4 MICA INSPECTION

8 CARTRIDGE IMPREGNATION

12 RESEARCH & ENGINEERING

MICA CAPACITORS

In our series of advertisements just completed, we have attempted to show "How Excellence is built into Sangamo Mica Capacitors" through featuring one department or process each month.

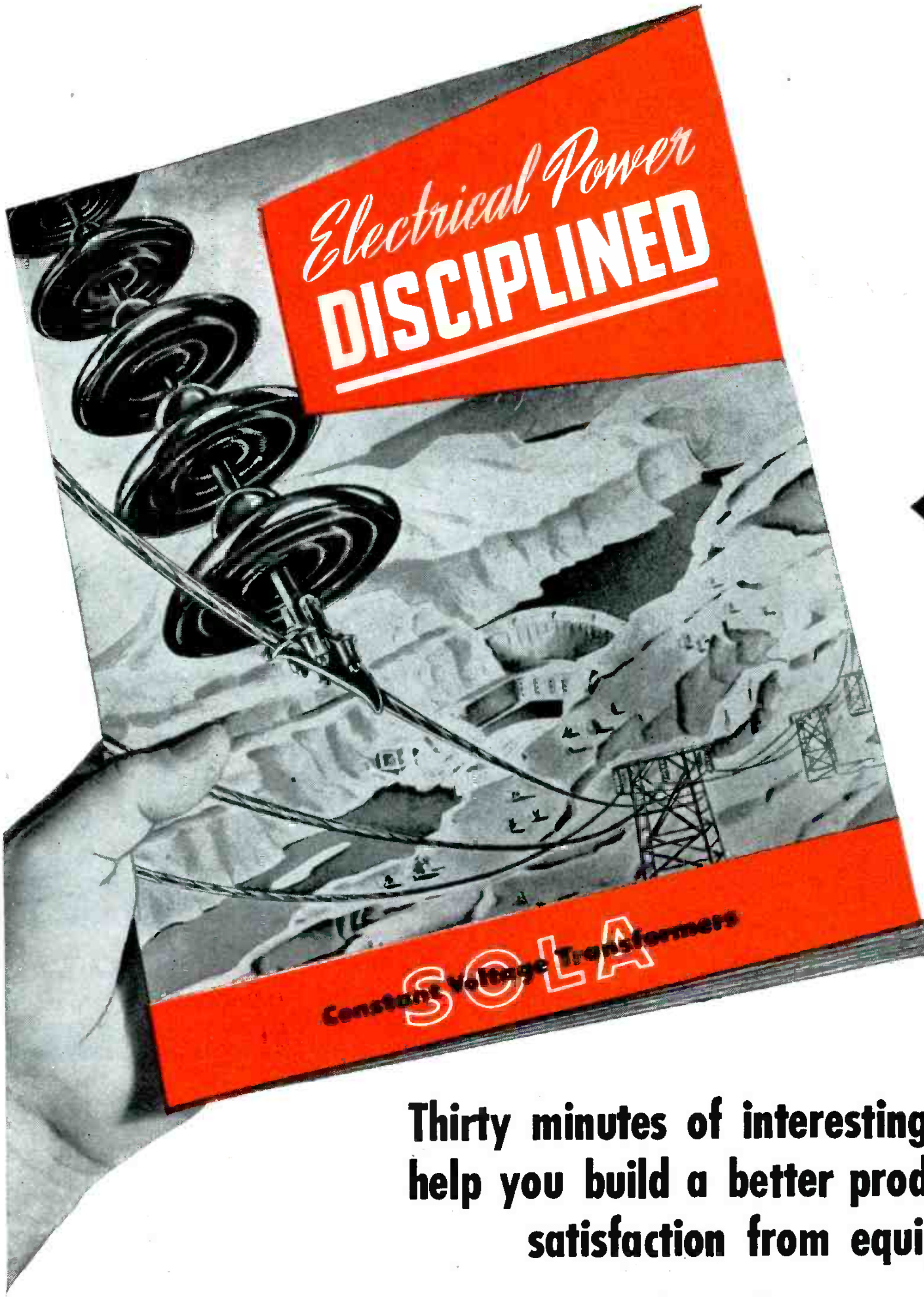
This review, depicting the various steps in the manufacture of a mica capacitor is a reminder of how important the SANGAMO MICA CAPACITOR production set-up is to you in the matter of quality control from the first operation — MICA SPLITTING—all the way through to the final operation—FINAL TESTING.

WRITE FOR *Catalog*

As a user of MICA CAPACITORS, you will want to have the story of SANGAMO EXCELLENCE for reference. Therefore, we have bound the entire series of advertisements featuring the departments shown here, into a booklet. Simply write and ask for your copy of the booklet "HOW EXCELLENCE is built into SANGAMO MICA CAPACITORS."

COMPANY SPRINGFIELD ILLINOIS

• • WATT HOUR METERS • • • TIME SWITCHES • • •



for:

designers

•

manufacturers

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maintenance engineers

•

salesmen

•

users of electronic and electrically operated equipment

Thirty minutes of interesting reading that will help you build a better product or get greater satisfaction from equipment now in use

What is a Constant Voltage Transformer?—why is it necessary?—how does it operate?—where can it be used?—what new developments have resulted from its world-wide, war-time use?—

. . . these and many other important questions are fully answered in this new SOLA handbook.

The Constant Voltage Transformer is an exclusive SOLA product—the ONLY voltage regulating TRANSFORMER. In principle, design and construction it is different and should not be confused with ordinary types of voltage regulating networks.

It employs no tubes and has no moving parts. It is fully automatic in operation, it is not dependent on manual control or supervision and protects both itself and the equipment it serves against voltage surges or short circuit. It instantly corrects voltage fluctuations as great as 30% to within ±1% of rated value.

Your product will serve more people—*better*—with built-in Constant Voltage. There are SOLA units specially designed for that purpose—fully described in this new handbook.

SOLA Constant Voltage Transformers

> **Write for your copy**
>
> *You will find in this handbook a final answer to the problem that confronts every manufacturer or user of electrically operated equipment.*
>
> **Ask for Bulletin DCV-102**

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • etc. **SOLA ELECTRIC COMPANY, 2525 Clybourn Avenue, Chicago 14, Illinois**

or spreading it around

A powerful Western Electric public address system spreads sound evenly throughout New York's huge Madison Square Garden which seats more than 18,000 people.

equipment leads the way!

have also developed scientifically accurate instruments for *measuring* and *analyzing* sound and vibration. These instruments have many important uses today—will have still more tomorrow.

Through their lifetime of pioneering in this field, Bell Labs and Western Electric have gained a unique knowledge of sound and how to handle it. Count on them for the finest equipment for measuring sound or spreading it around!

Western Electric

Distributed by Graybar

Buy all the Victory Bonds you can . . . and keep all you buy!

knowledge in all of these fields

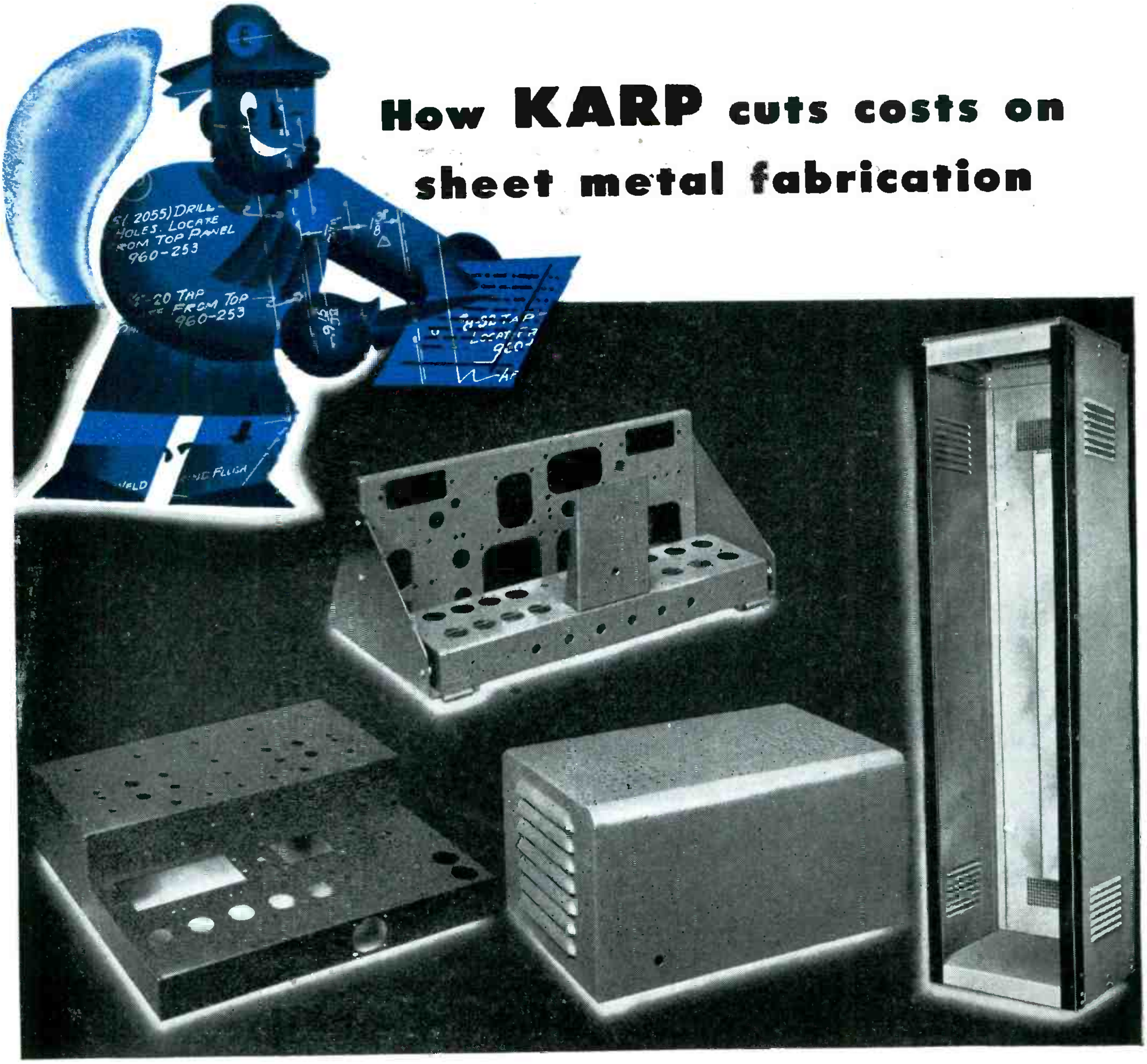
MOBILE RADIO

HEARING AIDS

SOUND MOTION PICTURES

VACUUM TUBES

How KARP cuts costs on sheet metal fabrication



Every job we do is a special-built job, individualized to exact specifications. Yet our superior machine installations and vast stocks of dies and jigs permit us to fabricate your order economically and with precision—frequently saving you the cost of special dies.

Since 1925, our specialty has been the fabrication of cabinets, housings, chassis and enclosures for electronic, electrical and mechanical apparatus. Prior to and during the war, we continued and intensified this specialty, and shall now continue it in peace. Therefore, we are not reconverting to any other line We are not a "war baby"—but our wartime experience has added to our facilities and abilities.

Tell us your sheet metal fabrication needs. We can serve you with satisfaction and speed. More often than not, we can save you money, too.

ARMY E NAVY

ANY METAL • ANY SIZE
ANY GAUGE • ANY FINISH

KARP METAL PRODUCTS CO., INC.

124-30th Street, Brooklyn 32, N. Y.

Custom Craftsmen in Sheet Metal

READY TO SERVE YOU AGAIN!

Thordarson has returned from the war and is ready *now* to serve its many customers. *Thordarson* regrets there has been an interruption in service performance to regular customers and that orders could not be filled during the war. Here's the reason.

The superior quality of *Thordarson* transformers and other electronic devices was recognized immediately by Uncle Sam at the outbreak of the war and *Thordarson* production (100%) was required to fill all-important government orders.

Now the same high quality that was so acceptable in the recent emergency is available to you. *Thordarson* transformers—always the gauge of superior quality and unexcelled performance—are now even better because of many new additions and developments made during the war. *Thordarson* research-engineering plus *Thordarson* quality team together in the production of better equipment and devices for the electronics industry.

New distribution policies and sales promotion plans make *Thordarson* products and complete informative data on their application and use available to all customers—everywhere!

ALWAYS THINK OF *THORDARSON* FOR TOP-NOTCH TRANSFORMERS!

500 WEST HURON ST., CHICAGO, ILL.

ORIGINATORS OF TRU-FIDELITY AMPLIFIERS

THORDARSON

ELECTRIC MANUFACTURING DIVISION

MAGUIRE INDUSTRIES, INCORPORATED

SMALL SPACE

LONG LIFE

MOISTUREPROOF

HEATPROOF

DUMONT
PAPER
CAPACITORS
TYPE P6

DUMONT RESINOID SEALED • WILL NOT MELT AT 300° F

NO AIR VOIDS FILLED UNDER VACUUM

CAT. NO.	CAPACITY MFD	200 V.D.C. SIZES DXL	400 V.D.C. SIZES DXL	600 V.D.C. SIZES DXL	1000 V.D.C. SIZES DXL
P6-1	.001	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-2	.002	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-3	.003	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-4	.004	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-5	.005	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-6	.006	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-7	.008	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-8	.01	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-9	.02	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/2"
P6-10	.03	3/8 X 1"	3/8 X 1 3/8"	1/2 X 1 1/2"	3/8 X 1 1/2"
P6-11	.05	7/16 X 1 3/8"	1/2 X 1 3/8"	1/2 X 1 1/2"	3/8 X 2"
P6-12	.1	7/16 X 1 3/8"	5/8 X 1 3/8"	5/8 X 2"	3/4 X 2"
P6-13	.25	5/8 X 1 3/8"	3/4 X 1 3/8"	3/4 X 2 1/2"	7/8 X 2 1/2"
P6-14	.5	3/4 X 1 3/8"	7/8 X 1 3/8"	3/4 X 2 1/2"	1 X 2 1/2"

Also made in 1600 and 2000 volts

SIZES ± 1/32"

DUMONT ELECTRIC CO.

MFR'S OF CAPACITORS FOR EVERY REQUIREMENT

34 HUBERT STREET NEW YORK, N. Y.

In Springs—it's the X-Dimension that gives a Glider and You a Lift

Ever hear of the X-Dimension of a Spring? Probably not. But, sure as you're born it's there, in every spring. Take, for instance, the intriguing what-is-it pictured below. It's a glider release spring, an assembly which holds the pick-up rope until the parent plane hitches on—then let's go at a precise jerk on the towline.

If Hunter had only manufactured and delivered dependable glider release springs on time and in needed quantities, ts job would have been satisfactory. But Hunter invented the device for All American Aviation, Inc., and assigned the patents to them. That's the X-Dimension at work.

It's also at work in such pioneering efforts in spring manufacture as control gaging and statistical methods in quality control. It's your guarantee of good springs, your insurance against failures and customer complaints. It's *more* than you bargained for—in springs.

Announcing RCA-6C24

1100 WATTS OUTPUT AT 160 MEGACYCLES!

PRICE 45^{00}

TECHNICAL DATA

Filament Voltage (A.C.), volts	11.0
Filament Current, amperes	12.1
Amplification Factor	30
Direct Interelectrode Capacitances, micromicrofarads	
grid-to-plate	4.4
grid-to-filament	4.6
plate-to-filament	3.2
Overall length (less lead wires), inches	6⅛"
Max. diameter, inches	1⅞"

Typical Operation at Maximum Plate Volts

	Class B* Audio Amplifier or Modulator	Class B Telephone R-F Amplifier	Plate-Modulated Class C Telephone	Class C Telegraph
Plate Volts	3000	3000	2500	3000
Plate Milliamperes	800#	200	400	500
Driving Power (Approx.) Watts	30#	16	75	75
Power Output (Approx.) Watts	1600#	200	800	1100

*Two tubes #At max. signal

Here's a tube that fills that important need for medium power in the new FM and television bands—a compact and efficient tube for commercial, emergency, government, and industrial service, in the frequency range above that of the popular RCA-833A.

The 6C24 is a triode having low interelectrode capacitances and low lead inductance for high-frequency applications. Forced-air cooling of the sturdy copper radiators results in a simple and convenient system.

The 6C24 is designed for either fixed or portable operation. Takes full input up to 160 megacycles.

Industrial Applications

The 6C24 is rated at both 400 and 600 watts plate dissipation. This higher rating requires increased air flow, but is of particular interest to designers of electronic heating equipment in which it is desired to hold tube and circuit conditions to moderately low efficiencies for conservative operation of the 6C24.

Application Assistance

If you have an application for the 6C24, or for other RCA tubes, and would like the assistance of our application engineers, please write, stating your problem. For technical bulletin on the 6C24, send the coupon for complete technical data, curves, drawings, and application hints. Address: Radio Corporation of America, Tube Division, Commercial Engineering Department, Section 62-102E, Harrison, New Jersey.

Keep Buying Bonds

The Fountainhead of Modern Tube Development Is RCA

Send Coupon Now for Free Technical Bulletin

RCA, COMMERCIAL ENGINEERING DEPARTMENT
Section 62-102E, Harrison, N. J.

Please send me free bulletin on the RCA-6C24 triode giving complete technical data, drawings, curves, and application hints.

Name............

Position............

Company............

Address............

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

RCA

Now RCA Offers a Complete Line of Dry Batteries, Too

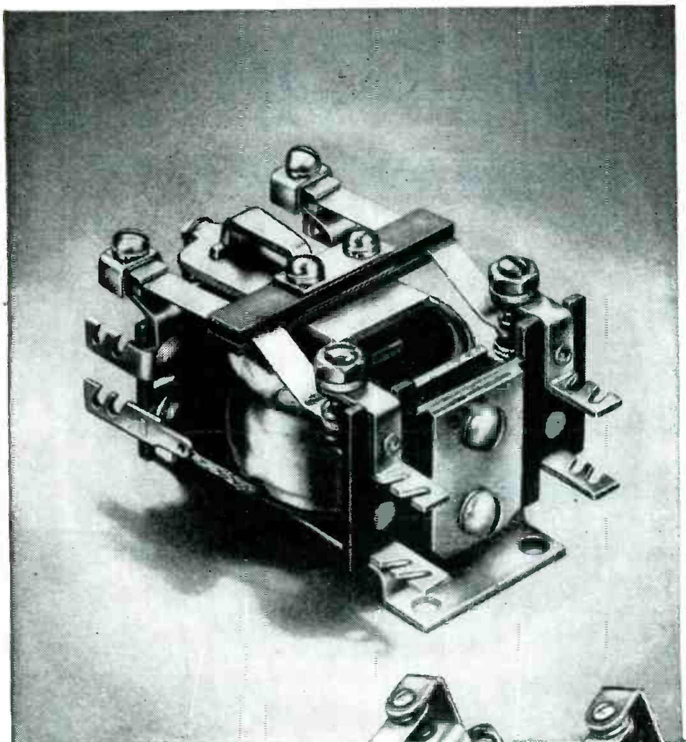
62-6536-102

RADIO CORPORATION OF AMERICA

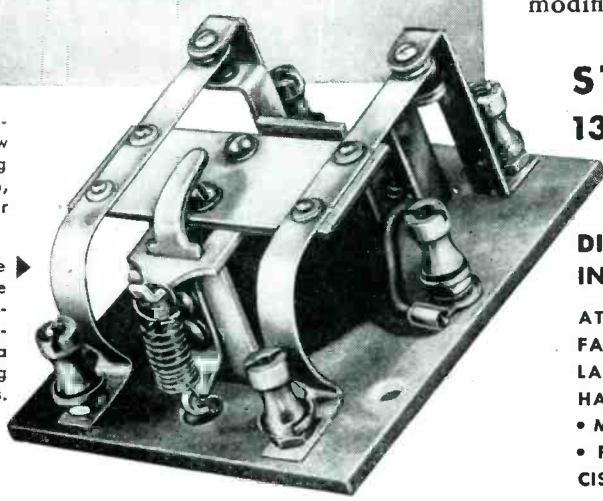
TUBE DIVISION • HARRISON, N. J.

A STANDARD RELAY FOR DOZENS OF SPECIAL APPLICATIONS

. . . requiring a compact light weight unit that handles plenty of power and is highly resistant to shock and vibration



▲ TYPE 10XBX—Two-pole, double-throw contacts, featuring phenolic insulation, metal base, and solder terminals.



Modified 10 Frame construction Type 10XBX117 for R-F application. Features include bonded mica insulation and binding post type terminals. ▶

The design flexibility of Struthers-Dunn 10 Frame a-c and d-c relays coupled with their proven dependability under adverse operating conditions make them ideal for many applications usually requiring more costly special types. 10 Frame Relays are small and light and particularly built to withstand shock and continuous vibration.

Features include: — One- to four-pole, single- and double-throw contact arrangements; insulations suitable for power or radio-frequency circuits; high contact pressures and plenty of "follow-up" for long contact life.

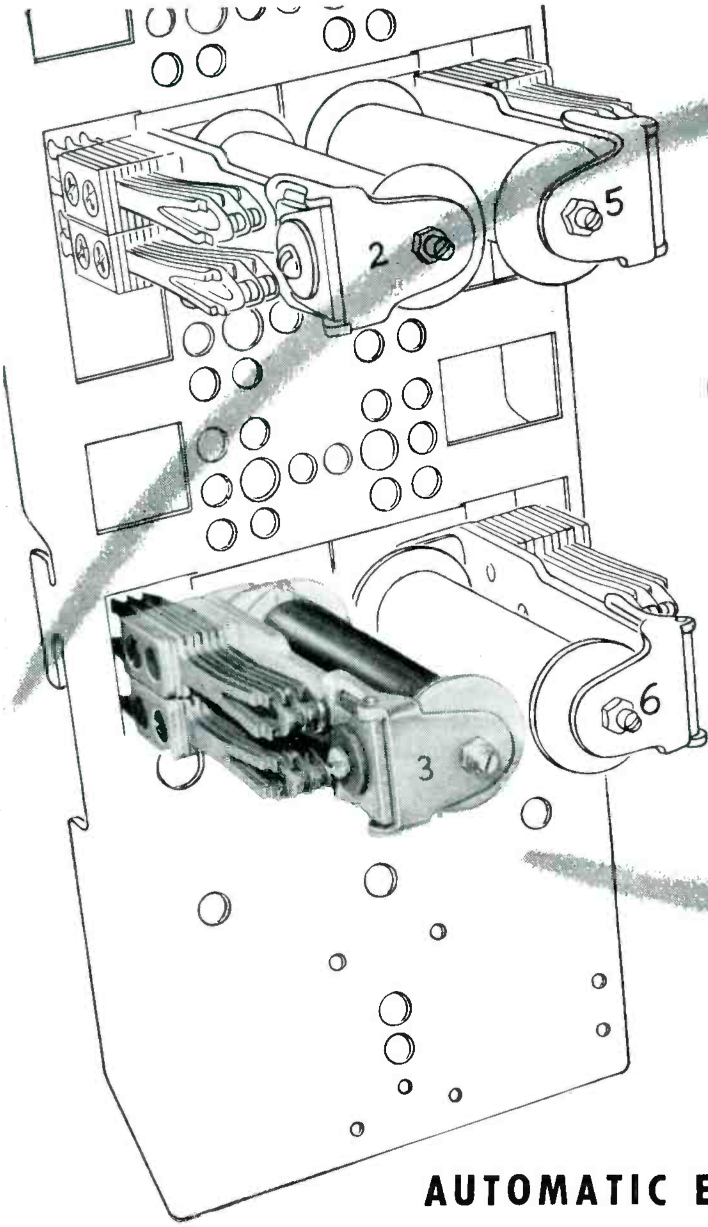
Struthers-Dunn #10 Frame Relays are currently used in many Radar, Radio, and Communications circuits for shipboard, aircraft and general use, including a wide variety of industrial installations requiring extra quality and plus performance. Write for Data Sheet 10-000 describing the 10-Frame Relay Series and outlining a few of the many available modifications.

STRUTHERS-DUNN, Inc.
1321 Arch Street, Phila. 7, Pa.

DISTRICT ENGINEERING OFFICES IN THESE CITIES TO SERVE YOU:

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL • NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

STRUTHERS-DUNN
5,312 RELAY TYPES



More

THAN 300,000,000 OPERATIONS

AUTOMATIC ELECTRIC'S CLASS "B" RELAY

Want real proof of relay ruggedness? Many months ago, several Class "B" relays, taken from regular production, were placed on "life test." Today, with no attention except for occasional lubrication, they are still functioning satisfactorily—and every one has hung up the amazing record of more than 300,000,000 operations! For ruggedness—for all the other features you need, specify Automatic Electric's Class "B" relays.

Independent twin contacts for dependable contact closure ... efficient magnetic circuit for sensitivity and high contact pressure ... unique armature bearing for long wear under severe conditions ... compact design for important savings in space and weight. Now available for coil voltages to 300 volts DC and 230 volts AC, with capacities up to 28 springs; also with magnetic shielding cover, when specified.

The Class "B" relay, and many others, are shown in Catalog 4071. Write today for your copy.

Relays by

AUTOMATIC ELECTRIC

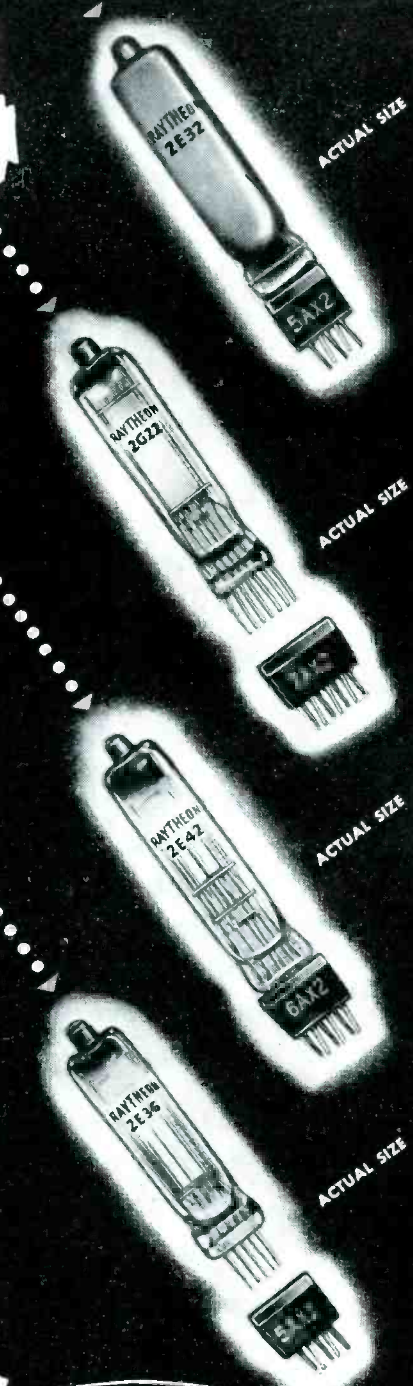
AUTOMATIC ELECTRIC SALES CORPORATION

1033 WEST VAN BUREN STREET • CHICAGO 7, ILLINOIS

In Canada: AUTOMATIC ELECTRIC (CANADA) LIMITED, TORONTO

PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED

NEW RAYTHEON SUB-MINIATURE TUBES for Pocket Receivers



Since 1938 Raytheon has pioneered in the design, development and production of small, low drain, long life tubes. These have helped to make possible the modern extremely compact hearing aid.

Now for Radio Receivers—Now Raytheon announces a physically similar kit of flat style, sub-miniature tubes for radio receiver applications. Included is a shielded RF-pentode amplifier, a triode-heptode converter, a diode-pentode detector-amplifier and an output pentode for earphone operation.

Much Smaller Radios Possible—These tubes make it possible to construct radios a fraction the size of prewar "personals," with sensitivity rivaling much larger sets.

The ratio of performance to battery drain is maintained very high, thus assuring the maximum possible operating life from the small size batteries now available.

The line consists of tubes approximately 1 9/16" long x 0.3" x 0.4" in cross section. Each type is available with pins for use with small commercially available sockets as illustrated, or may be had with long flexible leads for wiring the tube directly into the circuit.

No progressive radio manufacturer will overlook the tremendous possibilities inherent in the small pocket receiver—built around the new Raytheon sub-miniature tubes. But call on Raytheon for *every* tube need—large or small—for the finest in engineering, production and performance.

ELECTRICAL CHARACTERISTICS

	2E31† 2E32# Shielded RF Pentode	2G21† 2G22# Triode-Heptode	2E41† 2E42# Diode-Pentode	2E35† 2E36# Output Pentode
Filament Voltage	1.25 V	1.25 V	1.25 V	1.25 V
Filament Current	50 ma	50 ma	30 ma	30 ma
Max. Grid-Plate Capacitance	0.018 μμf	0.065 μμf‡	0.10 μμf	0.2 μμf
Plate Voltage**	22.5 V	22.5 V	22.5 V	22.5 V
Screen Voltage	22.5 V	22.5 V	22.5 V	22.5 V
Control Grid Voltage*	0	0	0	0
Osc. Plate Voltage	—	22.5 V	—	—
Plate Current	0.35 ma	0.2 ma	0.4 ma	0.27 ma
Screen Current	0.3 ma	0.3 ma	0.15 ma	0.07 ma
Osc. Plate Current	—	1.0 ma	—	—
Transconductance	500 μmhos	60 μmhos (Gc)	400 μmhos	385 μmhos
Plate Resistance	0.35 meg	0.5 meg##	0.25 meg	0.22 meg

*With 5 megohm grid resistance connected to F—.
**Higher voltage operation is possible as shown on engineering characteristics sheet available by request.

†Flexible lead Types.
#Plug-in Types.
##Approximate conversion Rp.
‡Signal grid to mixer plate Capacitance

RAYTHEON
MANUFACTURING COMPANY

Radio Receiving Tube Division

NEWTON, MASSACHUSETTS • LOS ANGELES
NEW YORK • CHICAGO • ATLANTA

EXCELLENCE IN ELECTRONICS

CINAUDAGRAPH

designed over 100 different

PERMANENT MAGNETS

FOR

RADAR

Many manufacturers shared in the development of Radar. Skilled scientists in many a research laboratory contributed to the perfection of this remarkably effective instrument for detecting, locating, and defining objects at a distance through fog or storm, in the night.

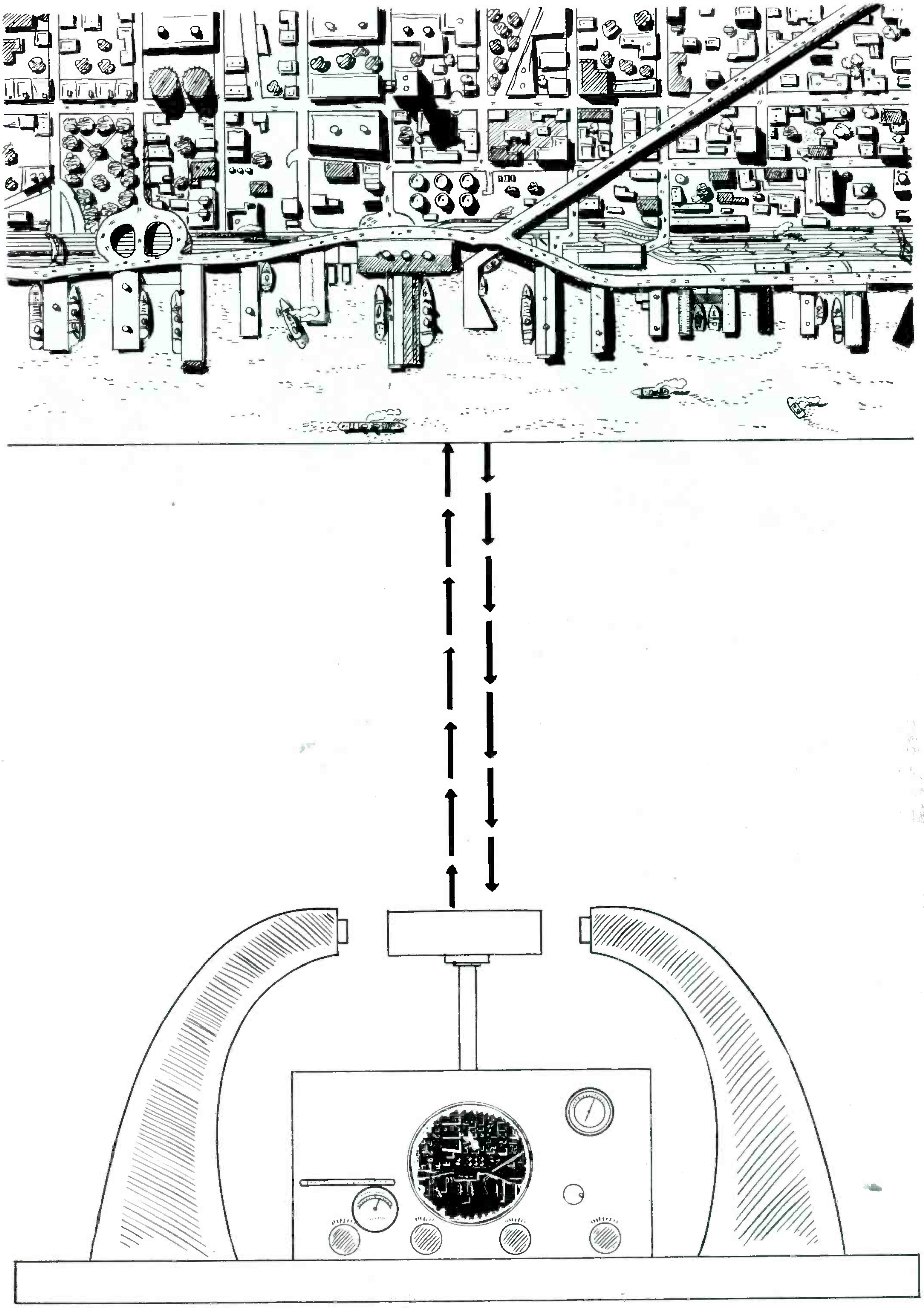
In every modern Radar Set a permanent magnet is an essential element. We, at Cinaudagraph, feel that it was distinctly a tribute to the skill of our engineers and workmen that we were called upon to design and manufacture a large portion of the permanent magnets for all the Radar Sets. Our engineers designed over 100 different types of magnets, and tens of thousands of these were manufactured in our plant.

In the rapidly developing field of electronics, the permanent magnet is bound to play an important part. Our engineering department will be glad to help on magnet problems in connection with any apparatus or instrument you are planning to produce.

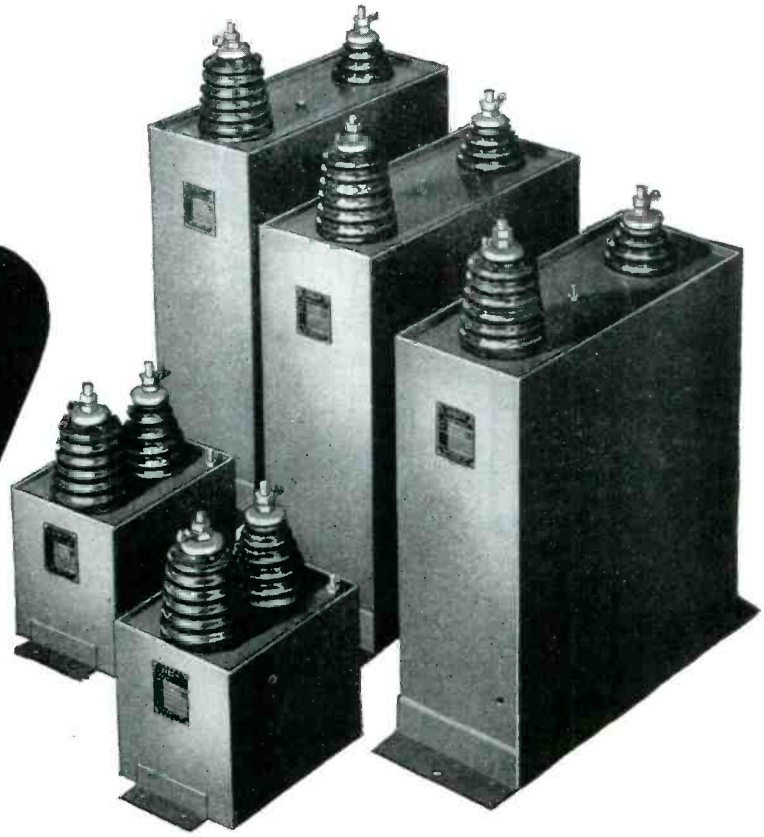
Send for our pamphlet, "Permanent Magnet Design"

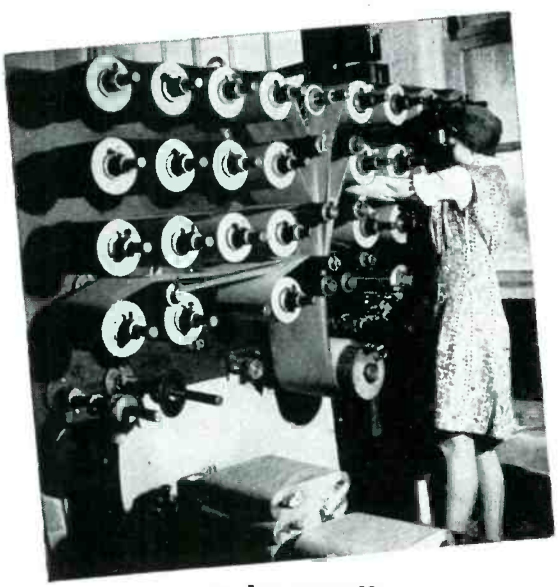
2 SELLECK ST. **CINAUDAGRAPH CORPORATION** STAMFORD, CONN.

12-CC-1



CAPACITOR DREADNAUGHTS





● *Interested?*
Write for detailed literature.

● Outstanding production equipment in the hands of Aerovox craftsmen, accounts for these veritable capacitor dreadnaughts. In exacting services such as radio transmitters, heavy-duty electronic equipment, and in the electric power field, these units have won citation after citation for exceptional ruggedness.

Such ruggedness stems from the Aerovox winding facilities second to none. Special winding machines insure that the multi-layered sections are uniformly and accurately wound under critically-controlled tension. Also, a system of impregnation tanks, pumps and control equipment guarantees the necessary drying after vacuum impregnation that is positively unexcelled by any impregnation process anywhere.

Hermetically-sealed welded steel containers; heavy-duty porcelain insulators; cork gaskets and pressure sealing; nonferrous metal hardware; silver-soldered joints; sturdy mounting means—these are the externals of these capacitor dreadnaughts. Standard listings of Type 20 up to 50,000 v. D.C.W. Capacitances from 0.1 to 10 mfd.

AEROVOX Capacitors

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. · SALES OFFICES IN ALL PRINCIPAL CITIES

Export: 13 E. 40 ST., NEW YORK 16, N. Y. · Cable: 'ARLAB' · In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

CLAIM STAKING

Hallicrafters and Very High Frequency

Based on the facts in the case, Hallicrafters can stake out a very strong claim to leadership in the very high frequency field. The facts include such things as the Model S-37, FM-AM receiver for very high frequency work. The Model S-37 operates from 130 to 210 Mc.—the highest frequency range of any general coverage commercial type receiver.

Hallicrafters further supports its claim to domination in the high frequency field with the Model S-36A, FM-AM-CW receiver. The 36A operates from 27.8 to 143 Mc., covers both old and new FM bands and is the only commercially built receiver covering this range.

Further developments in this direction can soon be revealed—adding further support to Hallicrafters claim to continued supremacy in the high frequency field.

HALLICRAFTERS NEW $600,000 HOME NOW UNDER CONSTRUCTION.

hallicrafters RADIO

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT • CHICAGO 16, U. S. A.


Both are
FERRANTI
from 19¢
THE LOWEST PRICED TRANSFORMER to
$19.00
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Both backed by
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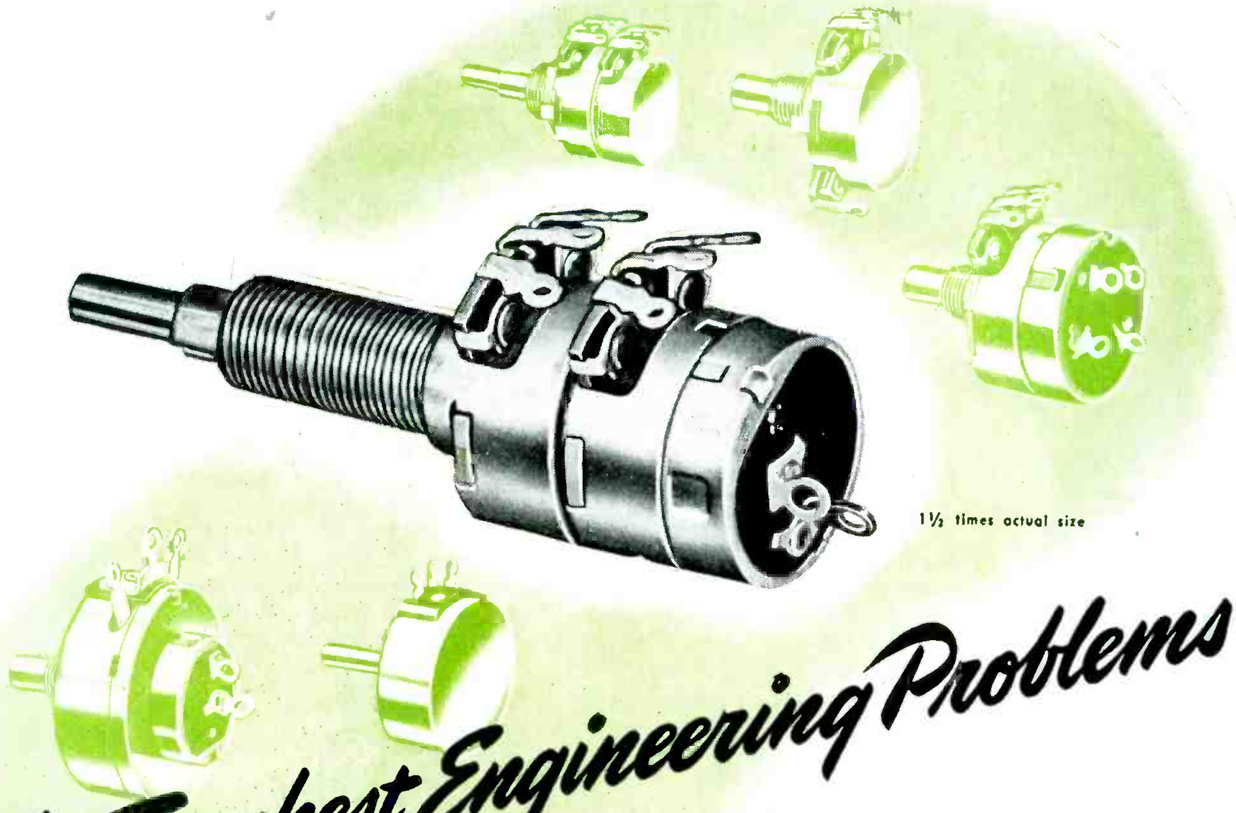

1½ times actual size

The Toughest Engineering Problems

Featured is CTS Type G-C-45-47 concentric shaft tandem tone control, volume control and off-on switch. This resistor was specially designed for use where panel space is limited and the going is rough—as in auto radios, for example. Both volume and tone controls are combined in this resistor and occupy only as much panel space as a single resistor.

This featured G-C-45-47 resistor is just one example of the ability of CTS engineers to solve new problems . . . to provide special adaptations for new requirements.

Electronic engineers all over the world depend on CTS for:

- A resistor engineered for the application.
- Uniform quality throughout the shipment.
- Each resistor carefully tested to assure top performance.
- Delivery when promised.

Call on CTS specialists for aid in solving *your* variable resistor problems.

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Kansas City 2, Missouri
Phone: Logan 7495

Frank A. Emmet Co.
2837 West Pico Boulevard
Los Angeles 6, California
Phone: Rochester 9111

George A. Coleman
420 Market Street
San Francisco 11, Calif.

BRANCH OFFICES

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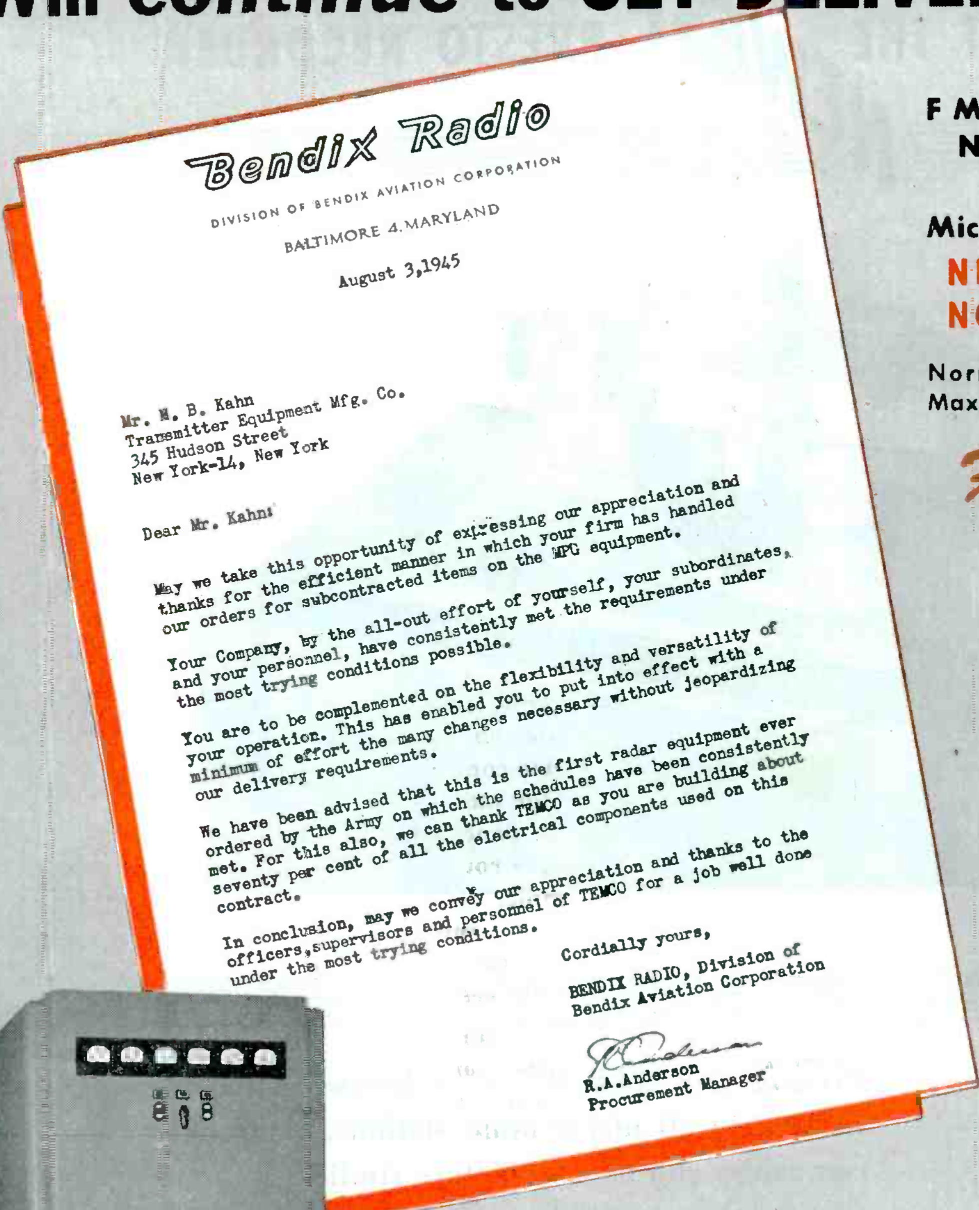
CHICAGO TELEPHONE SUPPLY *Company*

ELKHART ★ INDIANA

VARIABLE RESISTORS AND ASSOCIATED SWITCHES

Manufacturers of Quality Electro-Mechanical Components Since 1896

In F M too—
The Same TEMCO Team
Will continue to SET DELIVERY RECORDS



Bendix Radio

DIVISION OF BENDIX AVIATION CORPORATION

BALTIMORE 4, MARYLAND

August 3,1945

Mr. M. B. Kahn
Transmitter Equipment Mfg. Co.
345 Hudson Street
New York-14, New York

Dear Mr. Kahn:

May we take this opportunity of expressing our appreciation and thanks for the efficient manner in which your firm has handled our orders for subcontracted items on the MPG equipment.

Your Company, by the all-out effort of yourself, your subordinates, and your personnel, have consistently met the requirements under the most trying conditions possible.

You are to be complemented on the flexibility and versatility of your operation. This has enabled you to put into effect with a minimum of effort the many changes necessary without jeopardizing our delivery requirements.

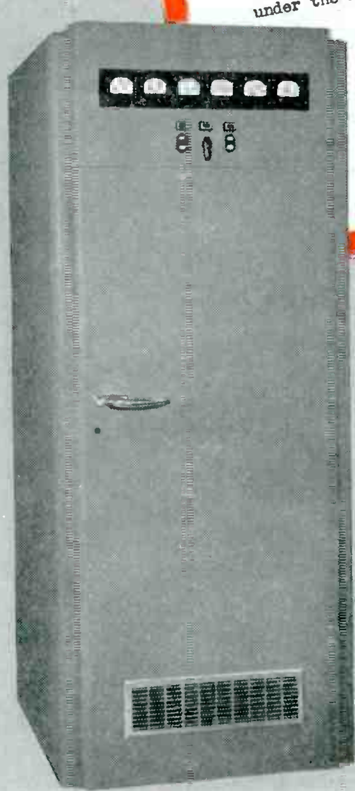
We have been advised that this is the first radar equipment ever ordered by the Army on which the schedules have been consistently met. For this also, we can thank TEMCO as you are building about seventy per cent of all the electrical components used on this contract.

In conclusion, may we convey our appreciation and thanks to the officers, supervisors and personnel of TEMCO for a job well done under the most trying conditions.

Cordially yours,

BENDIX RADIO, Division of
Bendix Aviation Corporation

R.A.Anderson
Procurement Manager



Improved
F M Broadcasting Equipment
NOW Being Produced by
TEMCO'S
Microwave Radar Technicians

NEW MODEL 250 BCF NOW IN PRODUCTION

Normal Rated Output 250 Watts
Maximum Rated Output 375 Watts

Features...

- New miniature high frequency tubes permitting high efficiency and perfect shielding.
- Newly designed amplifier circuit completely eliminating tank radiation, feedback and radio frequency potentials from transmitting frame.
- Built-in center frequency deviation meter calibrated directly in cycles.
- Frequency range of 88-106 megacycles.
- Frequency stability ± 1500 cps or better of assigned center frequency.
- Audio frequency response ± 1½ db 30-16000 cps (after deemphasis).
- Audio distortion 50-16000 cycles less than 2% RMS.
- Noise level FM db below ± 75 Kc swing.
- Noise level AM 70 db below 100% modulation.

Write for complete descriptive data, prices and information for filing with FCC for license application.

TEMCO

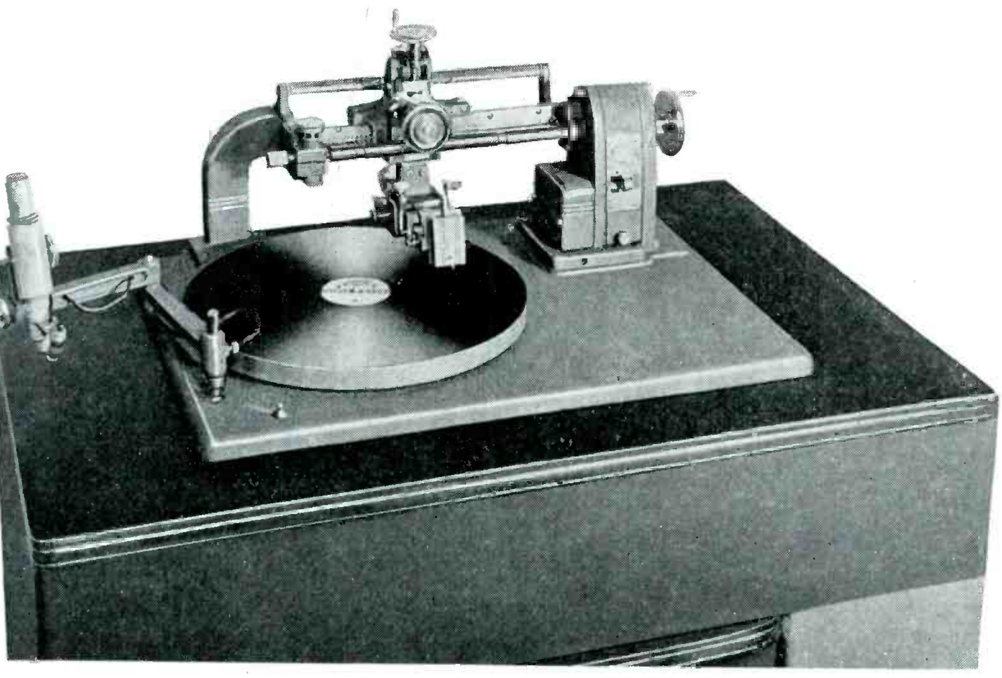
RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.

345 Hudson Street, New York 14, N. Y.

PRESTO-1946

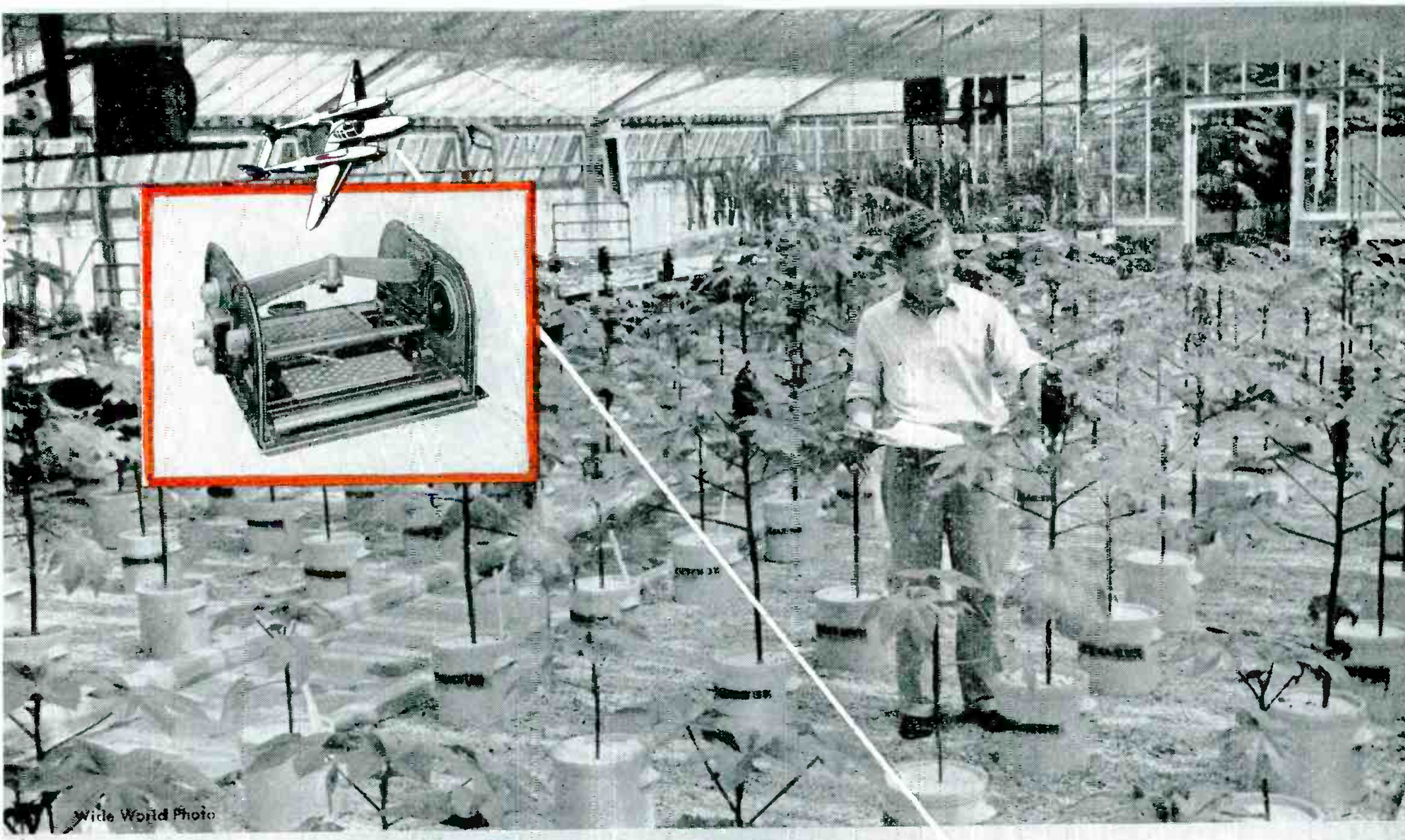
A PREVIEW OF THE *NEWEST* PRESTO RECORDER



Presto's new 14A Recorder herewith makes its bow to all major radio stations, recording companies and motion picture studios. In presenting this model for the first time, Presto offers many new features that are fully described on Page One of Presto's postwar catalog. Send for Page One today.

PRESTO
RECORDING CORPORATION
242 West 55th Street, New York 19, N. Y.
Walter P. Downs, Ltd., in Canada

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS



Wide World Photo

TURN ON THE HEAT

when and where you want it . . .

. . . with NICHROME*

In addition to toasters, electric irons, radiant heaters, stoves, etc., the uses for electrical heating elements have multiplied into an almost endless list of new and novel applications during the war.

From keeping aerial cameras warm in the stratosphere to protecting delicate roots underground, Nichrome heating elements have been impressed into service to deliver dependable heat . . . *wherever and whenever* it is required.

In all of these applications the vital factor of dependability leaves no room for compromise with quality.

For this reason and because Nichrome insures long heater life and close control over wide temperature range, it has been specified for *more new electrical heating applications than any other alloy resistance wire.*

Although there are several excellent Nickel-Chromium combinations there *is only one* NICHROME and it is *made only by* Driver-Harris. For improved performance and longer life in your new products, specify Nichrome and other resistance alloys by Driver-Harris. Tell us what you need.

*Trade Mark Reg. U. S. Pat. Off.

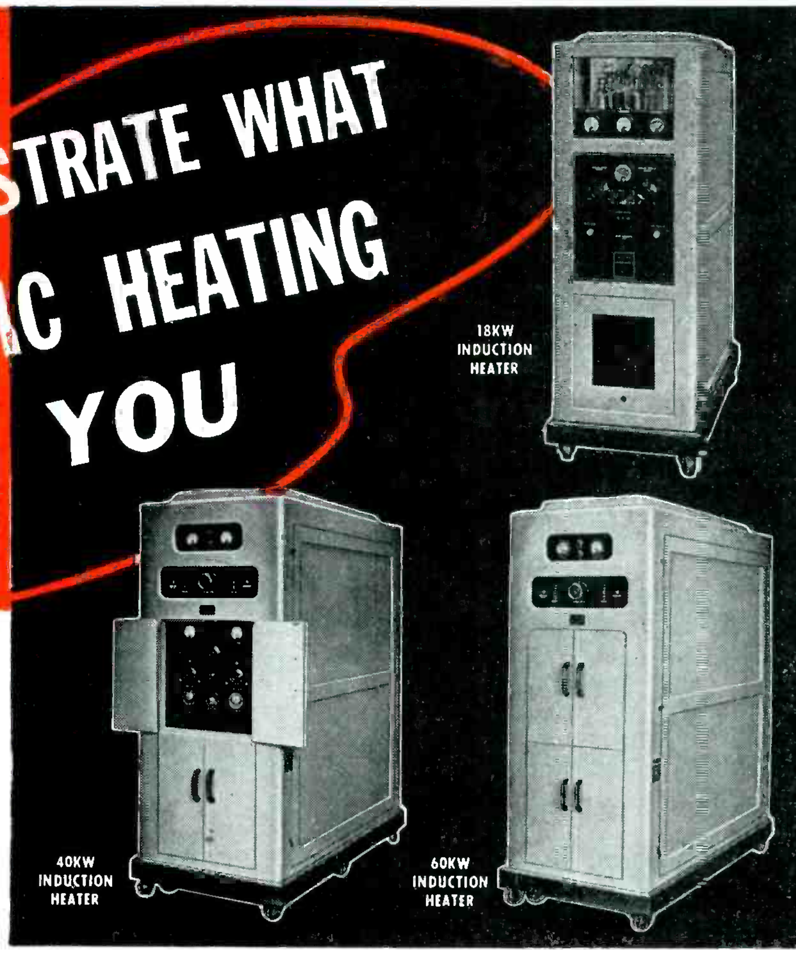
NICHROME
is made *only* by

D H
SPECIAL PURPOSE ALLOYS SINCE 1899

Driver-Harris
COMPANY
HARRISON, N. J.

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle

LET US DEMONSTRATE WHAT ELECTRONIC HEATING can do for YOU



PROOF BY TRIAL . . . that's our motto. Before you invest in electronic heating equipment you should be shown how any process requiring heat can be done *better*, *faster* and *more economically* for you with a Scientific Electric unit.

Our engineers will gladly—*without obligation*—make a study of the heating process under consideration. They will then make recommendations supported by practical demonstrations on the S.E. heater best suited for the job.

This procedure will enable you to figure accurately the economies that will result; also permit you to estimate the time required to pay for the equipment out of resultant savings.

You can submit your heating problems to us with the assurance that absolute secrecy will be observed, if so desired. Investigate the advantages of applying electronic heating in your manufacturing operations NOW. Consult with us at your earliest opportunity.

Write for free copy of
The ABC of Electronic Heating

3 KW DIELECTRIC HEATER
Dielectric Heating Units priced from **$1500.**
(3 KW complete)

5 KW INDUCTION HEATER
Induction Heating Units priced from **$1285.**
(for 5 KW complete with 1 work coil)

Manufacturers of
Vacuum Tube and Spark Gap Converters Since 1921

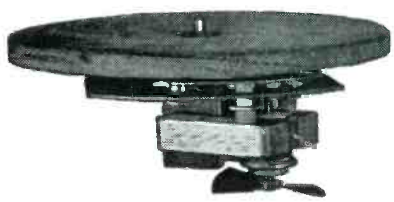
Scientific Electric Electronic Heaters are made in the following range of power; 3—5—7½—8—10—12½—15—18—25—40—60—80—100—250 KW.—and range of frequency up to 300 Megacycles depending on power required.

Scientific Electric

DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. GARFIELD, N. J.

- PRECISION WIRE WOUND RESISTORS
- WHEATSTONE BRIDGES
- RADIO & ELECTRONIC TEST EQUIPMENT
- RADAR ASSEMBLIES



Eastern Electronics Corp.

PHONOGRAPH TURNTABLE UNIT

The need at this time for large quantities of phonograph turntable assemblies has prompted us to quickly design and tool up for the immediate production of this item. Engineers will find this compact turntable meeting all of their requirements for performance. We are prepared to make immediate deliveries and suggest that purchasing agents place their orders at once.

PERFORMANCE: — Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic.

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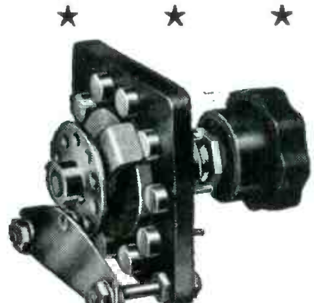


ROTARY SELECTOR SWITCH

Designed for use where low contact resistance and mechanical sturdiness is required. Its construction insures long wear with low contact resistance of less than .001 ohm. May be arranged to have several sections to obtain multi-polar switching.

Well suited for precision test instruments; shunt ammeters, thermo-couple types, Wheatstone Bridges, and similar devices.

Korect-Ohm Precision Wire Wound Resistors

General Specifications

KORECT-OHM Resistors are wound on a sectional Ceramic bobbin, the direction of the winding being alternated on each section so that the resistor is non-inductive. Resistors can also be inductively wound when required.

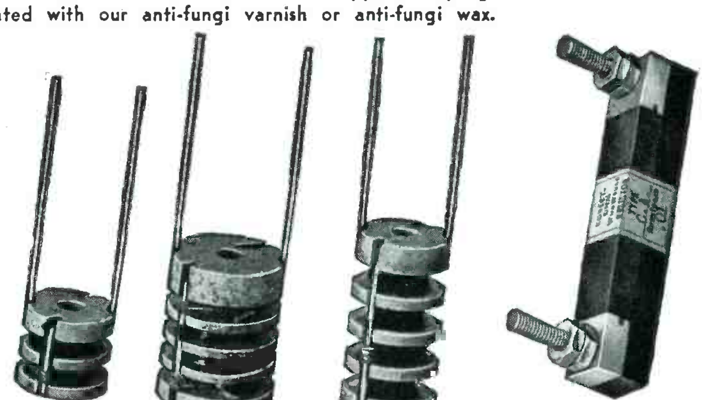
To insure stability Korect-Ohm Resistors are aged and treated to relieve strains due to winding before the final adjustment is made.

Final resistance adjustment to an accuracy of better than .1%.

TEMPERATURE COEFFICIENT. Resistors are wound with selected alloy wire having a resistance change vs. temperature of less than .08% between —55 degree C and plus 55 degree C.

IMPREGNATION. A radically new material, INSO-FLEX, used for impregnating Korect-Ohm resistors has been developed by our engineering laboratory. This new material has several outstanding advantages, being extremely flexible it does not chip nor crack due to expansion or contraction under temperature variations. INSO-FLEX has high insulating qualities and is highly resistant to alkalies and weak acids, is resistant to moisture and mechanical shock. It forms an intimate bond between the ceramic bobbin, winding and lead wires. Being flexible, the lead wires may be bent and formed without disturbing the moisture-proof bond between the lead wires and INSO-FLEX covering.

Korect-Ohm resistors can also be supplied impregnated with our anti-fungi varnish or anti-fungi wax.



Type C Maximum resistance 500,000 ohms.

Type A Maximum resistance 1,000,000 ohms.

Type B Maximum resistance 1,000,000 ohms.

Type XM Instrument resistance shunt .1 ohms or lower. 25 watts.

We will make special resistors to any value or tolerance.

Our Regular Line of Resistors are ready for delivery.

Eastern Electronics Corp.

41 CHESTNUT STREET, NEW HAVEN, CONN.

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ELECTRONICS DESIGNER'S

HERE 3 CAPACITORS DO TWICE THE WORK OF 25

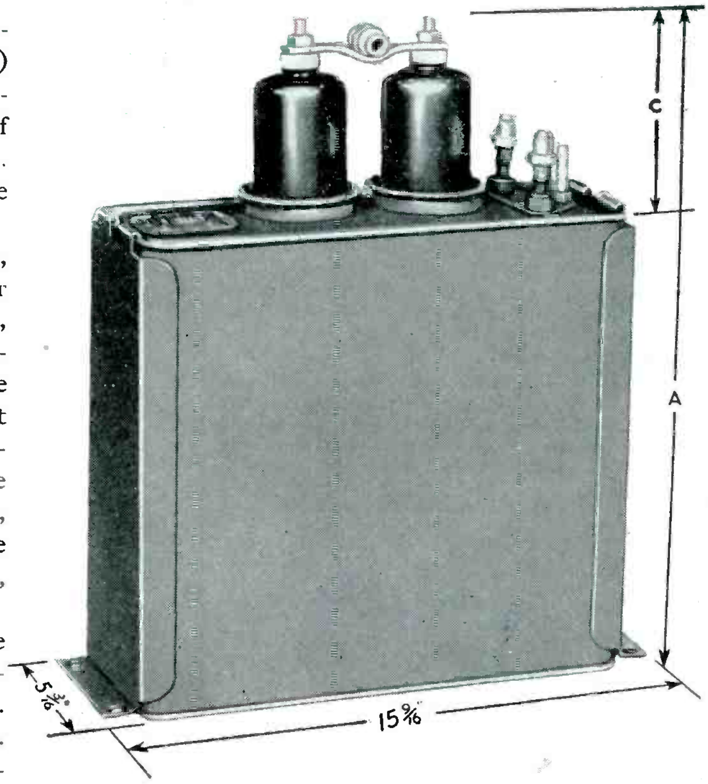
A MANUFACTURER of induction heaters replaced 25 mica capacitors in his resonant (tank) circuit with three General Electric HFP parallel-plate, water-cooled capacitors. He saved nearly half the cost and space, and more than doubled the kva. Result: a more compact, more powerful, and more efficient heater.

Class HFP capacitors, with their two sets of heavy, sheet-aluminum plates, are specifically designed for use in resonant circuits of high-frequency oscillators, such as those employed in electronic heaters. Outstanding features of Class HFP capacitors are compact construction, and ability to operate at high voltages and to carry heavy continuous currents at frequencies from 50 kilocycles up into the megacycles. The special dielectric is a new, stable, synthetic liquid which combines the desirable characteristics of low loss, high dielectric constant, and high dielectric strength.

A coil of copper tubing, for water-cooling the capacitor, is installed inside the case in direct contact with the grounded pair of capacitor plates. Couplings are provided for connection to 3/8-in. copper tubing. The cooling feature permits a compact assembly and high current rating per unit volume.

The cases are of nonmagnetic metal, hermetically sealed, and flexible enough to take care of thermal expansion of the liquid dielectric. Capacitance tolerance is from plus 5 per cent to minus 5 per cent of the rated capacitance at 25 C; Q factor is above 2000 for full load operation at frequencies from 50 kilocycles to one megacycle. Internal inductance is low, which gives resonant frequencies from 3 to 9 megacycles, depending upon the capacitance rating. Write for Bulletin GEA-4365. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

Keep on buying BONDS—and keep all you buy



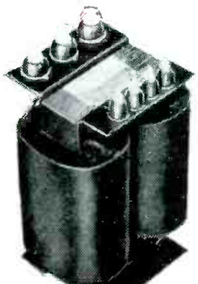
CLASS HFP HIGH-FREQUENCY, PARALLEL-PLATE, WATER-COOLED CAPACITORS

Maximum Permissible Rms Working Voltage	Microfarad Rating	Maximum Permissible Rms Working Current in Amp at 540 Kilocycles	Approximate Dimensions in Inches A	Approximate Dimensions in Inches C
2000	0.025 0.030 0.034	170 204 230	16 7/32	2 1/2
3000	0.0165	168	16 7/32	2 1/2
6000	0.0075 0.01	153 204	18 7/16	4 7/16
6600	0.009	202	18 7/16	4 7/16
9000	0.0029 0.005 0.0056	88 153 171	18 7/16	4 7/16

GENERAL ELECTRIC

DIGEST

Timely Highlights on G-E Components



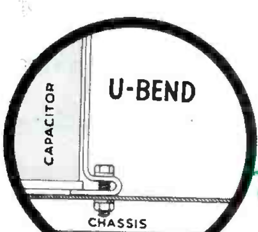
LIGHT-WEIGHT TRANSFORMERS *for tight spots*

When size and weight are important and weather resistance isn't, G-E core-and-coil transformers solve a lot of electronic-design problems. Uniform coils, automatically wound over the finest-grade core laminations, are of the same high quality and give the same reliable performance as G-E cased transformers.

Standard core and coil units include 60 types and ratings of plate transformers, 106 filament transformers, 34 plate-and-filament transformers, and 61 reactors. Ratings up to 50 kva (physical size) are wound on standard laminated cores; larger units can be built from special parts. Write for Bulletin GEA-4280.

Small ONLY IN *Size*

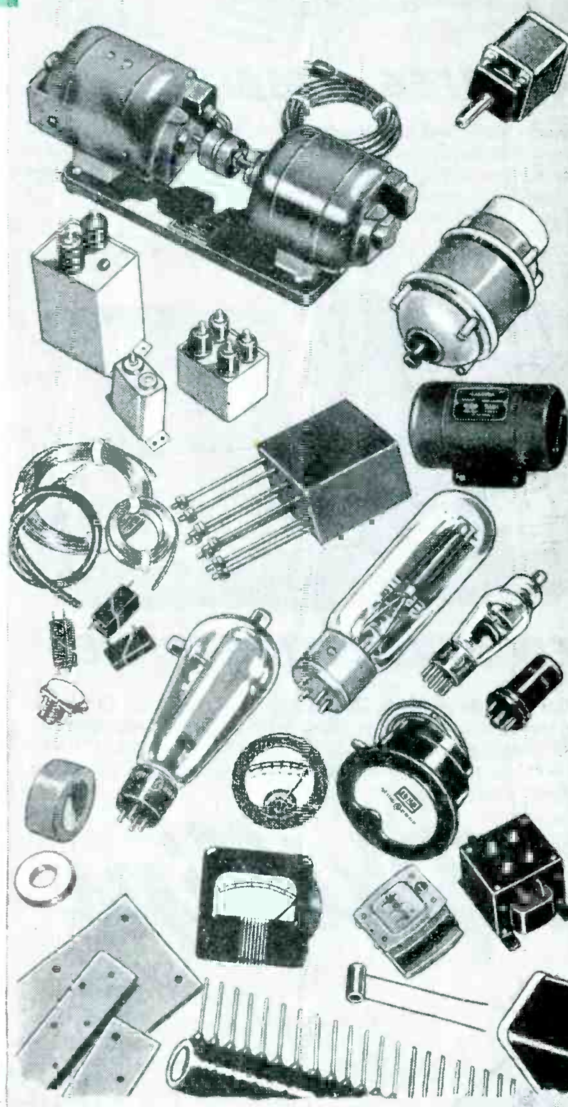
Inside these G-E small panel instruments are packed accuracy and reliability usually associated with larger G-E instruments. They have space-saving internal-pivot construction. They respond quickly. Accurate readings are easily made. The instrument weighs a mere 3 ounces and is just 1½ inches wide and less than 1 inch deep. Either watertight or conventional construction is available for direct-current, audio-frequency and radio frequency applications. Write for Bulletin GEA-4380.



BRACKETS *that hold their own*

A distinct advance in bracket design simplifies the mounting of rectangular-cased G-E capacitors. A U-bend replaces the conventional L-shape and provides a spring-washer effect for secure capacitor mounting. At the same time, it reduces strain on both capacitor and chassis, and compensates for tolerances in capacitor case heights.

For either base or inverted mounting, U-bend brackets are available for most G-E rectangular-case a-c and d-c capacitors. Write for Bulletin GEA-4357.



Capacitors • Sensitive control and time-delay relays • Limit switches • Motors, dynamotors, amplidynes • Motor-generator sets • Alnico magnets • Small panel instruments • Formex* magnet wire • Radio transformers • Switchettes • Selsyns • Chokes • ***also tubes, crystals, plastics products, insulation materials, and many others***

General Electric Company
Apparatus Dept., Sec. 642-10
Schenectady 5, N. Y.

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........GEA-4280
........GEA-4357

NAME ....

COMPANY ....

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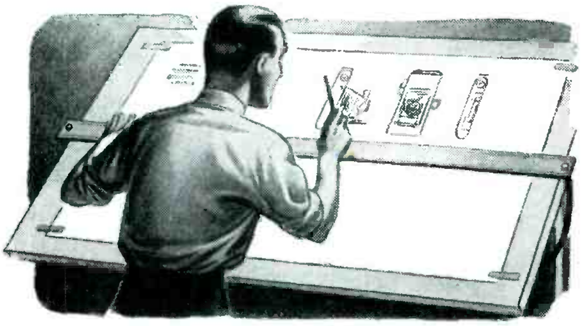
TROUBLES SUBSIDE

It was a slow and troublesome job to drive small slotted screws in fastening a pressed fabric panel on this electrical relay for the P-80 Jet Plane. Frequent driver skids gouged the special fungus-resistant varnish, forced disassembly and junking of marred panels.

OUTPUT HITS STRIDE

Assembly of this part was speeded up 400% when a change was made to Phillips Recessed Head Screws. Fumbling was ended, and a spiral driver could be used, permitting faster driving. Driver skids were eliminated, along with waste of parts and time for disassembly and reassembly.



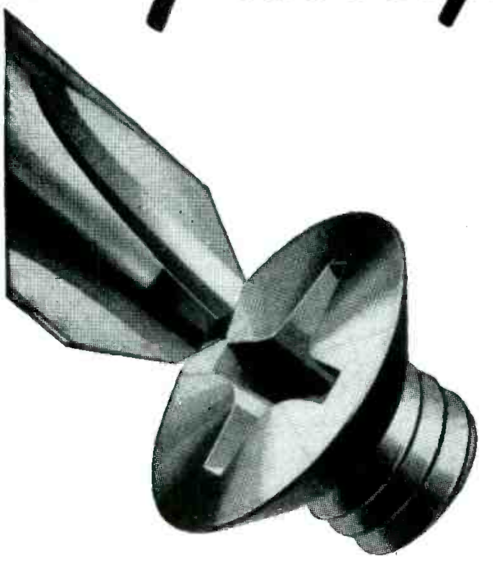
NEW STRENGTH SUPPLIED

Design engineers favor Phillips Screws, because they not only speed output and reduce costs . . . they also permit design improvements that add strength, often with the use of fewer screws. This advantage is especially evident in compact, complicated assemblies.

SHOW IT WITH PRIDE

Wherever screw heads are exposed, the Phillips Recess adds a sales advantage. No unsightly burrs to snag clothing or nick fingers – and sidetrack sales! Its ornamental design blends with modern contours – and it needs only a quarter turn to line up – looks well in any position.

It's Phillips ... the engineered recess!



In the Phillips Recess, mechanical principles are so correctly applied that every angle, plane, and dimension contributes fully to screw-driving efficiency.

... It's the exact pitch of the angles that eliminates driver skids.

... It's the engineered design of the 16 planes that makes it easy to apply full turning power – without reaming.

... It's the "just-right" depth of recess that enables Phillips Screw Heads to take heaviest driving pressures.

With such precise engineering, is it any wonder that Phillips Screws speed driving as much as 50% – cut costs correspondingly?

To give workers a chance to do their best, give them faster, easier-driving Phillips Recessed Head Screws. Plan Phillips Screws into your product now.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

Made in all sizes, types and head styles

25 SOURCES

American Screw Co., Providence, R. I.
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Pawtucket Screw Co., Pawtucket, R. I.
'heoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
The Steel Company of Canada Ltd., Hamilton, Canada
Wolverine Bolt Co., Detroit, Mich.

ELECTRICAL IMC INSULATION

Dieflex Varnished Tubing Products are made of closely braided sleevings completely impregnated and treated with special insulating varnishes. A smooth inside bore to prevent snagging, uniformity of size, complete roundness, maximum flexibility, and excellent ageing qualities are found in all Dieflex products. They do not fray or pinch when cut.

Cotton or Fiberglas Base Tubings and Sleevings—Dieflex Varnished Tubing Products are made both with cotton base or glass base braided sleevings in all standard grades and sizes.

Dieflex Varnished Tubing Products—both cotton and Fiberglas base—are made to meet and surpass the V.T.A. and A.S.T.M. standards. Grade A-1 Magneto quality, Grade B-1 Radio quality varnished tubings, and Grades C-1 Extra Heavily Coated, C-2 Heavily Coated, and C-3 Lightly Coated Saturated Sleevings are "tops in quality."

Silicone Treated Fiberglas Tubings and Sleevings are also now available. These are made by impregnating and treating Fiberglas Sleevings with the latest Dow Corning high temperature resins.

★CHICAGO 6
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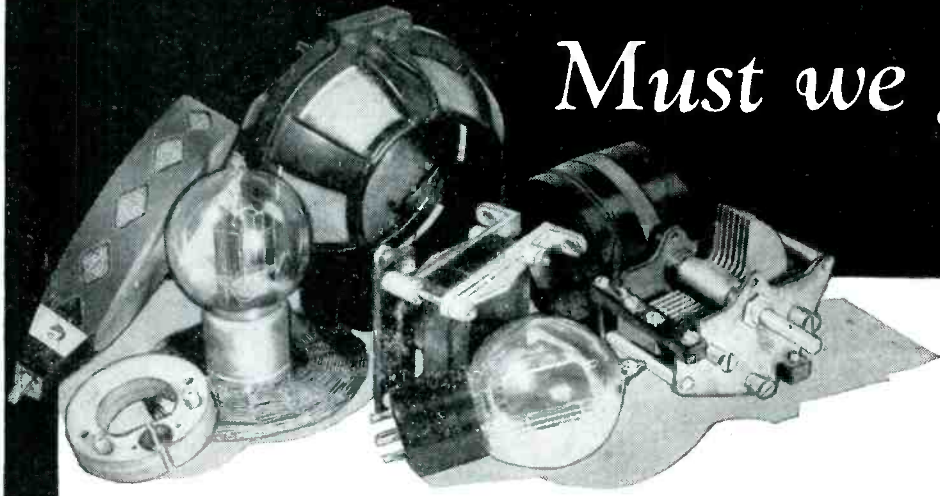
MANUFACTURERS CORPORATION

Representatives in:
MILWAUKEE 2: 312 East Wisconsin Avenue
DETROIT 2: 11341 Woodward Avenue
MINNEAPOLIS 3: 1208 Harmon Place
PEORIA 5: 101 Heinz Court

OTHER IMC PRODUCTS—Vartex Varnished Cloth and Tapes—Varslot Combination Slot Insulation—Varnished Silk and Paper—Fiberglas Electrical Insulation—Manning Insulating Papers and Pressboards—Dow Corning Silicones—Pedigree Varnishes—Hard Vulcanized Fibre and Fishpaper—Laminated Bakelite—Adhesive Tapes—Asbestos Woven Tapes and Sleevings—Cotton Tapes, Webbings, Sleevings, Wood Wedges, and other insulating materials.

Must we go back?



The evolution of electronics will always remain a bright page in the history books of science. And the record has been significantly brilliant during the past four years when improvements and developments were advanced at a faster rate than normal. With the ending of the war, there may be a few who do not feel the urgency to progress at a similar pace . . . who will be willing to relax the rigid wartime standards. Or there may be those who do not too accurately gauge the temper of the consumer, now in a mood to anticipate only the best from an industry which has accomplished such miracles in the past few years.

Along with many other far-sighted producers, we here at Marion fully intend to maintain our wartime quality pattern, and to cooperate in every known way to provide even better products for a peaceful world. We endorse the postwar standardization program of the Army and Navy Electronics Standards Agency, and will continue to manufacture all Marion electrical indicating instruments in conformity with JAN specifications. Our customers have a right to expect nothing else.

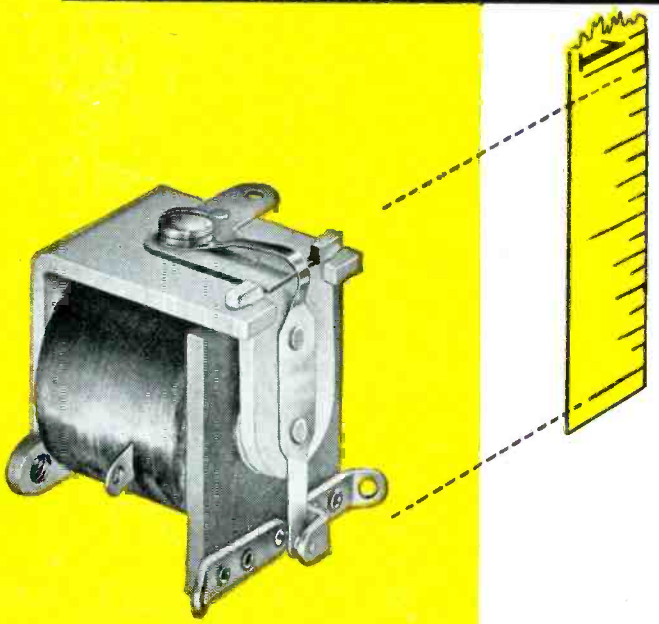
It is important to note that continued adherence to the Electronics Standards Agency program need not result in increased costs, either to the manufacturer or the consumer . . . while it will definitely result in improved product performance wherever such standardized components are used.

We, the manufacturers, engineers, consumers of electronics, are part of a vital, daring, visionary industry. It is with this realization that we are faced with the responsibility of deciding, at this time, whether we can relax, or whether we shouldn't give as much to a world at peace as we gave to a world at war.

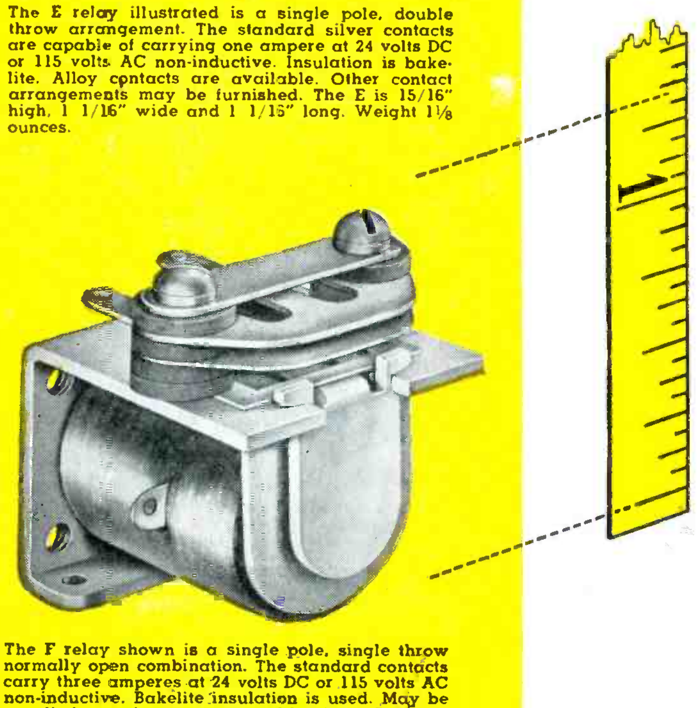
Your comments will be welcomed.

MARION ELECTRICAL INSTRUMENT CO.
MANCHESTER, NEW HAMPSHIRE
EXPORT DIVISION 458 BROADWAY · NEW YORK 13, N. Y., U. S. A.
CABLE ADDRESS: MORHANEX

COMPACT CONTROLS
with Allied's "E" and "F" Relays



The E relay illustrated is a single pole, double throw arrangement. The standard silver contacts are capable of carrying one ampere at 24 volts DC or 115 volts AC non-inductive. Insulation is bakelite. Alloy contacts are available. Other contact arrangements may be furnished. The E is 15/16" high, 1 1/16" wide and 1 1/16" long. Weight 1⅛ ounces.



The F relay shown is a single pole, single throw normally open combination. The standard contacts carry three amperes at 24 volts DC or 115 volts AC non-inductive. Bakelite insulation is used. May be supplied on other contact combinations. Silver is standard contact material, alloy contacts can be substituted. The F is 1 11/32" high, 1 3/16" wide and 1 3/32" long. Weight is 1⅞ ounces.

DESIGNED for electronic controls in which space limitation is a critical factor, the E relay is small enough to fit into an area of approximately one cubic inch. Light too, it weighs about one ounce. The F relay, although available in two pole, double throw, is only slightly larger and weighs less than two ounces.

Used in your electronic assembly these relays will save you space and weight. Moreover you will be assured of positive and quiet operation, for into these relays go the same careful design and manufacturing precision found in Allied's larger relays.

Whatever your relay applications, check with Allied. In addition to sensitive, telephone, power, differential and other types of relays Allied manufactures solenoids and electro-magnetic devices. A number of strategically located plants are available to supply your immediate requirements. Allied's quality standard is in keeping with your post war products . . . write today for more information.

ALLIED CONTROL COMPANY, INC.

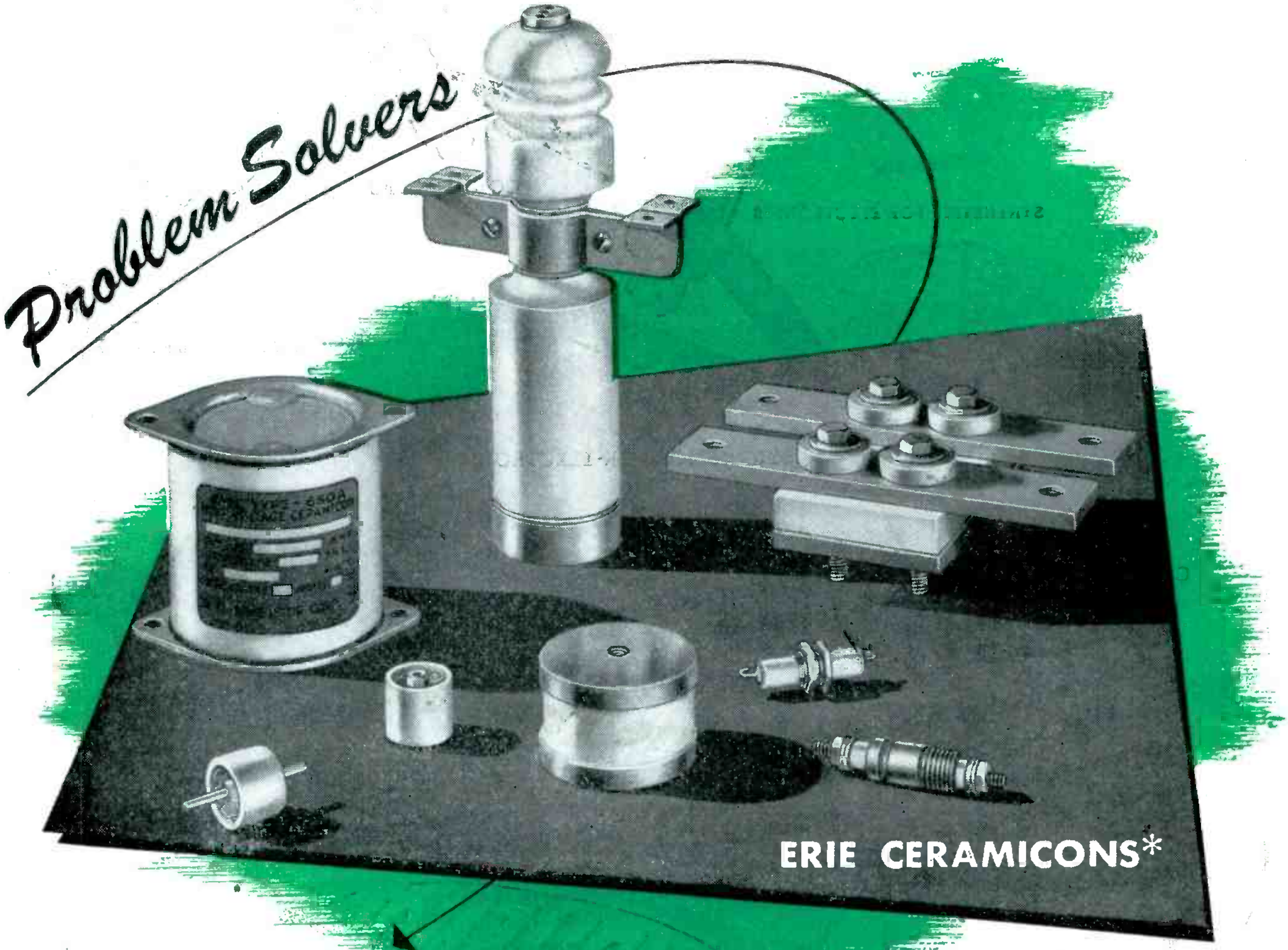
GENERAL OFFICES: 2 East End Ave. (of 79th St.) New York 21, N. Y. *Factories:* New York City (2 East End Ave.)—Plantsville, Conn. *Chicago*—4321 N. Knox Avenue, Chicago 41, Illinois. *In California:* Allied Control Co. of California, Inc. 1633 South Hope St., Los Angeles 15, Calif.

Centralab
METALLIZED STEATITE
COIL forms, spacer rods, strain insulators and rotor shafts of steatite can now be bonded in an inseparable union with brass, stainless steel, silver, copper and other metals. These shafts of steatite and metal are indicated wherever high frequency insulating material is specified. Both electrically and mechanically they fullfil the most exacting requirements. . . . Centralab is now equipped to supply metallized Steatite in practically any form.
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee
PRODUCERS OF: Variable Resistors • Selector Switches • Ceramic Capacitors, Fixed and Variable • Steatite Insulators and Button-type Silver Mica Capacitors.

With a proven background of honorable service on far-flung battlefronts around the world, Amphenol components — greatly improved by wartime experience and augmented in number, style and type — are now available to normal markets. Simplifying both buying and selling, this wider selection of high quality, tested items can be procured from one manufacturer. To know these popular Amphenol products better — write today for the new Condensed Catalog No. 72.

AMERICAN PHENOLIC CORPORATION
CHICAGO 50, ILLINOIS
In Canada • Amphenol Limited • Toronto

U.H.F. Cables and Connectors • Conduit • Cable Assemblies • Connectors (A-N, U.H.F., British) • Radio Parts • Plastics for Industry



For Electronic Heating and Television Capacitor Applications

WITH the growing importance of electronic heating and television, design engineers can find the solution to many of their capacitor problems in Erie Ceramicons.

These silvered-ceramic condensers offer advantages because of their low inductance at high frequencies and extremely simple construction that eliminates circulating currents tending to reduce power ratings. Design is further simplified by the fact that where required, corona shields are incorporated directly into the ceramic dielectrics.

Erie Resistor has developed a number of High Voltage and High KVA Ceramicons of special design and several standard styles are now in production. Included in the above group is a specially designed 30,000 volt feed-thru Ceramicon; a dual filament by-pass unit having conductors to carry 325 amps. The standard Erie Resistor High Voltage ceramic condensers shown include two styles of double cup Ceramicons; a new double cup unit for television power supply filtering, rated at 500 MMF and 10,000 volts D. C.; two High Voltage feed-thru Ceramicons; and a High KVA, High Voltage, multiple plate condenser comparable in size to mica type CM75 but particularly adapted to use at very high frequencies.

Write for data sheets on standard Erie Ceramicons for television and electronic heating applications. You are invited to make use of our extensive knowledge and background for the development of special Ceramicons for these applications.

*CERAMICON IS THE REGISTERED TRADE NAME OF SILVERED CERAMIC CONDENSERS MADE BY ERIE RESISTOR CORPORATION.

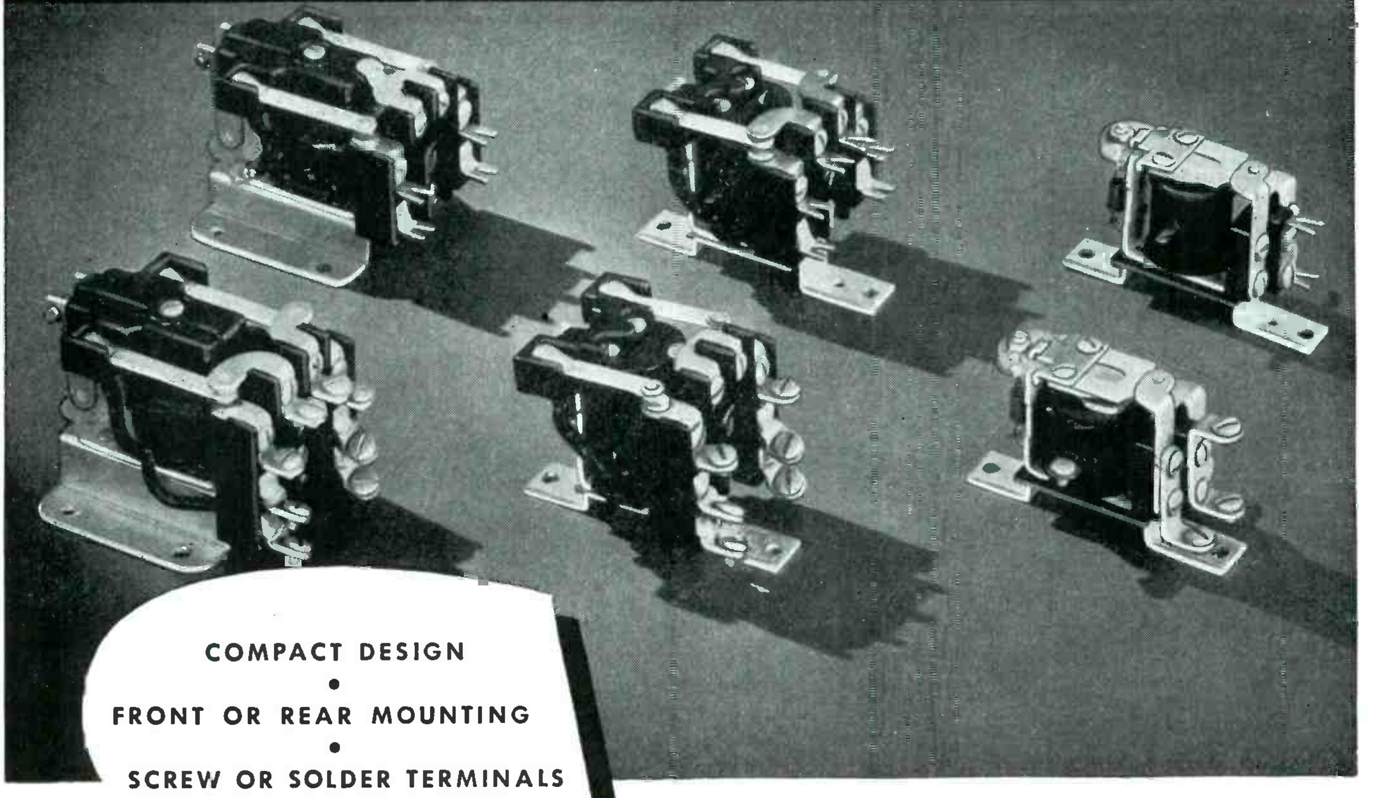
★ BUY VICTORY BONDS ★

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND TORONTO, CANADA.

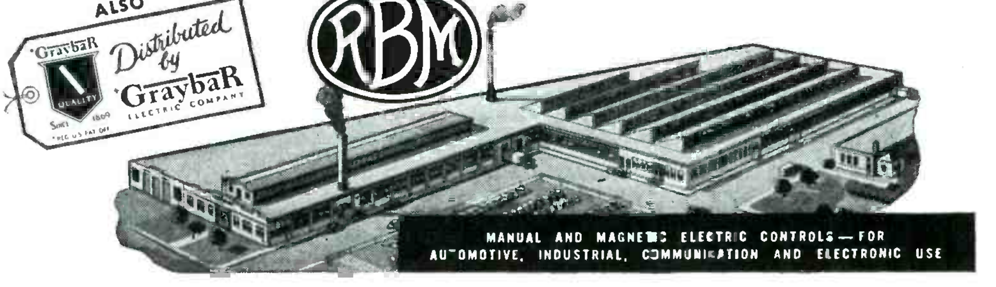
An *Outstanding New Line* of A·C and D·C RELAYS



COMPACT DESIGN
•
FRONT OR REAR MOUNTING
•
SCREW OR SOLDER TERMINALS

● R-B-M announces a new and improved design of magnetic relays rated 10 amperes at 24 volts D. C. and 110 volts A. C. and 5 amperes at 220 A. C. Relays rated at one horse power single phase 110 and 220 volts A. C. Silver to silver contacts. Self-aligning armature. All wiring terminals accessible from front. Contact arrangement—single and double pole; normally open, normally closed and double throw. Steel mounting with A. C. and D. C. relay mounting dimensions interchangeable. Available in open type or with sheet steel general purpose enclosure. Bulletin 510 on D. C. relays and Bulletin 560 on A. C. relays available upon request. Write Department A-12 . . .

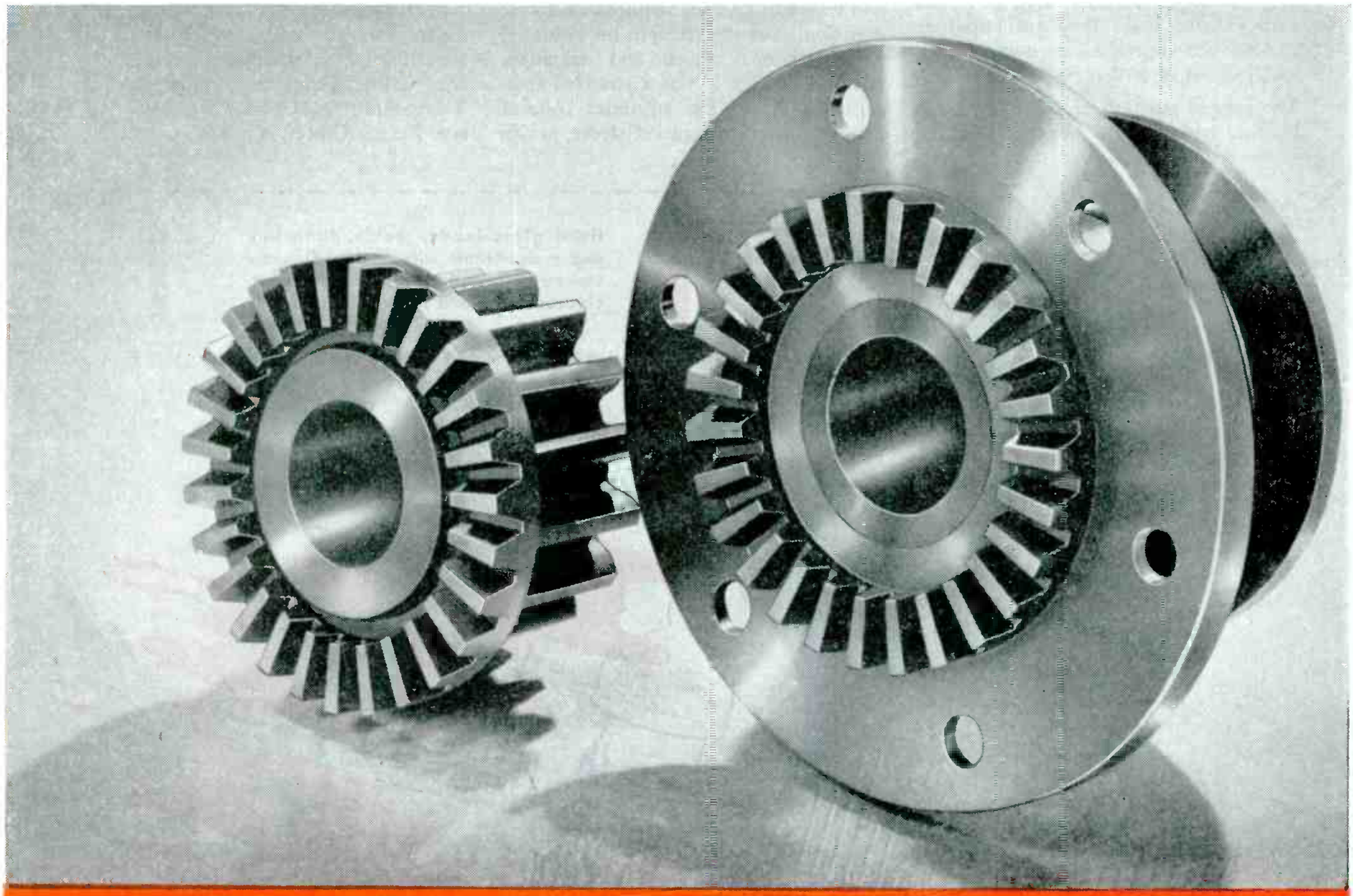
R-B-M MANUFACTURING COMPANY
Division of
ESSEX WIRE CORPORATION
LOGANSPORT, INDIANA



Take Action

SPECIFY G-S SMALL GEARS

Gears are no better than the skill of the organization which produces them. No branch of the component part field is so dependent upon craftsmen. Wise buyers of gears know this fact and buy not a gear but the product of an organization which they know to be qualified to produce superior work. That's the reason why *G-S* is the world's largest exclusive manufacturer of small gears. This experience is not merely a statistic but is tangibly expressed in the ability of our organization to put the utmost quality in every job. *G-S* Small Gears offer economy, longer life, trouble-free operation, smooth performance, unfailing dependability. Let us discuss *your* Small Gear problems with you, *now!*



FRACTIONAL HORSEPOWER 12 TO 96 D.P.

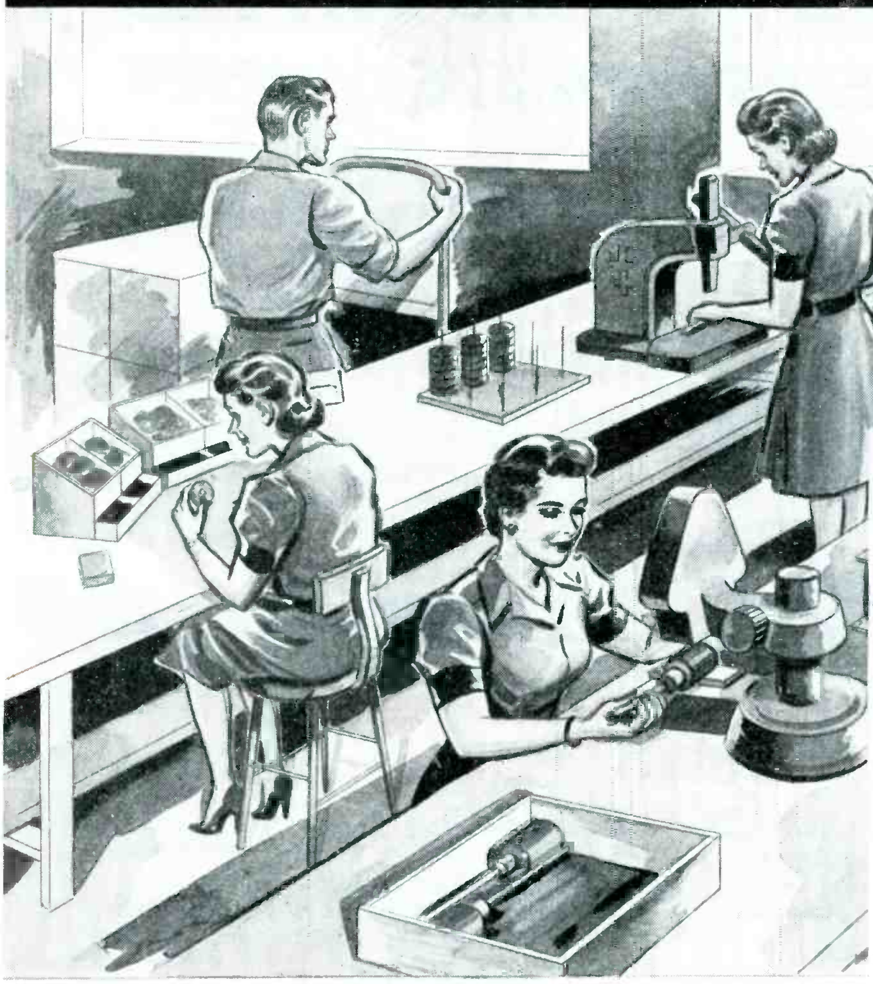
GEAR Specialties

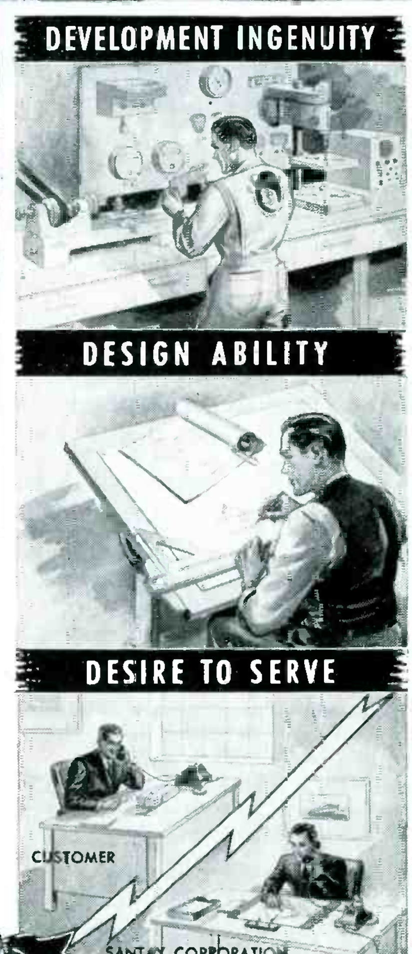
Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

SELECTOR MECHANISMS





MANUFACTURING FACILITIES

Santay has the manufacturing facilities to produce *Selector Mechanisms* for you.

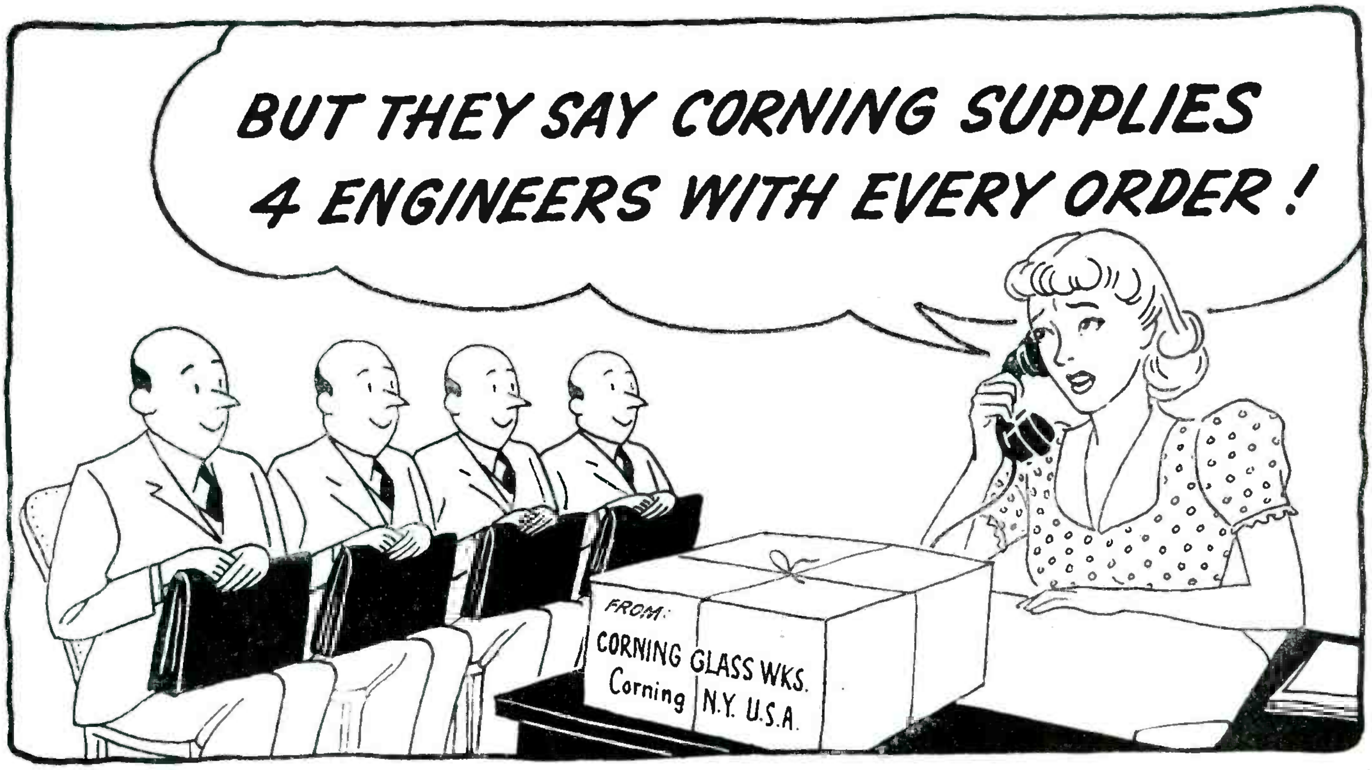
In addition to the necessary machines needed to perform assembly operations, Santay has (1) the engineers to design and the tool makers to build the special jigs and fixtures, so often needed, and (2) the production engineers and methods to assure accurate work and prompt delivery.

When you are considering a Selector Mechanism, of your own design or a combination of your design and ours, consult Santay.

INJECTION MOLDING AND METAL STAMPING • ELECTRO-MECHANICAL ASSEMBLIES

SANTAY CORPORATION, 353 NORTH CRAWFORD AVE., CHICAGO 24, ILLINOIS

REPRESENTATIVES: *POTTER & DUGAN, INC., 29 WILKESON STREET, BUFFALO 2, NEW YORK • PAUL SEILER, 7779 CORTLAND AVENUE, DETROIT 4, MICHIGAN • OUTISSER BROS., 110 E. NINTH STREET, INDIANAPOLIS 2, INDIANA*



HOW 4 SPECIAL CORNING SERVICES CAN SAVE YOU LOTS OF GRIEF!

IT'S quite a job getting a new electronic product into production. Materials, methods and prices buzz around your head like a bunch of bees. But you don't have to solve your problems all alone. For Corning has four special engineering services to help you:

1. Sales Engineers—To keep you in touch with latest developments and explain your problems to Corning's technical experts for prompt solution.

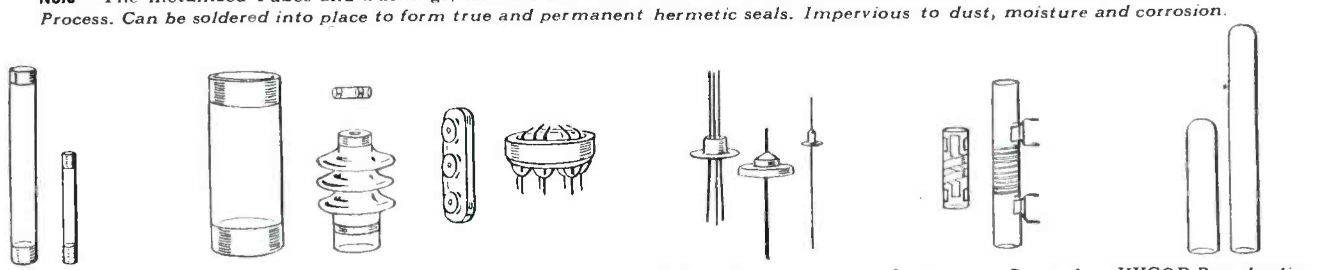
2. Product Engineers—Technical men who translate Corning Research in Glass into practical applications which may solve your particular headaches.

3. Plant Engineers—These men are anxious to see you get the best possible price on your order. They often point out changes in design which reduce costs.

4. Technical Service Engineers — These men get you started right. They help your people lick the production bugs.

Of course, Corning Electronic Glassware also means thousands of glass formulae so you can get the right one for your job. It means Corning's unique metallizing process forming a permanent bond between glass and metal. Tubes, bushings, headers, etc., can be soldered in place to form permanent hermetic seals. It means an entire plant at Bradford, Pa., devoted exclusively to the manufacture of electronic specialties quickly, in large quantities. To get the fastest service in solving your pet problem, write, wire or phone Electronic Sales Department, E-12, Technical Products Division, Corning Glass Works, Corning, New York.

Note *— The metallized Tubes and Bushings, Headers and Coil Forms below are all made by the famous Corning Metallizing Process. Can be soldered into place to form true and permanent hermetic seals. Impervious to dust, moisture and corrosion.*



Metallized Tubes for resistors, capacitors, etc. 20 standard sizes ½" x 2" to 1¼" x 10". Mass-produced for immediate shipment.

Metallized Bushings. Tubes in 10 standard sizes, 5/16" x 23/32" to 1" x 4 7/32" in mass production for immediate shipment.

Headers—The best way to get a large number of leads in a small space for assembly in one operation.

Eyelet Terminals—Single or multiple eyelets permit design flexibility. Standard items readily available in quantity.

Coil Forms—Grooved for ordinary frequencies—metallized for high frequencies. In various designs and mountings.

VYCOR Brand cylinders—very low loss characteristics. Stands thermal shock up to 900°C. Can be metallized.

CORNING means Research in Glass

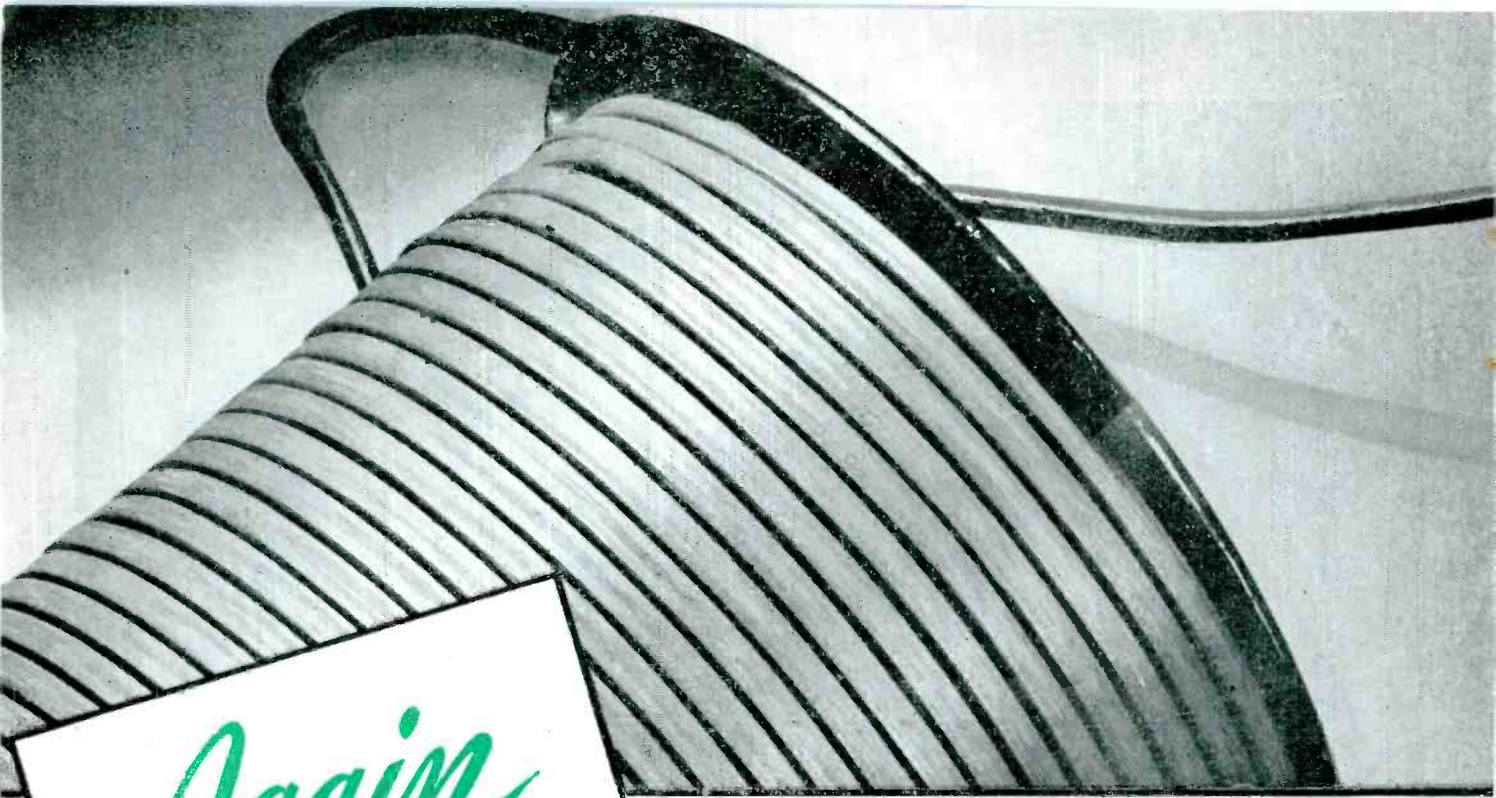
Electronic Glassware

VYCOR TRADE MARK REG. U.S. PAT. OFF. — T.M.REG. CORNING U.S. PAT. OFF. — T.M.REG. PYREX U.S. PAT. OFF.

"PYREX", "VYCOR" and "CORNING" are registered trade-marks and indicate manufacture by Corning Glass Works, Corning, N. Y.

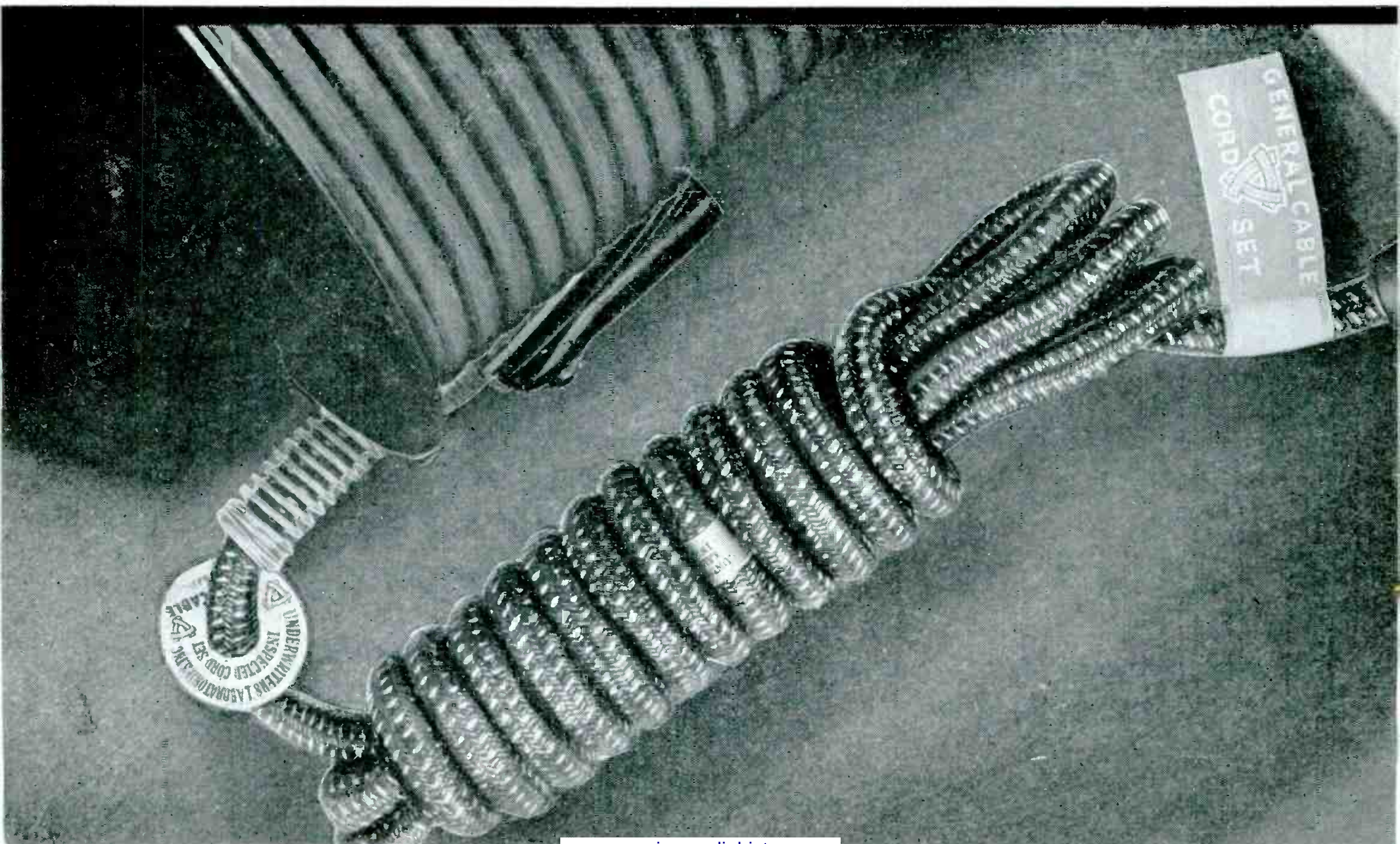
JENSEN RADIO MANUFACTURING COMPANY • 6607 SOUTH LARAMIE AVENUE, CHICAGO 38, ILLINOIS

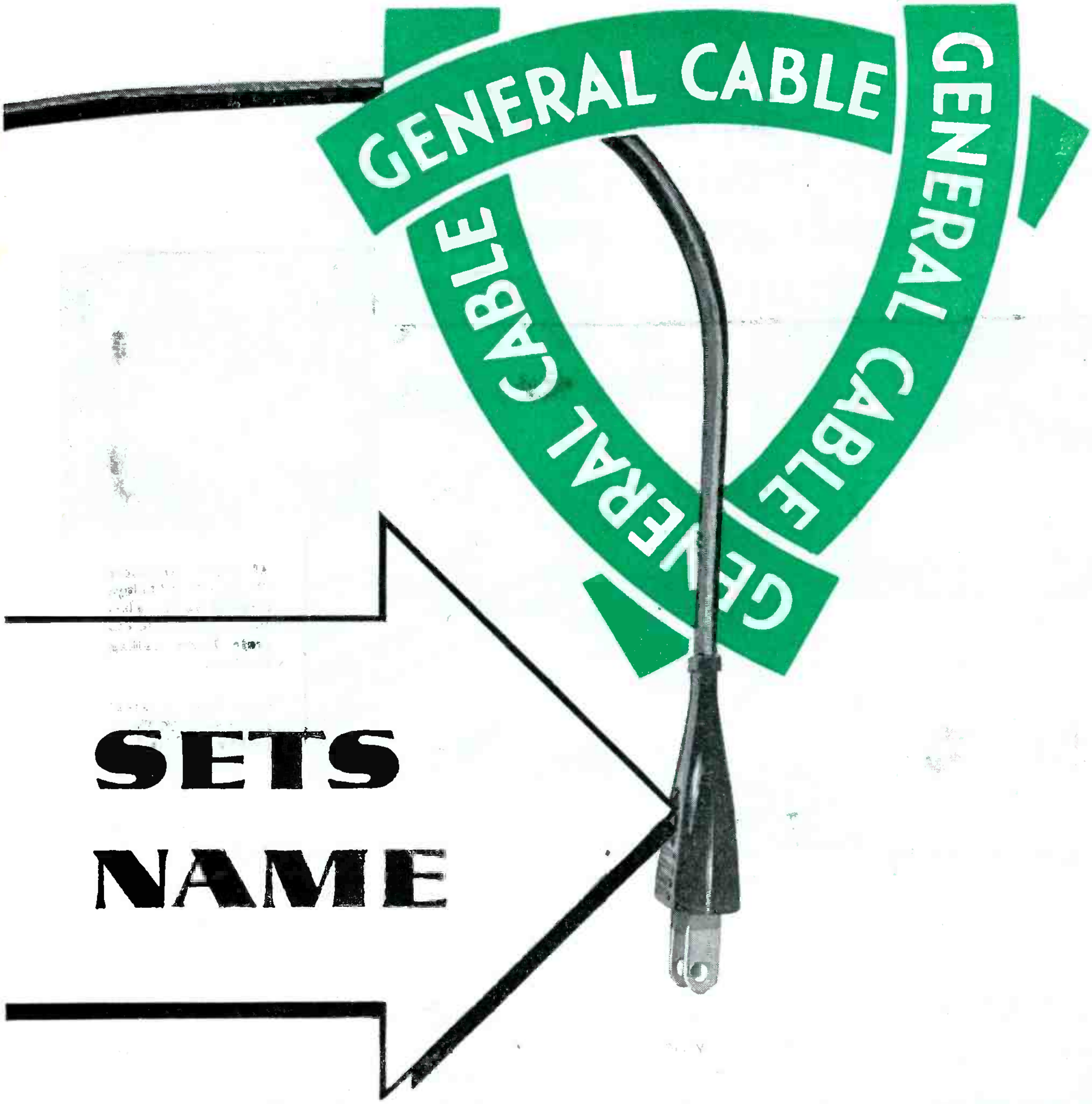
IN CANADA—COPPER WIRE PRODUCTS, LTD., 137 RONCESVALLES AVENUE, TORONTO



Again

CORDS AND CORD WITH THIS FAMOUS





This distinguished trade mark in the electrical wire and cable industry is once again the hallmark of quality on Cords and Cord Sets.

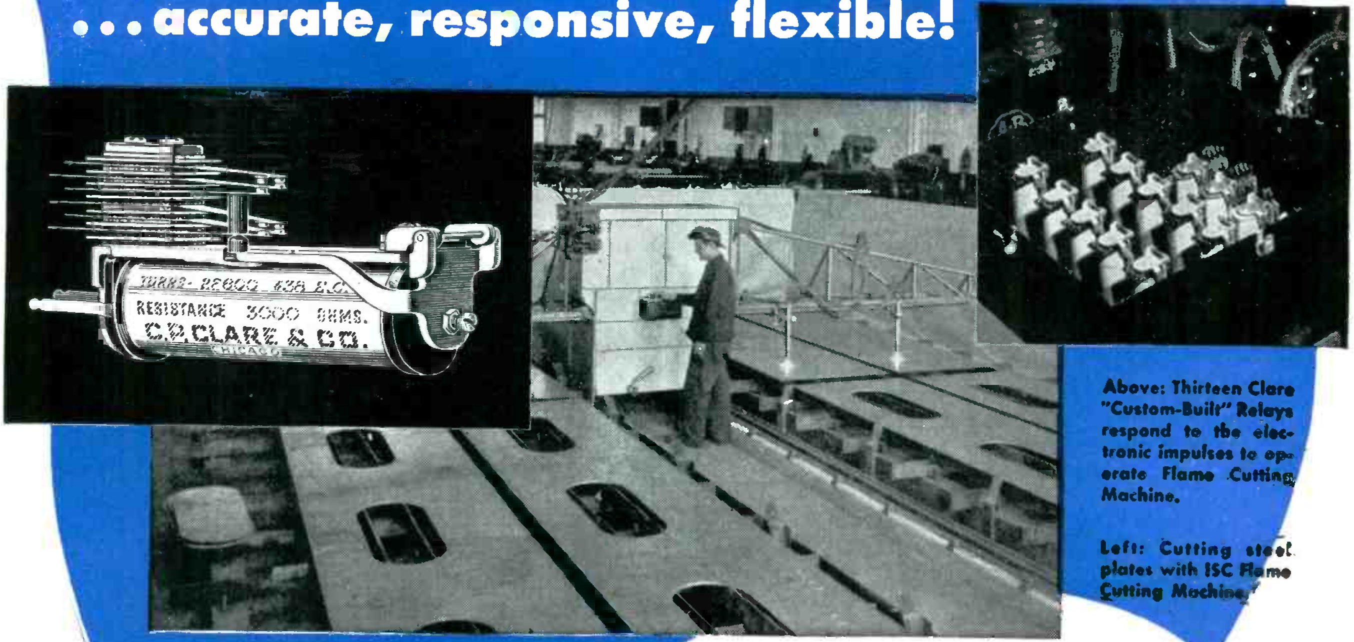
General Cable research and advanced engineering, plus expanded facilities and war-developed techniques have been adapted to the production of cords and sets that represent entirely new standards of quality and value.

Whatever your requirements may be, General Cable is now ready to serve you with a complete line of quality cords and cord sets.

GENERAL CABLE
CORPORATION

General Cable Corporation Sales Offices are located at Atlanta, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Houston, Kansas City (Mo.), Los Angeles, New York, Philadelphia, Pittsburgh, Rome (N.Y.), St. Louis, San Francisco, Seattle, Washington (D. C.)

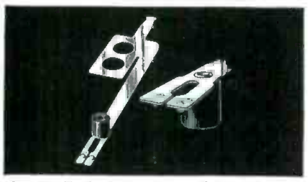
This ISC Flame Cutting Machine is Equipped with Thirteen Clare "*Custom-Built*" Relays ... accurate, responsive, flexible!



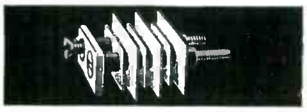
Above: Thirteen Clare "Custom-Built" Relays respond to the electronic impulses to operate Flame Cutting Machine.

Left: Cutting steel plates with ISC Flame Cutting Machine.

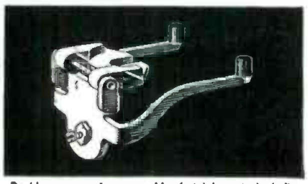
Contacts are welded to nickel silver springs by special process. May be of precious metals or alloys in 12 different standard, or special, types and sizes.



Spring bushing insulators are made of Bakelite rod under patented process. Resist vibration and withstand heavy duty service.



High voltage spring pile-up insulators of special heat-treated Bakelite. Has minimum cold flow properties, low moisture absorption content, and permits punching without cracks or checks.



Double arm armature assembly of stainless steel shaft, operating in a marine brass yoke. Heelpiece core and armature assembly of magnetic metal.

• Thirteen Clare "Custom-Built" Relays are used in the operation of this ISC Flame Cutting Machine which is used for oxygen-acetylene burning in shipyards and steel works.

These Clare Relays operate on electronic impulses to start, stop, reverse and jog the 3-phase A. C. motors which connect and disconnect auxiliary circuits for various automatic and manual operations in the cutting process.

This Flame Cutting Machine is a product of the Struthers Wells Corporation of Titusville, Pa., under license of the Industrial Scientific Company of New York City, designers of the machine.

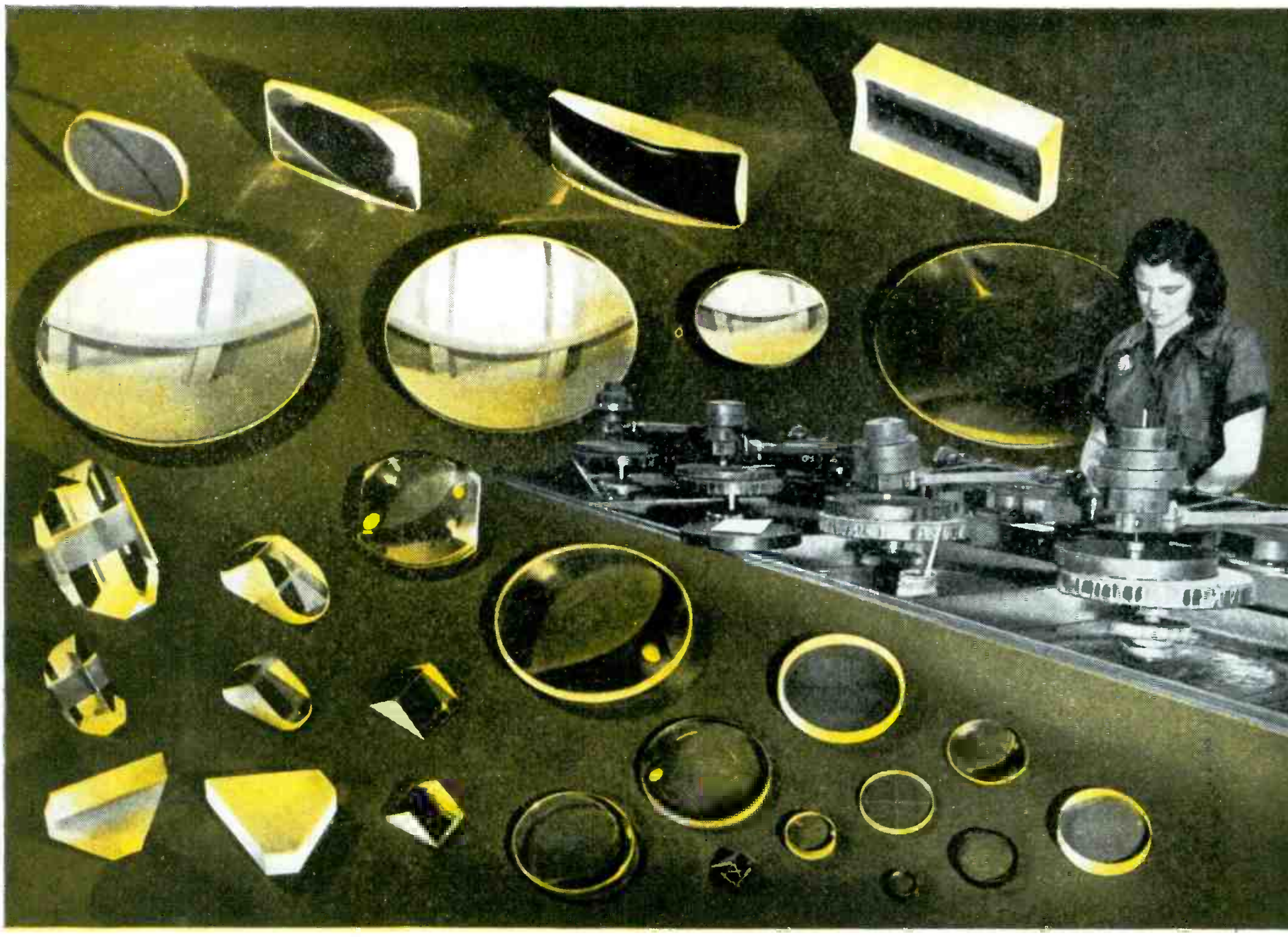
Whether your design problem involves sequence control of machine tools, electric eye controls, counting equipment, alarm systems, radio, radar or other electronic controls, Clare can "custom-build" a relay to meet your exact requirements.

Let Clare engineers know your specific relay problems. Let them show you the wide range of contact arrangements, spring assemblies and special contacts that can be "custom-built" into a Clare Relay to meet your specifications.

Write for the Clare catalog and data book today. It will pay you to know all about Clare "Custom-Built" Relays and what they can mean to you in the reduction of relay costs. Address: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical, Electronic and Industrial Use



Optics to order—by AMERICAN methods

Every component in this picture is as precise as a top-flight craftsman could have made it by hand. But each and every one of them was produced in large quantities. Furthermore, they were all made to order for exacting customers to meet rigid specifications.

Modern machines, of our own improved design, operated and controlled by highly-skilled American workers, enable us to produce precision optics at a high production level. The result is fine quality at a saving.

Our compact group of trained technicians is ready to go to work for a few additional manufacturers. But, as reconversion progresses, our plant becomes increasingly busy. Those who need optics should readily see the wisdom of making their requirements known to us at an early date so that we can give them the prompt service demanded by these times.

A new booklet, "Precision Optics by American Methods," tells how our company has developed optical manufacturing techniques, why we continue to concentrate all our efforts on the production of precision optics for others, and how we can be of exceptional service to those who need optical components. We shall be pleased to send you a copy of this new booklet on request.

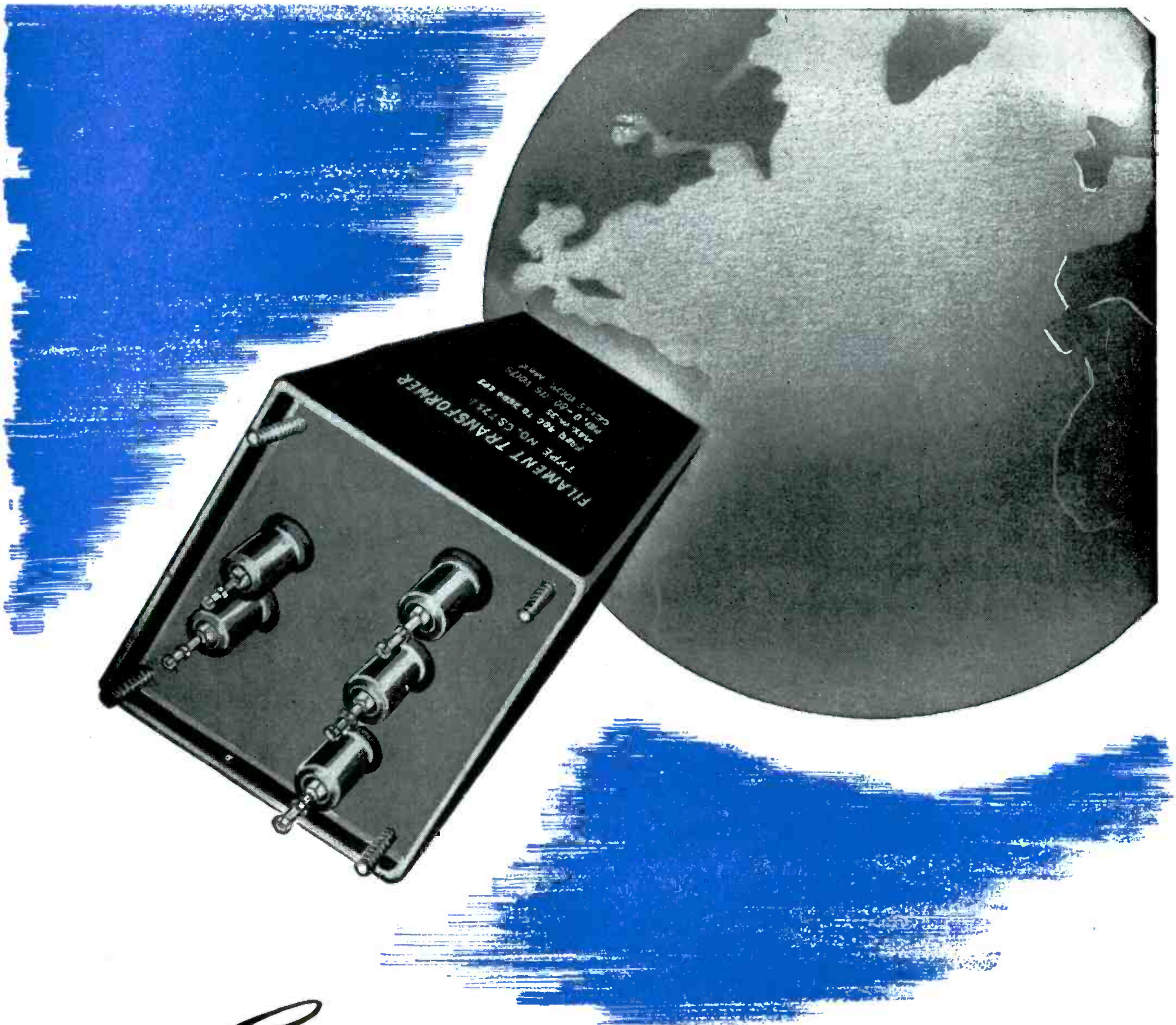
for precision OPTICS *come to*

AMERICAN LENS COMPANY, INC.

45 Lispenard Street, New York 13, N. Y.

LENSES • • • PRISMS • • • FLATS • • • REFLECTORS


Quiet
BALLENTINE
PHONOGRAPH DRIVE
Efficient—reliable—above all, *QUIET*—
that's the Ballentine Phonograph Drive.
Basic refinements in design, *precision dynamic balance*, the most advanced manufacturing technique and equipment make the Ballentine Phonograph Motor unequalled for low background noise or rumble.
Send for descriptive bulletin.
RUSSELL ELECTRIC COMPANY
364 WEST HURON ST., CHICAGO 10, ILL.
Manufacturers of
BALLENTINE PHONOGRAPH DRIVE



Light? We call it "LIGHT FANTASTIC"!

. . . a transformer headed for 65,000 feet "altitude" . . . at 350 degrees temperature!

And to top it off, it had to be "lighter than anything on the market," *they said. What, we asked, was it for? They couldn't tell us, and we don't know to this day, but we do know it was badly needed.

"It has to operate not only on a 60-cycle current at ground level, but from 400 to 2600-cycle current, and what's more, at a simulated altitude of 65,000 feet."

Thermador built this special transformer equipment. It passed the above mentioned requirements. That wasn't enough. They gave it another test, in which they changed the temperature from ambient (the temperature of a fairly warm room) to 350—in two hours. It passed that test, too. This is all we know of one of the most mysterious jobs we ever did, in the not-mysterious method in which we built all of our tansformers.

*For reasons of military security names cannot be given.

THERMADOR TRANSFORMERS

DEFEAT HEAT • COLD • HUMIDITY

THERMADOR ELECTRICAL MANUFACTURING CO.

5119 SOUTH RIVERSIDE • LOS ANGELES 22, CALIFORNIA

ACTUAL SIZE

The cast iron pump was modern two or three generations ago. It was a big improvement over the old oaken bucket. But today we use a comparatively small faucet that supplies water at a twist of the wrist. It is another milestone on the road to greater efficiency in miniature.

This same tendency is evident in the development of the Electronic Tube. The Tung-Sol Miniature is the result of the trend to smaller component parts. It is used to great advantage in reducing the over-all size of equipment. But more important, Tung-Sol Miniatures do a more efficient job than the old style tube; especially in high frequency circuits. They have a low capacity and high mutual conductance. Shorter leads give them low inductance. Smaller elements weigh less, making Miniatures more rigid. This helps to eliminate distortion from vibration.

When planning new electronic devices or when improving old ones, discuss circuits and tube selection with Tung-Sol engineers. Their services are at your disposal. Such conferences are held in strictest confidence.

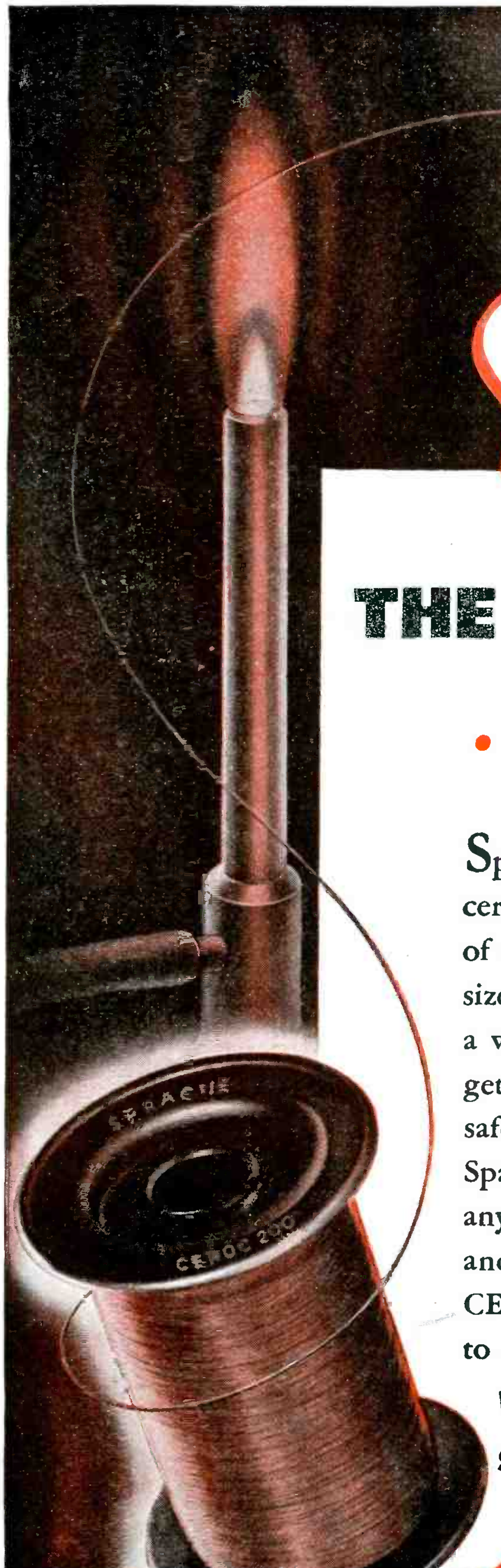
TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors



A CLASS "C" INSULATION—
INORGANIC CERAMIC—
APPROXIMATELY 1/4 MIL THICK—
PERMITS CONTINUOUS
OPERATION AT 200° C.

THE WIRE INSULATION

...that will not burn!

Sprague CEROC 200 is an inorganic, non-inflammable ceramic wire coating supplied in a preferred thickness of only ¼ mil and holding vast opportunities for smaller size and lighter weight with greatly increased power for a wide variety of electrical equipment. By using it, midget size windings can be made to do man-size jobs—with safe, conservative operation up to 200°C. if necessary. Space factor is higher than that of any other type of wire insulation and, despite its ceramic nature, CEROC 200 can readily be wound to meet most requirements.

MIDGET-SIZE WINDINGS
DO MAN-SIZE JOBS!

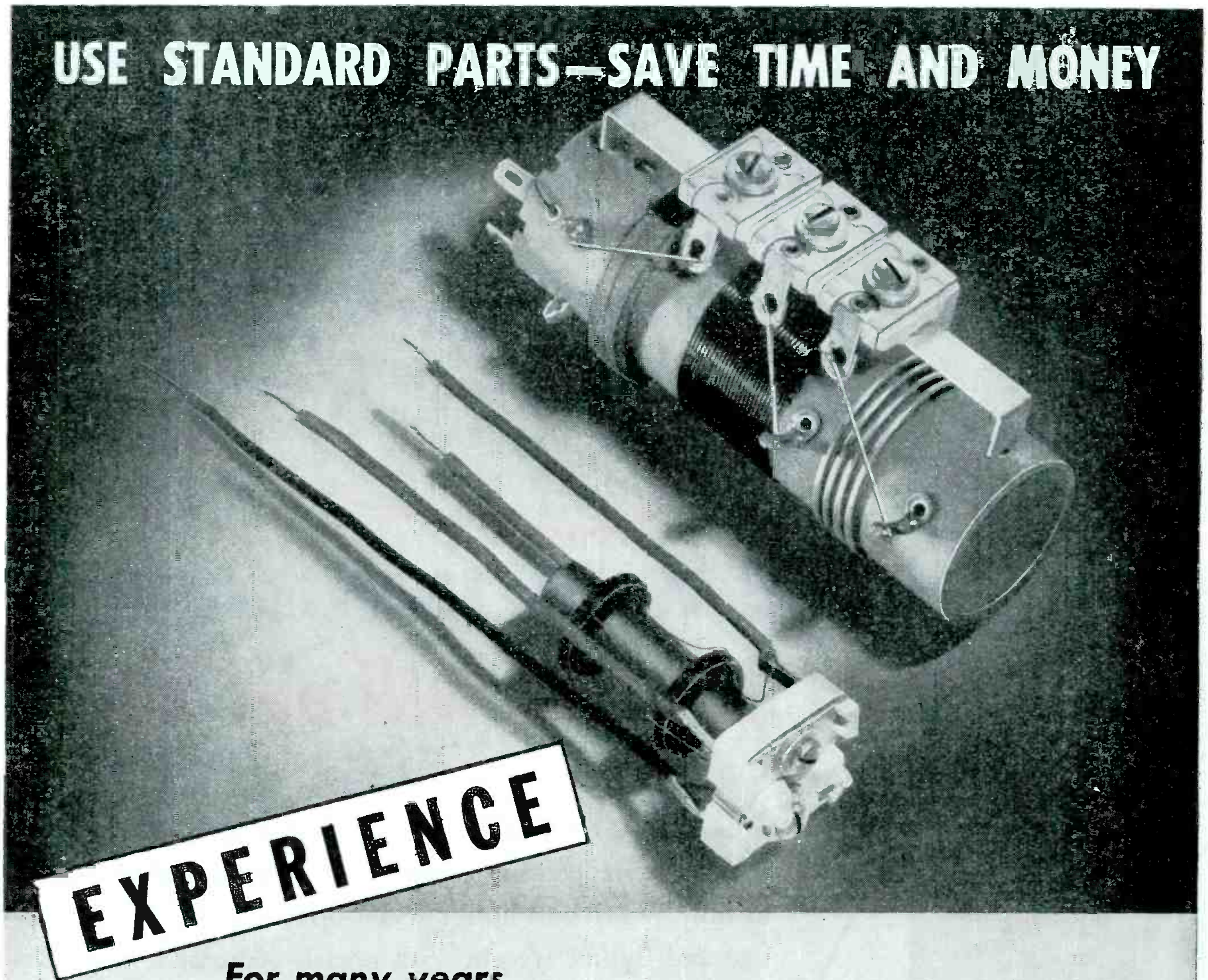
Write for copy of CEROC 200 Bulletin 505

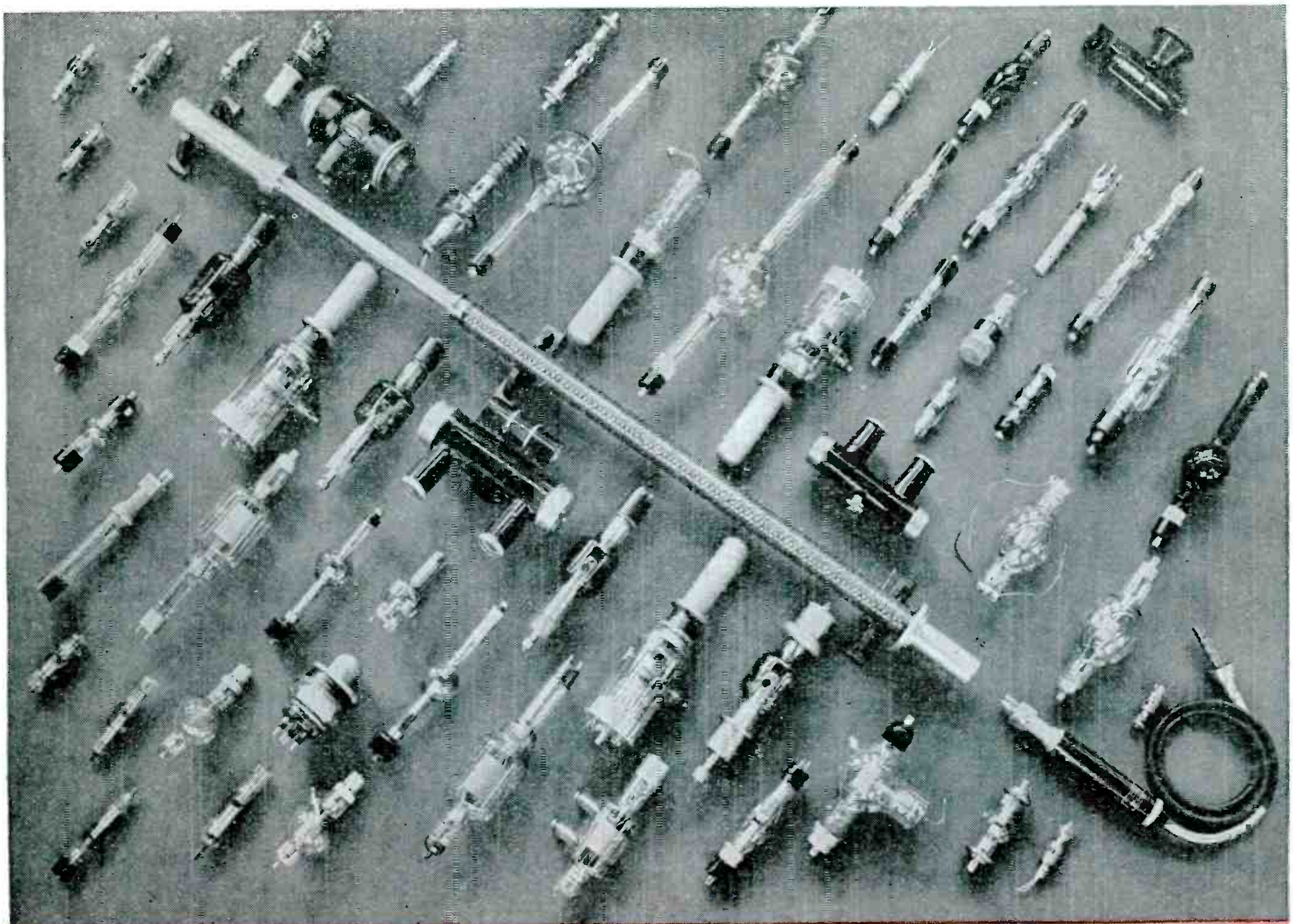
SPRAGUE ELECTRIC CO., NORTH ADAMS, MASS.

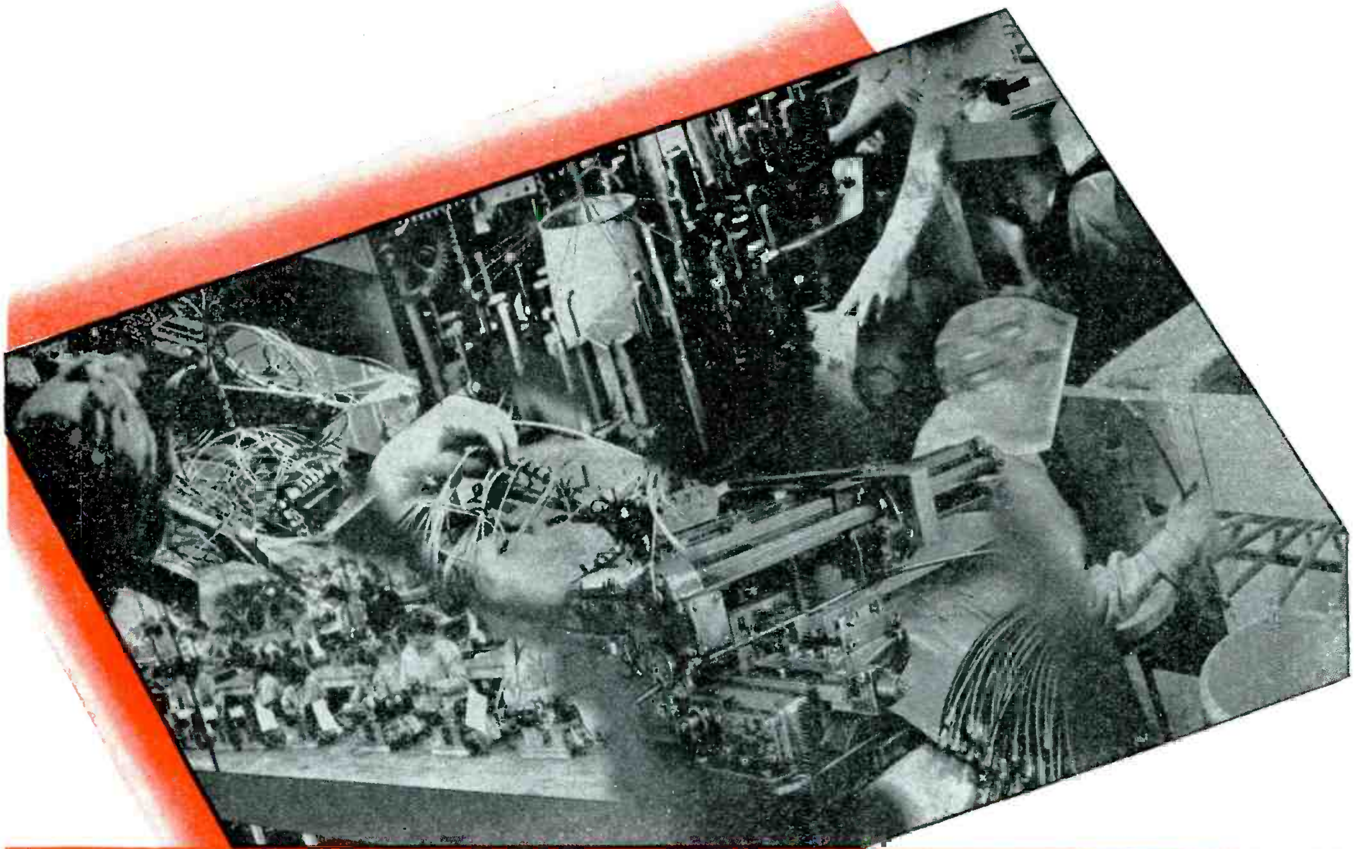
SPRAGUE *Ceroc 200

(*Trademark Reg. U. S. Patent Office)

Pioneered and Produced by the Makers of SPRAGUE CAPACITORS *and* *KOOLOHM RESISTORS


USE STANDARD PARTS—SAVE TIME AND MONEY
EXPERIENCE





ENGINEERED CABLE ASSEMBLIES at a fixed production cost to you

If your product requires WIRING HARNESSES... CABLE ASSEMBLIES... BONDING JUMPERS... CABLE or TERMINALS—you'll find that a lower cost of manufacturing, at a fixed production cost to you, is one of many advantages Whitaker offers you.

In turning the production of your wiring requirements over to us you are assured quality merchandise made to the most exacting specifications. When your men install the completed assemblies they will find every lead and every terminal properly positioned for the right connection. The economies gained will be big factors in enabling you to lower your cost of manufacturing.

In addition to an engineered wiring service, Whitaker also offers a quality line of standard cable products . . . Write for latest catalog, and complete information.

Whitaker Can Wire It

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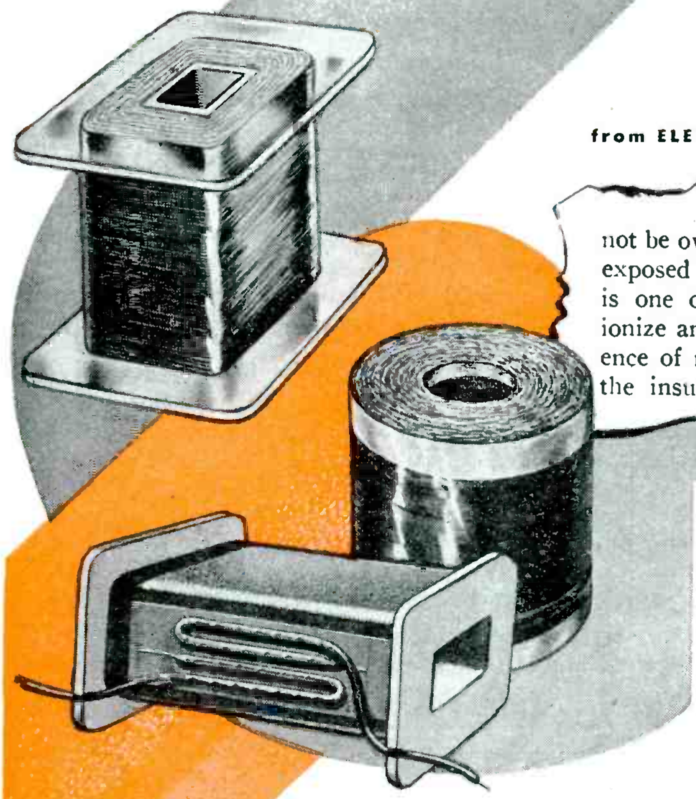
Read this paragraph

from ELECTRICAL MANUFACTURING, AUGUST, 1945, page 212

> However, cellulose acetate insulation cannot be overlooked, particularly for low temperature coils exposed to severe humidity conditions. Cellulose acetate is one of the few insulating materials that will not ionize and attack the copper magnet wire in the presence of moisture so that it plays an important role in the insulation of extremely small magnet wire coils.



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Use Lumarith films and foils for interlayer insulation, inter-phase insulation, slot insulation, coil wraps and covers, laminates, wire insulation. Special A78 mat finish (one side) can be supplied.

Use Lumarith sheets, rods, tubes and molding materials for coil forms, separators, bus bar insulation, radio and instrument housings, fluorescent lighting parts, formed insulators, bezels, coil supports, nameplates, switch gear windows.

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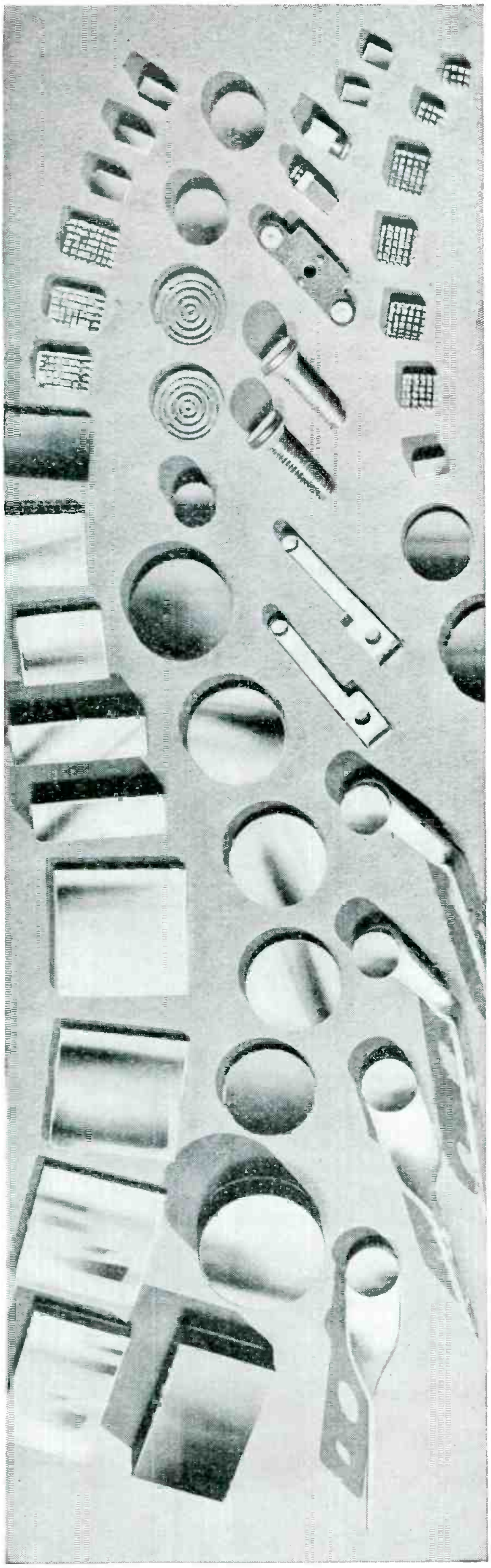

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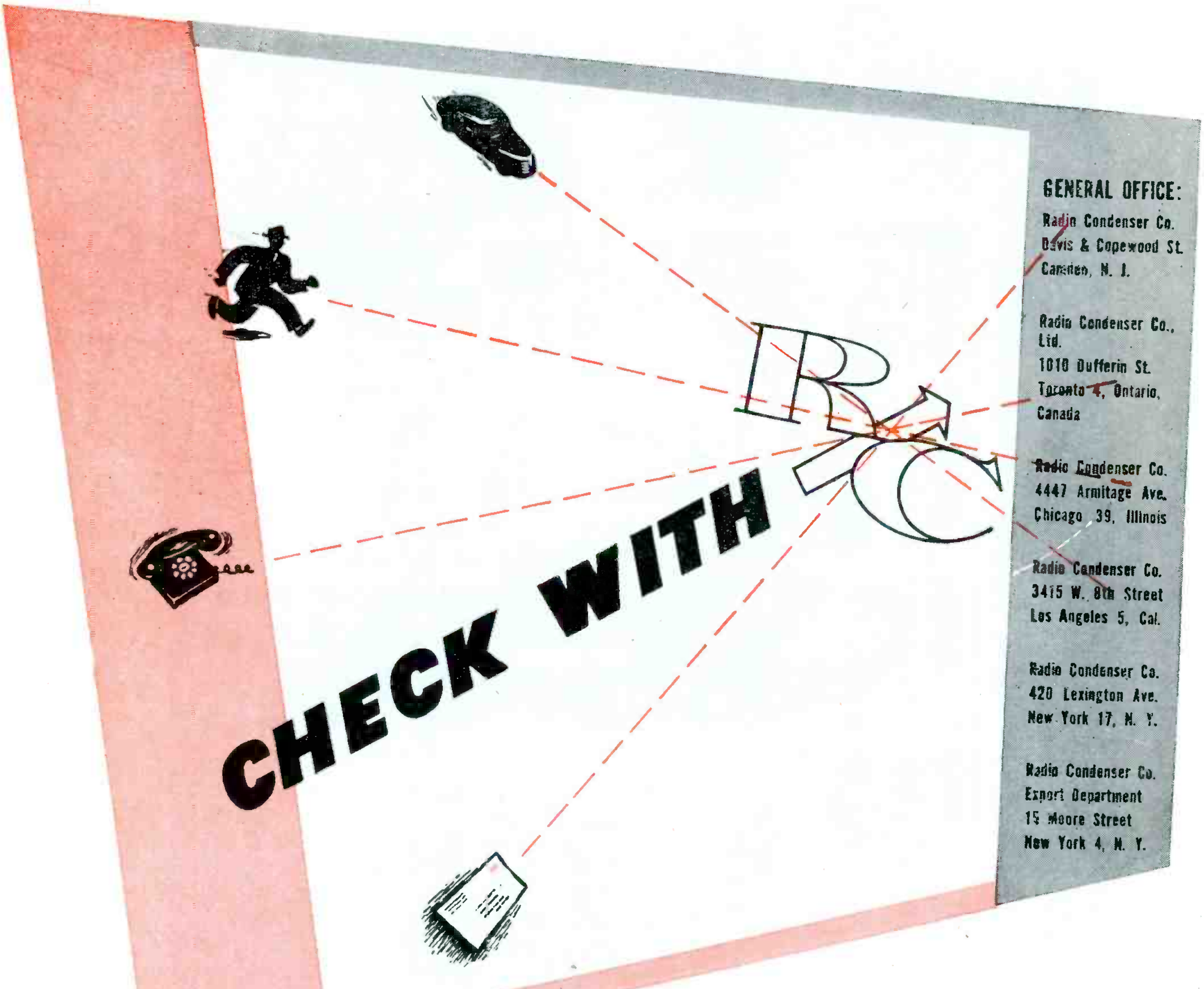

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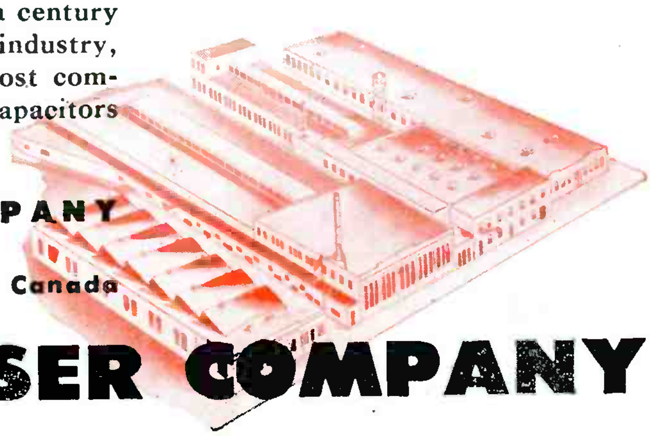

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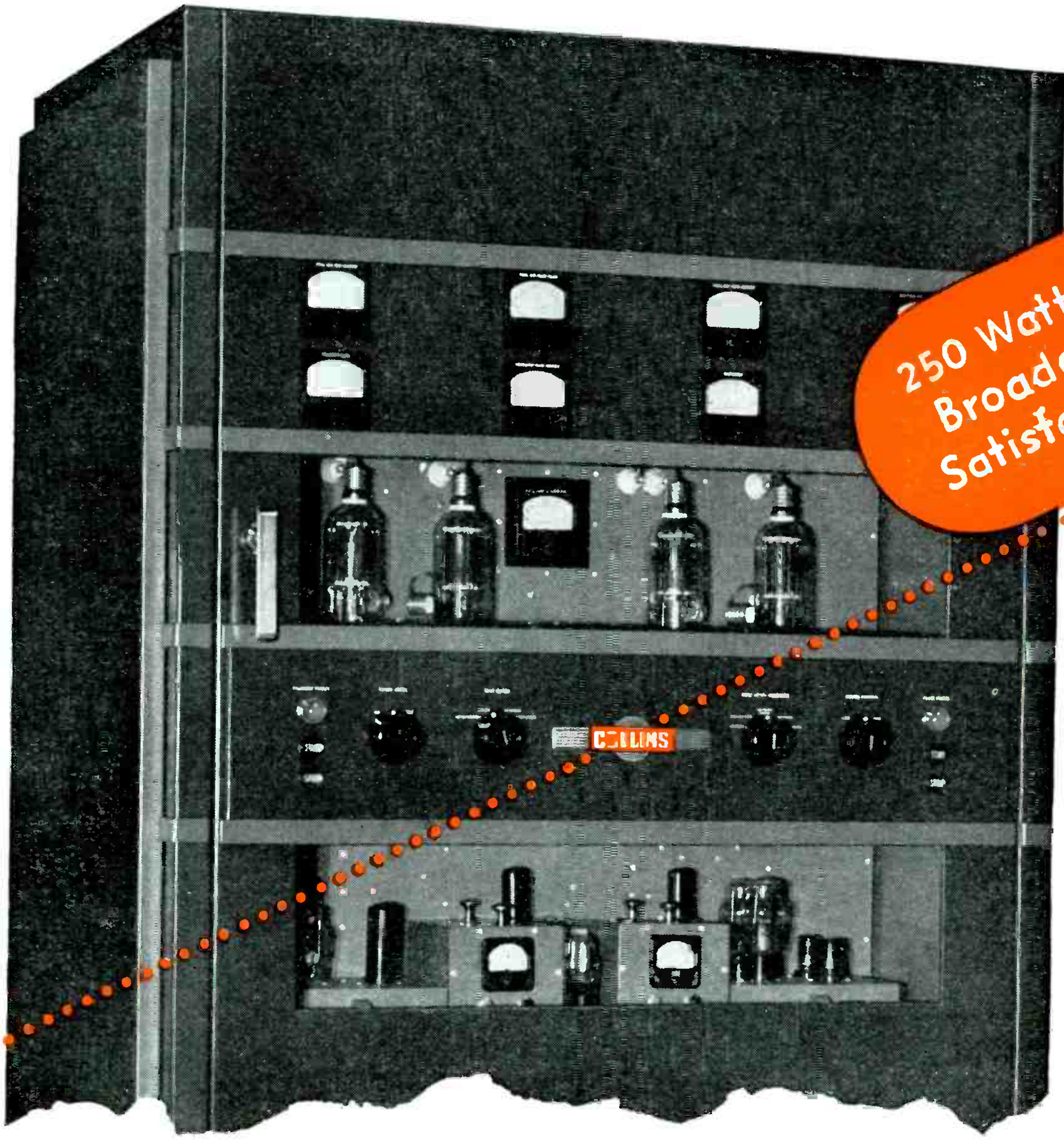
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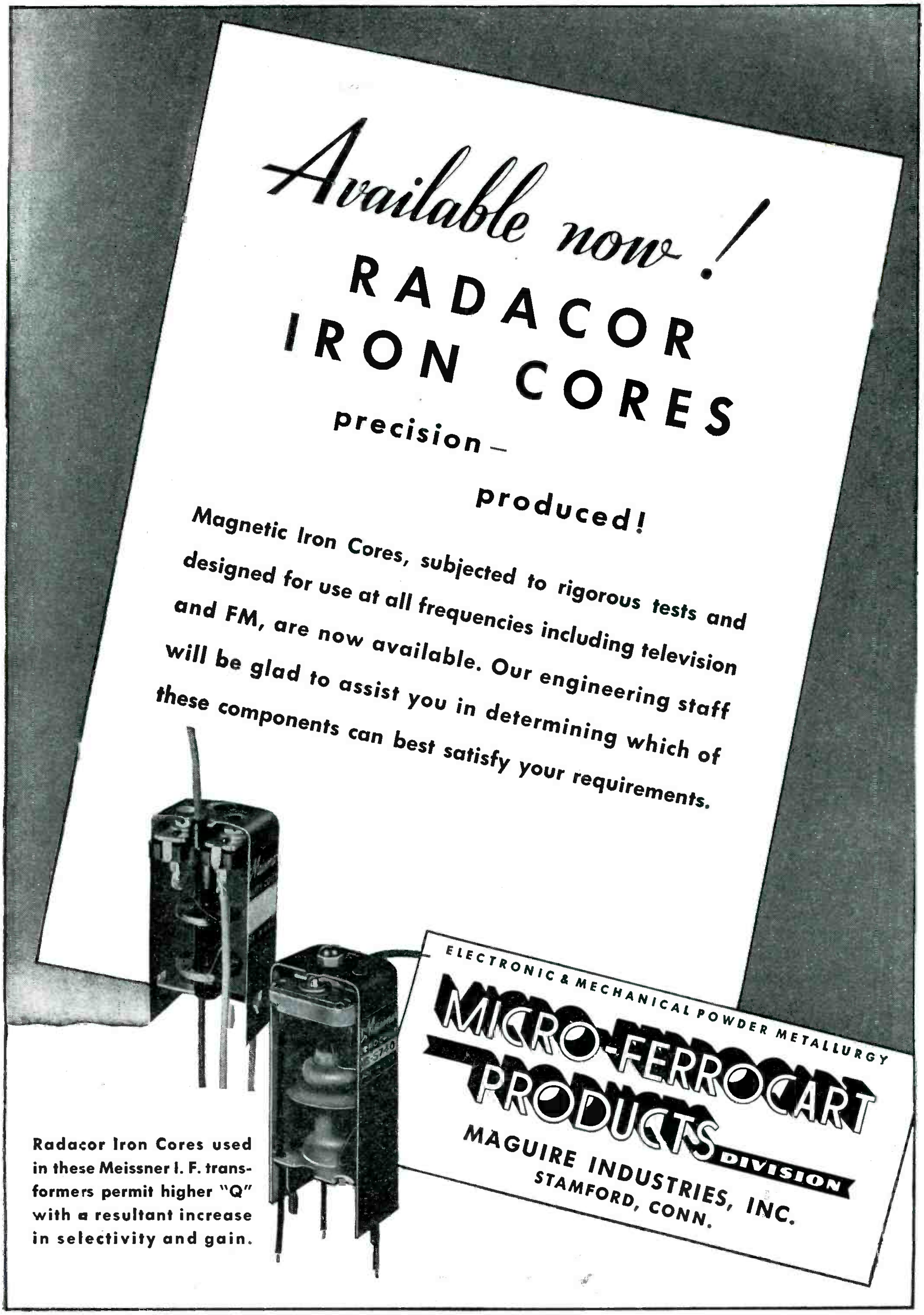
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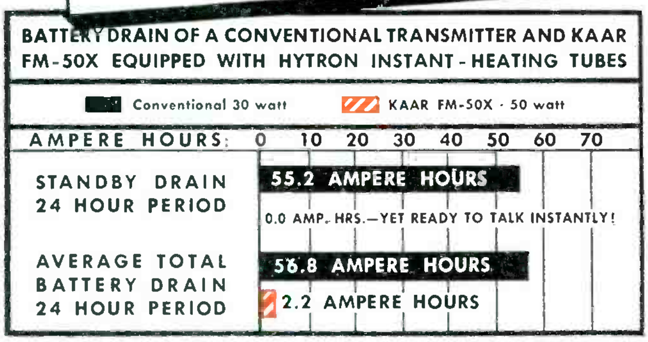
MORE POWER OUTPUT *BUT* LESS BATTERY DRAIN
WITH HYTRON INSTANT-HEATING BEAM TETRODES

ZERO STAND-BY CURRENT Thoriated tungsten filaments of the Hytron 2E25, HY69, and HY1269 permit simultaneous application of all potentials. During stand-by, no precious filament current is drawn from the battery. Especially with the larger tube complements of FM transmitters, is conservation of battery power mandatory.

MORE OUTPUT—GREATER RANGE Only 4% of the current required for cathode types, is necessary to operate the instant-heating 2E25, HY69, and HY1269. (See table below.) Even in a mobile FM transmitter, 100 watts output is practicable. Imagine the advantages of such increased output in police, marine, or other mobile equipment.

SPARES PROBLEM SIMPLIFIED Using the 2E25, HY69, and HY1269, you take full advantage of the beam tetrode's versatility. The 2E25, for example, can power a whole transmitter—AF and RF—AM or FM. If more output is required, HY69's or HY1269's in push-pull still confine the spares complement to only two types.

ADVANTAGES OVER CATHODE TYPES Yes, the 2E25, HY69, and HY1269 cost more than cathode types. But they are worth it. Not only are they easier on the battery, and permit larger outputs, but they are designed, built, and tested for transmitting. Some advantages are: centering of filament potential at 6.0 volts, r.f. shielding to eliminate the necessity for neutralization, low-loss insulation throughout, plate connection to top cap, and rugged construction.



This chart, prepared by Kaar Engineering Co., is based on typical metropolitan police use of 140 radiotelephone-equipped cars operating three shifts in a city of 600,000 population. The 24-hour survey included 904 messages originated by cars and 932 messages acknowledged by cars. Transmissions averaged: 13 per car, 15 seconds in length, and 3 minutes 15 seconds transmitting time.

ABBREVIATED DATA
HYTRON INSTANT-HEATING BEAM TETRODES

Characteristic	*2E25*	*HY69*	*HY1269*
Filament Potential (volts)	6.0	6.3	6/12
Filament Current (amps.)	0.8	1.5	3.2/1.6
Plate Potential (max. volts)	450	600	750
Plate Current (max. ma.)	75	100	120
Plate Dissipation (max. watts)	15	30	30
Grid-to-Plate Capacitance (mmfd.)	0.15	0.25	0.25
Maximum Seated Height (inches)	3 5/8	5 1/4	5 1/4
Maximum Diameter (inches)	1 7/16	2 1/16	2 1/16
Class C Power Output (watts)	24	42	63
Class C Driving Power (watts)	Less than one watt		

Pre-Assembled TO REDUCE YOUR COSTS!

Also Available with Phillips Recessed Heads

SEMS

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FASTENER UNITS

PRE-ASSEMBLED SHAKEPROOF LOCK WASHER AND SCREW

Assemblers simply pick up a Sems Fastener Unit and drive it! No need to put a lock washer on a screw because the Sems Unit is a combination of both. Thus an entire operation is eliminated . . . assembly speeds up, costs speed down.

Learn now—right on your own assembly line—the multitude of advantages that this modern fastening method offers you.

Shakeproof Engineers will analyze your particular fastening applications, recommend the correct type and size of Sems Unit and show your workers how they can easily and quickly reduce motions and gain vital assembly time. Ask for this special service today . . . a Shakeproof field engineer is ready to give you the benefit of his extensive fastening knowledge.

Get a Free Sems Fastener Unit Sample Test Kit —Write for Kit No. 23

HERE ARE FOUR WAYS SEMS UNITS SAVE TIME AND MONEY

No time wasted putting a lock washer on a screw. Sems are delivered as a single unit—ready for immediate installation.

No dropped or lost lock washers. The lock washer on a Sems Fastener Unit can't drop off—but is free to rotate.

Easy to use in hard-to-reach parts. Sems Units assure fast assembly and there's no chance to "forget" the lock washer.

The right type and size lock washer for each connection. Important too, every Sems Unit includes a Shakeproof Lock Washer with Exclusive Tapered-Twisted Teeth.

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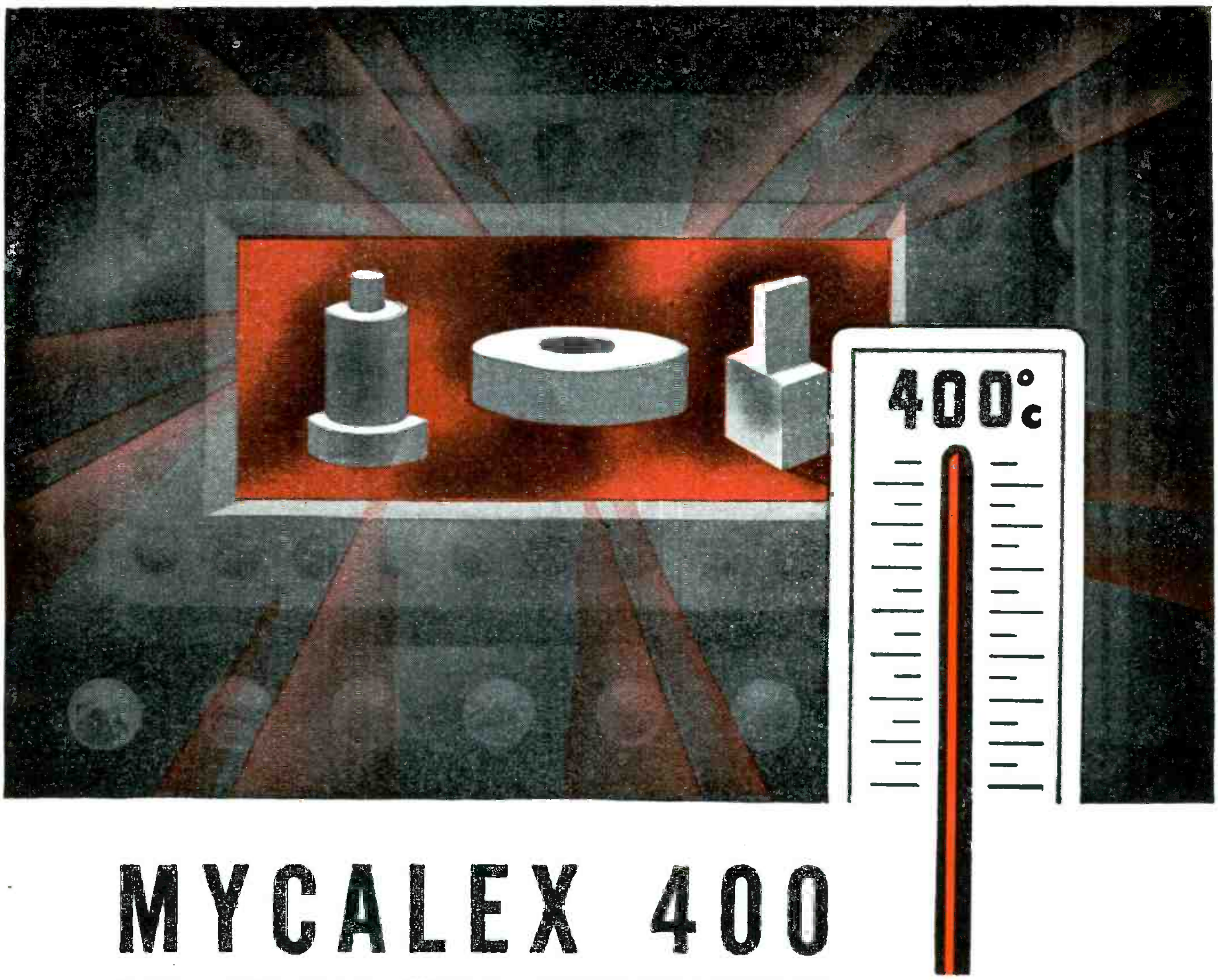

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WITHSTANDS HIGH TEMPERATURES

An outstanding characteristic of MYCALEX 400 is that it can withstand temperatures above 400° C. without softening or any permanent change in dimensions or properties.

Thus MYCALEX 400 has proved of great value as a low loss insulator in communications and other high frequency apparatus intended for use at elevated operating temperatures.

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A series of ceramic capacitor dielectrics, with dielectric constant selectable from 8 to 19. Low power factor, high dielectric strength. Meets Army and Navy requirements as Class H material (JAN-I-12). To specifications.

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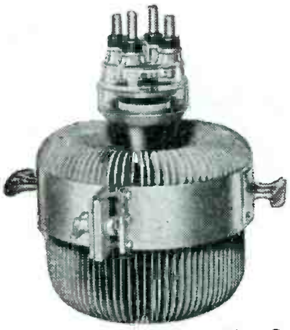
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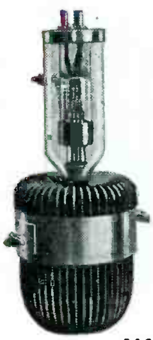
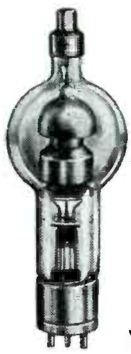

WL-892R


WL-677


WL-678

CONTROLLING


WL-857B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RECTIFYING

TUNE IN: John Charles Thomas
—Sunday, 2:30 P.M., EST—NBC
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11:45 A.M., EST—ABC

Westinghouse
Electronic Tubes at Work

CONTROLLED ATOMS or CONTROLLED LIVES

SINCE August 6th when the first atomic bomb was released over Hiroshima, the American people have been subjected to a continuous barrage of pronouncements on the use and control of atomic energy. Some of this comment has been strident, and much of it conflicting. A considerable portion of it has been of sincere and constructive excellence.

It has not been easy to separate the wise counsel from the merely noisy, and it is small wonder that the minds of many are troubled and confused.

However, the sheer mass of discussion poured into press and microphone has awakened us all to the gravity of the issue. In terms of any problem on which Americans ever have been called to exercise a judgment—This is It!

Even the dullest now recognizes that atomic weapons hang over modern civilization like the Sword of Damocles, and understands in some measure how fragile and taut is the hair of political balance that holds it suspended.

From this point on, we need the coolest and most carefully considered judgment that can be brought to bear. Discussion highly charged with emotionalism will but increase the tensions both at home and abroad, and render wholly insoluble a delicately intricate problem.

What Is The Problem?

The major outlines of that problem now are coming into focus in understandable terms:

1. The scientists have opened up a new and virtually unlimited storehouse of energy, and the engineers have discovered how to turn it into a military explosive incomparably more powerful than any we have known. We know that this energy may also be used to produce heat for useful power, and we suspect that the radioactive substances produced by the process in hitherto unimagined quantity may also have medical, industrial, and other constructive applications.

2. Terrifying as have been the demonstrations of the atomic bomb thus far, we know that they are as nothing in comparison with its potential destructiveness. The explosive force of individual bombs can be increased tremendously, and means for their effective delivery to predetermined targets in wholesale quantity already are at hand. The experts tell us that no practicable means of interception can be devised, and that reprisal in kind probably will be the only answer to an enemy attack with atomic weapons.

3. So far as we can see now, even successful retaliation would be at best an answer of hollow effect. Any two nations each having wholesale stock-piles of bombs could accomplish the practical destruction of each other. Since a first treacherous blow might well constitute an enormous advantage, a nation actuated by a ruthless urge to conquest or revenge might have the best chance of survival. But since the widest possible dispersal of bombs and launching units would be dictated by the strategy of atomic weapons, it is doubtful that one nation could destroy another without itself suffering destruction. On both sides the major centers of population could be wiped out, and the nation of least concentrated industrialization and commerce would suffer least. However, no one can be sure that the concentrated explosion of as many as 20 thousand atomic bombs would not poison the atmosphere of the world to an extent that would be fatal to great masses of population, not only within the country bombarded, but perhaps in the country which launched them.

4. The problem is further complicated because, so far as we know now, any large-scale commercial use of atomic energy as a power source is more or less inextricably linked to a potential military use. It is true that, if atomic power becomes economically feasible (which is by no means certain for a long time to come), it would require only low-grade concentrates of fissionable material, which would need further elaborate and costly processing before reaching explosive potential. But the process of producing such low-grade concentrates constitutes perhaps two-thirds of the industrial effort required to make effective bombs. It follows, then, that if nations were to equip themselves to produce large quantities of low-grade concentrates for power generation, the effort required to develop large-scale bomb production would be materially reduced. Moreover, the maintenance of an effective inspection to police agreements not to produce bombs might be forbiddingly difficult if atomic power generation were allowed.

5. In addition to the major problem posed by the use of atomic bombs in international war, any nation which produces or possesses such bombs, or the fissionable materials with which they are loaded, faces still another in the danger of their falling under the control of paranoid elements in its own population.

What Are We Going To Do About It?

We face the hard fact that we have produced a weapon capable of destroying whole nations—perhaps even the whole world. Although we were importantly aided in its development by the nationals of other countries, we, together with Great Britain and Canada, now must take the initiative in deciding what shall be done with it. We have only two choices. We can try to keep this weapon as a monopoly of our own, or we can try to place it under broad international control.

Can We Keep It To Ourselves?

If we know one certain fact about the atomic bomb, it is that it cannot long be held as a monopoly of those nations which produced it.

If Nazi Germany had succeeded in developing the weapon first, it probably would have attempted to achieve world dominion, with utter destruction as an alternative. Such a course is not within our range of choice. It violates every principle for which we stand.

Much reckless nonsense has been uttered concerning the inability of other nations to master the scientific, engineering, and industrial problems involved. It is the virtually unanimous opinion of those who worked on the project that several nations today are fully equipped in science, engineering, and industrial organization to produce atomic bombs and to provide the means for launching them. At least one of these nations, Russia, has also access to an ample supply of the necessary raw materials. The only debate is over whether it would take three, or five, or ten years for her to marshal her resources to produce bombs in multiple thousands. Once such an atomic race were on, we have no reason to believe that Russia might not divert more resources to the task than we ourselves should be willing to put into it.

Additional nonsense is talked as to how we might attempt to cope with the problem of living in a world in which mutually suspicious or hostile nations faced each other, with stores of atomic weapons on both sides. We hear talk of dispersing our cities and even of moving underground. No one has seriously reckoned the difficulty or the cost of following such counsel of despair. Still less has anyone appraised the neurotic effect upon men's minds of living by any such preposterous formula, under continuously mounting tension day after day, and year after year.

Certainly, if we could find no way to prevent the competitive production of atomic weapons, we should be driven at least to the selective dispersion of our bomb-launching facilities, of certain key industrial establishments, and of our centers of government and governing personnel. We should be forced, also, to change our traditional requirement that only Congress can commit us to active war. We should be forced to organize ourselves as a police or military state, with our scientists regimented and muzzled, with all of us under constant surveillance against the smuggling and planting of time-bombs, and constantly alerted against attack through the air.

Before we commit ourselves to any such intolerable procedure, we should be mad not to explore all possible means for making it unnecessary.

The Only Feasible Alternative Is Effective International Control

This cardinal principle has been recognized in the statement of November 15th, issued jointly by President Truman, and Prime Ministers Attlee and King. Their statement frankly concedes that against atomic weapons there can be no adequate military defense, that no nation can command a monopoly of such weapons, that responsibility for eliminating atomic energy as an instrument of war and for devising safeguards over its use for the advancement of science and other peaceful and humanitarian ends rests upon the civilized nations of the world.

They propose that a commission be set up at once under the United Nations Organization to make recommendations: (a) for extending between all nations the exchange of basic scientific information for peaceful ends, (b) for control of atomic energy to the extent necessary to ensure its use only for peaceful purposes, (c) for the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction, and (d) for effective safeguards by way of inspection and other means to protect complying states against the hazards of violations and evasions.

Already criticism is leveled at the wording of the statement, at alleged omissions, at the wisdom of choosing the United Nations Organization as the medium through which to seek agreement in view of the weaknesses of the UNO Charter.

None of these issues should be crucially important. What matters is that an invitation has been issued in good faith for the nations of the world to meet and decide upon means for assuring the elimination of weapons, the existence of which no one can afford to tolerate.

The decision cannot be other than international; it will require the best thought of the best brains the world can muster. The smaller nations have an equal stake with the large, and from them may well come the most fruitful suggestions. But Russia now holds the key to the success or failure of our proposal. If she accepts our invitation, no other nation will refuse.

Alternatively, there will be an international armament race paced by atomic weapons. It will mean an end of free science, a severe policing and regimentation of international travel and trade, and innumerable restrictions upon those individual freedoms which we have just fought so desperately to preserve. This is the dismal prospect if we fail to arrive at a genuinely international accord on the control of atomic energy. But even this interval would promise to last only for an uneasy period, until someone started pressing the push-buttons on the panel-boards of extinction.

The only permanent solution lies in finding means to eliminate war itself. That we cannot hope to achieve overnight, but we can, and do hope that the nations will now agree to eliminate atomic weapons and their radioactive by-products as instruments of war.

If they do that, we can move forward more surely to the constructive development of the incalculably valuable resources that science has newly opened to our use. And, we can hope also for a progressive improvement in international understanding.

Unless the nations can reach agreement on this paramount issue of atomic energy, it is difficult to conceive of any vital issue on which they might agree.

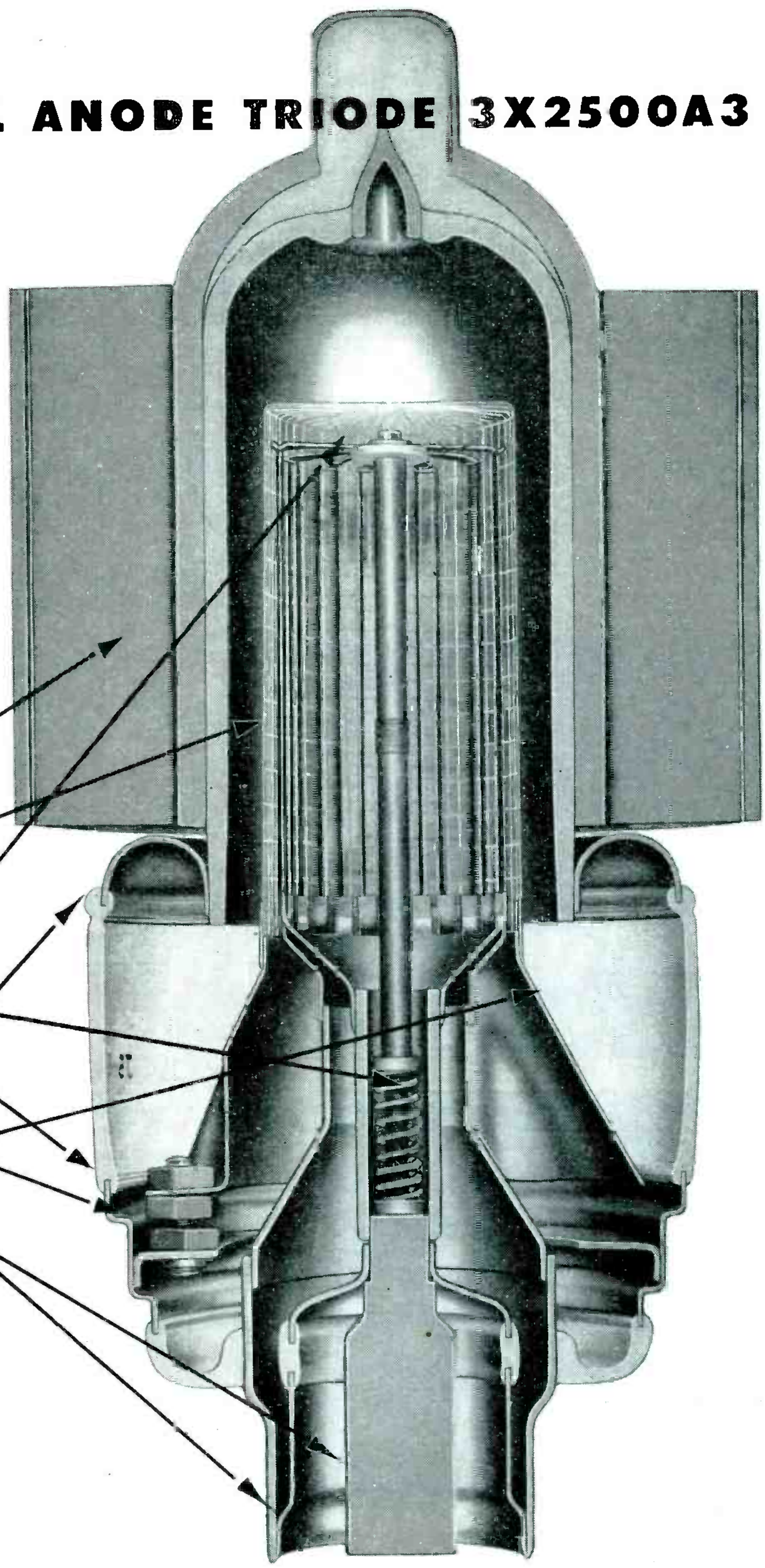
James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 42ND OF A SERIES

Eimac TUBES REG. U. S. PAT. OFF. THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

NEW EIMAC EXTERNAL ANODE TRIODE 3X2500A3



Rugged mechanical construction
Outstanding electrical efficiency

In the new 3X2500A3, Eimac engineers have developed a highly efficient external anode triode which, in Class C service, delivers up to 5 KW output at a plate voltage of only 3,500 volts. The mechanical design is radically simple, incorporating a "clean construction" which gives short, low inductance heavy current connections that become an integral part of the external circuits at the higher frequencies.

The external anode, conservatively rated at 2500 watts dissipation, has enclosed fins so as to facilitate the required forced air cooling.

Non-emitting vertical bar grid does not cause anode shadows ordinarily created by heavy supports in the grid structure.

Thoriated tungsten filament. Note unusually large filament area, and close spacing.

Filament alignment is maintained throughout life of the tube by special Eimac tensioning method.

New glass-to-metal seals do not have the RF resistance common to iron alloy seals, nor the mechanical weaknesses of the feather-edged types.

Grid ring terminal mounts a cone grid support which acts as a shield between plate and filament.

A coaxial filament stem structure forms the base of the tube. This makes possible proper connections to the filament lines.

Grid and filament terminal arrangements make it possible to install or remove the 3X2500A3 without the aid of tools.

The new mechanical and electrical features of the Eimac 3X2500A3 external anode triode make it valuable for use on the VHF as well as low frequencies. More complete data and information yours for the asking.

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TYPE 3X2500A3 — MEDIUM MU TRIODE

ELECTRICAL CHARACTERISTICS

Filament: Thoriated Tungsten	
Voltage	7.5 volts
Current	48 amperes
Amplification Factor (Average) 20	
Direct Interelectrode Capacitances (Average)	
Grid Plate	20 $\mu\mu$fd.
Grid Filament	48 $\mu\mu$fd.
Plate Filament	1.2 $\mu\mu$fd.
Transconductance (i_B=830 ma., E_B=3000 v.)	20,000 μmhos

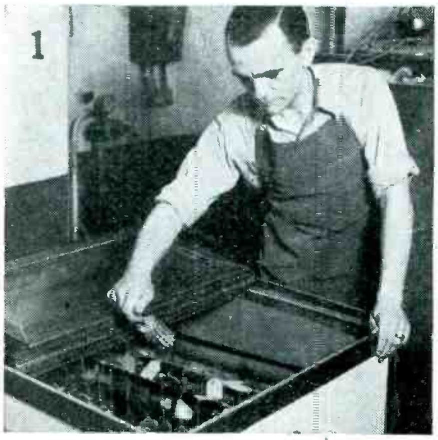
1123

Pre-Testing of
MALLORY SWITCHES
Assures Precision Performance

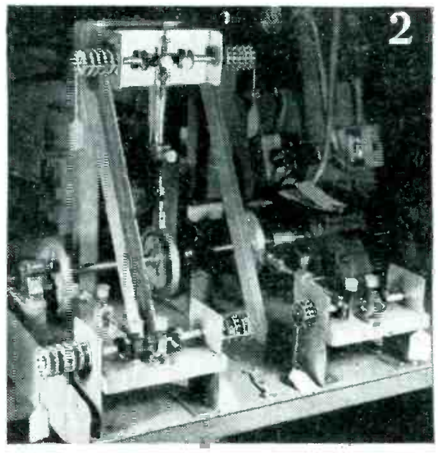
MALLORY has pioneered in developing new designs for both rotary and push-button switches, and in manufacturing them from improved materials. To make sure of the electrical performance and long life of these switches, Mallory puts them through punishing tests.

The complete line of Mallory *standard, pre-tested* precision switches and other electronic components is available from your nearest Mallory Distributor. See him today, and ask for your free copy of the Mallory catalog—containing specifications for switches, jacks, plugs, capacitors, resistors, rectifiers and other parts. Or write us today.

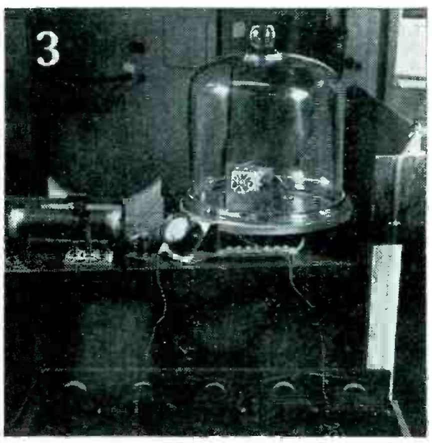
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



1 SALT SPRAY TEST: In a few short hours, switches are subjected in this salt spray chamber to conditions that equal years of marine service.

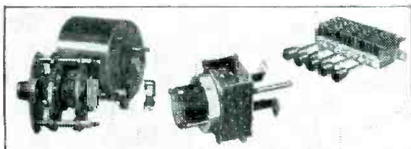


2 SWITCH LIFE TEST: Hour after hour, this machine continues to operate the switch until it is destroyed. Results enable Mallory to develop switches with operating life exceeding normal requirements.

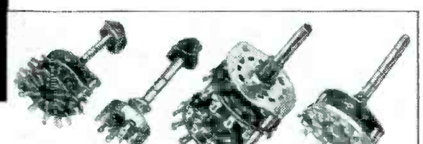


3 LOW ATMOSPHERIC PRESSURE TEST: The rarified air of the substratosphere is reproduced inside this large bell jar. Data from this test has aided Mallory in developing better switch construction for aircraft application.

4 FUNGUS CONTROL: In this laboratory, fungus cultures from the tropics are used in testing the fungicidal properties of new impregnating materials for the insulation in Mallory Switches.



P. R. MALLORY & CO. Inc.
MALLORY



Industrial and Electronic Switches

CROSS TALK

▶ **HEAT** . . . Electronic heating gets up into the high power regions where a potential user of the equipment naturally wants to know how much juice he must put in and pay for. His curiosity concerning how much he is going to get out is also natural.

In the case of motor-generator equipment, the horsepower rating of the driving motor and the kw output of a high-frequency generator are established by well-recognized and standardized testing procedure. In the case of the spark-gap or vacuum-tube oscillator, however, the kw output available for heating is not as readily measurable by the usual electrical means.

This may account for some of the efficiency figures we see quoted by manufacturers of spark-gap and tube heating equipment; certainly the situation calls for some quick standardization by the several bodies interested in such matters.

Speaking of tube-type machines, the plate efficiency of an oscillator will seldom exceed 65 percent and when one takes into account the tank losses, transformer losses, filament losses and other wastages of power, the overall ratio between output and input cannot be greater than one-half and is quite likely to be below.

Standard methods of measuring electronic heating efficiency and of rating this important quantity are urgently needed.

▶ **BOMB** . . . One of our imaginative broadcast stations phoned the atomic bomb people a day or so after the New Mexico trial explosion to request the Army to shoot off another bomb so that a sound-effects record could be made.

And incidentally, there were only two violations of security regarding the Kellex Corporation, one before VJ day by a broadcast station and one after the war's end by a national magazine of news comment.

▶ **MORE TALK** . . . Most present criticism of broadcast programs is on two points, advertising blurbs, and serials. Now this is just a hunch, but maybe this criticism is really against the great amount of talk on the air. Maybe people really want more music. Any casual turning on of the radio at practically any station at any time of the day will produce talk. If the listener wants music he must know when to get it, and, of course, even when he gets his music he must put up with a great deal of talk.

CBS has made a study of the serial situation to find out who listens to them, who likes them, and how much. Taking a typical Wednesday in Dubuque, CBS charted the situation from eight in the morning to six in the evening. In this day there were 40 quarter-hour periods and on this particular day listeners in Dubuque could tune to an average of about eight or nine stations at any particular moment. There were actually 347 individual programs during that time, 93 of them being music.

The listener who merely snapped on the radio had only a 27 percent chance of finding music and casually turning on the radio would result in a 73 percent chance of getting into the midst of a talk program. Considering that there was an average of 8 or 9 stations operating at any one time, the listener who wanted music would have to do a lot of hunting. After he had pushed several buttons or had dialed to several stations and found talk, he would probably turn the radio off and forget about it.

So far as serials are concerned, there were 51, and if you were serious you could listen to serials solid from nine to five except for a 15-minute period after lunch. During the rest of the time there were one, two or even three going on at once.

P.S. CBS's survey indicates that people like serials.

Fire-Control

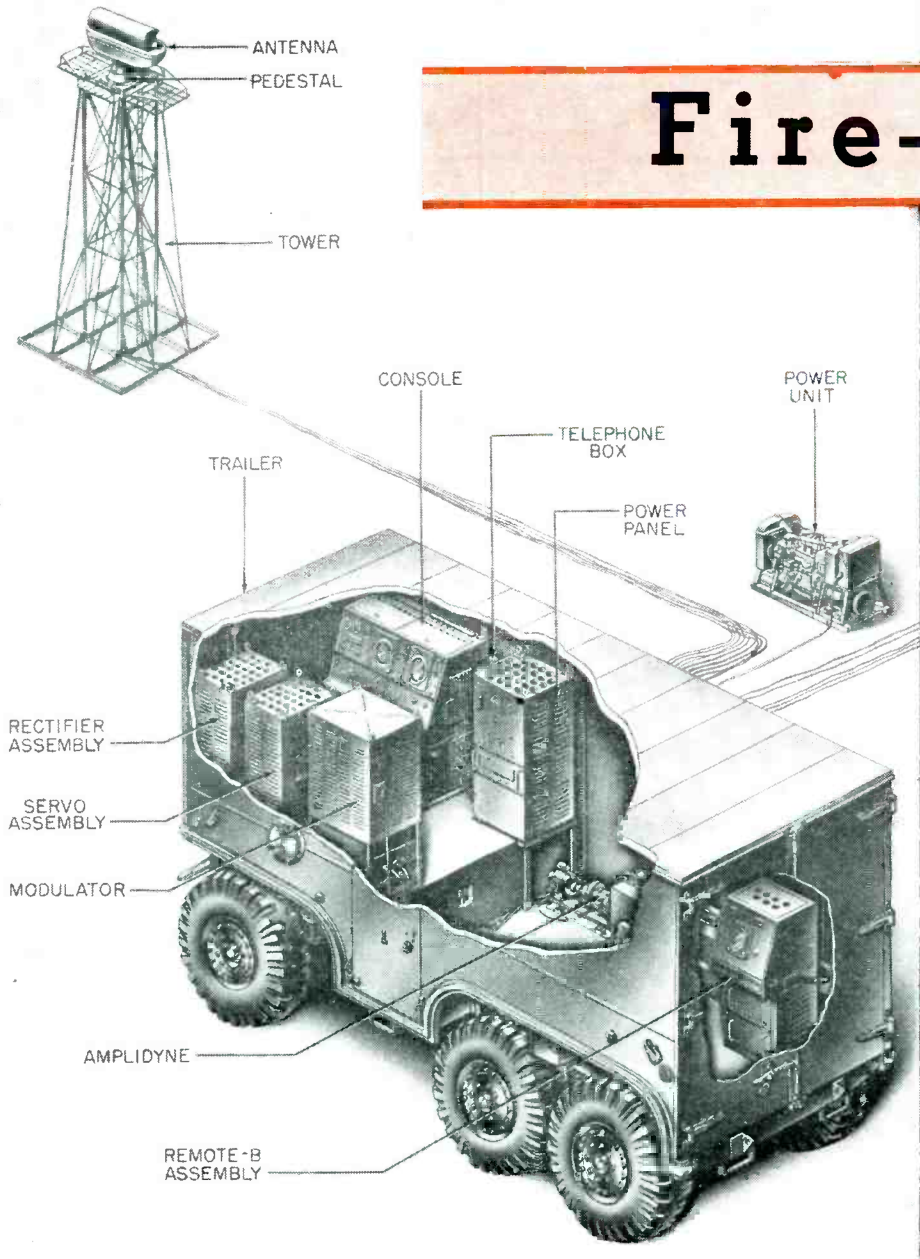


FIG. 1—The 3-cm fire-control radar AN/MPG-1, showing the trailer, power unit and antenna in operating position. The setup is adjacent to a gun battery, usually near a harbor or along a coastline

THE ALLIES faced a serious military situation in the spring of 1942. Attacks on important American harbors by PT boats were considered possible. At that time, no radar existed which could adequately detect and track these small, fast, maneuverable craft. So the Coast Artillery Board on the 20th of May set up characteristics for a radar which could supply position data on PT boats to a data computer for seacoast gun batteries.

Meanwhile, the National Defense Research Committee, with funds supplied by the Office of Scientific Research and Development, had begun to study the problem of supplying fire-control data to major-caliber guns at the Radiation Laboratory at M.I.T. When, therefore, in August 1942, the Signal Corps submitted the anti-motor-torpedo-boat project to NDRC for development, progress already had been made.

The Radiation Laboratory prototype set was assembled in mobile form and de-bugged by the 15th of November, 1943. After five days operation at a station in Boston harbor, the set was transported to a Coast Artillery test site at Fort Story, Virginia.

electronics WAR REPORT

A few months before completion of the prototype model, the Marine Corps became interested in the set for use with their seacoast artillery. This led to a revised unit, called the AN/MPG-1, which is housed in a trailer van made water-tight up to the roof.

General Design

When in use, the AN/MPG-1 is set up as shown in Fig. 1, overlooking the harbor or coastline it is meant to defend. Capable of being placed in operating condition a few hours after selection of a site, the radar can begin its tactical functions by the time the gun battery is installed. Present-position data on any designated target are transmitted to the battery command post where the information is fed directly into a computer which supplies firing data to guns, or is used to furnish data for a plotting-board course of the target from which its future position is predicted.

The technical characteristics of the AN/MPG-1 are given in Table I.

Because of the narrow beamwidth, dipole (window) jamming of the set is not readily accomplished. The resolution is such that at 20,000 yards two destroyers separated by 300 yards of open water are seen as separate targets on the tracking scope. This high resolution enables skilled operators to track targets readily through heavy concentrations of ships, buoys, islands and floating wreckage, with minimum danger of tracking the wrong target.

The high accuracy of major-caliber seacoast weapons dictated certain features of design. High resolution and extreme accuracy

Radar MPG-1

First description of microwave radar operating on 3 cm with sufficient speed and accuracy to enable coast artillery to hit maneuvering PT boats. Control of harbor traffic in peacetime is suggested by the design. Further details will follow in subsequent articles

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were required in both range and azimuth. Resolution requirements dictated small angular divergence of the beam. The antenna system in the horizontal direction had to be large in terms of wavelengths. However, angular position had to be controlled very accurately. Since the moment of inertia of similar bodies increases as the fifth power of the size, it was not practical to increase too much the size of the antenna assembly carried on the azimuth drive system. Very severe problems were presented by the requirements of the servo system which controls antenna position. Tracking had to be smooth and accurate to within 0.01 deg at tracking speeds of less than 0.01 deg to more than 1 deg per second.

It was decided to employ an electrical method of antenna scan rather than to try to oscillate a large mass physically. The scan had to be frequency-insensitive to assure accurate pointing of the beam, regardless of variations in characteristics of different transmitter tubes. A stigmatic optical system without spherical aberration had to be built having wide field, high speed, compactness and freedom from coma. It was necessary also to develop a modulator capable of being very accurately triggered and delivering a 0.25-microsecond pulse to the magnetron, with accurate control of the pulse rise and decay time. To achieve maximum range resolution permitted by the pulse length, a broadband i-f strip (approximately 10 mc bandwidth) and video circuits had to be developed for the receiver.

Some of the men responsible for the development and production of the AN/MPG-1 are listed in a footnote *.

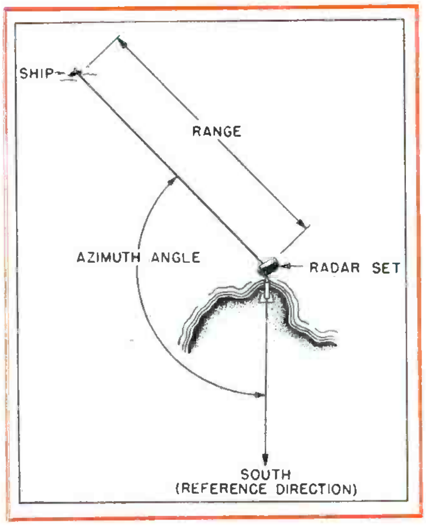


FIG. 2—Definition of range and azimuth

Design Details

Essentially, the direction, or azimuth, of a target is specified by the direction of the beam when it illuminates the target. Azimuth

FIG. 3—PPI view of Pearl Harbor, 80,000-yard sweep with 10,000-yard electronic range markers

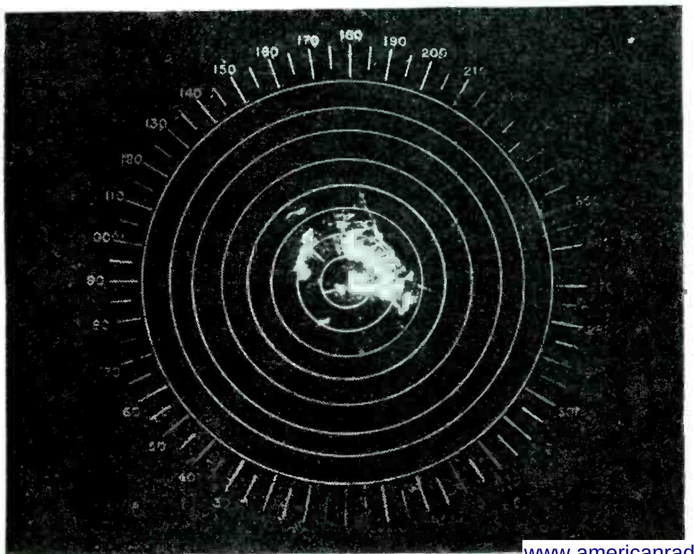
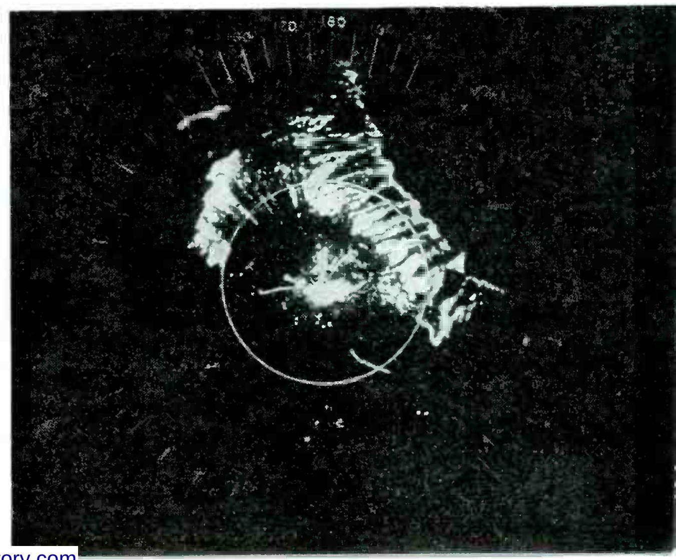


FIG. 4—PPI view of Pearl Harbor, 30,000-yard sweep with movable electronic range marker



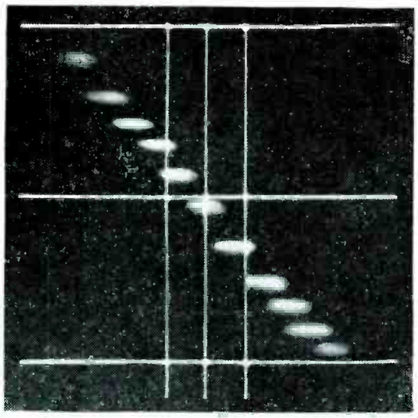


FIG. 5—B-scope presentation of eleven LCI's shown intercepted by the range marker in Fig. 4 at 12,900 yards and 329 degrees. Resolution makes it possible to distinguish ships separated by less than 300 yards of open water

and range are defined in Fig. 2.

Pulse transit time is measured by means of cathode-ray oscilloscopes. The oscilloscope range sweep is synchronized with a pulsed transmitter. At the moment an r-f pulse leaves the antenna, a linear deflecting voltage is applied to the oscilloscope electron beam. At the end of the desired time interval, the deflecting voltage suddenly falls to zero, allowing the electron beam to fly back to its original position where it remains until the transmitter is pulsed again, whereupon the cycle is repeated. Since the sweep trace is generated at a constant, known speed, any segment of this trace is a linear measure of time. After a pulse has been emitted and the sweep has begun, an echo may be received by the antenna. The echo signal is demodulated, amplified and applied to the indicator.

Surveillance

Surveillance data are viewed on a 7-inch conventional plan-position-indicator (PPI) on which two alternative maximum ranges, 80,000 and 30,000 yards, may be selected by the operator with the results shown in Fig. 3 and 4.

The PPI presentation is a polar map extending to the edge of the oscilloscope screen and displaying signals from all unshadowed reflecting objects at any horizontal distance from the antenna up to the maximum range of the set. The center of the map corresponds to the antenna location. Starting from the center of the screen in synchronism with the emitted pulse, the range sweep proceeds to the edge of the screen in the same relative direction as that taken by the pulse in free space. Rotation of the sweep is effected by means of a servo which causes the PPI deflection yoke to follow the movement of the antenna. To facilitate the taking of azimuth readings, a rotatable scale with an engraved line is provided over the scope face. When the engraved line is placed over a signal, the target azimuth is indicated on the scale. Target range is determined by the distance of the target signal from the center of the scope.

Eight fixed 10,000-yard electronic markers are provided on the 80,000-yard range. On the 30,000-yard range, instead of fixed markers a single electronic, movable range-marker is provided. This makes closer range estimates possible, for if the movable marker is cranked out to the target signal, the approximate range will be indicated on a dial. The movable marker may be used in selecting a target to be tracked on the tracking scope. If the movable range marker is brought into coincidence with a target signal and the antenna is positioned so that the target is in the line of sight, the target will appear near the center of the tracking scope when this scope is switched on.

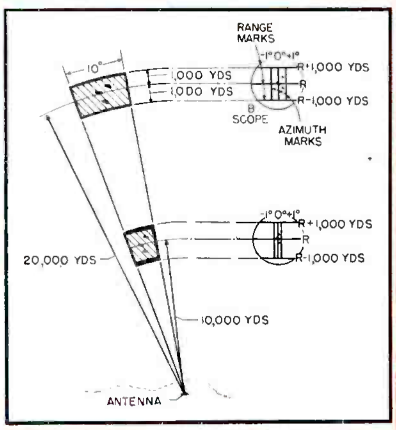


FIG. 6—A nearly distortionless map of the target area is obtained by means of azimuth expansion. Modified type-B presentation causes targets of like size and aspect to appear approximately the same on the oscilloscope screen regardless of their distance from the radar

TABLE I

CHARACTERISTIC	GENERAL	
FREQUENCY	10,000 mc (3 cm)	
POWER OUTPUT	35 kw peak, 35 watts average	
BEAM WIDTH (½-power points on transmitting beam)	0.6 degrees in hor. plane, 3 degrees in vert. plane	
ANTENNA GAIN	12,000	
TRANSMITTER	magnetron	
RECEIVER	superheterodyne	
Sensitivity	55 db below 1 mw	
Local Oscillator	klystron	
Intermediate Frequency	30 mc	
Bandwidth	10 mc (½-power points)	
Maximum Gain	1,000,000	
POWER CONSUMPTION (Complete equipment)	5 kva	
	SEARCH	TRACKING
PULSE REPETITION FREQ.	1024 cps	4097 cps
PULSE WIDTH	1 μ sec	0.25 μ sec
MINIMUM RANGE	200 yards	50 yards
MAXIMUM RANGE	80,000 or 30,000 yards	28,000 yards
RANGE ERROR	3% of max. range	Not over 20 yards
AZIMUTH ERROR	2 degrees	0.05 degrees

Tracking

An area 2,000 yards in depth by 10 deg in width is represented on the 7-inch tracking scope, as shown in Fig. 5. The center of this area corresponds to the intersection of the antenna line of sight with a circular arc, the radius of which is equal to the range represented by the PPI movable range marker. Type-B presentation is employed (rectangular coordinates) with range as ordinate and azimuth as abscissa. The range sweep starts near the bottom of the screen, the azimuth sweep at the left of center. Range and azimuth electronically-generated fiducial marks intersect in the center of the screen. The tracking operation consists of displacing the target signal until its front edge is centered at the crossed fiducial marks.

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* I. A. Getting, H. A. Straus, C. W. Miller, W. P. Manger, R. H. Caston, R. W. Illman, E. A. Holmes, A. E. Whitford, W. B. Coon, C. A. Wert, L. J. Rueger, E. Whitham, L. J. Chu, C. V. Robinson, H. Logemann, G. Hite, C. W. Sherwin, J. R. Niles, L. D. Smullin, R. V. Pound, F. T. Worrell, and D. B. Nichinson, all of the Radiation Laboratory, M.I.T.; M. Taylor, J. H. Taylor, P. De La Cova, R. J. Davis, A. R. Keskinen, J. B. Sherr, J. T. McNaney, S. J. Reisman, and A. E. Abel of the Bendix Radio Division; Lt. Col. J. J. Slattery, Capt. Vollum, Lt. D. M. Kerns, Lt. C. G. McMullen, W. B. Gould, W. B. Allison, R. A. Fletcher, F. W. Fisher and F. J. Kitty of the Signal Corps; Col. W. S. Bowen, Lt. Col. A. W. Clement, Maj. J. M. DuPare, and Sgt. L. A. White of the CAB; Lt. Col. M. B. Lampl, Army Ground Forces; Lt. Col. J. L. Dickey, USMC. This work was done under Contract Number OEMsr-262 under the auspices of the Office of Scientific Research and Development, which assumes no responsibility for the accuracy of the statements contained herein.

As long as the operators maintain the target signal in this position, accurate present-position data may be read from range and azimuth dials and transmitted electrically and by telephone to a gun data computer over a standard base-end transmission system. Range and azimuth-aided tracking machines with slewing and tracking controls are provided to permit smooth and accurate tracking.

Normal or expanded Type-B presentation may be selected by the operators. In the normal display, the range scale factor (in the vertical direction) is constant at 400 yards per inch, and the horizontal linear distance (on the tube face) representing 10 deg in azimuth is held constant regardless of range. With the expanded Type-B presentation, however, the scale factor in the horizontal direction is held constant at 400 yards per inch, resulting in an azimuth presentation which expands in direct proportion to range. As a result of azimuth expansion, signals from targets of the same size and aspect appear to be approximately the same size on the oscilloscope screen regardless of the target distance from the antenna. With this type of presentation, a nearly distortionless map of the target area is obtained as shown in Fig. 6. Since the useful length of the tube face is approximately 5 inches, only 2,000 yards can be shown in the horizontal direction; and for ranges in excess of 12,000 yards, the full 10 deg in azimuth can not be presented.

In addition to the fiducial markers, electronically-generated azimuth markers representing azimuth + 1 deg and azimuth − 1 deg, and range markers representing range + 1,000 yards and range − 1,000 yards, are presented on the tube face. A separate Type-B oscilloscope without expanded display is located at a remote point and is used in spotting fall of shot.

It is impossible to operate simultaneously the PPI and B-scope from synchronizing and video pulses originated by the AN/MPG-1. However, facilities are provided for simultaneously operating the B-scope and the PPI if synchronizing and video pulses and servo

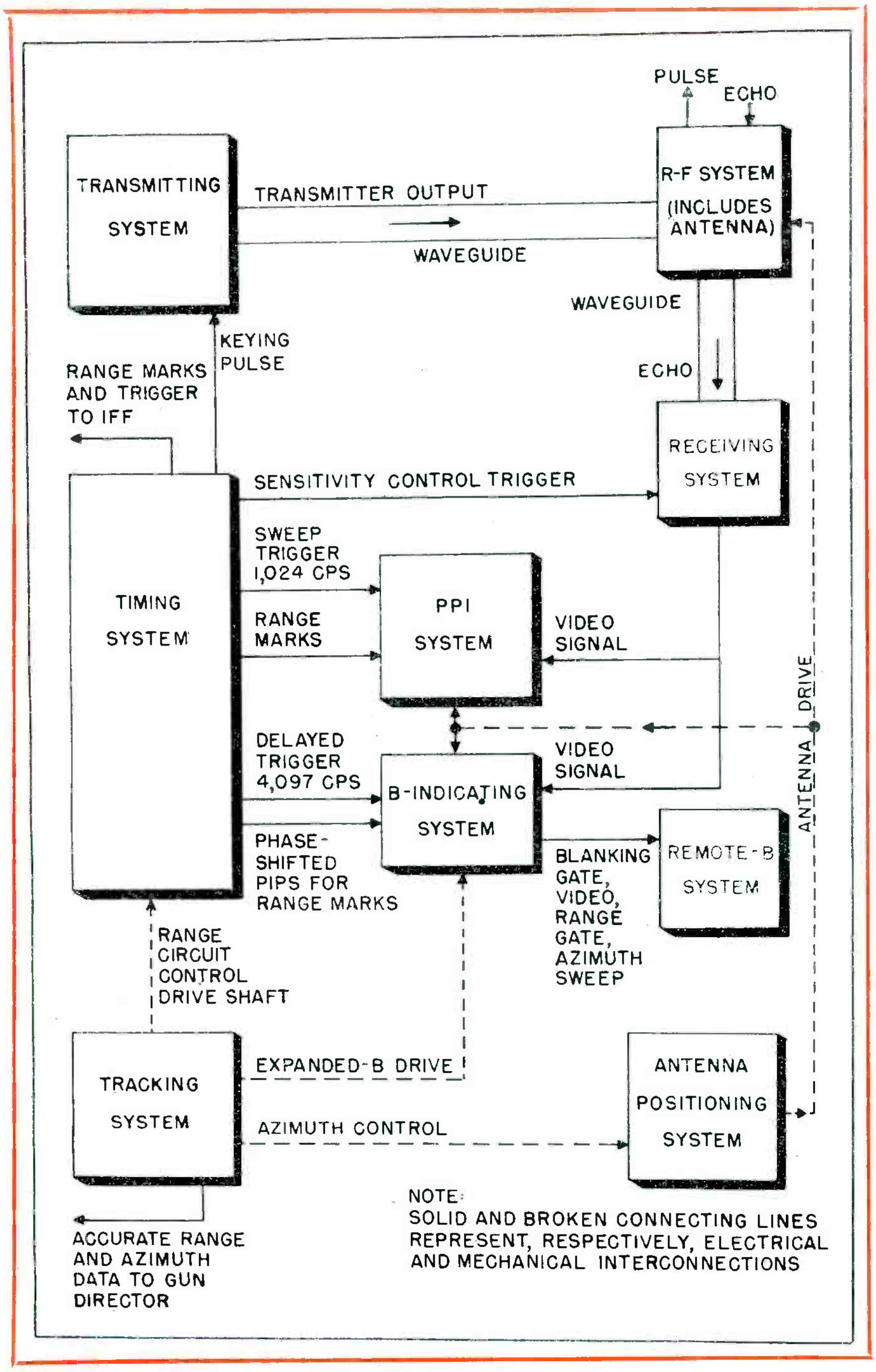


FIG. 7—Block diagram of the complete AN/MPG-1 radar, showing the nine major systems involved. Six of these are further broken down in the succeeding figures

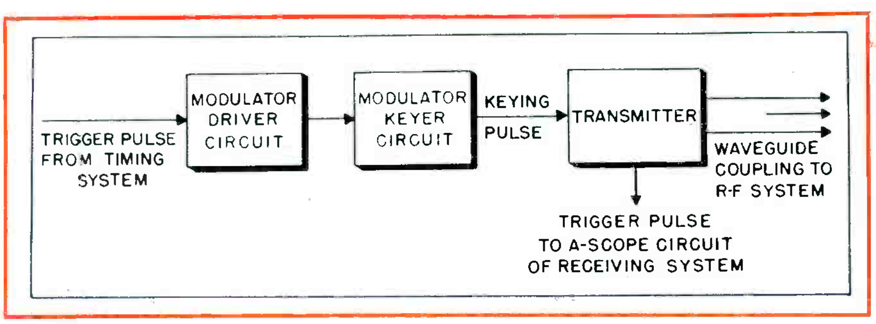


FIG. 8—The transmitting system, shown as a single block in Fig. 7

data are fed to the set from a remotely-located, separate-surveillance set. This makes it possible for the operators to accomplish general sector surveillance on the PPI while tracking specific targets on the B-scope.

Component Systems

For purposes of explanation, the AN/MPG-1 is best divided into nine systems, shown in block diagram form in Fig. 7. Block diagrams of the main groups of circuits within each system follow.

The transmitting system shown in Fig. 8, triggered by a pulse from the timing system, generates pulses of r-f energy which are radiated into free space by the r-f system. A rectangular voltage pulse (of one microsecond width when the PPI is used and ¼-microsecond width when the B-scope is used) is generated by the modulator driver circuit and applied to the modulator keyer circuit. A keying pulse (amplitude approximately −11 kv) is applied to the magnetron, which oscillates when the keying pulse is on. High-power, accurately timed, rectangular pulses of 3-centimeter energy are coupled to the r-f system by a waveguide.

The r-f system radiates the r-f pulses and feeds reflected energy to the receiving system. When properly adjusted, a coupling and matching device shown in Fig. 9 matches the transmitter impedance to the output. The duplexer, located in the receiver, contains the TR and anti-TR switch tubes which permit use of the same antenna for transmission and reception. Four waveguide feed arms, through which r-f energy is fed into the antenna, are provided in the rotating feed assembly. When the PPI is used, one of the feed arms remains fixed at the center of the antenna throat, and energy is radiated in the direction of the antenna axis. When the B-scope is used, the feed assembly rotates at a speed of 4 rps, resulting in 16 sweeps per second of the feed arms across the antenna throat. This action causes the emitted beam to sweep 16 times per second across a 10 deg sector centered on the antenna axis. The direction of the antenna axis is variable from zero degrees to 360 deg regardless of the type of presentation used. The antenna assembly forms the r-f energy into a narrow beam which is projected horizontally into space. Received energy is concentrated by the antenna assembly and fed to the receiver through the rotating feed.

The receiving system shown in Fig. 10 detects and amplifies the echo signals. A klystron local oscillator, a signal mixer and an afc mixer comprise a circuit which converts the received signal to an i-f signal of 30 megacycles. If the transmitter frequency drifts, the afc circuit changes the klystron repeller voltage, thus changing the local oscillator frequency by the amount needed to maintain a 30-megacycle i-f. The video output circuit detects and amplifies the i-f signal.

Pulse Timing

The timing system shown in Fig. 11 contains the synchronizing circuits for the entire radar set. Two outputs are obtained from the crystal oscillator and phase-shifter circuit; a 163.88-kc reference sine-

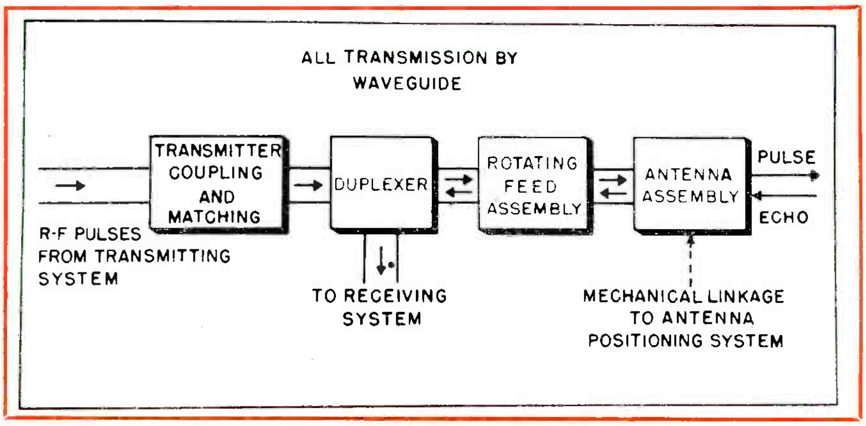


FIG. 9—The r-f system

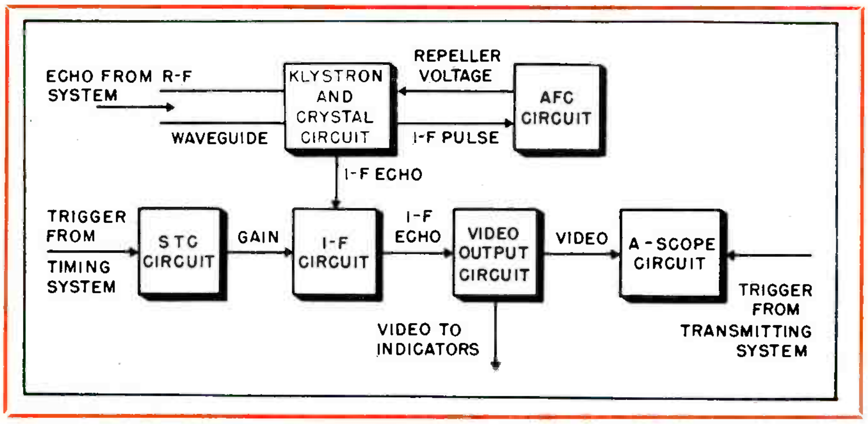


FIG. 10—The AN/MPG-1 receiving system

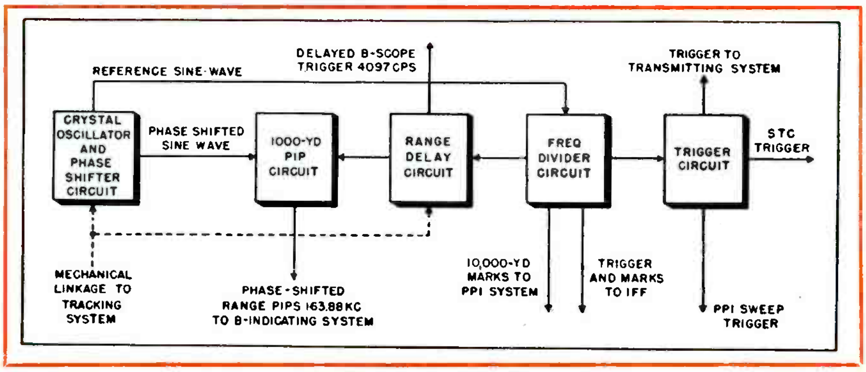


FIG. 11—The timing system

wave and a phase-shifted sinewave of the same frequency. The phase difference between these two sinewaves is proportional to the range tracking dial setting. Pulses recurring at a rate of 163.88-kc are derived from the phase-shifted sinewave and fed to the B — indicating system, where they are formed into 1,000-yard range markers. The time interval between two successive 163.88-kc pulses is equal to the time required by a radar pulse to make a round trip to a target 1,000 yards from the antenna. The 2,000-yard B-scope presentation, covering an area anywhere from zero range to 28,000 yards, is made possible by the range-delay circuit which provides delayed B-scope range-sweep triggers. The delay is proportional to the range-tracking output and is the means whereby the 2,000-yard B-scope area is moved in range. By means of this circuit the position of the movable marker on the 30,000-yard PPI also is made dependent on the range tracking output. Synchronizing triggers required for the radar set are derived from the reference sinewave.

The PPI system shown in Fig. 12 is used for general sector surveillance and selection of targets to be tracked on the B-scope. A synchronizing trigger is applied to the sweep circuits either from the timing system or a separate radar set. Besides generating the sweep voltage, the sweep circuit provides a switching gate for a remote range marker circuit which is operative only when the radar receives PPI data from a separate search set. The remote range marker circuit produces 10,000-yard markers for the 80,000 and 30,000-yard displays. However, the local range marker circuit provides 10,000-yard markers for the long-range PPI and a movable marker for the short-range display. Synchronized with the antenna through the servo circuit, the PPI deflection yoke always takes a position such that the direction of the range sweep indicates the direction of the emitted pulse.

The B-indicating system shown in Fig. 13 provides a rectangular map of a 2,000-yard by 10 deg sector centered anywhere within the tracking range of the set. The

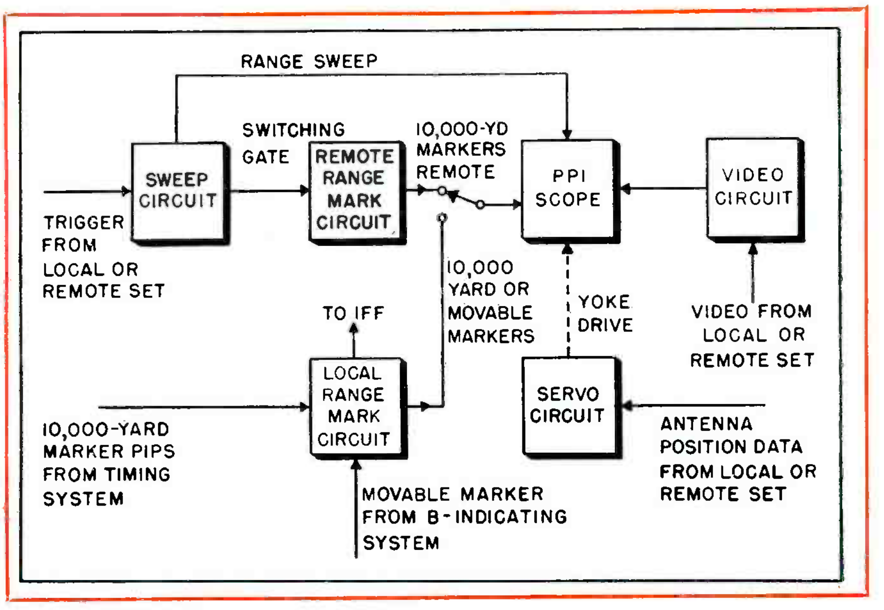


FIG. 12—The PPI system

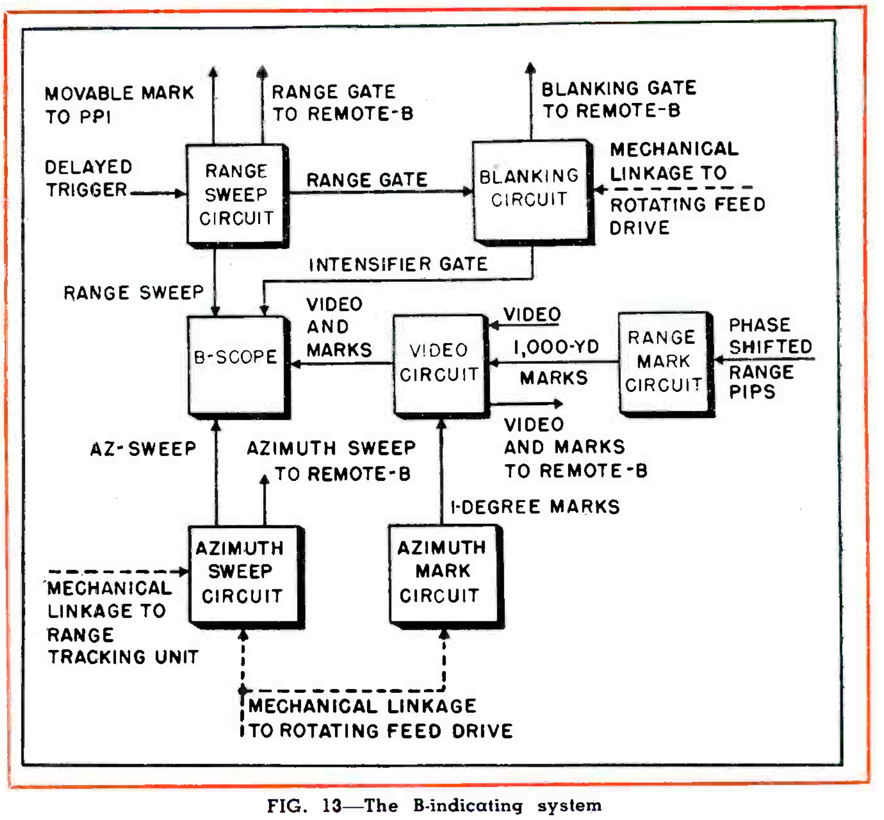


FIG. 13—The B-indicating system

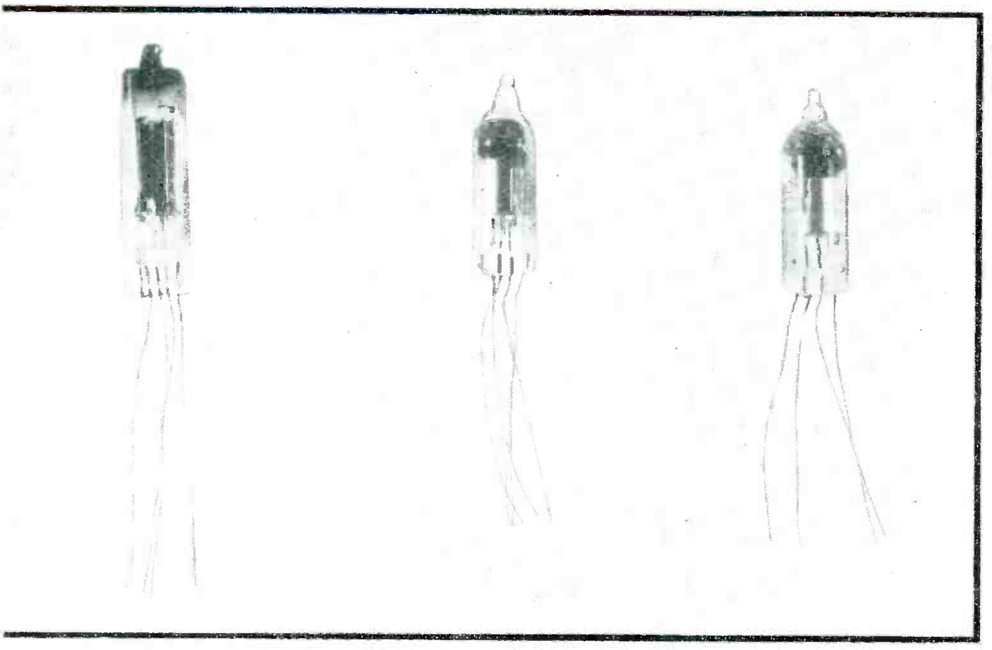
azimuth sweep, markers and blanking gate circuits are mechanically coupled to the rotating feed drive. Received signals intensify the range-sweep traces. During the range-sweep fly-back interval, the B-scope is entirely blanked out. Expanded azimuth presentation is obtained through mechanical linkage to the range tracking unit.

By means of the antenna positioning system, the antenna is made to slew or scan on PPI or to slew or track on B-presentation. The tracking system provides aided or manual tracking in range and azimuth.

A special spotting mechanism is provided in the remote-B system that allows an operator to read range and azimuth deviations of the center of impact when he places curcors over the shell-splash signals. By this means the center of impact of succeeding rounds is made to fall directly on the target, and the military function of the set is fulfilled.

Generator-Powered

An electronic detonator. Wind-vane drives compact generator and arms projectile after safe interval of flight. Careful design of miniature r-f oscillator, feedback amplifier and thyratron circuits locates burst point at optimum position



Fuze tubes, shown approximately actual size. At the left is a triode, in the middle a pentode, and on the right a thyratron

THE GENERATOR-POWERED proximity fuze for airborne rockets, developed at the National Bureau of standards under the joint sponsorship of OSRD and Army Ordinance, is another example of the electronic detonating technique described in ELECTRONICS for November 1945. With the advent of the proximity fuze the saying "a miss is as good as a mile" is no longer true, because it has now been found that near misses can frequently be ten times as effective as direct hits.

Fuze Characteristics

The fuze to be described contains within it a complete radio transmitter and receiver, amplifier, electronic detonator, wind-driven generator, and safety devices, arranged as shown in the block diagram of Fig. 1. The rocket itself, together with an insulated ring mounted on the nose, serves as the transmitting and receiving antenna. An equivalent antenna and feed system are indicated.

When the rocket is fired its acceleration releases a safety latch which permits the power vane to rotate in the air stream. The vane turns the generator at about 40,000 rpm to supply filament, plate, and bias voltages. It also drives a gear train which connects the firing circuit after the fuze has traveled a predetermined distance, termed safe air travel. The fuze can be set for any desired value of safe air travel greater than a certain minimum. This arming method insures that the fuze is always well away from the launching aircraft before it becomes active.

Within a fraction of a second after the rocket has been fired, the fuze circuit warms up and all transients die out. By the time the safe distance has been traversed arming is completed, and the fuze is ready for operation.

Fuze Radiation Reaction

Assume that the fuze transmitter is in operation and that the rocket has come close enough to its target to receive appreciable reflected signal. The rocket sends out a continuous wave, part of which is reflected back to establish a small voltage in the antenna. This voltage is proportional to the antenna current but not necessarily in phase with it. The presence of the reflecting target thus has the effect of changing the antenna impedance by an amount Z such that $Z = e/I$ where I is the antenna current and e is the instantaneous voltage due to the reflected radiation.

As the distance to the target decreases, two things happen: The size of e increases as the reflection becomes stronger and the phase between e and I changes by 180 degrees each time the target distance is reduced by a quarter wavelength.

The simple vector picture of Fig. 2 shows what goes on as the fuze approaches the target. Here Z_0 represents the antenna input impedance (usually resistive as the antenna is tuned to resonance), when there are no reflectors near by. The impedance due to the reflector is

Proximity Fuze

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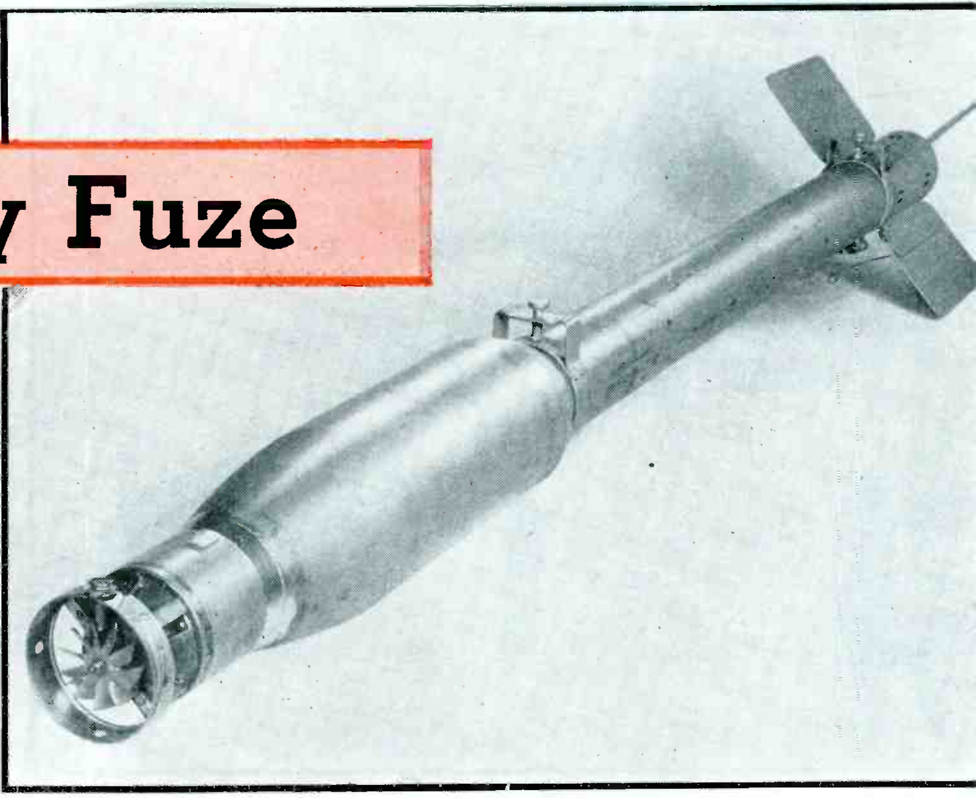
Washington, D. C.



Rocket armed with generator-powered electronic fuze

represented by Z. As the fuze approaches the target the end of the Z vector traces a spiral shown by the dotted curve. The total antenna impedance thus varies periodically from minimum (point A) to maximum (point B) going through one cycle each time the path shortens by $\lambda/2$. If the velocity of the fuze toward the target along the line joining them is v, then

$$f = \frac{v}{\lambda/2} = \frac{2v}{\lambda} \qquad (1)$$

where f is the rotational frequency of Z. This frequency has been called the Doppler frequency because the same result is obtained if the difference between transmitted frequency and received frequency is calculated, taking into account the relative motion of fuze to target.

For small reflections the value of I (antenna current) is little affected by e (voltage due to reflection) and we can say that the size of Z is determined by e alone. The reflected voltage is determined by four factors: The reflecting power of the target, the distance to the target, the amount of radiation directed toward the target, and the

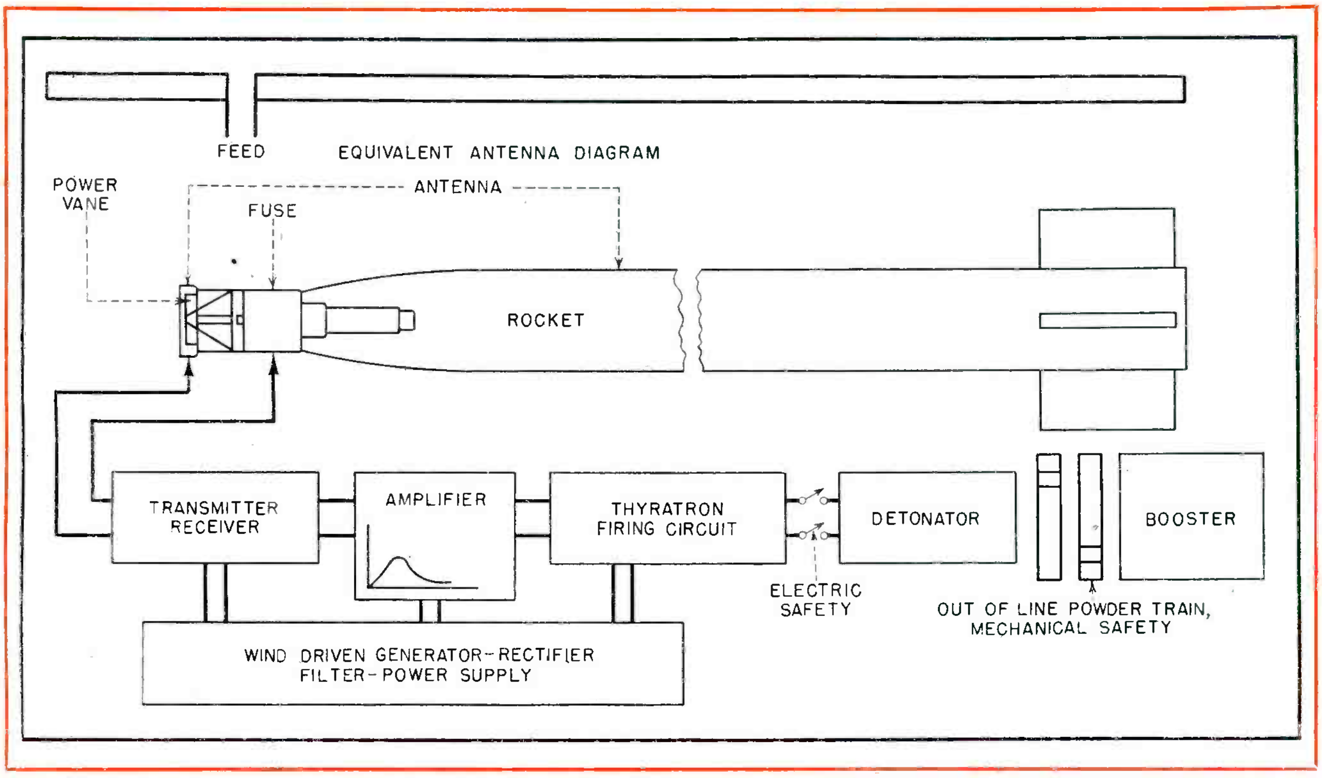
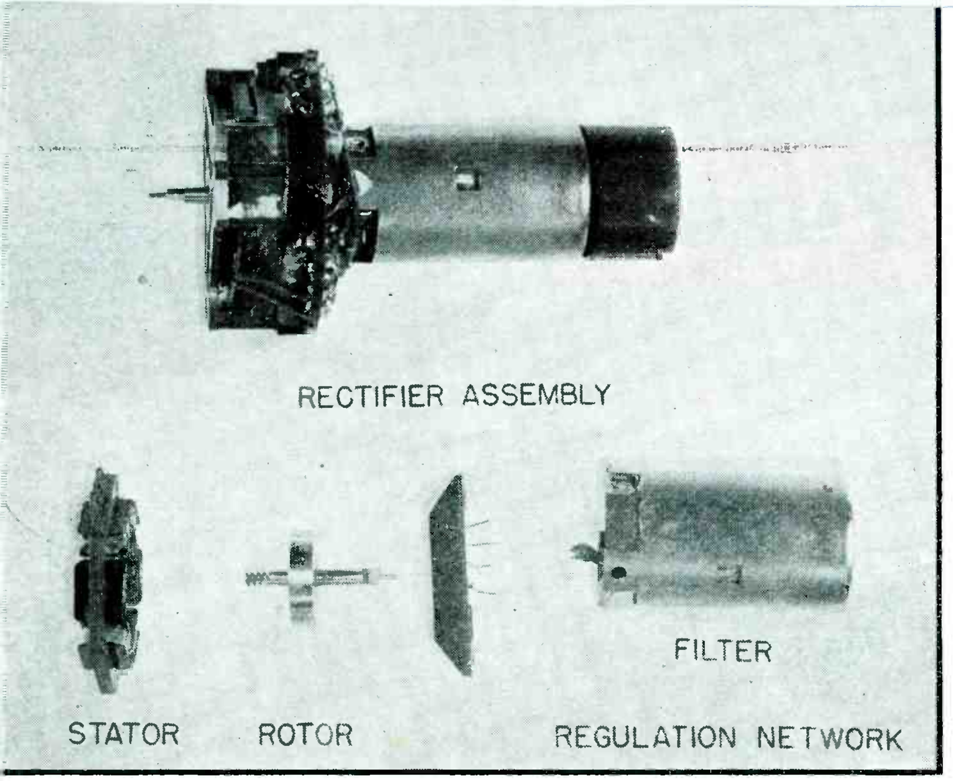


FIG. 1—Block diagram, showing at the top that the rocket constitutes a near-end-fed antenna. The electronic fuze fits into the nose of the rocket, and operates as shown to ignite a booster which fires the explosive charge



Separate parts of the wind-driven generator power supply for electronic fuse

receiving properties of the antenna for waves reflected back from the target. The first factor has been experimentally determined and found to be adequate. The second depends upon field strengths from antenna and target which decrease with increasing distance. The remaining two need further explanation.

Antenna Impedance Variation

The amount of radiation reaching the target is determined by the radiation pattern of the rocket antenna and the power radiated. Because an antenna has the same directional properties when used for receiving or transmitting, the radiation pattern is the same in each case. The square of the radiation pattern and the total radiated power thus determine the size of Z. In fact, it can be shown that the total radiated power is so related to Z_0 that Z is proportional to R_A, the resistance component of Z_0, no matter what the radiated power may be. Finally, then, the size of Z is determined by R_A and the radiating properties of the antenna, other things being equal.

The square of the radiation pattern is called the directivity pattern, the figure-eight loop around the rocket in Fig. 3 being the envelope of a typical pattern. The actual directivity envelope in space is a figure of revolution about the axis of the rocket, roughly a dough-nut-shaped figure. This envelope shows how well the fuze sees targets in various directions. With the figure-eight envelope the fuze sees mainly to the sides and not at all straight ahead, thus good shots are not detonated before they reach the target.

Figure 3 represents the situation when a rocket passes an airplane. The dotted curve plotted along the rocket trajectory and marked M-wave represents the idealized resistance component of Z at successive points.

Now $v = V_0 \sin\theta$, and $f = (2v\sin\theta)/\lambda$ if V_0 is the speed of the rocket in a coordinate system attached to the target. As the fuze approaches the target the size of Z grows rapidly because the distance shortens and the directivity improves. The rotation of Z slows down from the value $f = 2v/\lambda$ at large distances to the value $f = 0$ at the instant $\theta = 0$.

This analysis indicates that the characteristics of the reflected impedance are rapidly growing amplitude and rapidly falling frequency as the fuze approaches, and the reverse as it passes beyond the target.

Utilization of Varying Antenna Impedance

Advantage is taken of the combined increase in amplitude and decrease of frequency to cause the burst to occur in the ideal position. By incorporating proper shaping in the amplifier, the overall effective directivity pattern is made much

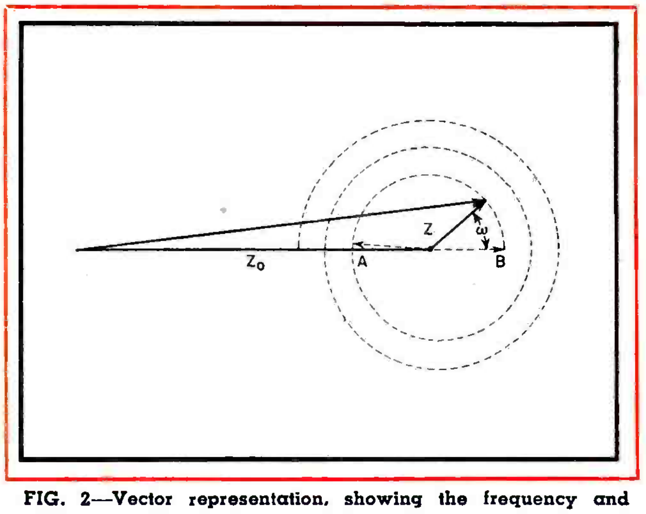


FIG. 2—Vector representation, showing the frequency and amplitude changes of antenna impedance

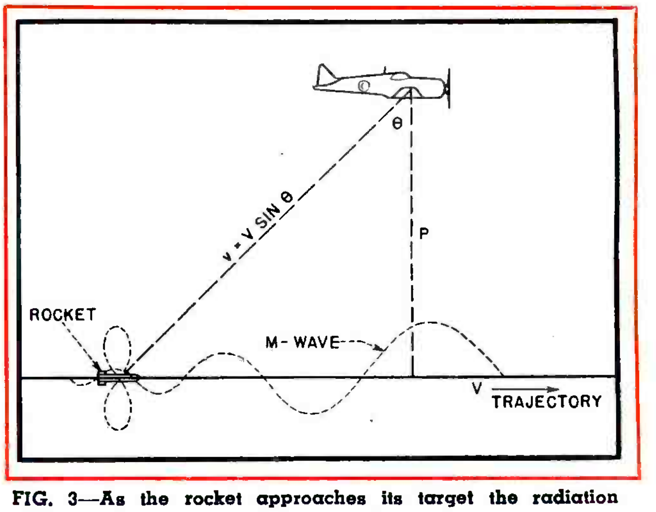


FIG. 3—As the rocket approaches its target the radiation resistance varies

sharper than that due to radiation alone. Figure 4 indicates the effect. By combining amplifier characteristics and radiation characteristics it is possible to draw an effective directivity pattern which is a locus of burst points.

To obtain proper operation, it has been found by experience that the fuze must burst when Z is a very small fraction of R_A. The fact that the fuze operates on a percentage change in antenna impedance implies that fuzes will function at a certain distance from a reflector without regard to the power radiated. Although fuzes have been made which work over a range of power levels as large as 5000 to 1, high power is desirable because it produces strong signals, strong reflection, and reliable operation.

Sensitivity of Transmitter-Receiver

When the effect of the reflecting target is expressed as a change of antenna impedance as outlined above, it is easy to see how a single tube can transmit continuous waves, receive the reflected signal, and select the low-frequency component.

The oscillator shown in the functional block diagram of Fig. 5 sees a variable load which changes periodically from increased resistance to increased reactance to decreased reactance to decreased resistance. If the plate circuit of the oscillator is tightly coupled to the antenna, the small reactance changes will alter the frequency of oscillation with but little effect on oscillator performance. The changes in resistance, on the other hand, alter the power drain on the oscillator, and certain parameters associated with the oscillation will follow these load variations. Thus the detected output voltage will have in it an alternating component of frequency $f = 2v/\lambda$ which can be selected and used as a working signal.

The design of an effective r-f oscillator which will give a strong, stable response to small load changes is based upon a figure of merit known as the sensitivity S and defined by the relation

$$\Delta V = S \Delta R_A / R_A$$

where ΔV is the change in detected output voltage, ΔR_A is the

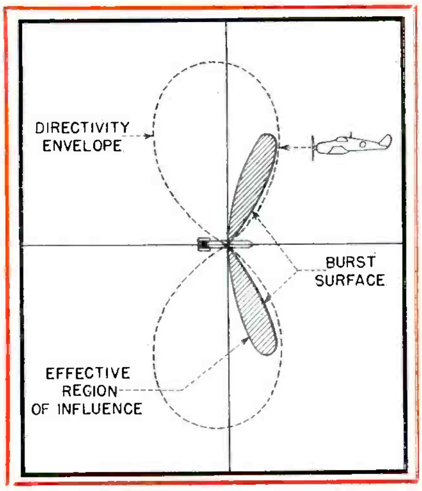


FIG. 4—By means of wave-shaping circuits in the fuze amplifier the effective influence region is modified as compared with the radiation pattern

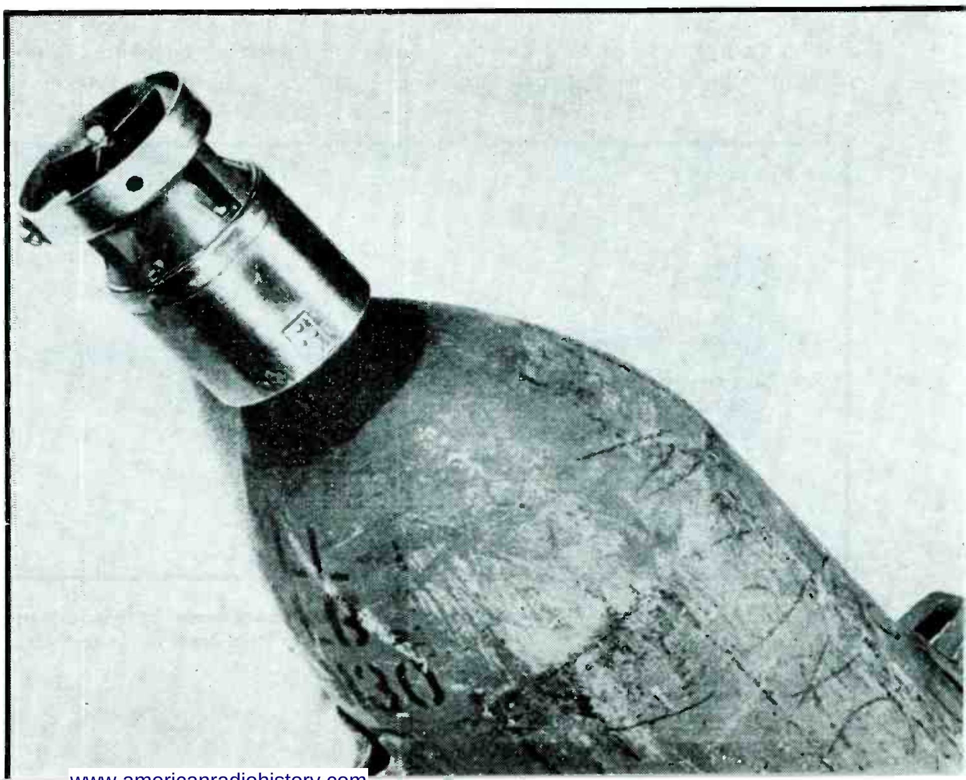
resistance component of Z, and R_A is the resistance component of Z_0. Usually R_A is equal to Z_0 because the antenna circuit is tuned to resonance.

To predict the performance of a transmitter circuit a typical curve of V vs log R_A is plotted as in Fig. 6 for various values of R_A. The slope of this load curve gives the values of S for small values of $\Delta R_A/R_A$ corresponding to the radiation resistance R_A of any antenna that may be connected to the r-f circuit. The curve labeled S shows the sensitivity of the circuit at each value of R_A. It is important to note that S is relatively independent of R_A over a large range. This independence of S with load changes means that the circuit is usable on a variety of antennas. The particular oscillator selected combines high efficiency with a large stable S which is relatively independent of tube parameters and load resistance.

One of the most important problems to be overcome in fuze production was the design and development of a triode oscillator tube that would give good power output with relatively small plate supply voltage, have a good S value, and operate in a simple circuit so stable microphonically that the small available signal would not be masked by vibration of the projectile during its flight at supersonic velocities. The resulting tube is similar in appearance to a standard hearing-aid type but more rugged in construction. In rocket applications, tubes are subject to accelerations of only 30 to 150 g, but the tubes developed to withstand the vibrations encountered were found sufficiently rugged for use at accelerations as high as 10,000 g.

Owing to limited space, highest efficiency of the oscillator is necessary to insure strong reflected signals and reliable operation. For small reflections, Δ_r is proportional to ΔR_A and the M-wave (Fig. 3) can represent the approximate wave

Bomb armed with electronic proximity fuze. It detonates above the ground, spraying fragments into dugouts and gun emplacements more effectively than contact-detonated bombs



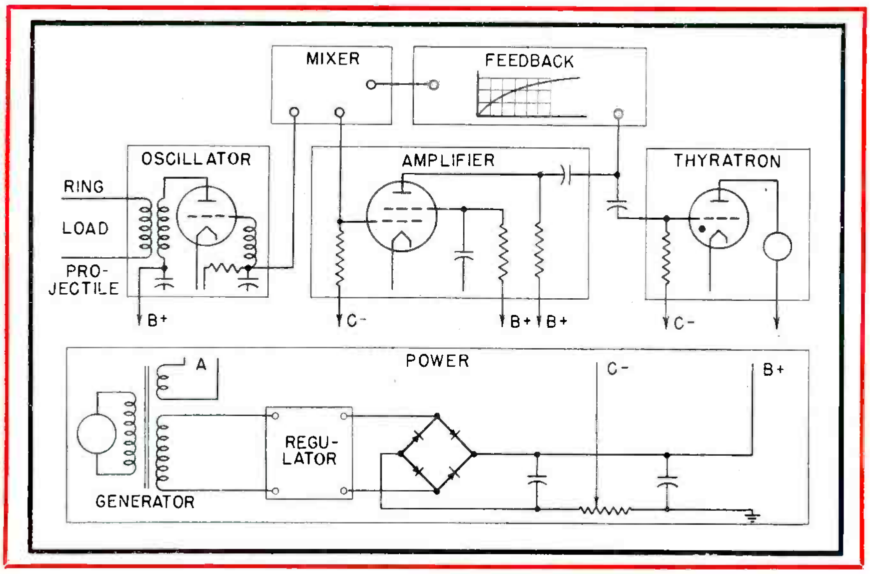


FIG. 5—Break-down of typical radio fuze circuit

form into the amplifier, as well as the variation of antenna impedance.

Signal Amplifier

Because the signal from the r-f section is too small to actuate a firing device directly, it is necessary to amplifiy it until it can reliably operate a thyratron.

The amplifier also performs important secondary functions. The shape of its gain characteristic assists the directivity pattern in properly locating the point of burst, and much of the tube microphonic noise, and filament a-c hum are suppressed by proper design. It is possible to make a single tube perform all these functions although there are limits to the amplification that can be obtained stably by a single tube while performing all of them. Dependence is placed upon the high stable S of the oscillator and, for discrimination, upon feedback.

The amplifier (Fig. 5) is conventional in every respect, using a small tube especially designed for high gain. The feedback network gives regenerative feedback at the desired frequency plus high degenerative feedback at high frequencies and no feedback at low frequencies. The consequent sharp cut-off at noise frequency suppresses tube microphonics and hum.

Hum Problem

Currently available heater-type tubes warm up too slowly and are more microphonic than the filamentary type, so directly heated filaments are used. Because of generator design requirements, a-c is used on these filaments, thus creating a very serious hum problem.

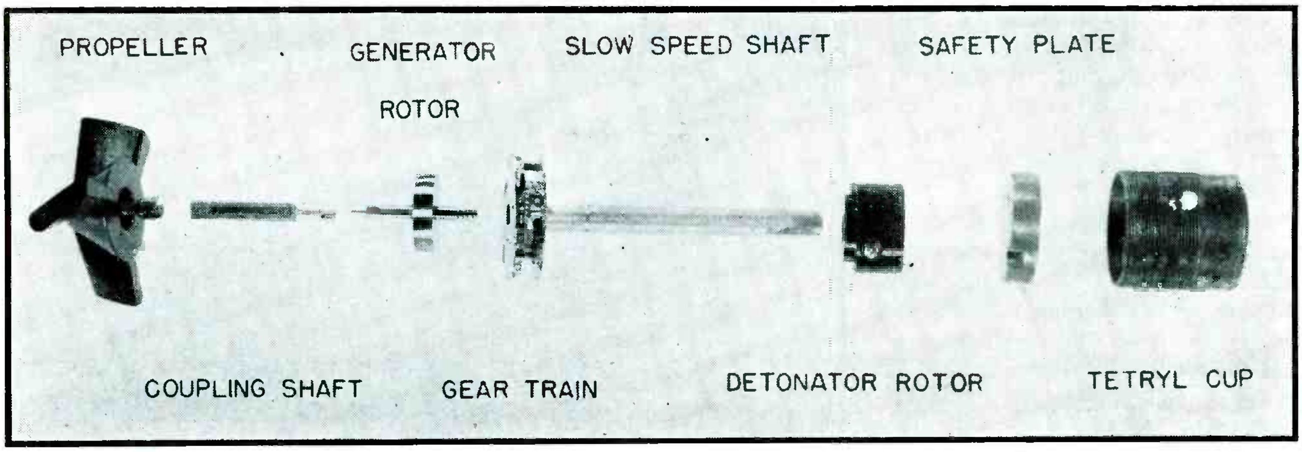
The r-f section puts out hum at filament frequency with an amplitude many times larger than the working signal which must be separated from it. If discriminating networks are connected to the output of the amplifier, it is overloaded by the larger hum input and the gain at signal frequency is greatly reduced. Discrimination at the input is possible but requires considerable circuit complexity.

So the amplifier is made strongly degenerative at hum frequencies. Thus, to suppress one volt of hum input, the amplifier only has to generate slightly more than one volt output which is fed back out of phase to the input where it cancels the hum from the r-f section. The net result is amplification at signal frequency very much greater than at hum frequency. The output signal-to-hum ratio is thereby made high enough to provide an ample margin of safety for proper operation.

Every stage in the fuse circuit must operate at its optimum power efficiency. Although there is more than sufficient power to drive the generator, the limitations of space prohibit a large generator. Also the number of separate stages that can be added is restricted.

Burst Location

The frequency of maximum gain is selected by trial to give proper burst location. As the fuze approaches the target the frequency first received is too high and the gain too small to actuate the de-



Safety devices, operated in sequence, by wind-driven propeller shaft, arm fuze after a rocket is fired from under the wing of an airplane tonator. When it gets closer the output of the detector increases because the target is in a better position to be seen, and the frequency is lower where the gain is higher. The combination of these factors makes the region of influence around the fuze more sharply defined than the directivity envelope alone would indicate.

When the output from the amplifier exceeds its critical value, the fuze functions and bursts the projectile. The actual explosion is initiated by the discharge of the final capacitor of the filter through the thyratron and a detonator similar to a blasting cap. Thyratron bias is a factor in determining the location of the burst.

The detonator ignites a powder train which in turn sets off the booster to explode the main charge. About one millisecond elapses between the firing of the thyratron and the moment fragments start leaving the projectile, during which time the missile has moved very little. Despite its small size, the thyratron is capable of repeatedly passing large peak currents, without changing its characteristics, allowing proper factory tests.

Power Supply

The use of a battery, even of the reserve type, seriously limits the utility of a rocket fuze. It must supply proper voltage after being carried aloft to very low temperatures (−40 C) and at present there is no acceptable battery which will meet both the severe temperature and space limitations. There is no spin and little acceleration in a rocket to actuate a reserve battery.

Because more power can be obtained for a given volume by using a generator than by any battery yet available, design of a small wind-driven generator was undertaken.

The power system consists of generator, regulator, rectifier and filter. The generator rotor is a small, permanent magnet and the stator is a series of coils. Separate filament and plate windings are provided. Raw a-c is used for all filaments. The plate voltage is rectified by a small selenium bridge rectifier and filtered by an R-C circuit. Bias voltage is obtained by the plate current drop in the filter and is adjustable to afford some compensation for production variation from generator to generator.

The large internal impedance of the generator serves two functions; it materially assists in the filtering action and it makes voltage regulation easily attainable. By adding a regulating circuit to the generator the variation of voltage with speed can be reduced almost to zero over a wide range of speed.

Figure 7 shows a typical speed-regulation curve. Achieving such a curve requires a careful selection of combined generator-regulator-filter parameters such that the best compromise on all values is obtained to reduce variations in mass production to a minimum.

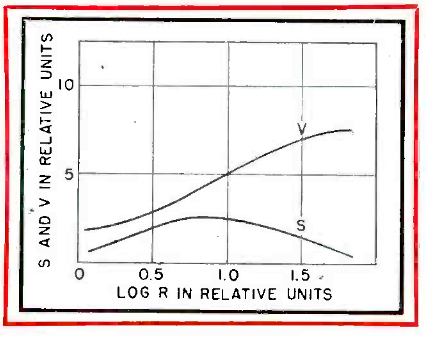


FIG. 6—Sensitivity varies so little that the fuze can be used in a variety of projectiles, i.e., with different antennas

An important secondary feature of the generator is its contribution to fuze safety. There is no power to actuate the mechanism unless it is flying through the air. Likewise, fuzes are inert once the generator stops spinning.

An incidental advantage of generator operation arises from the gear-reduction arming that can be readily incorporated. Long air travel-to-arming-time ratio is feasible if desired as it is in certain applications such as ground-to-ground firing of rockets or howitzers.

Safety Devices

In addition to driving the generator, the wind vane drives a gear reduction system to actuate the safety devices. By proper selection of the gear ratio any desired safe interval can be incorporated into the fuze. The slip of the vane is remarkably constant and the system can be used to adjust for any desired fixed air travel to the arming point.

As the propeller turns, a small, Bakelite rotor carrying the electric detonator slowly rotates. When it has turned so that it is in line with the powder train, the final connections to the circuit are completed and the rotor is disengaged from the shaft. The fuze is then armed and ready for action. Until then the detonator is neither in the circuit nor in line with the powder train, thus giving dual safety.

Production

The fuze must be small. Small tubes and small generators have been mentioned. Without other small components the device would still be impossibly large. The electronic industry has successfully supplied small resistors, capacitors, coils and rectifier cells; all strong, temperature resistant and vibration free.

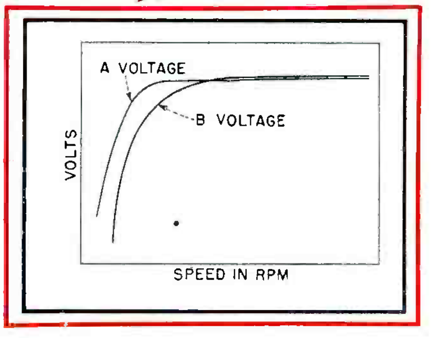


FIG. 7—Good regulation with varying generator speed is obtained by choice of generator and filter impedance

The production of fuzes required previously unheard of discipline at the assembly lines. One loose contact vibrating in response to noise can undo the work of the best components. Manufacturers responded magnificently in establishing mass-production facilities despite the stringent inspections and heart-breaking rejections which were necessary to maintain adequate quality in the final product.

This paper is based upon the work of the Fuze Development Staff, Ordnance Development Division, National Bureau of Standards, under the direction of Harry Diamond. The program was conducted under the sponsorship of Army Ordnance Department and Division 4, NDRC.

The SCR-584 Radar

Details of the r-f system and receiver of the outstanding anti-aircraft gunfire-control radar, including hitherto unpublished information on microwave plumbing, rotating joints, crystal mixers, t/r tubes, and gated i-f amplifiers. Operating principles and specifications were given last month

The radio-frequency pulses generated in the cavity magnetron of the SCR-584, as described in the first installment (ELECTRONICS, November, 1945, page 104), are conveyed to the radiator by a system of microwave plumbing and components known as the r-f system. The echo pulses received from the target are conveyed from the radiator to the receiver through the same system. In this article,

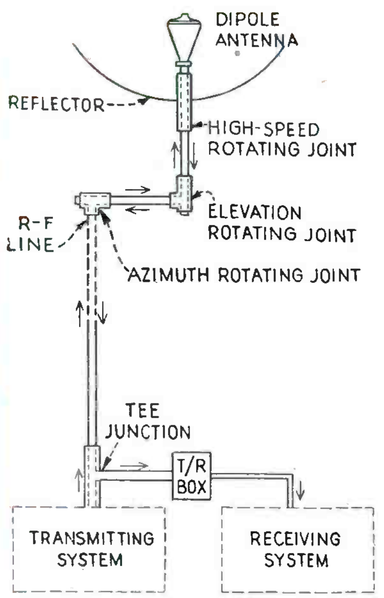


FIG. 1—Block diagram of the r-f system, by which the transmitted pulses and echoes are conveyed to and from the radiator

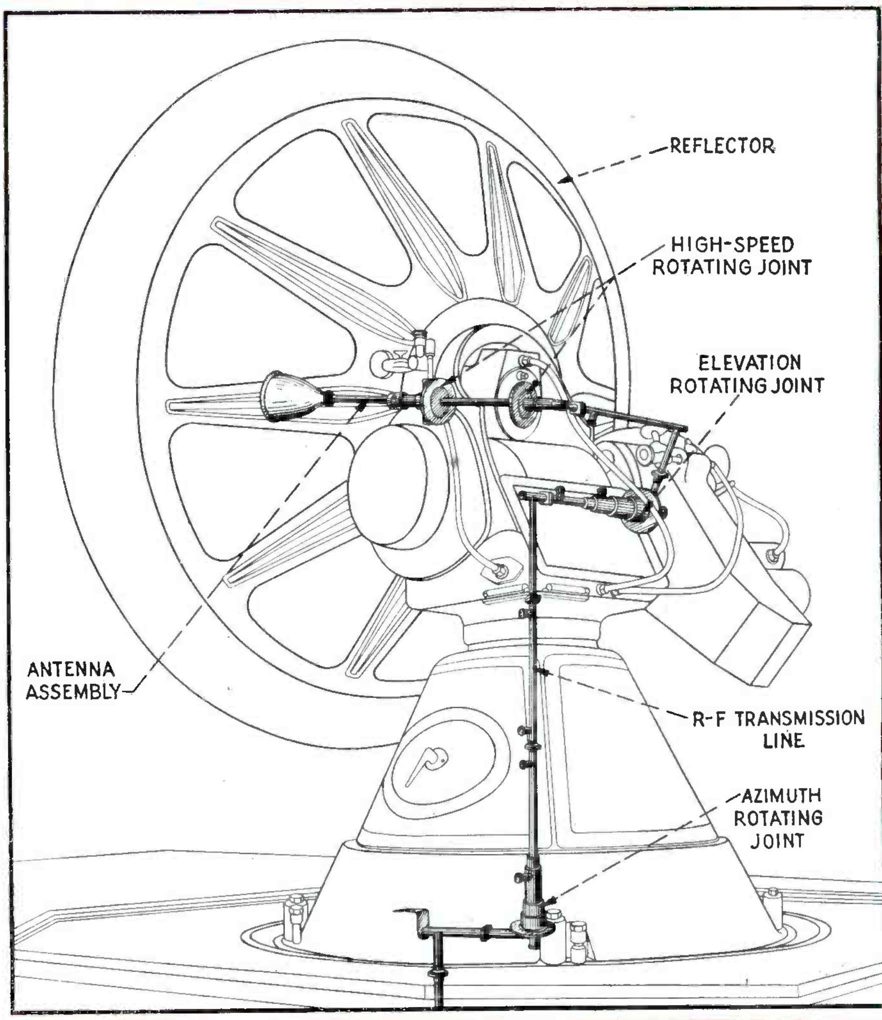
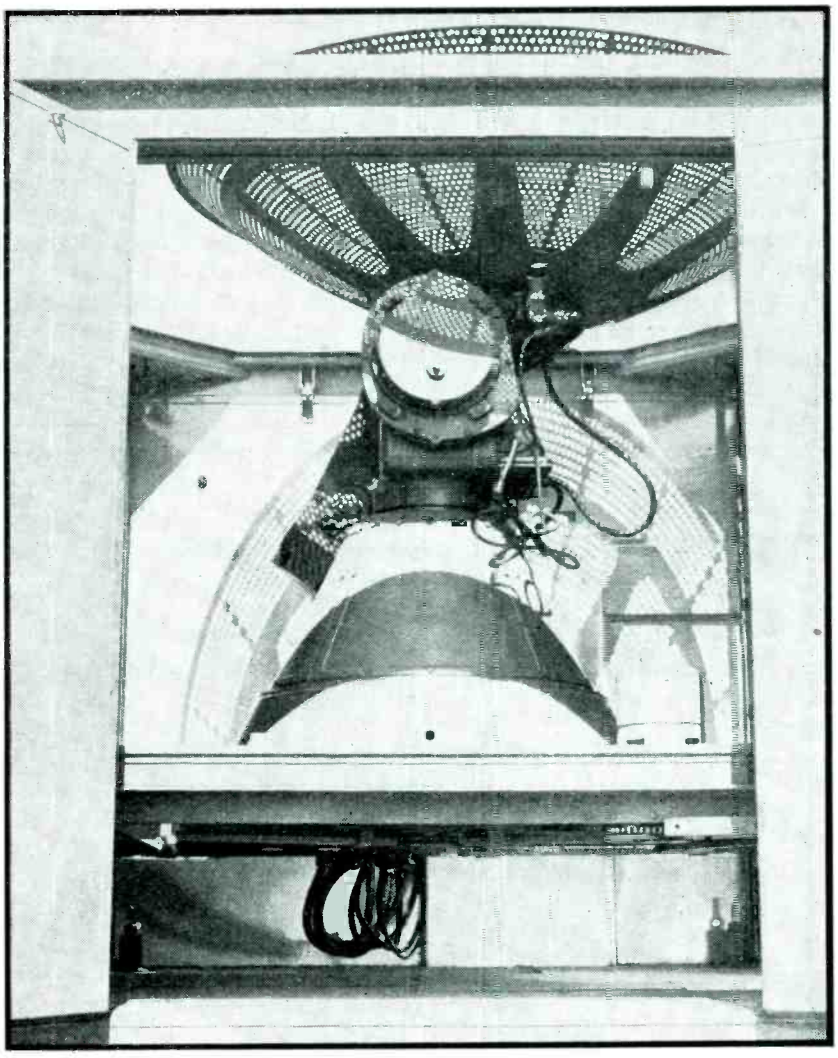


FIG. 2—Perspective view of the r-f transmission line and rotating joints, from magnetron output to dipole radiator

Closeup of antenna and platform of radar set SCR-584, partly raised out of the trailer. When in operation, the platform is up flush with the roof of the trailer



the details of the r-f system and receiver are described.

Basic Functions of the R-F System

The essential components of the r-f system are shown in the block diagram in Fig. 1 and in perspective in Fig. 2. As the r-f pulse leaves the transmission system it encounters a T-junction, which joins three coaxial lines. One branch leads to the radiator. En route the signal passes through three rotating joints. These joints permit the radiator to move in azimuth and elevation for helical scanning, and permit the dipole radiator to be spun about the axis of the paraboloid, for conical scanning.

The remaining branch of the T-junction leads to the receiver. In this branch the transmitted signal encounters the t/r (transmit/receive) box, a low-pressure gas discharge tube which breaks down and prevents passage of the strong transmitted signal to the receiver. At the conclusion of the transmitted pulse, the t/r gap deionizes, and the echo signals thereafter received are passed to the receiver. Coincidentally, the impedance of the cavity magnetron changes, so that the echoes are reflected from the transmission system with but minor loss due to absorption.

The transmission lines themselves are of the coaxial variety, with the inner conductor supported at intervals by quarter-wave stubs. The diameter of the inner conductor is increased at the stub, and for one quarter wave on either side, to increase the frequency band over which the stub support introduces negligible loss. A typical stub support and a joint in the line are shown in Fig. 3. The rotating joints are shown schematically in Fig. 4. Each joint consists of quarter-wave overlaps between outer and inner conductors, within each of which is a small gap. The gap permits passage of the r-f energy, by capacitive action, while allowing free rotation of the joint about the axis of the line. Each joint is covered with a gas-tight seal which permits the lines to be filled with dry air under five pounds pressure.

Dipole Radiator

The dipole radiator is shown in Fig. 5. A plastic housing surrounds the assembly to contain the air under pressure. The coaxial line is surrounded, at the left, by a quarter-wave collar which converts the single-ended feed of the line to the push-pull feed required to excite the dipole. The inner conductor is built up to large diameter, as shown, thereby changing the impedance of the line so that it matches the impedance of the dipole. The dipole itself consists of two rounded projections, one soldered directly to the outer conductor, the other connected to the inner conductor and projecting through a hole in the outer conductor. The two segments of the dipole are of different lengths so the radiation from it is slightly assymetrical with respect to the axis line. As a result the axis of the beam is displaced from the axis of the paraboloid and as the dipole spins the beam traces out a cone

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(conical scanning, see part I).

At the right of the assembly is a metal disk which reflects the forward radiation from the dipole, returning it to the reflector. This forward radiation would otherwise be largely wasted since it would spread outside the limits of the beam. The coaxial line is shorted at the righthand end, at such a distance from the dipole that the signal reflected from the short appears in proper phase at the dipole to reinforce the radiated signal.

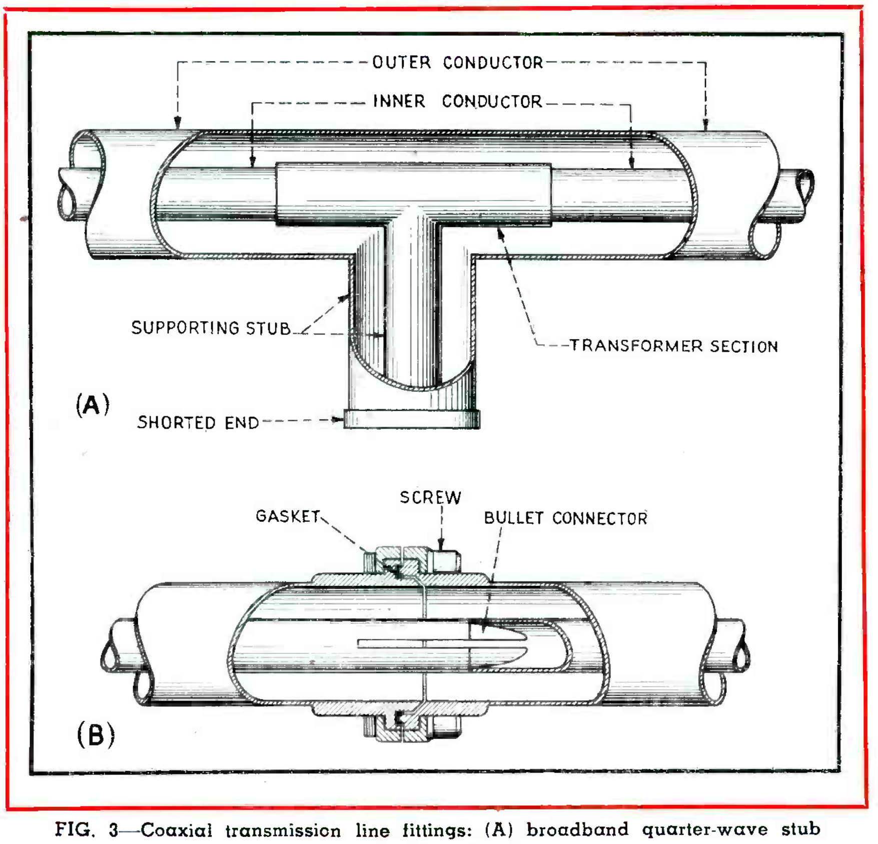


FIG. 3—Coaxial transmission line fittings: (A) broadband quarter-wave stub support; (B) in-line joint

Transmit-Receive Switch

The t/r box (Fig. 1) is a device which permits the use of the same radiator for transmission and reception. Its essential element is the t/r tube (type 713A) shown in Fig. 6. This tube comprises two conical electrodes supported on metal flanges which extend through the glass envelope and become part of a resonant cavity (Fig. 6A). The cavity is tuned by tuning plugs to resonate at the carrier frequency. Consequently when the transmitted signal appears at the cavity input (through a coupling loop), the cavity is excited, and a high potential appears across the conical electrodes. Sufficient free ions are present in the tube (supplied by an auxiliary keep-alive electrode within the tube) to permit almost immediate ionization of the gap. The breakdown short-circuits the cavity and detunes it so that the magnetic field within it collapses at once, and the signal is prevented from leaving the cavity via the output coupling loop. The tube is filled to a pressure of about 1 mm of mercury of water vapor, which ionizes in a few hundredths of a microsecond.

At the conclusion of the transmitted pulse, the gap deionizes (the recovery time is about 1 microsecond), and the cavity regains its tuned condition. Thereafter, when echo signals are received, they excite the cavity (but to such a low power level that the gap does not break down) and they are coupled through the cavity directly to the receiver input circuit of receiver.

In the discharge condition, the t/r box introduces an attenuation to the transmitted signal of over 60 decibels, which reduces the power from 300 kw to well under 100 milliwatts. This level is small enough to be harmless to the receiver but sufficient to excite the receiver so the transmitted pulse is visible on the type J range scope. The power consumed in maintaining the gas discharge is negligible compared to the 300-kw level of the transmitted pulse.

The Receiving System

A block diagram of the receiving system is shown in Fig. 7. The echo signal is passed by the t/r box directly to the crystal mixer, where it is combined with a local-oscillator signal 30 mc higher in frequency. The 30-mc intermediate frequency is then amplified in two i-f stages (preamplifier) which are mounted directly adjacent to the crystal mixer. The remaining i-f stages are located (for convenience) at some distance, in the receiver proper. After the fifth i-f stage, the i-f channel breaks up into two branches, one (the range channel) feeding the indicators, the other (servo channel) feeding the auto-tracking circuits.

The circuits of particular interest in the receiving system are those which convert the carrier frequency to the intermediate frequency. Care must be taken in these circuits to maintain the noise level as close as possible to the inescapable noise level introduced at the antenna itself.

Crystal Mixer

The three most serious sources of additional noise, in order of importance, are the crystal mixer, the i-f amplifier and the local oscillator. The first two i-f stages are located as close as possible to the mixer stage to avoid losses at low level in the connecting cable. By attention to such details it has been possible to keep the noise in the receiver output to within 15 db of the theoretical level present in the antenna circuit.

The multi-grid converter tubes

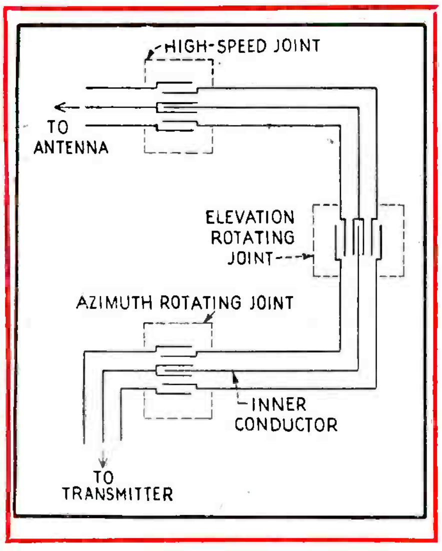


FIG. 4—Rotating joints. The r-f signal is transmitted past the air gaps by capacitive action

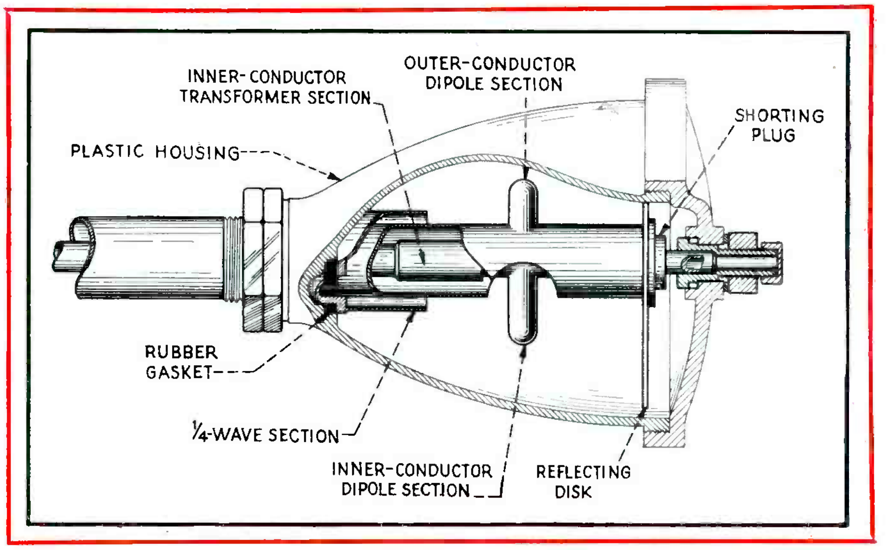


FIG. 5—Dipole radiator, transformer sections and reflector plate. A slight difference in the length of the dipole elements produces off-axis radiation for conical scanning

used in superheterodynes at lower frequencies are not suitable at microwave frequencies because of the noise introduced by random interception effects at the grid wires. The diode is accordingly chosen for microwave applications. The most efficient form of diode detector thus far uncovered is the silicon crystal. A slab of silicon, specially heat treated and etched, with a tungsten catwhisker bearing upon it, is mounted in a small cartridge and the whole assembly filled with a plastic compound.

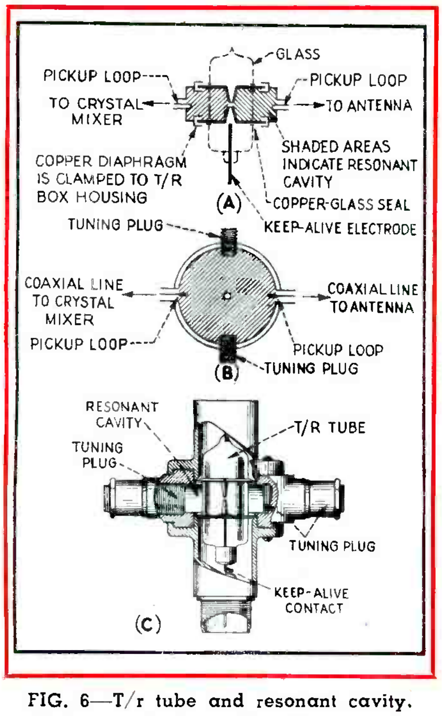


FIG. 6—T/r tube and resonant cavity. (A) Schematic view, side; (B) schematic view, top; (C) cut-away view

The cartridge is mounted in a housing, known as the mixer, shown in Fig. 8. The coupling loop at the lower left abstracts the received signal from the t/r box and passes it to the crystal. The local oscillator input, at a level of 25 to 50 milliwatts, is fed through the arm at the upper right, through a right-angle bend to a coaxial member whose inner conductor terminates near the crystal in a flat coupling plate. The level of the local oscillator signal is controlled by the screw adjustment until the rectified direct current passing through the crystal is about 0.6 ma.

The i-f output is developed between the base of the crystal cartridge and ground, and is fed out through the arm at the lower right to a flexible coaxial cable which connects with the i-f preamplifier. In the output line is placed a small metal cup, insulated from the outer conductor by a thin section of mica insulation. The capacitance thus formed acts as a short-circuit at carrier frequencies and thus prevents absorption of the r-f signal in the i-f amplifier. The capacitive reactance is, however, 100 times as great at 30 mc as at 3,000 mc, so the bypass has relatively little effect on the i-f components. The mixer has no tuned elements and is constructed to operate without adjustment over the range from 2,700 to 2,900 mc.

Local Oscillator

The generation of c-w power at 3,000 mc, even in the small amount

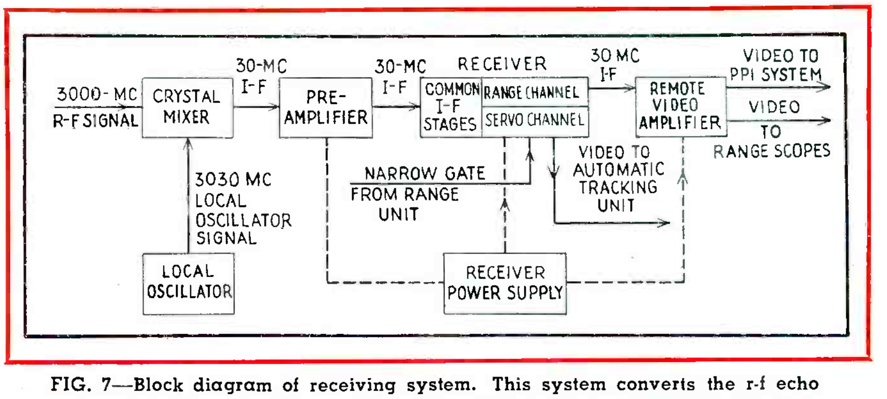


FIG. 7—Block diagram of receiving system. This system converts the r-f echo pulses at 3,000 mc to video pulses which actuate the c-r indicators and auto-tracking circuits

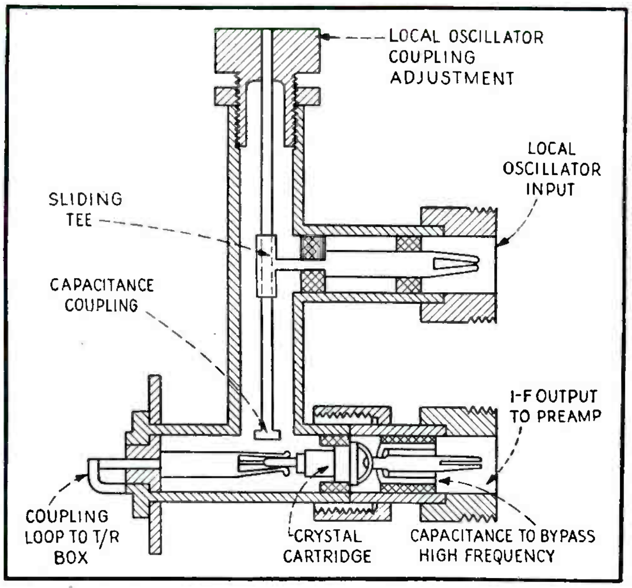


FIG. 8—Vertical cross-section of the r-f mixer. The local oscillator is loosely coupled to the silicon cartridge

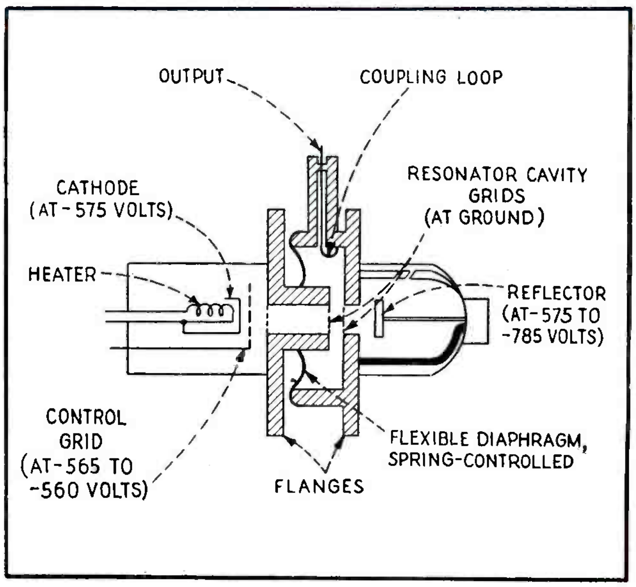


FIG. 9—Cross-section of the reflex klystron, used as a local oscillator in the receiver

required for local oscillator service, is a difficult task because of transit time limitations. To avoid these difficulties, the local oscillator tube employs the klystron principle to separate the effects of transit time from the oscillating circuit. The particular form of klystron used is a single-cavity type known as the reflex klystron, illustrated in Fig. 9. It operates as follows: Electrons from the cathode are formed in a beam and accelerated at about 575 volts. The beam passes within the center post of a cavity resonator and thence through two grids which are part of the cavity walls. The initial passage of the electrons causes a weak oscillation to be set up within the cavity, by shock excitation, and as a result the potential between the two resonator grids varies at the carrier frequency.

Electrons passing the gap thereafter find themselves alternately accelerated and decelerated by this variation in potential. On leaving the gap, the variations in electron velocity persist, with the result that the faster electrons catch up with those which pass unaccelerated, while the slower electrons fall back on the unaccelerated ones. In consequence, the electron stream becomes bunched, that is, more dense in spots and less dense in others.

Meanwhile the electron stream encounters a decelerating d-c field applied by the reflector electrode (about −700 volts). This causes the electron stream to reverse its path, while the bunching process proceeds, and to re-enter the resonator gap. If the velocity of the electrons and the reflector potential are properly chosen with respect to the wavelength and the dimensions of the tube, the bunched electrons arrive back at the resonator gap just as the potential across the gap is such as to cause maximum retardation of the electron bunch. The electron bunch thereupon gives up a portion of its kinetic energy to the resonator.

As the succession of electron bunches re-enters the gap, the oscillations are successively reinforced until equilibrium is reached between the energy abstracted from the cavity (via the coupling loop shown) and the energy input to the beam less losses within the tube. Power levels in the hundreds of milliwatts are readily produced.

The frequency of oscillation depends not only on the natural period of the resonator, but also on the phase with which the returning bunches enter the gap, and this phase may be changed by adjusting the voltage on the reflector electrode. This electrical method of tuning is employed to tune the receiver precisely to the transmitter frequency. The tube will oscillate at several values of reflector voltage; the most negative value is generally chosen. Care is taken to stabilize the accelerating and decelerating potentials applied to the klystron, to avoid electrical detuning. Care must also be taken to avoid feeding too great an output from the local oscillator to the crystal detector, since excessive power absorption by the crystal will injure the rectifying interface. The local oscillator is coupled very loosely to the crystal by the flat probe electrode shown in Fig. 8, not only to minimize this danger, but also to prevent absorption of the echo pulses in the local oscillator itself, which is tuned within 1 percent (30 mc at 3,000 mc) of the carrier frequency.

The I-F Amplifier

The i-f preamplifier is coupled to the mixer through a transformer, but thereafter the i-f stages are coupled by single tuned circuits, inductively tuned. The inductive element is placed in the grid of the following tube, rather than in the plate of the preceding tube, to minimize the resistance in the grid return, which would prolong recovery after overload. Type 6AC7 high-g_m pentodes are used. The avc voltage is applied to the grid of the second stage.

The output of the preamplifier is conducted through flexible coaxial cable to the remaining i-f stages in the receiver proper. A simplified schematic of the i-f, detector, and video circuits is shown in Fig. 10. The 3rd, 4th, and 5th i-f stages are substantially identical to the second stage, employing 6AC7 tubes with single-circuit inductively-tuned coupling. The interstage coupling is loaded with the plate resistance of about 850 ohms, producing a gain of about 7 per stage across an overall band of 1.7 mc. The 3rd stage has avc.

The sixth i-f stage is a dual unit, one tube feeding the remote video amplifier outside the receiver chassis, the other leading to a 7th i-f stage. This latter (servo) channel operates under gate control, that is, the 6th servo i-f stage passes signal only during a brief period corresponding to the time the desired echo is received.

The function of gating in the automatic tracking circuits will be evident from the following. When the radar views more than one target simultaneously, as may readily happen in antiaircraft activity, a separate sequence of echo pulses is received from each target. The automatic tracking circuits have no way of distinguishing between these sequences of pulses and they tend to move from one target to another, or to seek a position midway between targets.

To avoid this confusion, the radar operator must select a target and see to it that the radar follows that target to the exclusion of all others. The target is selected initially on the PPI indicator and then identified as a particular echo pulse on the type J range scopes. Thereafter the operator adjusts a control which keeps a hairline centered on the echo selected. The control is connected to a pulse-forming circuit which develops a narrow rectangular pulse (narrow gate pulse) which occurs just prior to reception of the desired echo.

The narrow gate pulse is applied, in positive polarity, to the screen grid of the sixth i-f stage in the servo channel. In the absence of the narrow gate pulse, the screen grid is grounded and this stage remains inactive. During the narrow gate pulse, however, the stage is suddenly activated and passes the signal to the succeeding i-f stage and thence to the detector, video and servo-control circuits. The width of the narrow gate is normally about 3 microseconds, and is thus capable of cutting off all echoes outside a segment of about 3,000 feet in the range coordinate. A recent modi cation of the equipment consists of the so-called N^2 gate (N^2 for narrow-narrow), in which the control gate is only 0.5 microsecond long, corresponding to a segment in range of about 500 feet.

One other precaution must be taken in the automatic tracking system. If the amplitude modulation on the pulse sequence (which arises from off-axis targets as a result on the conical scanning, see part I) is not of constant amplitude, the comparison between reference voltage and error signal cannot be carried out successfully. Consequently it is necessary to apply an amplified automatic gain control voltage to the 2nd and 3rd i-f stages. This voltage is obtained by passing the pulse sequence from the servo channel output to a diode detector which develops the peak value of the amplitude-modulated pulse sequence. This peak value is amplified through a cathode-follower stage and applied to the i-f stages.

The timing and indicating systems will be described in the concluding installment of this series.—D.G.F.

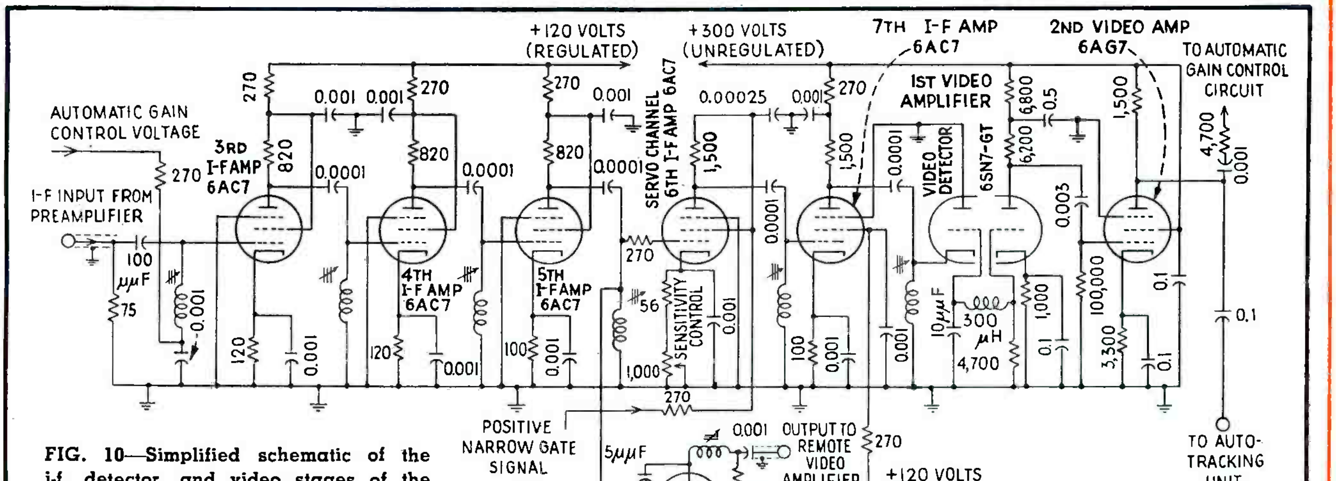


FIG. 10—Simplified schematic of the i-f, detector, and video stages of the receiver proper. These circuits are preceded by two i-f stages in a separate i-f preamplifier

Loran Receiver-Indicator

Circuit details and operation procedures of the navigator's equipment, which establishes the position of ships or aircraft by measuring pulse time differences, are described in this second article of a series

THE receiver-indicator of the Loran system, as stated in the first article of this series[1], measures the difference in the time of arrival of a pair of pulses, displayed on a c-r oscilloscope.

The oscilloscope sweeps are synchronized with the incoming pulses by an independent quartz-crystal oscillator adjusted by the operator to exact synchronism. The pulses are approximately 40 microseconds wide at the half-amplitude level. To match such wide pulses to an accuracy of one microsecond, it is necessary to superimpose the waveform of one pulse directly over the other.

The pulse-matching procedure is illustrated in Fig. 1, which comprises photographs taken directly from the screen of the Loran indicator. In Fig. 1A the horizontal traces are sweeps each approximately 20,000 microseconds long, synchronized at 25 sweeps per second, or 15,000 microseconds long at $33\frac{1}{3}$ pps. The upper trace is referred to as the master or A trace because on it is displayed the pulse from the master (A) station; the lower trace is the slave or B trace.

The pedestal on each trace represents a portion of the trace which is later expanded to reveal the pulse shape. The master pedestal is fixed in position at the left edge of the master trace. On it is displayed the master pulse. The slave pulse then falls somewhere to the right on the lower trace. The slave pedestal, whose position is adjustable, is moved until it falls directly under the slave pulse. These steps are illustrated in Fig. 1A through 1C.

When the set is first turned on, the pulses appear (Fig. 1A) in arbitrary positions, depending on the fortuitous phasing of the crystal synchronizing circuit relative to the incoming pulses. By slight adjustment of the crystal synchronizing frequency both pulses can be shifted left or right on the screen until the positions shown in Fig. 1B are found, i. e. with the master pulse on the master pedestal and the slave pulse below it and to the right.

The portions of the traces contained within the pedestals are then expanded (750-μsec sweep) by changing the sweep speed, with the result shown in Fig. 1D. By a fine adjustment of the slave pedestal control, the lower (slave) pulse is moved so that it falls nearly under the master pulse, and by adjustment of the crystal synchronizing control, both pulses are shifted to the left

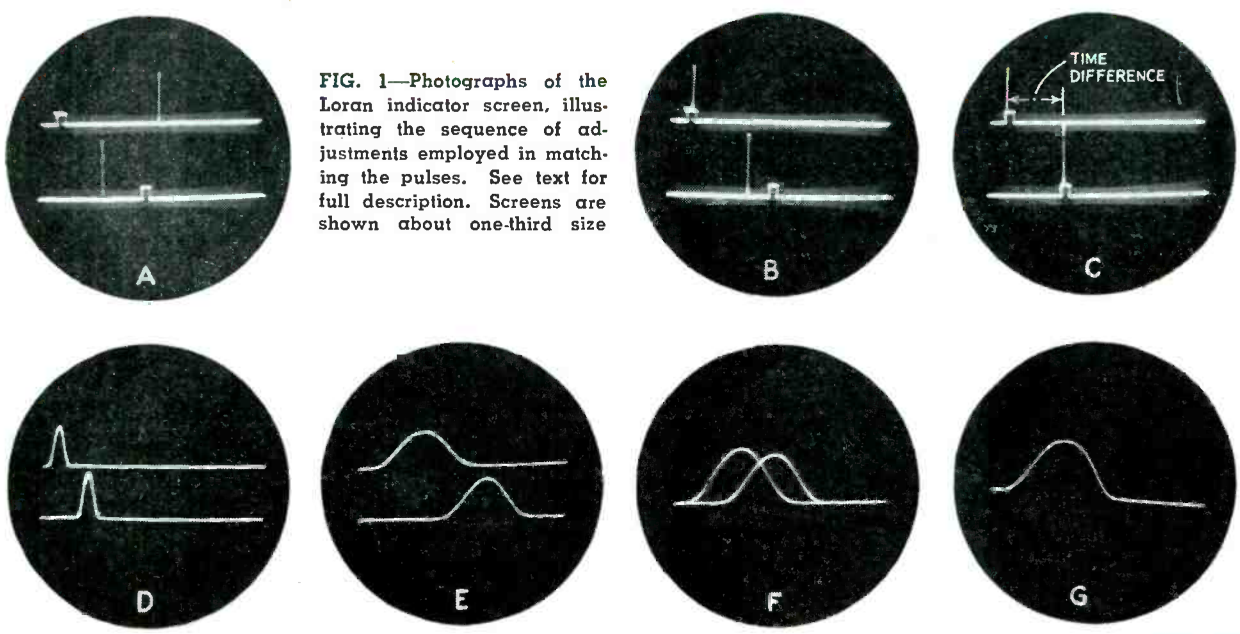
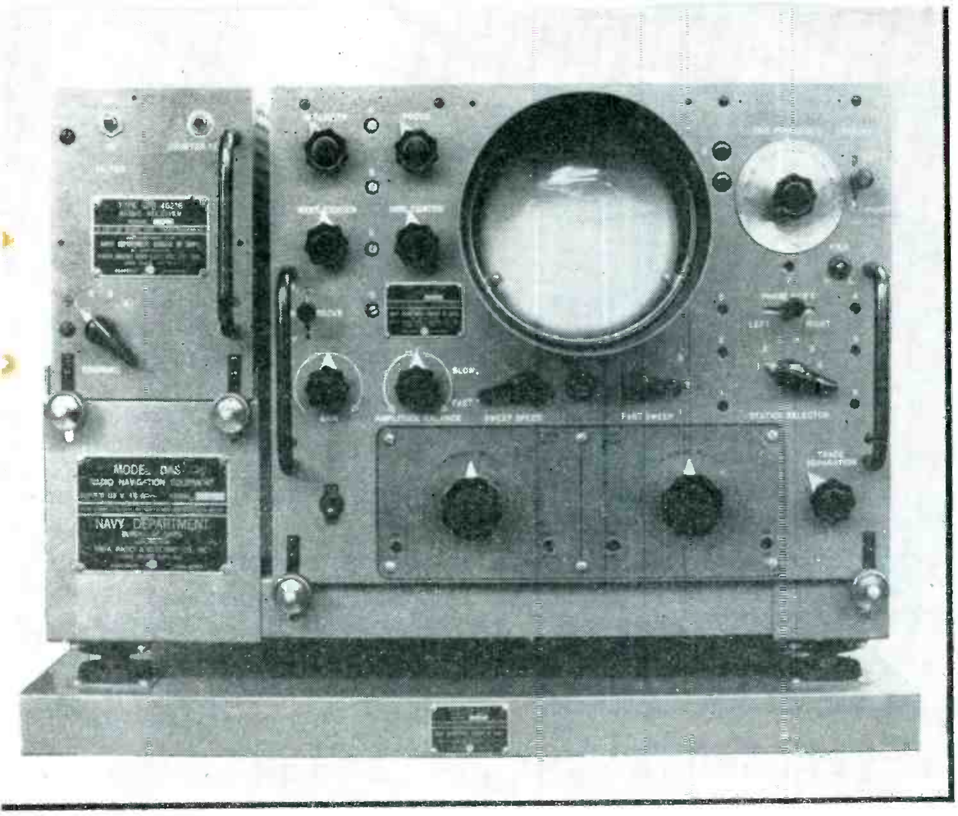


FIG. 1—Photographs of the Loran indicator screen, illustrating the sequence of adjustments employed in matching the pulses. See text for full description. Screens are shown about one-third size



The DAS-3 shipborne equipment. Except for its greater size and weight this receiver-indicator is very similar to the AN/APN-4

electronics WAR REPORT

of the traces, as shown.

A second expansion of the traces (200-μsec sweep) is then introduced, as shown in Fig. 1E, and the two traces are then brought together (Fig. 1F). Any difference in the heights of the two pulses is corrected by a differential gain control. Finally, by further adjustment of the slave pedestal, the two pulses are brought into exact coincidence, as shown in Fig. 1G.

Reading the Time Difference

The time difference is measured by calibration marks, derived from the quartz crystal synchronizing circuit and imposed on the traces as shown in Fig. 2. By throwing a switch, after the pulse match of Fig. 1G is obtained, the pulses are removed and the calibration marks substituted. The time difference is read in three steps which indicate in succession the units and tens, hundreds, and thousands of microseconds.

In Fig. 2A the fastest sweep (corresponding to Fig. 1E) is shown with markers extending above and below each trace. The small upward markers indicate ten-microsecond intervals, and the larger downward markers indicate fifty-microsecond intervals. The units and tens are read by considering the lower trace as a scale and one of the upper markers as a pointer, reading from a large marker on the lower trace to the next larger marker to the right on the upper trace. The time interval indicated is 24 microseconds.

The sweep is then contracted one step to 750 μsec and the markers shown in Fig. 2B appear. The traces correspond to those in Fig. 1D. The largest downward markers mark 500-microsecond intervals. The hundreds of microseconds are read in the same manner as in Fig. 2A, that is, from a large marker on the lower trace to the next larger mark to the right on the upper trace, counting in steps of 50. The partial time difference indicated is 350+ where the plus sign indicates the partial time difference previously read, 24 microseconds. Hence the total time difference, thus far measured to the hundreds, is 374 microseconds.

Finally the sweep is contracted to its original length, 20,000 μsec, corresponding to Fig. 1C. The markers then appear as shown in Fig. 2C. Each trace is divided into groups of 2,500 microseconds. The thousands of microseconds are read from the upper pedestal to the lower, in groups of 500. The partial time difference indicated is 3,500+, where the plus sign indicates the partial time difference, 374 microseconds, previously measured. The total time difference is then 3,874 microseconds.

This apparently involved method of measurement is not so complicated in practice as it appears when described verbally. The complete process, indicated in Fig. 1 and 2, can be carried out in less than a

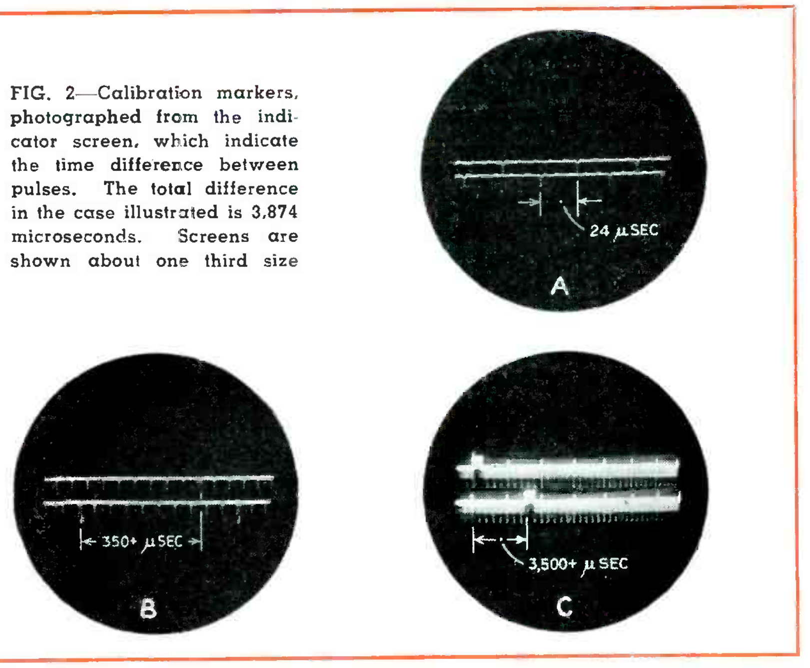


FIG. 2—Calibration markers, photographed from the indicator screen, which indicate the time difference between pulses. The total difference in the case illustrated is 3,874 microseconds. Screens are shown about one third size

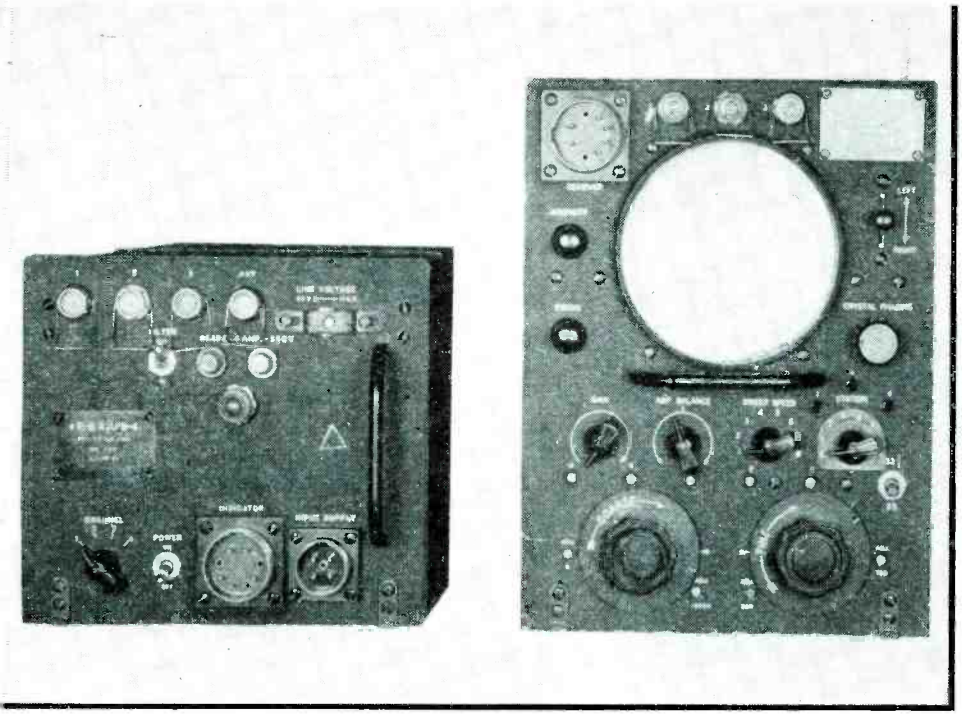


FIG. 3—Receiver (left) and indicator of the AN/APN-4 airborne receiver-indicator equipment. The sequence of patterns shown in Fig. 1 and 2 are obtained by manipulation of the indicator controls, as described in the text

minute by a well-trained operator, or in ten or twenty seconds by an expert.

The foregoing steps are then repeated on another pair of stations. The pulses from the second pair of stations are sent out at a slightly different pulse rate, (say 25 1/16 pps) but on the same radio frequency. Hence these second pulses are visible during the foregoing operations, but move rapidly across the screen, since the sweeps are not synchronous with them. The motion is sufficiently rapid that the second pair of pulses does not interfere with the measurement of the first.

To measure the second pair, the sweep rate of the indicator is switched to the rate corresponding to the second pulse rate. The second pair then remains stationary, and can be measured as above while the first set is in motion. In some regions of the world, as many as 6 pairs of pulses, each pair on a different rate but the same radio frequency, can be seen simultaneously. The identification of the pair being measured is made by noting the rate at which the c-r sweeps are set. The sweep-speed switch is marked with station-pair numbers which correspond with similar numbers marked on the Loran chart. The complete identification and time difference reading is given in several characters, a typical example being 1L1-3874. The figure 1 refers to the radio frequency (1 = 1,950 kc), the letter L to the basic pulse rate (L = 25 pps), 1 to the specific pulse rate (L1 = 25 1/16 pps), and 3,874 is the time difference (typified in Fig. 2).

External Appearance

The external appearance of a typical airborne Loran receiver-indicator type AN/APN-4 is shown in Fig. 3. The smaller unit contains the receiver proper and the regulated power supply. The operating controls are the radio-frequency channel switch at the lower left (whose numbers correspond to the first digit in the identification symbol) and the power switch. The larger unit is the indicator, which comprises the c-r oscilloscope and its associated timing and sweep circuits. The two small knobs, upper left, control the brilliance and focus of the c-r trace. The toggle switch, upper right, introduces small changes in the crystal frequency and thus shifts the pulses to left or right. Below it is the crystal-frequency control knob which is adjusted to bring the sweep traces into exact synchronism with the incoming pulses.

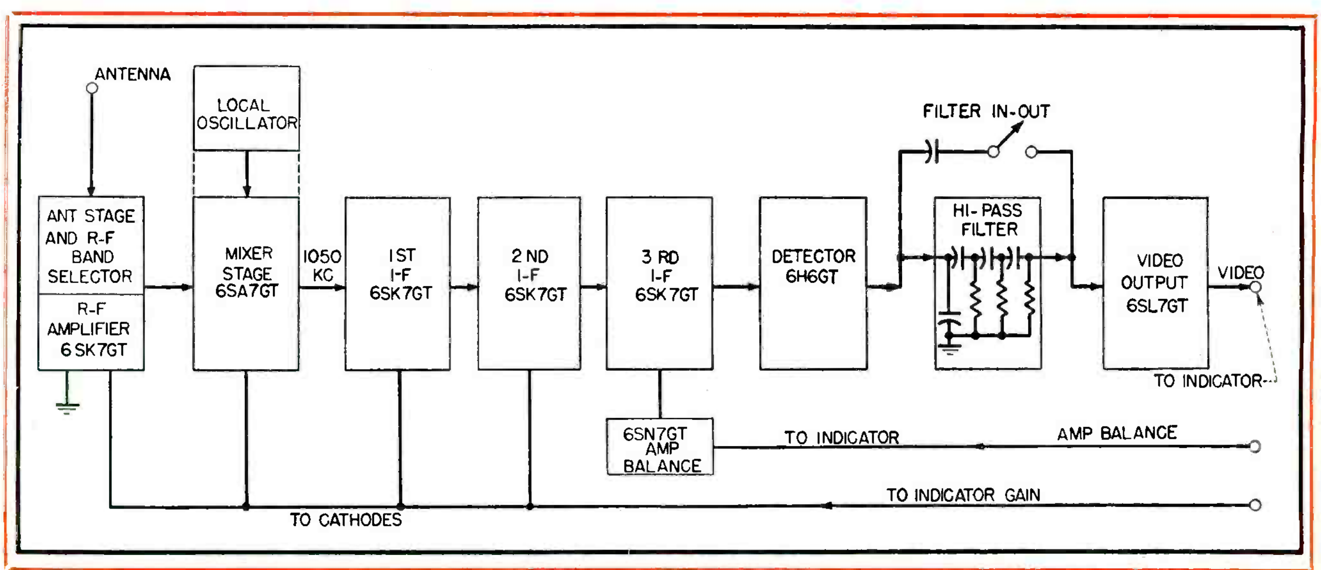


FIG. 4—Block diagram of the AN/APN-4 receiver. The circuits are conventional except for the differential gain control applied to the third i-f stage

The operating controls just below the c-r tube are overall gain, amplitude balance, sweep speed and station selector. The first controls the height of both pulses as they appear on the screen, whereas the second is a differential gain control which adjusts the height of one pulse relative to the other, as required in the matching procedure. The sweep speed selector introduces the successive changes illustrated in Fig. 1 and 2. The station selector selects the specific sweep rates to correspond to the discrete pulse rates of the different station pairs.

The two large knobs at the bottom are left to right the coarse and fine controls which shift the position of the slave pedestal in the matching procedure. The switch at the lower right selects the basic pulse rate, L for 25 pps and H for 33⅓ pps. The various controls are so arranged and marked that a glance at the settings gives the first three digits of the identification symbol. The AN/APN-4 weighs about 65 pounds and consumes about 275 watts, 400-2,400 cps, 80 or 115 v.

Several other Loran receiver-indicators have been developed. The DAS-3, the basic equipment used by the Navy aboard ship, is somewhat larger and heavier, and has a different arrangement of controls, but is otherwise similar to the AN/APN-4. It operates on 60-cps power. The AN/APN-9 is a more recent version for airborne use. It employs a three-inch c-r tube and non-linear sweeps which make possible a reduction in the number of tubes in the indicator circuit. It weighs 35 pounds and consumes about 175 watts, 400-2,400 cps. The method of matching the pulses differs in detail, but not in principle, from that described here.

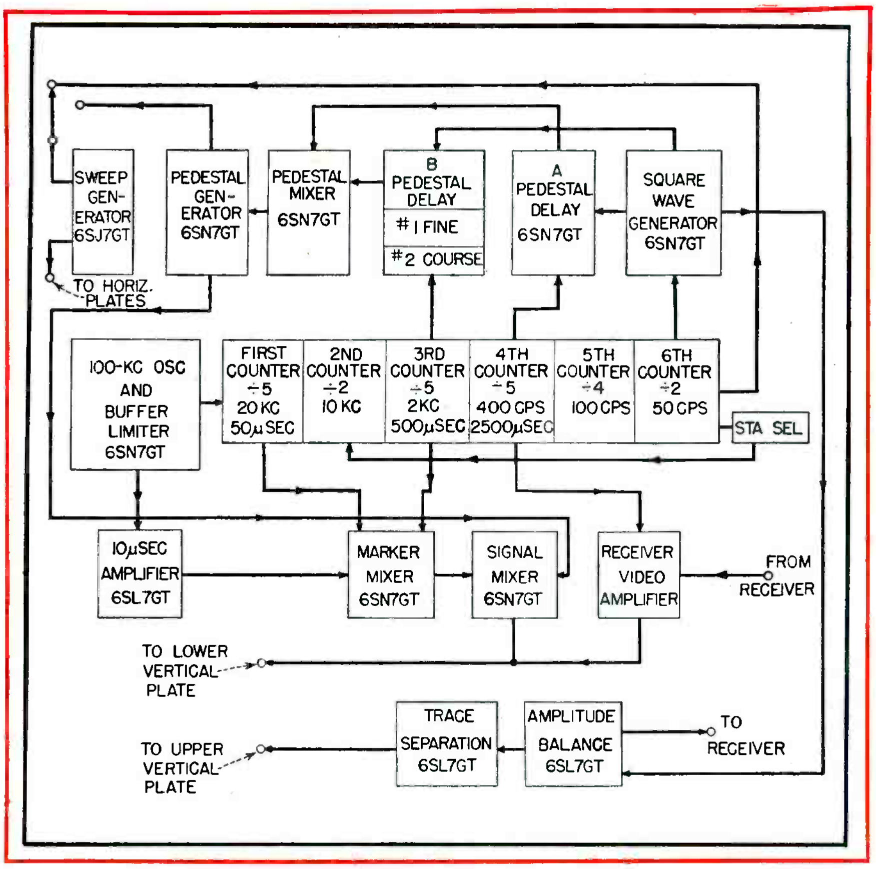


FIG. 5—Block diagram of the AN/APN-4 indicator. The 100-kc crystal timing source is converted by counter circuits to 25 or 33⅓ cps rectangular waves which control the sweeps and pedestals

Details of AN/APN-4 Receiver

The receiver of the AN/APN-4 (Fig. 4) is a wide-band superheterodyne, employing three i-f stages. The 6SK7 r-f amplifier and 6SA7 mixer-local oscillator are conventional, being tuned by a switch which selects four channels at 1,750, 1,850, 1,900 and 1,950 kc. The three intermediate-frequency stages (type 6SK7 tubes) operate at 1,050 kc, and have a bandwidth of approximately 60 kc at the 6-db (voltage) level. This bandwidth is somewhat narrower than the spectrum of the transmitted pulse, but permits reproduction of the pulse with the shape shown in Fig. 1G, with 40-microsecond width at the half-amplitude points. A 6H6 diode demodulates the i-f signal and transmits the pulses to the 6SL7 video amplifier, which feeds the indicator.

The cathode of the last i-f stage connects with the indicator from which is supplied a rectangular wave of voltage synchronous with the sweep traces. This rectangular wave passes through a cathode-follower stage and biases the last i-f stage on the negative half-cycles, thus reducing the gain of the receiver during the formation of one c-r trace, while allowing normal gain during the formation of the other trace. The amplitude and polarity of the rectangular wave are controlled by the amplitude balance control previously mentioned.

Two high-voltage supplies are contained within the receiver housing. One is a 2,600-volt low-current supply for the cathode-ray accelerating electrodes, arranged in two sections of 1,300 volts each, above and below ground. The low-voltage power is supplied at 260 volts, accurately regulated.

Details of AN/APN-4 Indicator

The indicator circuits are illustrated in the block diagram in Fig. 5. The basic timing source is the 100-kc quartz crystal oscillator. Across the crystal is a small variable capacitor which permits small adjustments of the crystal frequency. From this 100-kc source, the sweep traces at 25 pps or 33⅓ pps must be obtained together with the minor varations in these rates corresponding to the different specific pulse rates of the station pairs. the derivation of the 25 or 33⅓ cps wave from the 100-kc source is accomplished by a series of frequency-divider circuits. A total frequency division by 4,000 (in seven steps of 5, 2, 5, 5, 4, 2, and 2) is required to derive the 25-cps rate, and by 3,000 (5, 2, 5, 5, 3, 2, and 2) for the 33⅓ cps rate. The first six divisions are performed by counter circuits, the last factor of 2 by an Eccles-Jordan scale-of-two circuit.

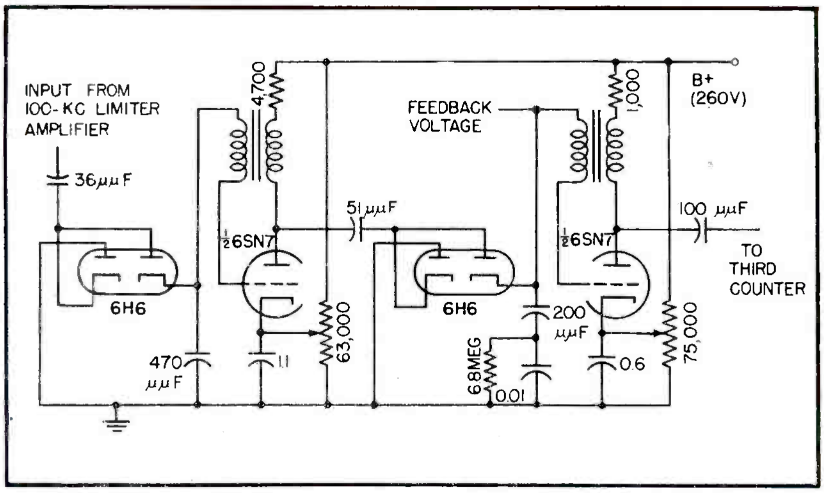


FIG. 6—First and second counter stages of the indicator, which divide the 100-kc input by 5 and 2, respectively. Four additional counters are used to introduce a total division of 4,000 for the 25-cps sweep or 3,000 for the 33⅓ cps sweep

Two of the six counter circuits are shown in Fig. 6. The 100-kc output from the crystal, having passed through a limiter amplifier, is fed to a 6H6 double diode so connected that it passes negative pulses to ground while passing positive pulses to a capacitor, and the voltage across it thereby increases in steps. When five such steps have been accumulated, the voltage across the capacitor has reached a sufficient level to trigger the following circuit, a 6SN7 blocking oscillator.

The blocking oscillator generates one pulse and discharges the capacitor in the process, which thereupon accumulates five more pulses from the 100-kc source and triggers off the blocking oscillator once more. Thus the blocking oscillator reacts once for each five input pulses and the frequency is divided by five.

The output of the blocking oscillator is applied to another double diode which, like the first, passes the positive pulses to a capacitor which charges to the level of two steps and thereupon triggers off a succeeding blocking oscillator (biased to respond to two steps). In all, six double diodes and six blocking oscillators are used in sequence to introduce the divisions previously enumerated.

The functions of the Eccles-Jordan circuit are numerous. First, the rectangular output constitutes the wave, previously mentioned, which provides differential gain control of the receiver during the formation of the two traces. The same wave, applied through a 6SL7 "trace separation" stage to the vertical deflection plates of the c-r tube, causes the slave trace to be displaced vertically from the master trace. Finally, the Eccles-Jordan wave, after passage through appropriate delay circuits, controls the formation of the master and slave pedestals, as outlined below.

Eccles-Jordan Circuit

The Eccles-Jordan circuit (Fig. 7) is similar to a conventional multivibrator, except that the grids and plates of the two triode sections are interconnected by conductive coupling. The circuit does not relax in the usual fashion of a multivibrator, but has two conditions of stable equilibrium. The circuit remains in equilibrium until the synchronizing pulse is received, causing the two triodes to exchange polarities suddenly. The circuit remains in this condition until another pulse causes a reversal to the original condition. The sync pulses, as they arrive from the last counter, display negative as well as positive polarity. These pulses are passed through a 6SN7 connected as a diode, which removes the negative pulses and passes the positive pulses to the Eccles-Jordan circuit.

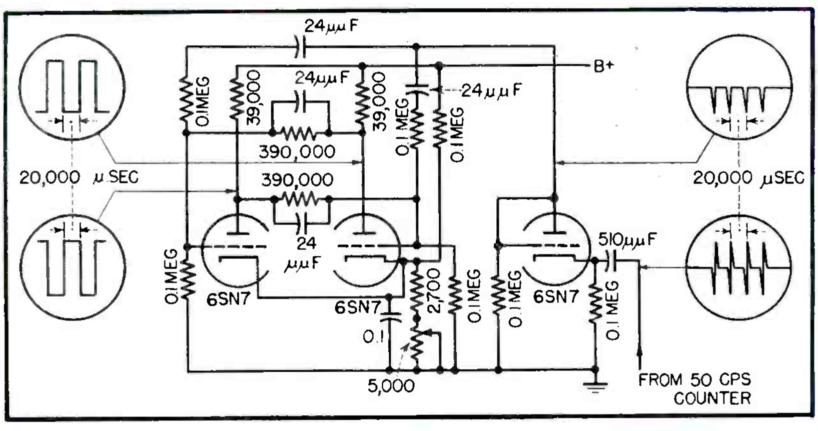
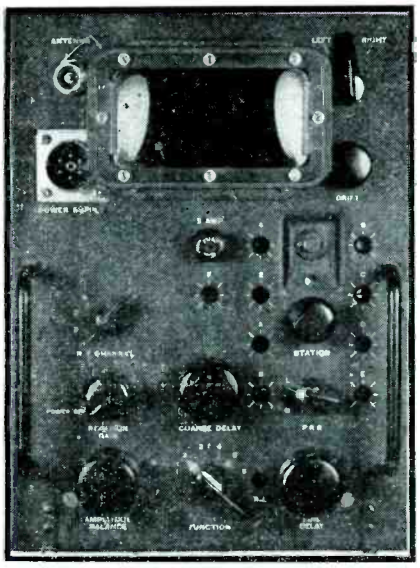


FIG. 7—Eccles-Jordan rectangular-wave generator which divides by a factor of 2 and provides rectangular waves at 25 or 33⅓ cps for controlling the sweeps and pedestals

Other Functions of Counter Circuits

Several additional functions of the counter circuits must be described. First, the counter circuits supply the calibration marker pulses. The 10-μsec markers are derived from the 100-kc source directly, the 50-μsec pulses from the first counter output (20 kc), 500-μsec markers from the third counter (2 kc), and 2,500-μsec markers from the fourth counter (400 cps). These markers, in proper relative amplitudes, are combined in a mixer stage and applied to the vertical deflection plates of the c-r tube.



The AN/APN-9 airborne receiver-indicator. The use of a 3-inch tube and nonlinear sweeps reduces size and weight to a single unit weighing about 35 pounds

The slight variations in the basic pulse rate (amounting to multiples of 0.25 percent of the pulse rate) are introduced by a feedback connection from the last counter stage to the input of the second counter stage. Additional voltage is thereby supplied to the steps of voltage accumulating at the input of the second counter, causing the second counter to fire ahead of the normal time by a slight amount. This produces a corresponding small increase in the final frequency. The amount of voltage fed back is controlled by a switch, in eight discrete levels. The corresponding sweep rates are 25, $25\frac{1}{16}$, $25\frac{2}{16}$ and so on to $25\frac{7}{16}$ sweeps per second, and similar values for the $33\frac{1}{3}$ rates.

Finally, the counter stages are used to synchronize the pedestal delay circuits so that the master pedestal always occurs at a given 500-microsecond marker and the coarse delay control moves the slave pedestal in 500-microsecond jumps.

Pedestal Circuits

The pedestal delay is introduced by a 6SN7 multivibrator circuit triggered off by the leading edge of the Eccles-Jordan output square wave. After a delay determined by its relaxation time, the multivibrator generates a pulse which in turn controls the formation of the slave B pedestal. By adjusting the resistance component of the multivibrator time constant, the delay thereby introduced may be varied from 20,000 to approximately 32,000 microseconds. The corresponding positions of the slave pedestal are directly below the master pedestal and some 12,000 microseconds to the right. This range covers the values of time difference to be measured between the incoming pulses.

A similar fixed-delay multivibrator causes the master (A) pedestal to appear in a fixed position shortly after the beginning of the master trace. The output waves of the A and B delay multivibrators are combined in a mixer and applied to the pedestal generator which produces short (150-μsec) square waves. On the slow sweep (Fig. 1A through 1C) these waves are combined with the traces to form the pedestals. On the fast sweeps (Fig. 1D through 1G and Fig. 2), the leading edges of the pedestals are used to trigger the sweep generator.

The sweep generator itself (Fig. 8) develops a linear sweep voltage by charging a capacitor across a constant-current series pentode, synchronously with the sweep control voltage (Eccles-Jordan output for slow sweep, pedestal generator output for fast sweeps). The saw-tooth deflecting wave is passed through a 6SN7 paraphase amplifier which develops two symmetrical sweep voltages of opposite polarity, which are applied to the respective horizontal deflection plates. The cathode-ray tube circuits are in the main conventional.

In the concluding article of this series, the shore-station equipment, including transmitter and radiating system, timer and synchronizer, will be described.—D.G.F.

REFERENCE

(1) The Loran System, Part I. ELECTRONICS, p 94, Nov. 1945.

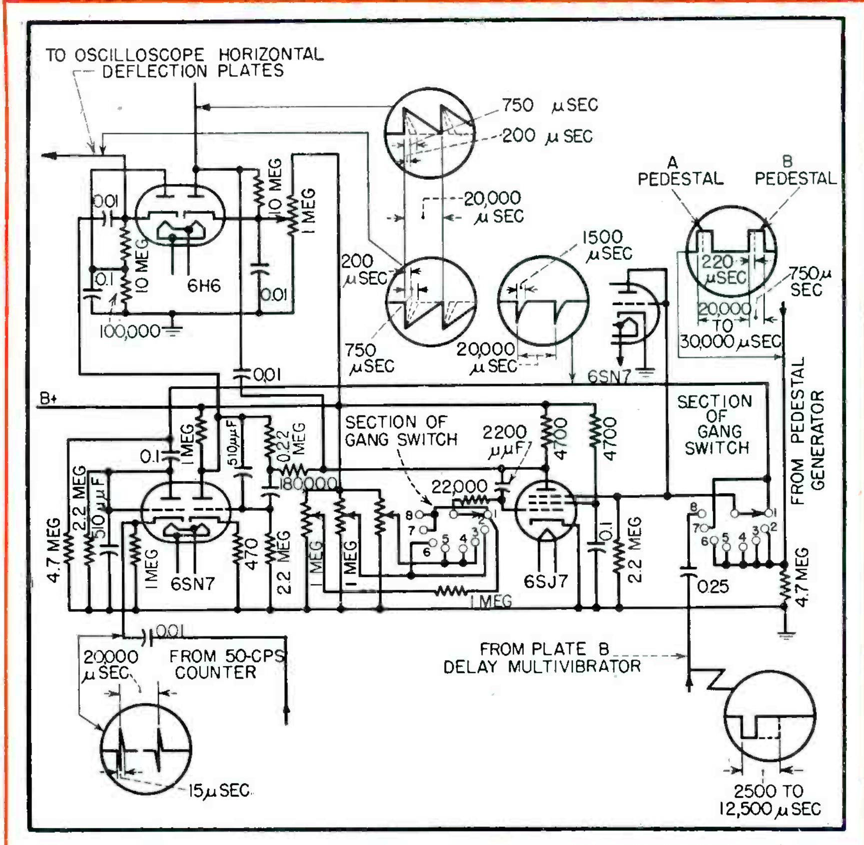


FIG. 8—Sweep generator which produces the saw-tooth waves (upper left) for the 20,000, 750, and 200 microsecond sweeps shown in Fig. 1 and 2. The 6SJ7 constant-current pentode develops a linear sweep voltage between its plate and ground

GEOPHYSICAL

Electronic circuits used today include variable-sensitivity amplifiers for the recording galvanometers, accurate time control for the recorders, and time marking for indicating the time and depth of shot that is fired to produce ground waves

By DAVID SHEFFET
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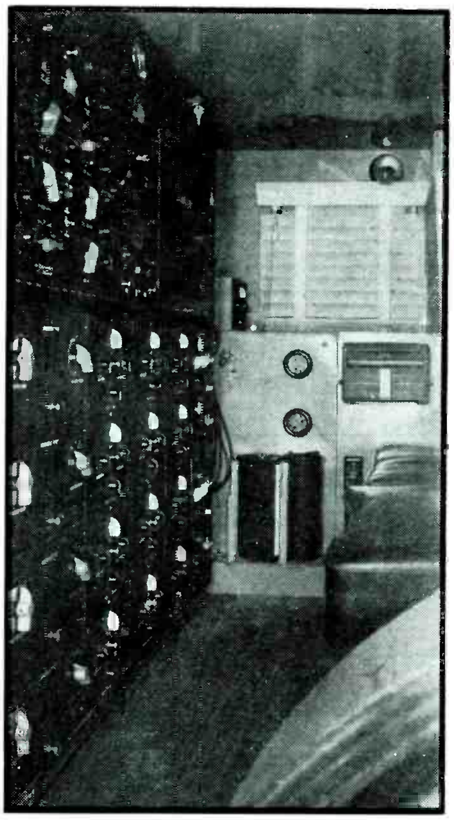
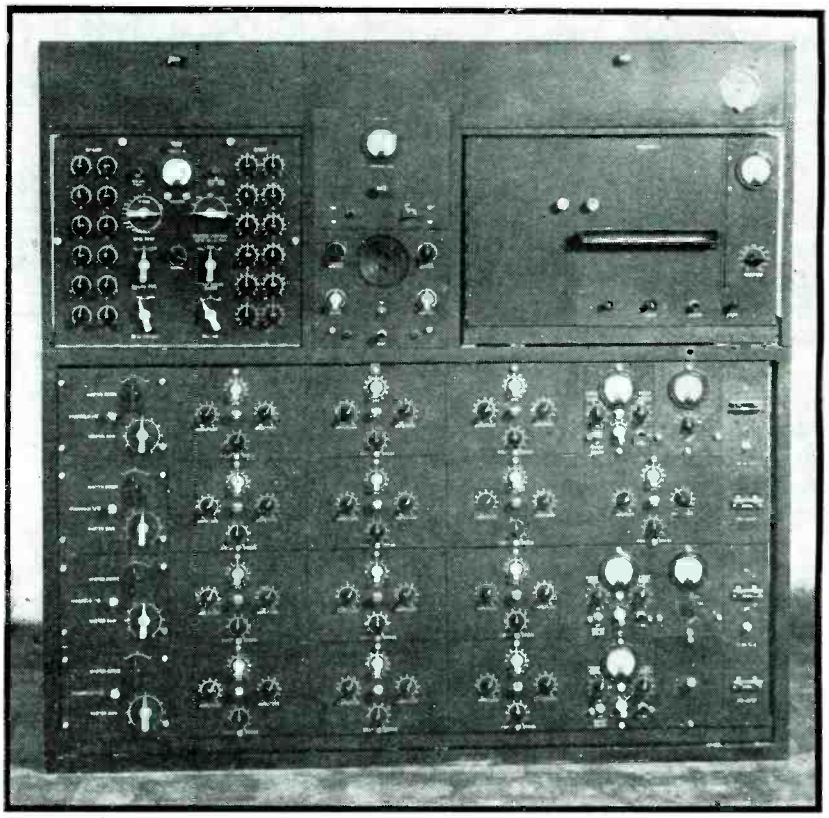
THE OIL INDUSTRY relies heavily on the electronics industry for many products. In the geophysical division alone there is a broad use of electronic components. At the present time there is an estimated annual expenditure for geophysical exploration of approximately four million dollars on the products of electronic manufacturers. Although this sum seems small compared with the astronomical output of manufacturers during the war, it represents a steady reliable market which is not likely to be reduced by the advent of peace. On the contrary, the persistent search for new scientific methods and techniques by the oil industry is likely to broaden the demand for electronic components.

Prospecting Methods

Practically all geophysical exploration for petroleum at present employs three basic methods of prospecting. These methods are seismic, gravimetric and magnetic. All three methods are used by oil companies in a complete exploration program. The gravity and magnetic methods are relatively inexpensive and fast in operation, and are used as reconnaissance methods to give a quick overall picture of an area. They do not provide accurate subsurface detail, but serve to outline general limited

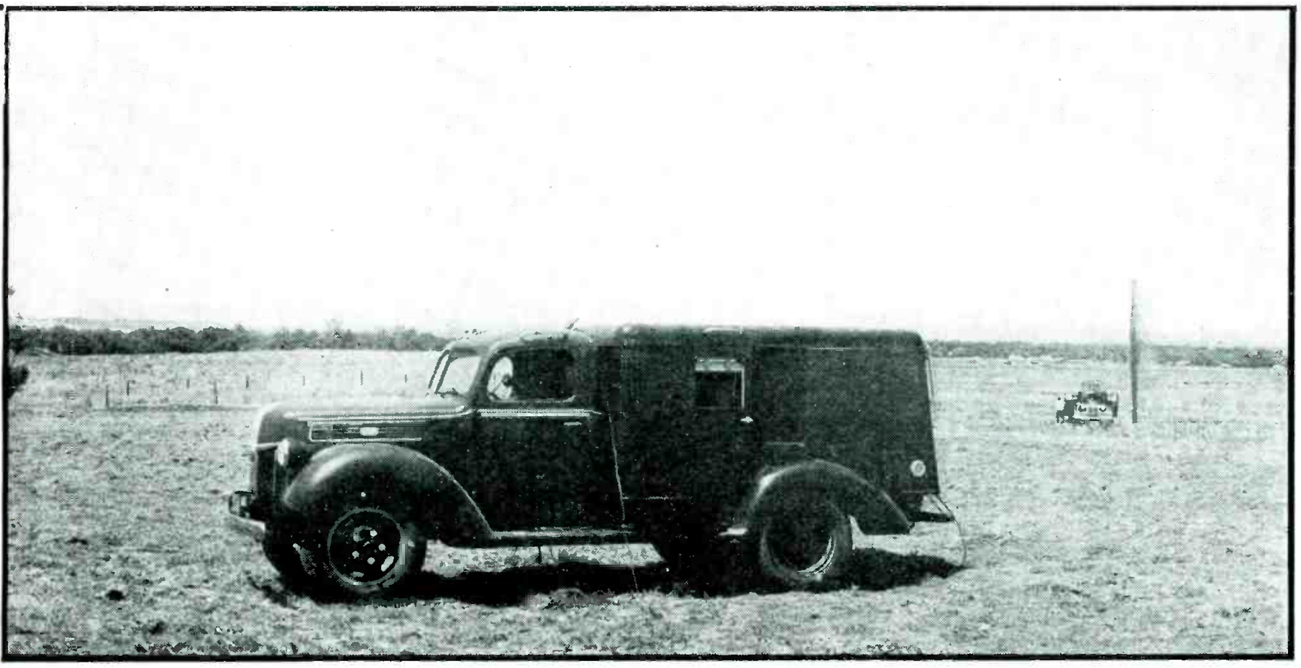


The recording equipment of the seismometer installed in the truck



The operator's panel includes terminal positions from seismometer cables, electrical test set, timing circuits, amplifiers, recording oscillographs, and firing controls

PROSPECTING EQUIPMENT



The truck for field surveys carries the recording equipment. In the background is the shooting truck beside a geyser of mud and water blown out of the hole as an aftermath of the shot

areas of interest which can later be more accurately delineated by the seismograph.

The gravity meter is an amazingly sensitive device for measuring the variations of the force of gravity with variation of geologic structure. However, all of its remarkable magnifying properties are obtained by means of mechanical and optical linkages. The electrical circuits involved are usually associated with simple relays for maintenance of limited temperature fluctuations.

The magnetic method involves the use of a magnetometer which is a combination magnetic, mechanical, and optical device for measuring the variations of the vertical magnetic field associated with geologic formations.

Of the three methods, the seismic method has borrowed the most from the electronic field. What is usually known as the seismograph actually is a system comprising a large group of earth-type microphones, cables, control circuits, amplifiers and a recording oscillograph. In addition, there are voice communication circuits and shot-firing circuits. All this equipment is used to record the vibrations generated in the earth by firing a charge of dynamite below the surface. The acoustic waves initiated by the explosion penetrate the geologic formations and produce reflected waves at the boundaries between different media because of sudden changes in elastic properties (acoustic impedance) across the boundary zones. These reflected waves return to the surface of the earth and are recorded so as to indicate depth and dip of the various reflecting horizons.

Seismograph Field Spread

In a seismograph field setup, or spread as it is usually known, a group of 24 or more seismometers (ground-contact microphones) is placed on the earth in a line either running through the shot point or offset from it. The exact arrangement and number of these seismometers and configuration of the spread varies considerably between companies and between different areas surveyed by a given company. As few as 12 and as many as 96 seismometers have been used by some operators. The length of the spreads may vary from 200 feet to 3,000 feet. It is important in any spread to know the exact distances between seismometers and shot point because these enter into the final calculations of depth and dip of the subsurface strata.

Amplifiers

The seismometers connect through multiconductor cables to a control and test panel in the recording truck. This control panel feeds the outputs of the seismometer groups to a large number of identical recording amplifiers. These amplifiers connect to a multiple galvanometer recording oscillograph which records the output of each channel on sensitized photographic paper. It is common practice at present to use 12 or 24 amplifier channels and a single galvanometer block in the oscillograph, which contains a corresponding number of recording elements plus a spare.

There are many kinds of seismic

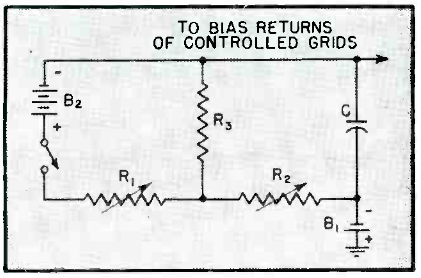


FIG. 1—Time-rate volume expander increases gain of amplifiers after the shot is fired

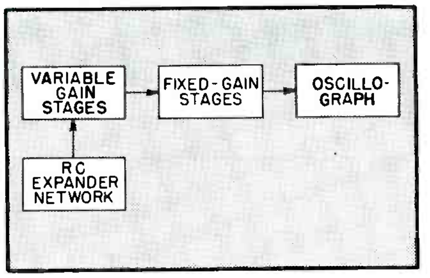


FIG. 2—To record all reflected signals at comparable amplitudes, gain is controlled by a time-rate expander

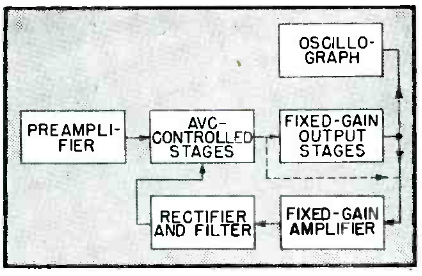


FIG. 3—For maintaining constant input to the oscillograph, avc can be obtained from the amplifier output

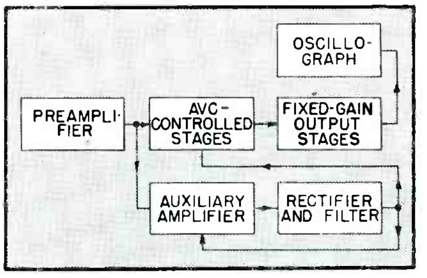


FIG. 4—A loop containing an auxiliary amplifier can provide over- or under-control for avc

amplifiers in use by geophysical companies. Most of them use automatic volume control or adjustable time-rate expanders or combinations of both. In seismic shooting the range of input signal which must be recorded varies as much as 10,000 to 1, according to the area worked. This wide amplitude range must be reduced to an average range of 2 to 1 or better at the oscillograph, and this must be done in a period that rarely exceeds four seconds and is often as short as one second. The threshold sensitivity of the amplifier should be adjustable in steps between one microvolt and one millivolt. This requirement means that when the amplifier is wide open, any signal above the threshold value of one microvolt will operate the automatic volume control. With the gain reduced 60 db, signals have to exceed the threshold of one millivolt to operate the avc. These are common requirements today for fully automatic volume-control systems.

Preadjusted time-rate expanders in which the gain varies with time are also used. In this system some variable gain elements such as remote-cutoff pentodes have their bias set at a predetermined level, thereby reducing the amplifier gain to the point where the initial high output of the seismometers after the explosion is fairly well controlled. At a definite time after the initiation of the shot, the bias is reduced at a predetermined rate by a capacitance-resistance network so that the gain of the amplifier increases while the energy of vibrations from the earth is decreasing. It requires experience in each area to know just what rate of gain expansion is necessary to compensate for the decrease of shot energy and obtain a uniform record. This experience is not so necessary when using a truly automatic volume control, therefore many operators today employ automatic volume-control amplifiers.

Gain Control

Figure 1 shows a circuit of a resistance-capacitance expander network such as is used in the time-rate expander system given in the block diagram of Fig. 2. When the switch is closed, capacitor C is charged to a voltage determined by adjustment of R_1. This voltage plus B_1 is the initial bias on the grids of the controlled tubes. The firing of the shot operates a relay which opens the switch; C discharges through R_2 and R_3. R_2 is adjustable so that the rate of gain increase can be set to match the expected rate of decrease of signal energy. Battery B_1 represents the final bias reached and determines the maximum gain of the amplifier when the capacitor has discharged.

One ingenious variation of the time-rate expander system uses the resistance-capacitance gain expander system, but the resistance that discharges the capacitance is not fixed during the period of the record. Instead, the resistance itself is electronically controlled by the average signal amplitude, so that the gain expansion rate is a function of the signal. This characteristic is like a one-way avc because the gain of the amplifier can increase when signal level decreases, but cannot decrease if signal level temporarily increases because the expander capacitor cannot recharge once it has started on its discharge cycle.

In the development of automatic volume control for seismic recording, the problem at first seemed simple because avc was already being used in radio receivers quite successfully. The thing that made it difficult was the fact that the major frequencies recorded were between 25 and 100 cycles. In radio receivers the stages controlled by the avc voltage operate at several hundred kilocycles or in the megacycle range. The rectified and partly filtered intermediate-frequency voltage which supplies the avc bias has no residual components that are likely to be amplified by the stages which it controls. Thus there is excellent protection against oscillation of the system at one of the fluctuation component frequencies.

Avc Problems

In a seismic amplifier the frequencies amplified are so close to the highest equivalent control frequency of the avc voltage that it is not a simple matter to obtain a wide amplitude range of control with sufficient speed of control and still maintain stability. The way in which the rectified avc voltage is filtered is very important. Too much filtering insures stability but reduces the rate of avc action. In some shooting locations this slowness does no harm but in others the avc cannot follow the rapid dynamic changes of the shot energy. Too little filtering produces instability which may vary from intermittently-appearing low-frequency rolls to continuous low-frequency oscillation. It is even possible to get good stability when the shot energy is medium to high, but get low-frequency incipient oscillations when the signal input is low.

Not only is the method of filtering important, but the type of variable elements controlled by the avc voltage is equally important for successfully attaining smooth dynamic action with dependable stability. The obvious control elements are variable-gain tubes such as the 6K7G or 6U7G. In a single-ended amplifier using the signal output to supply the avc voltage, these tubes can be controlled over a reasonable range with fair dynamic action. The avc voltage can be applied either to the control grids or to the suppressors. When applied to the control grids, the filtering is usually more critical than when the avc bias is applied to the suppressors. If the gain in the avc loop exceeds unity at any frequency where the input and output are in phase, the system will oscillate.

Figure 3 shows a block diagram of a typical automatic volume control amplifier. In this figure the preamplifier is a fixed-gain amplifier. However, this amplifier may also have its gain varied with time as shown in Fig. 2 or it may be included in the avc loop along with the succeeding stages of Fig. 3.

Another type of avc that has been used is the input type of control shown in block diagram in Fig. 4. In this system there is no feedback of output signal to be rectified and filtered for avc bias. Because the bias is generated by the input signal through a separate amplifier, the control action is independent of the output signal and consequently it is possible either to over-control or under-control the output. It is easily possible to produce zero output with a large signal input unless precautions are taken. One method of avoiding this effect is to let the auxiliary amplifier avc itself to a small extent.

The advantage of this system is absence of possible feedback in the controlled stages of the main amplifier and therefore reduction of the amount of filtering necessary in the avc filter. Thus greater speed of avc action is possible with good stability. The chief disadvantage of this system is that it requires careful matching of tube characteristics between the tubes in the main amplifier and in the control amplifier. If the tube characteristics vary with age it is possible to get both over-control and under-control on the same record. In the feedback or output control system of Fig. 3 a certain amount of tube variation can be tolerated because of the self-compensating characteristics of the feedback system. If the gain in the feedback loop should change with age or with power supply voltage variation, the worst that can happen is a uniform gradual under-control which does not show too badly except at large signal levels. It is impossible to over-control with an output control type avc system.

Electronic Variable Resistor

A method of control which is very popular in seismic recording makes use of electronic resistors as a part of an attenuator pad between amplifier stages. The 6H6 or 7A6 double diode can be used as an electronically controlled resistor with the avc bias voltage supplying the control. This circuit is shown in Fig. 5.

In a diode the plate is so close to the cathode that some emission from the cathode flows to the plate without any external voltage being impressed on the plate. Not all electrons flow to the plate, but there are so many of sufficiently high initial velocity that they strike the plate in great numbers and we call the result a high contact potential. When no external voltage is applied between plate and cathode, the resultant electron stream can be used as a low resistance. Biasing the plate negatively with respect to the cathode reduces the electron flow and increases the plate-to-cathode resistance. The range obtained varies from about 1,000 ohms to several megohms. It is necessary to use a back-to-back arrangement of diodes in order to prevent distortion over a wide range of signal voltages. It is possible to use a single half-wave diode over a limited range of signal levels. Con-

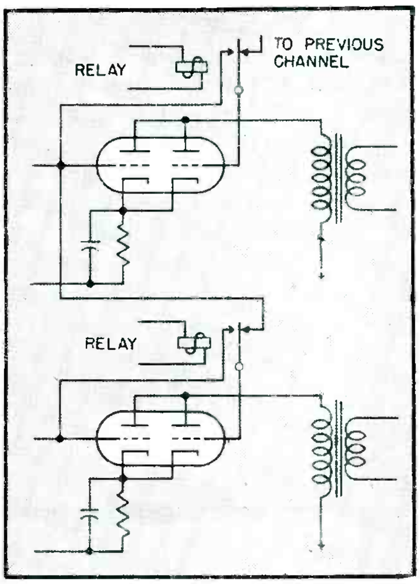


FIG. 7—Circuit for introducing overlap in the seismic record

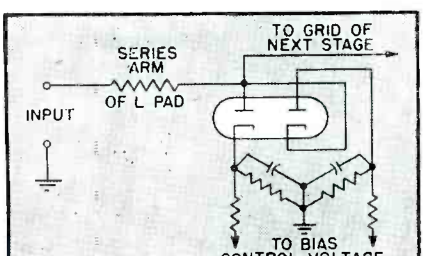


FIG. 5—Controlled duodiode is used as a variable resistance in an avc system

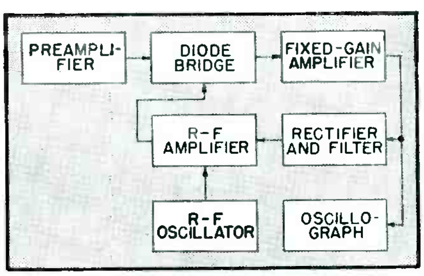


FIG. 6—A radio-frequency link can be used to control the diode resistor

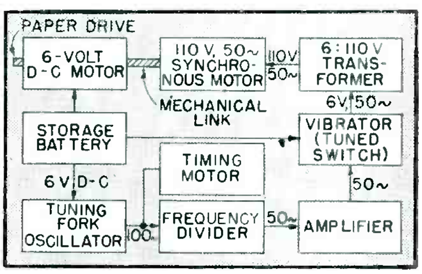


FIG. 8—Paper drive is held constant by the time-marker tuning fork

tact rectifiers such as copper-oxide and selenium rectifiers can also be used in a manner similar to vacuum-tube diodes.

One of the big advantages of the diode system is the fact that the avc voltage is applied to the diodes in a balanced bridge connection. If the bridge is well balanced, any residual low-frequency component in the avc bias voltage will not appear between the output terminals of the bridge which connect to grid and ground of the following stage. This means that less filtering is required after the avc rectifier in the diode control system. Therefore, it is possible to obtain greater speed of avc action for a given amplitude control ratio with the diode system than with variable-gain pentodes. In any system, the closer the degree of amplitude control, the greater must be the gain in the avc loop and the more the filtering required to maintain stability. Increasing the filtering reduces the rate of control.

Methods of Applying Avc

Another method which is used in connection with diode resistors involves a radio-frequency link. A radio-frequency oscillator drives an amplifier which is modulated by the rectified filtered avc voltage. The variable amount of radio frequency which is controlled by the signal output of the main amplifier is then applied to the diodes so as to change their effective resistance. This operation can be seen in the block diagram of Fig. 6.

Still another method which is in present use in seismic recording dispenses entirely with thermionic elements in the controlled stages. Tiny lamps are used in a balanced-bridge arrangement to control the amount of signal passed through the amplifier. The variation of control is obtained by applying current at radio frequency (or any frequency very high compared with the seismic frequencies) to the tiny resistance elements. The amount of high frequency current which is applied is controlled by the rectified and filtered seismic frequencies near the output of the amplifier.

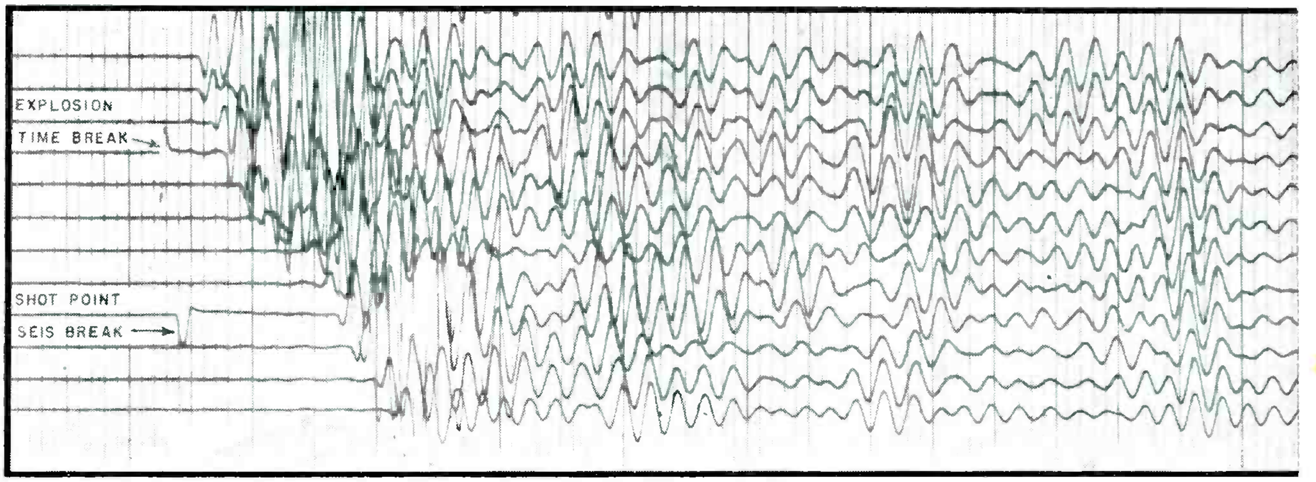
There is considerable variation in methods of overall control of a large number of channels. Some companies prefer individual avc complete in each amplifier channel. Others use a single master avc amplifier which receives its input signal from the combined outputs of several channels and supplies a form of average control bias equally to all channels. Another method is to pair adjacent channels and have a common avc amplifier controlled by the outputs of both channels produce a common control bias for both channels.

There are many combinations of simplified control. They have the advantage of saving parts and therefore space, weight, and cost. The disadvantage is in the much closer matching of control tube characteristics and the necessity of changing tubes more often. Where each channel has its own independent avc system, much greater variation in tube characteristics can be tolerated. Variations with use do not show up badly on the recording paper because there is partial compensation for gain variations when the avc control bias of an amplifier is a function only of its own signal output. Another disadvantage of master avc systems is in the wide initial variations in signal levels between different channels on certain types of long seismometer spreads.

Use of Filters

In all seismic amplifiers there must be a certain amount of tuning to discriminate against unwanted frequencies that mask the desired seismic frequencies. The desired band falls between 25 cps and 100 cps. This band is usually cut into smaller bands of interest according to the area in which the exploration occurs. Methods of filtering vary considerably between companies. Some use fixed band-pass filters of the conventional variety and some use combinations of high- and low-pass filters, with both upper and lower cutoff points adjustable by front panel control. Some use empirically shaped filters whose characteristics were determined from years of field experience in many shooting areas. These filters are unconventional in that the slopes above and below the center frequency may be widely different from each other.

It has been found highly advantageous in many areas to secure seismograms using different filters.



Portion of a seismogram, showing the time break of the explosion, the shot-point seismometer break, and the arrival of

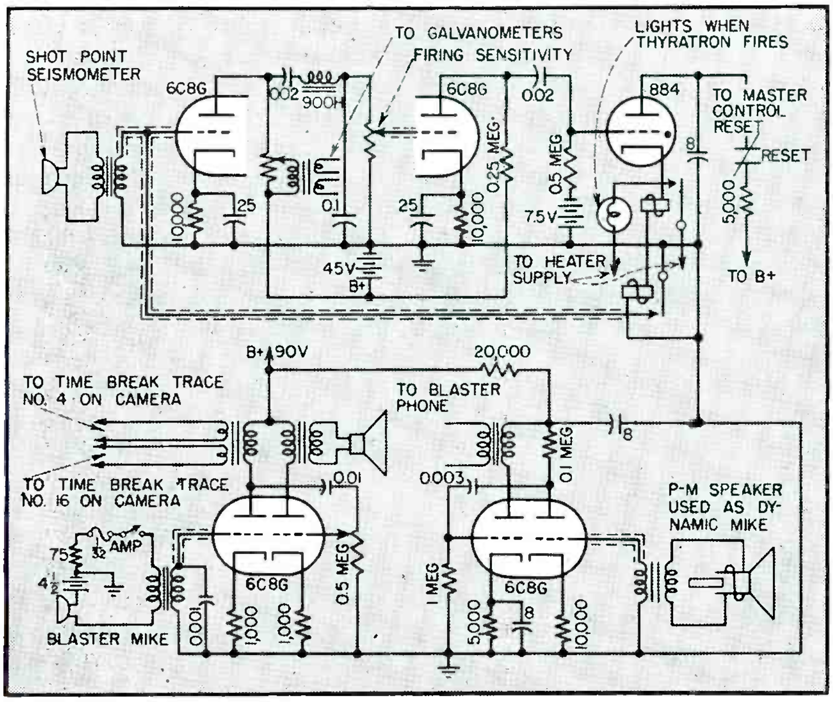


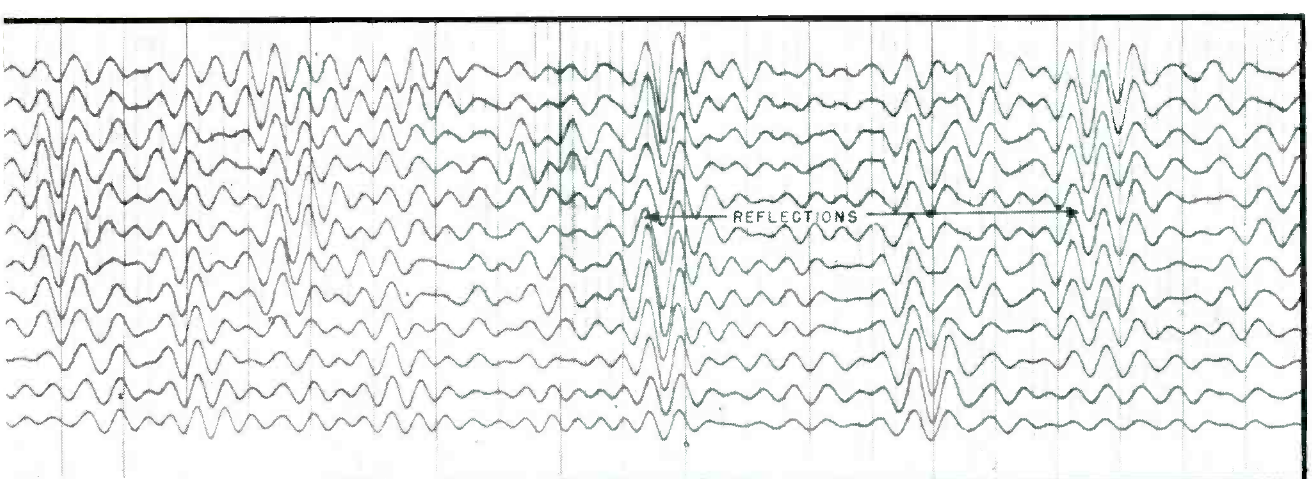
FIG. 9—Communication circuit for field use picks up essential information of the blast itself

Two or more shots can be recorded with different filter settings. Recently some operators have employed two or more sets of amplifiers to obtain two or more records simultaneously with different filters on the same seismogram. This practice has the advantage of reducing dynamite- and other operating-costs. Twelve amplifiers are used for the output of all seismometers on the spread in one filter setting and twelve others in another filter setting, known as dual recording. Triple and quadruple recording have also been used. Many times, information is gained from the combination record that would not have been evident from a seismogram secured with a single filter.

Phase Distortion Limitations

The amplitude and phase distortion requirements in a seismic amplifier are far more critical than in an ordinary audio amplifier. Seismic amplifiers are designed to have a certain type of frequency discrimination and with it goes a certain unavoidable amount of phase distortion. One of the practical difficulties in making a large number of amplifier channels is that of making them all alike in amplitude and phase response. In conventional audio amplifier work, listeners may disagree as to whether two amplifiers sound alike or not. In seismic recording the slightest difference between two amplifiers appears immediately on the seismogram and leaves no room for doubt. Amplifiers are therefore carefully matched for phase and amplitude response. No frequency component of interest must vary more than one-half of one-thousandth of a second in time lag or lead from the standard adopted. Because the ultimate data used in the computations are time determinations secured from seismograms, it is important that amplifiers have a minimum variation in phase from one to another. A phase difference which causes a time lag of 0.001 second introduces an error of approximately four to eight feet in depth and an even more appreciable error in dip computations.

At 50 cps the time of one cycle is 20 milliseconds, so that a deviation of one-half millisecond represents nine degrees maximum tolerance in phase shift at that frequency. Below 50 cps the phase-shift tolerance is even less. Customary laboratory practice is to align amplifiers for phase and amplitude by comparing each channel to the standard with a common signal input and each output connected to a different set of oscilloscope plates. The degree of opening of the resultant ellipse, and its slope, is a measure of the phase and amplitude variations, respectively, between the two chan-



the percussion wave at the stations in the field spread. Later, reflections from different strata arrive at the stations nels. In the final overall test the galvanometer camera is used for a simultaneous check on all channels.

Seismic Recording Practice

A commonly used procedure in seismic recording is to add a part of the voltage from one seismometer group to the next adjacent group in a specified direction of the spread. This process is referred to as overlap or compounding, and is used for the purpose of improving the record by accentuating the appearance of the reflected waves against the random noise background.

A commonly used method of electronic overlap is shown in Fig. 7. When the relay contacts are in the right-hand position, each channel except the first one in a group receives some signal from the immediately preceding one, but from no other channel. This is mixed in the common plate circuit with the original signal of the channel itself. When overlap is not desired, the relay contacts are moved to the left and the two sections of the twin triode are in parallel for a single signal source and independent channel operation.

One of the most important elements in a seismic recording truck is the timing system. Without an accurate reliable timing system the records would be useless regardless of their purely seismic quality. All computations of subsurface depths depend on accurate timing. The heart of the timing system is a temperature-compensated tuning fork. It is common practice to use a 100-cycle fork driven by a vacuum tube system. A synchronous timing motor driven by the 100-cycle voltage from the fork oscillator has a disk mounted on it which has slots cut radially. These slots are spaced so that they permit light from a timing lamp to strike the sensitized paper across its full width in a narrow beam every hundredth of a second. One slot out of ten is wider so that a darker line is placed on the paper every tenth of a second. This darker line makes it much easier for the record computer to add the total time from the beginning of the record to a reflecting point.

In addition to knowing the exact time interval between any two timing lines it is also necessary to maintain the recording paper speed constant so that a given time interval on one record will cover the same length of paper as on any other record. This consistancy is essential if any comparison is to be made between records. There are several methods of accomplishing this result. Only one method will be described here because of its electronic interest. It is used chiefly where 100-cycle tuning forks are the standard for timing. Lower-frequency forks can be used but they are bulky.

The electric motor which drives the paper is usually a 6-volt d-c motor because the primary source of power in field recording trucks is a storage battery. In order to run this motor at constant speed a unique method has been developed whereby the speed is electronically controlled by the 100-cycle tuning fork. The d-c motor receives its power as usual from a 6-volt storage battery, but it is mechanically coupled to a small 110-volt, 50-cycle synchronous motor. This a-c motor maintains the d-c motor at the proper synchronous speed although most of the driving power for the d-c motor comes from the storage battery. The additional power necessary to hold the d-c motor to the proper speed is supplied by the 50-cycle synchronous motor.

In a typical installation a 1/100 horsepower synchronous motor controls a 1/30 horsepower d-c motor. The precise 50-cycle power for the synchronous motor is obtained from the 100-cycle tuning fork through an electronic frequency divider which drives a power amplifier. In order to eliminate large power tubes in this amplifier and their heavy drain on storage batteries, the power level is amplified only to the point where it will drive the coil in a tuned mechanical vibrator. This vibrator then supplies the storage battery power in accurate 50-cycle pulses which are stepped up by a transformer and smoothed by a filter before reaching the synchronous motor, as shown by block diagram in Fig. 8.

Communication Circuits

It is important that continuous communication be maintained between the recording truck and the shooting truck. Where the distance between trucks on a spread is less than 2,000 feet it is convenient to use telephone lines. For greater distance, radio communication is used. In addition to voice transmission, provision must also be made for transmission of the time break (instant of explosion) and shot point seismometer first break. The latter gives the time of transmission through the earth from the position of the explosive in the hole to the top of the hole. Figure 9 shows a typical two-way wire telephone system and includes the shot point seismometer and blaster time break amplifier and cutout circuit. It is necessary to cut out automatically all stray signals from the shot point as soon as the time break and shot point seismometer break have been received because these signals are recorded through some of the same galvanometer elements that are being used for seismometer groups on the spread.

In radio transmission where amplitude modulation is used, it is often difficult to pick the exact starting point of the explosion time break because of static and other random noises in the receiver when the signals are weak. The explosion time break is a high-frequency pulse very similar to static. To get around this difficulty, one method used is to modulate the transmitter just prior to the shot with a constant 1,000-cps tone which is cut out at the instant of the explosion. The carrier is left on an additional length of time in order that the shot point seismometer break can also be recorded. In some cases it is not necessary to record the shot point seismometer break, so the explosion time break can be used to cut off the carrier and this event recorded at the receiving point is used as the time break.

Still another method is to start a 1,000-cps modulation on the carrier by means of the explosion and stop the modulation by means of the shot point seismometer pulse arrival. This system is shown in detail in the diagram of Fig. 10 which gives the wiring at the shooting truck. In the bottom center block the left-hand thyratron (type 2050) is fired by the explosion and operates the left-hand relay to connect the 6C8G oscillator at the lower right to the triode amplifier in its own envelope. This amplifier feeds the modulator in the transmitter shown in the upper right block. Shortly after the 1000-cps modulation has started, the shot point seismometer voltage amplified by the 6C8G in the lower left fires the right-hand 2050 thyratron. The relay in the thyratron plate circuit grounds the oscillator output.

At the receiving truck the 1000-cps wave train may be recorded in its original form or only the envelope may be recorded. The initiation of the wave train, or leading edge of its envelope, gives the time of the explosion and the trailing edge gives the shot point seismometer arrival time.

In the lower left-hand block is shown a circuit which checks the times as transmitted by radio against the original pulses directly from their source. This record is used only as a check against any possible defects which may arise in process of continued operation. The thyratrons drive the relays so hard that the relay delay is too small to be significant. An ingenious method of transmitting the two timing pulses by means of frequency modulation while reserving amplitude modulation for voice communication is described by Shook, Olson and Kerr in *Proc. I.R.E.* for October, 1944.

Complete Recording Units

The operator's panel is built in a single rack. At the top left is the control panel where all seismometer cables enter, and the signals from the various groups are distributed to the proper amplifier channels. This panel also includes means for testing breaks or shorts to ground in cables or seismometers. At the top center is located the fork oscillator system and telephone amplifier beneath it. On the right is the galvanometer type recording oscillograph, usually referred to as the camera. In the bottom half of the rack there are twenty-four amplifier channels. Each chassis contains two channels. At the left of the channel array are the master switches which enable the operator to select rapidly any desired amplifier characteristics before shooting. Each pair of switches controls its corresponding row of channels. On the right-hand side of the amplifiers are the battery test panels and master firing controls.

This complete system is placed in a truck for use in rough country. These trucks are designed to operate in wooded or swampy sections where they often make their own roads and are able to knock down small trees.

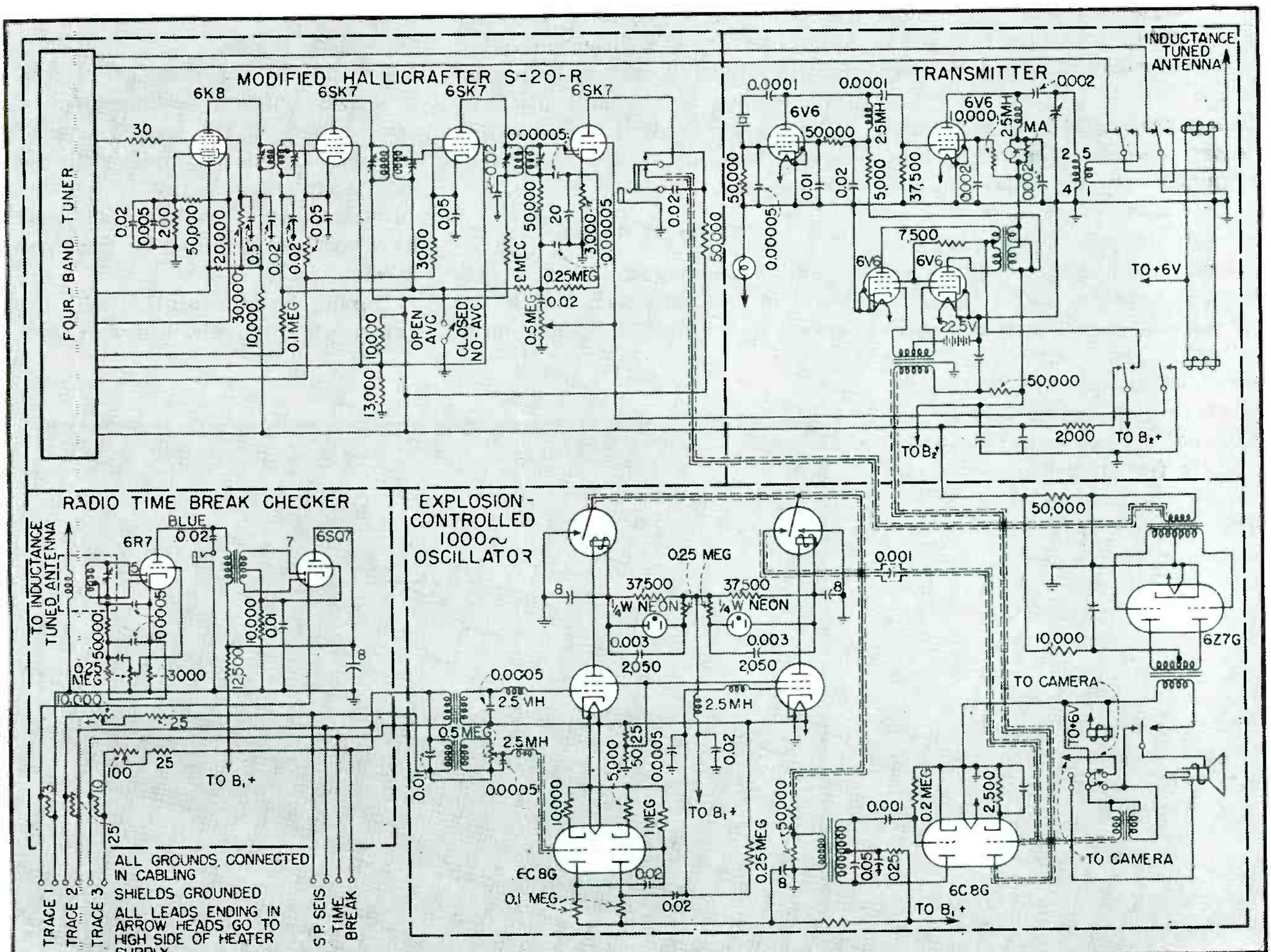


FIG. 10—Communication equipment and keying circuit are used to modulate a carrier from the time the shot is fired until the percussion wave reaches the ground surface above the firing point

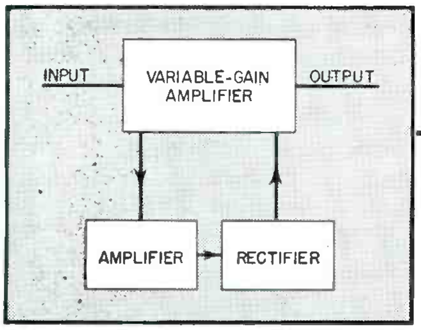


FIG. 1—Block diagram of an electronic volume-expander circuit in which the rectified signal is used to control gain

VOLUME

By ROBERT W. EHRLICH

Maplewood, N. J.

MANY people, having listened to volume-expansion amplifiers, have found them to introduce undesirable wows, gasps, pops, or just plain distortion in the reproduced output. There is, however, ample justification for volume expansion in the fact that a certain amount of volume compression is used in making a majority of recordings and sometimes in broadcast work. In addition, the reduction of amplification at low levels helps to reduce record scratch and background noise during such passages.

This paper represents the results of a series of experiments to find the answers to expander design. The expander to be discussed is the electronic type, wherein the signal is rectified and the resulting d-c voltage is used to control the gain of a variable-gain stage as shown in Fig. 1. There are many other ingenious ways of introducing volume expansion, but it is felt that this type provides the necessary flexibility for application to varied types of program material.

The expander illustrated in Fig. 2 was developed in connection with these experiments. It has been found to give satisfactory results with a wide range of program material, and, even when improperly adjusted, it does not have many of the undesirable characteristics experienced with other circuits. The complete circuit of the expander is shown in Fig. 3.

Requirements

The design of an electronic volume expander involves a number of interesting problems beyond those ordinarily encountered in amplifier work. The variable-gain stage must operate at not just one point on its characteristic, but rather over the complete range of its characteristics without introducing distortion. The amplifier which feeds the rectifier circuit must have means for adjusting its gain without any audible indication, and this gain must be variable to suit the various input signal levels.

Finally, the rectifier must be capable of rectifying a complex a-c signal without introducing objectionable ripple into the signal circuit. Moreover, the time constants throughout the expander circuit must be so adjusted that full expansion can be obtained in something like 5 to 15 milliseconds, while the time taken to return to normal gain is about one second. By careful attention to all of these requirements, satisfactory operation can be obtained.

Choice of Circuits

The variable-gain stage is the heart of the expander, and its selection is the first consideration in design. Perhaps the most widely used tube for this purpose is the 6L7, in which the d-c bias voltage on grid number 3 controls the gain of the tube with respect to grid number 1. Another popular method is to use a variable-mu tube such as the 6SK7 and let the d-c bias on the signal grid control the gain.

A less common but very ingenious circuit uses a triode tube as one leg of a voltage divider for the signal. The other leg is a fixed resistor. By varying the bias on the triode, the tube assumes different values of plate resistance, and thus there is a variation of the relative signal voltage which is taken off across the triode.

Because of the complex biasing problems on multi-element tubes, and because of the wide range of tube characteristics involved in the expansion stage, many of the circuit constants for that stage will have to be determined by trial and error.

During experimentation with the expansion stage, circuits were con-

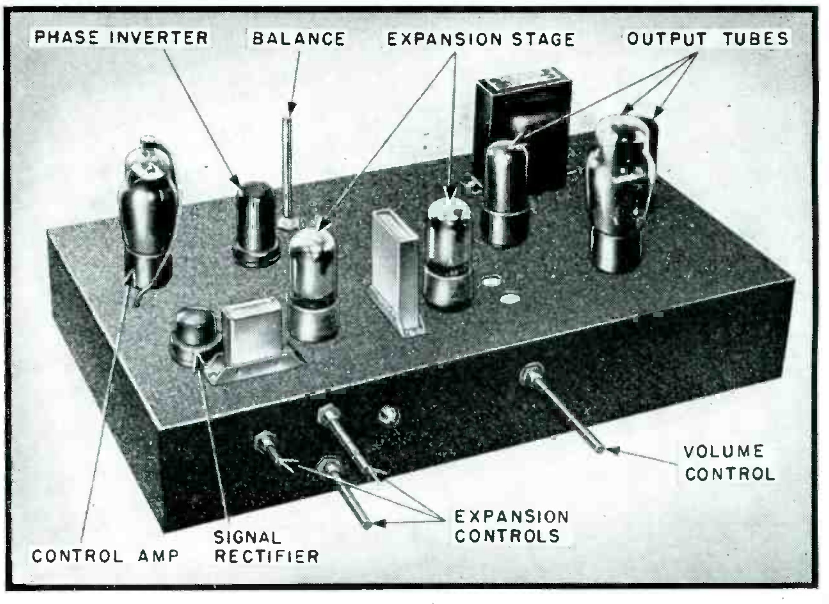


FIG. 2—Chassis of the experimental expansion amplifier

EXPANDER DESIGN

An electronic volume expander provides full expansion of a wide range of program material in about ten milliseconds and return to normal gain in one second. The problems encountered, methods of solution, and results of experimental work are included

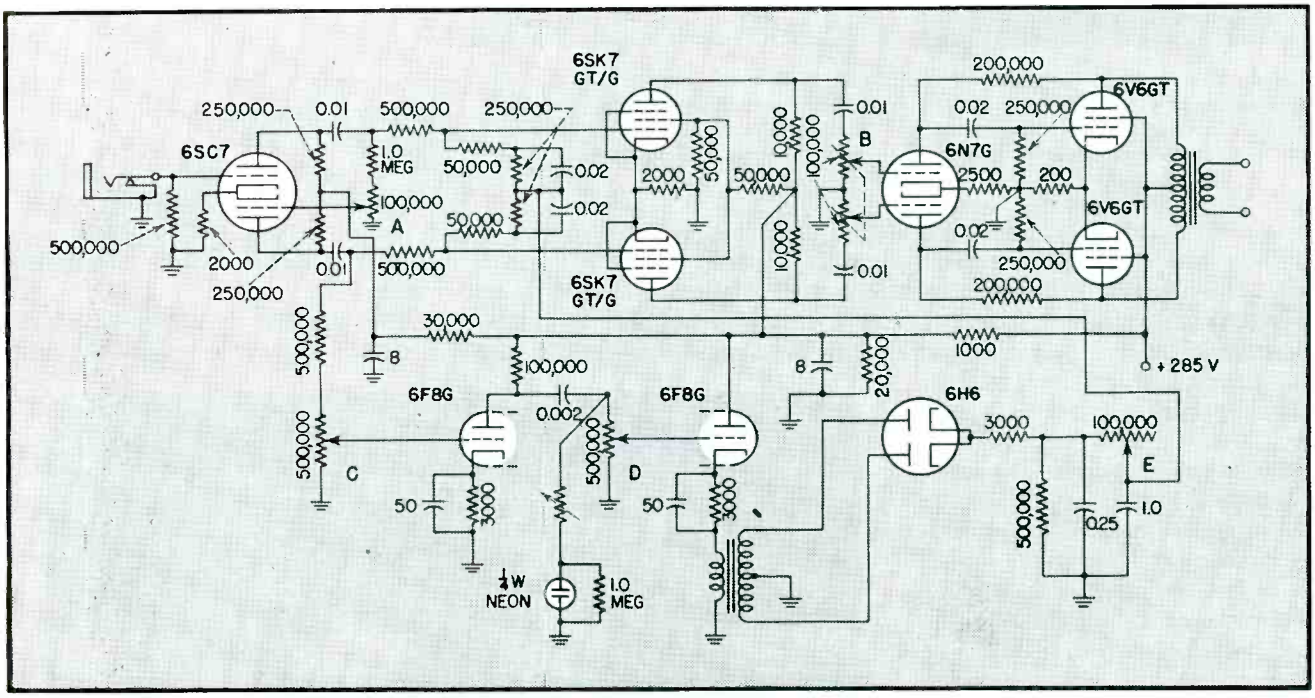


FIG. 3—Final circuit of the expansion amplifier. The lettered controls are identified as follows: *A*-balance; *B*-volume; *C*-input level; *D*-expansion; *E*-time constant

sidered where the input to the control circuit is taken from the output of the expanding stage rather than the input. This type of circuit would have the advantage of reducing the amplification necessary to drive the control circuit. It was found to be unsatisfactory, however, because of dynamic instability caused by the regenerative action. Any delay in expansion was greatly accentuated. Moreover, since the control voltage was proportional to the square of the signal input, the curve of gain vs signal was very steep at higher levels. With one circuit tried, the action of the expander was delayed by one or two seconds, after which the expansion would take place very suddenly. The result was that the gain had no relation to signal strength with a typically variable input signal.

The push-pull circuit for the expander of Fig. 3 was selected after several disappointing experiments with single-ended circuits. Not only do the latter have a tendency to distort due to curvature of the tube characteristic, but they also are affected by any residual ripple that may come through from the rectifier. These effects are largely cancelled out in a push-pull stage.

Advantages of Push-pull

Another advantage, though not apparent at first, is the possibility of avoiding the use of bypass capacitors. Changes of screen and cathode voltages in an expanding stage are in such a direction as to oppose the change in gain caused by a change in grid bias. If the cathode or screen voltage variation is retarded by a large bypass capacitor, it is possible for the gain of the stage to increase before this capacitor can change its charge. When it does charge, it pulls the gain down. The result is that the amplifier gain overshoots its final mark and there is a tendency for thumps to be heard in the output. Figure 4 is an oscillogram which illustrates this type of transient response.

Effect of Transients

Another difficulty inherent in single-ended circuits is the possibility of introducing low-frequency transients or thumps in the output, due to rapid expander action. Such transients are cancelled out in a push-pull stage, since the control bias is applied to both grids simultaneously. Even with push-pull operation, however, it is still necessary to keep the transients in the output of the individual expander tubes from becoming so large as to cut off the following stage. This can be accomplished by transformer coupling, a special phase-inverter tube[1], or, as in Fig. 3, through the use of

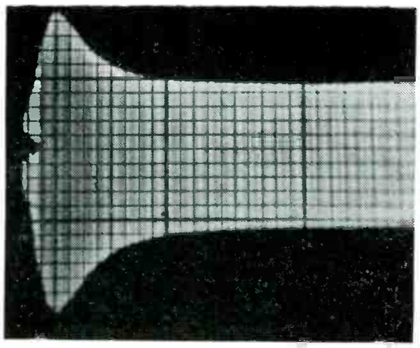


FIG. 4—This oscillogram shows the overshooting of gain caused by a 10-μf cathode bypass capacitor connected across a 10,000-ohm cathode resistor

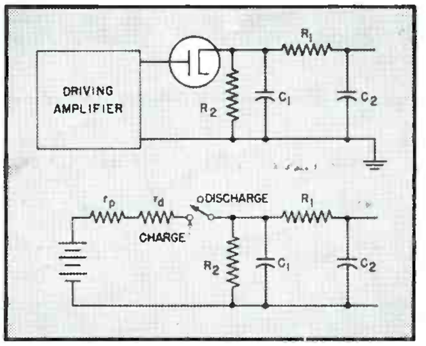


FIG. 5—A simple rectifier and filter circuit is shown at the top. Its equivalent circuit shows the factors that determine the charging and discharging time

low values of plate load resistance and low values of coupling capacitors. The loss in low-frequency response is compensated for by the *RC* networks in the grid circuits.

In the control amplifier circuit of Fig. 3, there are two gain controls. One is used to vary the amount of expansion, and the other compensates for major differences in input signal level. A more common means of controlling expansion is the use of a potentiometer in the rectifier circuit, but this was found unsatisfactory because of its effects on the time constants in the rectifier.

Rectifier Problems

The rectifier with is associated filter is perhaps the most important section of the amplifier, for it is here that the dynamic nature of the entire unit is determined. Improper consideration of these factors can lead to serious volume distortion. The problem is to get an *RC* filter circuit which will react very rapidly to impulses of signal, and still eliminate all traces of rectifier ripple from the signal circuit. The solution is to make all resistors through which the capacitors charge very small, and those through which they discharge very large.

Figure 5 shows the type of rectifier circuit to be considered, along with its equivalent circuit. The charging time is determined principally by the internal impedance of the driving amplifier, r_p the plate resistance of the diode, r_d and R_1; along with capacitors C_1 and C_2. The discharge time is determined by resistors R_1 and R_2 and capacitors C_1 and C_2. It is important also to remember that any other capacitors associated with the expander circuit can affect the time constants.

Calculation of the exact time constants of a circuit such as that of Fig. 5 is rather complex, but the following simple formulas developed by E. W. Kellogg and W. D. Phelps[2] will give the necessary values closely enough.

Charging time constant $= (r_p + r_d)\ C_1 + (r_p + r_d + R_1)\ C_2$

Discharge time constant $= R_2\ C_1 + (R_1 + R_2)\ C_2$

Adjustment of values should be made so that the minimum charging-time constant will not be over 15 or 20 milliseconds and the discharge-time constant not less than 0.5 second. In addition, the total resistance between the controlled grid and ground should, if possible, be kept below the maximum value specified for the tube used. The use of a cathode-follower circuit in the driving amplifier circuit of Fig. 3 makes the driver impedance very low and makes it easy to obtain a low charging time. Control of the time constant is obtained by making resistor R_1 in Fig. 5 variable.

Figure 6 shows an oscillographic determination of the minimum charging time for the expander of Fig. 3. A 500-cycle signal was keyed into the circuit with expansion full on, the 3000-ohm series resistor shorted, and the time-constant control set at its minimum value.

The number of cycles required for 64-percent expansion indicates the charging-time constant, eight milliseconds in this case. In practice, the insertion of the 3000-ohm buffer resistor was found valuable in materially reducing rectifier ripple. This resistor brought the time constant up to 12 milliseconds.

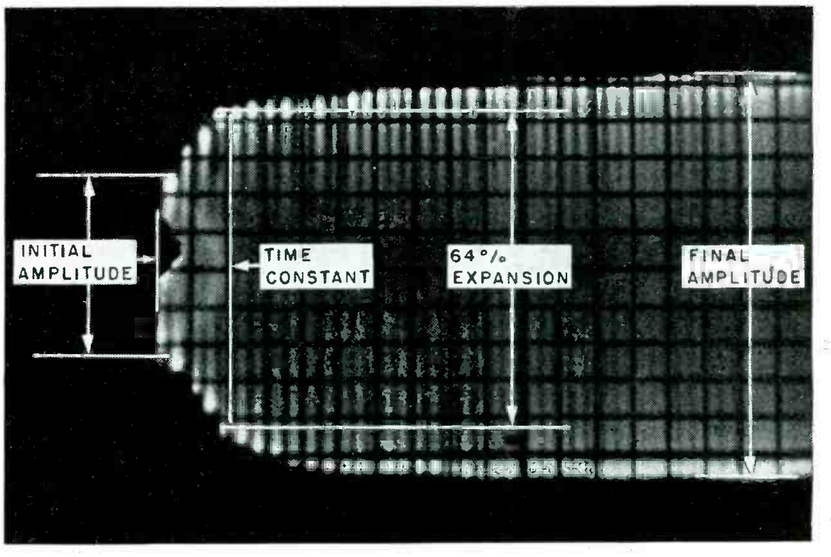


FIG. 6—Oscillogram showing the shortest possible transient response for the circuit of Fig. 3. The notch at the left was caused by masking tape over the stationary spot on the screen

Static Test

Performance is determined by testing for change in gain, or expansion, with respect to control voltage. For this test, control voltage is most easily obtained from a battery and potentiometer. A gain curve for the expander is shown in Fig. 7. The points to be noted are first, that the maximum change in gain without distortion must be at least about three times (10 db), and second, that the curve of gain versus voltage should be fairly straight over the range selected.

To compensate theoretically for a typical compression characteristic, all of the expansion would have to take place in the upper two db (20 percent) of the control voltage swing. This characteristic is neither necessary nor desirable. For one thing, the input level to such a circuit would be very critical, necessitating many readjustments of input level. Furthermore, this type of curve can lead to undesirable dynamic characteristics, especially in connection with overlong time constants. This combination will make the expansion come on suddenly, many milliseconds after the initial input impulse. The effect is difficult to describe, but it is unquestionably unpleasant.

Operation

Setting of the amount of expansion and the time constant is complicated by the fact that it is practically impossible to detect the action of a properly adjusted expander. There is a natural tendency to advance the expansion control to the point where the effects of the expander can be heard, for if time and effort have been put into the construction of such a circuit, one likes to hear it work. As a matter of fact, the only way to tell accurately how well an expander is operating is to play the same passage twice, once with expansion on and once with it off. This is only possible with phonograph records, for which reason records are probably the best source of program material for one who is learning to use an expander.

Once some experience has been gained with the expander, the two gain controls *C* and *D*, and the neon indicator in Fig. 3 can be used to advantage in setting up the expander for operation with any type of signal. The resistors associated with the neon lamp are so adjusted that the lamp begins to glow when the signal voltage is large enough to drive the expander to full expansion. The level at this point is adjusted by control *C* in such a way that the lamp will blink at peaks of modulation. For any radio station or record, this adjustment can usually be made in a few seconds, and it will hold as long as the same input source is maintained. With the signal level in the expansion control circuit so adjusted, it is then possible to set the second gain control, *D*, in terms of its own panel calibrations to give the number of decibels expansion desired for the particular program material.

Typical Control Settings

Actual settings of the expansion and time-constant controls will naturally vary for different types of program material. Symphonic selections are perhaps easiest to expand. This type of music will take all the expansion the amplifier can give, at the shortest time constant, without any unpleasant reaction. The only limit here is the point where soft passages are too soft to hear and loud ones uncomfortably loud. Martial band music also falls into this category.

Dance music is a little more difficult to handle, and expansion should be used cautiously. The time constant should be short when the music is slow; but if the music is fast and hot, a long time constant is required to swamp out the rapid volume impulses and prevent jerkiness.

Speech is also difficult to handle but expansion can still be used to advantage if it is used sparingly. Time constants on speech should be kept short to preserve the natural expression. An over-long time constant and excessive expansion can lead to a very undesirable gasping or breathless effect.

One type of material for which expansion is not recommended is a vocal or instrumental solo. The performer puts in his own volume expression, and expansion will seriously distort it. The effect is at its worst when the expansion control circuit has peaks in its frequency response so that certain notes are expanded out of proportion to the rest.

Table I indicates in convenient form the expander settings recommended for various types of material.

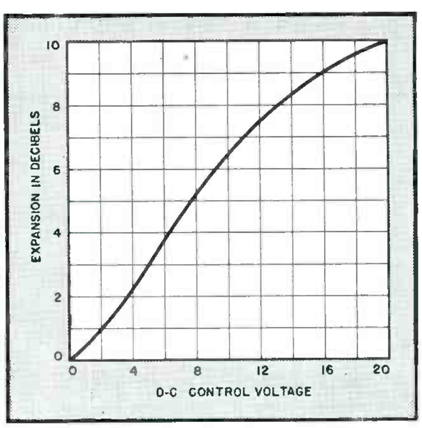


FIG. 7—Static gain versus control-voltage characteristic of the push-pull expansion stage shown in Fig. 3

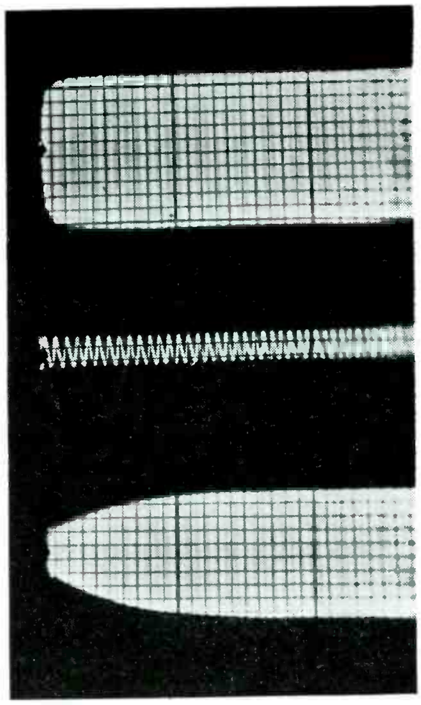


FIG. 8—Variation in charging-time constant available with the circuit of Fig. 3. Minimum is shown at the top of the illustration, and maximum at the bottom. In the center, a 60-cycle trace is given for reference

TABLE I. RECOMMENDED EXPANDER SETTINGS

Program Material	Expansion	Time Constant
Symphonic Music, Band Music	Full	Short
Dance Music (slow)	Medium	Short
Organ Music	Low	Short
Speech, Dance Vocals	Low	Short
Swing Music (fast)	Medium	Long
Operatic Vocal Solos, Instrumental Solos	Not Recommended	

REFERENCES

(1) Weidemann, Lt. Henry K., USNR, A Volume Expander for Audio Amplifiers, *QST*, p 19, Aug. 1945.
(2) Kellogg, E. W., and Phelps, W. D., Time Delay in Resistance-Capacity Circuits, ELECTRONICS, p 22, Feb. 1937.

CRYSTAL-DRIVEN for D-C Amplifiers

A 1000-cycle signal actuates a rochelle-salt crystal that drives a carbon button in series with the d-c signal to be amplified. The composite signal is amplified and demodulated at high level

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Of the many problems encountered in the design of a sensitive d-c amplifier, one of the most troublesome is that of drift of the zero-signal point due to unavoidable changes in supply voltages, circuit constants and tube characteristics. One solution is to impress the d-c signal on a high-frequency a-c signal in such a manner that the resultant amplitude of the combination signal is proportional to the instantaneous value of the incoming d-c signal. The modulated signal is then amplified and rectified at high level to obtain a d-c voltage or current proportional to the original d-c signal.

One method of applying this principle of operation involves the use of a mechanical chopper which periodically interrupts the d-c signal and applies the resulting a-c signal to the input of a conventional a-c amplifier. The principal limitation of this method is that the highest frequency component of the signal to be amplified must be low compared to the chopper frequency. This is sometimes difficult to achieve because of the upper freqency limit of the vibrating or rotating mechanical system due to mass, stiffness and other factors. Moreover, considerable hash is caused by the making and breaking of the contacts and this limits the lower range of signals to be amplified.

Construction of Driver

The device to be described is in effect a chopper which is less subject to the above mentioned limitations than the conventional discontinuous mechanical device. It consists of a carbon microphone button mechanically coupled to a rochelle-salt crystal. The method of coupling and mechanical details are shown in Fig. 1. The crystal unit is supplied excitation by an oscillator operating at a frequency of 1000 cycles. It is essential that the output of the oscillator remain constant. This condition is obtained by the use of a three-watt tungsten lamp in tne cathode of the first stage of the oscillator unit.

The d-c signal to be amplified is applied to the input transformer through the carbon button as shown in Fig. 2. Conversion of the d-c input to an a-c signal is accomplished by the carbon button due to the continuous vibration of the rochelle-salt crystal to which the button is mechanically coupled. This action results in a loss in signal of about 3 to 1 between the d-c input and the primary of the input transformer. A step-up ratio in the transformer of about 30 to 1 compensates for this loss and results in an overall gain of approximately 10 to 1 between the d-c input terminals and the grid of the first tube.

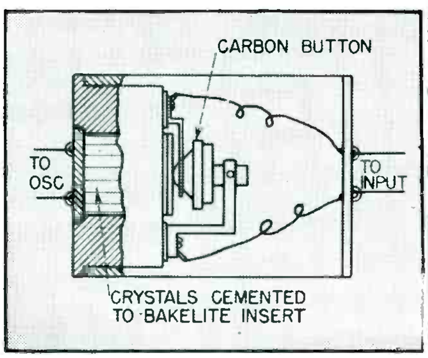

FIG. 1—Mechanical details of the crystal-driver assembly

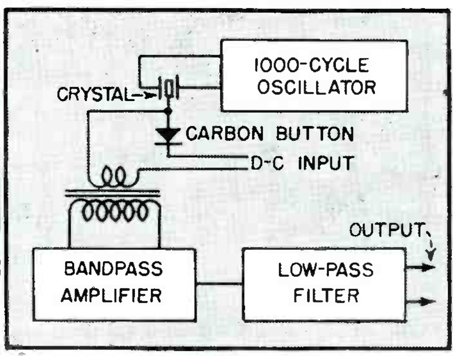

FIG. 2—The essential units of the system

Calibration

To permit accurate measurement of the d-c signal, means is provided for calibration of the system by the introduction of an accurately known calibrating potential.

As shown in Fig. 3, the calibration system consists of a ladder

MODULATOR

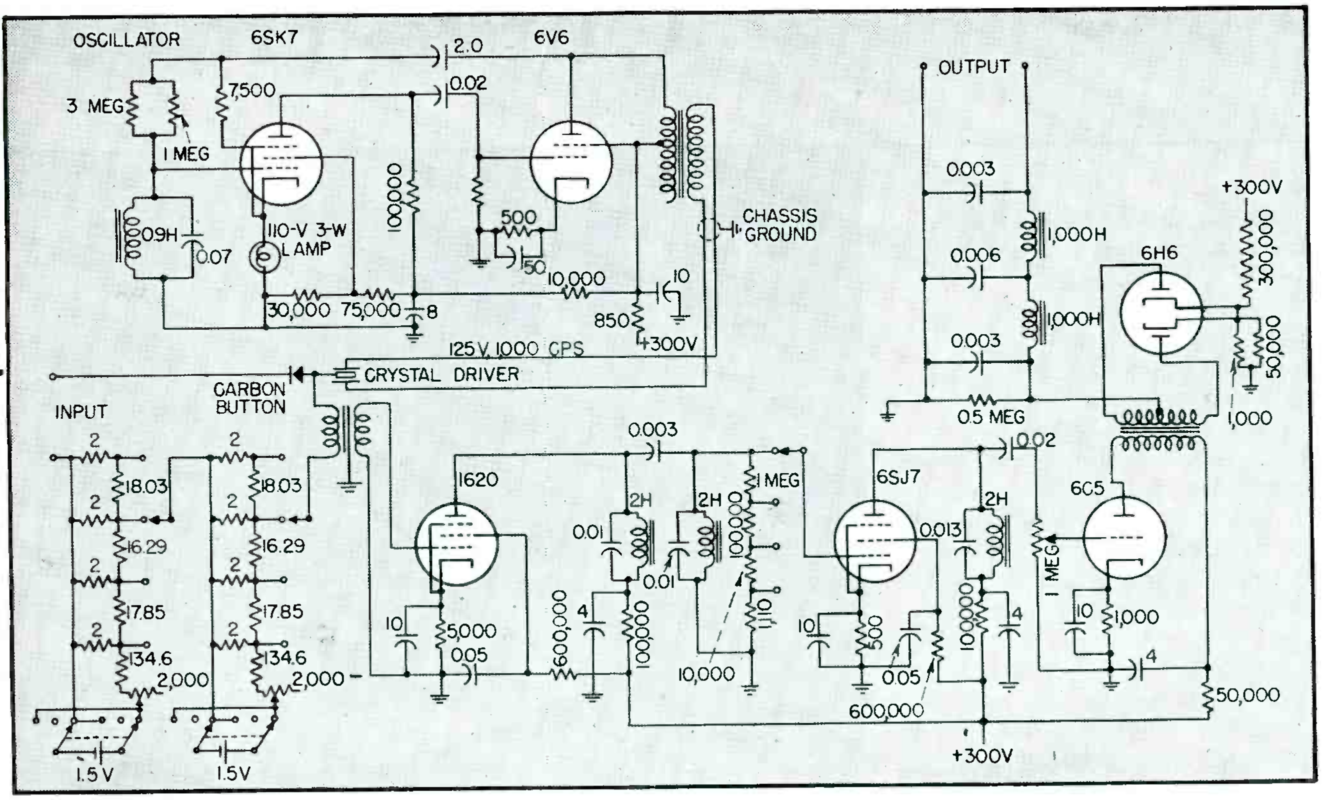

FIG. 3—The circuit shown above provides a d-c output of 40 volts with an input of 20 microvolts

network supplied by a 1.5-volt battery, with a switch for reversing the polarity. The calibrating voltage appears across a 2-ohm resistance in series with the input and is continuously adjustable over the entire range of the amplifier. A duplicate calibration system may be used as shown to balance out any steady d-c potential that may be present in the input.

The a-c signal resulting from the action of the converter is amplified by a three-stage bandpass amplifier. The response of the amplifier used is flat within ±0.5 db from 900 to 1100 cycles, making possible observation or recording of signals from 0 to 100 cycles. This pass band might be extended if a higher frequency response were desired. The carrier signal is effectively eliminated by a low-pass filter having a cutoff freqency of 150 cycles, and an attenuation of 70 db at 1000 cycles. The output filter operates into a 500,000-ohm load.

The input impedance of the device is limited by the carbon button to around 75 ohms. This impedance might be increased by adding series resistance, with a consequent loss in voltage sensitivity. A gain control and step attenuator are included in the amplifier, to provide for a wide range of input levels.

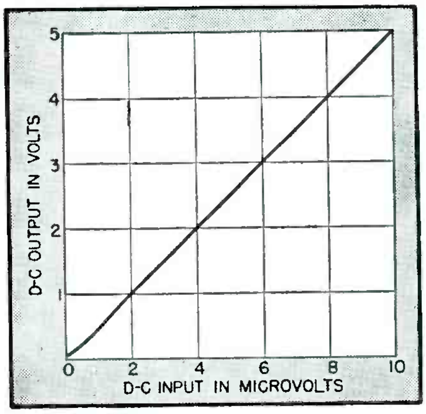

FIG. 4—The calibration voltage was used as the input signal to obtain this curve

Output Voltage

In Fig. 4 is shown a linearity curve of the over-all system. This curve was obtained by using the calibration voltage as the input signal and reading the output voltage on a high-impedance d-c meter. The attenuator was turned to the maximum sensitivity position and the gain control adjusted to give 5 volts output with an input of 10 microvolts as read on the dial of the calibration system. The curve was repeated on each scale with results that deviated only about three percent. The maximum output voltage obtainable is 40 volts with an input of 20 microvolts. This makes it possible to calibrate the system at any convenient output voltage up to this value.

The instrument was used satisfactorily in making field measurements of signals ranging in level from 2 microvolts to 30 millivolts and varying in frequency from 0 to 100 cycles. No zero shift was observed.

For use on the high-sensitivity range, it was found necessary that the input tube and the crystal driver be properly cushioned to prevent microphonics and that adequate shielding be employed.

Curve-Tracer

By R. K. HELLMANN

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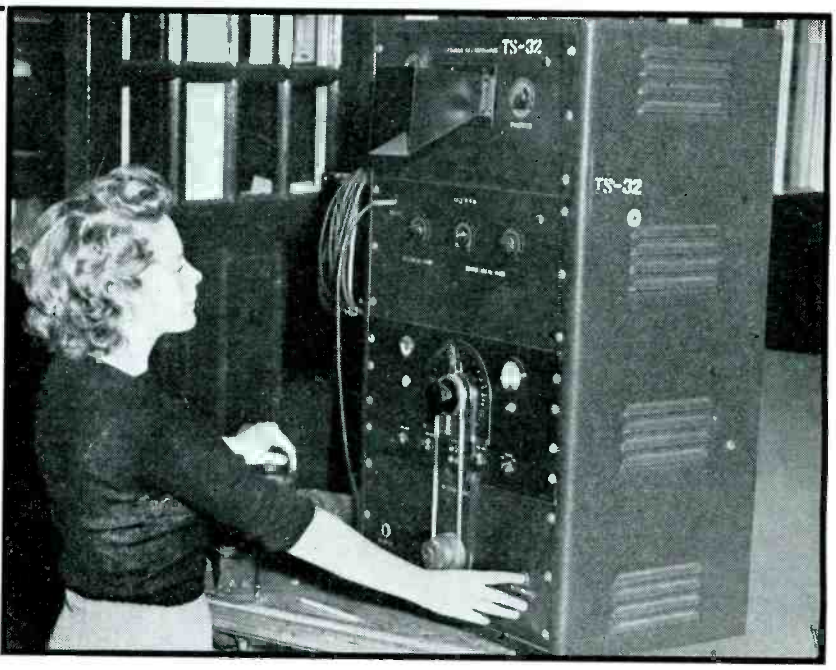
Great American Industries, Inc.
Meriden, Conn.*



With her left hand the operator holds a handset receiver which is being production tested for frequency response. The belt, center, drives the bfo and synchronizes it with the c-r sweep. Trace appears at top, inside light shield

ACOUSTICAL DEVICES such as telephone handset receivers, loudspeakers, and microphones are now manufactured in accordance with performance specifications which call for a predetermined output-versus-frequency curve with comparatively narrow tolerance limits. In order to control production quality it is necessary to check the performance of each unit produced.

Among the various methods of recording a test curve the semi-permanent trace obtained with a cathode-ray tube of long screen persistence was found the most practical solution. A curve traced in this manner with a relatively slow sweep can be made visible between 3 and 15 seconds, which is long enough to produce the impression of the complete diagram, and short enough to cause no interference with a subsequent curve.

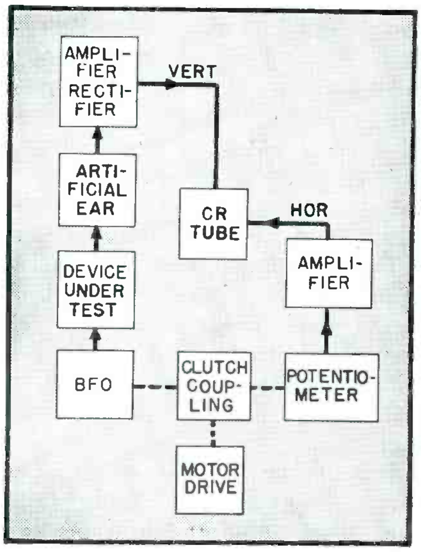


FIG. 1—Curve tracer includes these units. Artificial ear is a crystal or capacitor microphone

The curve tracer described here is based on this recording principle. A study of the literature reveals considerable previous work in this direction, largely with the view of producing diagrams automatically by means of advanced electronic arrangements, whereas in the present instrument straightforward circuits and methods are used. However, the fact that in its present form it has withstood the rough treatment on the assembly line over a period of five years while testing well over a million units justifies this report.

Operation of the curve tracer is shown in the block diagram in Fig. 1. The device under test is fed from a beat-frequency oscillator whose frequency is varied by a mechanical drive. The same drive also actuates a potentiometer which controls the horizontal deflection of the luminous spot in the cathode-ray tube. The device under test may be, for instance, a handset receiver. It is coupled to an artificial ear. The output of the latter is amplified, rectified, and applied to the vertical deflection plates of the oscilloscope.

Frequency Sweep

The mechanical drive affords automatic scanning and consists of a reversible a-c motor with double gear reduction. On the slow shaft is a coupling device which, in the engaged position, connects the motor drive by means of a pretensioned metal belt with the pulley on the beat-frequency oscillator. Also on the slow shaft is a cam which operates two adjustable sets of contacts.

Figure 2 illustrates the operation of the drive circuit. When the starting button is pressed, the armature of the motor is energized through the contacts of the holding relay so the motor moves forward, starting the frequency sweep.

for ACOUSTIC DEVICES

Quality control over full-scale production output of handset receivers is obtained through the use of a powered-sweep bfo, a long persistence c-r tube, and suitable test fixtures

When the cam opens the adjustable end contact, the holding relay releases and reverses the motor. This moves the beat-frequency oscillator toward its starting frequency.

Near the rest position, a cam-operated switch opens the armature circuit and stops the motor. If the inertia of the armature should carry the cam beyond the range of this rest position a second contact on the same adjustable arm closes and makes the motor rotate in a forward direction until it comes to rest between the two contacts.

When the end contact in the forward direction opens, a quick-acting relay lifts the bias of the cathode-ray tube. The bias is normally sufficiently negative to blank out the beam. In this manner a trace is produced on the screen only during the forward sweep. Since current density in the spot and accelerating voltage are high to make the afterglow of the trace last a long time, this precaution is necessary to prevent burning of the screen with a stationary spot.

Provisions are made to operate the drive and the frequency-determining potentiometer by hand so details of the diagram can be retraced. To this end the coupling device on the slow motor shaft can be pressed inward to disengage the metal belt from the shaft of the drive and the associated cam. However, engagement with the potentiometer which controls the horizontal beam displacement is retained. When released, an arrangement of spring pins relocates the oscillator control at the starting frequency as determined by the adjustable contact arm.

Since manual operation does not energize the holding relay the cutoff bias must be lifted in that case by pressing a button marked 'Manual'.

Potentials at both ends of the sweep potentiometer can be adjusted by two separate controls so the frequency range of the sweep, as set by the adjustable cam contacts, can be spread out to any desired length on the screen.

Test Fixtures and Circuits

It will be realized that the curve tracer as a production testing device is only as practical as the auxiliary apparatus and fixtures.

Figure 3 shows the test fixture and circuit of a handset receiver. Since the cavities in the molded cap of the handset establish the shape of certain parts of the response curve, the test fixture consists of a handset with a special cap that is quickly detachable by means of a bayonet lock. A spring holds the unit against the coupler of the artificial ear with the prescribed pressure of 1 kilogram and also holds it safely in the loading position. The receiver under test is connected to the low-impedance output of the beat-frequency oscillator through a resistance equal to the nominal receiver impedance at 1000 cycles, and the voltage is adjusted at the same frequency so 1 mw is delivered to the receiver.

A crystal microphone made by Ballantine Laboratories and equipped with a coupler of approximately 12 cu cm has been found highly suitable for this application.

In order to stabilize the receivers magnetically a cam transfers the receiver leads momentarily to the source of stabilizing current during the closing of the handset arm in the fixture and restores them to the audio voltage just before the receiver seats itself on the coupler.

A somewhat more elaborate fixture is illustrated in Fig. 4. It accommodates the two receivers of a headset and is therefore equipped with two artificial ears. These are mounted on a support plate which can be lowered by a foot lever for

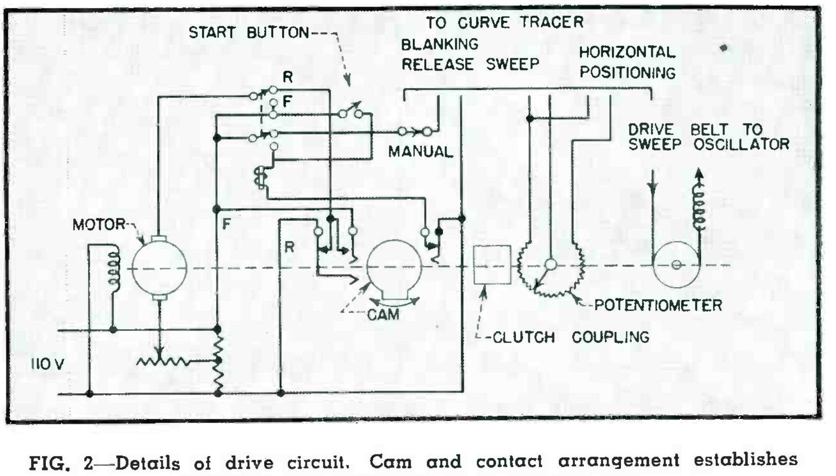


FIG. 2—Details of drive circuit. Cam and contact arrangement establishes start and stop positioning of mechanical train

loading. The receivers are placed in positioning recesses in the loading platform. When the pedal is released the ears are lifted by a spring which presses their couplers against the receiver units and the individual loading weights.

When used for testing high-impedance headsets of the resonant type, this fixture is associated with the circuit shown in Fig. 5. This was developed in accordance with the observation that sufficiently informative curve-tracer diagrams are obtained if both receivers, coupled to their respective ear cavities and connected in series, are run together. The output of each ear can be connected to the curve tracer input by means of switch T.

The data to be checked are the frequency and amplitude of the resonance peak, its width at 6 db down, and the impedance at peak output. Measuring the latter is at the same time an insurance that the output measurement in series connection does not introduce errors due to uneven voltage distribution. The test circuit can accordingly be arranged to provide four conditions which are selected by means of a 3-deck, 4-position switch, *S*.

After placing the headset in the fixture the operator proceeds as follows: position 1 of the main switch S is a calibrating position. Voltage E_1 is adjusted at 1000 cycles to a standardized value, and a fixed small fraction is fed directly into the curve tracer input whose gain is then adjusted against a calibrating mark on the screen.

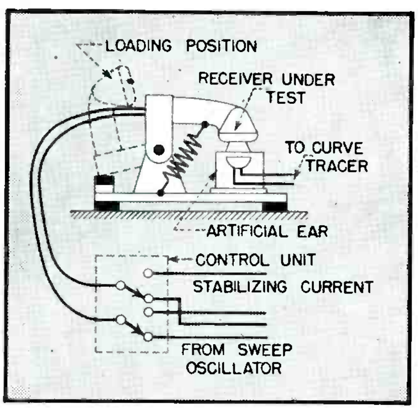


FIG. 3—Production test fixture duplicates physical arrangement of actual handset receiver

In position 2, one-half of the standardized input is fed to the two receivers in series and the resonance peak is noted. Immediately, the curve is repeated with full input voltage in position 3. The location and magnitude of the main resonance can be noted as well as its width at a level 6 db below the peak, which will still be visible faintly from the trace taken in position 2.

By switching *S* to position 4 a comparatively small measuring resistance *R* is inserted into the circuit and the potential drop across it connected into the curve-tracer input. The resulting curve represents E_1R/Z and can, as *R* and E_1 are constant, be interpreted in terms of *Z* as a function of frequency. It is particularly convenient to read impedance at the output peak frequency, which has been set as a specification requirement.

When it comes to testing high-fidelity receiver units whose output level must be kept within narrow limits and is to be determined in terms of absolute sound pressure, the crystal microphone is no longer used.

Figure 6 shows a production line fixture using a Western Electric 640-A capacitor transmitter with a 6-cu-cm coupler, preamplifier and power supply.

The fixture is combined with a demagnetizer which reduces the initially fully-charged receiver magnet to a value indicated by the curve-tracer diagram.

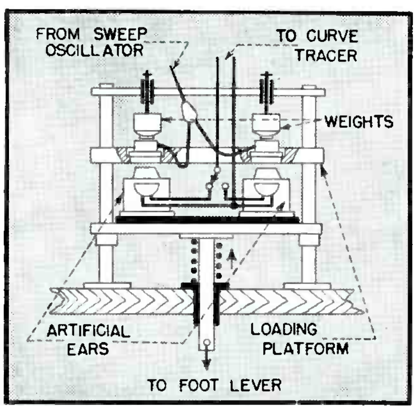


FIG. 4—Duplex fixture tests two receivers of a headset at once. Circuit is shown in Fig. 5

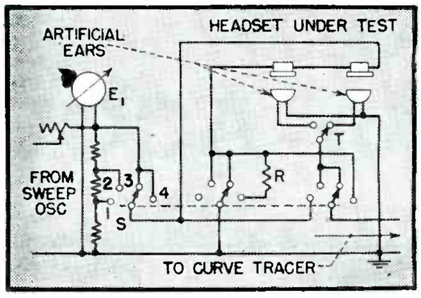


FIG. 5—Headset receivers are tested in series using the production fixture of Fig. 4. Individual outputs are connected to the curve tracer by switch T

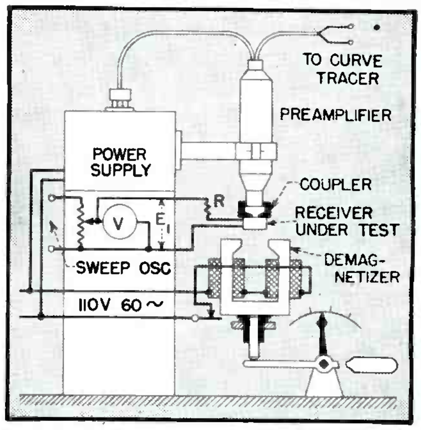


FIG. 6—High-fidelity receiver-units with narrow limits are tested in this fixture which combines a capacitor microphone and hand-actuated demagnetizer

The U-shaped laminated yoke of the demagnetizer is excited with 60-cycle a-c and can be lifted by means of a hand lever to expose the receiver magnet to a stronger or weaker alternating field. In the lowest position the exciting winding is disconnected.

For use with this fixture the standard curve tracer was modified slightly. The bias of the cathode-ray tube was adjusted so that a faint spot was normally visible instead of completely cut-off. The clutch mechanism was provided with a detent at the 1000-cycle point in the disengaged (manual) condition.

With this arrangement the first test operation is to set the sweep frequency by hand to 1000 cycles and adjust the input voltage E_1 so that the light pointer hits the zero-db level marked on the screen (see also Fig. 7B). The calibrated voltmeter will then indicate, in db above a reference level, the sound pressure developed by the receiver under test. By gradual demagnetization, response can be brought between limits marked on the voltmeter dial.

The clutch is subsequently re-engaged to the lower starting frequency and the sweep with a brilliant trace is initiated by pressing the starting button. The curve will, of course, go through zero at 1000 cycles and therefore represent deviation from that point.

Screen Markings

To facilitate rapid interpretation of the diagrams produced by the curve tracer, the screen markings deserve special attention. Figure 7 illustrates three types of markings used.

Lines and symbols are usually drawn directly on the outside of the screen. The choice of a particular marking scheme depends, of course, largely on the test specifications. In Fig. 7A for example, which shows the pattern obtained with the fixture of Fig. 3, it was possible to describe the tolerances of the output curve simply by an upper and lower limit. The shaded areas were painted red so parts of the ordinarily bluish-green trace changed to that color as soon as they exceeded the permissible limits. It would be conceivable to utilize this for an automatic rejection feature by placing in front of the screen a phototube which has been made selectively responsive to red by suitable filters.

The two dashed frequency lines serve as calibration points for frequency adjustment, and the horizontal markings serve for gain adjustment by means of a standard unit.

In Fig. 7B, the curve will always go through the intersection of the 1000-cycle line and a zero-db horizontal. Again a number of calibration markers can be seen. Due to higher accuracy required with this test, the width of the trace had to be considered. Unless push-pull deflection amplifiers are used, the diameter of the luminous spot is likely to vary from one end of the curve to the other. If this is the case, the lines denoting the limits should be corrected so that the interference between any part of the spot and the limit line is not acceptable. To use for this purpose the imaginary center of the spot was generally found unsatisfactory in practice.

In Fig. 7C still another method of marking is indicated. A number of taut black wires are placed across the screen to denote such values as minimum amplitude and frequency limits. This method is particularly convenient for small production runs.

Interpretation

Referring to Fig. 7, a few typical clues to production faults as indicated by the curve tracer can be seen. In the high-fidelity receivers, Fig. 7A and 7B, the slight hump at about 2000 cycles is controlled by an acoustical coupling resistance which connects two cavities inside the receiver.

If this resistance is produced by a piece of silk, its porosity must be kept in a prescribed relation to the volume of these cavities to produce a flat response curve. Too little porosity will result in a pronounced peak in the curve, too much, in a dip. If the silk breather has come loose, this is usually revealed by a rake near the top of the hump.

The peak near the high frequency end is caused by acoustical cavities between the diaphragm and the earpiece of the receiver. In this space a moisture guard in the form of a thin diaphragm is usually placed. Slackness of this membrane may modify the shape of this peak considerably and it is therefore important to control its tension carefully. The shape of output curve in this region reveals to the skilled operator the nature of the required correction.

In the response curve shown in Fig. 7C the location and height of the resonance peak is influenced largely by the condition of the magnetic diaphragm. One of the common faults indicated by a shift in the resonance peak is distortion of the seating surface caused by insufficient lapping or faulty clamping. The degree of sag due to magnetic attraction determines the effective air gap of the receiver and is therefore revealed in both the output and impedance curves. Likewise the degree of magnetization can be determined.

Obviously there are many problems in quality control of acoustical devices where testing by the curve tracer can be applied advantageously. These include production testing of loudspeakers and radio receivers. For testing the latter, the sweep frequency generator can be used to modulate the signal generator, and the demodulated signal as picked off the voice coil of the receiver under test could be used for vertical deflection. Such a test would take only a few seconds but might present a better picture of the audio performance of a receiver than methods presently used.

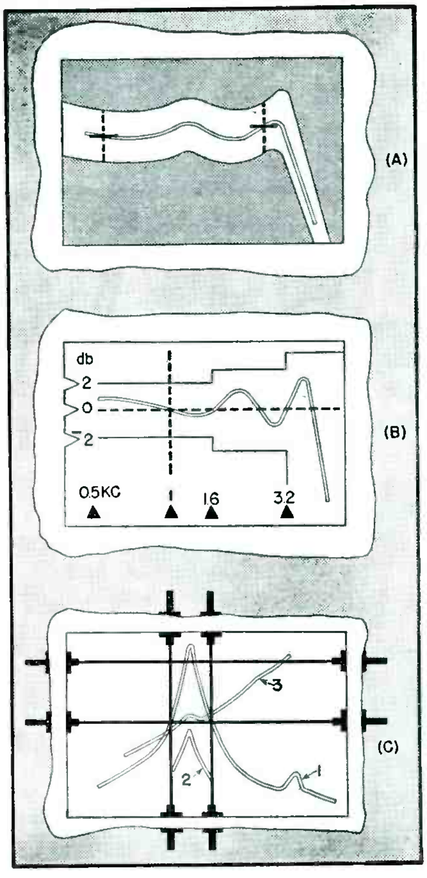
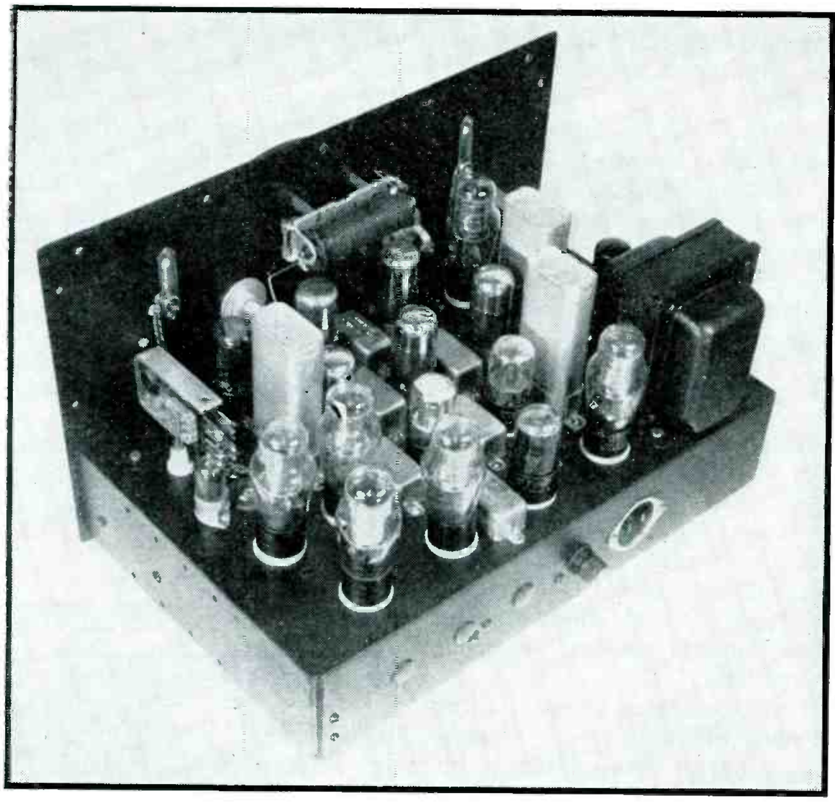


FIG. 7—Three alternative types of screen markings for production-line evaluation of curve-tracer readings. Pattern at A has shaded area painted red to show plainly any deviation of the trace from established limits. Marking B has limit lines established for contact with peaks in curve. Taut black limit wires are used at C for ease of changing on short runs

Machine Gun



Rear view of indicator, designed for operation from 115-volt, 60-cps power. Overload relay operates if gun stops before firing the full 17 rounds required to shut off the timer

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THE testing and qualifying of machine guns requires checking as to rate of fire. Since these measurements must be made from a single burst which lasts but a second or two, ordinary methods of measurement are not adaptable.

One system used in practice employs a cycle recorder as a means of comparing the time duration of about 20 rounds with a time base (usually the 60-cycle line frequency), the rate being calculated from the tape.

The rate-of-fire indicator here described was developed to fill the need for an instrument which could be more conveniently used where testing operations require a large number of measurements to be made rapidly. The instrument is of radically new design, is direct-reading from 600 to 900 rounds per minute, and operates from the 60-cycle a-c line.

Circuit Principles

The instrument consists essentially of an electronic counter, timer, gate circuit, vacuum-tube voltmeter, calibrator, and voltage-regulated power supply, arranged according to the block diagram in Fig. 1.

The mechanical switch unit is clamped to the top cover, directly over the belt-feed slide assembly of a .50 calibre machine gun. The reciprocating action of the slide mechanism actuates a Micro-Switch to initiate generation of a saw-tooth voltage pulse each time a round of ammunition is fired. Firing of the gun thus generates a series of periodic saw-tooth wave forms. These are differentiated

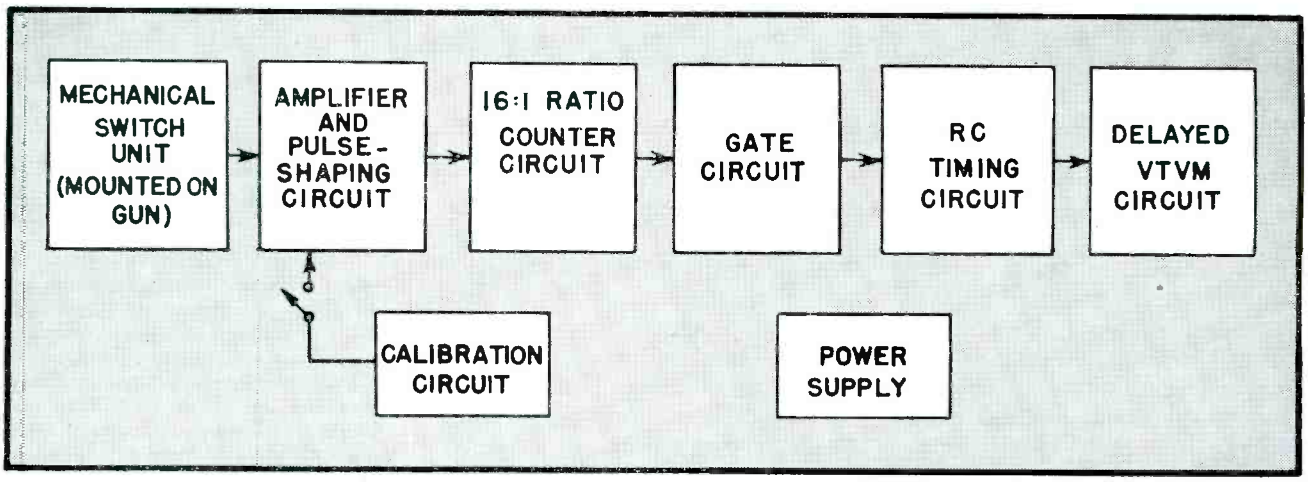


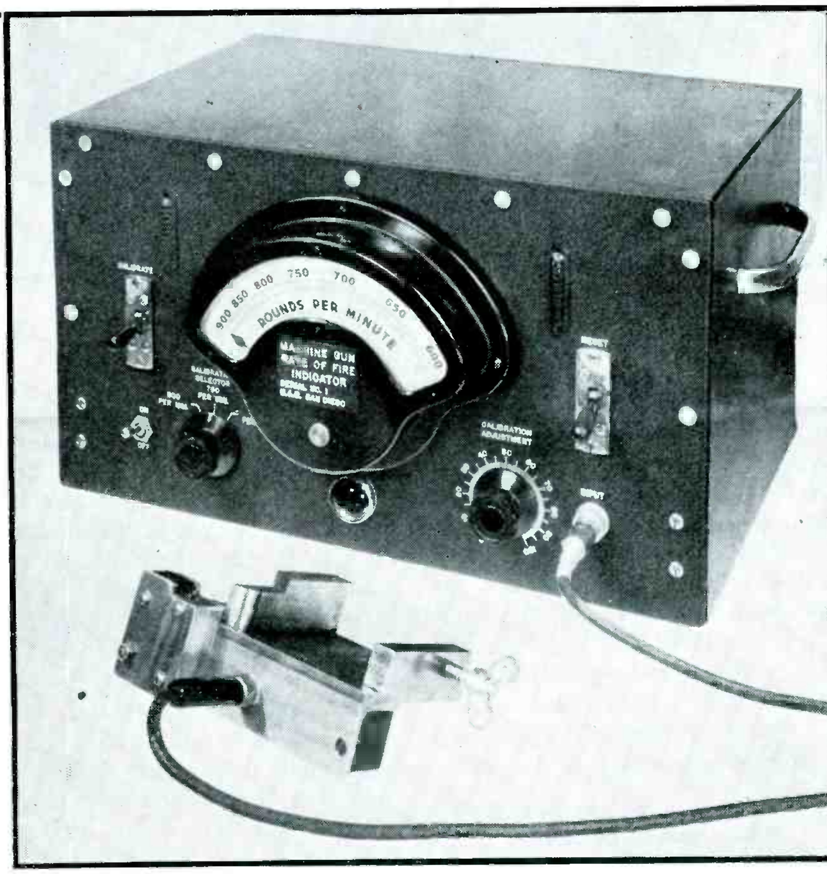
FIG. 1—Block diagram of machine gun rate-of-fire indicator

Rate-of-Fire Indicator

Electrical impulses initiated by a mechanical switch are counted and timed by a series of five Eccles-Jordan trigger circuits and the rounds per minute indicated directly by a vtvm. Non-military production uses are indicated

into negative pulses of short duration and impressed on the grid of the input amplifier to be limited to the proper amplitude for the triggering of the counter circuit.

The timing circuit is controlled by the counter and its associated gate circuit in such a manner as to start and stop the timing action of the timer according to the time required to fire 17 rounds. This time interval is thus a direct measure of the rate of fire. A timing capacitor is charged for the exact duration of the counting period, and the resulting potential of the capacitor is a function of the charging time. This potential is measured by a delayed vacuum-tube voltmeter which is calibrated to read in rounds per minute.



Front view of machine gun rate-of-fire indicator, with mechanical switch that clamps on gun and closes a circuit once for each round of ammunition fired

Counter Circuit

Since the primary requisite of the counter circuit is to control the timing period of the timer according to the rate of fire, the counter cannot introduce any time error. This is not true with simple counter circuits based on the accumulation principle, where the occurrence of each pulse causes a capacitor to charge step by step until a predetermined potential is reached which permits a trigger tube to respond. Since the grid potential at which a trigger tube responds is never exactly constant, a time error results, as illustrated in Fig. 2.

Due to the resistance of the driving circuit, the voltage of a capacitor cannot be changed instantly. Therefore, the leading edges of the steps are not sufficiently steep to reduce error to within an allowable tolerance. For this reason, counter circuits based on the trigger principle were used. A series of five Eccles-Jordan trigger circuits provides a counting ratio of 16 to 1.

The operation depends upon each stage having two conditions of stable equilibrium. Every impulse impressed on the input circuit causes a transition from one state of equilibrium to the other, two impulses being required to complete one cycle. Each stage following the first receives a negative triggering impulse upon every alternate operation of the preceding stage. Hence, the fifth trigger stage, which functions to control the gate circuit, remains in one state of equilibrium for the exact duration between the first and seventeenth rounds, or 16 intervals.

Any number of rounds between 17 and 32 can be fired but only the first 17 are counted and timed. A reset switch is provided for the purpose of restoring each trigger circuit to its initial state of equilibrium, and also to discharge the timing capacitor in preparation for a firing test.

Two neon lamps on the front panel (see photos) are connected to the first and last counter stages, and serve as an added check on the operation of the instrument. The lamp at the right should ignite on

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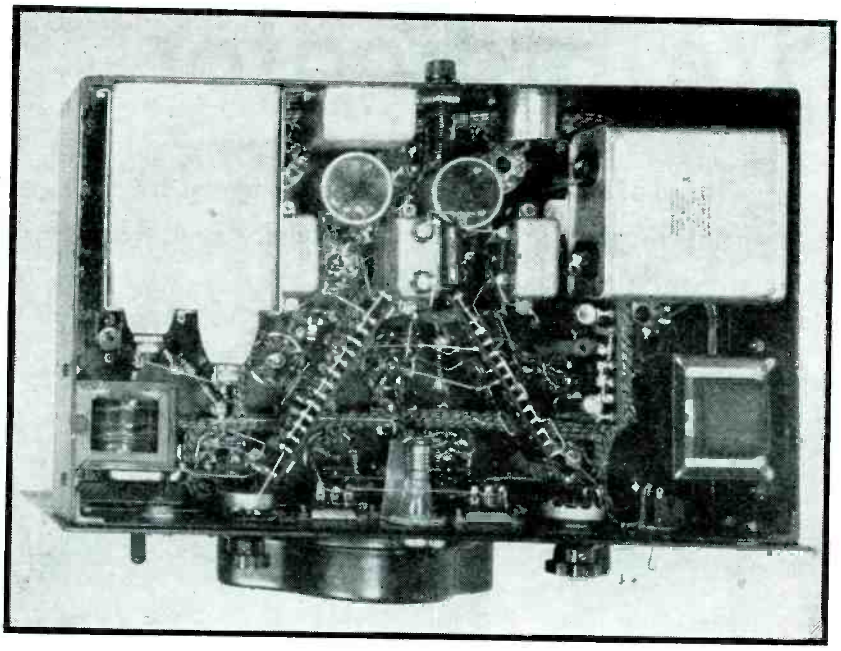
The views expressed herein are those of the author and do not necessarily reflect the views of the Navy Department.



Under-chassis view of machine gun rate-of-fire indicator

the first impulse and not extinguish until the 17th impulse, while the lamp on the left should glow on every other impulse from the mechanical switch.

Loctal type 7N7 tubes were used in the trigger circuits since the two triode sections of this tube have more identical characteristics than those of the equivalent type 6SN7 tubes. The mutual conductance of one section of a 6SN7 tube is greater than that of the other section.

Timer and Gate Circuits

Most electronic switching arrangements which suggest themselves are not suitable for use with a delayed-bias vacuum-tube voltmeter, since the timing capacitor must charge from zero or its initial potential to a more positive potential so as to exceed the cutoff bias of the vacuum-tube voltmeter. If a vacuum tube had been used as the switching mechanism, a timing capacitor in the cathode circuit would have been required to obtain a positive rising potential. Such an arrangement results in undesirable leakage resistance between cathode and filament of the tube, or between the filament winding of a transformer and ground, as the case may be.

These problems and the accuracy required imposed special considerations for the electronic switching and timing circuits, resulting in the development of the design shown by the schematic circuit in Fig. 3. In principle, the zero bias voltage on the grid of the gate tube causes the tube normally to conduct, and the current flowing through the plate load resistor results in a plate voltage of less than the igniting potential of the neon switch lamp. The potential of the timing capacitor is zero, it having been fully discharged during the operation of the reset switch.

Upon firing the first round, the final trigger circuit shifts its state of equilibrium, initiating a negative gate pulse which drives the gate tube far beyond cutoff. Since the *RC* time constant of the input circuit is longer than any interval to be measured, the grid remains cut off until the end of the gate pulse.

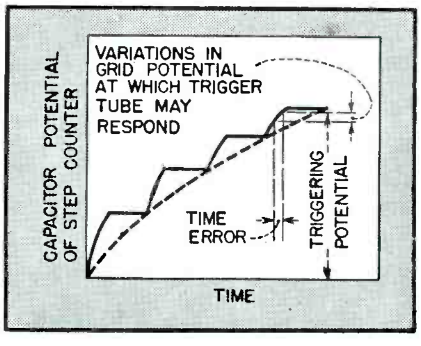


FIG. 2—Characteristics of a conventional step counter, illustrating time error

Thus, the gate tube has an output pulse with an amplitude exactly that of the regulated power supply, as shown in Fig. 4. This voltage is applied to the neon switch-lamp, causing it to ignite and start the charging of the timing capacitor. The voltage of the capacitor increases exponentially at a rate determined by the *RC* time constant.

After the 17th round has been fired, the final trigger stage reinverts to its initial state of equilibrium and a positive pulse is suddenly applied to the grid of the gate tube. This reduces the plate voltage to a value below that of the extinguishing potential of the neon switch-lamp and cuts off the *RC* timing circuit, leaving the capacitor with a definite charge.

By this time, the timing capacitor has charged to a potential more positive than the plate voltage of the conducting gate tube, resulting in a sudden reversal of voltage across the neon switch-lamp as it extinguishes. This reduces the deionization time and the error which would result from an inconsistent deionization time.

After the circuit through the neon switch-lamp has been cut off, the timing capacitor should retain its charge over a reasonable period of time, to prevent the meter reading from drifting. The extent to which this can be accomplished depends upon the leakage of the capacitor itself and its associated circuit elements.

Leakage currents were minimized by removing the base from the neon switch-lamp, replacing insulation of the reset switch with polystyrene, designing the vtvm to have high input resistance, and using a special timing capacitor having very high leakage resistance. Oil-impregnated capacitors are now available with leakage resistance in the order of 20,000 megohms per microfarad. Such a long *RC* time constant makes possible the holding of the charge on the capacitor without loss of more than one percent in over three minutes.

The main consideration in the vtvm design was to obtain a high input resistance and a high degree of accuracy.

A type 6C4 miniature tube was used because its electrodes pass directly through the glass, greatly increasing the insulation resistance as compared with ordinary tubes. Some input conductance also results from initial electron velocities emitted by the cathode. This was reduced by operating the heater of the vtvm at reduced voltage.

Filament voltage regulation of the vtvm was found to be advantageous in maintaining meter calibration independent of line voltage fluctuations, especially when operating the heater at reduced temperature.

Time-Delay Vacuum-Tube Voltmeter

The voltage applied to the timing circuit, the plate voltage of the vtvm, and the delay bias voltage must be well regulated. A two-stage cascade voltage regulator is used for this purpose. The regulated output voltage which is applied to the timing circuit is adjustable plus or minus 2.5 percent from the front panel. This control is provided for making calibration adjustments to compensate for the effect of temperature variations on the timing circuit.

The range of the vtvm is determined by the value of the degenerative feedback resistance in the cathode circuit and the meter damping resistance.

If for any reason the gun should not completely fire the full number of rounds necessary to stop the timing action, the timing capacitor would continue to charge until the grid potential of the vtvm approached zero. The plate current would then overload the meter. To remedy this condition, an overload relay is used in the meter circuit and operates when the current exceeds full-scale readings.

The meter scale is non-linear because rate is an inverse function of time. This was also a reason for using delayed bias, since the meter would have otherwise read from infinity to 600 rounds per minute.

The divisions of the meter scale are individually calibrated. Calibration points were established by means of a variable low-frequency generator of known accuracy. The output of this generator was used to operate a polarized relay, the contacts of which were connected to the input of the indicator in the same manner as the mechanical switch unit.

Calibration Circuit

The accuracy of the indicator is greatly increased by means of a calibration circuit which generates pulse-repetition frequencies for checking and adjusting the meter indication. The greatest accuracy is

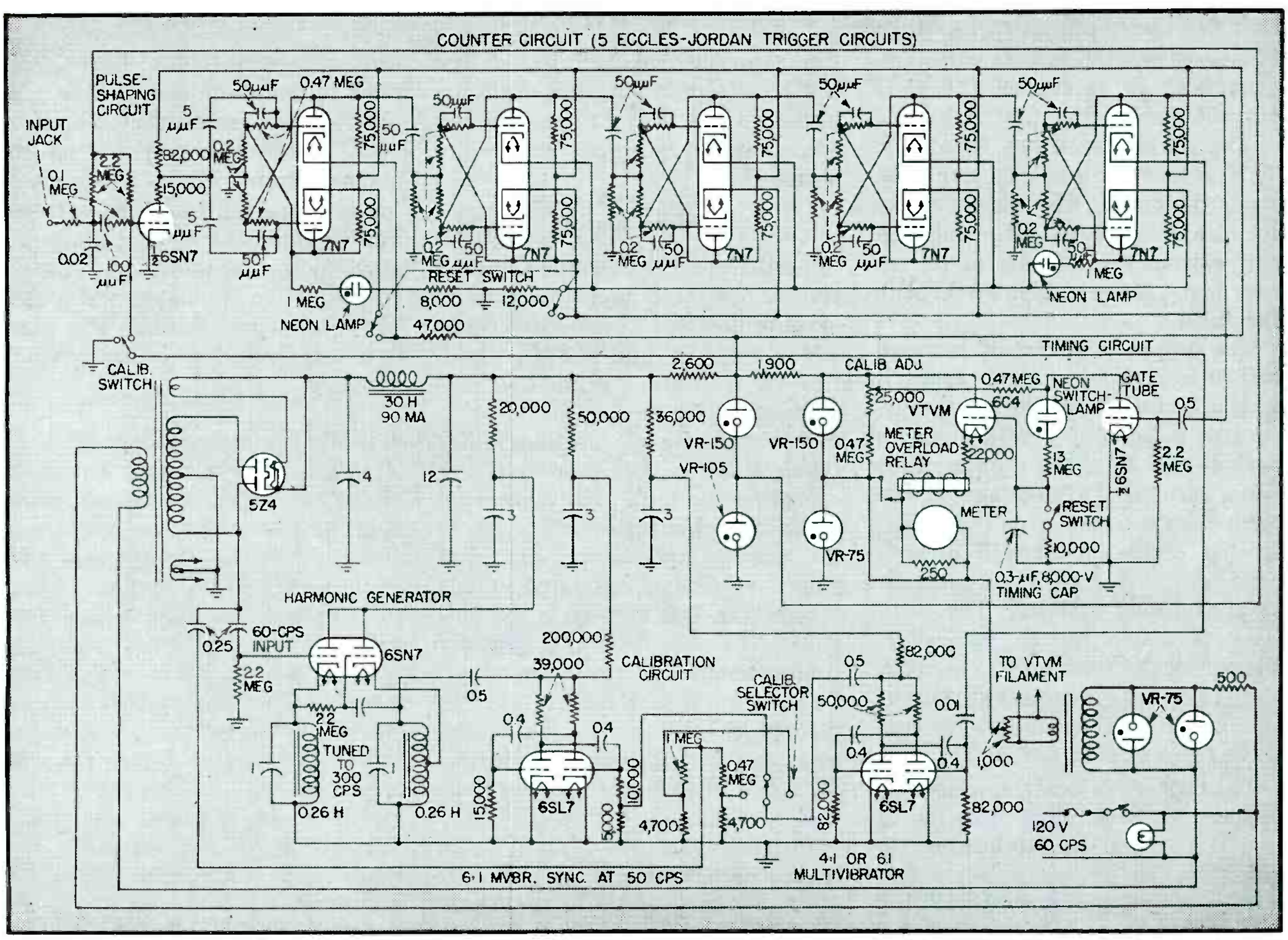


FIG. 3—Circuit diagram of rate-of-fire indicator, capable of indicating directly on a meter the rate of occurrence of any industrial or other operation in the range of from 600 to 900 operations per minute. The circuit can readily be adapted for other ranges

required at 750 rounds per minute, corresponding to the rate of fire of .50 calibre machine guns. A multivibrator is sychronized to generate this frequency and also 600 and 900 cycles per minute to check both low and high ends of the meter scale. When generating 10 or 15 cycles per second, the multivibrator is directly controlled by the 60-cycle line frequency, functioning as a 6:1 or 4:1 frequency-dividing circuit. When generating 12.5 cycles per second, the multivibrator operates at a 4:1 ratio, and is synchronized by a 50-cycle source which in turn is controlled by the 60-cycle line frequency. This is accomplished by means of a harmonic generator which multiplies the line frequency by five and a multivibrator which divides the result by six.

The harmonic generator is excited from the high-voltage winding of the power transformer, resulting in a unusually high negative bias and a plate current pulse of short duration. The angle of plate current flow was reduced to less than 36 degrees at the fundamental frequency so as to cut off the plate current during the first half-cycle of the harmonic output frequency. This prevents the conducting tube from distorting the output wave form, and increases the tank circuit efficiency since part of its energy is not being dissipated through the tube.

The output tank circuit is tuned to 300 cycles per second. Since it is shock-excited by the plate curcurrent pulse every fifth cycle, a periodically damped output wave form results. This voltage is impressed on the grid circuit of a self-excited oscillator through a peak limiting resistor which also serves as a grid leak resistor. The oscillator is tuned to the same frequency as the harmonic generator, and thus a synchronized output voltage of uniform amplitude and wave form is obtained.

This 300-cycle control voltage is applied to both plate circuits of the 6:1 ratio multivibrator in phase so as to favor even frequency ratios, thereby maintaining the required frequency division over wider limits of voltage variation.

The output of this 50-cycle multivibrator is directly injected into a 4:1 ratio multivibrator, via a selector switch, and 12.5 cycles per second or 750 cycles per minute are obtained.

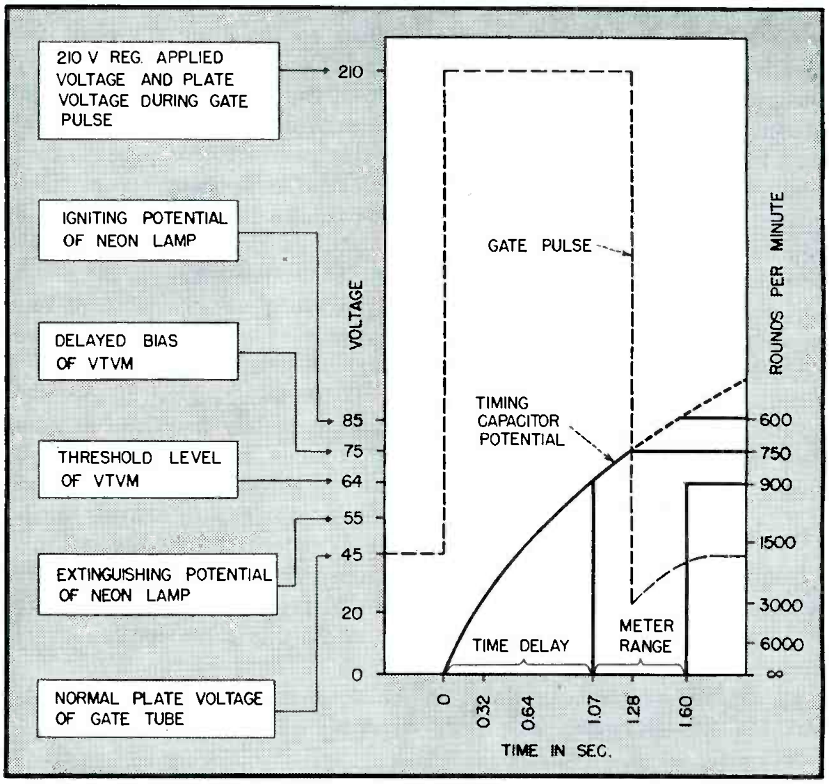


FIG. 4—Timing action of circuit. Rate of fire is 60 (N—1) rounds divided by the time interval

Power Supply

The harmonic generator and multivibrators were found to stay in synchronization over extremely wide limits of line voltage variation, so no voltage regulation was necessary.

A conventional rectifier-filter type voltage supply is provided for operating the unit. The first regulated output supplies 255 volts to the counter circuits and the input stage. A second regulated supply follows the first and has a d-c output of 210 volts which supplies the timing stage and the vtvm stage. To prevent the initial current surge through the voltage regulator tubes when the instrument is first turned on, a 5Z4 heater-type rectifier tube was selected.

Although the total current drain on the high-voltage supply is only 65 ma, a fairly large power transformer was used in order to supply the filament drain of 4.8 amperes.

The voltage-regulated supply for filaments has an a-c output of approximately 5 volts, which is applied to the vtvm heater. Two type VR-75 tubes are connected back-to-back across the primary of the filament transformer, and a resistor is connected in series with the line to limit the peak voltage applied to the transformer. The potential of the secondary winding is 75 volts above ground, the same as the cathode bias of the vtvm.

Industrial Applications

In industrial plants it is often desirable to have a direct indication of the rate at which a punch press, printing press, or other machine is operating. The instrument described can be used without change for applications like these if the action being monitored is in the range of 600 to 900 movements per minute. The only attachment required on the machine is a simple switch that operates once for each movement to be counted. For higher or lower rates, the circuit can readily be modified and a new meter scale calibration obtained.

Other possible industrial applications include monitoring of life tests and acceptance tests of electromagnetic devices like relays and solenoid valves.

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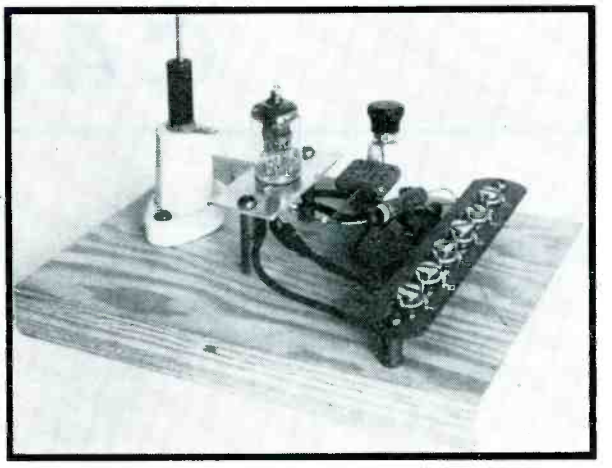

FIG. 2—Experimental mixer layout. The large stand-off insulator supports a three-foot antenna; the small stand-off connects to the antenna post of a conventional receiver

Checking UHF Oscillator Stability

Design of a simple mixer that permits heterodyning an uhf oscillator against a crystal-controlled multiplier. The difference frequency is fed to a conventional receiver to observe frequency shift

FOR COMPARING oscillator frequencies by the heterodyne method, the simple circuit shown in Fig. 1 has been used with excellent results. The device is used with an ordinary all-wave radio, or better, with a communications receiver which responds to the difference frequency of the two oscillators. Audible response is obtained by heterodyning the intermediate frequency of the receiver to a suitable audio frequency, as in c-w telegraph reception, or by modulating one of the oscillators.

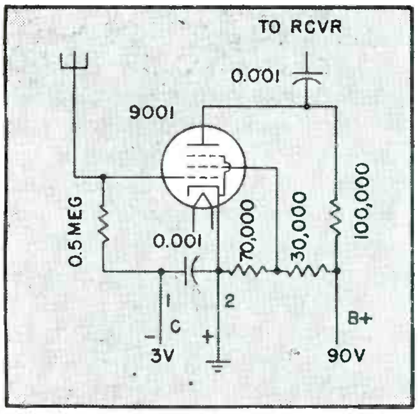

FIG. 1—Untuned mixer for comparing the frequency of an uhf oscillator with that of a crystal-controlled multiplier. Terminals 1 and 2 may be connected together if a plate potential of 45 volts is used

The antenna post of the receiver is connected through a capacitor to the plate circuit of the mixer shown in the diagram. This connection is made at the binding post on the small stand-off insulator, visible in Fig. 2. The mixer-unit antenna is a suitable length of heavy wire, ordinarily about three feet, plugged into the larger stand-off insulator.

Optimum values of external grid bias for the mixer range from 2 or 3 volts with 100 volts on the plate to zero at 45 volts on the plate. Since operation at the lower voltage is often quite satisfactory, it has been found convenient in such cases to connect terminals 1 and 2 together and to use a 45-volt B battery. The plate current at this voltage is about one milliampere. Grid-leak bias might also be used at higher plate voltages by omitting the grid-return capacitor and adjusting the grid resistor.

The oscillator whose frequency stability is to be observed is operated in the same room with the mixer (which is connected to the receiver) and a crystal-controlled frequency multiplier that gives a very stable signal at about 112 mc.

Operation

The oscillator under test is adjusted to a frequency such that the difference between it and the frequency of the crystal-controlled multiplier may be tuned in on the receiver. Thus, if the oscillator under test operates at a frequency of 100 mc, and the receiver is capable of detecting frequency variations of 1 kc, frequency instability amounting to 1 part in 100,000 may be observed. For maximum sensitivity, the difference frequency should fall in the range of highest resolution of the receiver. For most receivers, this optimum value is in the lowest frequency band.

Since the mixer is essentially untuned, it will respond to all the lower frequencies used in communications. Nearby broadcasting stations may be heard at almost any setting on the receiver dial by operating an ordinary test oscillator, adjusted to a suitable frequency, in the vicinity of the mixer.

CASE STUDIES

By **MICHAEL LECHNER**
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DURING the past two years, the following four production problems were encountered and solved in the plants of four electronic equipment manufacturing companies.

Problem No. 1

The first problem involved setting up the process and increasing production on four units comprising a uhf radar receiver. It consisted of a mixer-converter, power pack, i-f section, and video sweep section which were assembled on separate lines and later combined with additional equipment as one complete unit which moved first to company inspection and testing and then to Government inspection and final test.

Figure 1 shows the floor layout where the problem was handled. Note the proximity of all major sections to each other. Resistor boards, cabling, and other sections were set up as subassemblies and, because of required compactness, each was small.

Since the workmanship required was very exacting and the work often inaccessible, this was no mass production item comparable with those found in the three succeeding problems. Workers needed on assembly, wiring, and soldering required skill considerably higher than that found in average factories. Thus a school was maintained separate from production. There, every girl was taught to read resistor and capacitor values, wire stripping, tinning, and all types of soldering. Under the supervision of an experienced teacher, workers left the school as skilled mechanics.

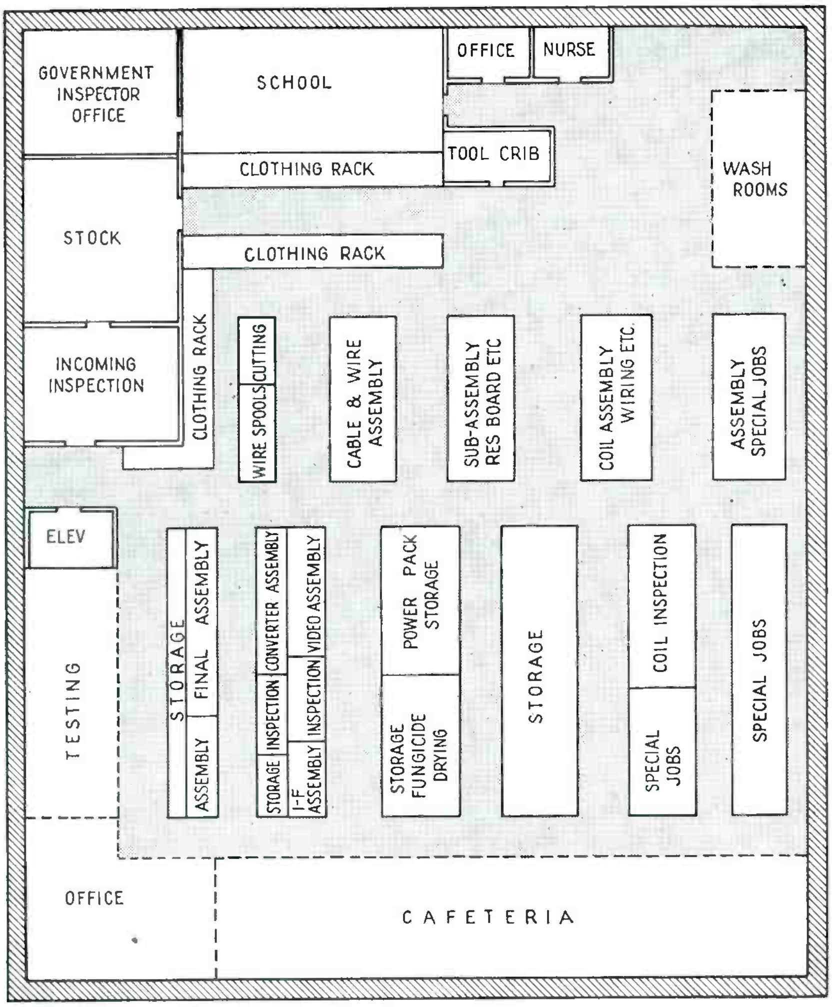


FIG. 1—Production-floor layout for radar manufacture described in the text under problem No. 1

The first unit to consider is the converter section. The chassis itself was 4 x 9 in. Into this small space were crowded 6 tubes, 5 jacks, 90 screws, 44 nuts and about 125 solder joints, with a large number of other parts. To add further production difficulties the chassis was subdivided with panels.

There were two ways to consider handling the converter section: (1) having wires and parts crimped by one operator and connections soldered by another, or (2) having each operator responsible for wiring and soldering a complete box. We tried the latter. This job required very skilled girls in each position. By the first method we could have sandwiched in fewer skilled operators.

The first operator on assembly had about 25 solid parts to assemble into the chassis. So a ramp storage shelf was built for this position as indicated in Fig. 2. The ramp was made of plywood. The boxes were paper and nailed into the stand. In back of each box (X) was included on a white paper strip pertinent information about the parts in the box. This strip was fixed into place with transparent Scotch tape.

Good features of the ramp were its low cost and re-usable value and the fact that the supervisor could tell at a glance what parts or hardware were needed. The operator

OF PRODUCTION

Details of what one engineer did to raise productivity in four different plants manufacturing electronic gear. He shows how consideration was given not only to the tangible jigs and fixtures but also to the more abstract factors of personnel relationships

A typical electronic equipment production line in action

was clocked working the same job with a conventional type half-circle parts holder at thirty minutes and with the ramp at twenty. Each box was fixed so the operator could follow only the set routine.

At the start, the first operator was assembling one tube socket or one part at a time. A jig was devised which cost about $15.00. It is shown in Fig. 3. Now the operator could assemble 10 parts at one time. This was done by first assembling 20 nuts on a piece of rod, then dropping one into each Spintite. In the same fashion a lockwasher is put on top of each nut. Then the chassis is placed downward on the Spintites, parts are set in place and the screws threaded home.

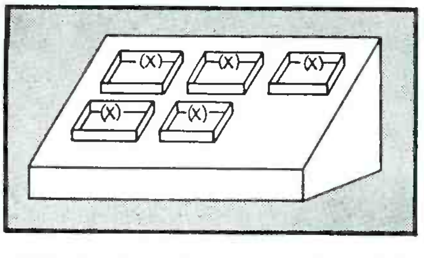


FIG. 2—Plywood ramp holds solid parts in storage for assembly. Identification is fastened in at X with transparent tape

On the next assembly operation an all-purpose wooden hardware holder of the type in Fig 4A was being used. Slots were made for hanging-in small metal pans, as in Fig 4B, when additional storage was required for small parts, and a half-circle group of four wooden holders were utilized when the assembly operation warranted.

After the assembly section there was a storage pen made of shelving and 3-in. pegs of wood, like that in Fig 5A, so the sets could be stacked on end, while single sets were kept in pens of the type shown in Fig 5B.

For the chassis wirers and solderers wooden holders were made as shown in Fig. 6. They were made so the chassis could be reversed sideways for easier operation, and the few parts required were directly in front of the operator. Tacked up within visible range was a blowup of the operation. Resistors, and sometimes the wires, were colored in these diagrams.

In complicated sets it is best to have a first-inspection tag on each chassis which means the chassis is complete and correct in every detail including stencils. This particular unit has $\frac{1}{2}$ by $\frac{3}{16}$-in. stencils. If there is any great quantity of these it is advisable to use templates and a spray gun. The next

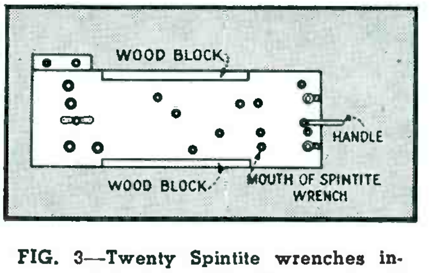


FIG. 3—Twenty Spintite wrenches incorporated into this jig made it possible for an operator to install ten parts on a chassis at once

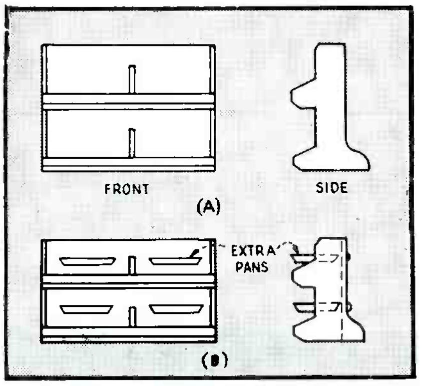


FIG. 4—Standard hardware holder, A, is modified as at B to give extra space for small parts at various positions on assembly line

inspection should follow the assembly section. The tag on the chassis will include the repairs found necessary, the initials of the repairer and the inspector's number. On critical, compact work, if an inspection is not made at this point the cost of repairs later is extreme. It also lessens the work and the field of inspection of the final inspector and chances of ultimate rejection by the government inspectors is much less.

In the i-f section, another jig of Spintites was prepared for seven tubes and jacks. This operation was cut five minutes with the jig. Originally, each operator tried to do wiring and soldering in the i-f section chassis on the table. A simple wooden holder was made like that illustrated in Fig. 7. This jig held the protruding coil cans firmly in place and could be moved or slid around at will.

Work being in an open chassis, things were arranged so wiring, jumpers, and resistors were crimped-in by operators and the chassis was moved down the line for another operator to solder these. Then the next operator would do more crimping and another more soldering. This method did not require all personnel to be highly skilled.

In order to keep coils on the line a bank of squares shown in Fig. 8 was used.

For the power-supply section a simple jig was developed for mounting can-type capacitors. The operator inserted the can into a metal holder, then pushed the bare chassis down and installed the necessary lockwashers and hex nuts. This method saved about three minutes on each chassis. Also, operators will do better work if a chassis has a solid or firm foundation under it while they perform their operation.

In the video section the assembly operator was spending fifteen minutes to assemble three tube sockets, which had a fixed and springy tube clamp. An assembling tool, Fig. 10, was made inexpensively of ½-in. tool rod. With this tool, which cost about $8, the operation was cut from fifteen minutes to five and a half.

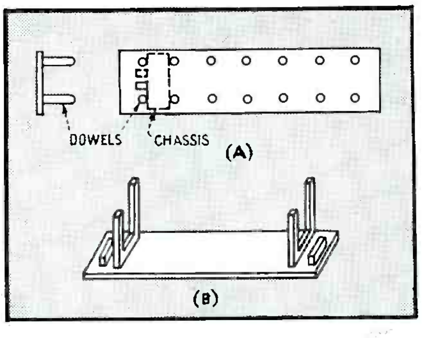


FIG. 5—Following assembly, radar chasses were stacked on end in pens like A. Rack B serves similar purpose for a single unit

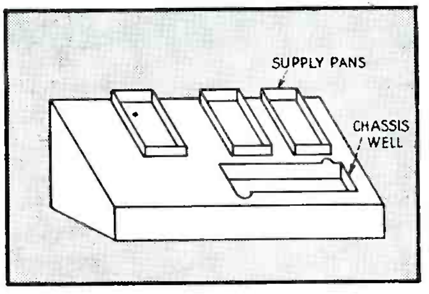


FIG. 6—Many wiring and soldering operations were handled in ramps like this. Chassis-well was made to hold units in several positions and at proper angle for light and access

The video-section line required one operator to insert four cables of different sizes and colors, so the holder of Fig. 11 was contrived. It was made of light wood and just about 4 inches short for each cable so the protruding cable ends could be grasped easily. The highest point was within easy reach of the operator.

Some simple chassis holders were made of wood. See Fig. 12. With this pitch, the most light from overhead reached all parts of the set. The arrangement also prevented operators from continuously blocking the light, and from becoming fatigued by bending over.

Problem No. 2

The second problem to be met concerned production of 8-tube recorders, subassemblies and assembly and wiring for uhf amplifiers and generators. The results were as follows: Recorder labor costs were cut from $20 each to $11. Subassembly labor time was reduced 60 percent. General production of main assemblies increased 70 percent.

The floor section was set up as shown in Fig. 13. Note that wire cutting and cabling adjoin and that both are close to the production sections.

The recorder chassis was cumbersome because side brackets which can be seen in Fig. 14, were being assembled at position one. A chassis should be easy to handle on a production line. Assembly of brackets was changed to the end of the line.

Tables were covered with heavy paper so the chassis could be slid along in an upright position. All heavy wires were put in first, close to the chassis. Then jumpers and connections were added.

Supplies were prepared for solid runs of 50 units at a time and production stock control sheets were kept up to date—weekly for an overall check. After a time check for each position the process was set so that the assemblers were at least a few units ahead of the capacity of the three lines.

In the cabling section, production was increased 25 percent by the use of colored lines and tracers to duplicate the cable proper. This was on a large board slightly to the

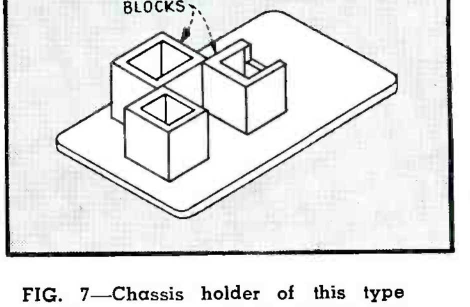


FIG. 7—Chassis holder of this type steadies inverted unit for wiring and facilitates soldering

left of each cabler. Smaller cabling boards were put on swivels, as seen in Fig. 15. These are easy to swing yet they bind while a girl is working.

On resistor board subassemblies we cut labor time about 30 percent by using a small rack of step-up shelves as shown in Fig. 16. On these, tagged paper boxes were directly in line of vision of the operator. Each box was nailed down so it could not be moved. It was set to follow the process in correct sequence. This eliminated lots of errors. Resistors and mica capacitors were handled the same way.

For the wiring of resistor boards we used two devices shown in Fig. 17. For a 12-in. board wired on one side, Fig. 17A was used and, although there was a slight spring deflection when the girls wired, they liked it because it gave them a sense of openness and freedom while they worked. Another jig, Fig. 17B, was used for resistor boards from 3½ to 6 in. in length. Large resistor boards were divided into three operations. First, crimp jumpers, base wires, and sleeved wires; next, set-in wires and some resistors; third, finish crimping and solder all connections.

Hot irons and carbon tetrachloride fumes are not pleasant, so cleaning of solder joints was done well along at the end of the table. However, if the solderer is taught to hold her iron just long enough to get a clean finish on the joint, there never need be too much rosin there. This time factor depends on the thickness of the solder, its alloy, and the size of the iron, and it can be determined by the supervisor who makes a few practical tests himself. Thousands of connections were made which required no cleaning.

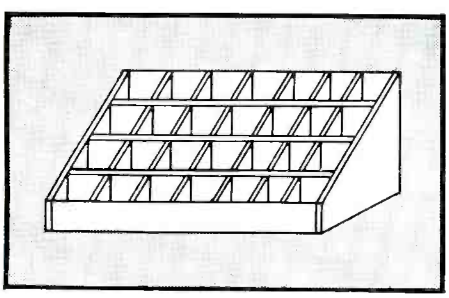


FIG. 8—Bank of squares was made to size for holding a supply of coils at their assembly point on the line

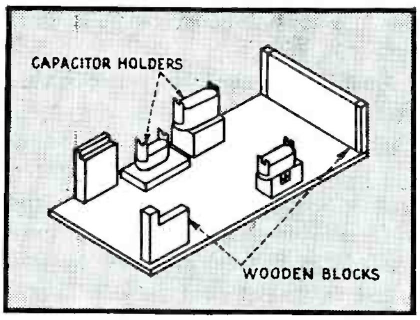


FIG. 9—Can-type capacitors were added to chassis with the aid of this kind of jig. Holders were loaded first, then the inverted chassis was dropped on top and washers and nuts put in place

For the large high-frequency amplifiers and generators, each operator had a little moveable stand as illustrated in Fig. 18, with each wire identified and its ultimate connection shown. This was enclosed in a thin plastiglass cover to keep it clean. It is advisable to make these for operations which exceed twenty connections, both to prevent forgetting over a weekend holiday and to guide a new operator.

Problem No. 3

The third problem was to improve production on power-supply units used for aircraft high-frequency transmitters. Production of 190 per month was increased to over 1000 per month in five weeks with the labor force increased 25 percent. Production cost at 190 per month was $15.00 each; at 1000 per month, $4.50 each.

On the mechanical assembly line, large terminal lugs were being removed from 4-in. upright can capacitors and replaced with smaller ones. A girl was holding the can in her left hand and using an open-end wrench with the other. She was doing about 110 per eight-hour day. A simple fixture like that in Fig. 19 was made and fastened to the table. The cans were inserted into the sockets, leaving the girl's left hand free. Two days after the jig was used a normal day's run for the same operation was 260 per day.

Another operator assembling 4 tube sockets into the chassis used an assisting jig which had an unsteady base. She was doing 25 units a day. The jig was placed on a wider paddle base. Her production moved up to an easy 55 per day.

An operator on the assembly sec-

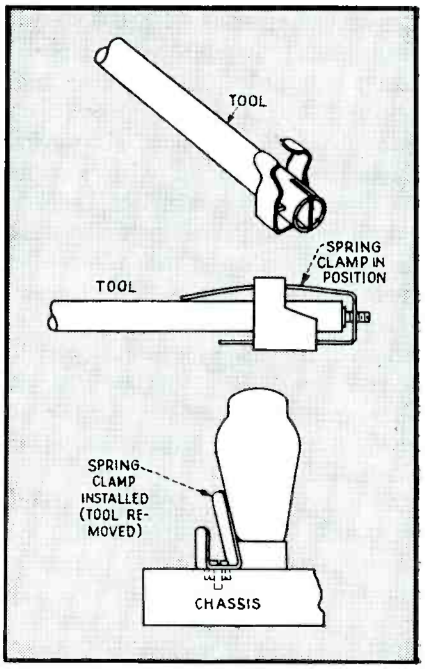


FIG. 10—Special tool saved 9½ minutes on each unit in the assembly of three tube sockets and clamps. Made of ½-in. tool rod, it cost about $8

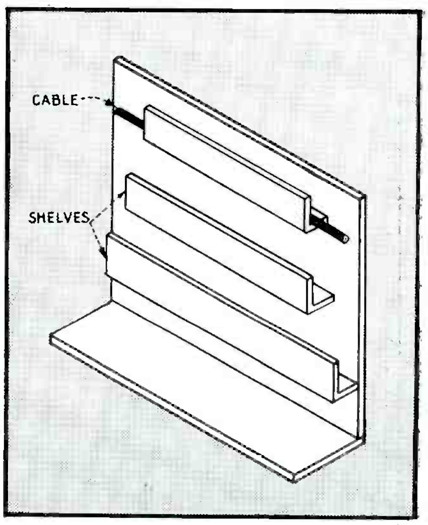


FIG. 11—Angle shelves were designed to hold four different cables for installation in chassis. For easy grasp, shelves were about four inches shorter than cables

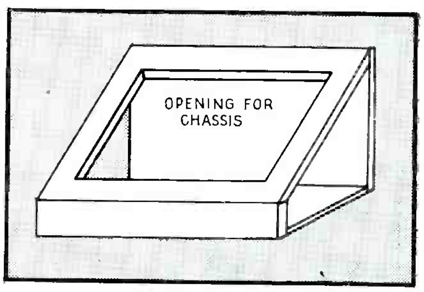


FIG. 12—Angle of pitch in this wooden chassis holder is such as to combine good light and a restful working posture

tion had to assemble 4 No. 8 round-head screws through a front panel into 4 stop nuts. The foreman had used 5 different men and women on this job in the course of six weeks. Each one wound up with a lame shoulder or a weak wrist. Investigation showed there was no holding jig for the unit and that the seated operator used a heavy 14-in. screw-driver. This operation was a bottleneck. An operator could only do about 30 a day by this method. A heavy screw cutting its own thread into a stop nut is hard work, after the first dozen.

Three 1 by 1-in. wooden strips were nailed on the table to stop the chassis from moving and the operator was supplied with an ordinary carpenters' ratchet screw driver. There were no more lame shoulders and sprained wrists. The practice had been to use an open-end wrench on the inside of the chassis—the operator holding one stop nut at a time. The simple steel jig shown in Fig. 20 was devised to hold four nuts at a time.

Most of the assembly work in this particular case was done by men. There still persisted the old bugaboo that a woman couldn't tighten up a screw and nut. The men, who were all too scarce anyway, were needed for heavier work so we had to use women or stop the job. Therefore, we taught girls who figuratively never saw a screwdriver before how to do a good job. They listened and they were shown how.

We got the correct screw driver to fit the particular screw slot. We got them correct chairs, taught them how they could burr a screw and how to avoid it, and showed them how to rest while they threaded the screw and only use pressure in the last turn and a half. Wherever possible we used a Spin-tite or a combination with a short holding screw driver. After two weeks women were producing more than the men.

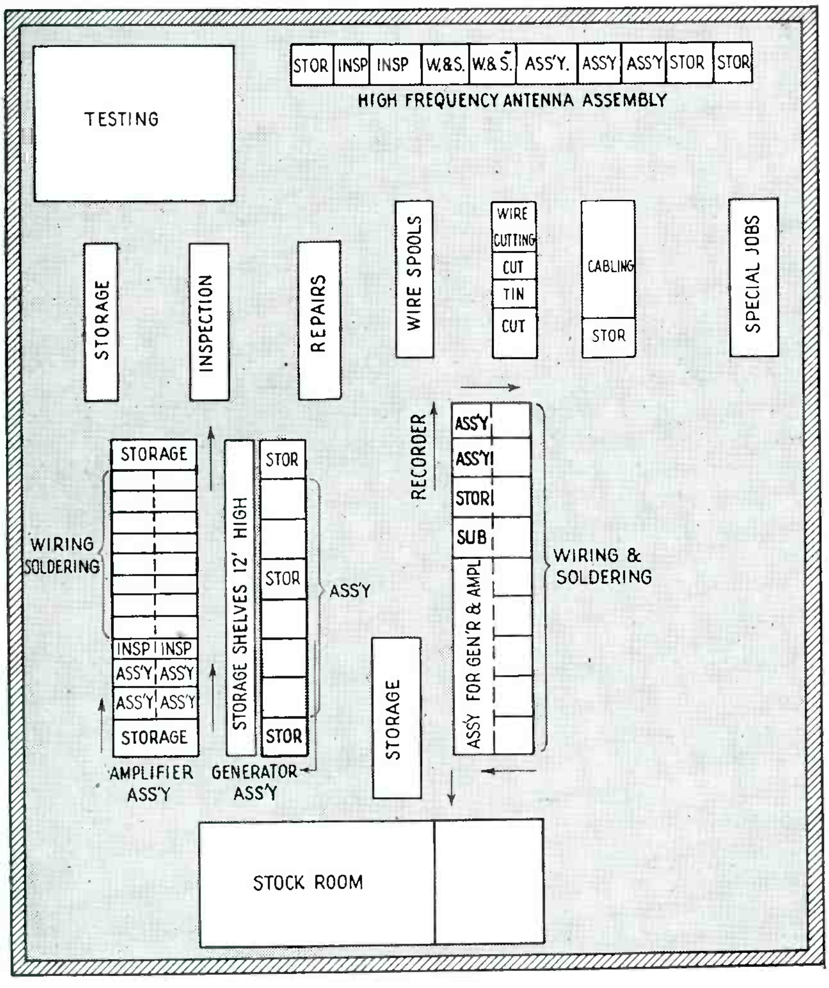


FIG. 13—Plant arrangement on recorder, amplifier, and generator project listed in the text as problem No. 2

Production of a five-tube superheterodyne receiver was to be raised from 70 each 8-hour day. Three weeks later it was 190-210 each day.

Here's how it was done:

Main production lines were set up with other sections nearby as shown in Fig. 21. Note that machines and heavy noisemakers were kept away from the assembly lines and that there are numerous storage spaces for sets. Notice also the accessible position of the cage.

The chassis itself was about 6

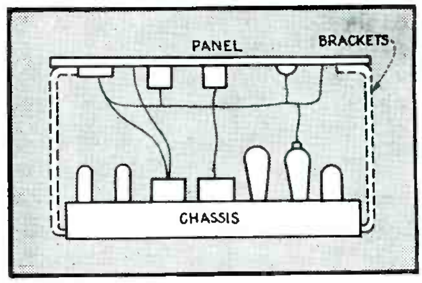


FIG. 14—Open side view of recorder. Panel and chassis were joined with side brackets at the end of the line instead of at the beginning of the line to keep the chassis easy to handle

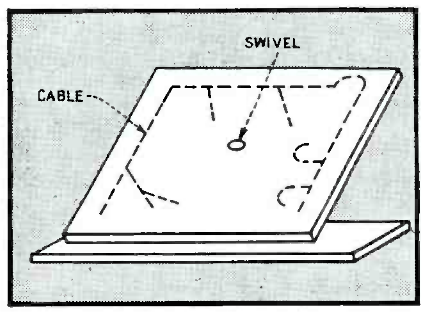


FIG. 15—Swivel boards for wire cabling turn easily but bind under pressure of operator's hands. A drawing of finished cable is taped down on board and nails and cleats added for cabler to follow

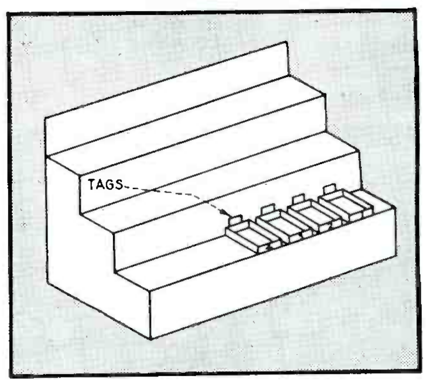


FIG. 16—For subassembly of resistor boards, parts boxes were fastened in position and tagged as shown. Ideal location is at eye level

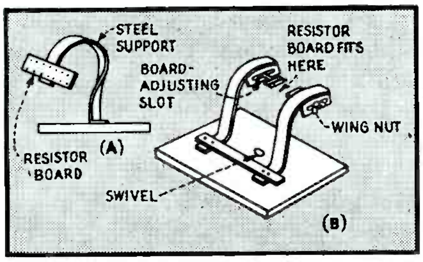


FIG. 17—Holding jig for 12-in. wiring resistor board is shown at A. Operators like it because of accessibility. Double-sided boards were wired in a fixture like B, which revolves

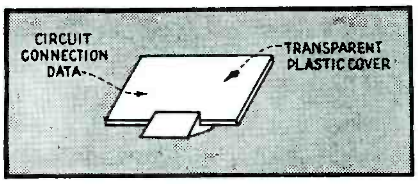


FIG. 18—Where an operation includes more than twenty connections, a small movable stand is helpful to display a sketch of wires and connections. Data is covered with sheet of transparent plastic to keep it clean

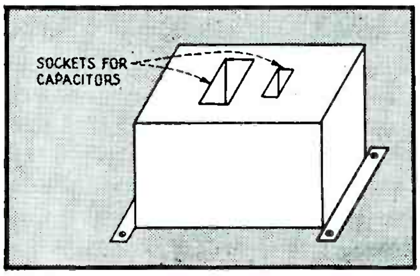


FIG. 19—Fixture designed to hold can-type capacitors while an operation was performed on the connecting lugs. This arrangement left both hands free

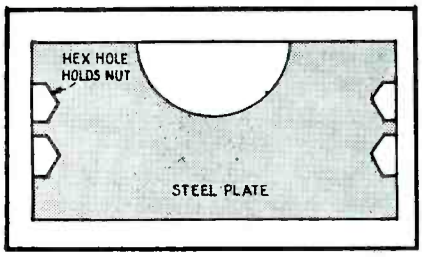


FIG. 20—This unit replaced an open-end wrench for holding four stop nuts behind a panel while screws were driven through with a carpenters' ratchet screw driver

by 11 in. and was set up on a jig and ramp combination as illustrated in Fig. 22.

For assembly of the i-f coils and the capacitor gang we used two power-driven screw drivers. These were on balanced pulleys which swing easily up or down. With these, production time on this operation was cut from 4 minutes to 1 minute even.

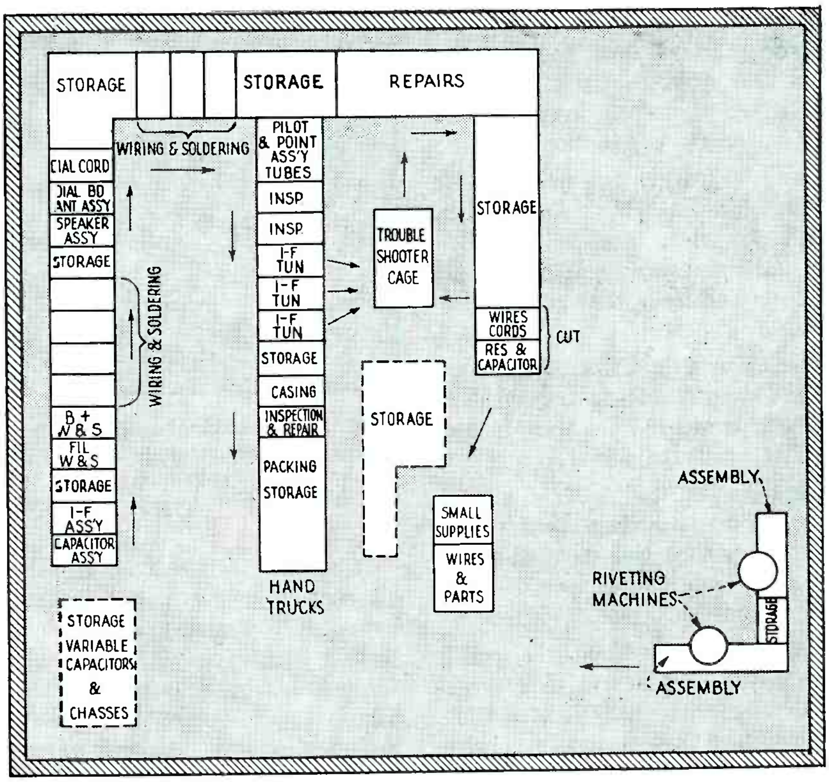


FIG. 21—Five-tube superheterodyne receivers were built in this layout, discussed under problem No. 4. Noisy riveting machines are well away from other operations

Tube sockets were being riveted by operators who had not been trained to judge their foot pressure correctly. As a result they were battering rivets and wasting lots of motion and time. After three days of careful instruction, 200 units a day were rolling away from these two.

After making a time check of each position, all operations were broken down to 1½ minutes. Each operation was simplified. All resistors, wires, paper capacitors, and cords were pre-cut to size.

An accurate metal-on-wood jig was set up for the speaker assembly and it increased production 200 percent. All operators had a good supply of parts before them at all times.

One operator learned or worked faster than another. If she piled up her next neighbor, these extra sets were stored in boxes elsewhere and worked into the line a few at a time about two weeks later.

If one operator was too fast for her operation, part of a slower operator's work would be diverted for her to help out. Eventually it became incorporated into her operation. This way a line can be balanced.

All supplies were put into fixed boxes on ramp stands. They were so set and filled that they had to be picked from right to left in an order we believed to be the best method.

Each operator was encouraged to memorize every point-to-point connection to cut out waste motion. With a little patience most of them knew their job thoroughly after the second day.

Problems with People

The following are notes on the psychological factors involved in the various projects which have been described.

At the plant involved in Problem No. 2, too many men and women were spending too much time in their respective rest rooms. It was pointed out to supervisors and employees, tactfully, that a longer and more healthful life would be induced at the work tables than in smoke-filled rooms.

For a week or two, a few workers who were lagging were shifted every few days to give them a sense of shortlived security. It worked wonderfully.

Indifferent supervision in the past had resulted in a loss of any feeling of responsibility by the workers. So we had to prove to them that what they did was final. Repair work was not brought back to them on the production line.

In order to get the first girl on wiring and soldering to spark the line, a few were tried at this position until one was found who could feed the line more than it could absorb.

During overtime, assemblers were taught how to solder. It paid dividends when other lines were in dire need of first-rate solderers.

Changes in the production line were not made during the first few days. This time was devoted to observation and notes were made away from the tables.

The changes which did result were made slowly and carefully—either one or two things at a time. Where lines have to continue operating to maintain a minimum quota, any change, no matter how small, must first be approved by the operator. She must be sold the idea, otherwise the foreman or engineer will meet the proverbial stone wall.

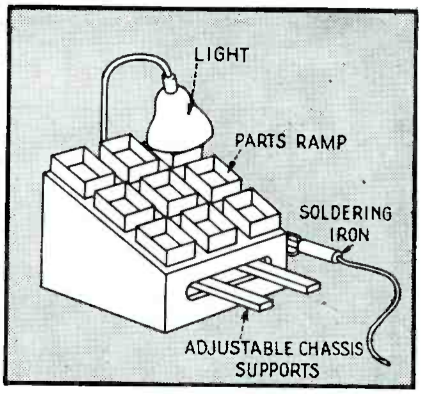


FIG. 22—Chassis-holding jig and parts ramp were combined in this unit for assembly of five-tube receivers. Note soldering iron in support at right

It is usual for the average assembly section to move with the same tempo as the wiring and soldering section which follows. At plant No. 3, however, time was of the essence. Simply to add operators was out of the question. We couldn't get any. The big problem was to have operators do 60 sets a day where they had been doing 20.

So the assembly section alone was kept working overtime the first week. The units were loaded on trucks and kept right at the head of the table for the wiring and soldering section. There they stood in plain view for all to behold.

Combined with this spur to activity was the excellent co-operation of the first wirer who fed the line at a rate of 60 a day.

One man was appointed as a material expeditor. His duties required a visit with each foreman twice a day. It was his job to act as liaison between production, stock, and purchasing. This arrangement kept the foremen at their respective lines. This man saved everybody lots of leg work, and his appointment was well worth the cost.

Frequently we were short of parts. When this happened, the unfinished units were not allowed to clutter up the tables. They were kept on trucks, shelves, or under the table, but never in direct sight of the workers. Later, when the parts were received, the unfinished units were fed into the line without interrupting the continual production pace.

In plant No. 4 one problem was to sell the operator who wired and soldered tube filament wires on the idea of producing 200 a day where she had been doing 70. She was asked to operate for a day as a guinea pig in time study. She practiced some of the suggestions she was given. Because of a desire to impress us, she cut down on motions, and her daily production gradually moved up to 200 a day.

An attempt was made to interest the people on the line in daily quotas. After a week each line was competing with the other to gain that quota. To spur this on, hourly figures were posted in four spots on the production line. This way the operators were being paced hourly to avoid spurts in production.

When an operator consistently had similar rejective work, it was brought back for her to repair. That way she learned to avoid the same errors.

Each worker was required to learn her job from memory. Previously they had spent 20 percent of their time looking at the sample. Each knew the difference between what was acceptable and what was not. They were shown concrete examples of each kind, good and bad.

PEOPLE in PRODUCTION

A worker must be kept interested in her job, no matter how small or monotonous. She must feel she is contributing an important part of the entire job.

Each worker should understand the part the completed unit plays in the final function of the gear.

A production line crew should work as a team. Each individual must depend on the others. It is surprising how this one element will cut absenteeism.

If possible, workers should be arranged so neighbors are friendly, without the extremes where cliques are formed. In the event one girl slows up or is absent, her two neighbors will absorb her work for a day or so.

Contingent on maintenance of production, encourage word games, charades, etc. Tests show production is usually increased.

The most effective way to keep women workers from spending too much energy talking is to have amplified recorded music. Tempo of inter-mixed popular and classical records should vary.

It is a good practice to shift workers around on the same production line. Thus each one gets to know three or four operations and can fill in during an emergency when others are absent.

Workers must respect the foreman, whether they like him or not.

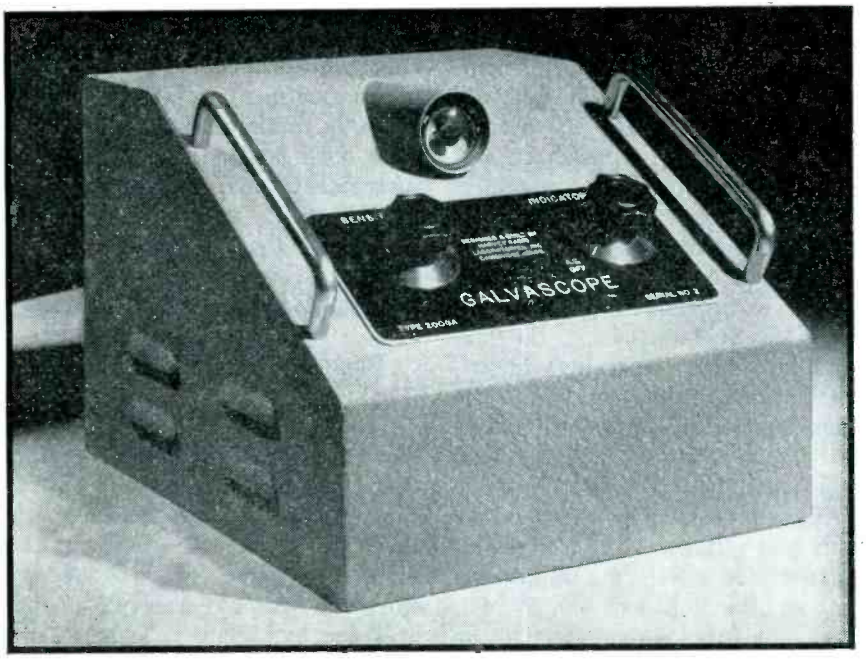
Race, color, and religious belief need cause no friction if competition between groups is eliminated.

It is a good point for the foreman or even top management to sit down once in a while and work on the line. Not too productive. But fine for morale.

Get operators to give their work a quick visual inspection before passing it on. It takes a few seconds but often saves more by keeping rejects out of inspection.

A-C Galvanometer

Operating theory, circuit analysis, and design considerations of a highly sensitive null indicator for a-c bridges. Stability and ruggedness are adequate for checking product quality in manufacturing plants. Nulls are indicated by a 6E5 electron-ray tube



Exterior of the electronic a-c galvanometer, showing hooded indicator tube and operating controls. The indicator bias knob at the right has an associated on-off switch for 115-v, 60-cycle a-c power. Tubes and other components are accessible after removal of bottom plate

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Use of headphones as a balance detector for a vacuum-tube bridge is generally unsatisfactory in a manufacturing plant or its laboratories due to a high noise level. The electronic a-c null indicator to be described provides high effective sensitivity for this purpose by a combination of two factors—high optical sensitivity and high electrical sensitivity. It also constitutes a more satisfactory method of detecting balance of an impedance bridge used to check incoming electrical components.

If balance of the bridge is to be precisely determined it is almost invariably necessary to determine an increment of minute value. For easiest optical detection, which in turn means greatest accuracy, the incremental angle must be as large a fraction as possible of the initial angle. This condition is realized with an initial angle of zero degrees. In another sense, this arrangement produces what might be regarded as optical amplification.

Indicator Circuit Requirements

In a type 6E5 electron-ray tube, a negative voltage of the order of 7.5 volts must be applied to the triode grid to cause eye closure (zero shadow angle), as shown in Fig. 1. Inspection of the characteristic of this tube shows that as the grid-cathode voltage is varied from zero to approximately minus 7.5 volts, corresponding to shadow-angles of 90 and 0 degrees respectively, the cathode current undergoes but slight change. This fact permits the use of a cathode resistor to produce operating bias.

Balance, as applied to an a-c bridge, is frequently a relative term, since many times complete balance is not secured; in fact, the nearest approach to a complete null may represent a minimum signal of some magnitude. Under such circumstances the balance indicator, to be satisfactory, must be sufficiently flexible to permit two major accomplishments, detection of a very small signal, and detection of a very small change in a relatively large signal. The first of these is required to take care of practically complete bridge balance, while the second is necessary to cover the more common case in which the residual signal is comparatively great. With proper handling of the controls, however, balance can be just as sharply displayed for a residual signal as for a virtually perfect bridge balance.

The detection of a small signal imposes two basic requirements. In the absence of signal the eye must be closed, but not overlapped. This requirement is easily met by bias voltage developed across the 6E5

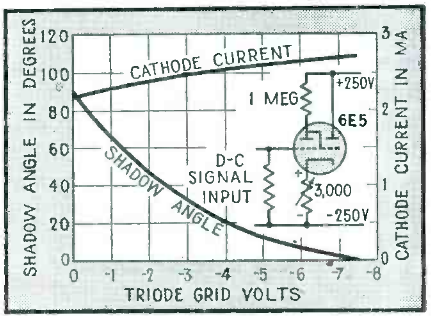

FIG. 1—Shadow angle vs grid voltage and corresponding change in cathode current for a type 6E5 tube used in the circuit shown

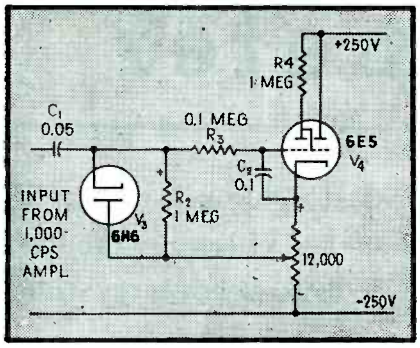

FIG. 2—Indicator and rectifier circuit

cathode resistor, which is preferably made variable. The second requirement is that the electrical sensitivity be high, and this is satisfied by a high-gain a-c amplifier which in this instance is tuned to 1,000 cycles.

Signal Rectifier and Low-Pass Filter

A signal rectifier and a low-pass filter are interposed between the amplifier output and the grid-cathode circuit of the indicator, as shown in Fig. 2. The filter is needed to secure sharp edges on the eye opening, since any rapid variation of indicator grid-cathode voltage would produce fuzzy edges. Obviously the filter has a longer time constant than is necessary to eliminate a 1,000-cycle ripple, but this arrangement helps minimize lower frequency a-c components such as 120 cycles. A still longer time constant would be desirable from the standpoint of removing 60-cycle ripple, but if the filter is made any larger the indicator becomes very sluggish. The chosen values seem to represent a good compromise.

The signal rectifier is so connected that the d-c output voltage acts in opposition to the initial bias. As noted above, the bias remains nearly constant for shadow angles from 0 to 90 degrees, and the small change is in a downward direction. Since it was a decrease in net grid-cathode voltage which produced this change the circuit is slightly regenerative, thereby causing a small increase in sensitivity.

Function of Rectifier Circuit

The 6H6 has a non-linear resistance characteristic in terms of the polarity of an applied potential, so that if the plate is positive with respect to the cathode the resistance is relatively low, while with reversed polarity the resistance is very high. If the shunt resistor has a value sufficiently high compared to the forward resistance of the diode, the parallel combination will exhibit a marked difference in resistance between potentials of opposite polarities.

The diode V_3 and resistor R_2 in Fig. 2 constitute the major portion of the load on the 1,000-cycle amplifier. This means that, if the diode is neglected for the moment, an alternating potential will appear across R_2. When the bottom end of R_2 is positive the diode will conduct and offer low resistance. On the next half cycle the diode plate is negative with respect to its cathode and will not conduct, thereby exhibiting high resistance. Since the driving source, the last amplifier stage, is a high-impedance device, it follows that the amount of voltage developed across its load is a function of the load impedance.

A low-impedance load thus develops a low voltage, while a high-impedance load develops a high voltage, so the top end of R_2 will average positive with respect to the bottom end. It is this voltage which after being filtered is applied between grid and cathode of the indicator, in series with the bias developed across the indicator cathode resistor. This new potential acts in opposition to the cathode bias, thereby opening the eye of the indicator.

For greatest rectification efficiency the resistor R_2 should be made as large as possible, but care must be exercised lest the resistance between grid and cathode of the indicator be increased to the point where instability appears. One megohm is a completely satisfactory compromise.

It is interesting to note that although the diode contact potential also acts in this circuit, its effect need not be taken into account because it is present at all times and is included in the initial bias adjustment (even though its value is unknown). Furthermore, tube noise and pickup within the instrument, and pickup in the bridge itself, can be biased out simply by turning off the bridge 1,000-cycle a-c source and adjusting the bias to produce eye closure.

Operation with Residual Signal

The detection of a small change in a relatively large signal requires that at balance the indicator shadow angle be zero degrees, and that the electrical sensitivity be high. In order to produce eye closure (without overlap) in the presence of signal, it is necessary to provide extra bias by increasing the cathode resistor shown in Fig. 1. Use of some 12,000 ohms, as shown in Fig. 2, produces a potential of 25 to 30 volts, depending on the individual tube. A portion of this voltage, ranging from a minimum of 7.5 volts to the full potential, depending on the magnitude

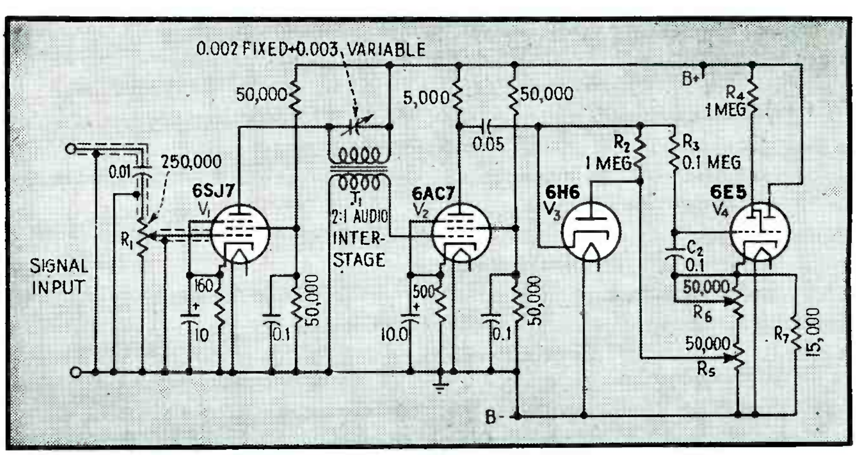

FIG. 3—Overall schematic circuit diagram of the electronic null detector. The conventional power supply is omitted. Sensitivity is controlled by R_1, indicator bias by R_5, and minimum bias by R_6

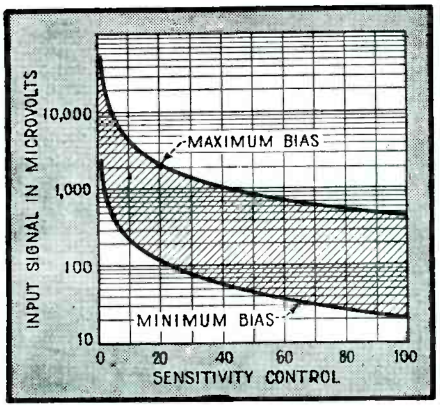

FIG. 4—Sensitivity control setting vs input signal for zero-degree eye opening over range of indicator bias

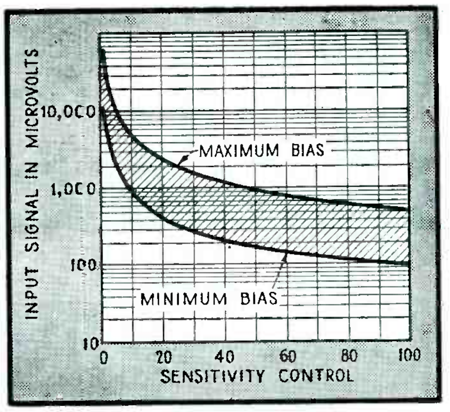

FIG. 5—Sensitivity control setting vs input signal for ten-degree eye opening over range of indicator bias

of the residual bridge signal, is applied to the indicator grid. When the algebraic sum of the two voltages is minus 7.5 volts on the grid the eye is closed, regardless of the magnitudes of the two individual voltages. The presence of extra bias and the absence of signal will cause the eye to overlap, and a certain amount of signal voltage is required to open it to the point where it is just closed. If the controls are correctly adjusted, the residual bridge signal, translated into a d-c signal, is just sufficient to produce zero-degree eye opening, while any departure from balance causes an increase in this signal which is displayed as an opening of the eye. The only additional requirement is that the amplifier must not overload under maximum voltage conditions, but this requirement is met by conventional a-c amplifier design.

Adjustment of Controls

The overall schematic circuit diagram appears in Fig. 3. The instrument is provided with two panel controls, one for sensitivity and the other for indicator bias. The sensitivity control is simply a gain control R_1 in the input circuit of the amplifier, while the indicator bias control is a potentiometer R_5 located in the cathode circuit of the 6E5. If a single variable resistor (or potentiometer) were used here it could not be turned through its entire range, because minimum bias of about 7.5 volts is needed at all times. The series resistor R_6 develops this minimum voltage, thereby making the panel control useful over its entire range. Variable resistor R_6 is screwdriver-adjusted so that minimum bias can be set exactly as required for operation or upon replacement of the 6E5. In practice, it is simpler to use relatively high-resistance potentiometers for R_5 and R_6, shunting them with a lower resistance. For this reason, a 15,000-ohm resistor is connected in parallel with the 50,000-ohm potentiometers.

Operating Limits

The sensitivity curves in Fig. 4 and 5 show performance for eye openings of 0 and 10 degrees respectively. The curve for minimum bias and zero angle is difficult to locate accurately, because it shows a barely detectable departure from exact eye closure. A signal any smaller would escape detection. It is not easy to make precise determination of this condition, which means that the accuracy of this limit curve is somewhat doubtful, although it serves to demonstrate that the instrument possesses good absolute sensitivity. Limit curves for eye openings of greater than zero degrees are far easier to determine, and reliance can be placed on their accuracy.

Figure 4 shows input voltages (1,000 cps) for zero-degree eye angle under various combinations of sensitivity and indicator bias control settings. The curve marked MINIMUM BIAS is one limit, and that marked MAXIMUM BIAS is the other limit. By reading vertically from any given sensitivity control setting it is possible to determine the range of signal which will produce zero-degree eye angle, depending upon the position of the indicator bias control.

Inspection of Fig. 4 shows that the minimum signal which can be detected is 20 μv. With the sensitivity control set at maximum, zero-degree eye opening can be secured with signals up to some 470 μv by proper adjustment of the indicator bias control.

Reference to Fig. 5 indicates that with minimum bias a signal of about 95 μv will produce a ten-degree eye opening, while with maximum bias this opening is produced by a signal of some 510 μv. By varying the amount of bias a ten-degree opening will result from the application of any signal between these limits.

All of the sensitivity data shown in Fig. 4 and 5 relates to absolute sensitivity. The incremental sensitivity is also important, and can be secured by use of these curves. Take, for instance, the case of maximum sensitivity and maximum bias. Figure 4 shows that 470 μv causes zero-degree opening, while Fig. 5 indicates that a signal of 510 μv produces a ten-degree opening. This means that an increment of 40 μv below an initial 510 μv, or some 8 percent change, is required to actuate the indicator over the optical range from ten to zero degrees. For precise work the maximum angle should not exceed ten degrees, and should preferably be nearer five degrees. If this angle is used the voltage increment is cut approximately in half.

Conclusion

Actual use of the instrument has proved that both the absolute and incremental sensitivity are as great as needed at any time. Under average conditions it is necessary to turn the sensitivity control down a bit in order to avoid very touchy bridge controls. Since the instrument contains no moving parts whatever, it is mechanically and electrically rugged, and cannot be damaged by mechanical shock or vibration or by electrical overload. Its operation is little affected by vibration, unlike the vibration-type a-c galvanometer, and stray fields of considerable magnitude do not influence it.

Reduction of HETERODYNE

REDUCTION of constant-frequency interference such as is caused by heterodyne signals can be accomplished by utilizing the principle that heterodyne waves both amplitude and phase modulate the carrier of the desired signal. This method of interference reduction involves simultaneous detection of amplitude and quadrature modulation components of an interfering wave and subsequent canceling of the two detected outputs by balancing them against each other. The reception of desired signals, which are modulated in only one manner, remains unaffected.

The system is of particular advantage for communications in crowded bands where interference due to carrier heterodynes is objectionable, and increases the number of stations that can occupy a given frequency band without producing cross interference. In operation, the system to be described has attenuated strong interference heterodyne signals to below audibility with no apparent effect on the desired signal.

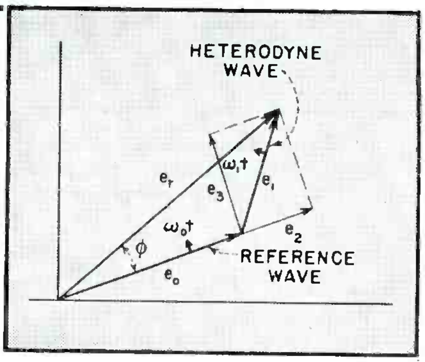

FIG. 1—Vector relations of two waves show phase and amplitude modulation of one by the other

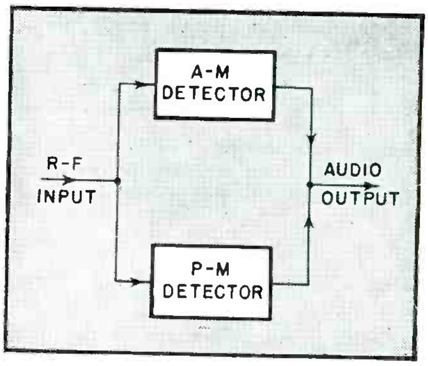

FIG. 2—System by which amplitude and phase, modulation components are independently detected

Principle of System

It is an accepted fact[1] that the sum of two waves is a wave which varies in both amplitude and phase. If one of the waves is taken as a reference, the second wave can be said to produce amplitude and phase modulation of this reference wave. In Fig. 1 let e_0 be the reference wave, which may be the carrier wave of a desired signal, and let e_1 be the second wave, which may be an interfering and undesired signal. The combination of these waves can be resolved into a component e_2 which is in phase with the reference wave and produces pure amplitude modulation and a component e_3 which is in phase quadrature and produces pure phase modulation.

A heterodyne interference wave thus produces effects which differ from either those of a pure amplitude-modulated wave in which the resultant modulating vector is always exactly in phase with the carrier, or those of a narrow-band phase or frequency-modulated wave in which the resultant modulating vector may be in phase quadrature with the carrier.

The inherent characteristic of a heterodyne interference wave can be utilized to eliminate the interfering effects of the undesired wave in the reception of amplitude-modulated, or narrow-band phase or frequency-modulated signals, provided that suitable detection circuits as assumed in Fig. 2 can be devised. These detectors must be such that the amplitude-modulation detector responds only to sidebands which are in phase with a carrier, and the phase-modulation detector responds only to sidebands which are in phase quadrature with the carrier.

Principle of Detectors

Detectors devised by Crosby,[2] in which carrier segregation and amplification are utilized, are adaptable for this purpose. Referring to Fig. 3, the carrier, which has been derived from the desired signal by filtering or other means and then amplified, is applied to the balanced detector as shown. Also the entire received signal is applied in a balanced manner to the rectifiers.

In the absence of the carrier, there is no detection of the received signals, and in the presence of the carrier, only those resultant signal vectors which have components directly in phase or 180 degrees out of phase with the carrier are detected. For the a-m detector the segregated and amplified carrier should be in phase with the signal carrier, while for the p-m detector the segregated carrier should be in phase quadrature.

Basic Circuit

A more complete diagram of the system is shown in Fig. 4. The receiver i-f voltage is fed in parallel to a crystal filter for segregation of the signal carrier, and to two detectors through isolating amplifiers. The segregated carrier from the filter is amplified and fed to the two detectors, with the carrier voltage to one detector being shifted 90 degrees in phase.

One of the detectors detects amplitude modulation and the other detects quadrature modulation. For equal applied voltages, the outputs of the amplitude and quadrature detectors are equal. Thus, in the simultaneous reception, for example, of a pure a-m

INTERFERENCE

Adjacent-channel signals produce both amplitude and phase modulation of the desired carrier. From separate detection of these two modulations, two interference signals are obtained which cancel each other leaving only the desired signal

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wave and a heterodyne interference wave, the amplitude-modulation detector will respond to both the a-m signal and to the heterodyne signal, while the quadrature detector will respond only to the heterodyne signal. Consequently if the output of the quadrature detector is combined in the proper phase with the output of the amplitude-modulation detector, cancellation of the detected heterodyne signal will result. The output of the quadrature detector must be shifted an additional 90 degrees to bring its output signal into opposition to the heterodyne signal from the other detector. Also the output of the quadrature detector must be shifted an additional 180 degrees when the heterodyne interference wave changes frequency from above to below that of the carrier.

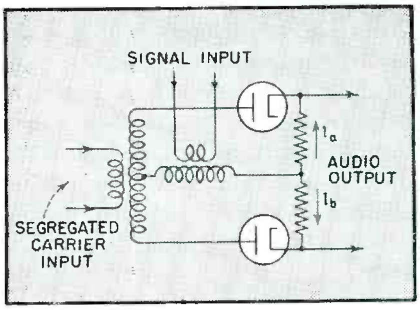

FIG. 3—Balanced rectifier is used to detect either a-m or p-m components of input, but not both

Effect of Segregated Carrier

Detecting systems, other than that described, are also usable. For example, a single diode to which the segregated carrier and received signal are applied will detect substantially only those signal components in phase with the segregated carrier, provided that the voltage of the segregated carrier greatly exceeds that of the total signal.

It is interesting to note the effects of the large phase shifts which occur in the crystal filter when the incoming carrier is slightly off resonance. One such effect causes detection of amplitude-modulated signals by the phase-modulation detector, because if the carrier is not at exactly 90 degrees phase difference with the amplitude-modulation components some detection of these components will result. This effect of carrier phase shift can be overcome by biasing the detectors so that the segregated carrier voltage will exceed the bias voltage only when the phase shift in the crystal filter is less than a predetermined amount which should be less than 45 degrees, at which condition the outputs from the two detectors are equal.

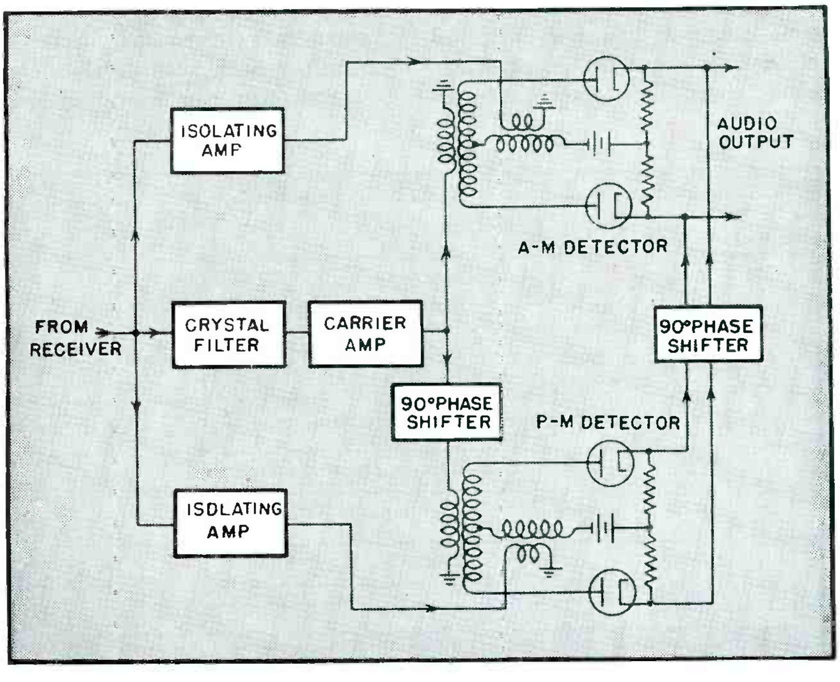

FIG. 4—By means of filters and phase shifters, the interfering carrier heterodyne can be eliminated in the detector stage, leaving only the desired signal

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ELECTRONIC TIMER for Aircraft De-Icer

Inflation and deflation of de-icer boots is controlled by an electronic timer that makes available four different types of cycling to meet any icing condition encountered. Thyratron and diode in timing circuit control stepping of telephone-type automatic switch

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De-icer equipment as currently used on aircraft provides a constantly recurring cycle of inflation and deflation of tubes or boots along the leading edges of protected airfoils, with no controls or adjustments to govern either the frequency of inflation cycle or the completeness of boot inflation. Despite this lack of flexibility the rubber de-icer boot, functioning on a fixed cycle arbitrarily set at 40 seconds, has proved to be an effective ice-remover.

Icing conditions are not only variable, but completely unpredictable since ice does not form at a standard rate or to a standard texture. In recognition of a real need, therefore, a de-icer timer has been developed to control the operation of de-icers and to provide effective ice elimination under varying icing conditions.

Ice Buildup and Removal

The two principal factors in the problem of ice elimination are the adhesion of ice to the surface and the continuity of the ice. Although both factors are normally present, either factor alone will retain an ice accretion. The natural lock of an ice formation over the leading edge of an airfoil will hold that formation in place although its adhesion has been completely destroyed. Similarly, isolated particles of ice can be retained solely by their adhesion to the surface.

Fundamentally, de-icer operation is based upon playing the factors of continuity and adhesion against each other. It is because the ice adheres to the de-icer surface that inflation of the tube elements breaks the continuity of the ice along the leading edge. Conversely, it is because the ice has continuity and enough tensile strength to maintain that continuity that the stretch of the rubber produces a peeling action which destroys the adhesion and lets the airstream carry the ice away.

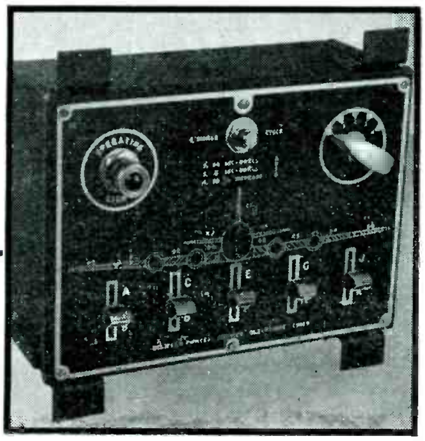
Years ago aircraft operators learned that de-icers give better ice removal if ice, at least an eighth of an inch thick, is allowed to accumulate before the boots are inflated. This is because the ice must build up to some definite thickness in order to develop enough tensile strength to overcome adhesion. If the de-icers are operated with insufficient ice accumulated on them, the stretch of the rubber crazes the thin layer of ice, breaking it into many very small pieces, some of which are dislodged but most of which remain. Then, further accumulation of ice builds on these remaining particles thus developing a flexible ice composed of a number of separate little islands. The establishment of such a condition renders de-icer operation on a continuing fixed cycle much less effective than normal since the rubber inclines to stretch between the ice islands without breaking them loose.

Importance of Timing

Although operators have learned to allow a buildup of ice to accumulate before putting the de-icer system into operation, there has heretofore been nothing they could do about the recurring cycles which

SELECTOR SWITCH SETTING	TYPE OF OPERATION	PURPOSE	START — BOOT TIMES — DUTY CYCLE — TIME	INTERVAL BETWEEN SUCCESSIVE OPERATIONS OF ANY ONE BOOT
1	MANUAL — SINGLE CYCLE	LOW RATE ICING	ABCDEFGHJK ... ABC; 40 SEC (1 CYCLE); INDEFINITE INTERVAL BETWEEN CYCLES; PILOT MUST PRESS BUTTON	INDEFINITE (PILOT'S CHOICE)
2	AUTOMATIC — 60-SEC DWELL	MEDIUM RATE ICING	ABCDEFGHJK ... ABCDEFGHJK; 40 SEC (1 CYCLE); 60 SEC INTERVAL BETWEEN CYCLES; 40 SEC	APPROX 95 SEC
3	AUTOMATIC — 0-SEC DWELL	HIGH RATE ICING	ABCDEFGHJKABCDEFGHJKABCDEFGHJKABCDEFG; 40 SEC (1 CYCLE); 40 SEC; 40 SEC; 40 SEC	APPROX 35 SEC
4	AUTOMATIC — 50 % INCREASE	HIGH ALTITUDE ICING	ABCDEFGHJKABCDEFGHJKABCDE; 60 SEC (1 CYCLE); 60 SEC; 60 SEC	APPROX 52.5 SEC

FIG. 1—Types of operating cycles available in the timer to meet various icing conditions encountered during all-weather flying



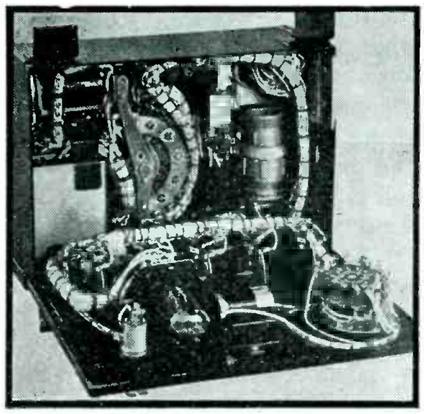
Eclipse-Pioneer electronic timer as built for use on four-engine aircraft. Cross-section drawing of plane indicates positions of de-icer boots controlled by the emergency manual toggle switches at bottom of control panel

automatically followed in sequence at intervals of approximately 40 seconds, other than to manually switch the de-icers on and off. If the rate of ice accretion was only moderate, the amount of ice built up between the first and second cycle was inadequate to afford good removal. Furthermore, if inflation was premature the ice deposit on the boots might become crazed and compromise the proper subsequent removal of ice.

The requirement, then, is for some controlled means of automatically closing switches in sequence at the most effective times for de-icing. The purpose of closing these switches is to complete a circuit to one or more distributor-valve solenoids, to control the opening of poppet valves and release a surge of pressure directly into the de-icer boot cells. These cells immediately punch out to a full inflation. The cells are deflated under their own pressure by unloading to atmosphere upon breaking the solenoid circuit through the timer. Suction accelerates the final stages of boot deflation.

For slushy ice, the rapidity of inflation is very important. With some types of de-icer systems, the inflation of boots is sluggish and as a result the ice sometimes has time to mold itself to the changing contour of the de-icer surface.

For very hard types of ice, the completeness of inflation and the resulting distortion of the rubber surfaces become more important than the rapidity of change. In the



Timer may be opened from the front and allowed to operate, for convenience in making adjustments or locating troubles. Selector switch (at lower right in this view) provides choice of four types of de-icer operation

older systems completeness of inflation on the larger-capacity de-icer boots could only be satisfactorily obtained by recourse to oversize air pumps, with an attendant weight penalty.

Electronic De-Icer Timer

The electronic de-icer timer to be described provides the needed flexible control of de-icer recycling when used with the manifold-solenoid de-icer system. This system replaces the central distributor and multiple tubing lines with pressure and suction manifolds acting in effect as reservoirs of both pressurized and evacuated air for the individual solenoid-controlled distributing valves located at the respective de-icer boot connections. The system not only simplifies the plumbing installation but also improves the rate of inflation and deflation of the de-icer tubes, and adds snap to this process by providing quick opening and shutting of valves along with preselection of inflation periods to suit the capacities of the respective boots. It reduces the control of inflations to an electrical circuit operating the solenoids for

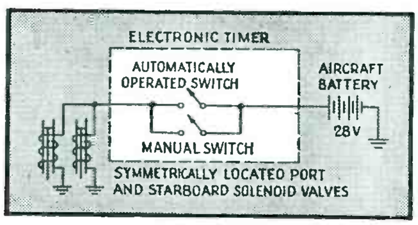


FIG. 2—One of the individual switching circuits controlled by the electronic timer

the most part automatically. Overriding manual controls permit the use of human judgement in anticipating or reacting to rapid changes in icing conditions.

Choice of Operating Cycles

In the latest lightweight system of mechanical de-icing employing the electronic timer mechanism, positive control over all kinds of icing is provided by a choice of four different operating cycles, described below and diagrammed in Fig. 1.

(1) *Single Cycle*, in which the unit inflates each boot in turn once, after the starting button is depressed, and then waits until the starting button is again depressed before proceeding with another inflation cycle. This operation is useful under low-rate icing conditions.

(2) *60-Second Dwell*, in which the unit inflates each boot in turn, waits 60 seconds, then inflates the boot again, waits 60 seconds, etc, until the unit is turned off or switched to another position. This is preferable under medium-rate icing.

(3) *0-Second Dwell*, in which the unit keeps repeating the inflating cycle but does not delay between successive inflation cycles. This obviously provides for high-rate icing.

(4) *50% Increase*, in which the cycling is repetitive without delay between cycles, but the inflation period for each boot is increased by 50 percent. This operation provides for higher altitudes and subnormal air flows from the engine air pump.

Circuit Details

The electronic timer circuit consists of a multiplicity of simple switch circuits plus a combined timing and control circuit. One of the switch circuits is shown in Fig. 2. From five to ten of these circuits are provided, one for each pair of symmetrically located boots required on the aircraft. The automatically-operated switch closes once during each automatic cycle for a predetermined length of time provided for by an electronic timing circuit. The mechanical structure of the automatic switching mechanism is such that the individual circuits can be closed only in a fixed sequence and one at a time.

A schematic diagram of the automatic control circuit appears in Fig. 3. Contacts S_1, S_2, S_3, S_4, and P_1 (shown with dotted lines) are the contacts of the selector switch on the front panel and the SINGLE-CYCLE starting pushbutton respectively. These provide the four variations in cycling.

Position 11 on the automatic switch has been arbitrarily chosen as the DWELL position of the system, wherein no boots are inflated. In order to provide for SINGLE-CYCLE operation, contacts which are closed at all positions except 11 are connected in series with the stepping circuit, consisting of thyratron tube V_1 and the automatic switch operating coil. These contacts are known as the off-normal contacts, and are shunted by contacts S_1 and P_1. Since P_1 is normally open and S_1 is open on position 1 of the selector switch, the automatic switch cannot move off position 11 until either P_1 or S_1 closes. As soon as P_1 is pressed, however, the stepping circuit is completed and the automatic switch moves its contact arms to position 1. The off-normal contacts close, and operation continues until position 11 is reached again. In this manner SINGLE-CYCLE operation is obtained. When the selector switch is turned to any of the three automatic positions (2, 3, or 4), contact S_1 continuously shunts the off-normal springs and the automatic switch cannot stop at position 11.

Contact S_2 is closed at all positions except position 2, for 60 SECOND DWELL. When S_2 is closed, only 0.1 megohm is in the discharge circuit of the capacitor, and the time interval is 5 x 0.1 or 0.5 second. Since this resistor is at position 11 (DWELL) of the automatic switch, the delay between cycles is negligible. When S_2 is open at selector position 2, the resistance of the discharge circuit becomes 12.1 megohms, and the time interval of dwell becomes 5 x 12.1 or 60.5 sec (values are approximate).

Contact S_3 closes only at selector position 4 and connects a second capacitor in parallel with the one used for all other selector switch positions. This increases the capacitance in the timing circuits by a factor which increases all discharge times 50 percent.

Contact S_4 closes only in the off position of the selector switch, and when closed shunts tube V_1. The automatic switch then steps rapidly around to position 11, where the off-normal springs open the circuit, and the automatic switch operating coil is left connected to power. The timer is thus made to reset to the DWELL position no matter what its condition when the unit is turned off.

Stepping Operation

The stepping operation can be broken down into three repeating sequences of the telephone-type rotary switch. Wiper arms are mounted on a shaft, each wiper arm having an associated bank of contacts arranged in a semi-circle with the shaft as a center. When the shaft is rotated, the wipers connect to each contact in their respective banks in turn. There are eleven contacts in each bank, providing for 11 positions in one-half revolution of the wipers. The wipers extend on either side of the shaft, so that two cycles are obtained from one complete revolution. The operating coil, when energized, attracts an armature on the other end of which is a pawl that engages the ratchet wheel. This pawl moves back one tooth on the ratchet wheel when the armature is attracted by energizing the coil. An insulating button on the armature at the same time opens interrupter springs. When the coil is deenergized, a retractile spring restores the armature and in doing so the pawl drives the ratchet wheel, shaft, and wipers in a clockwise direction through an angle equal to the angular distance between contact centers in the switch bank. Therefore, each time the coil is energized, the switch prepares to step, and each time the coil is deenergized, the switch steps.

First Sequence

For convenience, let the first sequence begin at the instant at which current starts flowing through the coil, but before the resulting pull has overcome the inertia of the armature, corresponding to the conditions of Fig. 4A. At this instant the potential across capacitor C_1, and consequently the potential difference between grid and cathode of V_1, is zero and no current flows to or from C_1. Tube V_1 is passing current through the operating coil and its interrupter contacts, and capacitor C_3 charges with the polarity shown.

Second Sequence

When the coil pulls the armature fully down, the pawl is drawn back ready for stepping, the interrupter contacts are open and for a short space of time the conditions in Fig. 4B exist. The interrupter contacts

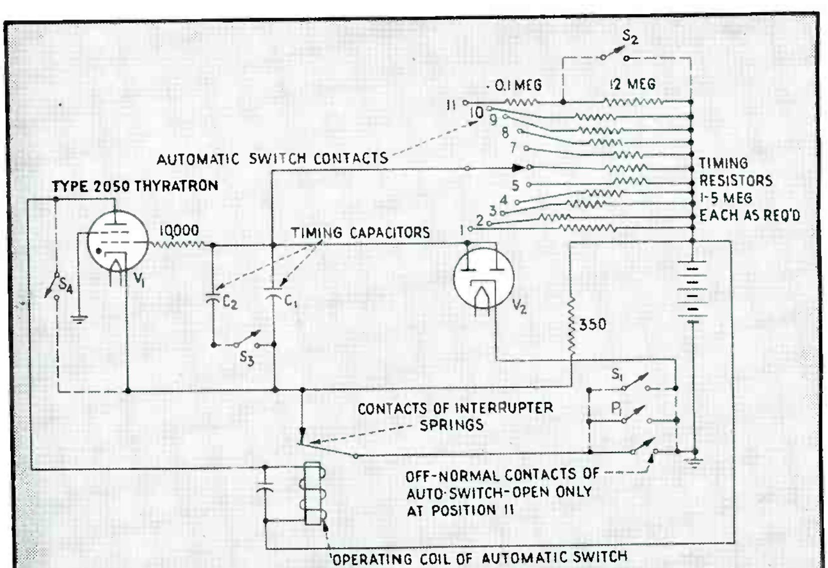


FIG. 3—Automatic control circuit used to operate ten de-icer boots on an aircraft. Stepper arms of automatic switch rest on position 11 during the DWELL interval between cycles. Other contacts (not shown) on the automatic telephone-type stepper switch energize solenoids that control boot inflation

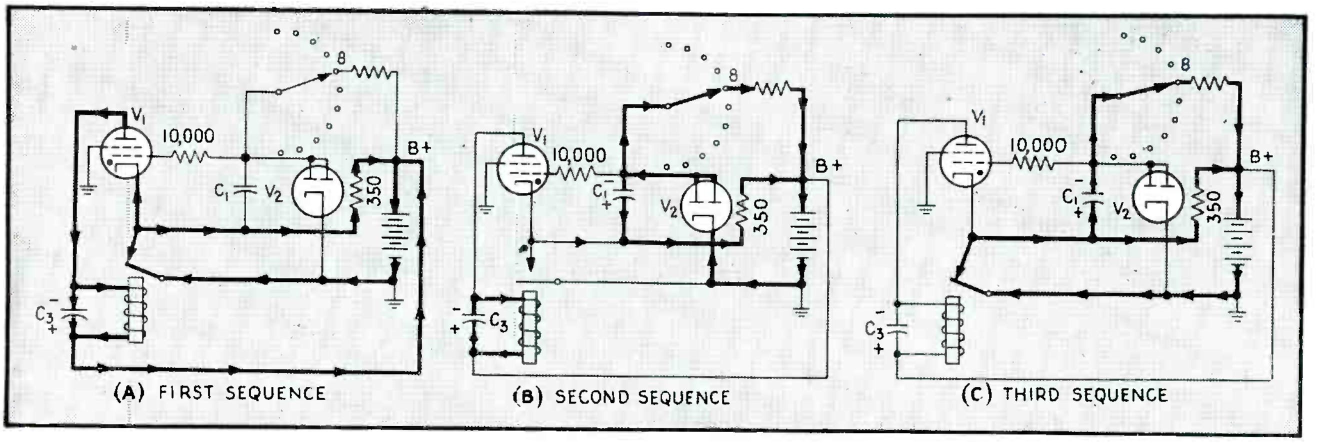


FIG. 4—Simplified versions of automatic control circuit, showing directions of electron flow for the three sequences occurring during a stepping operation associated with the inflation of one de-icer boot. The first and second sequences last approximately 0.05 second each, while the third sequence lasts for the duration of boot inflation time

are open, there is no path from the cathode of V_1 to ground, and the cathode is connected to B+ through the 350-ohm resistor. This places both plate and cathode of V_1 at the same potential and consequently no current flows in V_1. A small current flows for a short time between the coil and C_3, and C_3 discharges. The main current flow at this instant, however, is the charging current that flows from B+ through the 350-ohm resistor to the cathode side of C_1, and from the grid side of C_1 through tube V_2 to ground. Capacitor C_1 therefore charges with the polarity shown.

Third Sequence

At the end of this short interval during which the V_1 circuit is broken, the retractile spring of the automatic switch overcomes inertia and restores the armature to normal. The pawl drives the shaft and wipers to the next position, the interrupter springs close, and the circuit conditions of Fig. 4C exist. No current flows through V_1 and the coil because C_1 is still charged. The positive side of C_1 is connected to ground and the cathode, and the grid of V_1 is negative by the amount of the charge voltage, thus preventing the resumption of current flow in V_1. The plates of diode V_2 are connected to the grid and the negative side of C_1, while its cathode is connected to the positive side of C_1, and therefore no current can flow through V_2. There is a current path through which the charge on C_1 can leak off, however, formed by the battery and the resistor connected to the particular point on which the automatic switch wiper is resting. Since battery resistance is negligible, the time of discharge will depend only on the resistor and capacitor values. Discharge times for individual switch points are obtained by using different values of resistor. A flat percentage increase of all discharge times is obtained by adding additional capacitance in parallel with C_1.

As the charge on C_1 leaks off, the grid of V_1 becomes less and less negative, until finally it becomes approximately at the same potential as the cathode of V_1. Tube V_1 then passes current which energizes the automatic switch operating coil, and the system is at the condition of Fig. 4A again.

Adjusting Boot Inflation Time

During the discharge period of the timing cycle, the negative side of the capacitor is connected by the timing resistor to the positive side of the battery, thereby doubling the voltage across the capacitor and providing a nearly linear discharge rate over the voltage range to be used.

To facilitate changing the boot inflation times to agree with the requirements of a particular aircraft, the timing resistors are wired inside a standard AN plug connector which is in turn mounted on an receptacle inside the unit.

Contact Arrangements

Considerable effort was expended to reduce the number of contacts to a minimum. The contacts used for connecting to the various boot valves and the contacts that connect and disconnect additional resistors for different types of operation are mandatory. However, in the control and timing circuit, one pair of contacts (the interrupter springs) in conjunction with diode V_2 perform the functions of charging the capacitor, connecting it so that the grid is negative after charging, deionizing thyratron V_1, and breaking the circuit to the automatic switch coil after energization to cause it to step the wiper arms to the next position. If the diode were omitted, an additional set of contacts would be required to connect the grid side of the capacitor to ground during charging, and these contacts would have to be critically adjusted with respect to the interrupter springs so as not to provide a short-circuit path across the capacitor after charging.

The standard telephone-type automatic switch used in the timer has three banks of contacts, although only two are required for the circuit. By tying all the contacts in one bank to the power supply, connecting two sets of wipers in series, and using the contacts in the second bank to connect to the valves, it was possible to use the standard contacts of the switch to make and break, as well as carry, the three-ampere inductive load of the valve solenoids without appreciable deterioration of contacts over more than two hundred thousand operations. In terms of de-icing time, this is enormous life, and considerable savings are effected in weight and complexity over a system wherein the telephone switch contacts carry, but don't break, the load current.

Compact, rigid assembly of the vhf impedance-measuring unit is essential

VHF IMPEDANCE

By D. STANLEY HENRY

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An instrument with which to measure impedance in terms of resistance and reactance through the range of frequencies which have been assigned to the commercial f-m and television services is needed. Below this range r-f bridges are satisfactory and above this range slotted-line measurements are convenient.[1]

The instrument to be described is small and compact so that it can be used in many places inaccessible with conventional equipment. The grounding problem, which is always important and often critical at these frequencies, offers little difficulty principally because the device is complete in itself.

Description of Method

The range can be quickly varied to suit the particular problem so that in most cases it is unnecessary to supplement the unknown impedance with a known reactance in order to bring the unknown impedance within range of the instrument. However, greatest accuracy is obtainable through the resistance and reactance ranges commonly encountered in antenna and transmission line measurements. The resistance range is approximately 30 to 1000 ohms, and at 100 mc the reactance range is approximately ±15 to 500 ohms. The reactance range depends on the capacitance range of the capacitor used for C_3 in Fig. 1 and 2.

Resistance measurements are made in terms of a ratio of the voltage developed across a resonant circuit to the voltage resulting when the unknown resistance is introduced into the circuit. The unknown reactance is measured in terms of the variation of reactance of an accurately calibrated capacitor that is required to return the measuring circuit to resonance.[2]

The most logical means of measuring voltage and indicating resonance is a vacuum tube voltmeter connected to a resonant circuit L_1C_1 as shown in Fig. 1. Because a voltage ratio is used, the voltmeter need not be calibrated if its law of deflection is known. One of the adjustments requires tuning to produce 70.7 percent of the voltage at resonance. This voltage would be one-half of the voltmeter reading at resonance if the voltmeter were square-law. The added sensitivity of this type of voltmeter is convenient for increased tuning accuracy.

A balanced-modulator circuit will insure square-law operation because only second-order terms appear in the plate circuit. A 100-μa meter with at least 50 dial divisions is satisfactory for the meter. The required balanced voltage for the voltmeter is obtained from the balanced circuit L_1C_1.

Assume Q_2 of resonant circuit L_2, C_2, C_3 is reasonably high so that R_2 can be neglected. Let Z_2 be the impedance seen by a series generator in circuit 2 of Fig. 1 when it is isolated from circuit 1, then

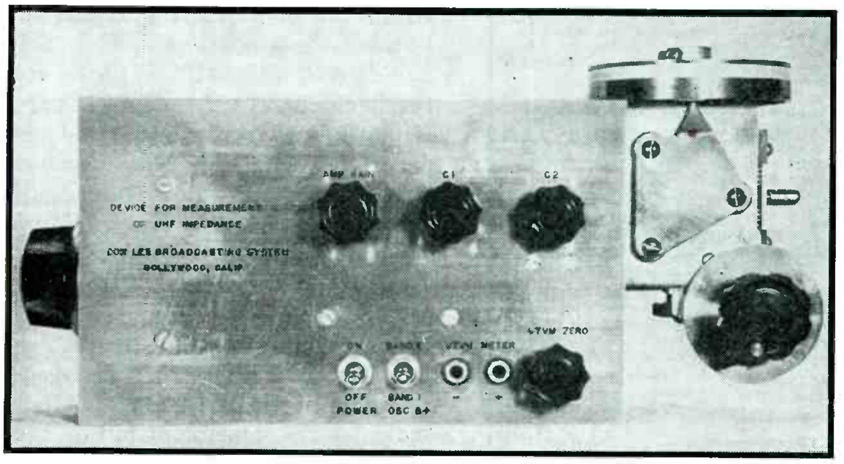
$$Z_2 = \frac{Z_R Z_X}{Z_R + Z_X}$$

When circuit 2 is coupled to circuit 1, the impedance appearing in circuit 1 due to circuit 2 is[3]

$$\frac{(\omega M)^2}{Z_2} = \frac{(\omega M)^2}{Z_R} + \frac{(\omega M)^2}{Z_X}$$

This equation shows that the various shunt impedances affect circuit 1 independently and any one may be added or removed without changing the effect of the others. Regardless of the physical arrangement of the unknown impedance, circuit 2 sees the equivalent resistance in parallel with the equivalent reactance. In cases where the series components are more desirable and useful, the parallel combination can be changed to the series equivalent.

It should be noted that the minimum capacitance of C_3 will appear across C_3 as an unknown reactance but the effect of this reactance is constant and will not modify the value of the unknown because it



Unknown is connected directly to the calibrated capacitor at the right

MEASUREMENTS

Equipment for making impedance measurements in the range from 50 to 150 mc is described and its probable errors are analyzed. Construction and operation of the equipment and method of making measurements are explained

has been shown that unknown components across C_3 affect circuit 1 independently.

It is important to connect the unknown directly to the terminals of C_3 rather than to electrically equivalent points, to eliminate error which would be introduced by the inductance of the leads connecting circuit 2 to C_3. The method of tuning circuit 2 described below will show that the circuit inductive reactance is tuned out.

Care must be taken to maintain the Q of circuit 2 as high as possible because the principal assumption in this method of measurement is that the resistance of circuit 2 is negligible. Consideration of this resistance would make the measurements unnecessarily tedious. Experience has shown that very practical and useful results can be obtained with such an assumption.

The resistance R_1 of circuit 1 is used as a starting point for making measurements but it is not necessary to know the ohmic value. At one point in the tuning procedure, circuit 1 will be detuned from resonance until the square-law voltmeter indicates one-half the reading at resonance. This indicates a voltage 70.7 percent of maximum and shows that a reactance equal to R_1 has been added to circuit 1. This reactance will then be replaced by an equal reactance of opposite sign which can be accurately determined from C_3. The constant driving voltage is effectively in series with L_1 and C_1 because this circuit is driven by a pentode which is practically a constant-current generator. The inductive coupling between L_1 and L_2, which presents resistance and reactance components to circuit 1, need not be known.

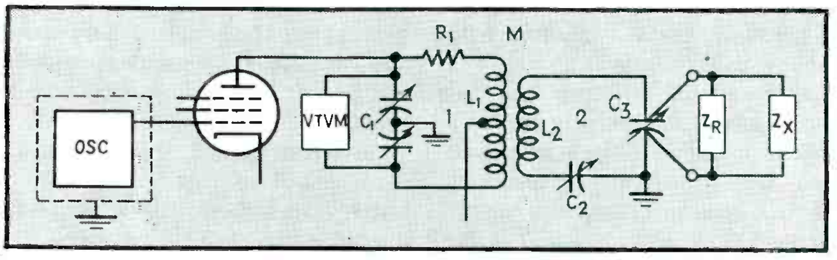


FIG. 1—The principle of measurement is that of a Q meter. The pentode prevents reaction of the measuring circuit on the oscillator and gives the generator a nearly infinite internal impedance

Measurement Procedure

In using the vhf impedance measuring circuit of Fig. 2, the following procedure is used:

1. Detune C_1 until it has no effect on the voltmeter and set the voltmeter to zero.

2. Set C_3 to minimum so that $\Delta C_3 = 0$.

3. Tune C_1 for maximum voltmeter reading and adjust the amplifier gain for a convenient reading, probably full scale. Circuit 2 is so far from resonance that it will have negligible effect on circuit 1 at this point.

4. Short C_3 by inserting a strip of crimped copper between the plates. This must be done at the plates rather than across the terminals to avoid the error caused by

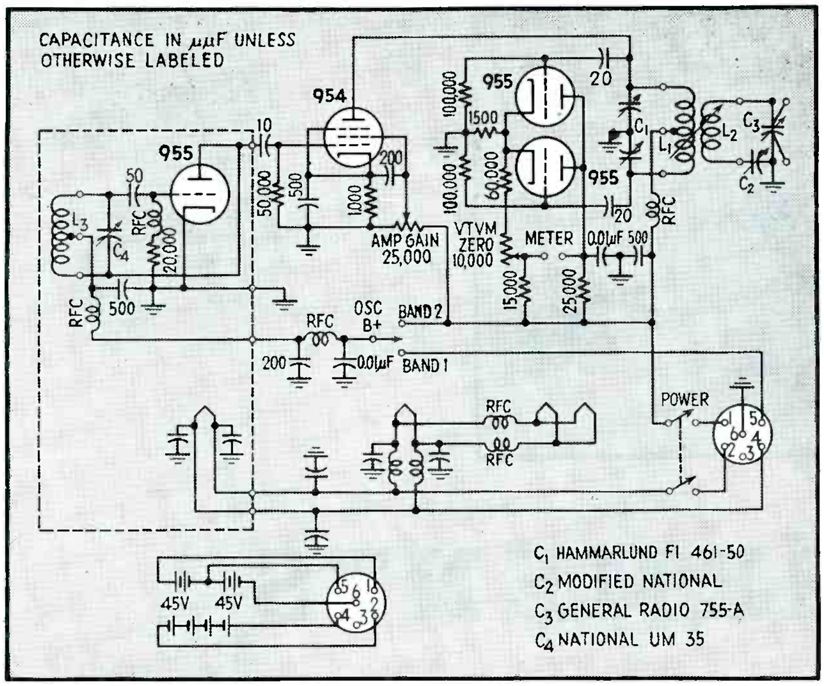


FIG. 2—A balanced, square-law vacuum-tube voltmeter is built into the instrument to measure the voltage across the resonant circuit

the inductance of a relatively long shorting bar across the terminals.

5. Tune C_2 for minimum voltage indication.

6. Remove the shorting strip and check C_1 for resonance.

7. Note the maximum voltmeter reading in dial units as V_1.

8. Detune circuit 1 by decreasing C_1 until the meter indicates one-half the maximum reading. At this point $X_{C1} = R_1$.

9. Retune circuit 1 to resonance by increasing C_3. This indicates that an impedance equal to R_1 has been presented to circuit 1 from circuit 2. Note (ΔC_3).

10. Add the unknown directly to the terminals of C_3.

11. Retune C_3 to cancel the added reactive component. Call the new setting of C_3 $(\Delta C_3')$. Note $(\Delta C_3')$ and the new voltmeter reading V_2.

12. $1/\omega(\Delta' C_3)$ is the unknown reactance, where $(\Delta' C_3) = (\Delta C_3') - (\Delta C_3)$. From step 9 above

$$\frac{(\omega M)^2}{1/\omega(\Delta C_3)} = R_1 \qquad (\omega M)^2 = \frac{R_1}{\omega(\Delta C_3)}$$

The voltages developed across C_1 are inversely proportional to the effective circuit resistances so that

$$\frac{E_1}{E_2} = \frac{R_1 + \omega^2 M^2/R}{R_1} = 1 + \frac{1}{R\omega\,(\Delta C_3)}$$

$$R = \frac{1}{\left(\frac{E_1}{E^2} - 1\right)\omega\,(\Delta C_3)}$$

. Let $P = (E_1/E_2) - 1$, and $V =$ voltmeter deflection in a square-law device, then $P = \sqrt{V_1/V_2} - 1$: $R = 1/P\omega(\Delta C_3)$: $X = 1/\omega(\Delta' C_3)$.

Analysis of Errors

From the above equations for R and X, we see that the accuracy of the measurements depends on a knowledge of frequency, (ΔC_3), and the voltage ratio used to find P. For greatest convenience in using an instrument of this type, it is necessary that the source of frequency be an integral part of the unit. The oscillator shown was calibrated with a heterodyne frequency meter, the fundamentals of which were referred to a frequency standard. Tuning circuit 1 through resonance may cause a frequency change of about 0.002 percent. It is safe to assume that errors in frequency will be negligible as compared with other probable errors.

By means of differentials, the relative effect of errors in the calibration or use of C_3 can be shown from $X = 1/\omega(\Delta' C_3)$. Assuming that $\Delta\omega = 0$, and taking logs we obtain $\log X = \log 1 - \log\omega - \log(\Delta' C_3)$; and differentiating obtain $dX/X = -d(\Delta' C_3)/(\Delta' C_3)$.

This result shows that the relative error in measuring reactance is inversely proportional to $(\Delta' C_3)$ and directly proportional to the error in finding $(\Delta' C_3)$. This is particularly serious for large inductances and small capacities because $(\Delta' C_3)$ is equal to the difference in the two settings of C_3. The resistive component of the unknown lowers the Q of the circuit so that the exact setting of this capacitor for resonance is more difficult. Sometimes it is better to tune through resonance until the voltmeter reading indicates the same point but on the other side of the resonance curve. Then one-half of the change in C_3 will be required $(\Delta' C_3)$.

The measurement of the resistive component involves the square root of the voltage ratio and also (ΔC_3) as the principal causes of error because again these errors will probably be large compared to the error in frequency. It is doubtful that C_3 can be set within about 2 or 3 percent because of the broadness of resonance.

The relative error in finding R which results from error in the voltage ratio is more easily predicted by considering the error in finding P. Let V_1 and V_2 be the meter deflections in any units and assume V_1 constant as the starting point, then $P = \sqrt{V_1/V_2} - 1$, taking logs; $\log P = \log(\sqrt{V_1/V_2} - 1)$, and differentiating

$$\frac{dP}{P} = -\frac{\left(\frac{1}{2V_2}\right)\sqrt{\frac{V_1}{V_2}}}{\sqrt{\frac{V_1}{V_2}} - 1}\,dV_2 = -\left[\frac{1}{2V_2\left(1 - \sqrt{\frac{V_2}{V_1}}\right)}\right]dV_2$$

The factor inclosed in brackets is plotted as a function of V_2 in Fig. 3. This curve indicates the range through which V_2 may be read for minimum error. The values of V_2 and (ΔC_3) are interdependent and can be adjusted toward optimum by varying the coupling between L_1 and L_2. This adjustment also is convenient in the measurement of reactance. If a large capacitance is to be measured, the coupling is made small so that (ΔC_3) will be large. Conversely, for a large inductance, the coupling is made close. This adjustment effectively doubles the useful range of C_3. Errors in determining P or (ΔC_3) affect R

in just the same manner as an error in ($\Delta' C_3$) affects the measured value of X. Of course, the errors can tend to cancel or to accumulate, depending on the relative sign of the differential value.

Description of Unit

If the power leads are filtered, no r-f will get to L_1 except through the pentode amplifier which approximates a constant-current generator. A butterfly circuit[4] oscillator is an ideal source of power for such a device because of its range, small size and simplicity.

The upper frequency limit of this particular unit is 150 mc. This limit is determined by the necessary inductance of the leads to C_3 because the terminals of C_3 must be available for connecting the unknown. L_2 must be large enough to couple sufficiently with L_1.

The square-law vtvm is best checked by plotting the square root of the meter deflection as a function of the applied voltage. If the meter response is square-law, this plot gives a straight line.

In use, the balance of the L_1C_1 circuit can be conveniently checked by tuning C_1 to resonance and then touching each stator section of C_1 in succession. The voltmeter reading should drop to nearly zero in each case. Small amounts of unbalance can sometimes be compensated by adjusting the center-tap by-pass capacitor. Choice of tubes or of bias operating point is relatively unimportant.

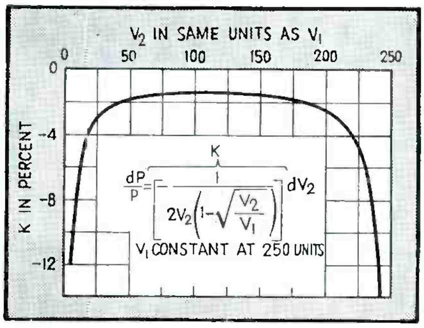


FIG. 3—Adjust coupling between circuits 1 and 2 of Fig. 1 to keep V_2 within the range of least relative error K which can be introduced by inaccuracies in reading voltages when measusing resistances

Typical Measurements

In making any measurement, it is comforting to be able to make it by at least two radically different methods. Because the range of this instrument overlaps the upper limit of the General Radio 916-A r-f bridge, a complete comparison of the two methods at 50 mc was possible. The average difference for random measurements was within five percent and in many cases less than two percent.

Figure 4 shows the results of a group of measurements to determine the characteristic impedance[5] of a 50-foot length of concentric line. The open-circuit and short-circuit reactances of the line are plotted as a function of frequency without regard to sign.

Figure 5 gives the characteristics of a dipole fed with a length of EO1 cable. As this is a balanced impedance and the instrument is an unbalanced device, the measurement is tedious but the curves indicate the results that can be expected and demonstrate the consistency of the measurements. The value of about 76 ohms resistance at resonance is reasonable.

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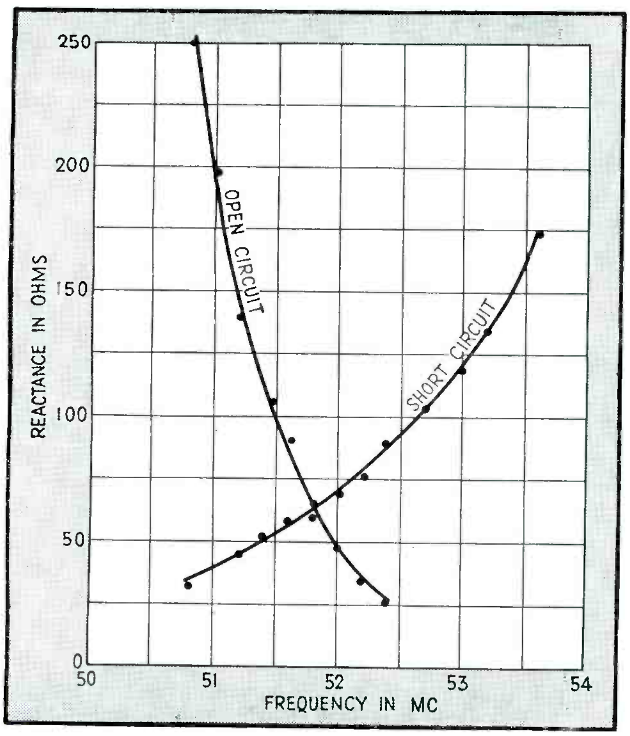

FIG. 4—Measurement of coaxial-line reactance made with the instrument

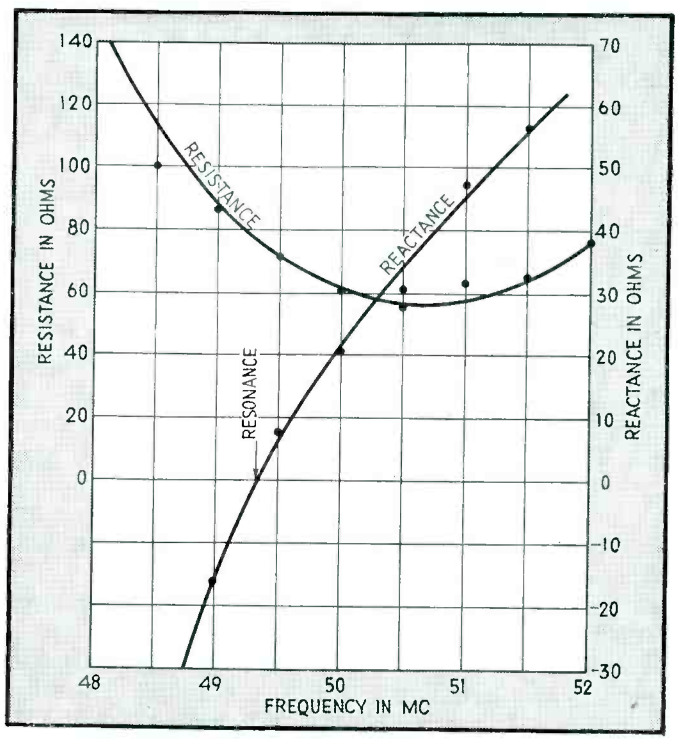

FIG. 5—Impedance of a dipole antenna as measured with the test instrument

Interference-Free WEATHEROMETER

Accelerated weathering is applied to plastic and rubber materials and measured with photoelectric equipment. Automatic cycling of wetting and irradiation is provided and no radio interference is caused. The action is about ten times faster than outdoor exposure

THE weatherometer to be described was developed to furnish accelerated weathering for testing components of aircraft radio equipment. Such tests are made on plastic and rubber material and nameplates. The device simulates the conditions of rain and sunlight and provides two hours of wetting, two hours of irradiation, two more hours of wetting and 18 hours of irradiation as prescribed in Federal and Navy aeronautical specifications. This is continued through 10 cycles or 240 hours.

The weathering conditions are provided by two infrared lamps for heat, ultraviolet lamps for irradiation, and a sprinkler for wetting. Three sunlight lamps were used for the ultraviolet source because a flaming arc was found to cause radio interference. The likely changes in the physical condition of the samples after testing are crazing, discoloration, blooming, and warping.

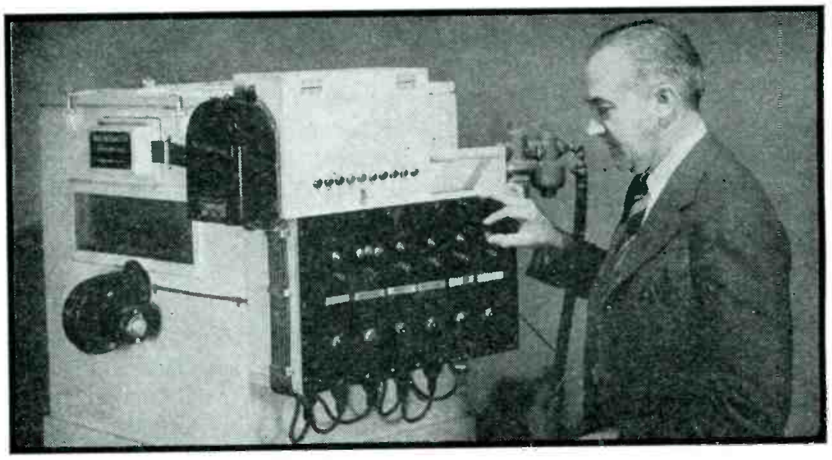

FIG. 1—Interference-free weatherometer for accelerated weathering tests of components

Weathering Equipment

The complete unit is shown in Fig. 1. The lamps are mounted in an aluminum reflector the length of the cabinet, with each infrared lamp between two sunlight lamps. The sprinkler is a brass pipe perforated with small holes and operated by a solenoid-type valve.

A wire rack is fitted inside the cabinet so that the sample material is centered at a vertex point where water spray, light rays, and air current from a blower meet.

Photoelectric equipment was constructed for measurement of the degree of weathering. In this, the light source is a six-volt automobile-type bulb mounted in front of a reflector and lighted from a storage battery. A Weston Photronic cell with a Viscor filter is connected to an ammeter with a 100-μa range. A variable resistor is used to adjust the light intensity.

The light-source is mounted behind a partition equipped with a one-inch circular aperture in one end of the box. In the other end of the box and 18 inches away is a similar partition equipped with a one-inch aperture in front of the cell.

Calibration

For test samples, strips of cellulose nitrate material 0.125 inch in thickness were subjected to the weathering cycle and outdoor exposure. The amount of discoloration was measured on exposed samples each day by light transmission methods.

The test samples were cleaned of dust and grease and measured by placing in front of the aperture at the cell. The cell receives the undeviated fraction of the light and part of the scattered light which is not deflected at angles greater than about 90 degrees. The total light transmission of the test sample is the fraction of the original light received by the cell which continues to reach the sensitive element. When the reading taken without the test sample is 100 μa, the reading taken with the sample in front of the Photronic cell aperture gives the percentage of total light transmitted.

Manual Controls

On the black Bakelite panel shown in Fig. 1 are eight toggle switches. The switch on the left side of the panel operates the blower, and the cluster of three switches controls the three sunlight lamps. A choice of one, two, or three sunlight lamps can be had. The next two switches to the right control the infrared lamps. Another switch operates the solenoid valve for the sprinkler.

The heart of the automatic control is the rotary selector switch shown in Fig. 2. This was obtained from a pin-ball machine and has 36 contacts of which 25 are used. This

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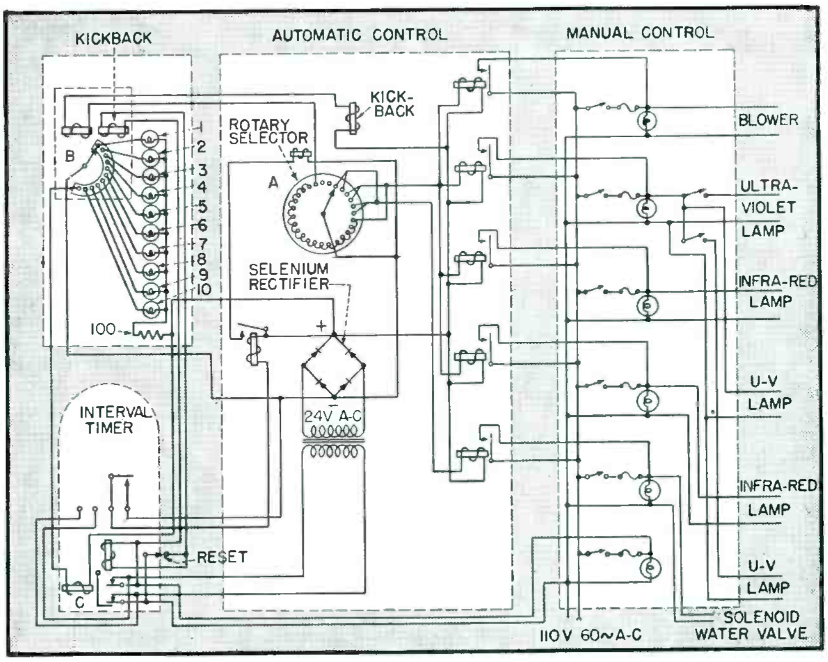

FIG. 3—Relay and switching circuits of the weatherometer

selector switch (*A* in the circuit of Fig. 3) is operated by two solenoid magnets, one magnet operating a ratchet-wheel and the other solenoid controlling the kick-back.

Weather Sequence

A cardboard dial is fastened to the shaft of this switch and is numbered from 1 to 24, denoting hours. The first two segments are also marked RAIN, the next two are marked SUNSHINE, the fifth and sixth contacts are marked RAIN and the remaining 18 are marked SUNSHINE. The 25th contact operates the kick-back solenoid which releases the ratchet and allows a spring to return the ratchet-wheel to its starting position. At the same time, the electromagnet in another selector switch of the telephone type (*B* in Fig. 3) which is mounted on the lid of the automatic control is energized.

To start the automatic cycling device, the switch on the extreme right of the manual control panel is operated. With all switches in their off positions, the automatic control switch starts the Telechron clock of the interval timer.

A pushbutton in the interval timer is used for a momentary impulse to lock relay *C* into place. With this relay locked and the automatic control switch on, the clock runs. The dial on the shaft is divided into 60 segments denoting minutes. A glance at the two dials shows the number of hours and minutes of any 24-hour cycle.

The relay which closes the circuit between the contacts of the solenoid valve switch is closed due to the position of selector switch *A* which is on its number 1 contact. Number 1 panel lamp of the ten shown on the front of the automatic cycling device is lighted denoting the first 24-hour cycle or day. Now at a glance we can add days to our computation of time of weathering or calculate the time necessary to finish the required 10 cycles of 24 hours. At the end of the 10th cycle, the selector switch *B* makes the 11th contact which energizes the electromagnet which unlocks relay *C*. This opens the a-c input and completely shuts the weatherometer down.

FIG. 2—The control panel of the weatherometer contains switches, fuses, and pilot lights. The rotary selector switch came from a pin-ball machine

Interval Timer

The interval timer makes a momentary contact of its built-in switch every hour. This impulse energizes the solenoid magnet of the rotary selector switch and, at the end of the first hour, the energized solenoid moves the ratchet-wheel contact to the second contact. This contact also connects to the solenoid-valve relay, and consequently the rain part of the cycle remains on.

At the next impulse from the interval timer, the selector switch moves up another contact; this breaks the solenoid-valve circuit and cuts in the relays controlling the blower, sunlight lamps and both infrared lamps. The weatherometer is now on the sunshine part of the weathering cycle. The interval timer continues to operate the selector switch through its controlling relay every hour of the 24-hour cycle.

When the 25th contact is made, the kick-back solenoid of the rotary switch *A* returns it to contact number 1 to begin the second cycle. This 25th contact also energizes the ratchet-wheel magnet of selector switch *B* and moves the switch arm to contact number 2, turning off the first light of the 10 denoting the number of cycles or days and turning on panel light number 2. This indicates that the first 24-hour cycle is completed and the second cycle is starting.

The acceleration factor of the interference-free weatherometer was found to be between 10 and 11 times greater than results obtained from outdoor exposure.

Vectorial Treatment of TRANSMISSION LINES

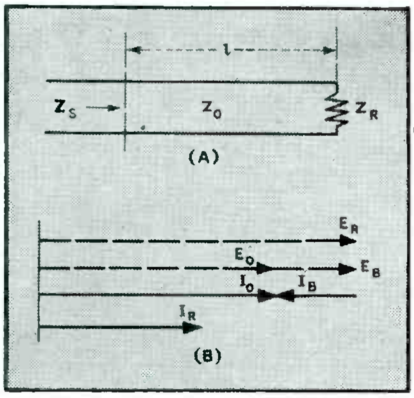

FIG. 1—(A) Transmission line showing relation of point, surge, and load impedances, and (B) currents and voltages at load for a load of $2Z_0$

By representing current and voltage as vectors, and distance along the line as phase displacement, a clearer treatment of transmission lines is obtained than that given by equations. Typical problems are solved

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MOST TRANSMISSION LINE problems can be solved by vectors. The use of vectors makes the action of the line clear and allows visualizations which would otherwise be difficult.

Conditions at Load

Standing waves on a transmission line are caused by two waves, the incident and the reflected waves, traveling in opposite directions. At certain points the two voltages add and at certain other points they subtract. In Fig. 1A let $Z_R = 2Z_o\underline{/0°}$. A 2:1 standing wave ratio will be caused by the mismatch, the maximum value of which will be $E_o + E_B$ and the minimum value $E_o - E_B$ and $E_o + E_B = 2\ (E_o - E_B)$ or

$$E_o/E_B = 3 \qquad (1)$$

where the symbols are as defined in Table I.

The load is resistive and higher than the line impedance, therefore there is a high of the standing wave at the load or

$$E_R = E_o + E_B \qquad (2)$$

The voltage vectors of Fig. 1B may be drawn from Eq. (1) and (2).

As to the currents involved, the incident current I_o is considered to be in phase with the incident voltage E_o but the reflected current I_B is considered to be 180° out of phase with the reflected voltage E_B. This is because of the sense of direction of flow which has been chosen.

The reflected wave may be considered as negative power because it is returning to the generator. The voltages are considered to have the same direction sense because both are measured across the line. A scale for the currents is chosen which will make the vectors I_o equal E_o and I_B equal E_B in length. The ratio of the scales used for voltage and current is dependent on the line surge impedance Z_o according to the relation

$$\text{Scale Ratio} = Z_o = E_o/I_o = E_B/I_B \qquad (3)$$

Conditions Away From Load

Figure 2A is a vector diagram of the line voltages and currents for the same load as in Fig. 1 but where l equals 45 electrical degrees of line.

A single vector is used to represent E_o and I_o. This vector is advanced 45° (counterclockwise) from the position of E_o and I_o in Fig. 1B because the incident wave will reach this point earlier. The vector E_B is drawn from the terminal of vector E_o, I_o and retarded (clockwise) 45° since the reflected wave

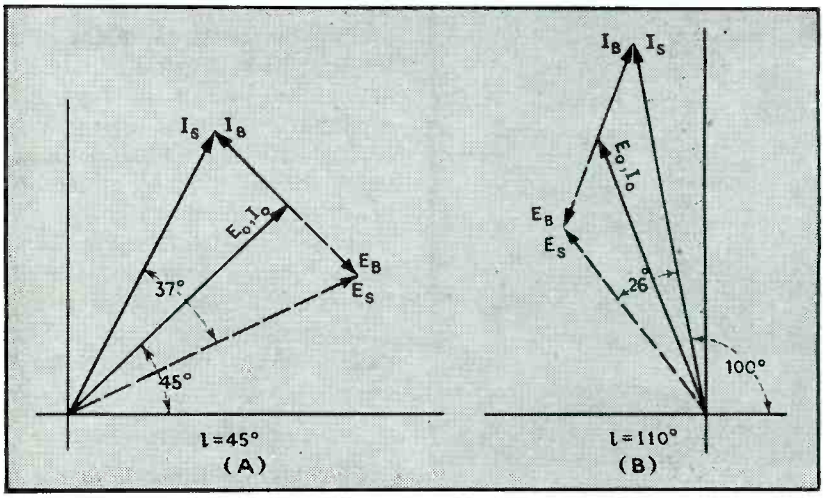
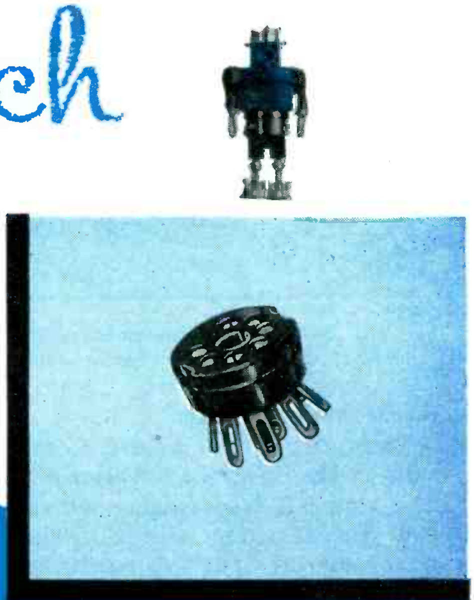
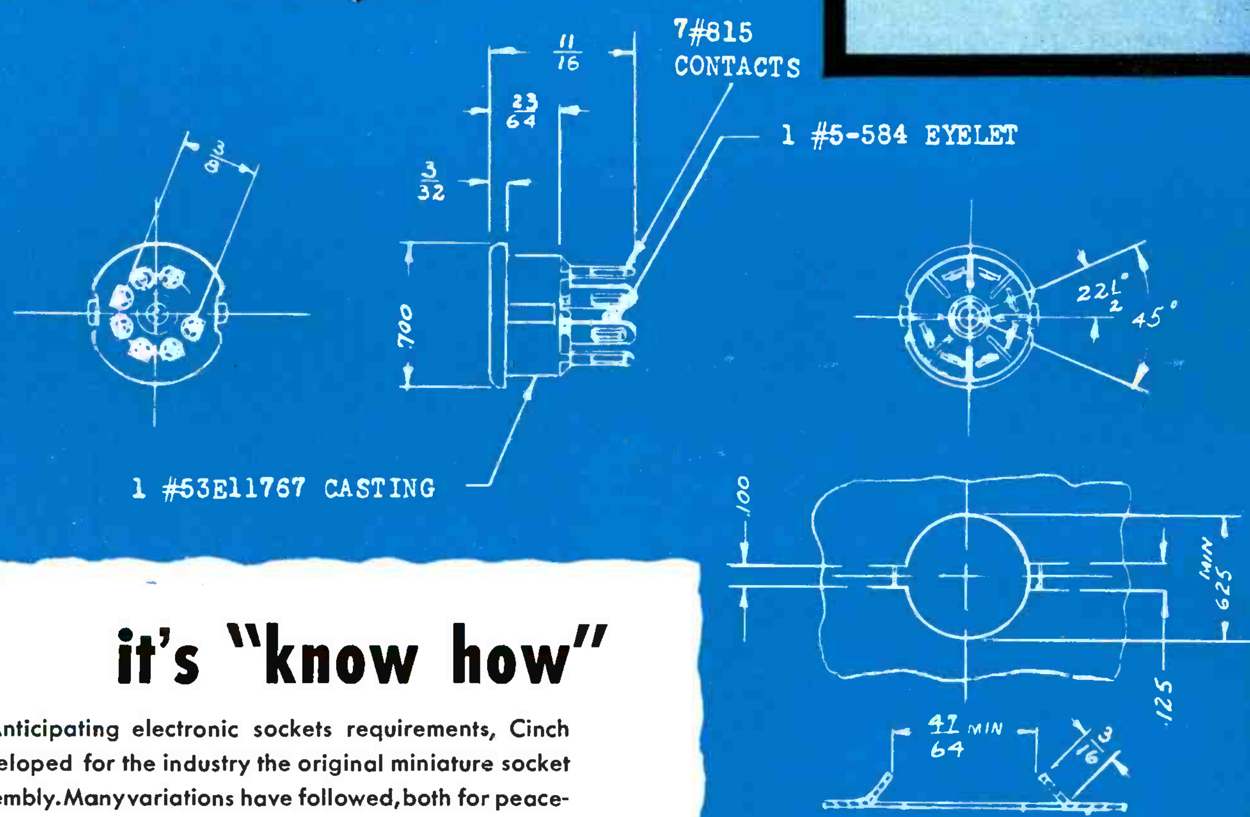


FIG. 2—Current and voltage relations for a line terminated in a resistance of $2Z_0$ (A) 45 electrical degrees from the load, and (B) 110 electrical degrees from the load

Miniature Chassis-Clinch Sockets





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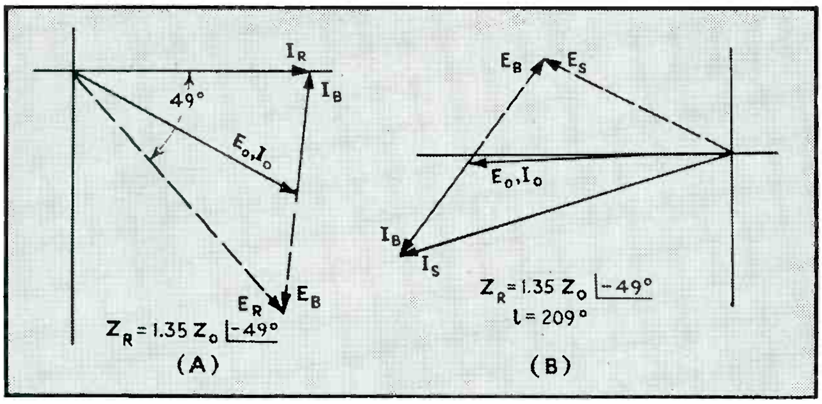

FIG. 3—Vectorial representations of conditions at a complex load (A), and some distance from it (B)

reaches this point later.

The vector sum of E_o and E_B results in the line voltage vector E_S. The vector I_B is drawn as before, 180° out of phase with E_B. The vector sum of I_o and I_B results in the line current vector I_S. This diagram reveals that

$$Z_S = E_S/I_S = Z_o \underline{/-37^\circ}$$

and also that the phase angle of E_S and I_S relative to E_R and I_R can be measured.

Figure 2B is the vector diagram when l is 110° and yields the following data

$Z_S = 0.608\ Z\underline{/26^\circ}$.

I_S is 100° ahead of load current I_R.
E_S is 126° ahead of load voltage E_R.

Figure 3A is the vector diagram at a complex load 1.35 Z_o $\underline{/-49^\circ}$. First the vectors I_R and E_R are drawn, making E_R equal 1.35 I_R and current leading 49°. I_R has been taken on the zero or reference axis although this is immaterial.

Connect the terminals of I_R and E_R and plot a point in the center of this line. This point is the terminal of the E_o, I_o vector. I_R can be seen to be the vector sum of I_o and I_B, and E_R the vector sum of E_o and E_B. The E_o, I_o and E_B, I_B vectors have now been determined so that the vector diagram for any point on the line may be drawn.

Figure 3B is the vector diagram 209° away from the load. The E_o, I_o vector has been rotated 209° counterclockwise from its position in Fig. 3A and E_B and I_B have been rotated clockwise 209° from their positions in Fig. 3A.

TABLE I
DEFINITION OF SYMBOLS USED IN THE TEXT

E_O, I_O	—Incident voltage and current at the load
E_R, I_R	—Voltage and current across load Z_R
E_B, I_B	—Voltage and current reflected by the load
E_S, I_S	—Voltage and current a distance l from the load toward the generator
Z_O	—Surge impedance of the transmission line
Z_R	—Impedance of the terminating load
Z_S	—Impedance at a point on the transmission line
l	—Distance along transmission line measured in electrical degrees from the load toward the generator

For other symbols used in text, see circuit diagrams

Antenna Feeding

A problem sometimes encountered in a high-frequency array is to feed three dipoles in phase, the center dipole to be fed 1.5 times the current of the outer dipoles. This problem is similar to that of feeding the towers of a broadcast transmitter at the necessary current amplitudes and phases to develop a required radiation pattern.

The feeding system is shown in Fig. 4A. Because the end antennas were similar, they were combined reducing the circuit to that of Fig. 4B and impedances expressed in terms of the feed line impedances. Fig. 4C is the vector diagram at the Z_1 load and Fig. 3A the vector diagram at the Z_2 load. Note that the two load current vectors are drawn to satisfy the antenna requirements. That is, they are in phase, and the length of I_R Fig. 4C is scaled two units representing current in both end dipoles, and I_R of Fig. 3A is scaled 1.5 units.

There are three requirements to be met: (1) dipole currents must be in phase, (2) dipole currents must be in a 1.5 to 1 amplitude ratio, and (3) a resistive 50-ohm load must be presented to the 50-ohm line. Using the two variables l_1 and l_2 it is probable that any two of these requirements can be satisfied. The first two have been chosen because they must be satisfied before the lines are joined. The loads must

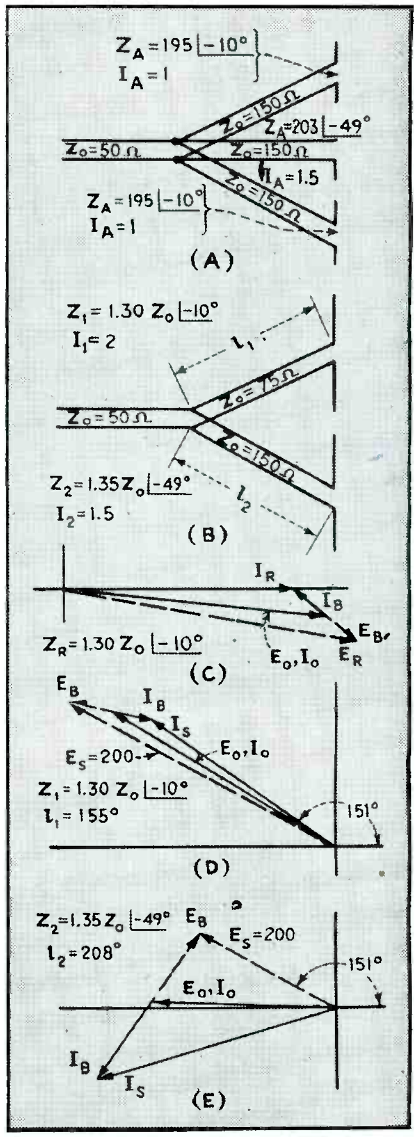

FIG. 4—Determination of feeding condition for a three-element array can be made vectorially. The given conditions are shown at (A), which can be simplified to (B) from which vectors at the upper antenna can be plotted (C). Vectors for the lower equivalent antenna are as at (A) in Fig. 3. The angular distance at which voltages on antenna feed lines are in phase is determined from (D) and (E)

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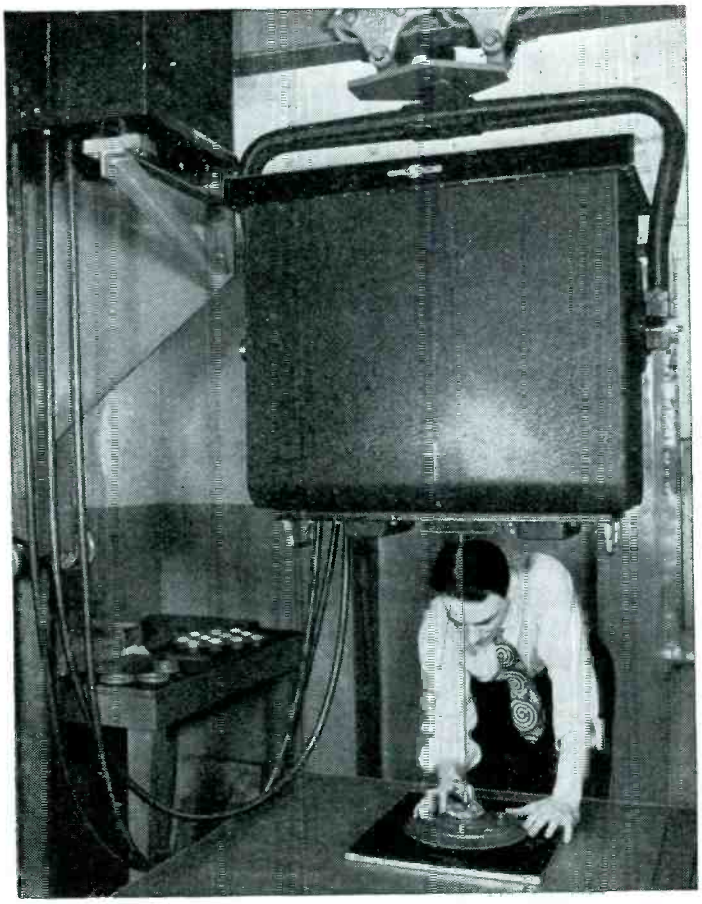

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give enough reflection to cause sufficient impedance variations along the lines to make a solution possible.

It is then necessary, by drawing trial vector diagrams for different lengths of l_1 and l_2, to find the lengths which will fill the first two requirements. Because the loads do not greatly mismatch their lines, lengths near even $\lambda/2$ multiples were tried in hopes of also partially satisfying requirement (3). Also, it is apparent that l_2 must be longer than l_1 because the current in Z_2 is to lead the current in Z_1 by 39° and must therefore be retarded.

Figure 4D is the solution. In order to connect the two lines together their voltages must be equal and in phase. The apparent difference in amplitude of the E_S voltages in Fig. 4D and E is due to 2:1 ratio of scales used for the 150 and 75-ohm lines. The current scales, however, are equal.

Impedance Matching

Figure 5 is the vector diagram of the input currents and voltage at the juncture of l_1 and l_2. The currents I_1 and I_2 in the two lines are added vectorially to give the 50-ohm line current I_S. The E_S vector is the same vector as E_S of Fig. 4D and 4E except that the voltage scale has been changed to conform to a 50-ohm line. The input impedance of 1.1 Z_o $\angle -21.5°$ would be considered satisfactory for most high-frequency work.

The impedance 55 ohms $\angle -21.5°$ may be matched to the 50-ohm line by the short-stub corrector shown in Fig. 6A. First draw the vector diagram of Fig. 6B at the load. As I_R is leading E_R an inductive or lagging current will be needed to bring them into phase. Also, the length of the I_S vector must equal the E_S vector to represent a 50-ohm load.

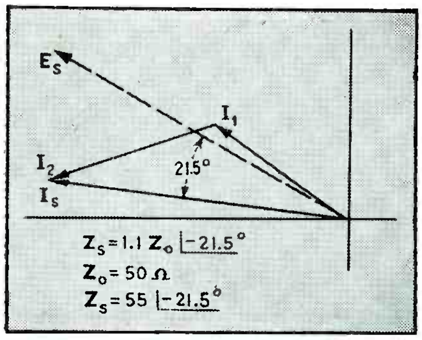

FIG. 5—At the juncture of the feed lines of Fig. 4B the voltages and currents have this relation as determined from Fig. 4D and 4E

Next draw the diagram of Fig. 6C. Draw the E_o, I_o vector of Fig. 6B at any angle (180° in Fig. 6C). From the terminal of E_o, I_o strike an arc of radius equal to E_B. Draw the vectors E_S and E_B, making the angle between them 90°. Draw I_B and I_S. I_O will then represent the inductive current to be drawn by the correcting stub. Note that it lags 90° behind the voltage E_S across the stub.

The 50-ohm line current I_{50} is the vector sum of I_O and the input current I_S to line l_1. The angle between E_O and E_B in Fig. 6B is 105.5° and the angle between E_O and E_B in Fig. 6C is 79°. The difference of 26.5° is caused by their rotation in traveling over the length of line l_1. The electrical length of l_1 will be half this amount or 13.25° because the vectors rotate in opposite directions. If desired, Fig. 6C may be redrawn in proper angular reference to the preceding diagrams. This results in Fig. 6D which is the input diagram for $Z_R = 1.1\ Z_o$ $\angle -21.5°$ and $l_1 = 13.25°$.

Figure 6C could have been drawn by calculating the magnitude of E_S first, and drawing E_B at right angles to E_S. The total power on the line will be the same at all points, therefore in Fig. 6B $P = E_R I_R \cos 21.5°$, or scaling E_R and I_R, $P = 200 \times 3.6 \times 0.930 = 670$. In Fig. 6C, $P = E_S^2/Z_o$ or $670 = E_S^2/50$, thus $E_S = 183$.

Stub Length

In determining the length of the stub l_2 of Fig. 6A, first consider the characteristics of a shorted line. There will be 100 percent reflection at the short, therefore E_B will equal E_O and I_B will equal I_O. There can be no voltage across the short, therefore E_B must be 180° out of phase with E_O at the short. Since the voltages are 180° out of phase, the currents I_O and I_B must be in phase and adding. A vector diagram could be drawn representing these conditions at the short.

Now draw Fig. 6E, the vector diagram for the input to the stub. I_O and E_S are copied from Fig. 6D. E_O and E_B are 45° out of phase in Fig. 6E and were 180° out of phase at the short. Since E_O turns counterclockwise and E_B clockwise, to have reached their position in Fig. 6E they must have moved in relation to each other by the larger angle between them, or 135°. Therefore l_2 of Fig. 6A must then be half this long or 67.5°.

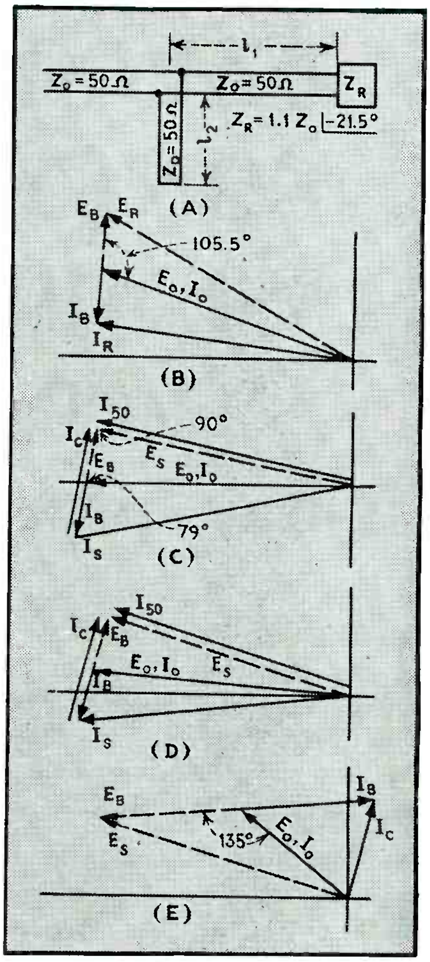

FIG. 6—To match the transmission and feed lines, a shorted stub (A) is required. Conditions at the load are shown at (B), and the inductive current to be drawn by the stub is determined from (C). (D) is (C) reoriented to agree with previous vector positions. (E) represents the input to the stub from which stub length is determined

Lines With Loss

So far only lossless lines have been considered. Transmission line problems involving lines having loss are complicated when handled by formulas, but the use of vectors simplifies this type of problem.

Because a transmission line is linear, the percentage loss to the incident wave will equal the percentage loss to the reflected wave. If the input and output powers are known or can be measured, the line loss can be determined, and apportioned for any length line.

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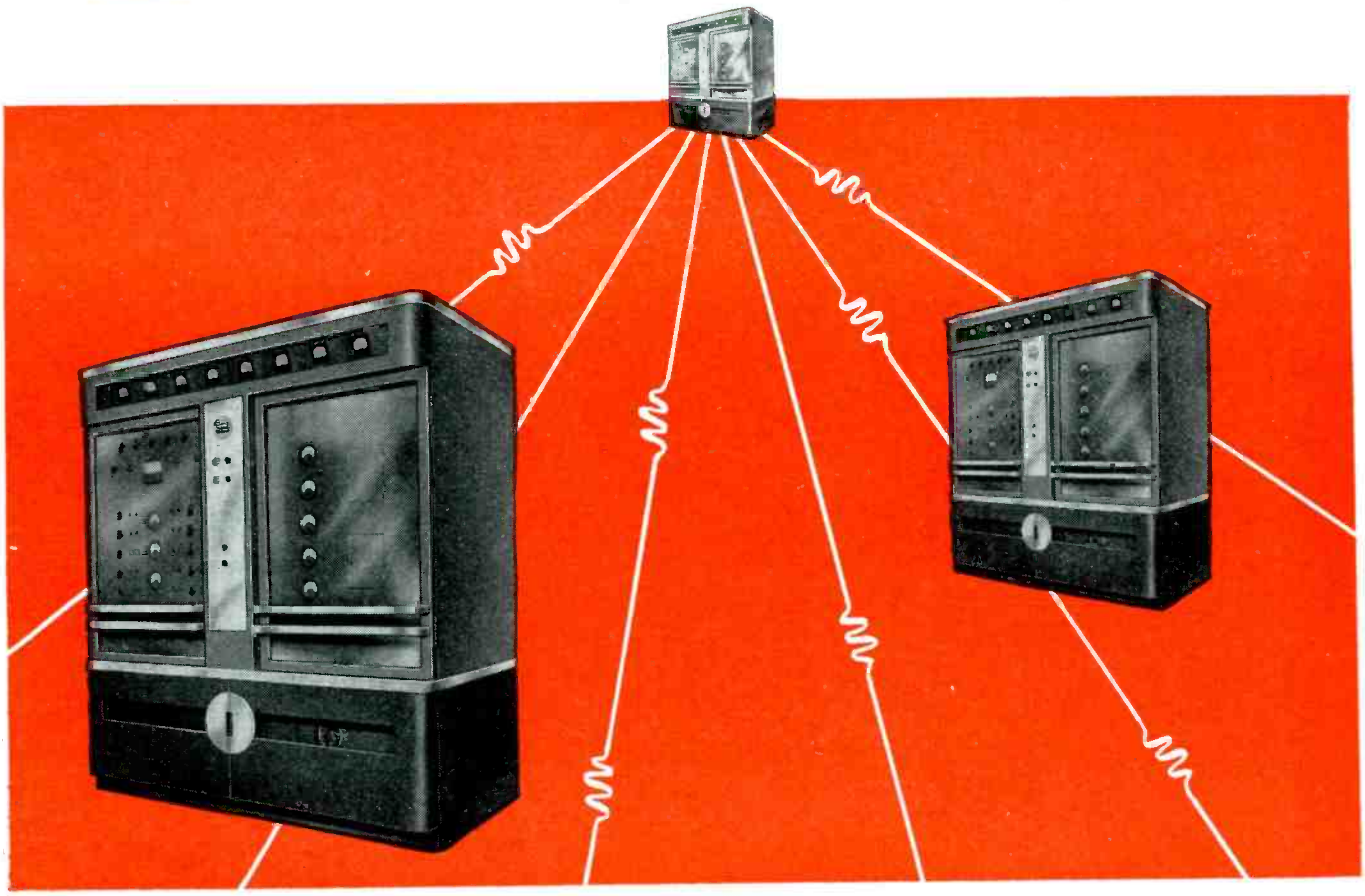

For many years, HARVEY OF CAMBRIDGE has built transmitters considered standards of quality and dependability. Yet, these new HAR-CAM FM Broadcast Transmitters that are about ready for release, will be far and away the finest ever to bear the HAR-CAM name.

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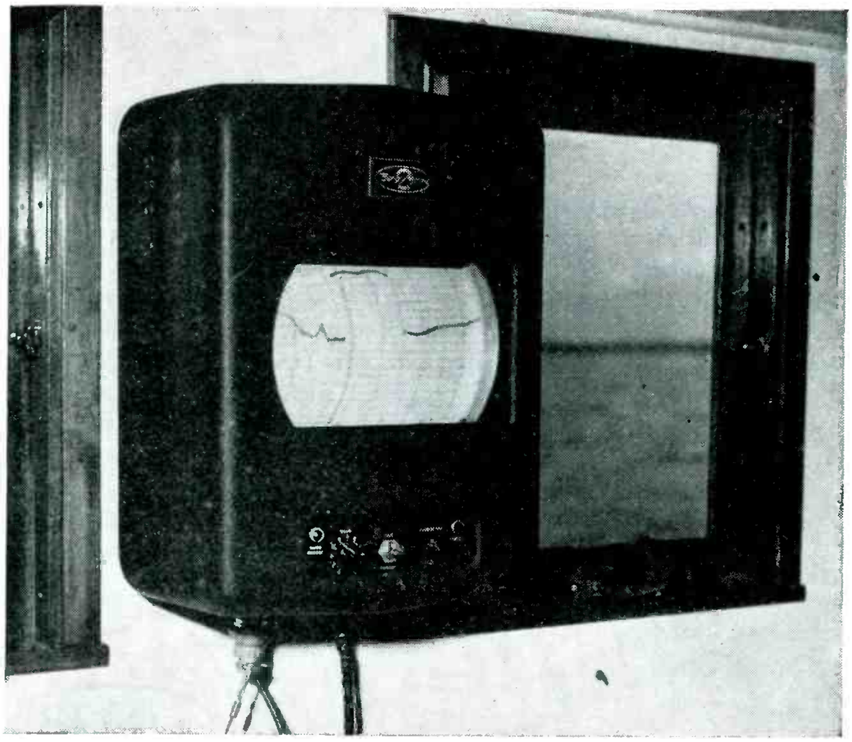
Electronic Depth Recorder

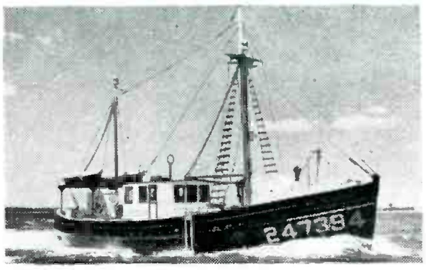
BENDIX-MARINE division of Bendix Aviation, Baltimore 4, Md., announces it will soon produce in volume a supersonic depth recorder for small boats and pleasure craft. The unit is designed to help make coastal navigation safer in fog and night and to locate fishing banks and schools of fish. Five vacuum tubes are utilized in the unit. Essentially there are two main units in the depth sounder; the recorder and the underwater transducer.

The cabinet of the recorder unit mounts compactly in a ruggedly built, splashproof aluminum case which measures 10 x 16 x 21¾ in. It houses the graphic recording mechanism, signal sender, echo amplifier, synchronous driving motor and power pack. Total weight is 90 lb. The underwater unit is a special crystal transducer which weighs 22 lb. and measures 7 in. in diameter. The same transmitter which projects supersonic signals downward from the ship's bottom, also acts as the echo receiver.



The recorder is shown mounted in the wheel house of a sea-going laboratory ship. Recordings made on Flushing Bay, N. Y. during a recent demonstration are shown here on the chart in the illustration. Lines at left and right show the depth of water in feet; the line at topcenter, the depth in fathoms. By changing the speed of the graphic recorder readings can be obtained either in feet or in fathoms

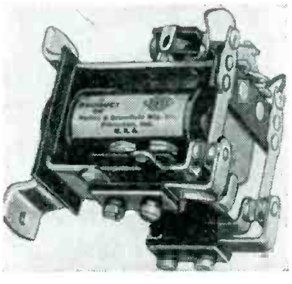
The device bounces a high-frequency signal off the bottom of the sea and draws a permanent and accurate picture of the ocean bottom. The design of the recorder minimizes maintenance costs. No special skill is required to maintain the unit.



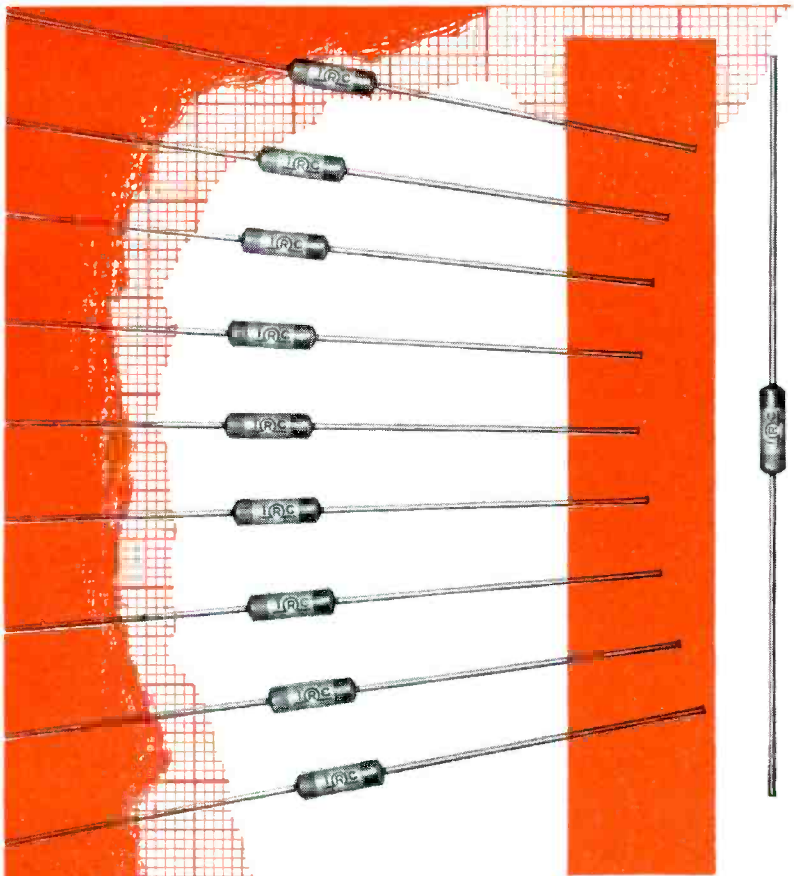
This view of the sea-going laboratory ship shows the outboard rigging (on the starboard side) which makes possible the use of the depth sounder developed as a completely portable unit

Plate Circuit Relay

STANDARD TYPE PLATE circuit relays (LMR Series) are available in both single and double pole contact arrangements. Single pole relays measure 2¼ x 2⅜ x 1⅜ in. Double pole types measure 2¼ x 2⅜ x 2⅛ in. Mounting dimensions are 2 tapped holes 6-32 thread, 1$\frac{3}{16}$-in. center to center. Relays are constructed with extra large coils to make them sensitive and to give good contact pressure at low current values. Standard adjustment is approximately



0.1 w for sp types, and 0.2 w for the dp types, with lower values available if necessary. Unless specified, contacts are of $\frac{3}{16}$-in. fine silver. Coils are available in all resistances up to 10,000 ohms. Contact arrangements available include spdt; spst normally open; spst, normally closed; dpdt dpst, normally open; and dpst, normally closed. Potter & Brumfield Mfg. Co., Inc., 214 Linden Ave., Princeton, Ind.



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Here's a brand new IRC resistor that until a few weeks ago was very "hush-hush" except to a few selected laboratories and prime contractors engaged in development and manufacture of VT proximity fuzes. Production on this small, efficient unit, in the last several months before V-J day, mounted to amazing figures to keep pace with the advancing victory tempo. Now this same high quality resistor is available in quantity to help solve many a "small space" resistance problem for you. Rated a full quarter watt, small 'round as a match stick and but 13/32" in length, this sturdy insulated wire wound can be depended upon for "Preferred Performance." For technical data refer to IRC Engineering Bulletin No.3, available on request from *Dept. 1-L.*

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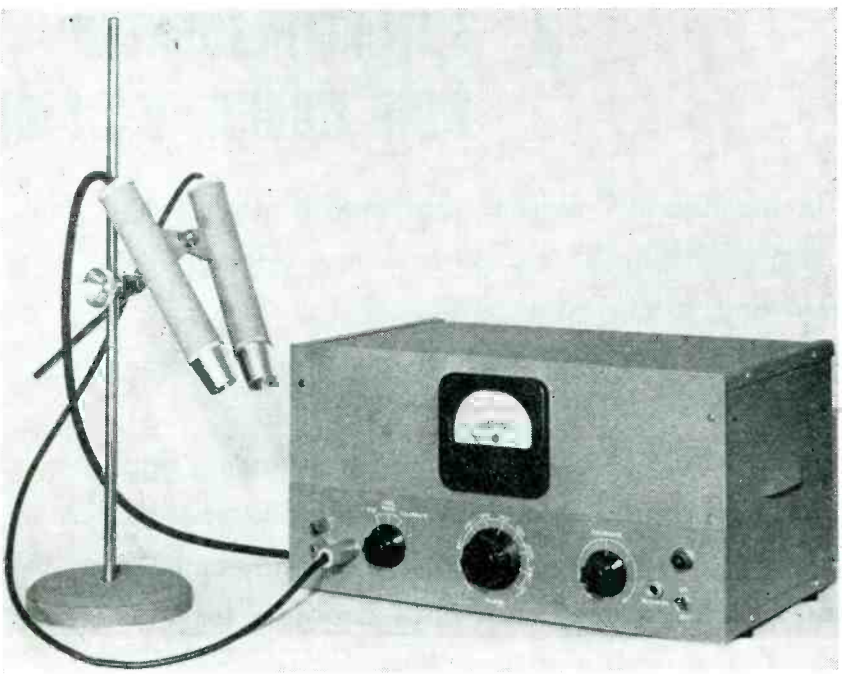
Electronic Tachometers

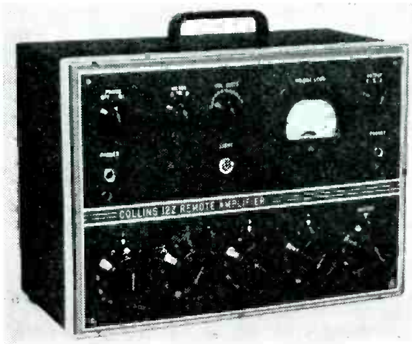
NEWEST ADDITIONS to Hewlett-Packard Company's (Palo Alto, Calif.) group of laboratory and production testing instruments are hp models 505A and 505B electronic tachometers. The tachometer (consisting of a photocell and light source hookup) used in conjunction with an electronic frequency meter, is used to measure the speeds of moving parts over a range from about 300 rpm (5 rps) to 3,000,000 rpm (50 rps). The unit is capable of measuring very high speeds of rotating parts which have small energy, or which cannot be mechanically connected to any measuring device. Danger of making multiple or fractional errors are eliminated, and an instantaneous record of the continuous speed is provided. A recorder connected to the output of the instrument makes a permanent record of these readings. Speeds below 300 rpm can be measured with the unit by means of slight additional preparation of the shaft or surface to be measured. Model 505A is calibrated in rpm; model 505B in rps. Some suggested applications include measurements of small, high speed motors, ultracentrifuges, or the electronic frequency meter can be used alone to measure the frequency of alternating current at frequencies as high as 50 kc. A technical data sheet is available from the manufacturer.



Collins Radio Products

COLLINS RADIO CO., Cedar Rapids, Iowa, announces:

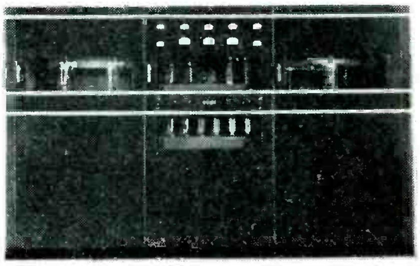
A new 4-channel high fidelity remote amplifier (type 12-Z) which embodies circuit refinements and component improvements. The unit weighs less than 35 lb, is easily and quickly placed in operation, and has self-contained power supplies, both a-c and d-c, the latter in the form of batteries. Front-access attenuators, provide easy maintenance. A master control is provided in addition to the individual control for each channel. A meter calibrated in v-u indicates the volume level, and also is used to measure operating voltages. Monitoring facilities are also included. Input impedance is 30/50 ohms. Output is 50 mw at less than 1 percent distortion into a 600-ohm load. The frequency response is 30-12,000 cps, ±1.0 db. Overall gain is approximately 95 db.



Type 12-Y remote amplifier is a lightweight, single channel, high

fidelity amplifier suitable for dance orchestra and newsroom pickup, sports broadcasts, and any other application where fast set-up is important. It weighs 7 lb in its carrying case, has three stages of amplification for a maximum gain of 84 db, a universal input, and 600-ohms output. The unit operates from 110 v, ac, 60 cps. Power supply is self-contained.

Type 21-A a-m broadcast transmitter for the 540-1600-kc range



has an audio frequency response curve flat from 30-10,000 cps, ± 1.5 db. Noise level is more than 60 db below 100 percent modulation. Distortion is less than 3 percent rms. The carrier frequency is maintained constant to within ± 10 cps. The transmitter carries full FCC approval for 5000 and 1000 w high-fidelity broadcast operation. Power output of 1 kw can be obtained instantaneously by operating a switch which controls plate voltages.

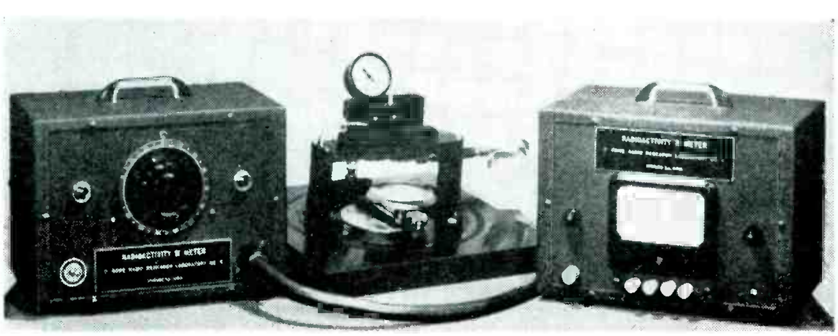
Type 300-G a-m broadcast transmitter utilizes high level class B modulation. It is rated 250/100 w.

The frequency response is flat from 30 to 10,000 cps, with a maximum derivation of ±1.0 db. Two separate temperature-controlled oscillator units are standard equipment, either of which will maintain the carrier frequency to within ± 10 cps. Power output can be reduced from 250 watts to 100 watts by a switch on the control panel. All circuits are properly metered.

Radioactivity Meter

TYPE R-M-82 R METER is a sensitive electronic device for measuring, directly, very weak radiations from small quantities of radioactive materials. It will indicate values from 0.000001 to 20.0 R units. The meter is calibrated directly in fractions of R units on a linear scale of a 4-in. meter. It has five R ranges which are quickly selected by pushbuttons. Full scales on these ranges at maximum voltage are: 0.0001, 0.001, 0.01, 0.1 and 1.0 units. By using minimum voltage the least sensitive range can be extended to 20 R units for full scale. The meter proper is an electronic device which measures currents as low as 0.001 ma. A high-voltage power supply with adjustable output from 100 to 2000-v d-c is part of the apparatus. Safety switches are provided so that there is no possibility of the operator being exposed to the high voltages. High sensitivity of the unit does not affect its stability. Especially trained personnel is not required to operate the instrument. Various types of units are employed for holding the chemicals to be measured. The illustration shows one of several arrangements. In this case the material holder and electrodes are enclosed in a bell jar for evacuation. The unit operates from 115-v, a-c, 60 cps. It is housed in two steel cases, each measuring approximately 11 x 8 x 8 in.

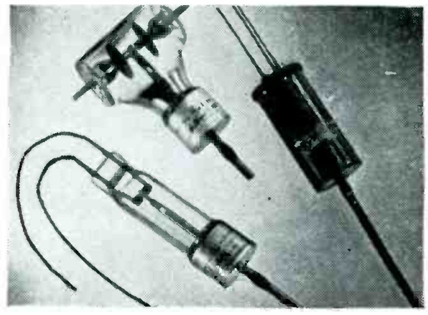
Rowe Radio Research Laboratory Co., 2422 N. Pulaski Rd., Chicago 39, Ill.



Vacuum Switches, Capacitors

THREE GENERAL ELECTRIC (Electronics Dept., Schenectady, N. Y.) vacuum switches are available for such applications as limit switches, thermostatic controls, radio antenna switching, inertia-controlled devices, stratospheric applications or radio transmitter tank-coil assembly switching. Features of these switches include extreme flexibility (either slow operation or thousands of contacts per minute); low resistance contact; immunity to oil, water, and dust; non-inductive switch-control circuit; elimination of separate low-voltage control circuits; low contact pressure; small operating force; and long contact life. They are noiseless and vibrationless, mount in any position, require little space and no maintenance, reduce fire and explosion hazards, and easy to install and handle.

Type GL-1S21 is designed for high-frequency and high-altitude applications. It's circuit is a spdt type; maximum hold-off voltage across stationary contacts is rated approximately 7500 rms; maximum continuous current rms, 20 amp. The interrupting rating, resistive load for total life of 1000 operations at 7500 volts a-c rms is rated 15 amp a-c rms; 1,000,000 operations at 7500 volts a-c rms is 3 amp a-c rms total life of 500,000,000 operations at 7500 volts a-c rms is rated 0.1 amp a-c rms. The other type switches include types FA-6 and FA-15 which utilize spdt type circuits. Type FA-15 has a maximum voltage, a-c, of 3000 rms and a maximum continuous current, rms of 15



amp. Type FA-6 has a maximum voltage, a-c of 550 rms and a maximum continuous current, rms of 10 amp. Bulletin No. EXT-1 describes these units.

G-E vacuum capacitors have been designed for circuits where the peak voltages range from 7500 to 16,000 volts. They are for use as plate-tank and by-pass capacitors in diathermy equipment, and in other r-f oscillators or amplifiers. They can also be used as neutralizing capacitors in r-f amplifiers in conjunction with small, low-capacitance padding capacitors. Types GL-1L32, 1L21, 1L36, 1L38 and 1L33 are the 7500-v types with ratings of 6, 12, 25, 50 and 100 $\mu\mu$f capacitance respectively. Types GL-1L31, 1L25, 1L22, 1L23 and 1L24 are the 16,000-v types with ratings of 6, 12, 25, 50 and 100 $\mu\mu$f capacitance respectively. Bulletin No. ETX-2 describes them in more detail.

Federal Products

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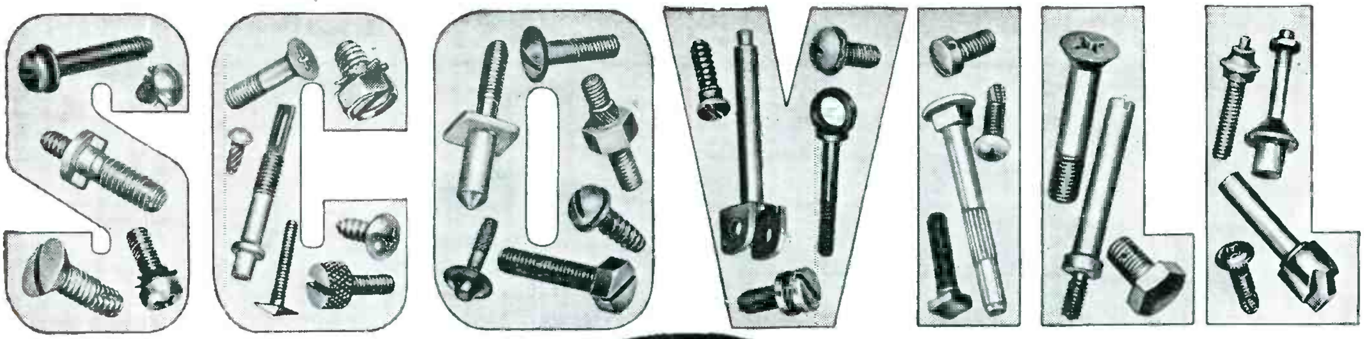

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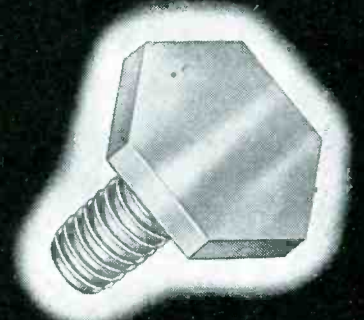

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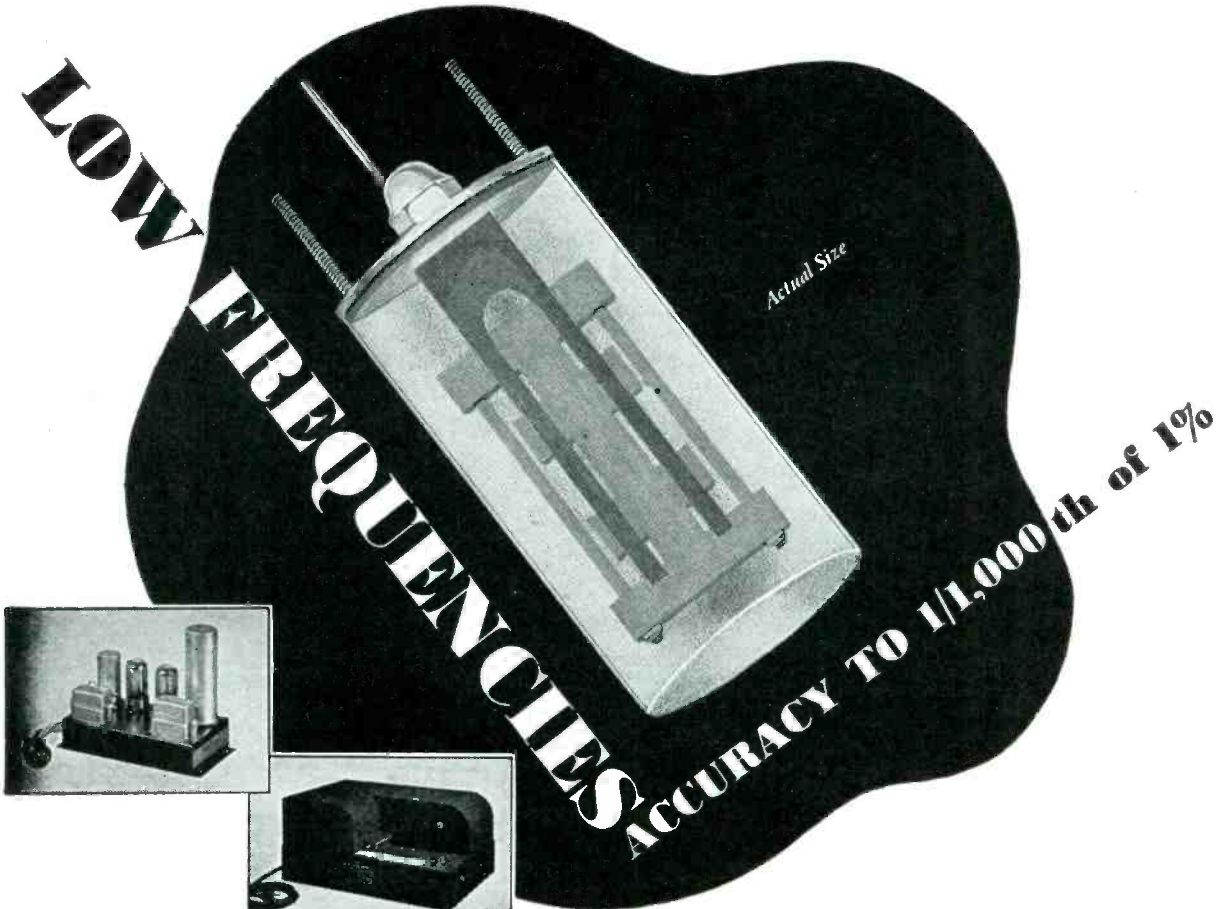

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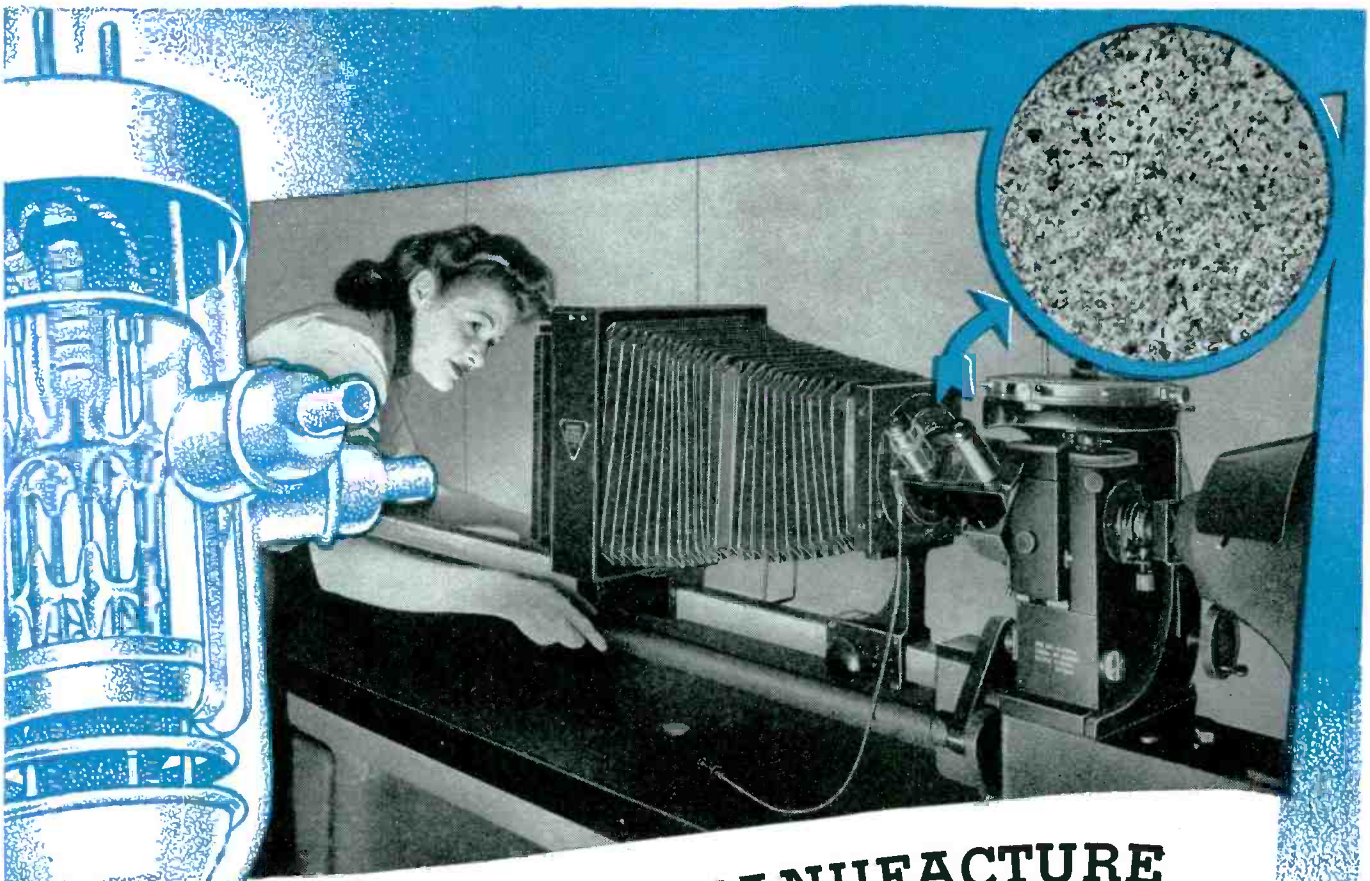

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From slender filament to anode block . . . *all* tube construction details, however small, are important to Federal. That is why this experienced and longtime manufacturer uses the illustrated high-magnification metallograph as part of its test equipment for checking raw material quality.

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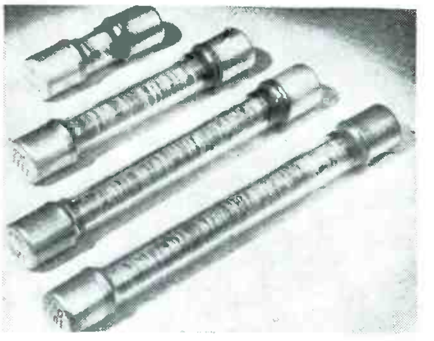
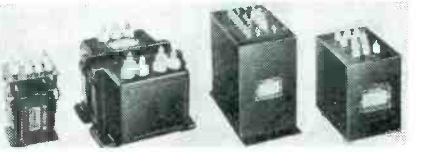
Radio Corp., 67 Broad St., New York 4, N. Y. Stacks are easily and quickly installed. Electrical connection is made through heavy silver-plated ferrules at each end of the glass tube. The size of these ferrules permits mounting in 30-amp fuse clips unpolarized or polarized by addition of a simple member to the fuse clip assembly. Units are

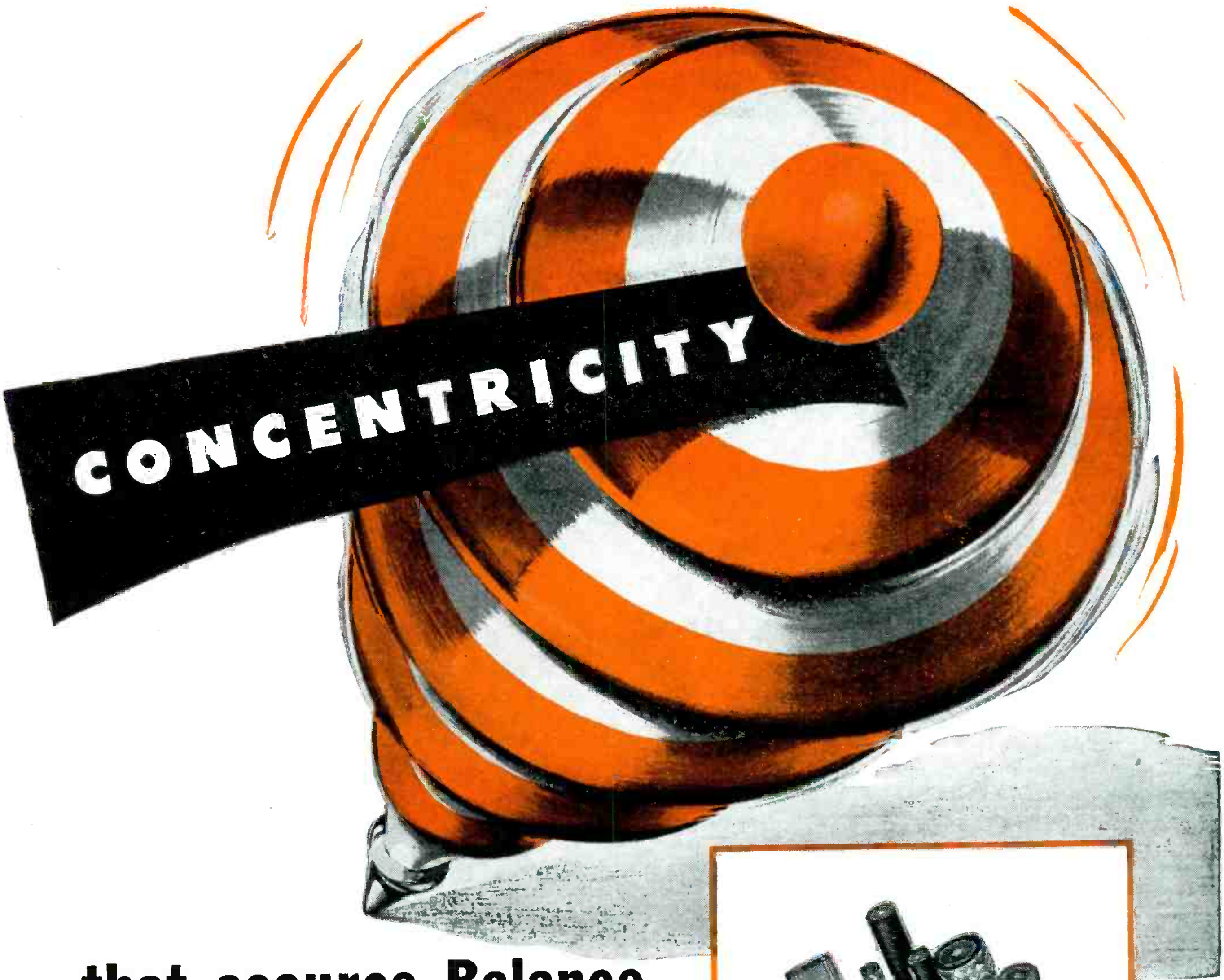


light-weight, have long-life, and provide silent, trouble-free operation. The rectifiers can be used for application with cathrode-ray tubes in television, or as high-voltage, low-current rectifiers for a wide range of uses in other electronic devices.

Other Federal products include a comprehensive line of iron core magnetic components, custom-built to meet specific requirements and incorporating design innovations. Available with power ratings ranging from milliwatts to kilowatts, components can be provided in any



of the basic types of construction—open, frame, semi-enclosed, and hermetically sealed. Various terminal types can be supplied, including standard nut-fasteners and solder-type binding posts with porcelain bases. Hermetically sealed units utilize either compression bushings on porcelain bases, or glass-to-metal fusion seals in one piece covers. This type of seal withstands successive immersion in ice-water after hot tin dip. Applications of the components include plate and filament supplies, audio-frequency and modulation transformers, power transformers and reactors.



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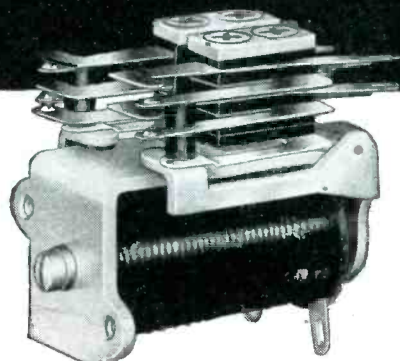


The Small Relays with the Big Performance

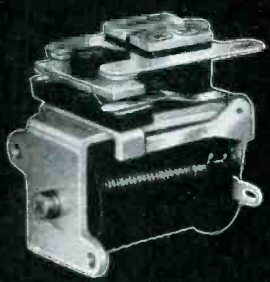
• Engineered and manufactured for the necessities of military aircraft operation, Cook "Aerotrols" have opened new fields in electrical and electronic remote control applications in radio-radar, wire communications, mining, manufacturing, testing and innumerable other fields where greater dependability and accuracy must be provided.

• Here are some of the general specifications of the "Aerotrol" "400" Series relays. The size of the "Aerotrol" without springs (the frame, coil and armature) is 15/16″ wide, 1 7/16″ long and 1″ high. Spring assemblies add to overall height, up to 1″ for 6 springs. Average weight for two spring pile-ups is 1¾ oz. The coil spool is one piece, moulded bakelite. Heel piece is arranged for two mounting screws with solder terminal for coil located at the armature end, at which end also, spring solder terminals are located. Coil winding capacity can be provided up to 10,000 ohms and for positive operation on current values as low as 2 milliamperes. Coil treatment normally includes impregnation with fungus lacquer and Insulex covering, and where required, the coil is treated for high humidity and other tropical conditions.

• "Aerotrols" are small, compact, yet rigidly constructed relays that have proven their dependability, not only in laboratory tests, but in actual operation under the most severe wartime conditions all over the world.

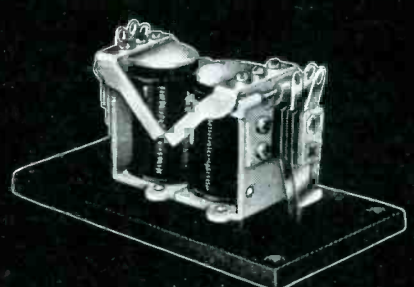
• "Aerotrols" are "application engineered" to provide specific performance suitable to circuit and control conditions. There are many selective features that can be incorporated into these relays. Bushings and insulators can be provided made of Cook patented "Cecotite" ceramics, to provide freedom from carbonization and wear, and to provide permanent stability of original adjustment and rapid frequency of operation. Mounting arrangements can be provided to meet installation conditions, including the plug-in types.

• "Aerotrols" of various types, such as time delay, latching, A.C. or D.C., both single and double pile-ups, can be supplied.



Illustrated above is an "Aerotrol" heavy current relay, with two Form "A" contacts operating on a double armature.

SEND FOR BOOKLET AR-145 FOR INFORMATION ON THE COMPLETE LINE OF "AEROTROL" RELAYS.



Illustrated above is a latching type "Aerotrol" combining two type "401" "Aerotrols." Any combination of the "400" series relays can be combined into a latching "Aerotrol."

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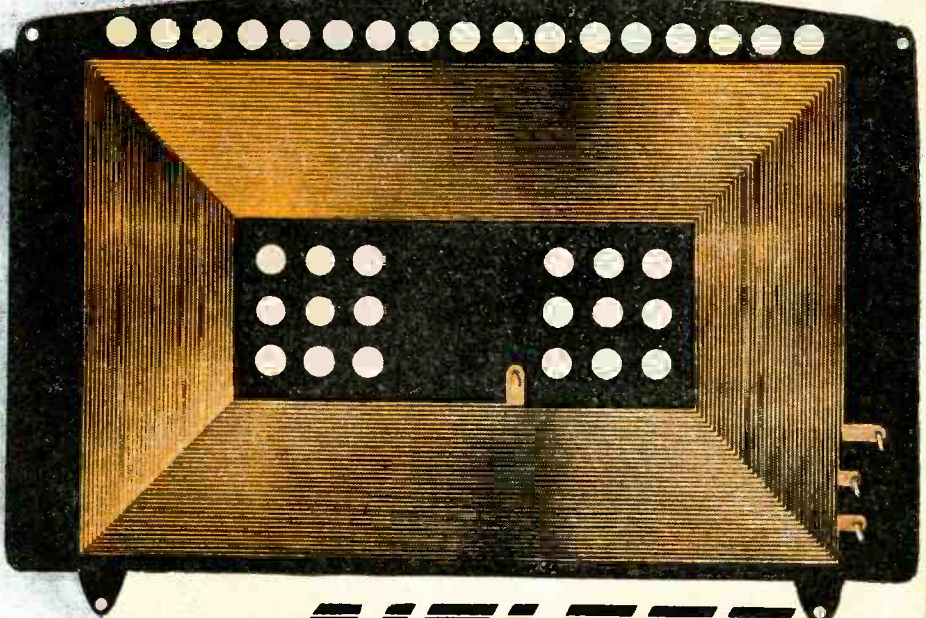

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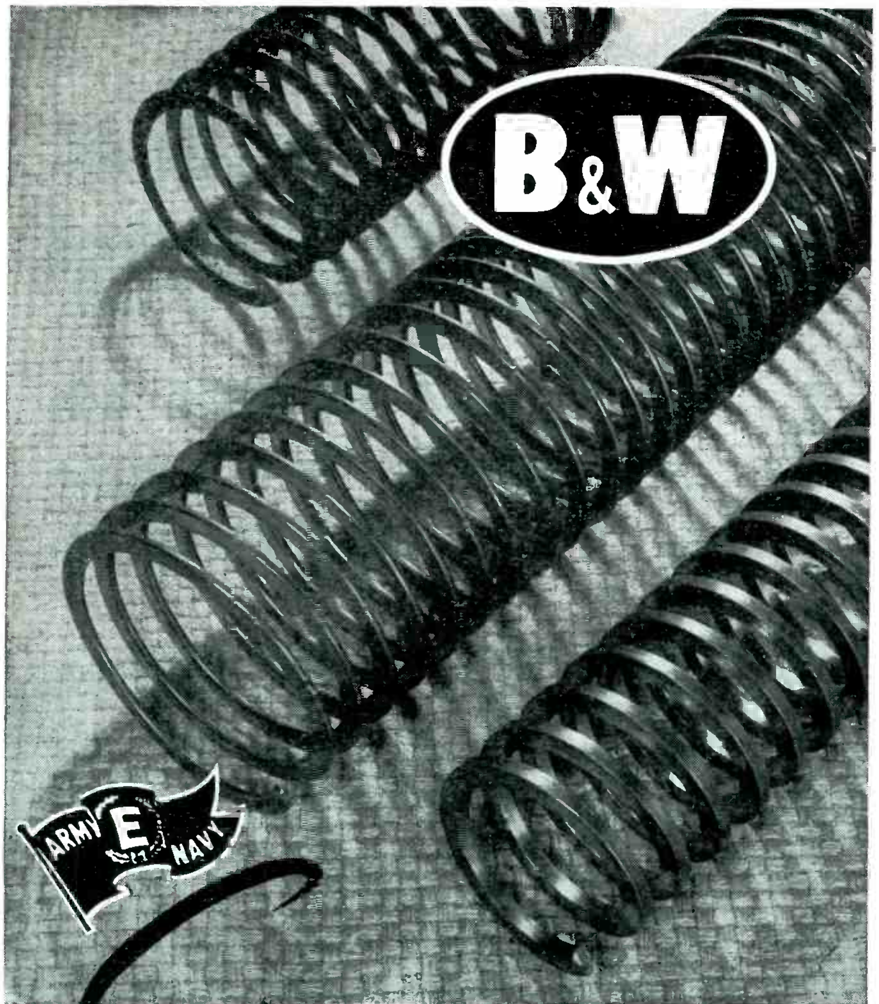
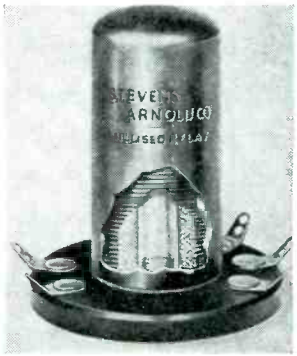


Ultrahigh-Speed Relay

THE NEW STEVENS-ARNOLD Company (22 Elkins St., South Boston, Mass.) Millisec relay is a hermetically sealed sensitive relay capable of speeds up to 1,000 operations per second. The basic design of the moving elements makes the ultrahigh speed possible and assures reliability if operated in the usual



speed ranges. A glass envelope surrounds all moving parts and protects them from moisture, dust or corrosive fumes. Sensitivities down to ½ mw are possible. Ratings up to 5 amp can be obtained. Closing time can be less than 1 millisecond. Outside dimensions of relays rated at 115-v, a-c, 1-amp, are 3 in. high and 1½ in. base diameter.

Frequency Meters

VIBRATING REED frequency meters manufactured by Aero Instrument Co., 3907 San Fernando Road, Glendale 4, Calif., are direct reading frequency indicators for use on lines where the successful operation of a-c equipment depends upon maintenance of known or constant frequency. They are self-contained, requiring no auxiliary apparatus. They consist of a number of steel reeds, of high Q, each of which is tuned to a single frequency within the band covered by the instrument. Indication is by the visual pattern formed by the vibration of the reed in resonance with the line frequency. Excitation is electro-magnetic, and the reeds are the only moving elements. Frequency ranges are available from 10 cps to 500 cps in increments of half or full cycles. Meters of one cycle increment ranges can be read accurately to 0.5 cycle and meters of one-half cycle increment ranges can be read

Molding Plastics with Metal Inserts?

Electronic Preheating Can Help You

Users of this completely automatic RCA electronic preheater report production increases in usable molded parts of 50% to 500%! Cost reductions may pay for the equipment in a matter of months.

Wide experience of plastics molders shows electronic heat reduces rejects, simplifies molding, increases output 50%

If you are combining metal and plastics — if you are molding plastics parts with metal inserts—you'll find that electronic preheating can be of considerable help. Speedy electronic preheating provides almost amazing plasticity... allows you to mold at low pressure.

Because molding pressures are low, the danger of forcing inserts out of line is greatly reduced. Furthermore, the possibilities for mold damage are practically eliminated. Along with these important advantages, electronic preheating makes for a generally improved product and considerably increased production rate.

If you are a molder, RCA engineers will gladly advise you on the proper equipment and procedures to use in obtaining improved results with electronic preheating. You will find greatly increased production, and lowered over-all costs. Records kept by molders using electronic preheating show production increases of usable parts as high as 500%, and cost reductions of at least 50% — all costs included. Send the coupon below for details.

If you are a plastics buyer and do not do your own molding, ask the custom molder who serves you about electronic preheating. He may be able to solve a problem for you by the use of electronic preheating. A recent survey conducted for RCA among plastics molders shows that an overwhelming majority of those questioned prefer electronic preheating as the Number One method of preheating because it gives a better molded product at higher production rates.

RCA Electronic Heating Equipment specially designed for the plastics industry offers a combination of advantages obtainable from no other manufacturer. The pace-setting RCA 2000-watt unit (Model 2B) has set the design standard for the industry. Completely automatic, it can turn out a pound of uniformly heated preformed material at 275°F in only *40 seconds*—25% to 50% faster than non-automatic units. Operating cost (including tubes, power, maintenance, and depreciation) is as low as 20 cents per hour! Send coupon for free bulletin. Write details of your plastics-molding problem to RCA application engineers. Address: *Radio Corporation of America, Electronic Apparatus Section, Box* 70-204H *Camden, N. J.*

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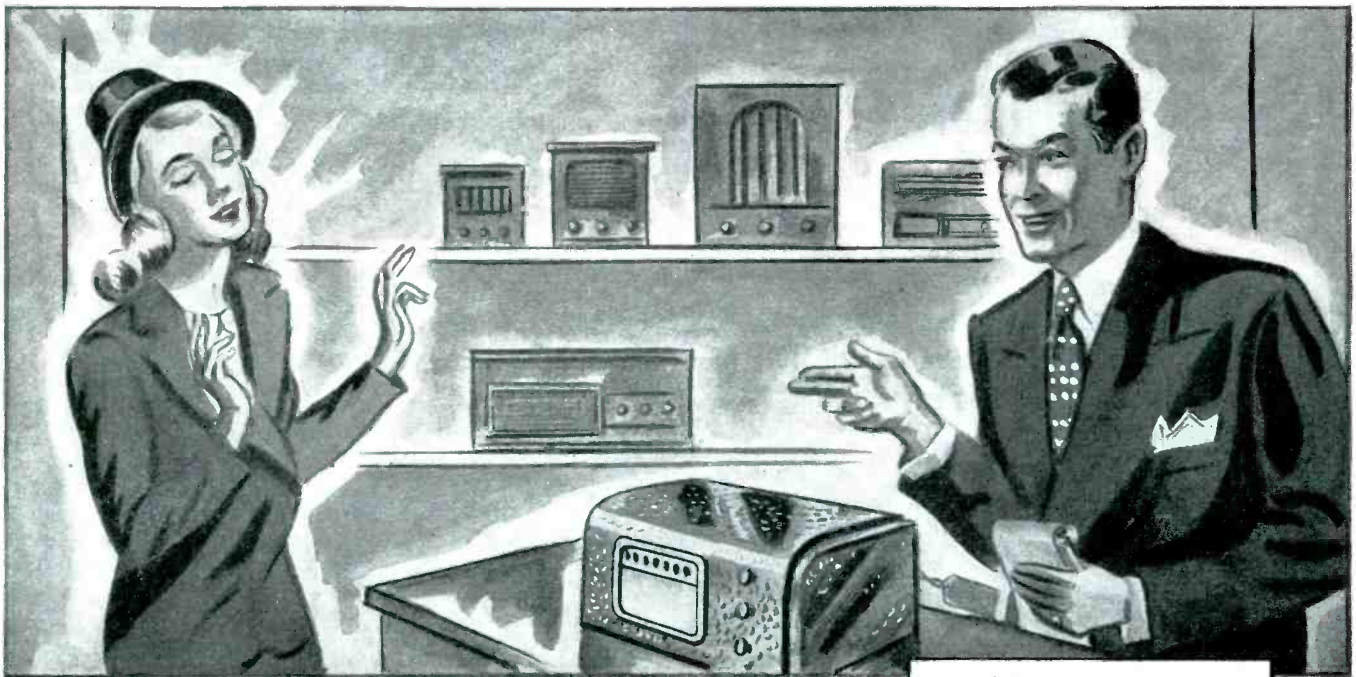

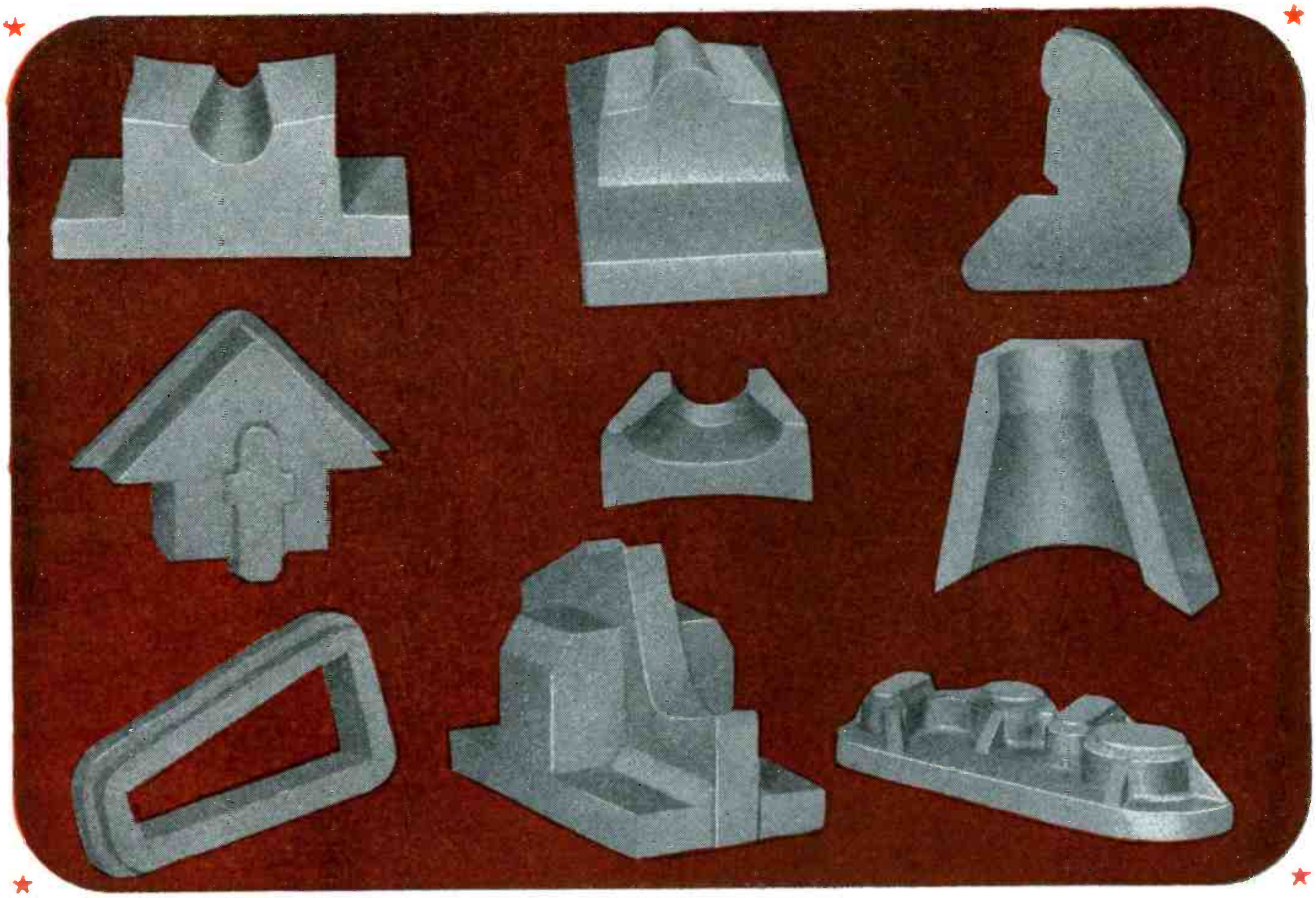

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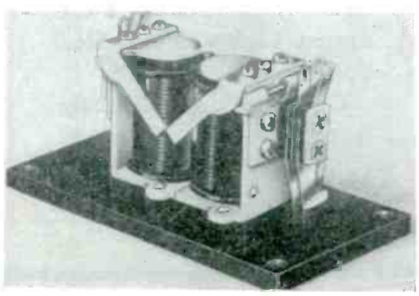
to 0.1 cycle by comparing the relative amplitudes of the reeds. The following standard models are available out of stock and for early production in large quantities: Model 7004, range 59 to 63 cps; model 7007, range 57 to 63 cps; model 7005, range 48 to 52 cps; model 7006, range 58 to 62 cps; model 7009, range 47 to 54 cps; model 7002, range 48 to 52 and 58 to 62 cps; model 4009, range 380 to 420 cps.

Another instrument produced by Aero is Model No. 1001 running-time meter which is also direct reading for use on a-c lines. It is for use in applications where the successful operation of equipment depends upon the regular servicing of such equipment based on actual lapsed time. This meter automatically and cumulatively registers the total operating (or idle) time of any equivalent, machine, circuit or system to which it is connected. It has a range from 0 to 9999.9 hours, and resets automatically at 10,000 hours.

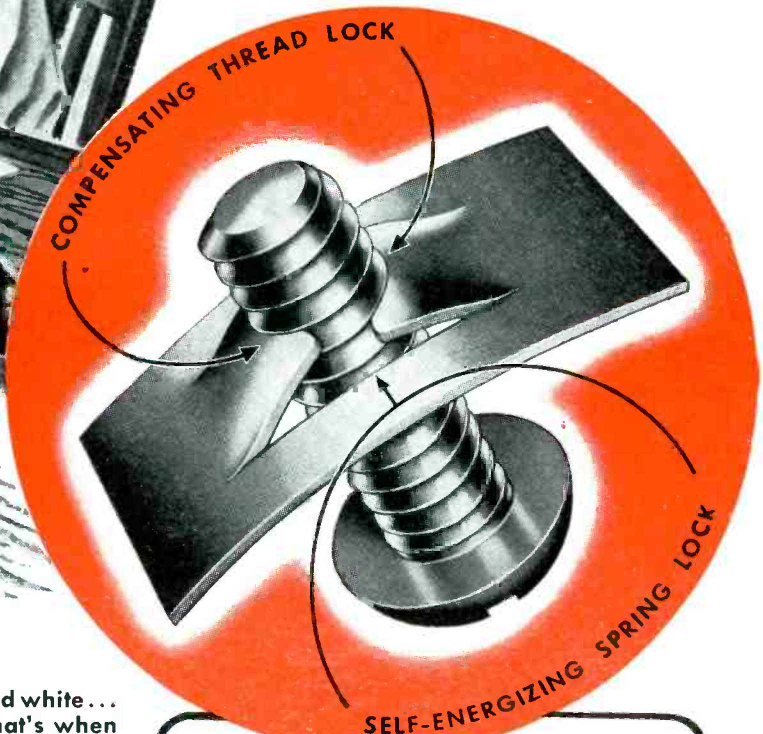
Small Latching Relay

THESE NEW, SMALL latching relays are called "Latching Aerotrols" and are made by combining two of the manufacturer's standard line of Aerotrol 400 Series relays, with an interlocking armature. This design makes it possible to combine any two Aerotrols of similar or different types into a latching relay. They can be supplied in either single or double pile-ups and with all standard spring pile-up formations and combinations. Mounting arrangements are designed to specification. Units are available for either a-c or d-c operation with maximum voltage of 125-v d-c, or 120-v 60 cycle a-c. Dimensions are $1\frac{9}{16} \times 2\frac{7}{8} \times \frac{15}{16}$ in. Magnetronic Div. of Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.



WHY SPEED NUTS ARE FIRST

with Time Study and Cost Departments



When ALL assembly costs are down in black and white . . . when TOTAL net assembly costs are figured . . . that's when SPEED NUTS really show results in the Cost Department.

For SPEED NUTS reduce assembly costs in many ways. They completely eliminate lock washers—saving the cost of the washers *and* the time necessary to handle and install them. Moreover, hundreds of SPEED NUTS have been designed to perform multiple functions and eliminate two or more assembly parts.

SPEED NUTS are applied faster and easier to speed up assembly. They can't "clog" with paint or enamel to delay the assembly line. "Self-retaining" types of SPEED NUTS do away with expensive welding and clinching operations. And SPEED NUT spring-tension resiliency also protects porcelain, plastic or glass parts against damage in transit.

A letter describing your fastening problem will bring you full details on how SPEED NUTS will reduce YOUR total net assembly costs, too.

NOTHING LOCKS LIKE A SPEED NUT

Only SPEED NUTS provide a COMPENSATING thread lock and a SELF-ENERGIZING spring lock. As the screw is tightened the two arched prongs move inward to lock against the root of the screw thread. These free-acting prongs COMPENSATE for tolerance variations. Compression of the arch in prongs and base creates a SELF-ENERGIZING spring lock. These two forces combine to definitely prevent vibration loosening.

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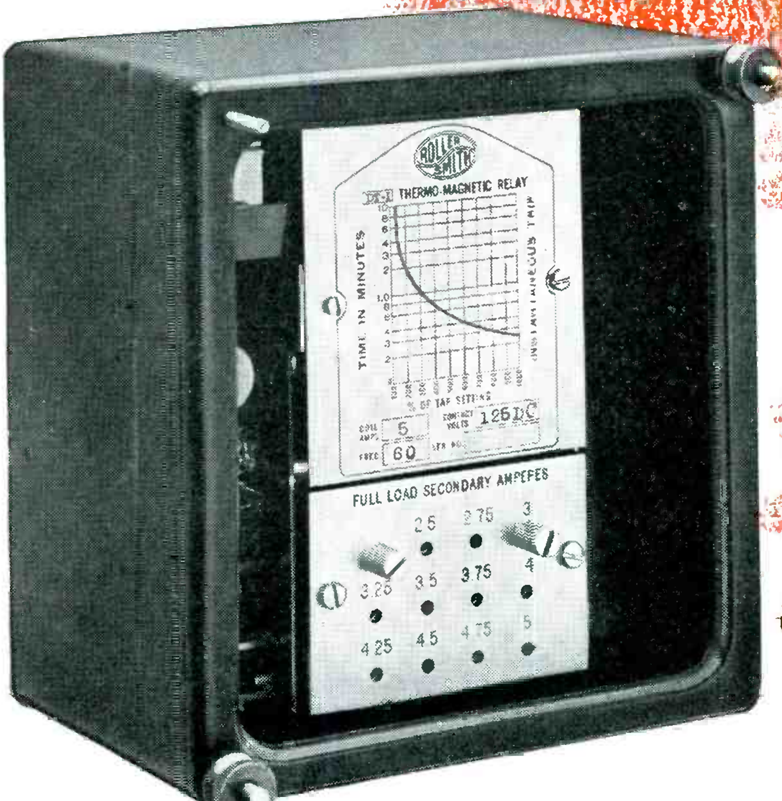


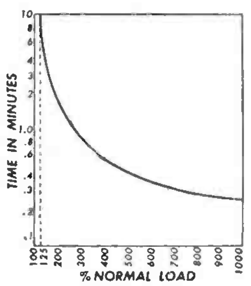
Time Delay
Thermal Overload Protection

Instantaneous Trip
Overcurrent Protection

DT-1—THERMO-MAGNETIC RELAY

HERE IS HOW IT WORKS—

Above 10 times normal current the magnetic trip operates. From 10 times down to 1.25 the circuit opens after the indicated time delay. ➡



● If you want to avoid expensive breakdowns of equipment due to unsafe overloads, you need the dual protection of the Roller-Smith type DT-1 Thermo-Magnetic Relay.

You get protection from dangerous overloads by means of a bimetal relay that opens the circuit before the winding temperature of the protected equipment becomes dangerous. There is a time delay before the relay opens which runs around 10 minutes at 125% rated load and 15 seconds at 1000% rated load. The magnetic trip operates instantly for currents in excess of 10 times rated load, the control circuit opens and the equipment comes off the line. For detailed information on the application and operation of the DT-1 overload relay, write for Catalog 6240 to Department E-6.

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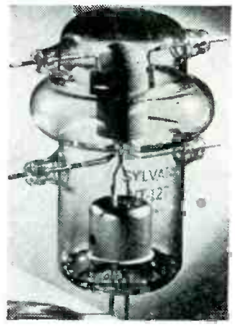
Radar Tube

GRAPHITE ANODES replace tantalum in these air-cooled radar transmitting tubes (type VT-127-A) to increase their life approximately thirty times over earlier types. The tube is called Marathon because specifications of the armed forces called for a minimum life of 500 hours in radar service and life tests in the field showed that the tubes were going strong at 5000 hours. Continuing field tests showed no signs of failure at the end of 10,000 hours. Sylvania Electric Products, Inc., Emporium, Pa.



Wire-Wound Resistors

ACCURATE FIXED wire-wound resistors, designated as type 188 Akra-Ohm, are small, close-tolerance units rated at 1 w with maximum resistance of 1 meg and having axial leads for convenient mounting by the leads on standard terminal strips. Units measure $1\frac{3}{16}$ x $\frac{3}{8}$ in. The 3-in. axial leads of No. 20 tinned copper wire permit use of the resistor either in original equipment or as replacements in circuits where carbon resistors are not sufficiently accurate or stable. Standard tolerance is $\pm$ 1 percent, although higher accuracy up to $\pm$ 0.1 percent is available on special order. These units supplement the manufacturer's previous axial lead, type 181-A rated at 0.3 w and having a maximum resistance of 150,000 ohms. Shallcross Mfg. Co., Jackson & Pusey Ave., Collingdale, Pa.

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MR-71B RECEIVER

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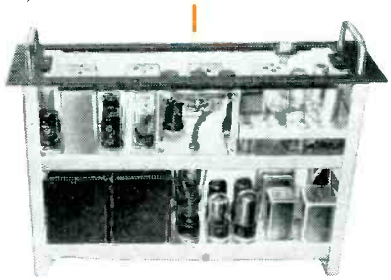
—incorporates positive squelch operation, rapid amplified AVC, and effective noise limiter.

—engineered so that all adjustments are available from front panel without removing unit from its rack.

For full information as to dimensions, weight, construction, electrical characteristics and service features, write the Sales Department, Bendix Radio Division, Baltimore 4, Maryland.



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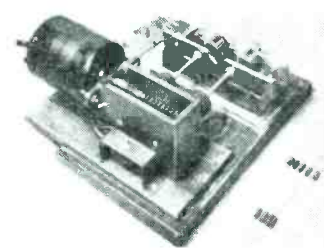
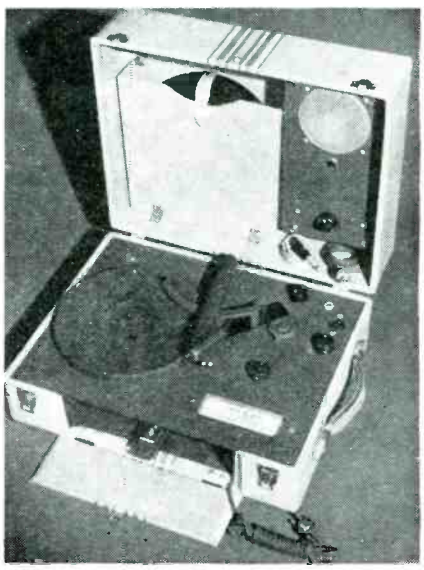
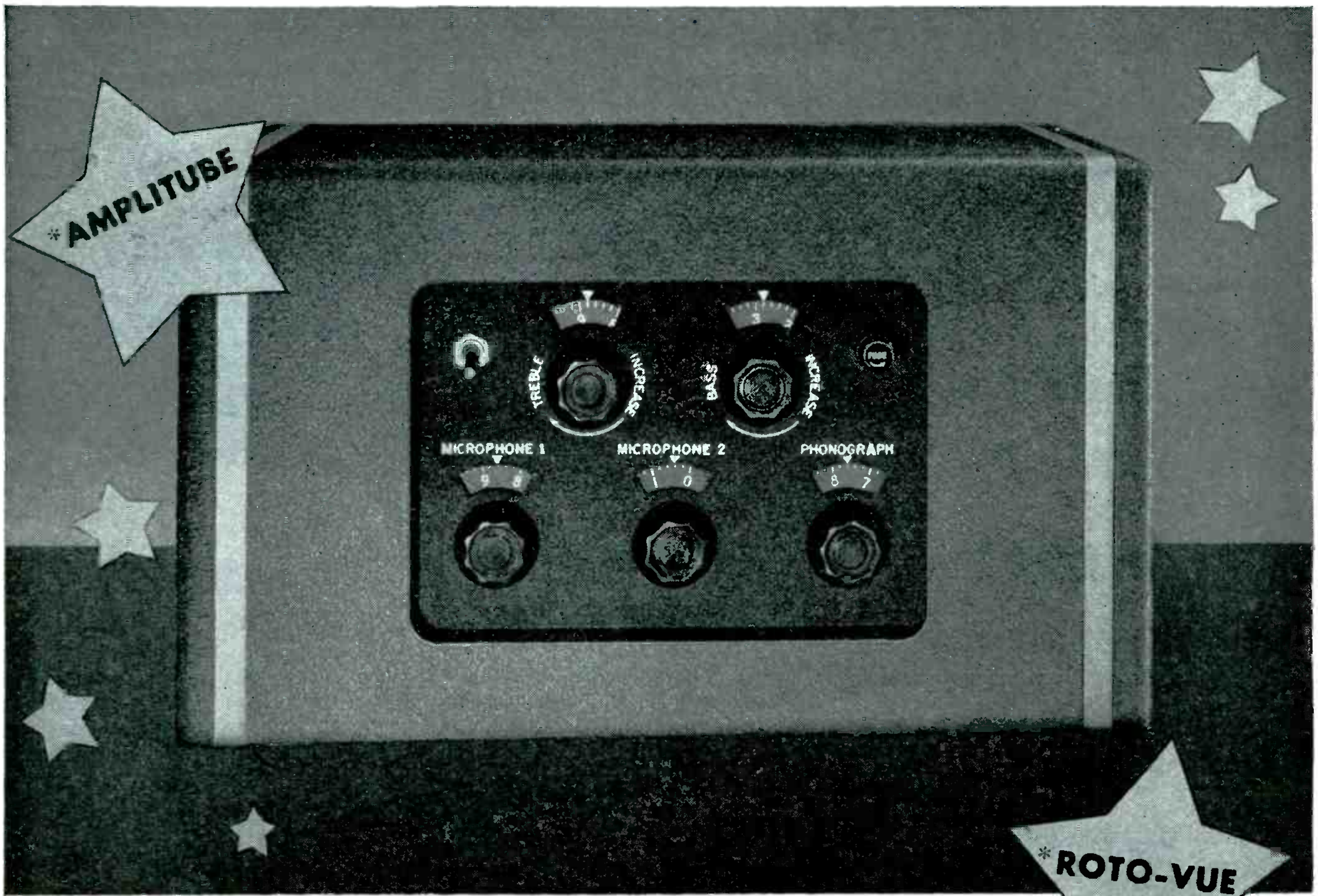


scrapers. An operator merely places a coil between two revolving drums and allows it several revolutions. A squeegee action created by the two revolving drums forces varnish between the coil turns. Coils are then ready for baking. Clippard Instrument Laboratory, Cincinnati, Ohio.

Spotting and Repeating Record Player

FAIRCHILD CAMERA & Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y., announces its first postwar classroom teaching accessories, in the form of a simple, low-cost combination word-spotter record-player designated the Language Master, for schools, colleges, and other training centers. The unit is basically a record player with a device that permits accurately spotting and repeating any desired passages on a record for analysis. For





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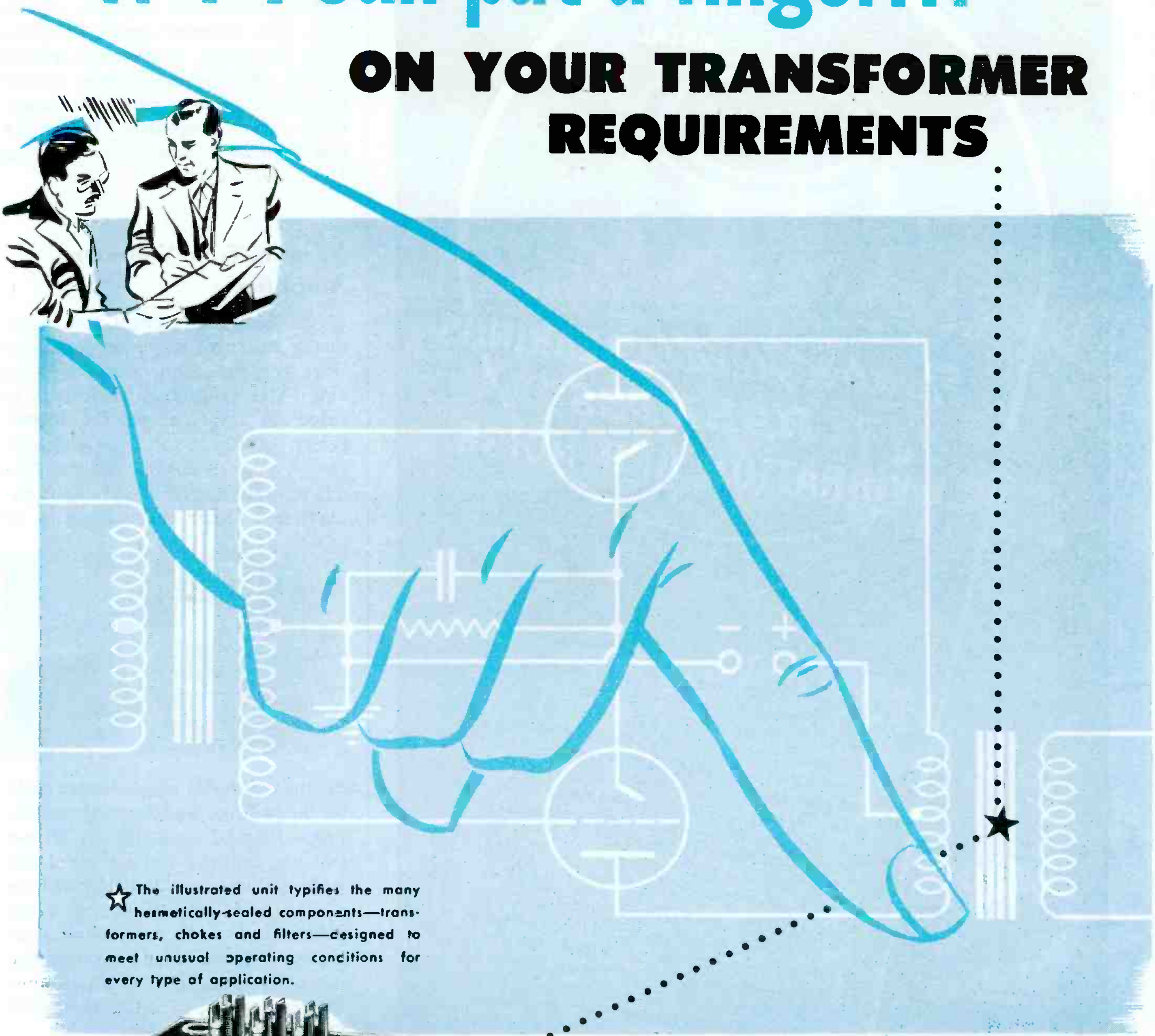
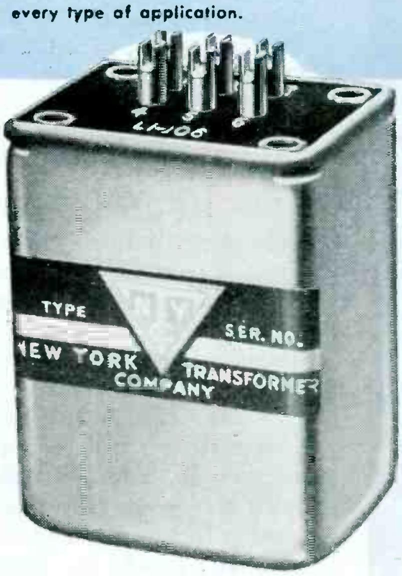


☆ The illustrated unit typifies the many hermetically-sealed components—transformers, chokes and filters—designed to meet unusual operating conditions for every type of application.



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The N-Y-T Sample Department has demonstrated its ability to continuously supply advanced transformer, choke and filter designs for most electrical and electronic needs. In every instance, all requirements are fulfilled efficiently, and economically.

Let us take care of any samples you may need for new equipment being designed.

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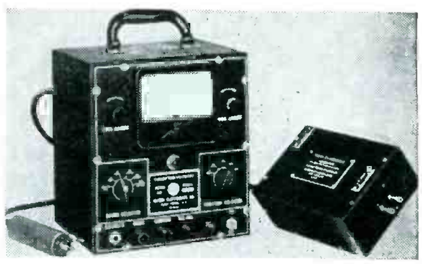
private study, the unit can be used with a pair of crystal headphones without an amplifier. A synchronous motor drives the turnable at 78 rpm. The recorder comes complete with the motor, a standard crystal pickup, spotting mechanism, 3-tube amplifier, and 5-in. permanent magnetic dynamic speaker. It weighs less than 20 lb and can be used on 110-v, 50/60 cycle ac.

Vacuum-Tube Voltmeter, Amplifier

MODEL NO. 451 VACUUM-TUBE voltmeter measures amplifier gain, network response, and output level at audio and radio frequencies. It is rated 25 mv, a-c, on the lowest range, 1000 v on the highest range, and 10 cps to 700 mc frequency range, with 7 $\mu\mu$f input capacitance. Other characteristics of



the unit include: single linear scale for all voltage and current scales; single zero adjustments for all a-c and d-c ranges; voltage regulated supply; stable operation; a rated accuracy of 2 percent of full scale values and large overvoltage capacity. The amplifier used with the voltmeter is model No. 101. Reiner Electronics Co., Inc., 132 West 25th St., New York 1, N. Y.

Tube Tester

MODEL NO. 2413 tube tester provides short and open element tests, plus a transconductance comparison check for matching tubes. Three-position lever switching provides simple and speedy operation and gives individual control for each tube element. The unit has a multicolor scale and comes supplied with instructions and test charts for quick reference. The case is furnished with a sturdy handle. It measures 10 x 10 x 5¾ in. Triplett Electrical Instrument Co., Bluffton, Ohio.

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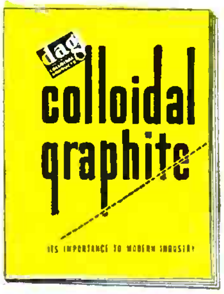

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Port Huron, Michigan

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VHF MOBILE RADIO COMMUNICATION SYSTEMS

Bendix—famous for many recent new developments in radio for industry and home—now announces advanced VHF radio communication systems for mobile use.

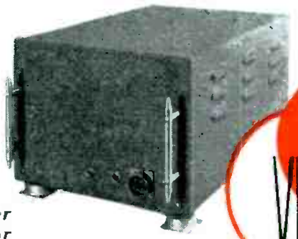
The new systems, which offer greatly improved performance characteristics and economy of operation, are available for use in three of the Very High Frequency bands — 30-44 megacycles, 72-76 megacycles and 152-162 megacycles.

All the equipment has been designed to use low input power. Any extended service can be provided with relay facilities.

For five years Pacific Division's radio research group has been working with military experts on advanced designs of VHF communication and control systems, and the new equipment embodies the latest developments for commercial application. In addition to new performance characteristics, the Bendix-Pacific equipment has been designed for compactness, long life and for easier service and maintenance.

Whatever application of radio voice communication you are planning, Pacific Division is interested in explaining the advantages of the new equipment to you. Pacific Division, Bendix Aviation Corporation, 11677 Sherman Way, North Hollywood, California.

Sales Engineering offices in New York and St. Louis.

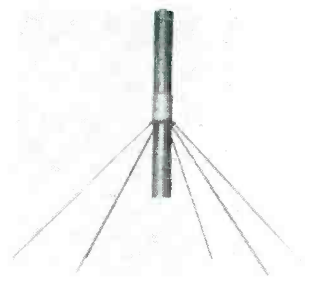


One of the new VHF communication units combining transmitter and receiver in a single cabinet for either mobile or fixed station installation.

Pacific Division
Bendix Aviation Corporation
VHF COMMUNICATION SYSTEMS

VHF Broad Band Antenna

TYPE MS-105A broad-band dipole antenna operates in the range of 108 to 132 mc in aeronautical service. Anywhere in this range, and without adjustment, the antenna will match into a 52-ohm coaxial transmission line and produce no more than a 1.5 to 1 standing wave ratio. A frequency range of 100 to 156 mc can be used with a standing wave ratio of not more than 2 to 1. The field pattern of the antenna is non-directional in the horizontal



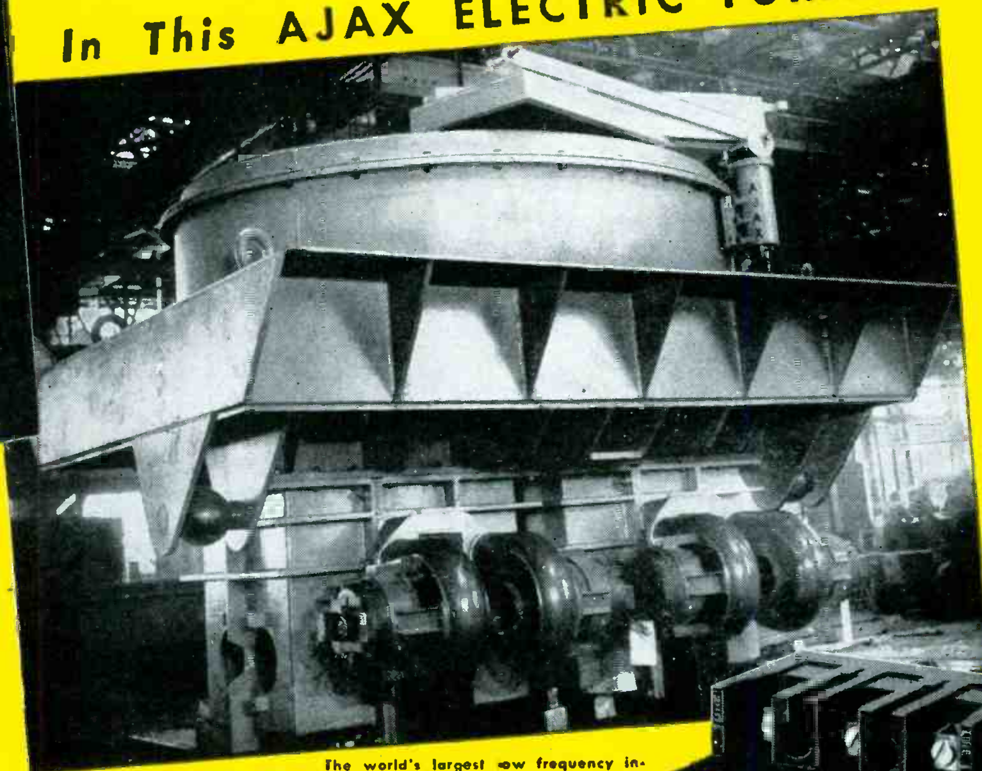
plane, and in the vertical plane is essentially the same as that of a standard dipole antenna, except that it has better frequency coverage. Polyethylene is used instead of air as a dielectric. Completely assembled, the antenna has an overall height of 38½ in. It weighs 4 lb. 10 oz. Mounting may be either on a wood or metal mast. The connector socket located inside the tublar base will fit a standard AN-PL-259A connector plug. A standard 52-ohm type AN-8/U coaxial cable or any cable similar to this may be used with the antenna. Bendix Radio, Baltimore 4, Md.

Copper Oxide Rectifier

A NEW, FULL-WAVE copper-oxide rectifier, rated at either 12-v a-c or 50 ma d-c has been added to the line of Coprox rectifiers available from Bradley Laboratories, Inc., 82 Meadow St., New Haven 10, Conn. The new unit is actually a double unit of the manufacturer's model CX-4D4-F23, recently redesigned to handle greater capacity than the original version. The single unit is now rated at 6 v, a-c and 50 ma, d-c continuous. It mounts on a single screw, is fully enclosed and completely sealed with a special plastic compound. Pre-soldered lead wires prevent overheating during assembly.

HEINEMANN
MAGNETIC CIRCUIT BREAKERS
PREVENT POSSIBLE DAMAGE
From Short Circuit or Dangerous Overload to Blower Motors
In This AJAX ELECTRIC FURNACE

Control cabinet containing HEINEMANN three phase, 230 volt Circuit Breakers.



The world's largest low frequency induction furnace for melting aluminum and aluminum alloys.

Immediate and dependable protection of the blower circuits is of the utmost importance for a unit such as this 500 KW Ajax melting furnace. The Ajax Engineering Corporation, realizing the flexible but unfailing protection afforded by HEINEMANN CIRCUIT BREAKERS, included them in their specifications.

In the words of an Ajax engineer, "Protection of the blower motor against overloads and short circuits is most essential. Magnetic protection also permits quick re-cycling, which is just as important."

Although tripping *instantaneously on short circuit or* dangerous overload, the HEINEMANN Magnetic CIRCUIT BREAKER provides a *delayed trip* on minor overloads, in inverse ratio to current.

Send for NEW Catalog Showing Complete Line and Engineering Data.

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary of Heinemann Electric Co., Est. 1888

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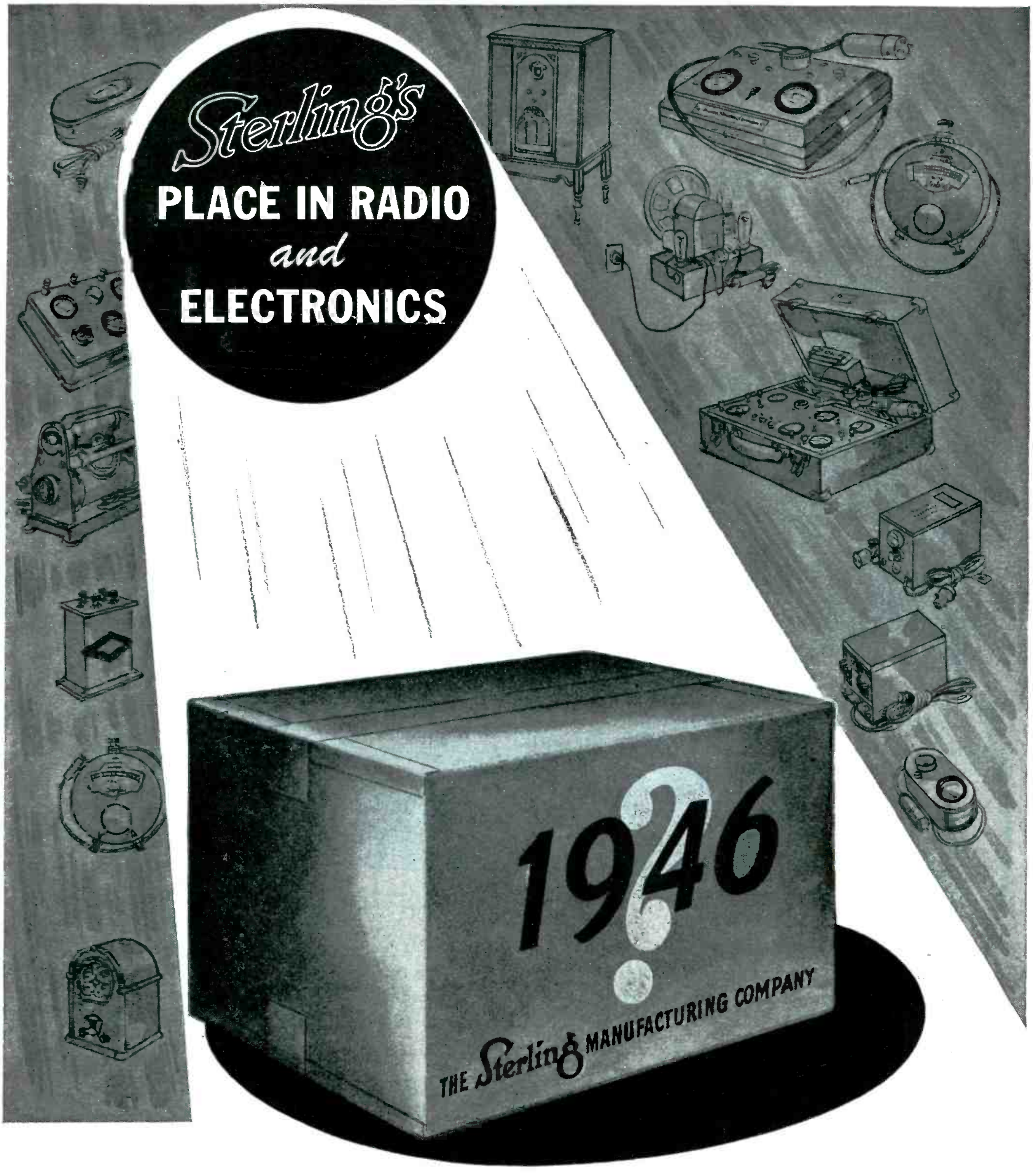

DOWN through the years with Radio—right from the very beginning—STERLING has built specialized apparatus for the Radio market and at times—complete Radio sets for world-wide distribution . . . Millions of STERLING products, battery eliminators, chargers, testers, have played a vital part in the development of Radio . . . Our wartime operations are now ended . . . Post-war products will reflect STERLING'S 39 years of successful electrical manufacturing experience.

The Sterling Manufacturing Company *9502 Detroit Avenue Cleveland, Ohio*

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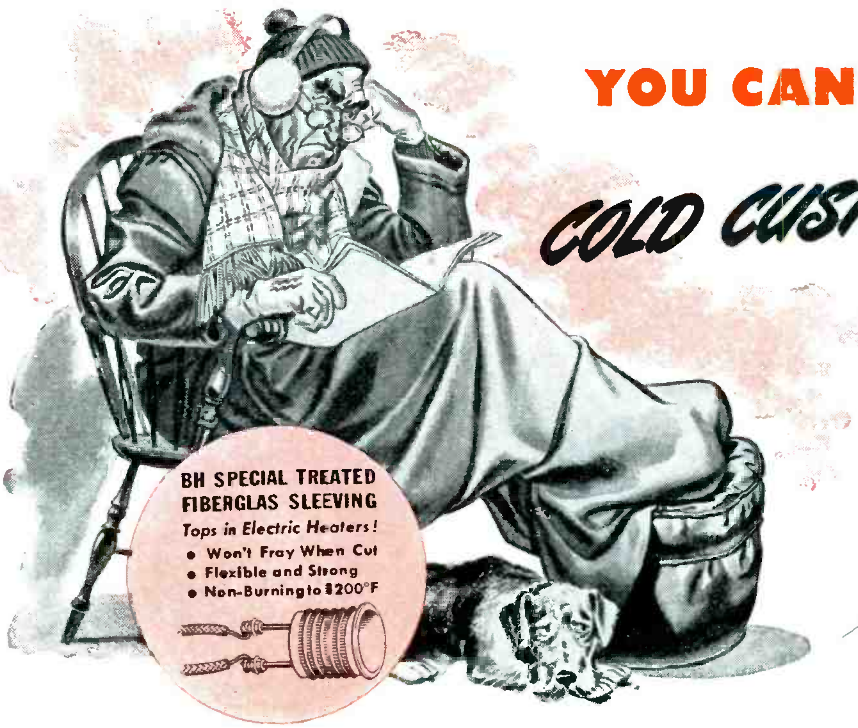

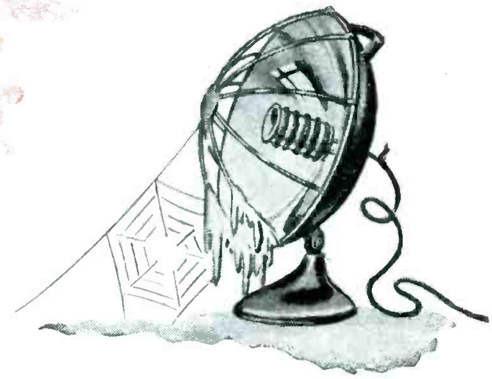

WHETHER he's Mr. Big of Industry or plain Mr. Homebody, the performance of your product's electrical insulation can make or break *his* good will, influence *your* future sales. Look at *all* the hazards of faulty or insufficient insulation. See why hundreds of manufacturers are protecting *their* products with BH Fiberglas Sleeving—the insulation that's way ahead in every important requirement, thanks to the *exclusive* BH process.

BH Fiberglas Sleeving is *permanently* flexible and non-fraying, the *original* sleeving to combine these qualities with heat resistance to 1200°F., with high tensile strength, and with resistance to moisture, oil, grease and most chemicals. It's easier to handle and install, and lasts longer in severest service. That's why BH Special Treated Fiberglas Sleeving, for instance, does a trouble-free job when the heat's on—why Mr. Room Heater Customer is sold *for good* when the heater's BH-equipped.

Whatever your product may be, if it depends on electrical insulation, you can count on one of the three BH Fiberglas Sleevings to meet your strictest needs. Send for free BH samples *today* —test them yourself—expect surprising results!

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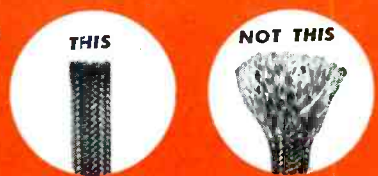

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BH *EXTRA FLEXIBLE* FIBERGLAS SLEEVING • BH SPECIAL TREATED FIBERGLAS SLEEVING
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*Ask for sample folder giving degree above characteristics are combined in these three sleevings. All standard sizes and colors—available in standard 36-in. lengths and 500-ft. coils.

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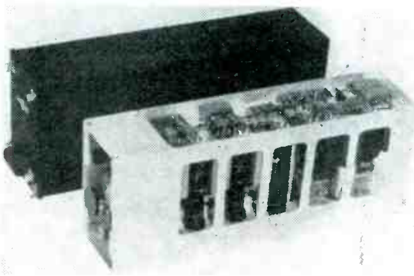
BENTLEY, HARRIS MANUFACTURING CO.

Dept. E Conshohocken, Penna.

Aircraft Communication Receiver

A NEW CRYSTAL-CONTROLLED, lightweight aircraft communication receiver (type 51K-1) from Collins Radio Co., Cedar Rapids, Iowa, uses the Collins Autotune for selecting the channel of operation. The receiver has ten different easily preselected frequencies for reception

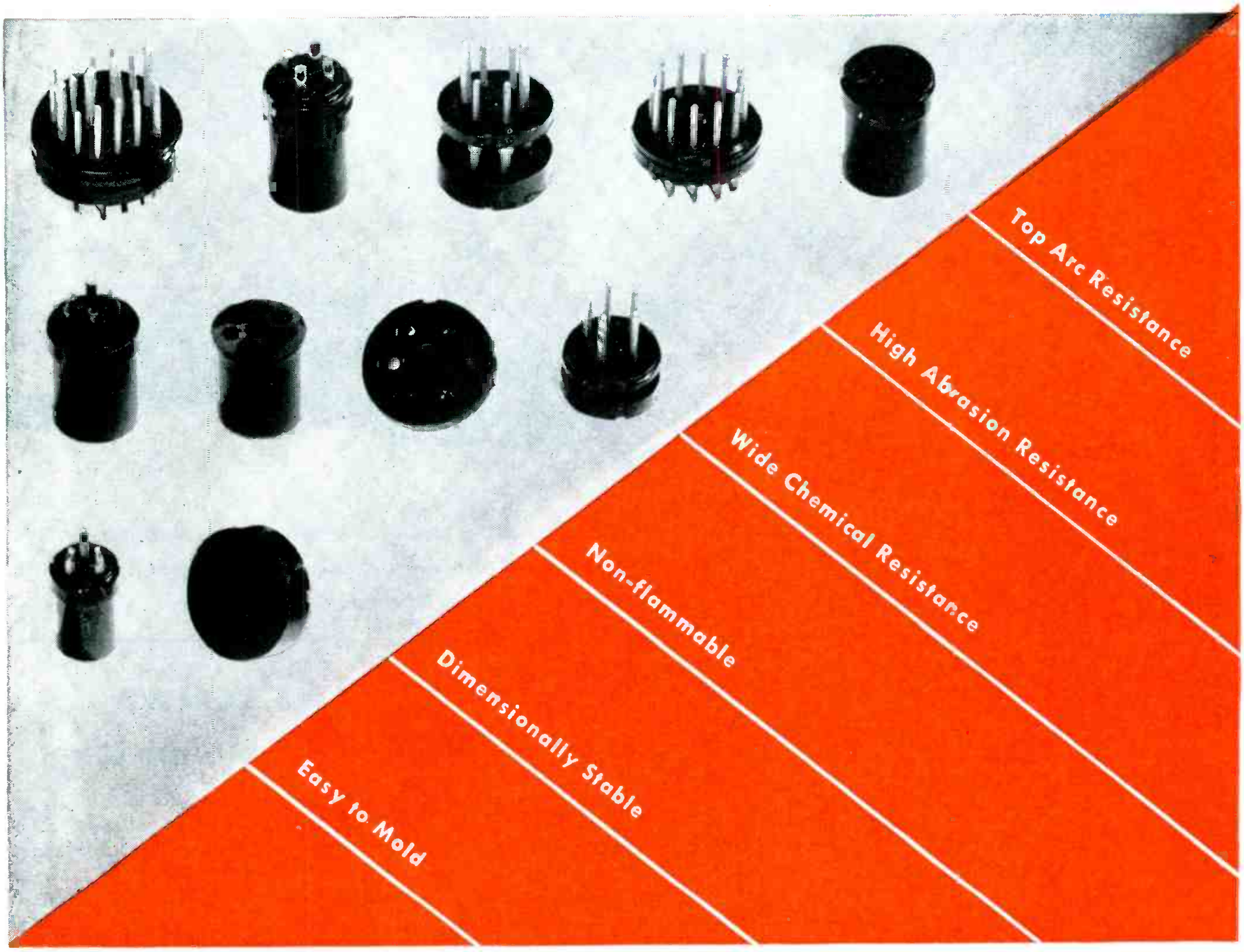


anywhere within the range of 2.4 to 18 mc. Two seconds is the maximum time required for the Autotune to change channels. The receiver is designed for commercial transport planes. It fits into ½ ATR unit, and weighs less than 20 lb. It operates from a 24-v d-c source. A 12-v model is also available.

D-C to A-C Converter

A D-C TO A-C ROTARY converter suitable for special applications where close control of frequency is desired is announced by Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill. Output frequency, indicated on a built-in, vibrating reed type frequency meter, can be manually corrected to 60 cycles by a power rheostat connected in series with the field coil. Types of converters available include models for input voltages from 6 through 64 volts for battery conversion, and from 110 to 120 volts for line conversion with ratings from 40- to 250-w continuous duty.

RESIMENE* 803A



Here is a cellulose filled melamine molding compound which combines characteristics which you may need. Resimene 803A has high arc resistance—125 seconds, which means long life in any part where arcing or flash-over is met. More stamina can be built into switch bases, connectors, plugs and other electrical parts with this important advantage.

But that is not all Resimene 803A offers . . . its abrasion resistance is higher than cellulose filled phenolic . . . it has higher alkali resistance than most thermosetting plastics and, in addition, it's not attacked by weak acids, most organic solvents or boiling water. These properties are combined in a molding compound of excellent moldability and good physical properties formerly expected only with general purpose phenolics. After-shrinkage of Resimene 803A is considerably less than any similar material . . . Resimene 803A is being produced only in black and olive drab.

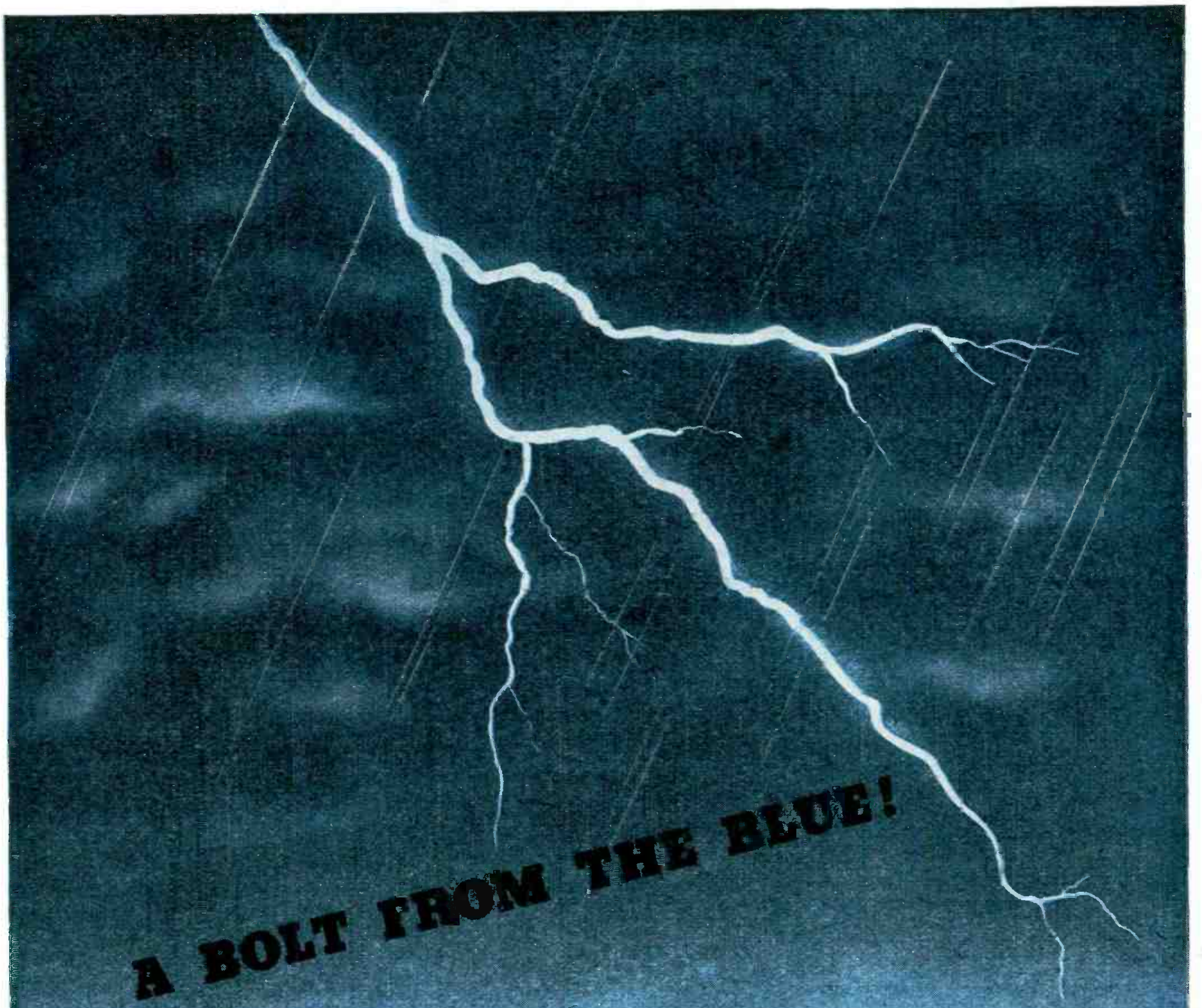
* * *

For full details and advice, write MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

The broad and versatile Family of Monsanto Plastics includes: Lustron polystyrene • Cerex* heat resistant thermoplastics • Vinyl acetals • Nitron* cellulose nitrates • Fibestos* cellulose acetates • Resinox* phenolics • Thalid* for impression molding • Resimene* melamines • Forms in which they are supplied include: Sheets • Rods • Tubes • Molding Compounds • Industrial Resins • Coating Compounds • Vuepak* rigid transparent packaging material.

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

MONSANTO PLASTICS
SERVING INDUSTRY... WHICH SERVES MANKIND



Represents a form of electricity that is hard to hold or control.

Controlling electrical currents is Formica's big job and it can do it today better than ever before. Some new developments in material and processing have provided grades that reduce high frequency losses to a new minimum, stand more arching, resist more heat.

Glass Cloth and glass mat with melamine resin have stepped up insulating efficiency, increased mechanical strength, produced a laminated material on an entirely new level of quality for many purposes.

These new materials retain the machinability and workability that always adapted laminated material to mass production. They mean better insulated electrical devices at low production costs.

FORMICA

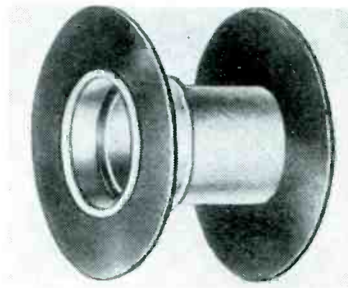
The Formica Insulation Company • 4661 Spring Grove Avenue • Cincinnati 32, Ohio

Power Supply

MODEL H (Porta-Power) provides hum-free operation of 4, 5, or 6 tube ($1\frac{1}{2}$ v) battery farm or portable radios, from 105-125 v, 50-60 cycle lines. The hum is eliminated by a two section filter composed of three capacitors of very high capacitance and two oversized iron-core chokes in the A supply; and two high capacitance capacitors and an oversized choke in the B supply. The A supply is rated 1.5 v at 200 ma; 1.35 v at 250 ma; 1.55 v at 300 ma; and 1.35 v at 350 ma. The B supply is rated 90 v at 13 ma and 101 v at 8.5 ma. The circuit is designed for optimum voltage regulation and changes in line voltages. The unit weighs $4\frac{1}{2}$ lb. General Transformer Corp., 1250 W. Van Buren St., Chicago 7, Ill.

One-Piece Coil Forms

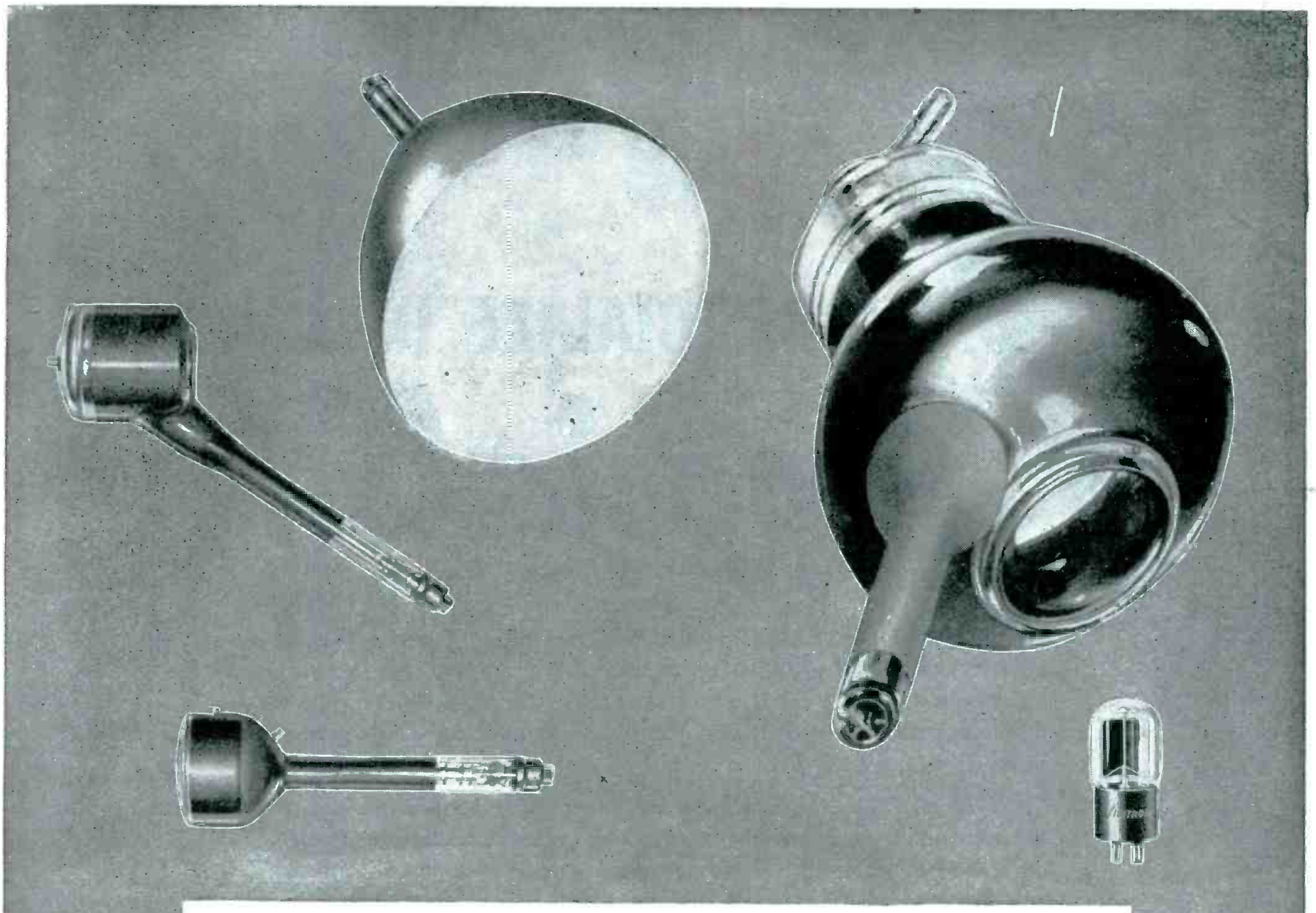
NEW DIE-FORMED bobbin coil forms for speaker field coils come in complete, strong one-piece assemblies, ready to go on mandrels of coil winding machines. The entire coil



base is shaped by die in one piece from spirally wound, heat-treated dielectric materials. Precision Paper Tube Company (2023 W. Charleston St., Chicago 47, Ill.) makes these coil forms to shape, measurement and other specifications.

Phonograph Turntable

IMMEDIATELY AVAILABLE are phonograph turnable units produced by Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn. Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic. Full-floating rubber mountings and rubber-cush-



VISITRON

Television Tubes

by

Visitron is not a new name in tubes. *Visitron* is Rauland's name for all electronic tubes made in the Rauland Tube Division. It is the mark of the advanced *Rauland* Television thinking and planning based upon a pioneering experience second to none. *Rauland Visitron* tubes for direct-viewing for the home and projection for the home and theatre are ready to take their places in the new era of Television entertainment now unfolding before us.

To be sure of your tube, be sure it's "*Visitron.*"

RADIO · RADAR · SOUND

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Electroneering is our business

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WE SPECIALIZE IN "Specials"

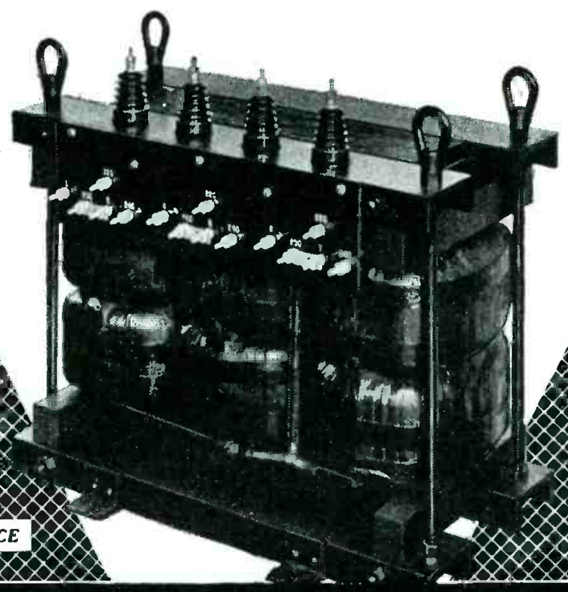
FOR NEARLY 20 YEARS, the Kenyon Transformer Company has done an outstanding job of satisfying the demand of large manufacturers for "special units" to fit exactly their most critical needs, with the same care that other manufacturers could provide items of their standard catalog lines.

THIS ACHIEVEMENT is a tribute to the skillful engineering ability of the Kenyon Pioneers who have maintained a leading place in the development of outstanding transformer equipment.

WE INVITE INQUIRIES from manufacturers of electronic and other types of equipment, and from industrial and commercial users of transformers.

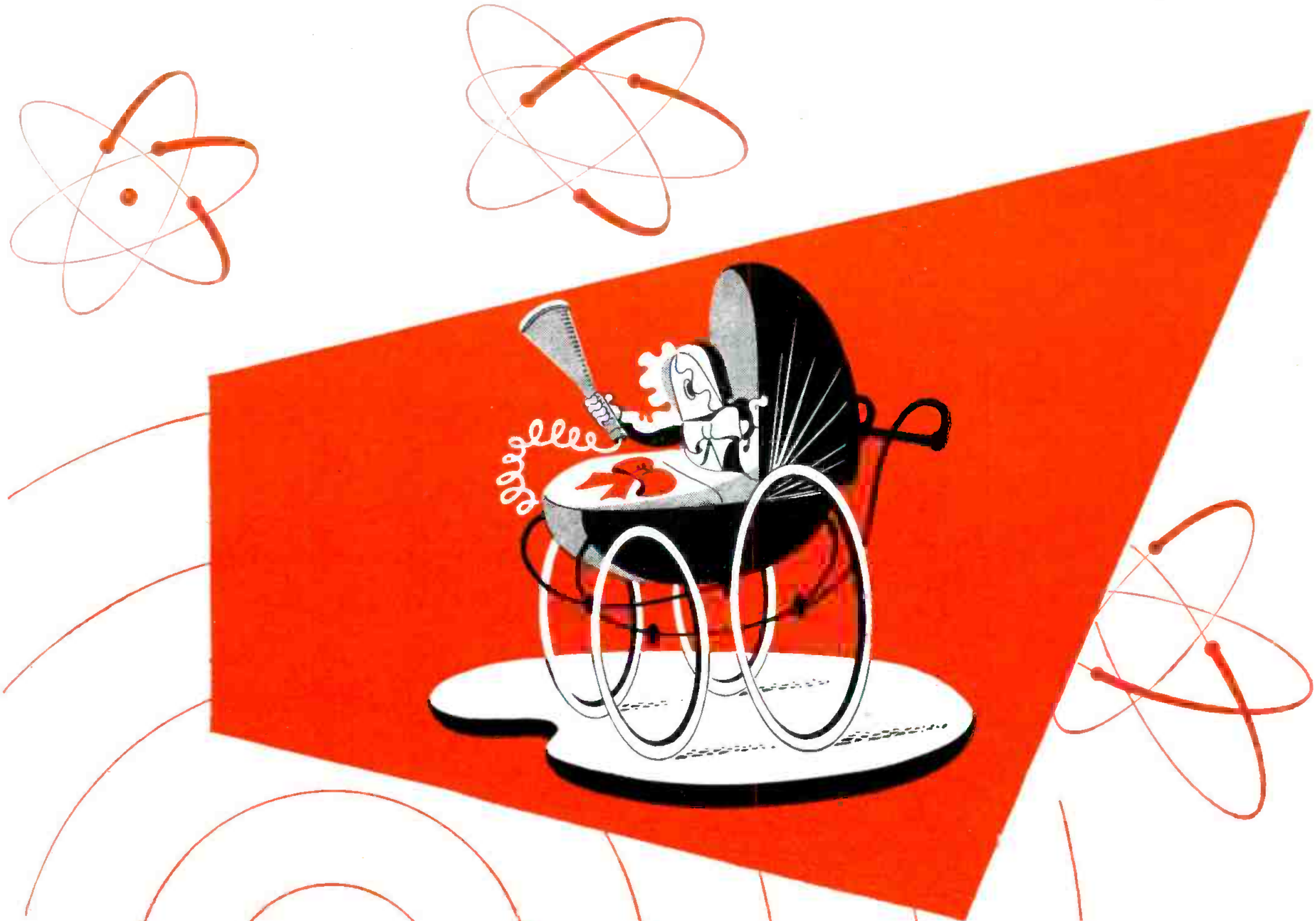
KENYON PREDICTS that the small additional cost of "specials" will be more than offset by the superior product—streamlined to fit each manufacturer's requirement.

Inquiries invited — write for our new 1945 ILLUSTRATED CATALOG.



THE MARK OF EXCELLENCE

KENYON TRANSFORMER CO., Inc. 840 BARRY STREET NEW YORK, U. S. A.



We grew up with electronics

Our engineers and executives grew up with Electronics. Before the war we manufactured commercial radio equipment. During the war we greatly expanded our engineering and research staff and did extensive work in advanced electronics for the Army and Navy. Our present engineering and research facilities occupy more than 30,000 square feet of space. Our current production program is centered on communications equipment for rail, air, highway, marine and commercial use. Other products, notably in the field of industrial electronics, are under development.

Aireon's engineering and research staff will be glad to consult with you on your electronic problems. Your inquiry will have prompt attention.

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Radio and Electronics • Engineered Power Controls

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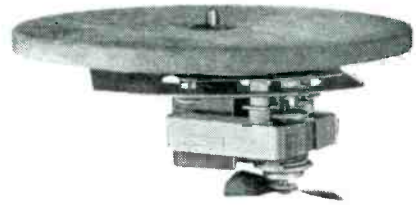
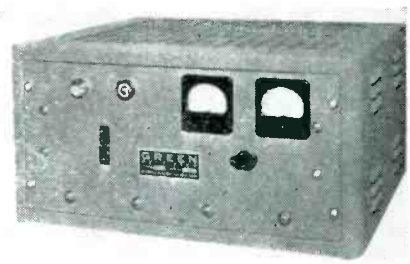


ioned drives are designed to assure quiet operation. The motor of these turntables is fan-cooled and will operate continuously with low temperature rise. All bearings are of proper size and are provided with self-lubricating features.

Stabilized Rectifier

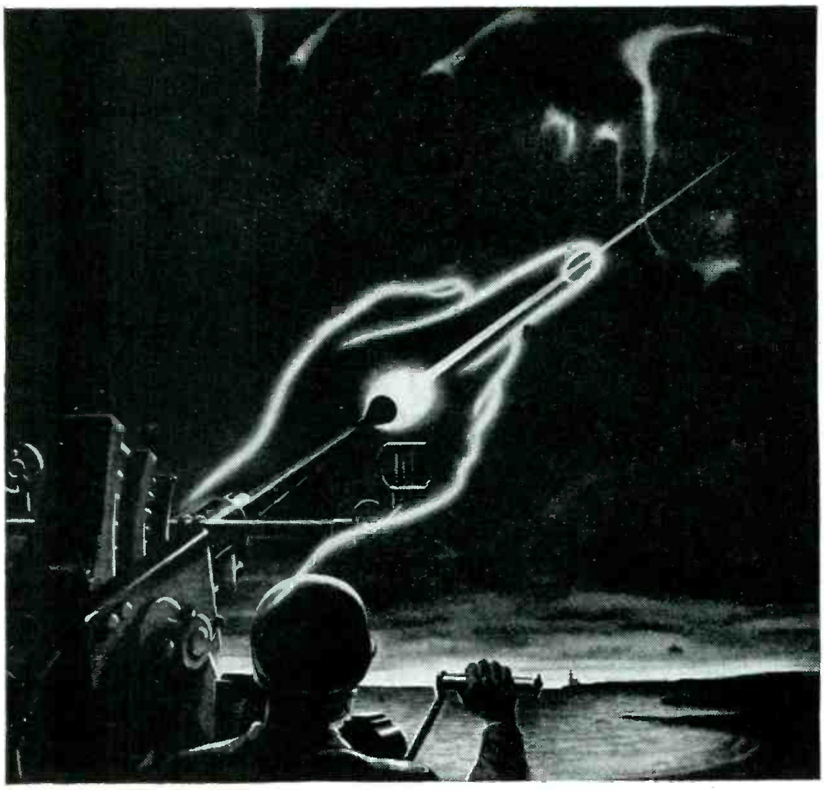
TYPE TRX-4 STABILIZED rectifier is for telegraph and similar services. The dynamic voltage regulation characteristic of the unit is such that the load current may be varied between zero and maximum at any demand frequency, with negligible variation in terminal voltage. The unit utilizes type TRX circuit which compensates for normal variation in a-c supply voltage to the rectifier

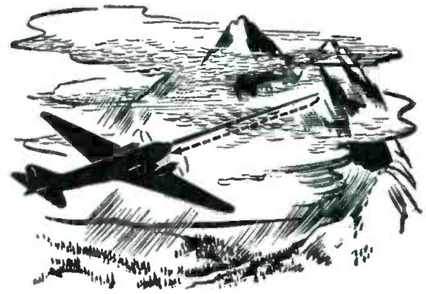


unit. Other features of the unit include: completely non-resonant filter; optional connection to 115- or 230-v, 50/60 cycle a-c supply; optional output ranges of either 110/120 or 150/160 v; circuit breaker switch protection on a-c side; volmeter, ammeter, and supervising lamps; and facilities for mounting in standard 19-in. panel cabinets. Models are available for 1-, 2-, 4- and 7-amp capacity. Green Electric Co., Inc., 130 Cedar St., New York, N. Y.

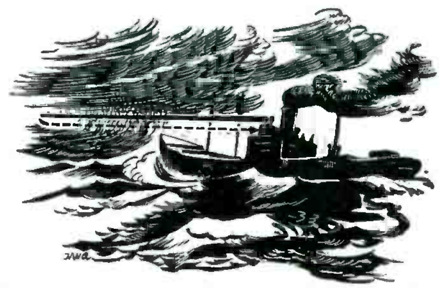
Vibration Pickup

DEVELOPED TO MEET the requirements of aircraft engine testing, this pickup has exceptional durability under conditions of extreme vibration, high output signal level, freedom from frictional effects, limiting response at low amplitudes,



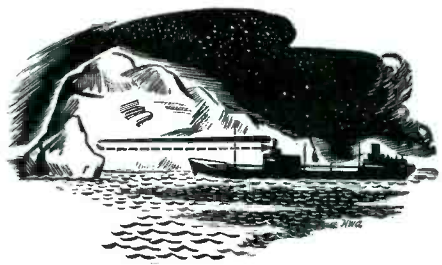


Points the way through cloud-hidden mountains



Points the way through fog-bound shipping lanes

Points the way for safe blind landings



Points out night-shrouded icebergs

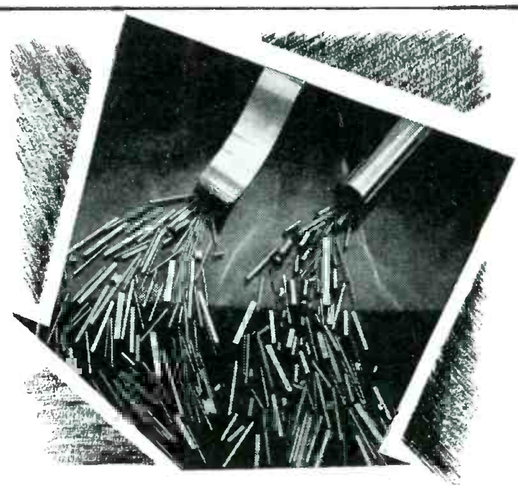
In War or Peace
NICKEL *helps* RADAR
POINT THE WAY

Nickel plays an important role in radar.

The tell-tale stream of electrons is fed to the cathode-ray screen from a pure Nickel cathode. *That's practically "standard" in all radar equipment.*

No other commercial metal offers so favorable a combination of electrical and electronic properties . . . plus the ability to be worked in such small sizes.

The multiple advantages of Nickel and high-Nickel alloys make them particularly useful in many additional radar and other still-secret applications where strong, corrosion-resistant materials are needed with special electronic or electrical properties. Send for your copy of "Nickel in the Radio Industry." The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.



"Electron-hatching" cathodes and other elements are produced in endless variety from Nickel strip and seamless Nickel tubing. In all types of electron tubes, Nickel is regularly used for these reasons: High strength and rigidity . . . High mechanical properties and resistance to oxidation at high temperatures . . . Resistance to rusting and corrosion . . . Low gas content . . . Good working qualities . . . Required electrical and electronic characteristics.

Photo, courtesy of Superior Tube Company, Norristown, Pa.

NICKEL ALLOYS

MONEL* • "K" MONEL* • "S" MONEL* • "R" MONEL* • "KR" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL* • *Sheet . . Strip . . Rod . . Tubing . . Wire . . Castings . . Welding Rods (Gas & Electric)*

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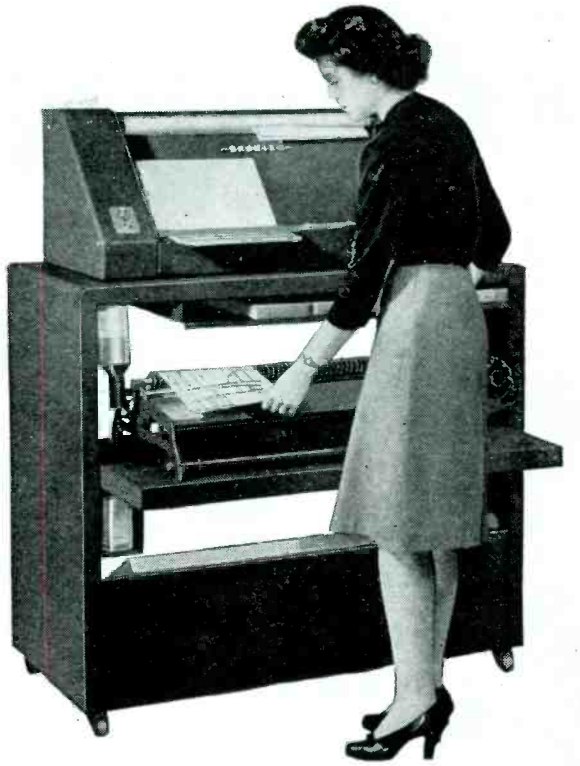

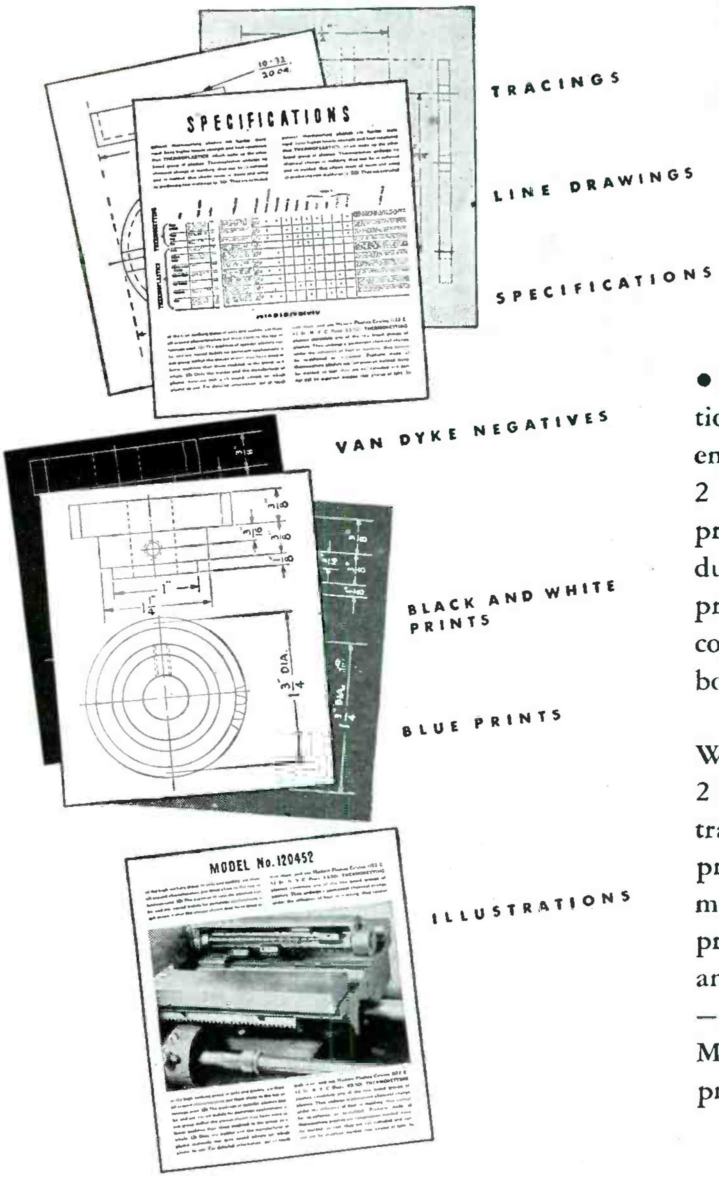

• Now you can use this new *photographic* reproduction process right in your own drafting room or engineering department! With the Bruning Model 2 BW and Copyflex Continuous Printer, there is practically no limit to the kind of materials you can duplicate! You can have copies of anything typed, printed, illustrated or drawn. Original material with copy on both sides can be reproduced from one or both sides.

Both Copyflex photographic and BW Black and White sensitized materials are exposed on the Model 2 Printer. Copyflex prints are developed with three trays and a simple drier (readily available). BW prints are developed in the Model 153M developing machine, combined in a convenient stand with the printing unit. Moderately priced, the Model 2 Printer and 153M Developer increase your duplicating scope —provide a wider range of duplicating advantages. Mail the coupon for literature about this modern print-making method.

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Please send me complete information on your Model 2 BW and Copyflex Continuous Printer—and on other Bruning printing and developing machines for making Bruning Black and White Prints.

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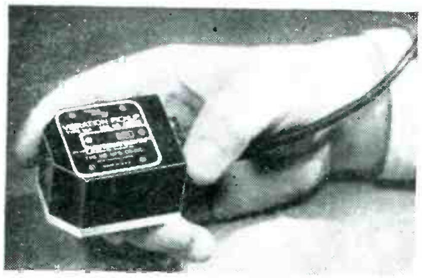
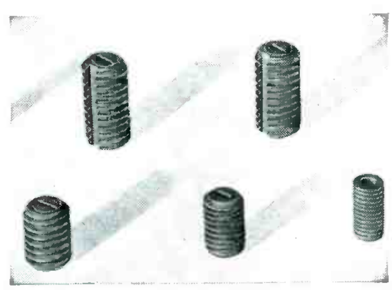
and stability of calibration over wide temperature ranges. Output is proportional to vibratory velocity, with uniform response from below 10 cps to approximately 1000 cps, and usable response to 4 cps. The pickup is usually operated as a seis-



mic instrument, but can be furnished with facilities for direct attachment of a light moving coil to the structure whose vibration might be influenced by a heavier mass. Pickups are supplied with a special flexible pigtail lead, and are easily and quickly converted for use in either horizontal or vertical planes without affecting calibration. The MB Manufacturing Co., Inc., New Haven, Conn.

Screw-Type Iron Cores

BECAUSE THESE IRON cores utilize threaded cores they are designated as Screwtype molded iron cores. No brass core screw is necessary for their adjustment. There is no metal

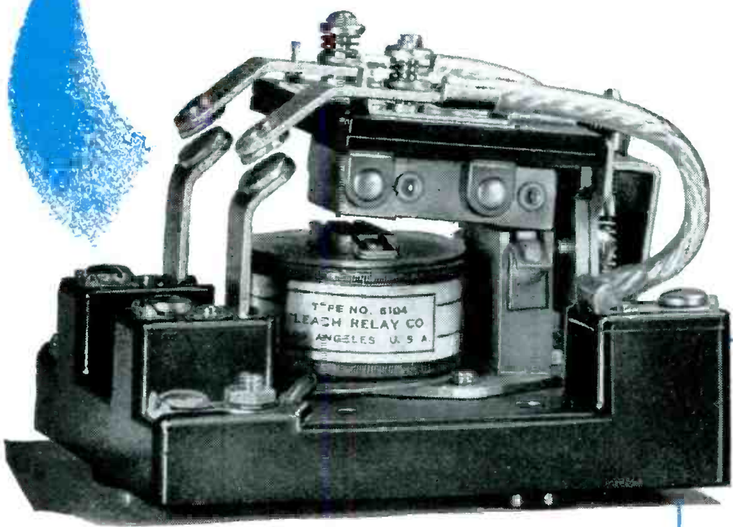


in the field of the coil and the cores themselves are not grounded. As a result a higher *Q* is obtained. Stackpole Carbon Co., St. Marys Pa.

A transmitter-receiver made by Bendix is completely interchangeable with British equipment.

More than 7,900 watts of power are used by the 435 vacuum tubes in the radio equipment of a B-29.

Relays BY LEACH



THE NEW 30 AMPERE RELAY

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● *All the engineering skill that has created for Leach its reputation as manufacturers of fine relays is at your service. Our Engineering Department will be glad to discuss with you any problems which you may have. Write for literature.*

LEACH RELAY CO.

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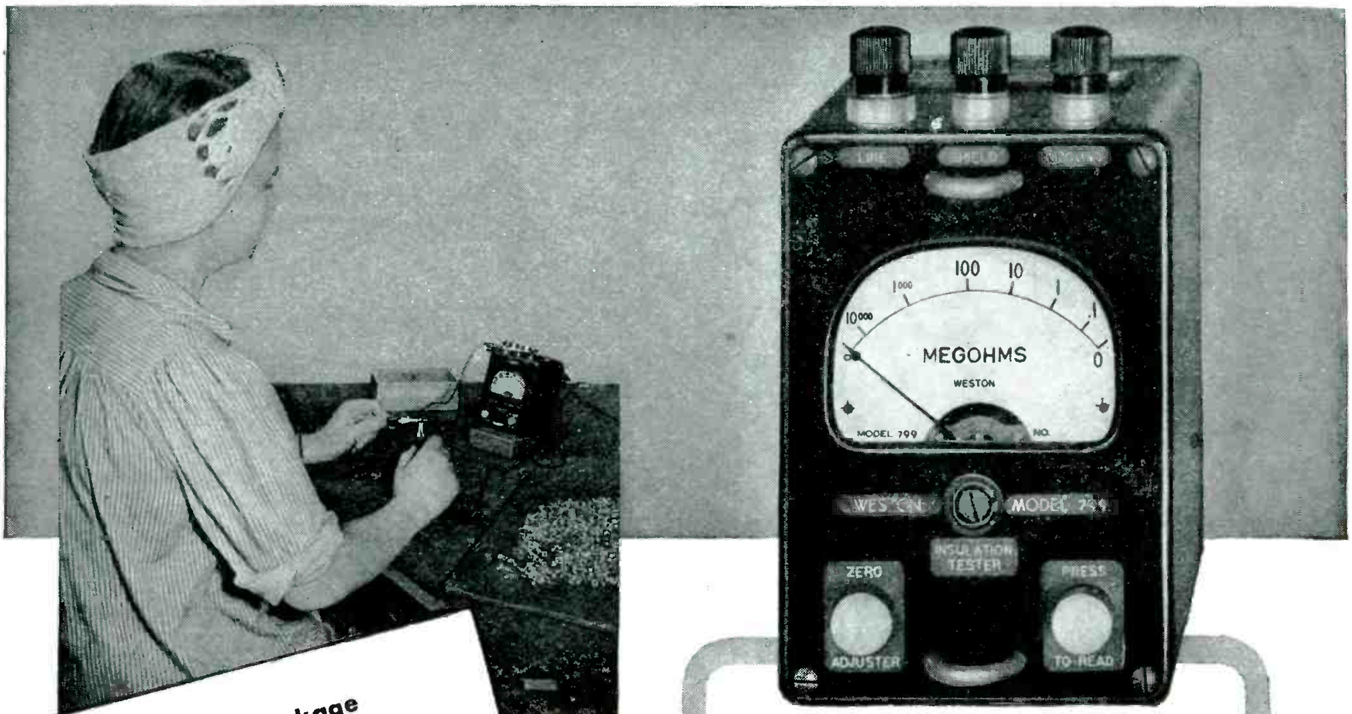

Now . . . **Leakage Resistance Measurements at Low Potentials!**

Because of its compactness and extreme high sensitivity, this direct reading instrument fills an important measurement gap in the production and servicing of a wide variety of components and electrical devices. Minute faults can be detected *in advance* . . . tests can be made without destructive breakdown. Test potential less than 50 Volts.

Here's what a few typical users say about Model 799:

"We use it for testing the leakage between windings in transformers, or from windings to core or case."

"We can test the leakage of low voltage paper and mica condensers with the 799, and without danger of damaging the dielectric."

"We test leakage resistance between individual wires in cable harnesses."

"Model 799 is also ideal for checking leakage due to moisture in fiber terminal strip."

For complete data on Model 799 Insulation Tester, communicate with the WESTON representative in your locality, or write...Weston Electrical Instrument Corporation, 618 Frelinghuysen Ave., Newark 5, N.J.

Weston

MODEL 799

INSULATION TESTER

• 10 BILLION Ohms •

will measure:

- Insulation Properties
- Resistance Leakage
- Conductivity of Insulating Materials
- Leakage due to Moisture Absorption
- Readings — .1 to 10,000 megohms

Weston *Instruments*

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MINNEAPOLIS • NEWARK • NEW ORLEANS • NEW YORK • PHILADELPHIA • PHOENIX • PITTSBURGH • ROCHESTER • SAN FRANCISCO • SEATTLE • ST. LOUIS • SYRACUSE
In Canada, Northern Electric Co., Ltd., Powerlite Devices, Ltd.

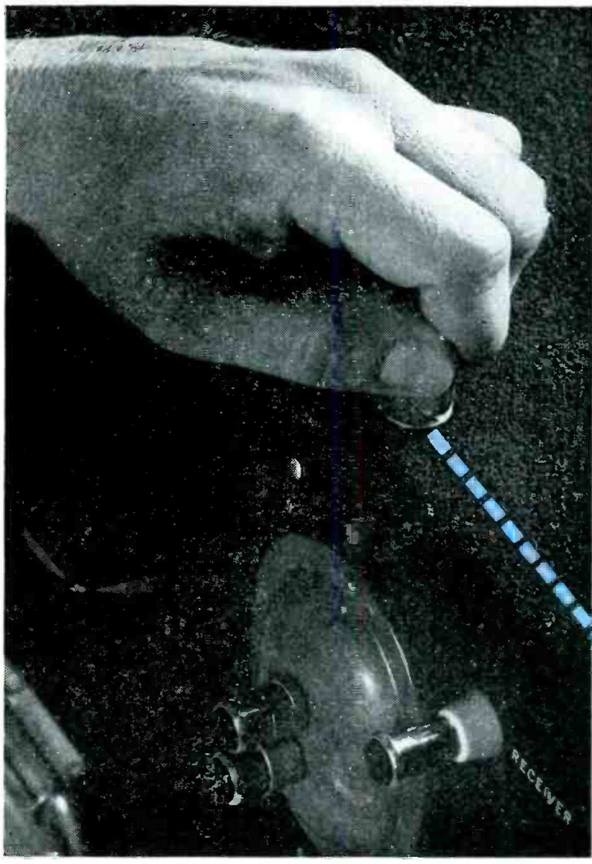
Literature

Frequency Meters. Bulletin No. 1770 supersedes this manufacturer's bulletin No. 1695. The newer edition contains sixteen pages and is illustrated with photographs and diagrams of switchboard, portable and miniature types of Frahm vibrating-reed frequency meters. A variety of special models are included. Meters are available on ranges as low as 15 cps up to 400 cps. Higher ranges are available on special order. An explanation of the resonant reed principle and vibrating-reed characteristics as well as how to read the scale are given. James G. Biddle Co., 1211 Arch St., Philadelphia 7, Pa.

Modified Schering Bridge. New photographs, photo-diagrams and explanatory material are included in a recently issued catalog, E-54 (2) which gives the characteristics and advantages of this direct-reading modified Schering bridge for use in the measurement of dielectric constant and power factor of a dielectric in solid or liquid form. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Vibration Test Equipment. L.A.B. Corporation, 31 Union Place, Summit, N. J. produced an 8-page loose-leaf bulletin which describes and illustrates three different types (VU-DM-100, VU-DM-500 and RV-3) of three and two-dimension vibration tests equipments for laboratory and production usages.

Electronic Counter. A 16-page bulletin illustrates and thoroughly describes Model No. 67, two-decade electronic counter for high-speed counting. This instrument is one of the adaptations of the Potter standard electronic counter-decade. Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.



DZUS*

SPIRAL CAM FASTENERS SERVE THE ELECTRONIC INDUSTRY

Just a quarter turn with a coin or screw driver and — click — the Dzus spiral cam fastener is firmly locked or quickly unfastened.

Navy's New Collins Autotune Transmitter — the versatile radio used on most two-place and larger types of naval aircraft — is equipped with flush head type Dzus spiral cam fasteners.

Photos, Collins Radio Co.

Flush head fastener stud

Grommet

Spring

Cut-away view of complete Dzus spiral cam fastener assembly

Radio and electronic manufacturers find that quick-acting Dzus spiral cam fasteners have all the qualifications to meet rigid specifications and requirements for firmly holding hinged or removable parts. This fastener is light but rugged, vibration-proof and permanently attached. It is easy to install and operate. It saves valuable time, especially with equipment that requires periodic inspection and adjustment.

There is a Dzus spiral cam fastener for every requirement in the electronic industry — supplied in various sizes and head styles. Send for the Dzus catalog today—and have at your fingertips the most complete line of self-locking fasteners available.

* The word DZUS is the registered trade mark of the Dzus Fastener Company, Inc.

DZUS FASTENER COMPANY, INC.

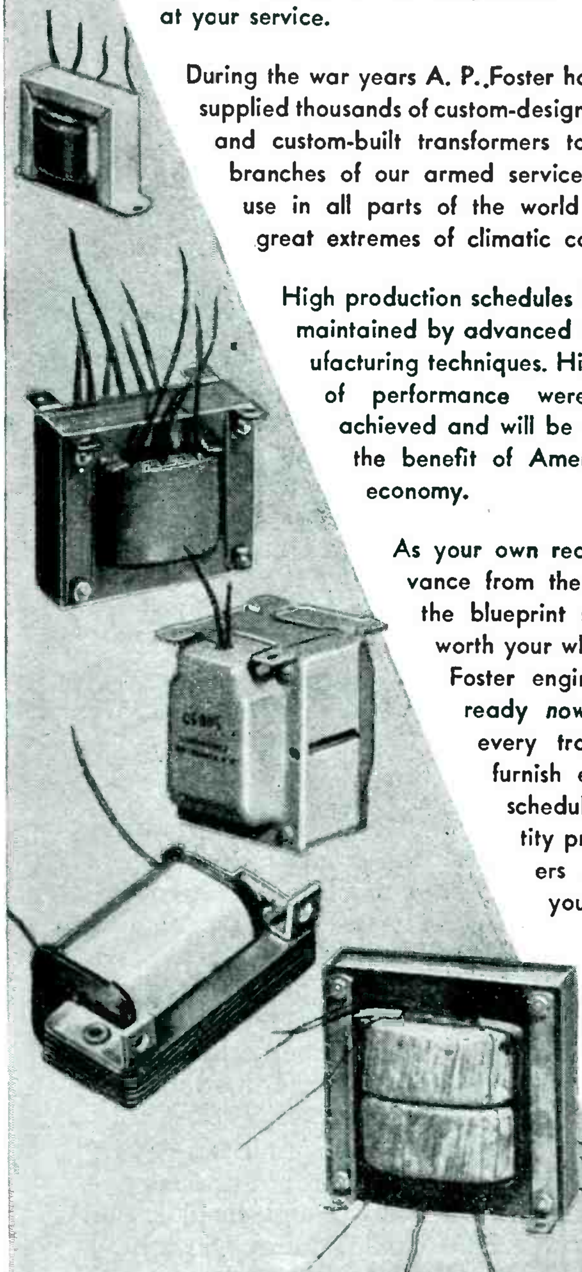
BABYLON NEW YORK

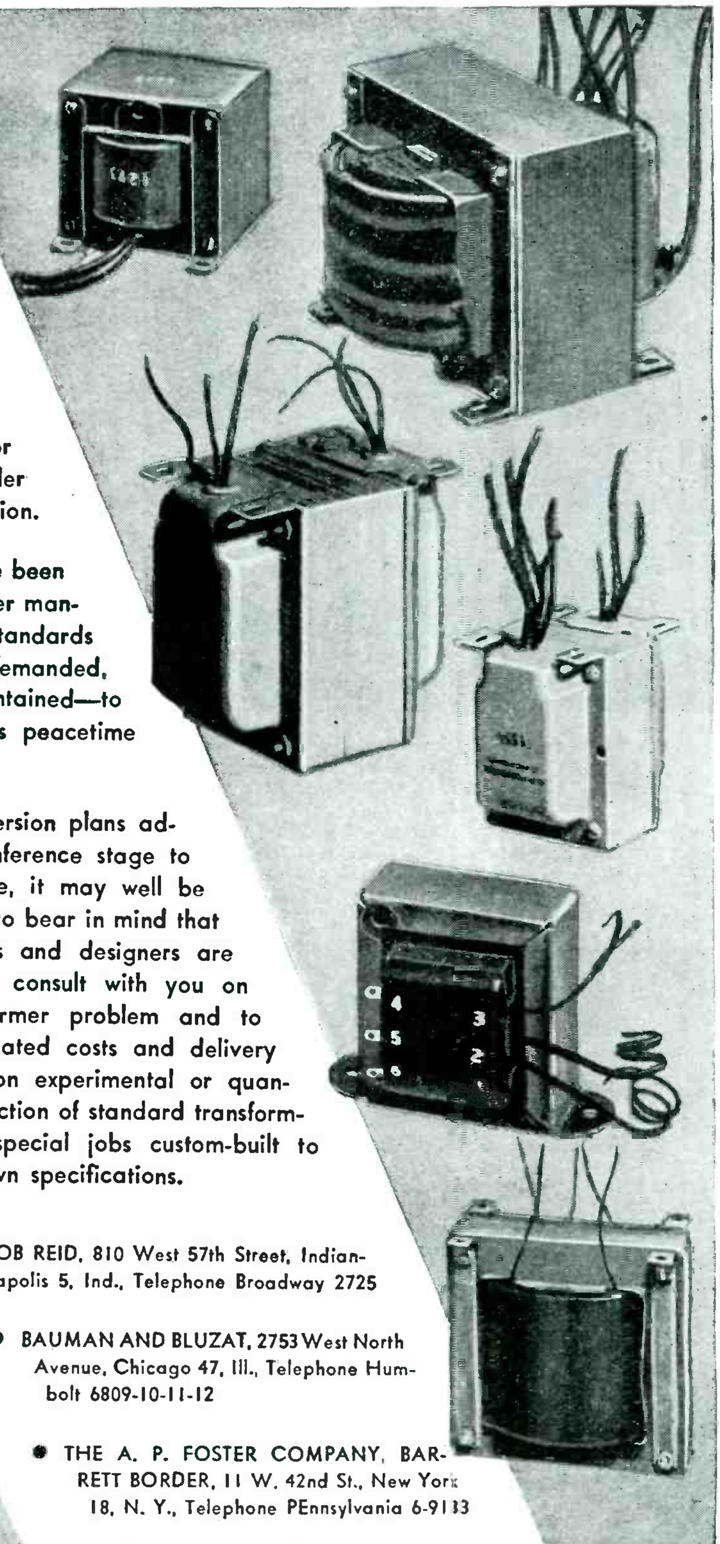
IN CANADA: RAILWAY AND POWER ENGINEERING CORP., LTD.

POSTWAR TRANSFORMERS

BY

FOSTER





Facilities for peacetime manufacture of transformers are already available at A. P. Foster, and, as war commitments are filled, will be increasingly at your service.

During the war years A. P. Foster has supplied thousands of custom-designed and custom-built transformers to all branches of our armed services, for use in all parts of the world under great extremes of climatic condition.

High production schedules have been maintained by advanced Foster manufacturing techniques. High standards of performance were demanded, achieved and will be maintained—to the benefit of America's peacetime economy.

As your own reconversion plans advance from the conference stage to the blueprint stage, it may well be worth your while to bear in mind that Foster engineers and designers are ready *now* to consult with you on every transformer problem and to furnish estimated costs and delivery schedules on experimental or quantity production of standard transformers or special jobs custom-built to your own specifications.

- BOB REID, 810 West 57th Street, Indianapolis 5, Ind., Telephone Broadway 2725
- BAUMAN AND BLUZAT, 2753 West North Avenue, Chicago 47, Ill., Telephone Humbolt 6809-10-11-12
- THE A. P. FOSTER COMPANY, BARRETT BORDER, 11 W. 42nd St., New York 18, N. Y., Telephone PEnnsylvania 6-9133

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A. P. FOSTER COMPANY

TRANSFORMER ENGINEERS & MANUFACTURERS

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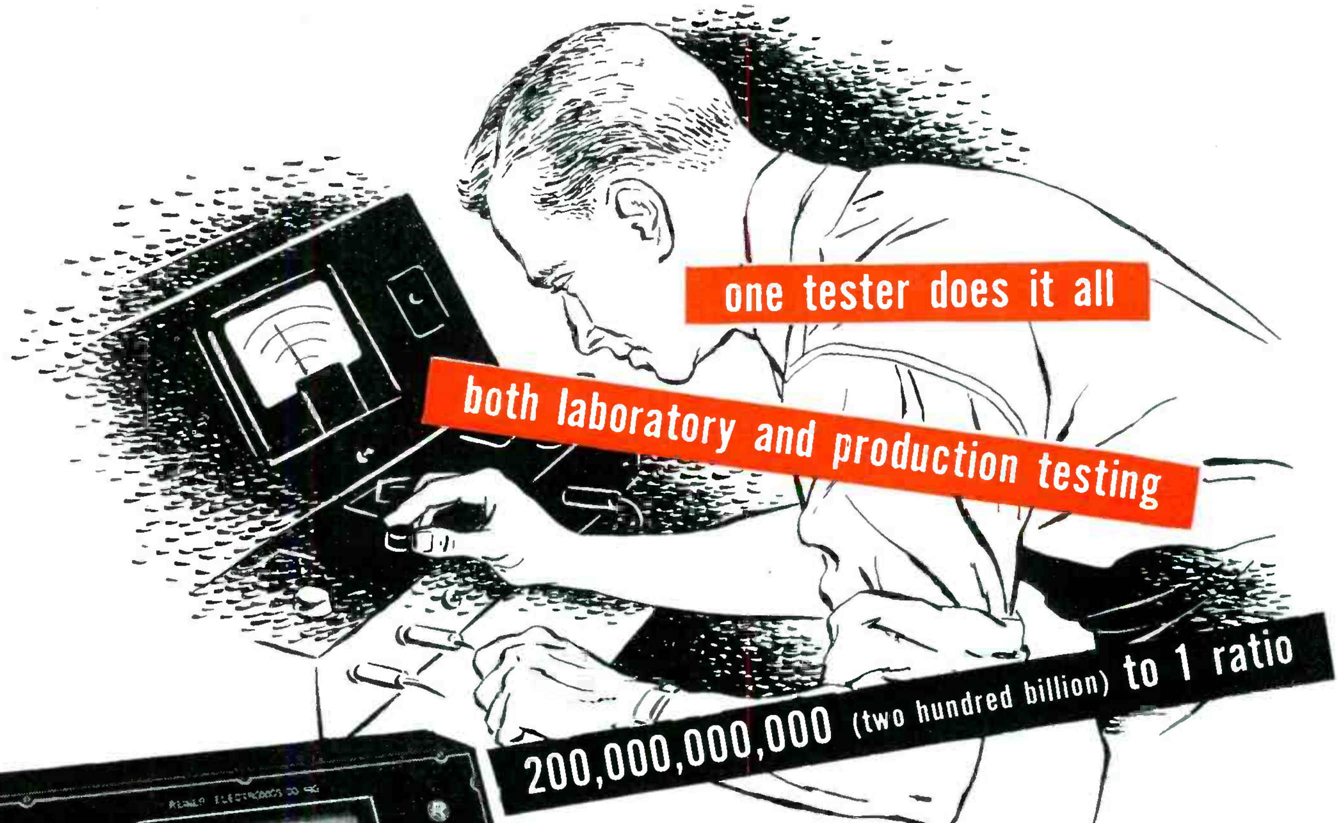

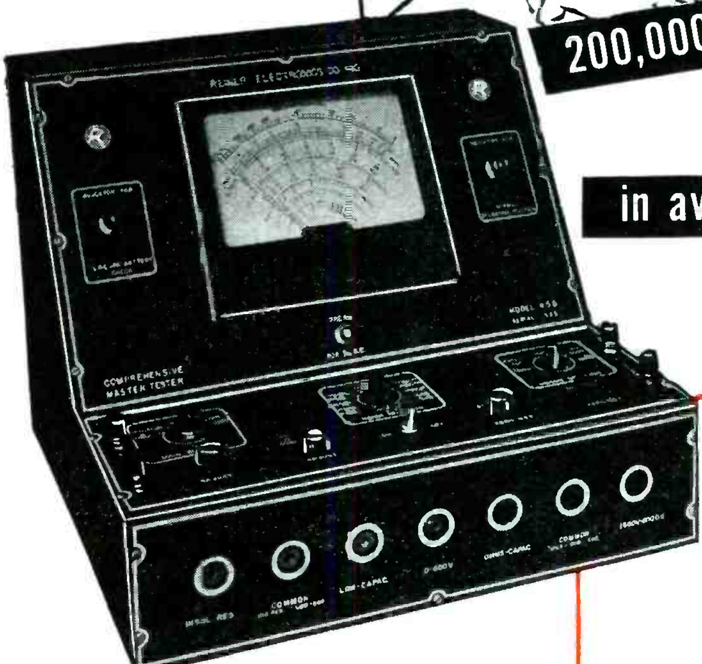

in available resistance measurements

REINER MODEL 456 COMPREHENSIVE MASTER TESTER

The highly accurate and efficient Reiner Master Tester combines in one compact unit an unusually large number of measurements and ranges — equivalent to 61 individual single range meters. It is an electrical measurements laboratory, especially designed for industry, with *eight* types of testers in one instrument:

1. INSULATION TESTER
2. CAPACITY METER
3. OHM METER
4. A. C. VOLTMETER
5. D. C. VOLTMETER
6. A. C. AMPERE METER
7. D. C. AMPERE METER
8. IMPEDANCE-INDUCTION METER (with charts)

Insulation testing at 500 volts to 10,000 megohms; at 1,000 volts to 20,000 megohns. ★ Capacity measuring one micro-microfarad to 1,000 microfarads. ★ Resistance measurements 0.1 to 1,000 megohms.

SIMPLE OPERATION: wide scales on the 9" rectangular meter permit direct, easy reading.

RANGES A. C. Current 6-15-30-60-150-300-600-1500-3000-6000-15000-30000 M. A. ★ D. C. Current 6-15-30-60-150-300-600-1500-3000-6000-15000-30000 M. A. ★ A. C. Volts 3-6-15-30-60-150-300-600-1500-3000-6000 ★ D. C. Volts 6-15-30-60-150-300-600-1500-3000-6000 ★ Ohms 0-1000-10000-100000-1 meg-10 meg-100 meg-1000 meg ★ Insulation Tests 500 volt/0-10000 megohms; 1000 volt/0-20000 megohms ★ Capacity High 5-2000 .5-200 .05-20 .005-2 .0005-.2 00005-.02 microfarads ★ Capacity Low 1-100 microfarads ★ Frequency range without probe A. C. volts 10 cps - 100 K. C., 25 microfarads input capacity. With probe provided 10 K. C. - 500 M. C., 1 microfarad input capacity.

SIZE: 16" x 12½" x 15" **WEIGHT:** 33½" lbs.
Delivered complete ready to use, with set of high voltage leads, set of shielded test loads, high frequency probe.

Reiner
ELECTRONICS

For further information on this and other Reiner precision equipment write to REINER ELECTRONICS Co., 125 W. 25 St., New York 1, N. Y.

Speech Input Systems. "Elements of Speech Input Systems" designates an 18-page booklet (Form No. WECO-T2154) which describes in simple language the principal components and performance data of a typical modern speech input system for both a-m and f-m broadcasting. Information Dept., Western Electric Co., Inc., 195 Broadway, New York 17, N. Y.

Permanent Magnets. Permanent Magnets for Industry is the title of a 24-page, illustrated manual which gives the factors affecting design, fabrication and application of Alnico permanent magnets. The Arnold Engineering Co., 147 E. Ontario St., Chicago 11, Ill.

Screws. A catalog containing 112 pages is devoted to the manufacturing processes, illustrations, and description of the many types of screws being made by New England Screw Co., Keene, N. H. This catalog is designated as No. 45.

Counting Device. Form No. 50 illustrates and describes among other types of counters an automatic batch-counting unit. Production Instrument Co., 710 W. Jackson Blvd., Chicago 6, Ill.

Bendix Radio Literature. Four separate pieces of literature available from Bendix Radio, Baltimore 4, Md., include the following: Bulletin No. SE-117 on type MN-57A loop position transmitter which indicates the position of a manually-driven loop antenna on an autosyn azimuth indicator; Bulletin No. SE-118 on type MI-32 interphone and isolation amplifier which provides interphone communication between as many as five different crew stations, and independent receiver selection by each of the five crew members without cross feed; a 4-page bulletin on type RA-2D communication receiver, an eight-channel, superheterodyne, crystal-controlled unit operating between 2700 and 7000 kc; and finally, an 8-page bulletin on type MN-31 Series automatic radio compass for aircraft navigation.

MODEL 56
WEBSTER RECORD CHANGER

. . . as new as the Post-War Era

In related industries—names with integrity and reputation go hand in hand. Thus — in radio-phonograph combinations — Webster Record Changer, Model No. 56, will continue in distinguished company — just as its predecessors have in the past. New brilliance of performance has been achieved — new mechanical perfection that will prove most pleasing to dealers and consumers alike. Read the following advantages — then contact us for full details and engineering council.

- ✓ Dependable heavy duty Webster 4 Pole motor — cushion mounted for silent operation. No audible rumble or "wow."
- ✓ Records drop quietly — velvet soft heavy-pile turntable covering.
- ✓ Installation done from top — quick, easy mounting.
- ✓ 14-inch square mounting base. Over-all depth —above and below mounting board—9 inches.
- ✓ Built for lasting performance. Practically no service calls are required.
- ✓ Perfectly crafted — highly styled — beautiful lines.
- ✓ Changes all standard records. Plays ten 12" or twelve 10" records in one loading.
- ✓ Fast change cycle — approximately 4 seconds.
- ✓ Simple, fool - proof operation. Can not be "jammed."
- ✓ Automatic shut-off after last record has played.
- ✓ Feather light needle pressure.
- ✓ Longer life for records — no cracks — no chipped edges.

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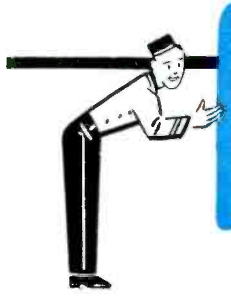

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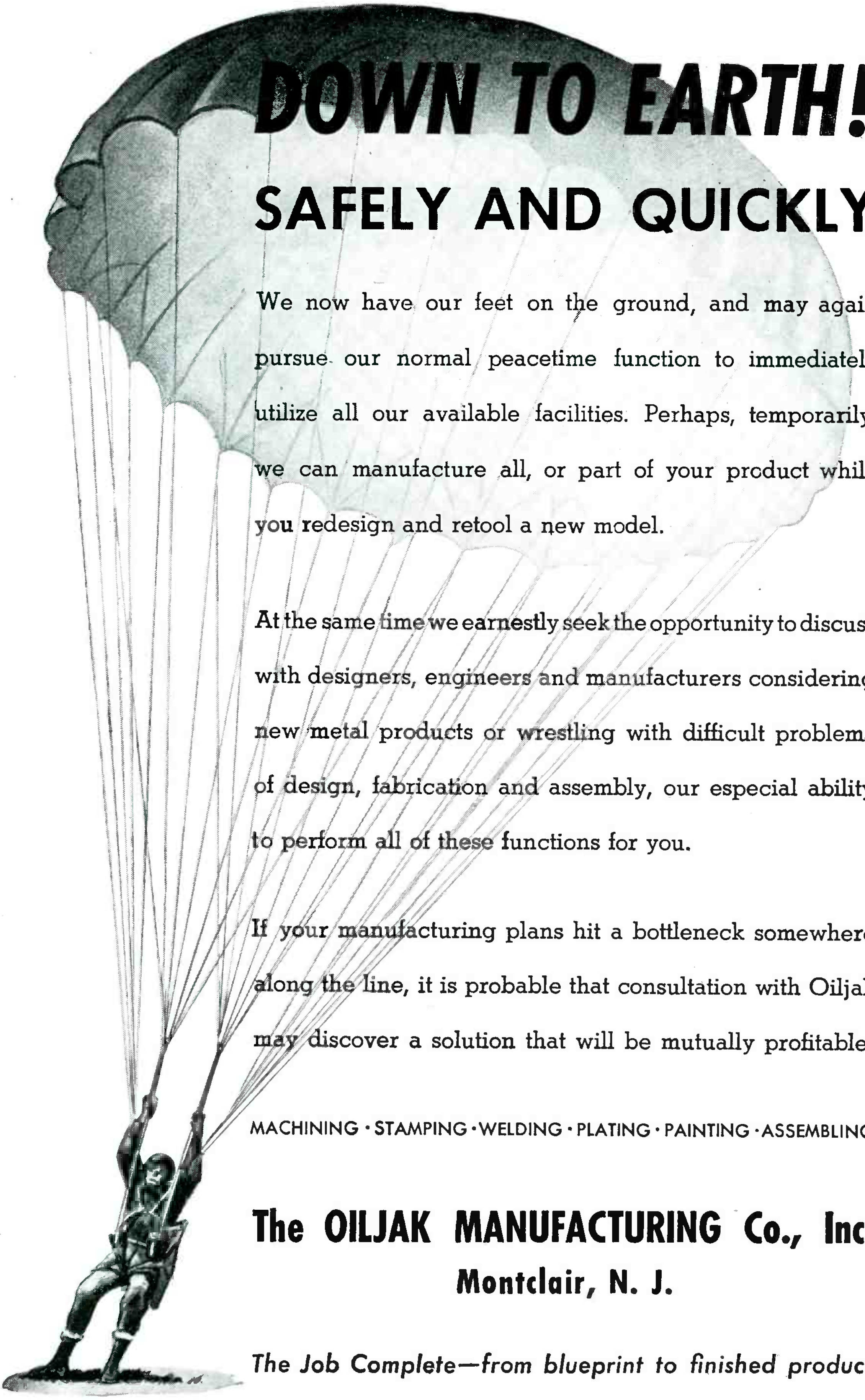

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SAFELY AND QUICKLY

We now have our feet on the ground, and may again pursue our normal peacetime function to immediately utilize all our available facilities. Perhaps, temporarily, we can manufacture all, or part of your product while you redesign and retool a new model.

At the same time we earnestly seek the opportunity to discuss with designers, engineers and manufacturers considering new metal products or wrestling with difficult problems of design, fabrication and assembly, our especial ability to perform all of these functions for you.

If your manufacturing plans hit a bottleneck somewhere along the line, it is probable that consultation with Oiljak may discover a solution that will be mutually profitable.

MACHINING · STAMPING · WELDING · PLATING · PAINTING · ASSEMBLING

The OILJAK MANUFACTURING Co., Inc.
Montclair, N. J.

The Job Complete—from blueprint to finished product

Electronic Components. Catalog No. RC-6 contains 32 pages of data on fixed and variable resistors, iron cores, line and slide switches. Stackpole Carbon Co., St. Marys, Pa.

Electron Optics. Precision Optics by American Methods is the title of a booklet from American Lens Co., Inc., 45 Lispenard St., New York 13, N. Y. The booklet contains information for television set manufacturers (or manufacturers using electron optics) on optical components or complete optical systems.

X-Ray Diffraction. Two reprints from North American Philips Co., Inc., 100 East 42 St., New York 17, N. Y. include a 4-page folder from *Rubber Age* entitled, "Use of Low-Angle X-Ray Scattering in the Study of Catalysts, Viruses and Other Materials," and a 16-page booklet entitled, "X-Ray Diffraction—Basic Theory, Principles and Applications", reprinted from *Petroleum Refiner*.

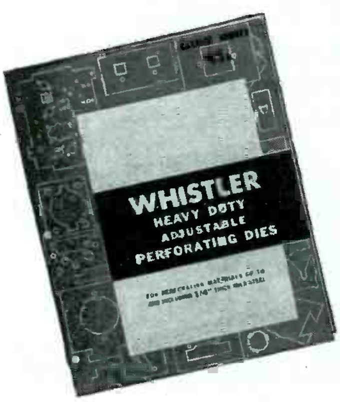
Electrical Insulating Materials. The electrical and mechanical properties of various insulating materials is contained in a 4-page quick-reference folder available from Continental-Diamond Fibre Co., Newark 12, Delaware.

Aircraft Accessories. "Electro-Mechanical Aircraft Accessories" is the title of a bound data book (No. EM-200) containing approximately 225 pages. The book contains graphs, drawings and illustrations in black and white as well as three-dimensional color pictures of such equipment as linear and rotary actuators, power units, screw jacks, flexible shafting and accessories, motors and controls. Lear Inc., Piqua, Ohio.

Beryllium. A 4-page bulletin illustrates and describes Brush beryllium metal, alloys and compounds for use in x-ray transmission and sound velocity. The Brush Beryllium Co., 3714 Chester Ave., Cleveland 14, Ohio.

PIERCING ¼" STEEL

...EASY WITH WHISTLER HEAVY DUTY ADJUSTABLE DIES



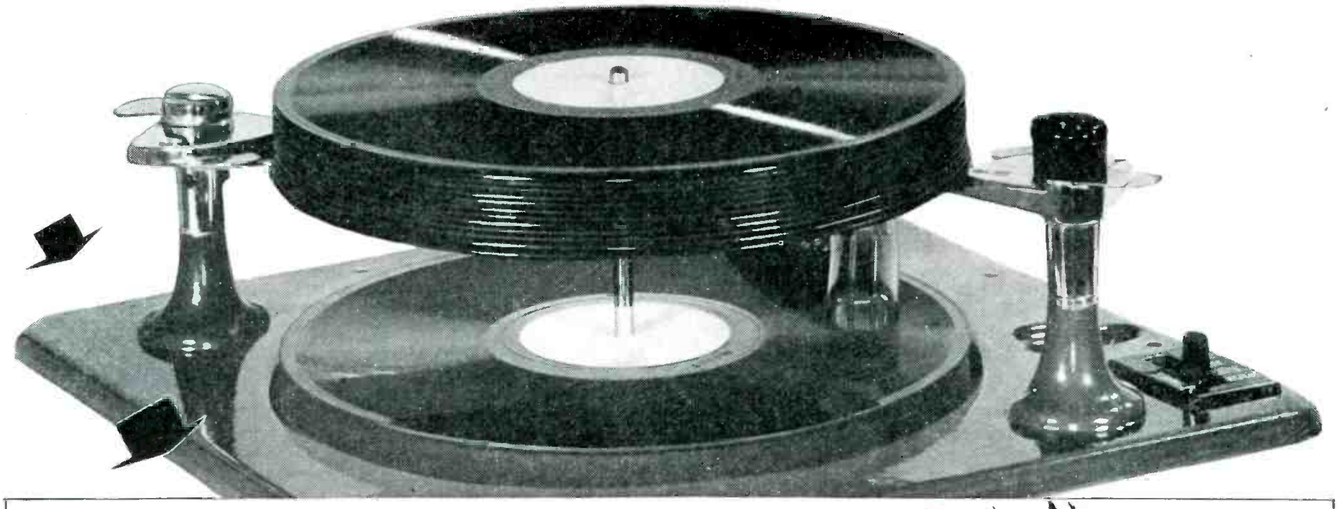
Manufacturing costs can be materially reduced and conversion speeded up by putting the "SX" series of heavy duty adjustable perforating dies to work in your plant.

Available from stock in standard sizes and shapes from ⅛" to 1½". Continued reuse in different groupings spreads original costs over a multitude of jobs. Closer centers permit more perforations per press operation. Absolute accuracy on short or long runs. Quick changeover of hole arrangements contributes to greater production from your presses.

If perforating, notching, slitting or rounding dies are used in the manufacture of your products and you are working with materials up to ¼" steel, then good business dictates that you write for the Whistler catalogs and know the time and money saving advantages of Whistler Heavy Duty Adjustable Dies.

S. B. WHISTLER & SONS, INC.

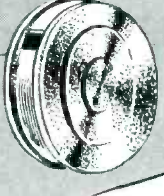
752-756 MILITARY ROAD BUFFALO 17, NEW YORK



MINIMUM FRICTION
LONG LIFE ♩ SILENT
CONSTANT SPEED

SEEBURG RECORD CHANGERS

The engineering features in SEEBURG RECORD CHANGERS are generally included in high priced professional transcription equipment.



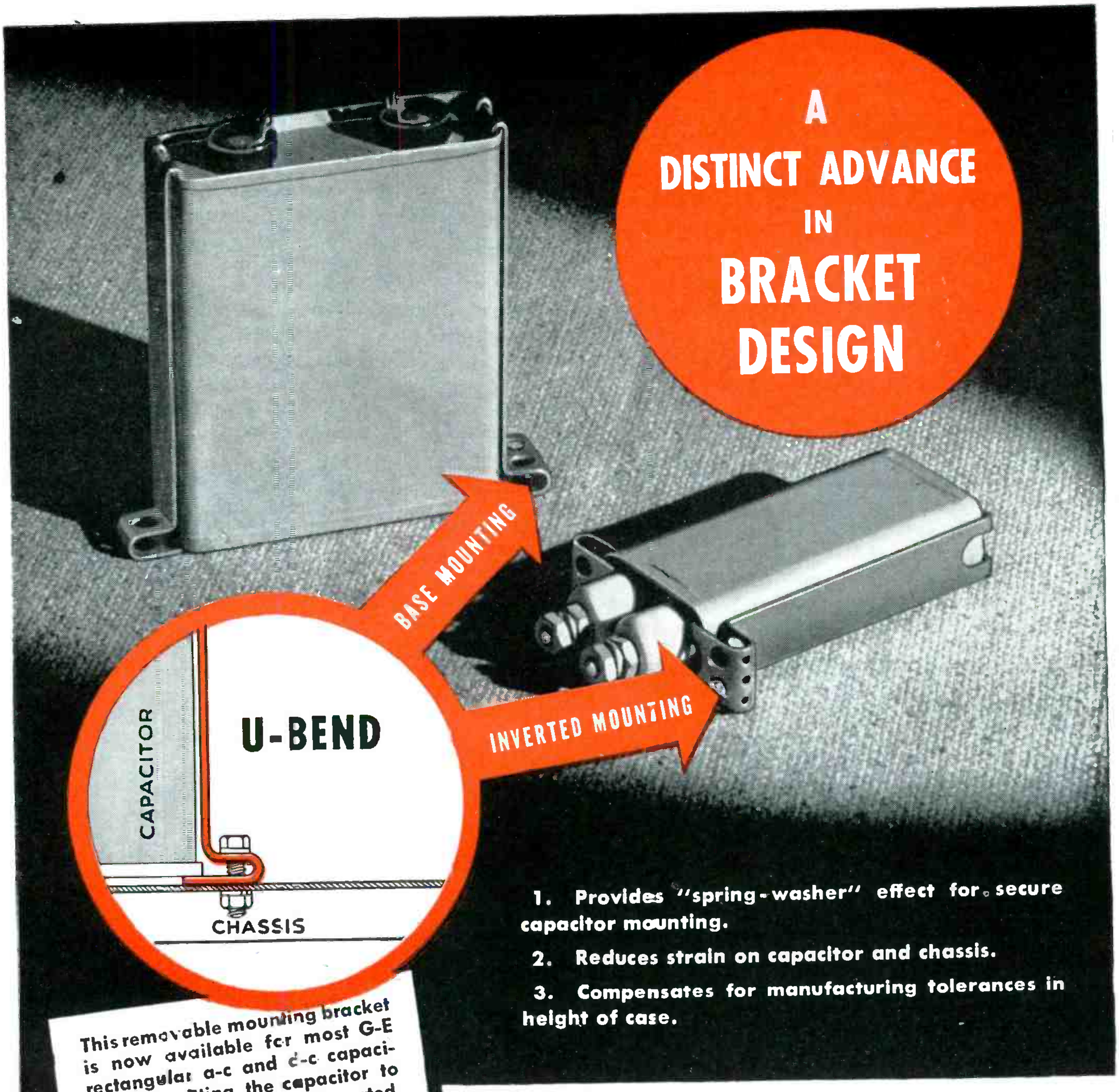
SEEBURG *Wire* RECORDER

The SEEBURG WIRE RECORDER is an electronic engineering achievement! One simple control knob operates the SEEBURG WIRE RECORDER to reproduce and record speeches, plays, meetings, music, radio programs, etc. No needles or discs are used.

IT WILL BE NECESSARY...
for radio manufacturers to make provisions in their circuits to accommodate the SEEBURG WIRE RECORDER. We therefore invite prompt inquiries from interested radio manufacturers.

Seeburg

J. P. SEEBURG CORPORATION · CHICAGO



In contrast with the conventional L-shaped bracket, this U-bend construction minimizes the stress on the metal chassis and prevents distortion when mounting bolts are tightened. The mounting foot is sufficiently flexible to compensate for normal tolerances in height of case, and for variations in dimensions of the bracket itself.

The brackets are sufficiently thick to provide strong, rigid support. A corrosion-resistant finish of lacquered zinc plate assures a good ground from capacitor to chassis. The brackets have either one or two mounting holes depending upon the width of the capacitor.

These brackets are an exclusive feature on G-E capacitors. Spade-type and L-shaped brackets can still be obtained when desired. Ask for Bulletin GEA-4357 for information on the G-E capacitors that can now be furnished with this improved feature. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

CAPACITORS

Buy all the BONDS you can
—and keep all you buy

GENERAL ELECTRIC

407-96-8700

INDUSTRIAL CONTROL

Capacitor-Discharge Roll Welder

ELECTRONIC CONTROLS and rectifiers combine with a bank of as many as 84 120-μf capacitors to operate a newly developed roll spot welder in one of the plants of Aluminum Corp. of America. Made by Federal, the unit provides speeds as high as 300 welds per minute on sheets of 0.032-in. aluminum, and can handle thicknesses up to 0.187 in.

According to the setting of controls, 1500- to 3000-volt charges are established in portions up to the total of the capacitor bank and then dumped into the welder transformer through the action of Westinghouse electronic controls, housed in the center cabinet in Fig. 2. Rectifier and voltage-regulating gear as well as part of the capacitor bank is in this same enclosure while the remainder of the capacitors are in the right-hand cabinet. Peak power demand is 100 kva on a three-phase system.

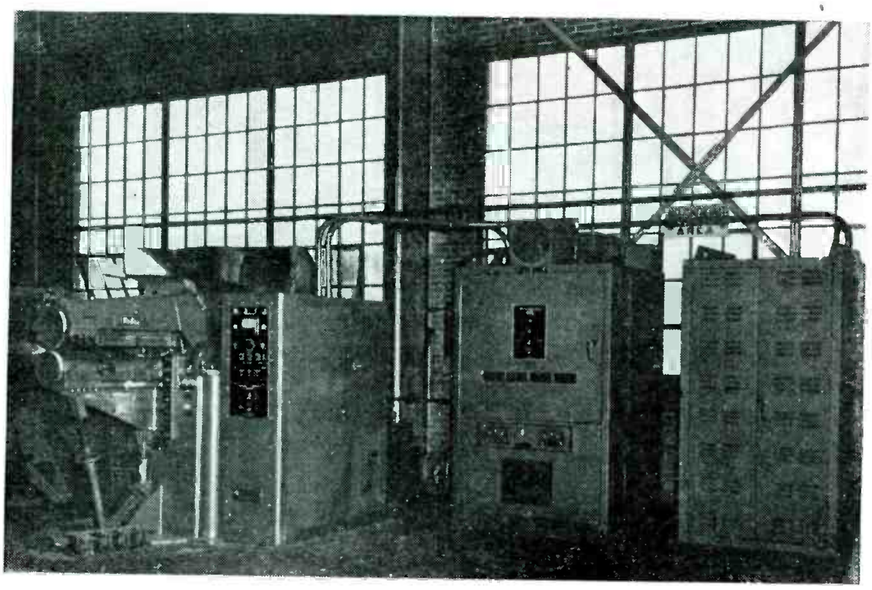


Fig. 2—Center cabinet of roll spot welder group contains main controls, rectifier, voltage regulating system, and some of the capacitors. Enclosure at right holds remainder of capacitor bank

Electronics in the Postwar Automobile

A REDUCTION of some 99.9 percent in the time required for heat-treating starter ring gears has been achieved by Studebaker Corp. with the use of electronic induction heating.

Under the old procedure, the ring gear was taken from the machining department and heated in a gas oven for an hour before quenching. A draw followed to temper the body of the ring, requiring another hour and a half.

Now, an electronic heater is located in the machining department in proper manufacturing sequence. Gear teeth are brought to a specified 1500 deg within 13 seconds and water-quenched on the spot within 7 seconds.

The illustration shows the fixture in use. Surrounded by a two-layer, water-cooled coil, the gear is brought to temperature in a 540-kc field. At the conclusion of the heating cycle, the gear is rotated at 75 rpm while quench water is applied through the outer perforated tube.

In addition to the time saved by this process, there are other advantages. It is possible to harden the part with the same precision used in machining it. Only the teeth are hardened. This aids in later assembly since the ring is expanded to fit with a permanent grip on the flywheel and all over hardening used to be a detriment in this operation. Tests show that the ring will withstand four times the number of starts expected in the normal life of an automobile and rejection from distortion and brittleness has been all but eliminated.

Flywheel ring gear for a Studebaker is set up in the hardening fixture recently added to the production line. With this equipment, a better gear is produced with a 99.9 percent reduction in heat-treating time

Infrared Spectroscopy for Rapid Analysis

THE ACCOMPANYING ILLUSTRATION shows a new infrared spectroscope and its developer, Dr. Donald K. Coles of Westinghouse Research Laboratories.

A sample of material—liquid, solid, or solution—is placed in the special holder in Dr. Coles' hand

There Is An Audiodisc And An Audiopoint For Every Recording Need

AUDIODISCS have all of the features essential to high fidelity recording. A superior lacquer is applied by a unique process that gives a flawless surface. In cutting, the thread throws well and there is no static. In playback, whether at once or in the future, there is low surface noise. Their playback life is unequalled. There are six types of AUDIODISCS:

RED LABEL tops all accepted quality standards for professional use. Double-sided in 6½", 8", 10", 12" and 16' diameters.

SINGLE FACE RED LABEL brings new economy to applications requiring but one side. 12" and 16" diameters.

YELLOW LABEL, Double-sided blanks of uniform quality and "wide latitude." Extra-fine adjustments unnecessary. Sizes as Red Label.

REFERENCE permits extreme economy in test-cuts, filing and reference recordings. Double-sided in 10", 12" and 16" diameters.

MASTERS for choice copies (pressings) after electroplating. Double or single face in 12", 13¼" and 17¼" diameters.

BLUE LABEL best discs at low cost. Thin aluminum base, same recording lacquer as professional AUDIODISCS. 6½", 8" and 10".

All AUDIODISCS are manufactured on aluminum base—and glass base too, except for the 6½" and Blue Label type.

AUDIO DEVICES, INC., 444 MADISON AVE., N. Y. C.

AUDIOPOINTS

Audiopoints, made by skilled craftsmen, are available in three types of recording styli and three types of playback points. Cutting and playback points are matched to give finest performance.

RECORDING POINTS

SAPPHIRE NO. 14, for professionals, designed to give proper thread throw. No finer made.

STELLITE NO. 34, professional type. Cuts quiet, shiny groove for several hours.

DIAMOND-LAPPED STEEL NO. 50, cuts a fine, quiet groove, gives from 15 to 30 minutes actual recording time.

PLAYBACK POINTS

SAPPHIRE NO. 113, finest obtainable. Complete fidelity and minimum disc wear.

BENT SHANK NO. 154, for heavy pickups.

STRAIGHT SHANK STEEL NO. 151, for light pickups.

Audio's resharpening and repolishing services give real economy in the use of **AUDIOPOINTS**, Nos. 14, 34 and 113. Consult your local dealer.

THEY SPEAK FOR THEMSELVES

they speak for themselves **audiodiscs**

Electronic function serves the infrared spectroscope at Westinghouse Research Laboratories. Infrared light output is converted to electrical current, amplified, and recorded on a pen-writing chart

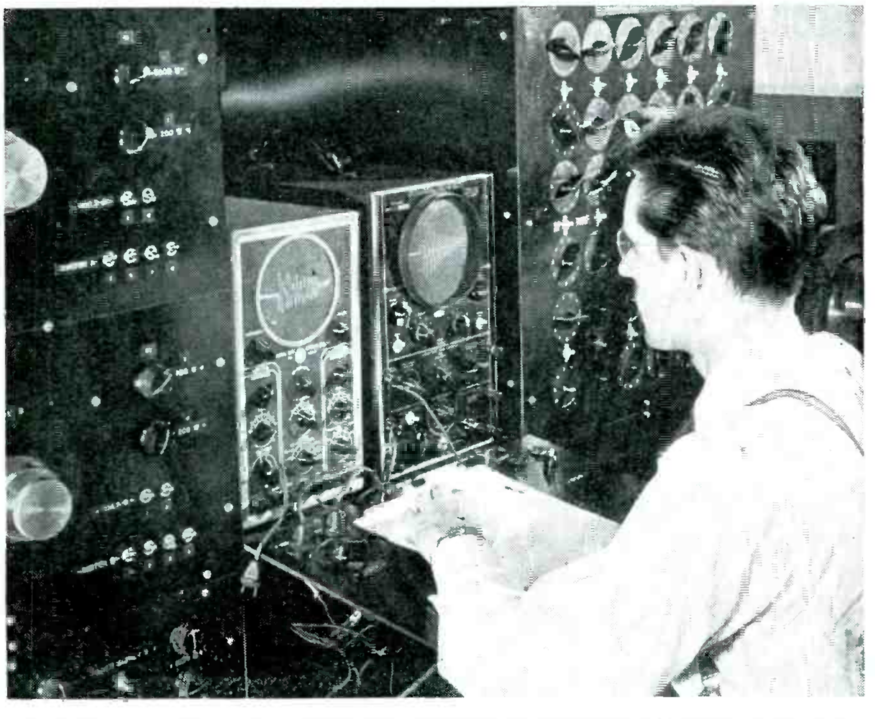
and inserted in the unit so a beam of infrared light, produced by a heated silicon-carbide rod, is directed through it. The invisible light is conducted along a 30-ft zigzag path by the action of mirrors and prisms, which are visible in the illustration, and ends up at a sensitive receiver which converts the light into electrical current. From there it is amplified and recorded on a pen-writing chart outside the machine.

Dips and peaks in the chart reveal the identity of materials in the sample and tell how much of each is present. Depending upon ambient temperature, molecules of each element have their own resonant frequency. Material in the sample manifests itself by absorbing infrared light at its own particular frequency. The resulting chart interprets the attenuation of a frequency as the presence of its corresponding material.

Cathode-Ray Tube Solves Production Problems

INTRICATE MATHEMATICAL PROBLEMS which might require years of ordinary calculations are solved in a few days by the mechanical transient analyzer shown here being operated by Dr. Gilbert D. McCann, who together with Harry E. Criner, developed the unit at Westinghouse Electric Corp.

Originally designed to meet new problems in the design of turbogenerator units, the analyzer has been pressed into service on such diverse calculations as those involved in vibration studies on ship propulsion equipment and the mechanics of packing electron tubes against damage in shipment.



Cathode-ray oscilloscopes provide the answers to mathematical problems in new Westinghouse analyzer

Electrical counterparts are assigned to all the mechanical factors involved in a problem, circuits are connected in appropriate sequence, and transient impulses are applied by rotating mechanical switches. The solutions are written on cathode-ray screens of conventional oscilloscopes.

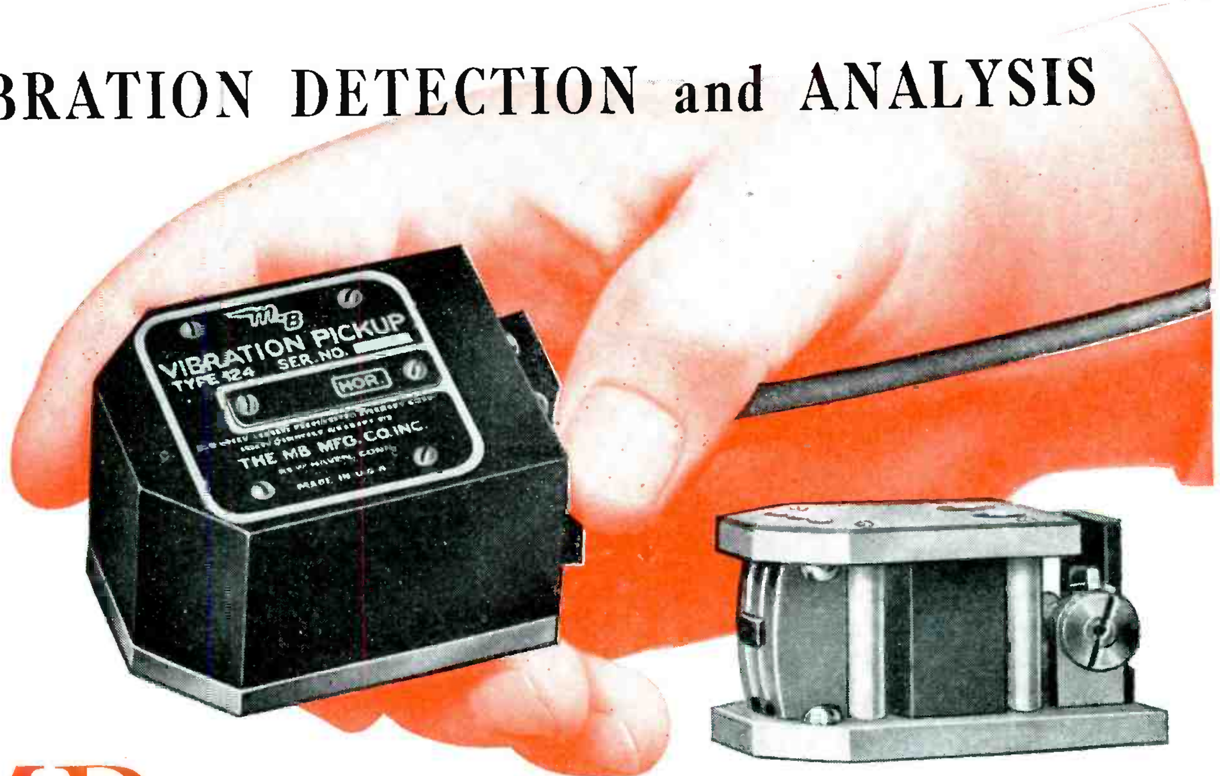
"Engineers have long recognized a relationship between mechanical and electrical systems," says Dr. McCann, "but the development of apparatus to carry through these relations for a practical purpose has been a stumbling block to their full use." The particular development which made the new analyzer possible is a specially constructed low-loss inductance which permits the representation of mechanical systems with extremely low damping.

Electronic Fuel Gaging

MINIMIZING ERROR and increasing reliability are two of the main achievements of a capacitor-type electronic fuel gage designed for

A HELPING HAND FOR...

VIBRATION DETECTION and ANALYSIS



MB VIBRATION PICKUP

SENSITIVE TO LOW AMPLITUDE VIBRATIONS, and exceptionally durable under *severe* vibratory conditions, this MB Pickup can be used on a wide range of equipment . . . from small, high-speed rotary motors, to massive, high-powered engines.

It has a high output signal level. With standard equipment, accurate vibratory wave forms can be seen, studied, and recorded.

The MB Pickup is usually operated as a seismic instrument. A lightweight coil, free to move in a powerful magnetic field, generates a voltage proportional to vibratory velocity. Though the complete unit weighs only 8½ ounces, where this weight would influence vibrations, provision can be made for attaching the very light coil directly to the tested structure.

Electrically damped, the MB Pickup maintains its calibration under wide temperature ranges. It can be used in horizontal or vertical planes without affecting the calibration. Adjustment is simple, quick.

Vibration reduction is an essential for product improvement—for extending service life. And the first step is accurate location and diagnosis. You'll find the MB Pickup a big help. Write for 4-page folder. It gives you complete details, specifications.

THE MB MANUFACTURING COMPANY, INC.
Vibration Division
1066 State Street, New Haven 11, Conn.

THE MB MANUFACTURING COMPANY, INC.
Vibration Division.
1066 STATE STREET, NEW HAVEN 11, CONN.
Please send descriptive folder on the Vibration Pickup.

Name .... *Position* ....

Company ....

Address ....

VIBRATION DIVISION

VIBRATION ISOLATOR UNITS AND MOUNTINGS • SPECIAL VIBRATION TEST EQUIPMENT

For Quick Visual Indication

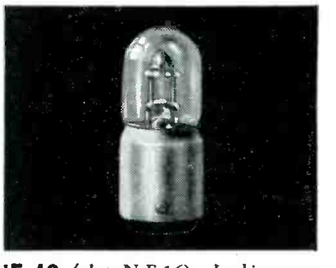
Investigate the Unique Characteristics of G-E Neon Glow Lamps

THE unique characteristics of General Electric Neon Glow Lamps recommend them for a variety of uses in radios and electronic devices . . . as indicators, voltage regulators, pilot lights and test lamps.

The uses described at right are typical. If you think G-E Neon Glow Lamps can be useful to you, write or phone the address below. Experienced General Electric Lamp Engineers will be glad to discuss your problems with you.

NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.

NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.



NE-48 (also N-E 16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*

*NE-16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.

CONSIDER THESE ADVANTAGES

1. **Distinctive orange-red glow — no colored cover glass needed.**
2. **Dependable performance and long life — rated at 3,000 hours.**
3. **Very low current consumption — less than ½ milliampere for smallest lamp.**
4. **Variety of sizes and wattages.**
5. **High resistance to vibration, shock.**
6. **Normally usable on a-c or d-c.**
7. **Screw base lamps for 105-125 v. circuits; similar lamps available with bayonet bases, but external resistance required.**
8. **Produce practically no heat.**
9. **Nearly flat volt-ampere characteristics.**
10. **Insensitive to voltage variations above critical value.**

ORDER NO.	NE-2	NE-51	NE-17	NE-48	④ NE-16	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts, Nominal	1/25	1/25	③	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage ① AC / DC	65 90	65 90	③	65 90	— ⑤	65 90	60 85	60 85	60 85	60 85	60 85	60 85
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Maximum Overall Length	② 1 1/16"	1 3/16"	1½"	1½"	1½"	1⅝"	2 1/16"	2"	3 5/16"	3¾"	3 5/16"	3¾"
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

① Applies to lamp when new.
② Glass part; wire terminals extend additional 13/16".
③ Designed for DC flashing operation in RC circuit.
④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION, LAMP DEPARTMENT

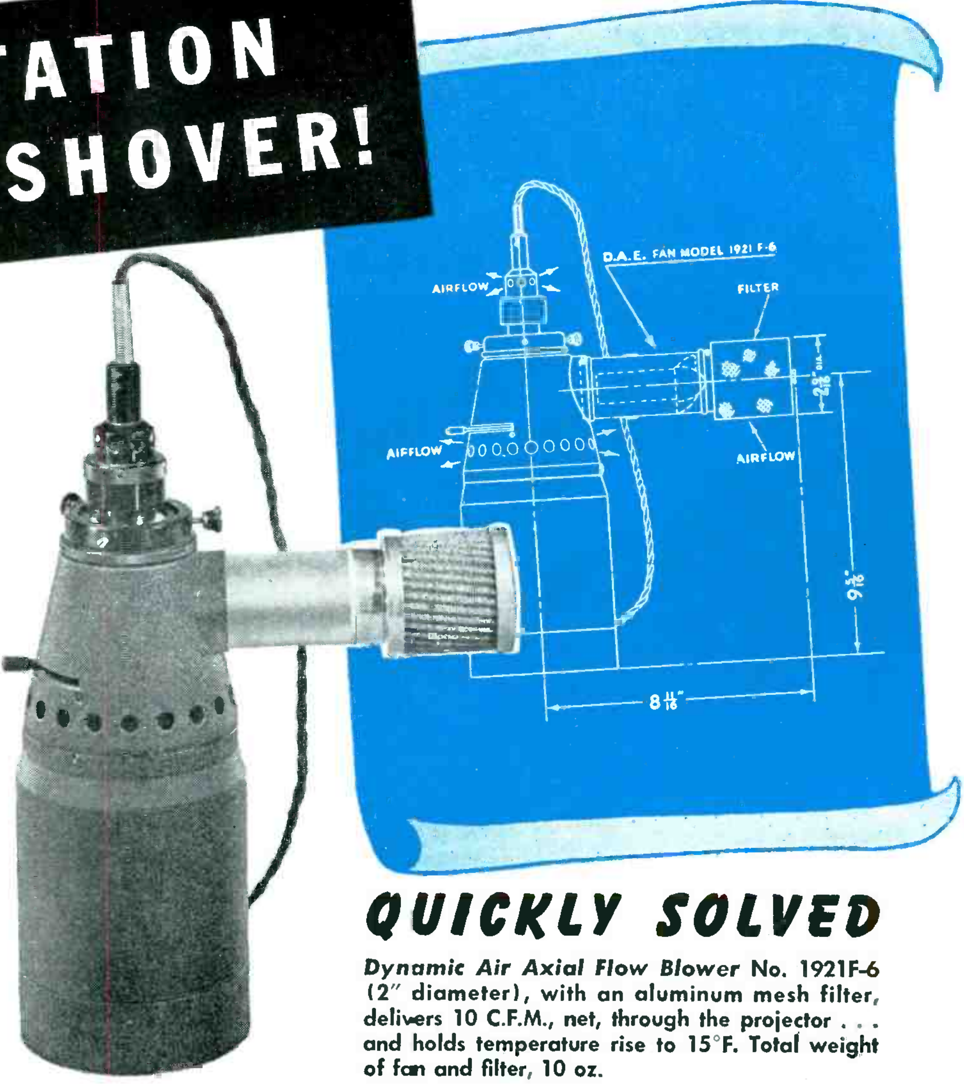
GENERAL ELECTRIC

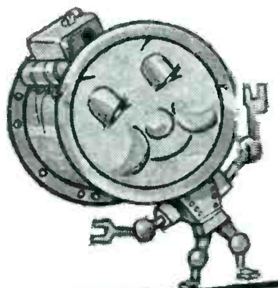
1 Newark Street, Hoboken, N. J.

ADAPTATION IS A PUSHOVER!

PROBLEM

To cool the portable projector to a maximum temperature rise of 35°F on the case surface, and to filter inlet air, eliminating dust from the air stream to keep multiple lenses clean. Current available: 20-23 V., D.C.





QUICKLY SOLVED

Dynamic Air Axial Flow Blower No. 1921F-6 (2″ diameter), with an aluminum mesh filter, delivers 10 C.F.M., net, through the projector . . . and holds temperature rise to 15°F. Total weight of fan and filter, 10 oz.

Once the facts of the problem were known, adaptation of a Dynamic Air Axial Flow Blower and a Dynamic-designed heating unit to deliver the correct air flow at the required temperature rise was a "pushover" for Dynamic's experienced air engineers! This problem is typical of help they are giving in many fields—for both war and postwar needs.

Pioneered by 14 years' laboratory and field development work, Dynamic's Axial Flow Blowers are the most advanced application of the "air delivered in a straight line" principle . . . with a big saving in space, weight and horsepower input.

If you have an air movement problem in connection with present or projected equipment, take advantage of Dynamic's long experience in solving difficult blower problems . . . *write or wire today!*

DYNAMIC AIR AXIAL FLOW BLOWERS—ENGINEERED TO SAVE SPACE, WEIGHT AND HORSEPOWER — ARE BEING USED FOR:

- Electronic tube cooling
- Airplane heating
- Warm air furnaces
- Oil burners
- Stokers
- Refrigeration locker plants
- Quick freeze units
- Trains and buses
- . . . and for many other types of equipment requiring blowers.

GENERAL SPECIFICATIONS

24/28-V D.C.	1/500 to 4 h.p.
115-V D.C.	1/100 to 4 h.p.
115-V A.C.	1/100 to ½ h.p.
400-cycle A.C.	1/500 to 1 h.p.

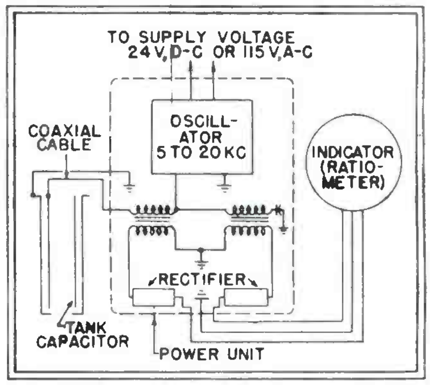
Prototypes Available

DYNAMIC AIR ENGINEERING Inc.
LOS ANGELES, U. S. A.
DESIGNERS and BUILDERS of HIGH EFFICIENCY AXIAL FLOW EQUIPMENT

aircraft use and shown in the accompanying illustration. The components of the system include a capacitor sensing unit, a power unit, and a cockpit indicator.

As shown in the circuit diagram, the unit contains an oscillator section consisting of a single-tube oscillator that generates a frequency of approximately 10,000 cps.

The output frequency of this oscillator is impressed on two parallel circuits, each containing a capaci-

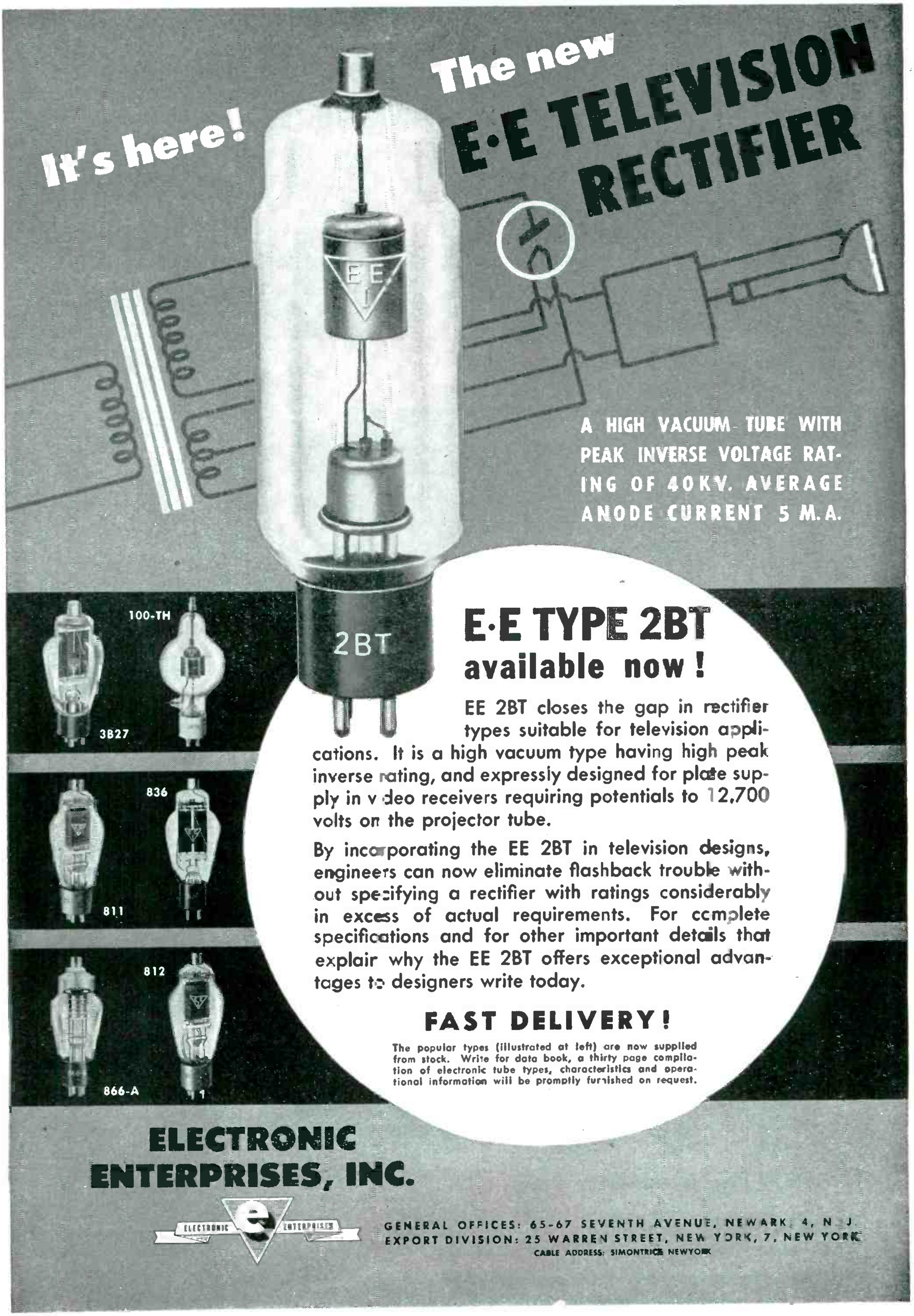


Circuit of gage that measures fuel to within three percent accuracy over all ranges of temperatures. Oscillator section consists of a single-tube generator

tor and an inductor. As shown, one of the capacitors is the tank unit whose capacitance varies as a function of the depth of fuel in the tank—its dielectric changes from 100 percent fuel to 100 percent air by intermediate stages as the fuel level is varied.

The other capacitor is fixed and serves as a reference for the variable capacitor. The cockpit gage takes the form of an indicating instrument reading the ratio between the rectified output of the fixed and variable circuits. The a-c voltage going to the rectifier on the variable side changes in ratio with the fuel level plus variations in the voltage and frequency from the oscillator. However, since the fixed side also exhibits the latter variations, the final ratio is independent of such irregularities.

The circuit designed by Simmonds Aerocessories, Inc., of New York, is such that accuracy of indication is maintained within one percent upon the replacement of any tube in the power unit. Failure of the tube will affect only one circuit,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The new
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E·E
2BT
A HIGH VACUUM TUBE WITH PEAK INVERSE VOLTAGE RATING OF 40KV. AVERAGE ANODE CURRENT 5 M.A.
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E·E TYPE 2BT
available now!
EE 2BT closes the gap in rectifier types suitable for television applications. It is a high vacuum type having high peak inverse rating, and expressly designed for plate supply in video receivers requiring potentials to 12,700 volts on the projector tube.
By incorporating the EE 2BT in television designs, engineers can now eliminate flashback trouble without specifying a rectifier with ratings considerably in excess of actual requirements. For complete specifications and for other important details that explain why the EE 2BT offers exceptional advantages to designers write today.
FAST DELIVERY!
The popular types (illustrated at left) are now supplied from stock. Write for data book, a thirty page compilation of electronic tube types, characteristics and operational information will be promptly furnished on request.
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EXPORT DIVISION: 25 WARREN STREET, NEW YORK, 7, NEW YORK
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6 different brands of *Varnished Tubing*

. . . TO COVER EVERY KNOWN REQUIREMENT

- Standard
- Double Saturated
- Triple Strength
- Impregnated
- Hygrade
- Mirac

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M-R Fibreglas Varnished Tubings are made in four grades; Standard; Double Saturated; Triple Strength and Impregnated.

STANDARD GRADE has maximum flexibility, is treated with a minimum of varnish and recommended for high temperatures where dielectric strength is not a factor.

DOUBLE SATURATED has all qualities of the Standard Grade but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

TRIPLE STRENGTH is built up with coats of especially flexible insulation varnish for dielectric ratings up to 3,000 volts and is particularly suited where assembly operations include the possibility of rough handling.

IMPREGNATED is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 8,000 volts and is unequalled for Long Life Under Most Severe Conditions. Write For Samples.

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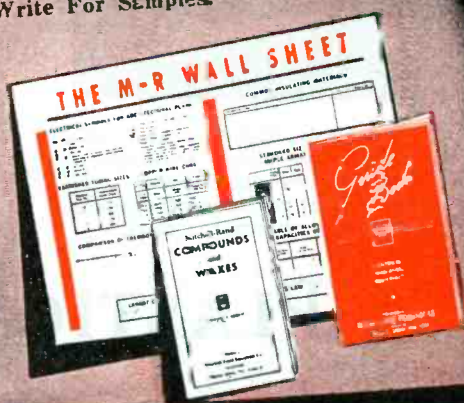
The Mitchell-Rand HYGRADE and MIRAC Varnished Tubings of long staple fibre yarn are comparable to Fibreglas Tubings in dielectric ratings, tensile strength, flexibility and long life. Write For Samples.



FREE FOR THE ASKING

Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drill sizes, etc.

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Insulating Varnishes of all types
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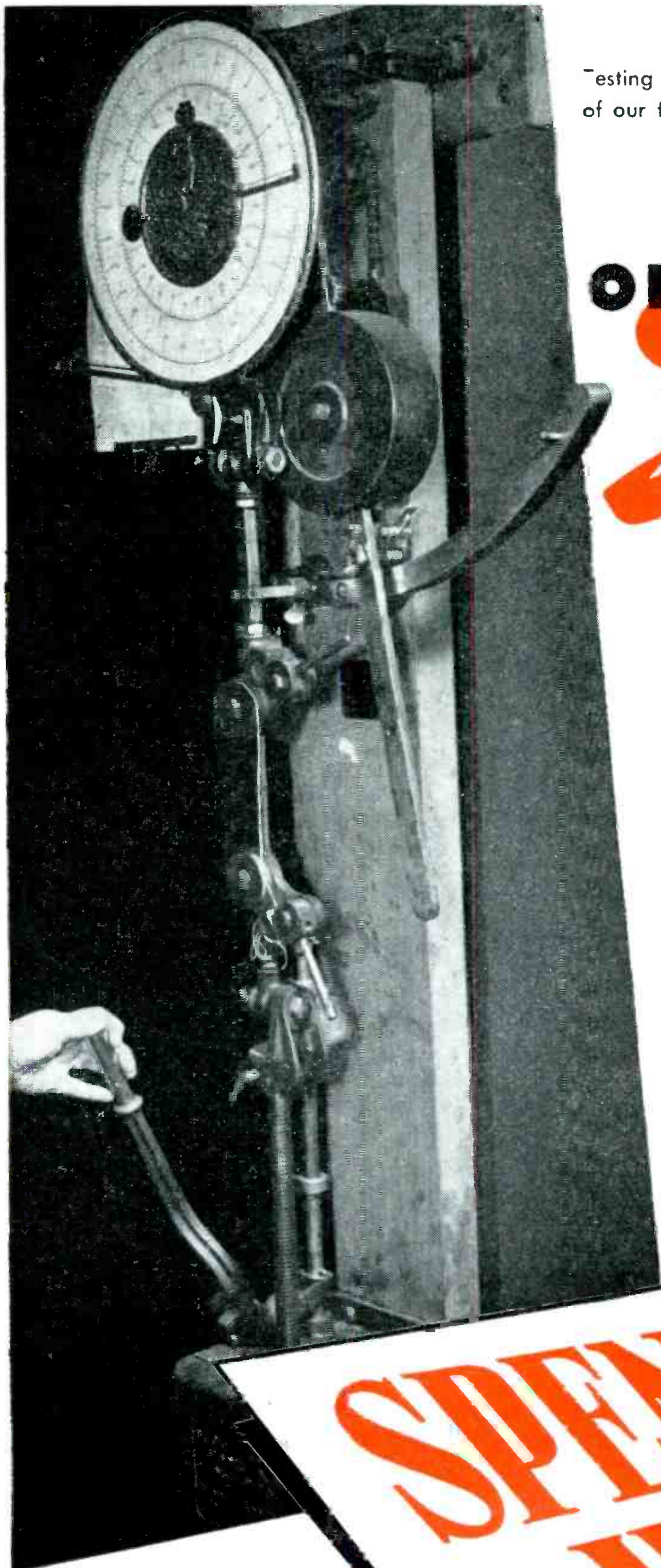

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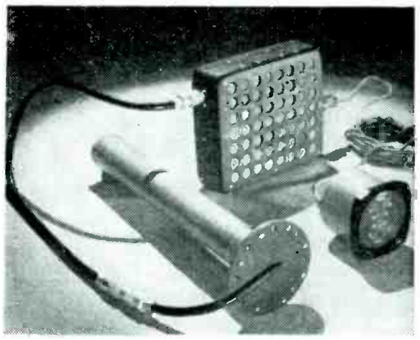
WEST BROOKFIELD PLANT
WEST BROOKFIELD - MASS.

thus only one indicator reading. Failure of the tube causes the indicator to read off scale.

Four types of sensing units for tank mounting are provided. They include a flange type as shown in the illustration, a non-flange type which mounts by bolts to the inner walls of fuel tanks, a quick-assembly type held in self sealing tanks by cemented synthetic end-fittings, and



Capacitor-type electronic fuel gage is composed of tank unit, power unit, and cockpit indicator. Coaxial cable is used between tank and electronic section in power unit. No. 22 wire to indicator

a stiffener type which serves as a structural member of the tank in addition to its sensing element functions.

Power units are supplied for use with d-c or a-c power supply—d-c units approximating $1\frac{3}{4}$ lb per indicator and a-c units running a little more.

Indicator

Cockpit gages are available in single and dual 100-deg arc types and small and large 250-deg units. Absolute adjustment for full and empty are made directly on the indicator, permitting calibration by a single individual. It is recommended that indicating gages be calibrated in weight of fuel rather than liquid measure, since this is more accurate. Junction transformer heads are used for multiple-tank unit installations as a means of hooking up inner and outer tube connections so that capacitances can be added.

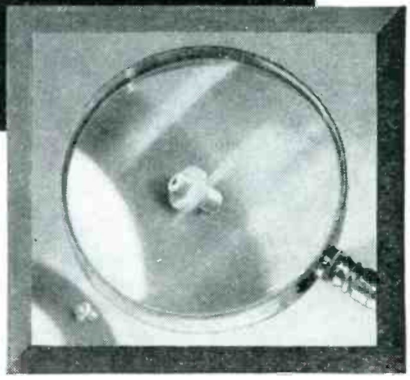
• • •

High-speed Components Tester

SUITABLE FOR THE high-speed testing of capacitors and inductors, the circuit of an electronic limit bridge shown below utilizes a pair of 6E5

SIZE DOESN'T MATTER

Transmission Line Support Arm



Radio Tube Cathode-Heater Insulator

. . . to STUPAKOFF

LARGE or small, simple or complicated, if the need is for the proper ceramic insulators the place to get them is Stupakoff. Two generations of experience, engineering knowledge, continuous laboratory research, and that intangible but most valuable asset—ingenuity, are concentrated on the solution of every insulation problem which comes to Stupakoff.

Precision in the final product is assured through absolute control over every procedure from selection of raw materials to final packing.

Quality comes first with Stupakoff, but is closely followed by efficiency which is extended to every known economy obtainable through the use of up-to-date equipment, specialized trained workers, and modern volume production methods.

Stupakoff takes pride in its ability to produce the finest, most intricate precision ceramics obtainable. The toughest ceramic problem you can pose is a challenge to Stupakoff engineers, and they never refuse a challenge.

Consultation entails no obligation. Write, wire or phone us.

★ *BUY VICTORY BONDS* ★

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STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Products for the World of Electronics

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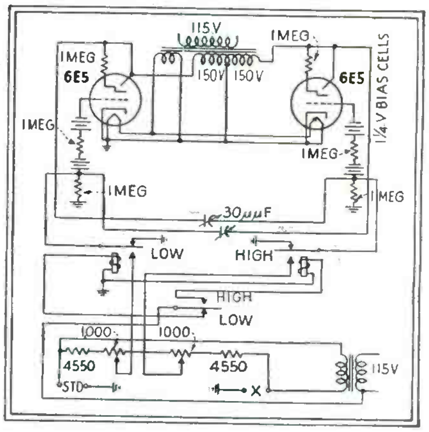
cathode-ray indicator tubes for high and low indication. This saves the time which might be lost waiting for a meter needle to come to rest.

Involving the circuit of a modified Wheatstone bridge as shown, the instrument can be used to



Circuit arrangement of capacitance and inductance limit bridge for high-speed production testing

measure impedances at 60 cps from 600 ohms to 2.6 meg which allows coverage of 0.001 to 4 μf in capacitors and 2 to 7000 henrys in inductors. Limit dials are continuously variable from 0 to 30 percent low and from 0 to 40 percent high, and accuracy is within ± 1 percent of the standard.

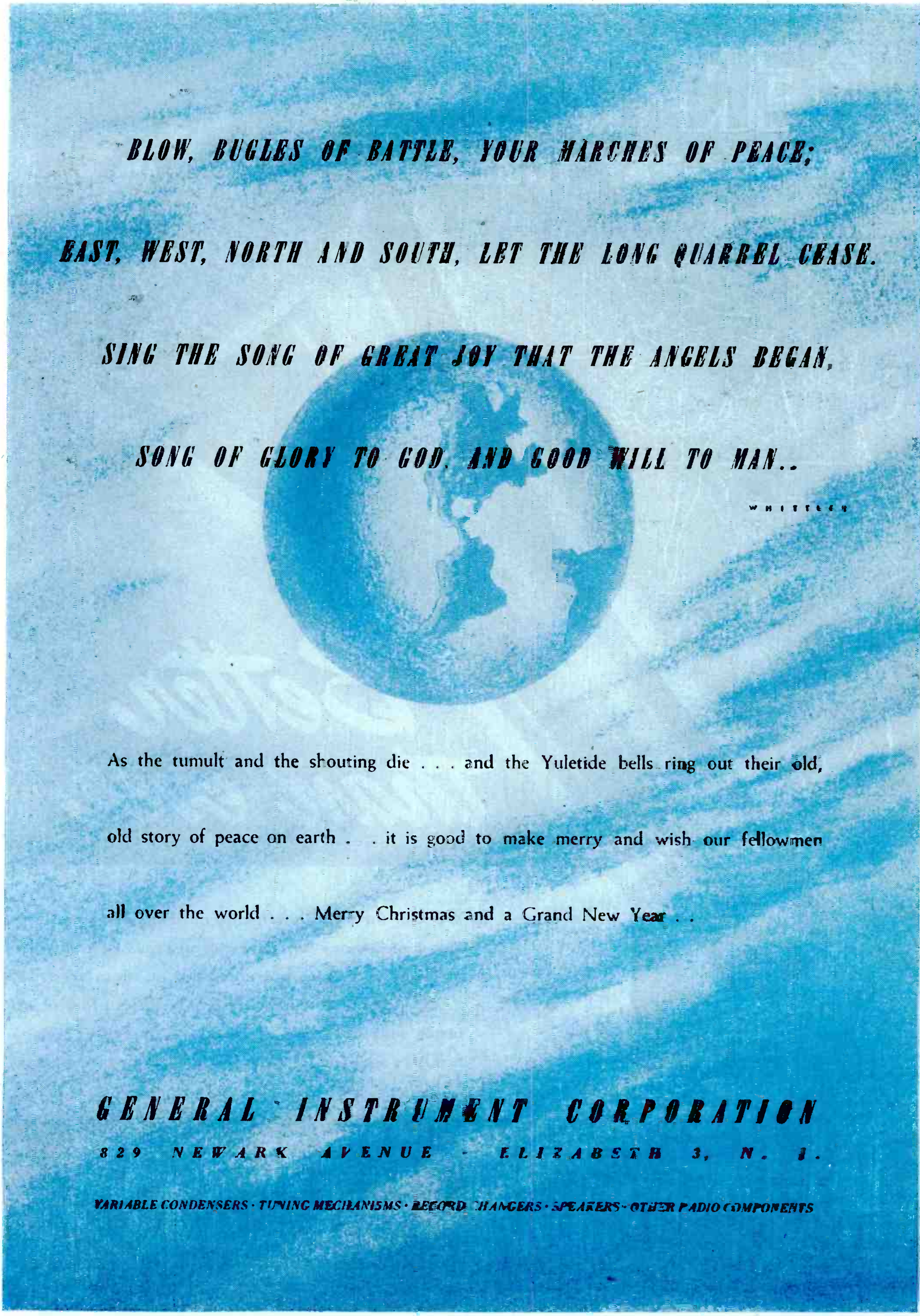
Provision is made by Industrial Instruments, Inc. for attachment of special external test fixtures by which production testing speeds on capacitors, for instance, can be brought up to 1000 per hour. An inbuilt test switch and arrangements for connection of a breakdown or insulation-resistance tester and a shorting contact to discharge capacitors at the end of testing are incorporated in one such fixture.

• • •

Highway Radio Control of Truck Traffic

SUCCESSFUL TESTS have been concluded by Galvin Mfg. Corp. and Standard Freight Lines using standard f-m on 30 to 40 mc to investigate the possibilities of radio for traffic control, dispatching, and routing of trucks.

These tests showed that two-way communication between trucks and fixed stations can be maintained


BLOW, BUGLES OF BATTLE, YOUR MARCHES OF PEACE;
EAST, WEST, NORTH AND SOUTH, LET THE LONG QUARREL CEASE.
SING THE SONG OF GREAT JOY THAT THE ANGELS BEGAN,
SONG OF GLORY TO GOD, AND GOOD WILL TO MAN..
WHITTIER
As the tumult and the shouting die . . . and the Yuletide bells ring out their old, old story of peace on earth . . it is good to make merry and wish our fellowmen all over the world . . . Merry Christmas and a Grand New Year . .
GENERAL INSTRUMENT CORPORATION
829 NEWARK AVENUE · ELIZABETH 3, N. J.
VARIABLE CONDENSERS · TUNING MECHANISMS · RECORD CHANGERS · SPEAKERS · OTHER RADIO COMPONENTS

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● Write for your copy of "Essential Characteristics" the most complete digest of tube information available.
KEN-RAD
DIVISION OF GENERAL ELECTRIC COMPANY
OWENSBORO, KENTUCKY
178-D12-8850

over a distance of about 50 miles while signals from the fixed station to the truck can be heard up to 80 miles. It is expected that 100,000 mobile units and 1000 land stations will be established in the months to come.

As illustrated, the installation has a control panel incorporating squelch and volume controls, a microphone plug, and signal lights to indicate whether the unit is set to receive or transmit. The loudspeaker mounts above the windshield. Two cabinets house the transmitting and receiving equipment which is operated from the regular storage battery. A whip-type antenna, mounted on the cab roof, hinges to prevent breakage. Design is for ease of understanding by inexperienced personnel.

Operating simplicity is a prime feature of f-m installation in truck freighter. Designed by Motorola, the transceivers have been tested in trucks of Standard Freight Lines

• • •

Pressure Sensing Unit Developed from Strain Gage

BASED ON THE PRINCIPLE of the familiar SR-4 strain gage, a new instrument known as the SR-4 pressure sensitive device has been introduced by Baldwin Locomotive Works. It is used to convert gas or liquid pressure to electrical energy for measuring, recording, and controlling purposes.

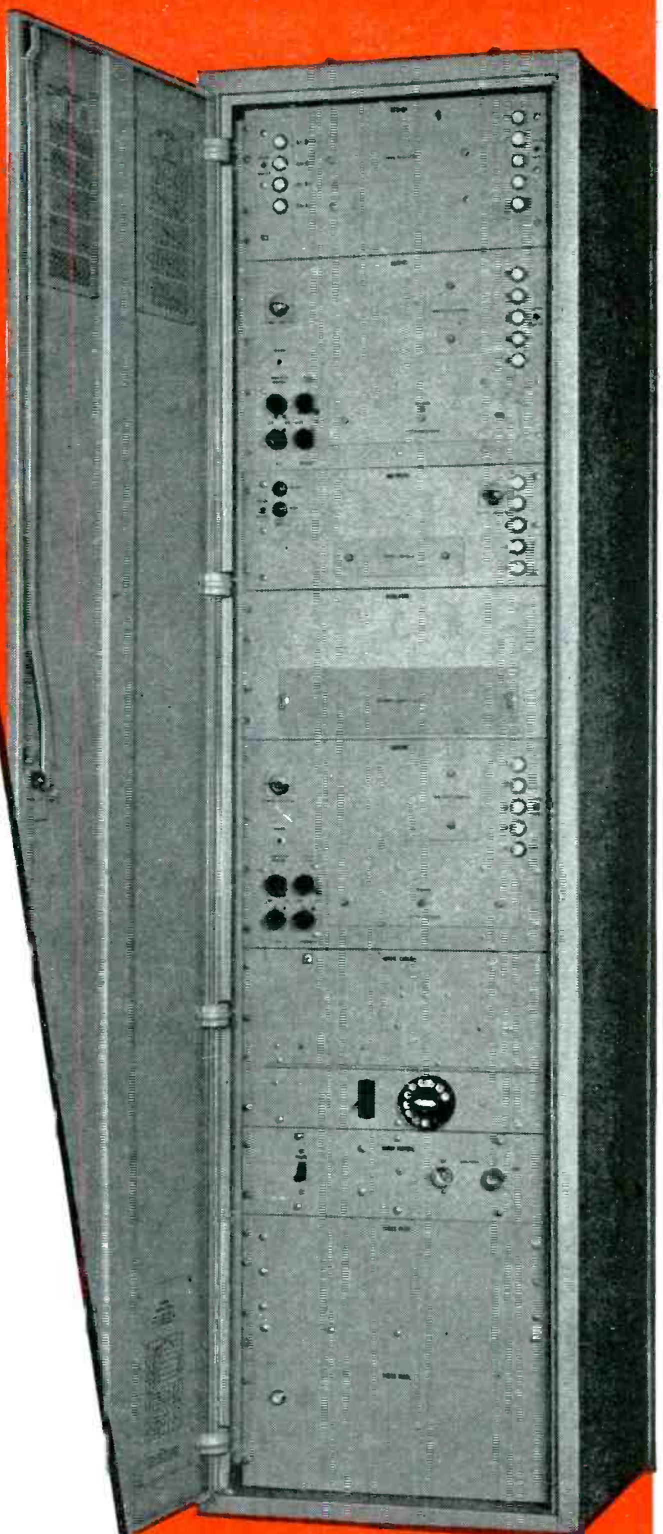
Designed in a series of ranges, the units have a top capacity of 0 to 20,000 psi and consistently reproduce an accuracy of 0.25 percent of full scale. This accuracy means that

DUAL DIVERSITY RECEIVERS

by PRESS WIRELESS

- Two identical superheterodyne receivers with isolating antenna matching network
- Five pre-tuned bands 2.4-23 megacycles
- Common crystal or self-excited HFO and BFO in thermostatically controlled oven
- Interlocking diversity AVC action
- Four diversity antenna combinations
- Electronic "eye" tuning indication
- Local and remote dial control
- Self contained power supply
- Cabinet rack and 19" panel construction

ENGINEERING BULLETIN SENT ON REQUEST



DUAL DIVERSITY RECEIVER
Press Wireless Model 6019A

PRESS WIRELESS, INC.

Executive and Sales Office, **1475 BROADWAY, NEW YORK 18**

Awarded to our Hicksville, L. I. plant for outstanding achievement in war production.

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There are fourteen practical advantages of theremoplastic insulation over older types of construction . . . advantages which PLASTIC engineering now makes possible at what, in most cases, is NO PRICE PREMIUM. Check them yourself: 1. Superior aging properties, 2. High resistance to oxidation, 3. Low moisture absorption, 4. High dielectric strength, 5. High tensile strength, 6. Resistance to flame, 7. Flexibility at low temperatures, 8. Resistance to abrasion, 9. Resistance to chemicals, 10. Resistance to oils and greases, 11. Ease of installation, 12. Increased capacity, 13. Attractive appearance, 14. Broad color range. Remember . . . when you're thinking of PLASTIC you're thinking of US!

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the devices can be used for hitherto impossible operations.

A fine filament of wire bonded to a hollow metal core is the heart of the device. The gas or liquid pressure to be measured is applied against this core. Increasing pressure stretches the filament and causes measurable changes in its electrical resistance. Resulting current changes are amplified and used to actuate a control system or they are read on an indicating instrument. Stretch of one-millionth of an inch can be detected.

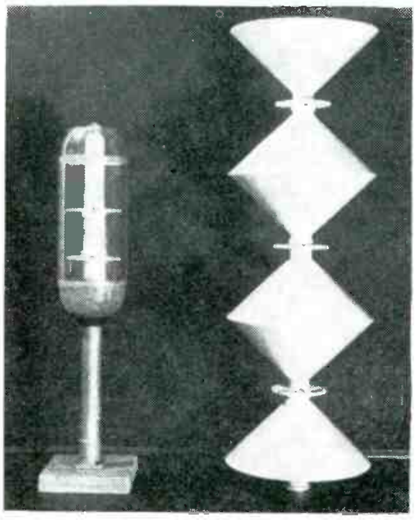
The unit is hermetically sealed and has an inbuilt compensator to cancel out the effect of any such extraneous force as temperature may produce. Size of the complete device is only one in. diameter by 5½ in. long.

• • •

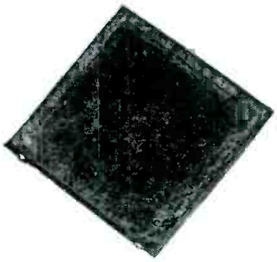
Railway Communications on 2660 MC

APPLICATION of nearly superhigh frequencies to railway communication has been announced by the Chicago, Rock Island Railroad. The system now being installed on the Chicago Division was developed as a result of experimental work conducted by E. A. Dahl of the Rock Island and H. H. Willis of the Sperry Gyroscope Co.

Communication between engineer and conductor is provided by transmitters and receivers equipped with press-to-talk hand sets, installed in

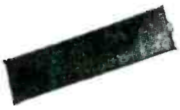


Two of the antennas used in experiments conducted on 2660 mc for railroad radio



6kv — .5 mfd — weight 27 oz.
size 6" x 6" x ½" thick.

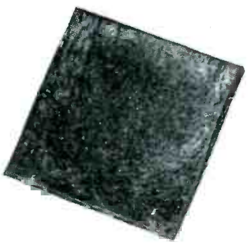
8kv — .03 mfd — weight 19 oz.
size 6" x 6" x 7/16" thick.



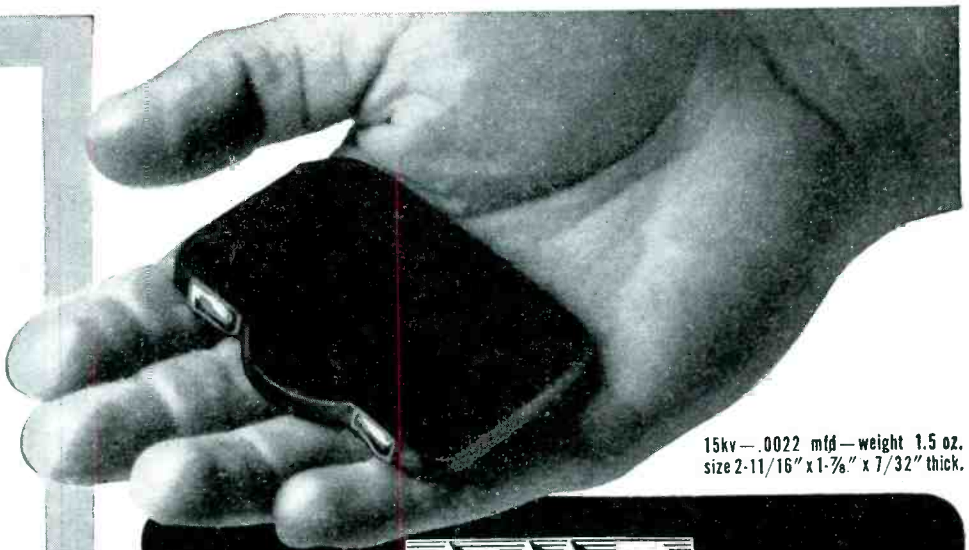
8kv — .012 mfd — weight 6 oz.
size 6" x 3" x ¼" thick.

3kv — .0028 mfd — weight .5 oz.
size 3" x 2" x 1/16" thick.

3½ kv — .00167 mfd — weight .4 oz.
size 3" x 1" x 1/16" thick.



6kv — .0025 mfd — weight 1 oz.
size 6" x 1½" x 1/16" thick.



15kv — .0022 mfd — weight 1.5 oz.
size 2-11/16" x 1-7/8" x 7/32" thick.

AMP HIGH-VOLTAGE CAPACITORS

FOR RADAR AND SIMILAR APPLICATIONS

The new AMP high-strength dielectric, and a special fabrication technique give AMP Capacitors these outstanding advantages:

Approximately 25% lighter in weight; approximately 25% smaller —
AMP Capacitors are smaller and lighter than any other type of high-voltage capacitors of equal capacity and voltage. High dielectric strength refractory film plus special molded and bonded construction reduce size and weight and eliminate necessity of usual can and oil filler.
A 15 kv., 0.0022 mfd. unit measures only 2-11/16" x 1-7/8" x 7/32" and weighs only 1.5 oz.

Minimum losses —
Complete molding and bonding of unit protects against edge breakdown and corona.

Peak performance at high temperatures —
AMP Capacitors operate effectively at higher temperatures than ordinary capacitors. Minimum capacitance drift — less than 0.015% per degree C. over a range of — 60° to + 100° C.

High voltage operation —
Dielectric sheets are homogeneous, and not limited to size, permitting use of very high voltage stresses per mil without corona. High voltage units can be made in one piece instead of usual assembled sections.

AMP High Voltage Capacitors are made to specification. Send specific information concerning your application. A careful analysis of your requirements will be submitted by our engineers.

AMP

AIRCRAFT-MARINE PRODUCTS INC.
1521-53 NORTH FOURTH ST., HARRISBURG, PENNA.

In Canada: DAVID C. ORROCK, 1405 Bishop St., Montreal, Que.
F. N. ADAMS, 726 Homer Street, Vancouver, B. C.
F. MANLEY CO., 43 Victoria Street, Toronto, Ont.

Boost the Performance

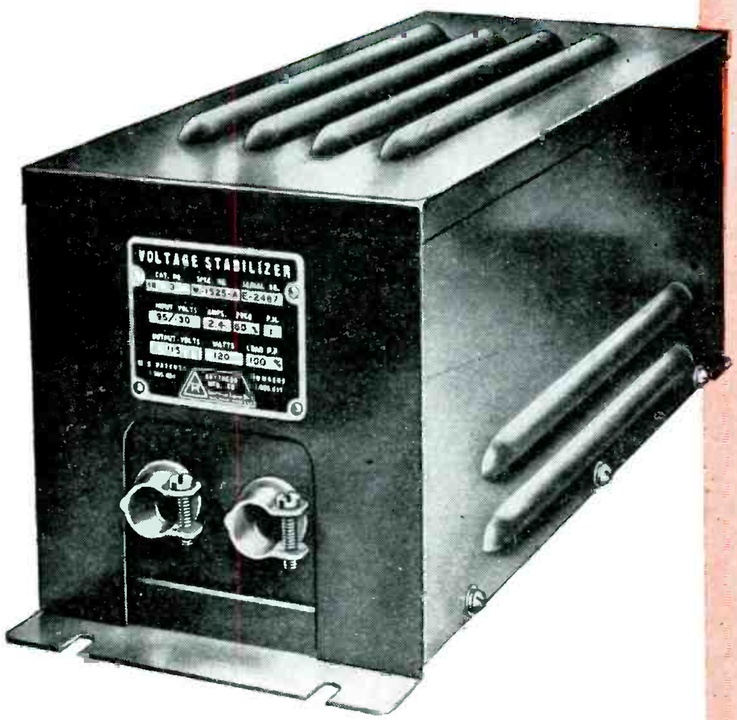
OF YOUR EQUIPMENT

with

RAYTHEON VOLTAGE STABILIZERS

THE PRECISION, accuracy and dependability of much electrical equipment are impaired by varying supply voltages.

If varying power supply handicaps your equipment why not install magnetic-type RAYTHEON VOLTAGE STABILIZERS? Long-proved, job-rated, and designed to meet practically any installation need, they are *boosting performance* in a wide variety of electrical equipment in many useful applications.



Get these principal operating advantages:

- Control of output voltage to within ±½% of 115 or 230 V.
- Stabilization at any load within rated capacities.
- Quick response. Stabilizes varying input voltage within 1/20 second.
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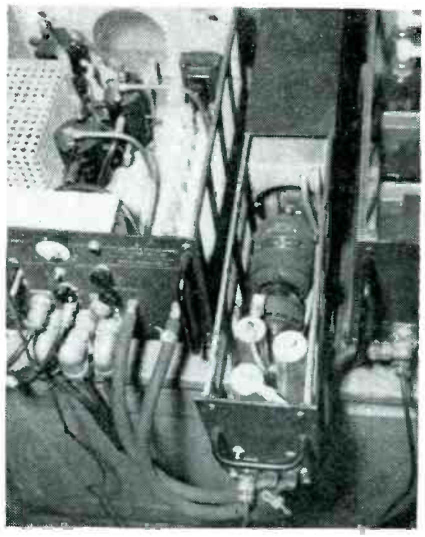
WALTHAM 54, MASS.

ELECTRICAL EQUIPMENT DIVISION
Excellence in Electronics

engine and caboose on freights, and engine and coach on passenger trains. Continuous contact with wayside stations is assured by relay stations placed along the right-of-way, and operated in conjunction with a carrier telephone system.

Ten watts of r-f power at 2660 mc, frequency modulated, is obtained from liquid cooled klystrons of the power-amplifier type. A fundamental frequency of approximately 4.92 mc is obtained from a



Microwave (2660-mc) transmitter and receiver developed by Sperry Gyroscope Co. engineers. The liquid-cooled klystrons at far left multiply ten times to produce the final frequency

crystal controlled oscillator. This is trippled twice, doubled and tripled again before being fed to a klystron frequency multiplier that raises it ten times to the carrier frequency.

Specially designed antennas, fed by stub-supported concentric lines, concentrate the radiated power into a pancake-like field. Consistent results have been obtained in practice where the trains were operating in tunnels or in deep gorges.

• • •

Ship-search Radar for Troopships

SAFE AND SPEEDY return of servicemen from overseas is the objective of a current program of installing ship-search radar equipment on transport vessels. All new bottoms as well as those not previously so equipped are having Models SO-1

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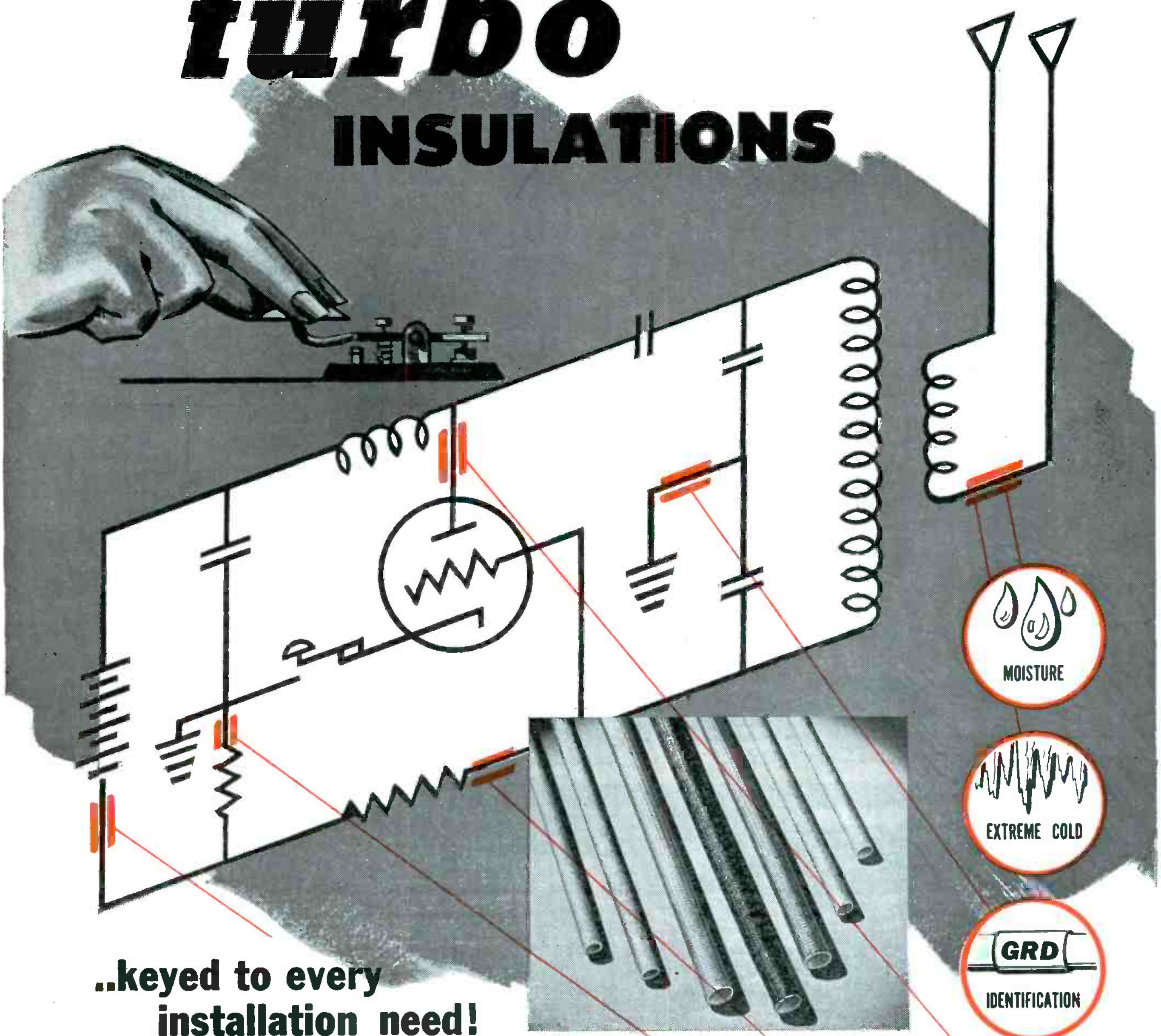

..keyed to every installation need!

Electronic communication circuits are a proving ground for electrical insulation. The varied conditions imposed—high voltage, heat, climatic exposure, battery acid, fumes, etc.—make several insulations, each with specific characteristics, essential. To meet these diversified requirements, TURBO engineers have developed four types of sleevings that assure unfailing operation under any given operating condition. Each is supplied in a full range of colors and sizes that speed installation and simplify maintenance.

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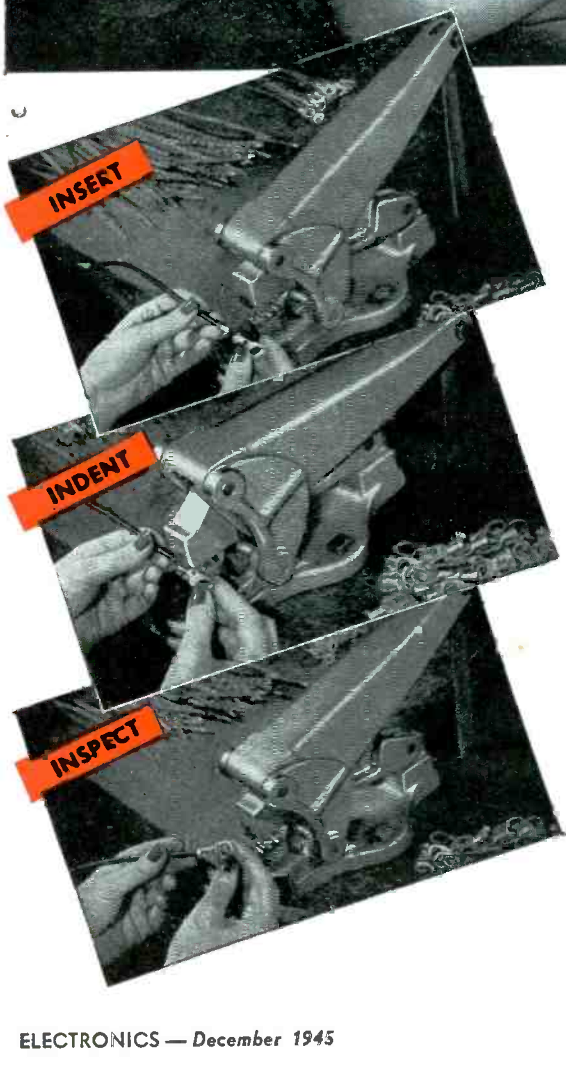

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Simple, compact, and relatively inexpensive, the Burndy HYTOOL (Cat. No. Y10R) provides new economies in making small wire connections . . . *regardless of quantities.*

In addition, each connection made is uniformly high in *mechanical strength* and *electrical efficiency* . . . because of the Burndy indent method, and Burndy's one-piece, pure-copper connector design. Here are the outstanding features of this HYTOOL:

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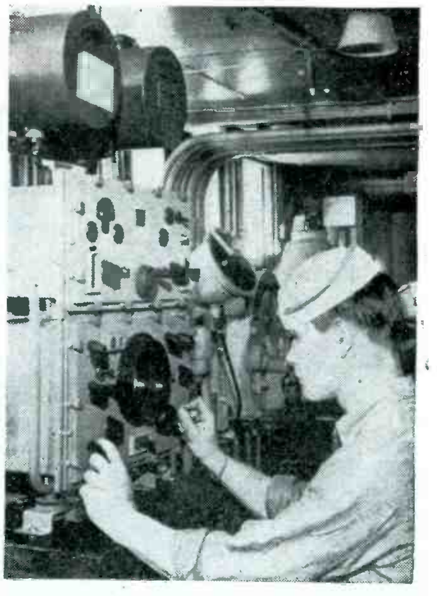
4. Economical for short runs . . . high production and low-cost on long runs.
5. Provides *uniform* indent, assuring uniformly strong, efficient connections.
6. **Price: $50.00 complete with die set.** F.O.B. factory.

Also available for pneumatic operation. For full details, get in touch with the Burndy representative near you, or write, Burndy Engineering Co., Inc., 107-L Bruckner Blvd., New York 54, N. Y.

Headquarters for CONNECTORS
Burndy

and SO-8 radar put in by Raytheon field engineers assisting Navy supervisors. That company has been the sole producer of both SO and SG microwave radars.

The SO type is a small modified version of the SG which finds a place on all combatant ships of the U. S. Navy. The SO system has been applied to thousands of land-



Installation of a type SO radar in the pilot house of a troopship is shown in this Signal Corps photograph. Raytheon gear of this model is being installed in troopships for speedier ocean crossings

ing craft, PT boats, attack transports, auxiliaries, and patrol craft.

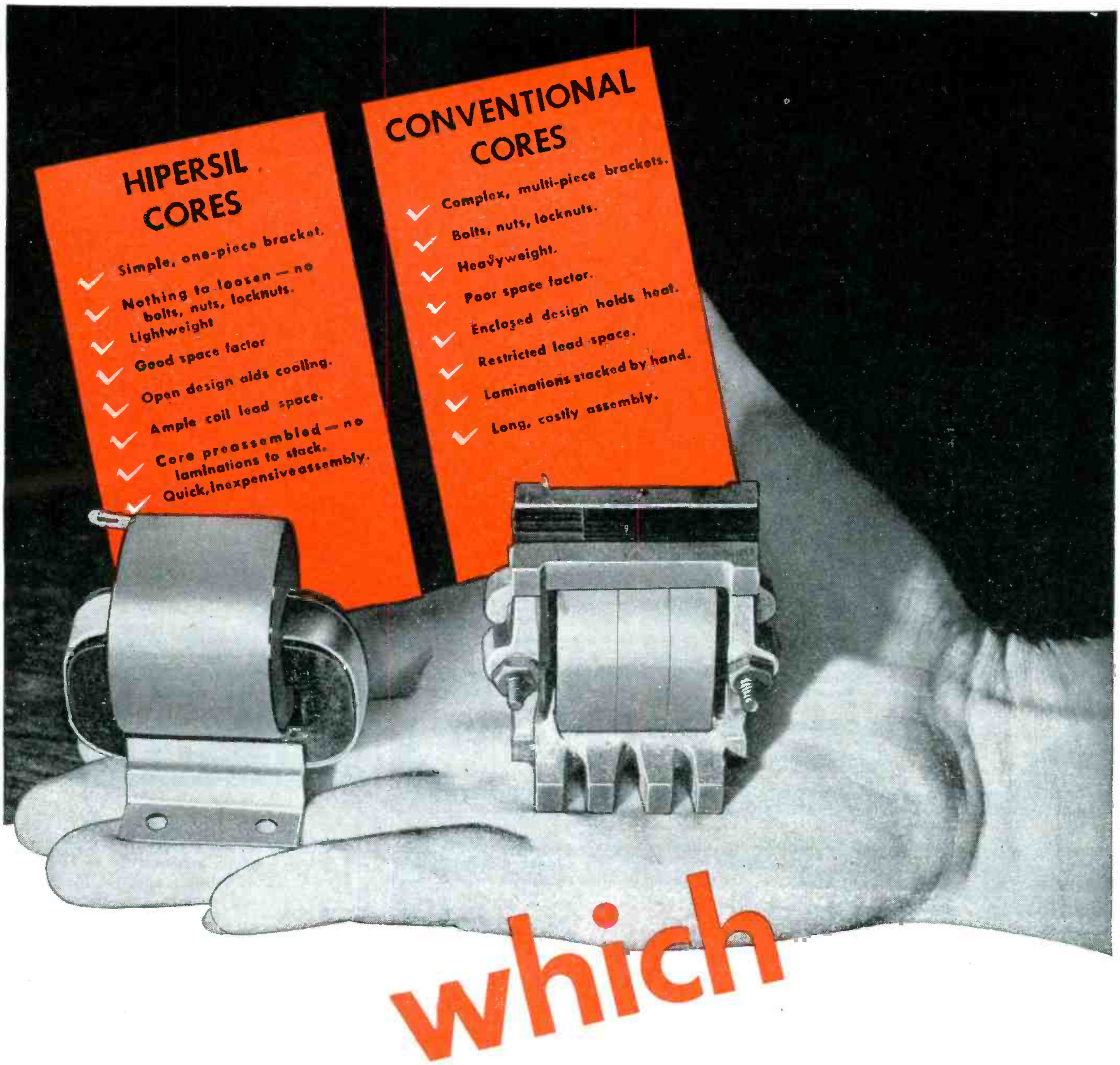
As used in the present transport of troops, the gear saves time in the ocean crossing because the ships' speed does not have to be reduced in fog or darkness, collisions and delays are eliminated, and the vessels can get in and out of ports regardless of weather or the time of day.

• • •

High-Frequency Aircraft Ignition System

THE SCHEMATIC DIAGRAM shows a high-frequency aircraft ignition system which was successfully flown last year on one engine of an AAF B-24 bomber at Vandalia, Ohio. Further tests are being made on B-24's at the Smyrna Army Air Base, Smyrna, Tenn.

Voltage at approximately 1200 volts is generated in the magneto, distributed, converted at the mani-



is a better answer to communications requirements?

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If space . . . weight . . . ease and cost of assembly . . . are factors at all, the answer is plain: HIPERSIL Cores can make a tremendous difference in simplifying manufacture, as well as in providing important improvements in performance.

HIPERSIL—the high-permeability silicon steel with ⅓ greater flux-carrying capacity—opens up new possibilities in electronic transformer design and manufacture. Full data on HIPERSIL characteristics and the advantages of Type "C" Cores may suggest new and better answers to your problems. Contact your Westinghouse representative or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa. J-70466

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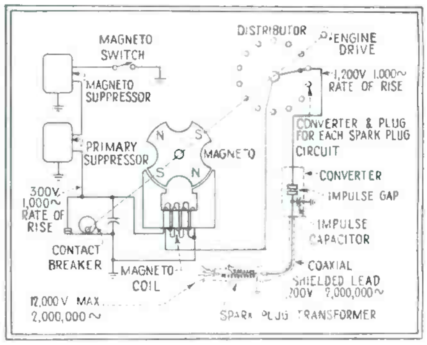
Hipersil Type "C" Cores are available for prompt delivery in a complete range of sizes, as required, and in five lamination thicknesses: 29 gauge, 5 mil, 3 mil, 2 mil and 1 mil.

fold ring into r-f at two to three million cps by an impulse-type frequency converter, delivered to the spark plug through a shielded coaxial line, and there transformed to about 10,000 volts for firing the plug. The final voltage step-up is performed in a small transformer sealed hermetically into the well of a standard aircraft spark plug.

The energy produced in this system has such a steep wave front that it is capable of igniting a cylinder charge despite fouled, leaded, or carbonized plugs, conditions which often arise from long periods of

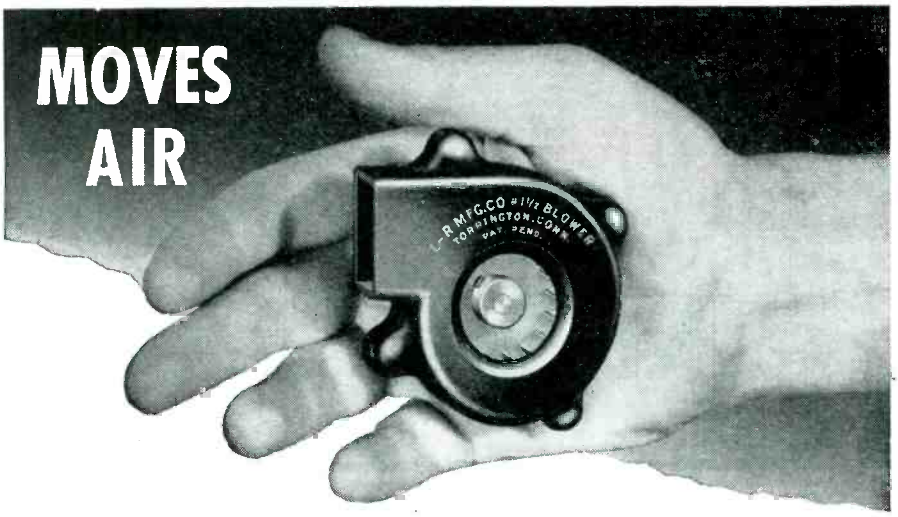


Circuit diagram of the high-frequency aviation ignition system. It will fire a spark plug shunted by 10,000 ohms resistance

idling, taxiing, or gliding. Inability of the pilot to get full power from the engine immediately under these conditions frequently causes forced landings. In tests, this circuit was able to fire plugs against a shunt resistance of 10,000 ohms where conventional systems begin to miss at 100,000.

Other advantages include increased engine output as a result of the possibility of using colder spark plugs without fear of misses from fouling; good high-altitude operation because of low-tension distribution; increased spark plug life since gap erosion is reduced by the low energy level; substantial reduction in radio interference; and a saving of 10 lb or more per engine.

Because the major portion of work to date has been directed to engines for large military aircraft, the possibilities for small personal planes and automobiles have not been explored as completely. However, the indications are that there may be many useful functions for



. . . 15 CUBIC FEET A MINUTE

The No. 1½* is one of many blowers manufactured by the L-R Mfg. Div. with C.F.M's at 8000 R.P.M. ranging from 15 to 270. They will outperform many larger types and where size and weight are factors, they solve cooling problems presented by electronic tubes or circuit components in airborne communication units as well as in many industrial applications.

*WEIGHT: 2 oz.; CAPACITY: 15 C. F. M. at 8000 R.P.M.; CONSTRUCTION: Housing of high impact phenolic plastic. Wheel is turbotype cadmium-plated steel; SIZE: 2⅝" long x 61/64" wide x 2½" high.

L-R MANUFACTURING DIVISION OF

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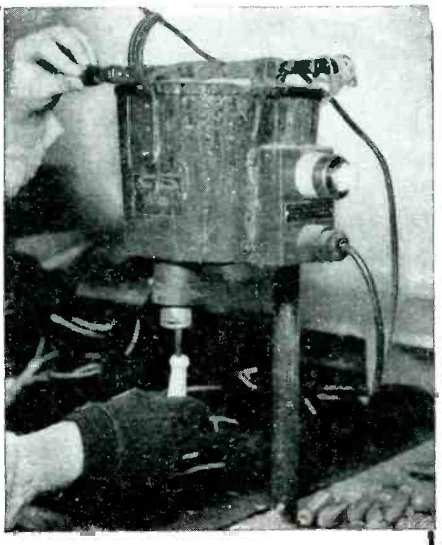

Of this 1 gal. Sta-Warm CN dispensing pot, the Kellogg Brush Mfg. Co. says "Your dispensing pots have operated in our plant for years without adjustment or failure." Pot is here seen loading brush handle with thermal chemical compound before inserting brush frame.

This veteran Sta-Warm CN dispensing pot symbolizes thousands similar to it which have operated "for years without adjustment or failure."

All Sta-Warm electrically heated tanks, kettles and pots are built to rigid specifications which insure uninterrupted production regardless of the compound being melted.

Many feet (sometimes a mile) of resistance wire constitute the heating element in Sta-Warm tanks. This heating element, in a wide variety of circuits, blankets sidewalls and bottom of each tank or pot to give widest distribution of heat at black heat temperatures, thereby resulting in low wattage per square inch of tank surface and aiding the long useful life of the heater. Dependable thermostats assure maintenance of proper temperature having practical variation of plus or minus 5° F. Heating, melting or dispensing of compounds will be a problem to you no longer . . . if you specify "Sta-Warm." Why not inquire today for new bulletin 038W?

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high-frequency ignition systems.

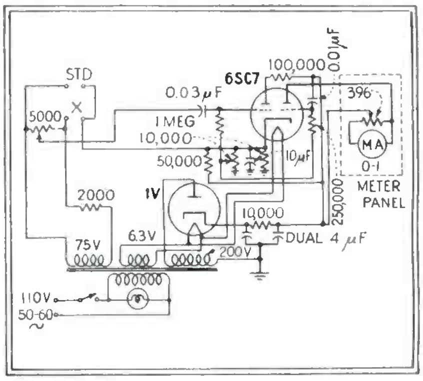
The development was derived from work done previously by Fred J. Hooven of Dayton, Ohio and was performed by P. R. Mallory & Co., which has concluded licenses with American Bosch Corp. and the Scintilla Magneto Division of Bendix Aviation Corp. with others under discussion for further development and manufacture.

• • •

Direct-indicating Comparison Bridge for Production Testing

DESIGNED FOR RAPID production testing where moderate accuracy is desired, the circuit shown in the illustration provides comparison of resistors, capacitors and inductors to a similar standard. It consists of an a-c slide-wire bridge and an electron-tube indicating circuit. The slidewire covers a range of approximately ±50 percent of the value of the standard.

Three working standards are used in calibration of the gear: one of nominal value and one each of upper and lower desired limits. Low and high values can be differ-



Schematic diagram showing use of type 1-V rectifier and 6SC7 null indicator in direct-indicating comparison bridge

ent. After adjustment, the separate indicating meter provides a within-limits reading up to a marked point on the scale or an outside-limits reading beyond. Thus the testing operator is not required to rotate dials or press buttons.

Accuracy of the equipment is largely dependent on the care with which limits are set as well as variations in line voltage. However, sensitivity and stability are such

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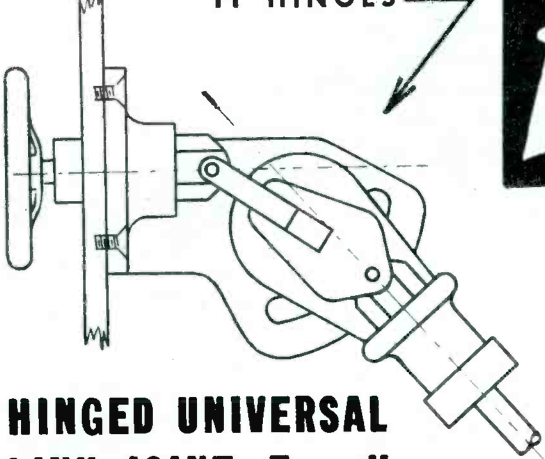

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This Piezo universal link joint, new in principle, transmits motion around corners and permits operation of shafts at angles from 0° to 90°. Easily installed with solid shafting; flexing or backlash is negligible. The input and output shafts turn in exact angular rotation. It is recommended for operation of dial and rheostat controls, switches, variable condensers and transformers, coils, and other mechanical adjustments. Write for folder 45A giving complete data and specifications.

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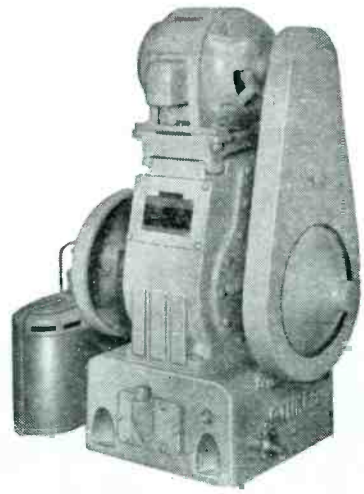

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as to permit successful operation with limits set as close as ±5 percent or as wide as ±50 percent of nominal. As made by Industrial Instruments, Inc., the range of measurement on capacitance is from 0.0001 to 1.0 μf; in resistance, from 2000 ohms to 20 meg; and in inductance, from 5 to 50,000 henrys.

• • •

Selsyn Indicating Systems for Remote Readings

By F. Wisk

Long Branch, N. J.

INDICATING SYSTEMS that provide readings remote from the scene of operations have found wide application in industry during recent years and have been used in many military equipments. In such systems, selsyn motors provide a convenient and flexible means of remote electrical position indication. A basic indicating system consists of a transmitter and receiver, with both units being electrically identical. The transmitter rotor is driven by external mechanical means and the receiver, at a remote point, indicates the position of the transmitter rotor. To understand the theory of operation of selsyn indicating systems a review of basic theory of the principles involved is in order.

Action on D-C and A-C

Referring to Fig. 1, coils A and B are placed in close proximity to each other. Assume that coil A is held in a stationary position and coil B is light and free to move if a force is exerted. If switch S is closed momentarily, a current will flow in coil A which in turn will be induced in coil B. Since the induced current in coil B will flow in the opposite direction to coil A, like magnetic poles will be set up as indicated and coil B will be repelled by coil A.

Referring next to Fig. 2, coil A is connected to a source of alternating current and creates induced current in coil B at the same frequency. The induced current in coil B is opposite in direction to coil A, hence in Fig. 2 coil B will be repelled by coil A. Although the magnetic poles of coils A and B are rapidly reversing they will still be opposing.

In Fig. 3 first assume that the

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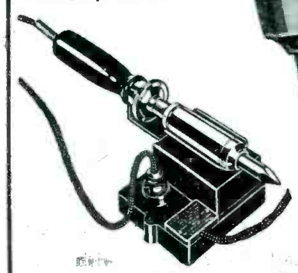

For further information or descriptive literature, write

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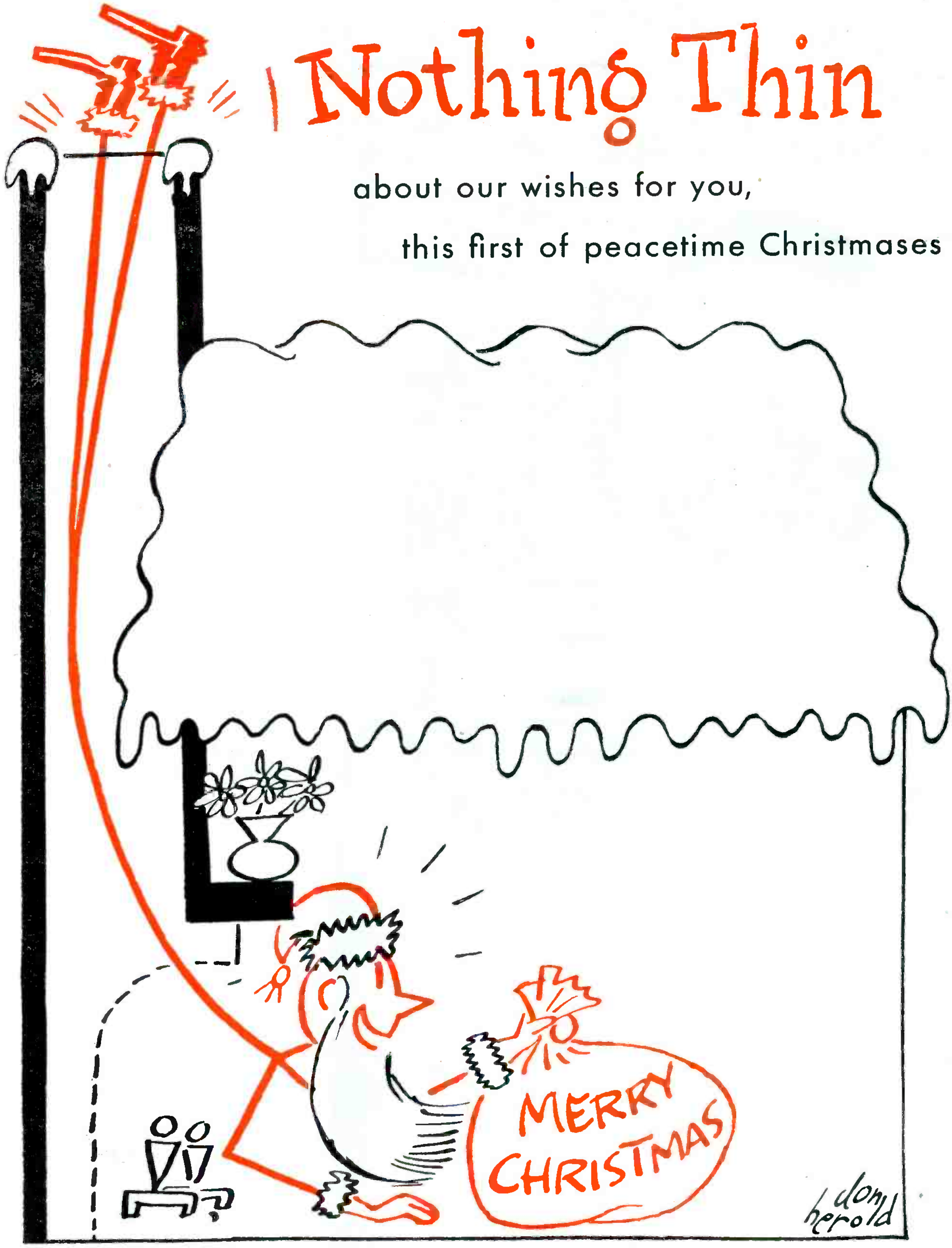

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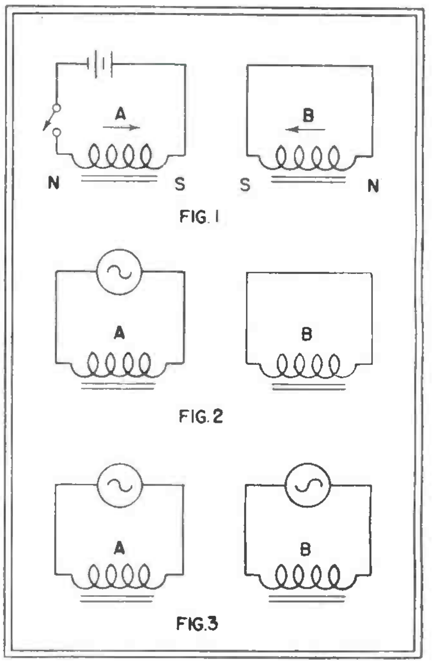
generator across coil A is operating and that the generator across coil B is turned off. Under these conditions, the same situation exists as in Fig. 2; coil A will repel coil B. If the generator connected across coil B is then used to supply current that is out of phase with



Figures 1 to 3 show the elementary steps in analyzing the operation of a selsyn indicating system

the induced current, enough current can flow in coil B to cancel the induced current and the coils will not repel or attract.

If the generator is adjusted to supply coil B with more current than the induced current, the magnegtic poles of coil B will be reversed and the coils will attract, since the poles of coil B will then be reversed.

Principles

To summarize the action (Fig. 3), three important conditions exist:

1. With the generator supplying coil A operating, and the generator connected across coil B off, coil A will repel coil B.
2. With both generators operating and the generator across coil B supplying sufficient current to cancel the induced current in coil B, the coils will not repel or attract.
3. If the generator across coil B supplies a larger (out of phase)

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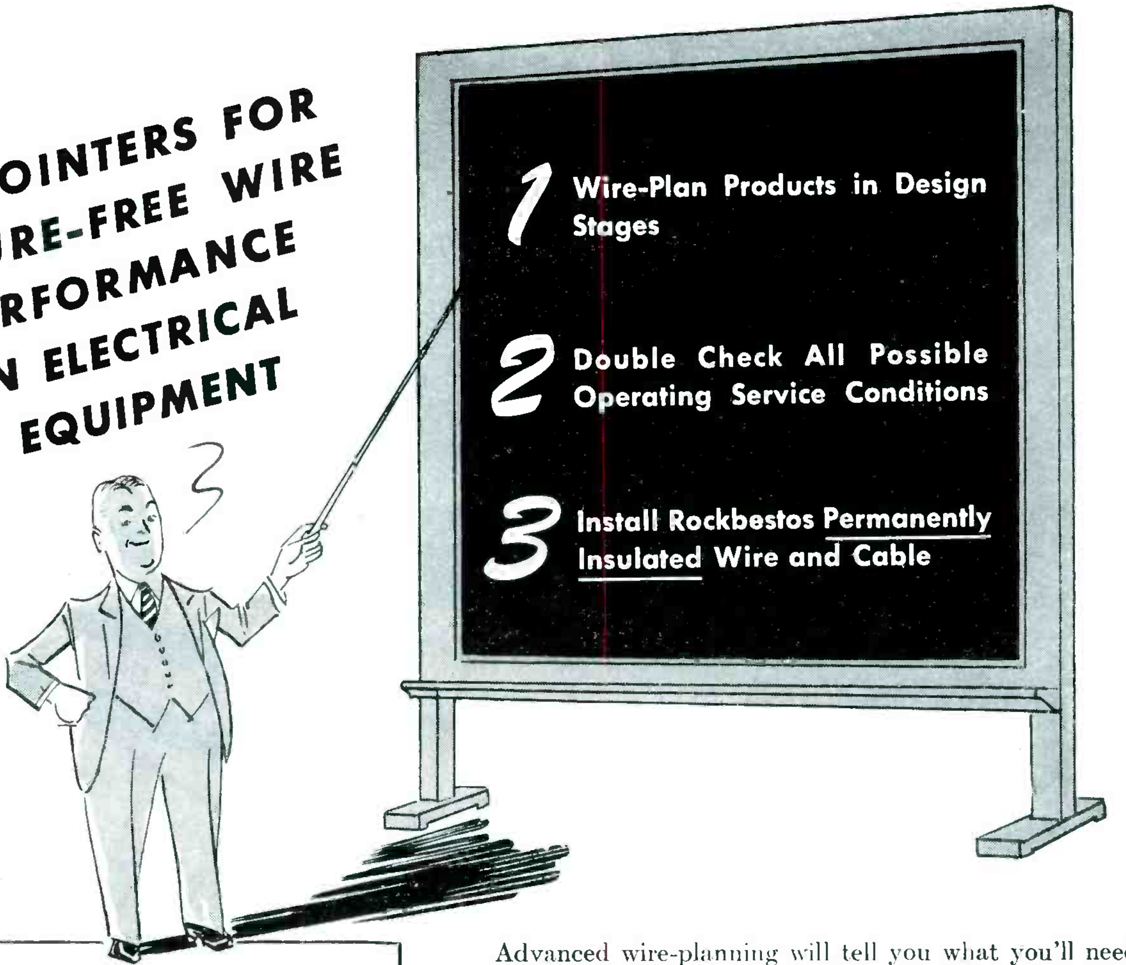

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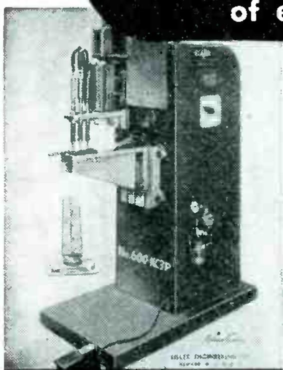

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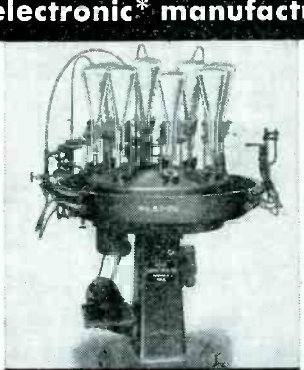

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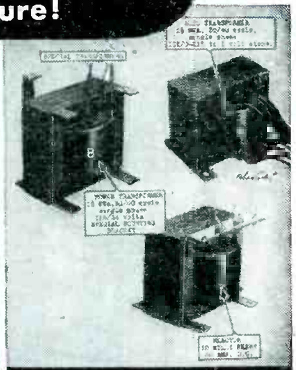

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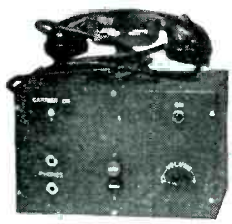

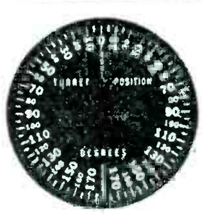

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current than the induced current, the coils will attract.

While in actual construction selsyn motors are of multi-stator winding design, for purposes of explanation one-, two-, and three-stator windings will be used.

In Fig. 4, rotors R_1 and R_2 are connected in parallel across a source of a-c. Stators S_1 and S_2 are connected in parallel. In the neutral position as shown, the coupling be-

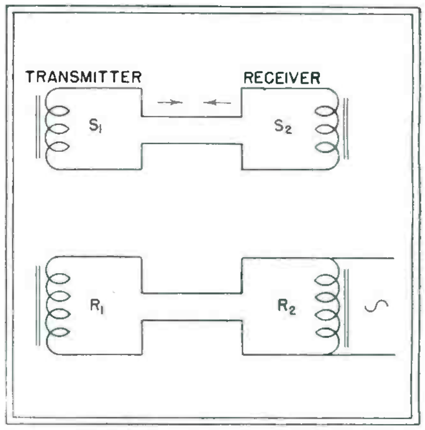

FIG. 4—When the coupling is equal, currents induced in S_1 and S_2 cancel

tween R_1-S_1 is equal to that between R_2-S_2, hence the induced voltage across S_1 and S_2 will be equal. Since S_1 and S_2 are connected in phase opposition the induced currents will cancel, hence there is no attraction or repulsion. In Fig. 5, the transmitter rotor R_1 has been turned clockwise about 45 degrees, the coupling between S_2-R_2 is now tighter than S_1-R_1, thus the induced voltage across S_2 is now greater than across S_1. Current will now flow from S_2 to S_1. This current flow is due to induced current, (R_2 to S_2), hence

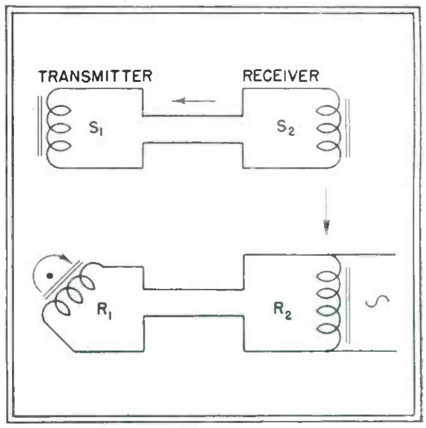

FIG. 5—Turning rotor R_1 produces a higher voltage across S_2 than across S_1

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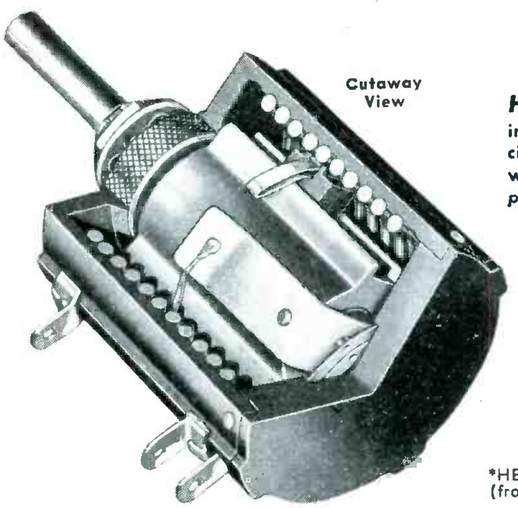
THE HELIPOT—a Beckman development widely used during the war on such precision instruments as radar, flight control units, depth sounding devices, and other critical electronic equipment—is now available to manufacturers and users of civilian electronic instruments!

The Beckman Helipot is a unique *new type* of potentiometer-rheostat which combines in *one compact unit* both the wide resistance range and extreme fineness of adjustment heretofore usually obtainable only through use of *two* separate rheostats, *two* control knobs, *two* adjusting operations. It is outstanding for all types of precision electronic equipment requiring high linearity, wide range and precise resistance control.

▸**WHAT IT IS:** The Beckman Helipot consists of a long, precision slide wire coiled helically into a small case and equipped with a slider contact assembly that is moved in the usual manner—by rotation of a shaft. A simple device automatically guides the slider contact over the helical path of the resistance winding so that the entire length of the wire can be contacted by rotation of *one* knob.

This unique design enables the Helipot to occupy no more panel space than a conventional single-turn rheostat. Yet the greatly increased length of the resistance winding provides a new standard of high accuracy *and* wide resistance range *in one unit*. It means, for example, that a ten-turn Helipot has *ten times the fineness of adjustment* possible with a single-turn rheostat of the same range. Or conversely, for the same fineness of adjustment a ten-turn Helipot has *ten times the range.*



IMPORTANT HELIPOT FEATURES

High Linearity—As a result of fulfilling wartime requirements for ultra-precision circuit controls, Helipots are mass-produced with linearity tolerances of one *tenth* of one *per cent*—and even less!

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*HELIPOT—T. M. Reg.
(from HELical POTentiometer)

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Current Helipot production is in several types and sizes, including . . .

Diameter	No. of Turns	Total Length Slide Wire
1½"	Up to 10	Up to 44"
3"	Up to 40	Up to 378"

Other sizes available on special order.

THE Helipot CORPORATION, South Pasadena 2, Calif.

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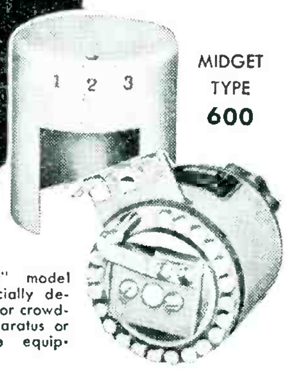

MIDGET TYPE **600**

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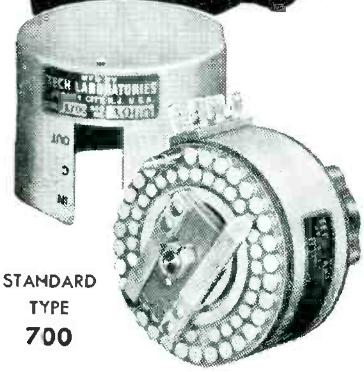

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S_2 will repel R_2. Since S_2 is stationary and R_2 is free to move, rotor R_2 will turn until the voltages across S_1-S_2 are equal (same degree of coupling), thus R_2 will rotate 45 degrees.

Neutral Position

Referring next to Fig. 6, rotors R_1 and R_2 are coupled with stators S_1, S_2, S_3 and S_4 in neutral position as shown; the degree of coupling between R_1-S_1 and R_2-S_2 are equal and the coupling between R_1-S_3 and R_2-S_4 are also equal. The degree of coupling of R_1-S_3 and R_2-S_4 is less than R_1-S_1 and R_2-S_2, hence the induced voltages across S_3-S_4 will be less than across S_1-S_2, however, in the neutral position as shown in Fig. 6, the voltages across S_3-S_4 are equal and opposite, likewise the voltages across S_1 and S_2 are equal and opposite even though higher. Since the voltages across the respective stators cancel, no movement of rotor R_2 takes place.

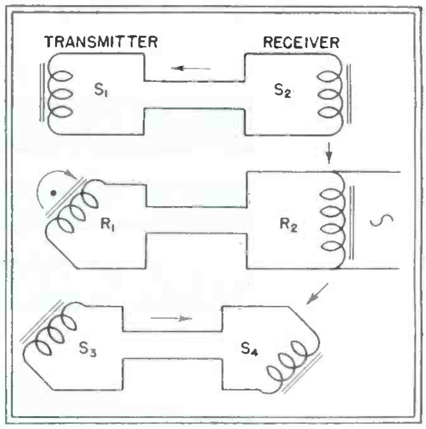

FIG. 6—If stator S_3 and S_4 are turned to the same angle, there is no movement of the rotors

In Fig. 7, transmitter rotor R_1 has been displaced 45 degrees, the coupling between R_2-S_2 is now tighter than R_1-S_1 hence current will flow from S_2 to S_1. As this current flow is due to induced current from R_2 to S_2, stator S_2 will repel rotor R_2. The coupling between R_1-S_3 is tighter than the coupling R_2-S_4 and the voltage across S_3 is greater than across S_4. Current therefore will flow from S_3 to S_4. The currents across the rotors are out of phase and the current from S_3 will predominate as it is of greater magnitude. Rotor R_2 will now be attracted by stator S_4. In the position shown

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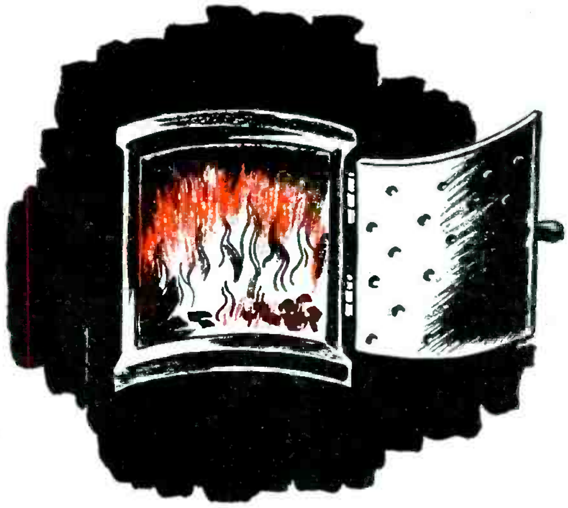

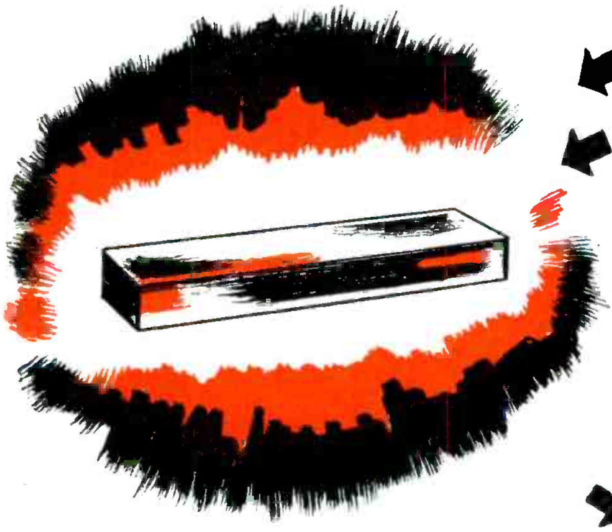

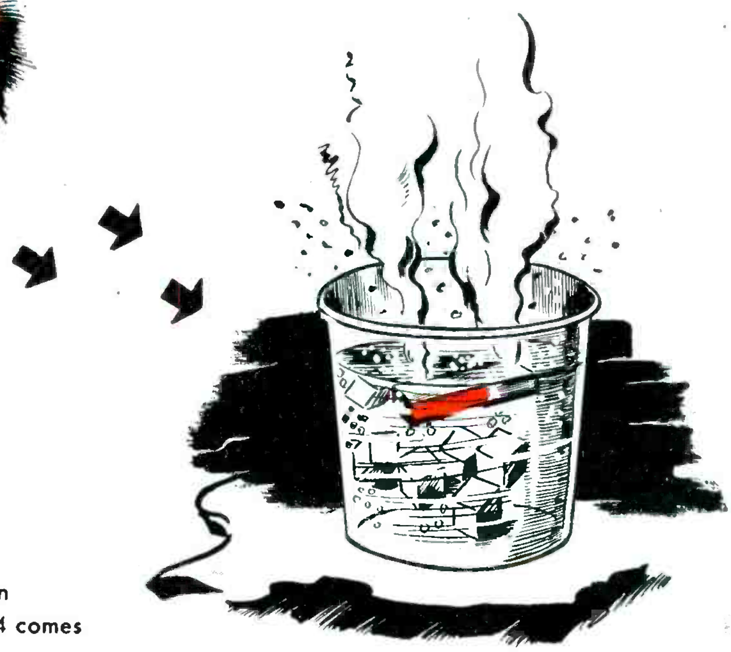

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does not crack

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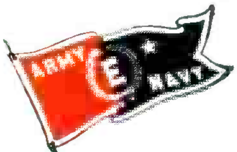

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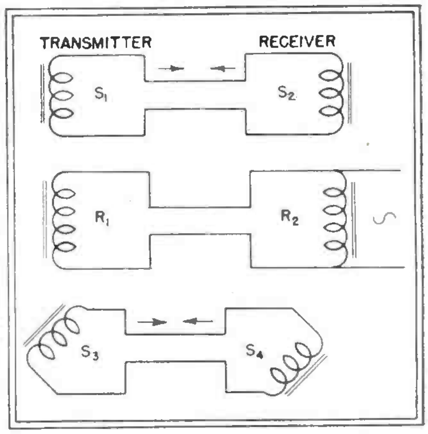

FIG. 7—Turning R_1 will cause R_2 to rotate

in Fig. 7, stator S_2 will repel rotor R_2 and stator S_4 will attract rotor R_2 since the current from S_3 has reversed the original poles of S_4.

In Fig. 8, three stators are shown displaced 120 degrees on each motor. In actual construction, interwound multiple poles are used. The same degree of coupling exists between R_1-S_1 and R_2-S_2, R_1-S_3 and R_2-S_6, R_1-S_5 and R_2-S_4. Since the voltages across the respectively connected stators are equal and opposite, the system is in neutral position.

Multiple Stators

In Fig. 9, transmitter rotor R_1 has been displaced 45 degrees by external means. Coupling between R_2-S_2 is now tighter than R_1-S_1, thus current will flow from S_2 to S_1 because the voltage is higher across S_2. This current flow is due to induced current R_2 to S_2 and S_2 will repel R_2.

Coupling between R_2-S_6 is greater than R_1-S_5, thus the voltage across S_6 is higher than across S_5, current

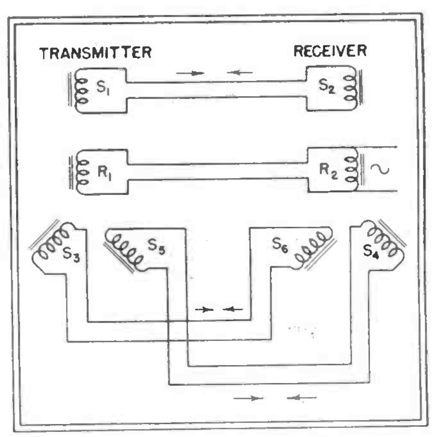

FIG. 8—Neutral position with three stators in each motor

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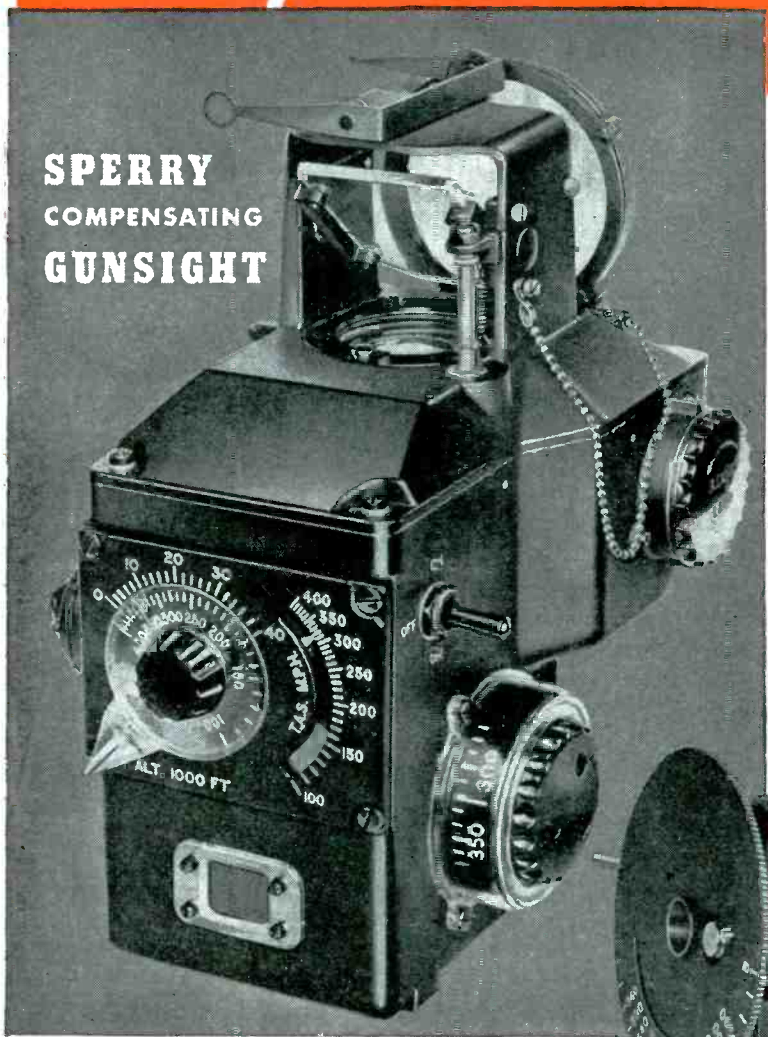

Before using Waldes Truarc Retaining Rings in Sperry gunsights, Sperry Gyroscope Co. engineers had difficulty with important taper pins working loose while the gunsights were in service. Due to vibration, pins occasionally loosened and fell out affecting the accuracy of the gunsights. Frequent, thorough inspection of taper pins in use didn't entirely solve the problem.

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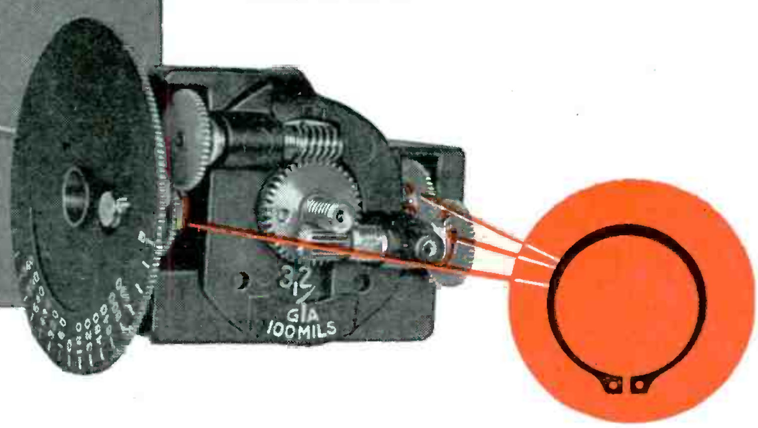

Waldes Truarc Retaining Rings are used to save weight, space, cost and man-hours in a wide range of products. For holding and positioning machine parts they offer definite advantages over nuts, shoulders, collars, and pins. They simplify and speed up production. They can be put on and taken off again and again —and still retain the perfect circularity which gives them their unfailing grip. Test them yourself. We'll furnish samples and complete data. Write Dept. H-12.

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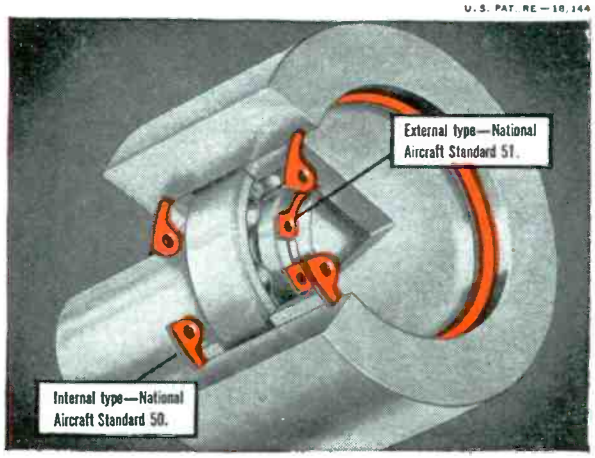

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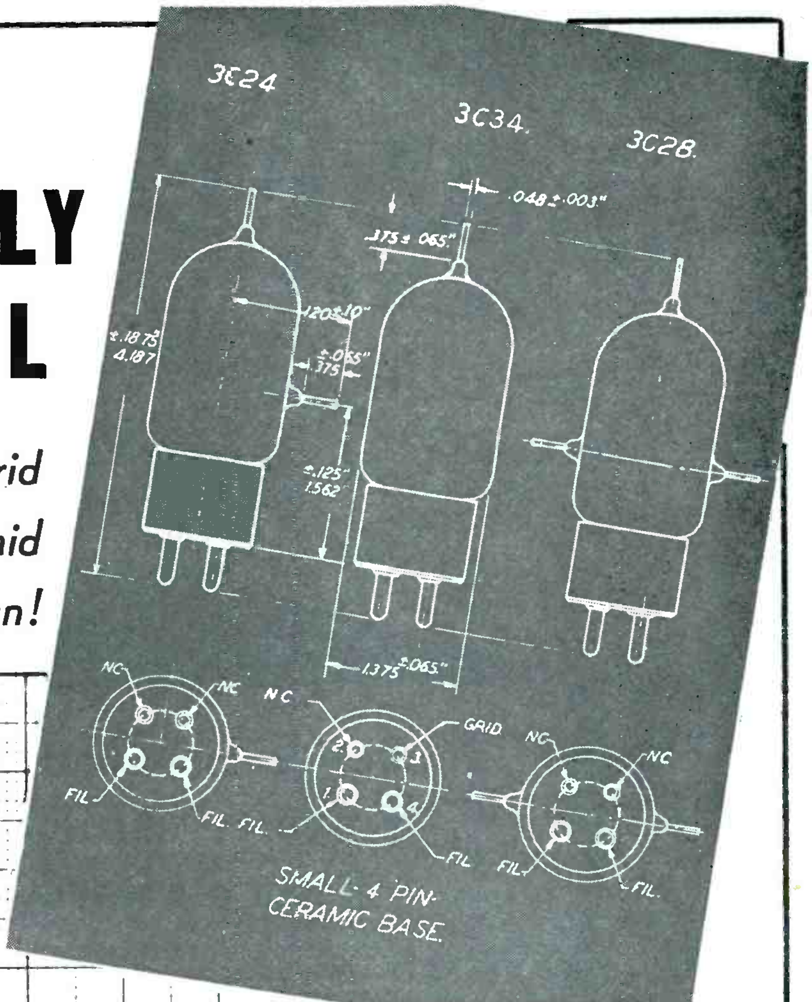

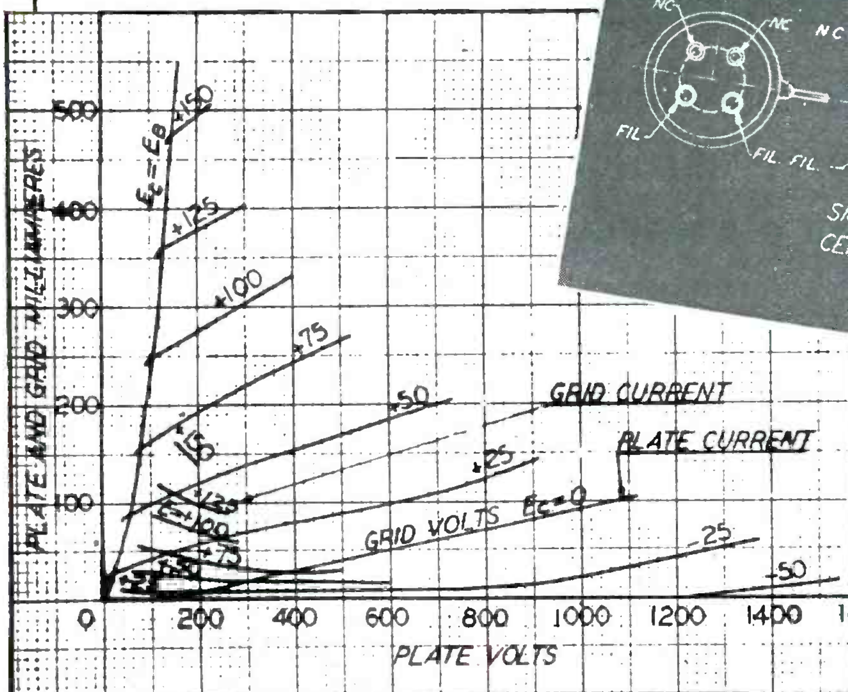

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Grid-Plate	1.6	1.7	1.8 mmfds
Grid-Filament	2.0	2.5	2.1 mmfds
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will flow from S_6 to S_5 and, since this current flow is due to induced current (R_2 to S_6), stator S_6 will also repel rotor R_2. Coupling between rotor R_1 and stator S_3 is tighter than R_2-S_4, hence the voltage across S_3 is higher than across S_4. Current will therefore flow from S_3 to

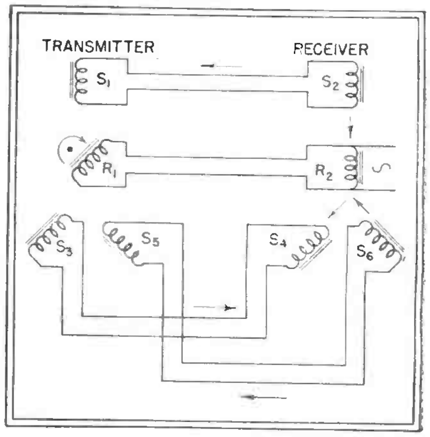


FIG. 9—Stators S_2 and S_6 repel rotor R_2; stator S_4 attracts R_2

S_4. Since the currents are out of phase, the largest will predominate and current from S_3 will reverse the poles on S_4; therefore coil S_4 will attract rotor R_2. Rotor R_2 will rotate 45 degrees and the voltages across the respectively connected stator coils will again be equalized; the induced currents will cancel returning the system to a neutral position with equal voltages across connected stator coils.

In Fig. 10, the transmitter and

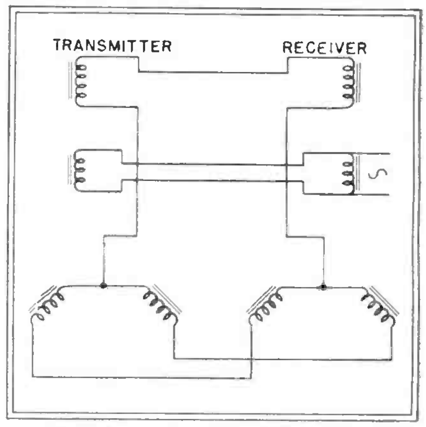
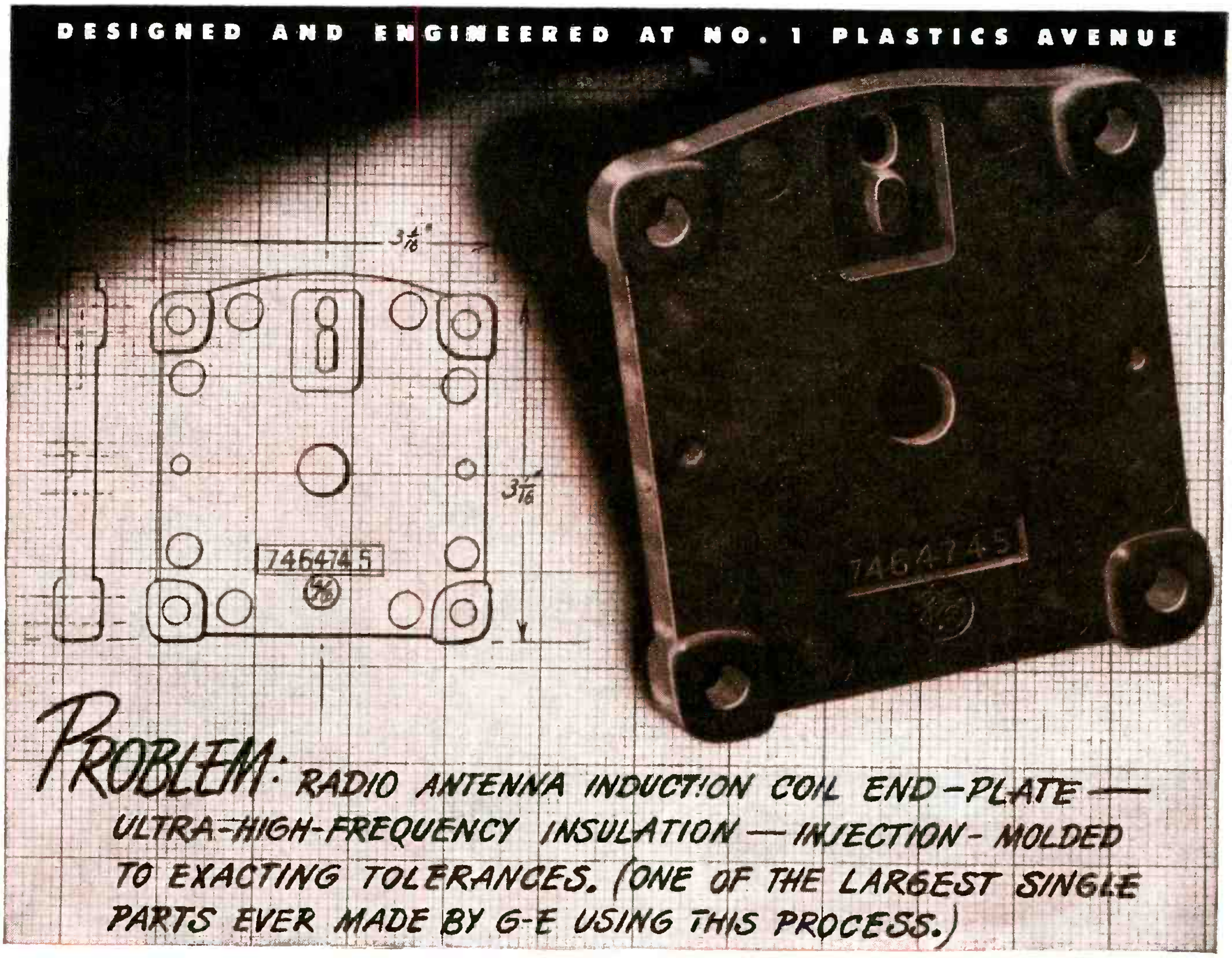


FIG. 10—Wye connection of coils equivalent to Fig 9

receiver coils are shown in wye connection which is electrically equivalent to Fig. 9. The reader should have no trouble solving the rotation of the receiver rotor through 360 degrees of rotation.



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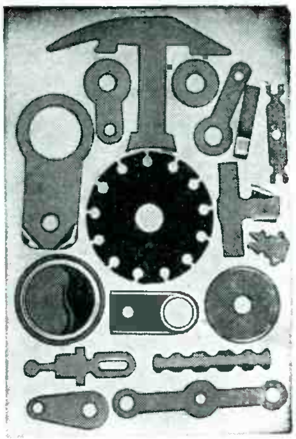

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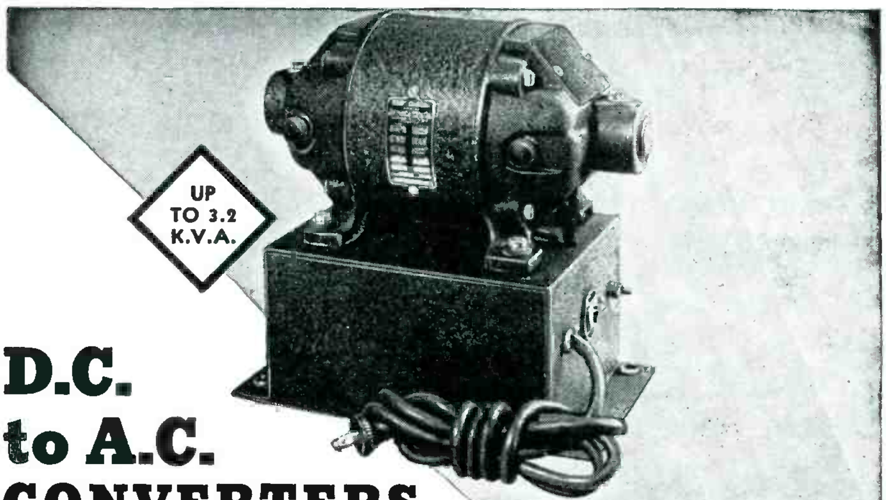

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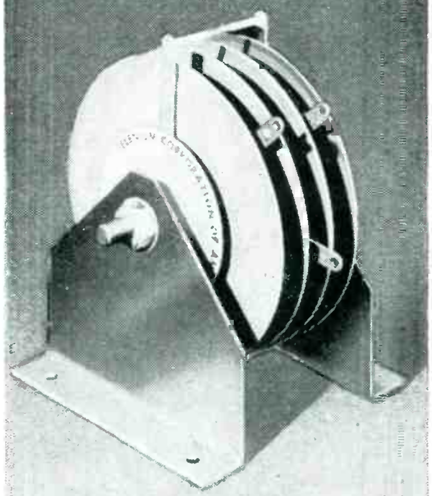
DC means SC



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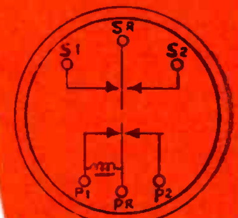

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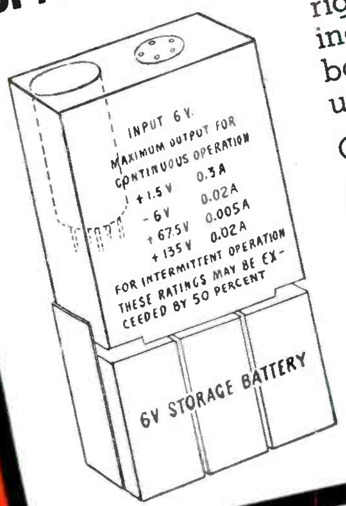
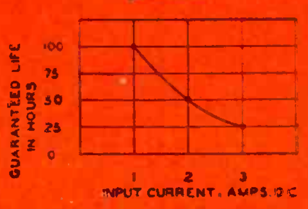
Obviously a standard size vibrator could not be used—so RADIART developed the VR-2 Midget Vibrator for the job.

Check the vibrator specifications given below as well as operating data on the illustration of the power supply for details.



The RADIART VR-2 Midget Vibrator can now be produced for civilian applications. Will this be of help in your product? Send us full information as to your requirements...our engineering department will fully cooperate.



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Input Voltage, Nominal . . . . . 6.0 V.
Input Voltage Range . . 4.5 to 7.5 V.
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Army Target Plane Controlled by Radio Transmitter

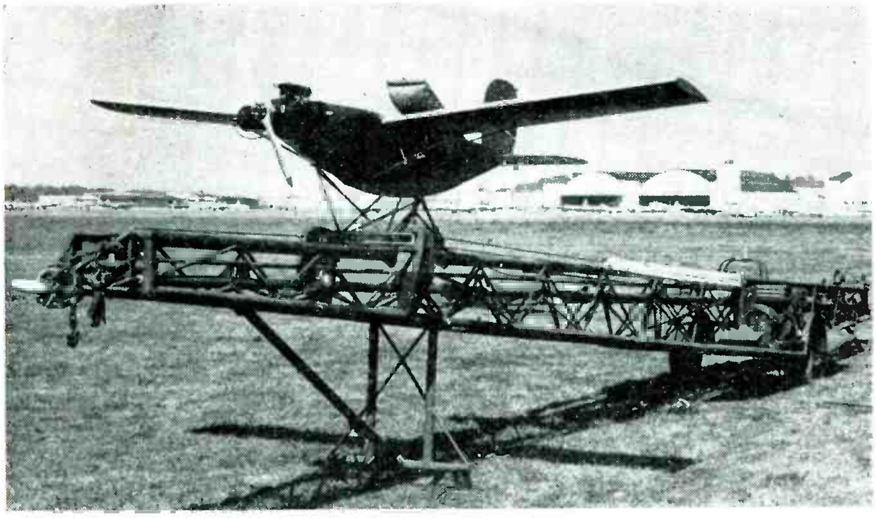
RADIO-CONTROLLED pilotless planes have been used by the Army as targets for aerial gunnery practice by B-29 gunners and also for anti-aircraft practice by ground forces.

The plane is controlled from the ground by a uhf transmitter that is modulated by five different audio frequencies. These tones are selected by a small control box at the transmitter which is equipped with a projecting lever to simulate the joy stick of a plane. Two of the a-f signals provide rudder control and two provide elevator control. The fifth frequency centers the rudder and releases a parachute when desired by the control operator. Only one frequency is used at a time and when none is being transmitted the parachute release frequency is automatically switched on.

Servo System

In the plane, a radio receiver and a selector circuit translate the signals and actuate a servo unit to provide mechanical action to control the elevators and rudder. The elevator and rudder servo controls remain in effect after the engine stops and the parachute is released, providing the receiver has not been damaged, so that dead-stick landings may be made in the event the parachute attachments are shot away.

Two models of the remotely controlled planes are standard equipment for the Army Air Forces. One model, the OQ-3, is a high-wing monoplane, 9 feet long, having a wing span of 12 feet 3 inches. The plane is constructed of welded steel tubing covered with airplane cloth and weighs 100 pounds. It flies at 103 miles an hour and is powered by an 8-horsepower 2-cylinder gasoline engine.



Radio-controlled target airplane model OQ-14 on its launching catapult. It provides realism for student gunners by simulating flight attitudes, dives and evasive action in response to modulated signals from a transmitter on the ground

A later model, the OQ-14, is powered by a 22-horsepower engine, flies 140 miles per hour and has a wing span of 11 feet, 6 inches. The planes are launched from a catapult driven by compressed spring coils or rubber cords. They fly at altitudes up to 3000 feet normally.

Another use for the plane was found recently, that of a training aid for students of radar in tracking flying objects in the air for gunnery practice. In addition, the Navy is using the target airplane in its training for automatic weapons target practice.

The first models developed had a telephone dial on the control unit, used a 3-hp engine with counter-rotating props to counteract torque, and had a tricycle landing gear. These features were eliminated in the experimental stages.

The target planes are the result of eight years of research work by Lt. Col. C. O. French, Jr. and his staff at Air Technical Service Command Headquarters, Wright Field, Dayton, Ohio. They are manufactured by Radioplane Co., Van Nuys, Calif. and Globe Corporation, Joliet, Ill.

Microwave Radio Relay to Replace Telegraph Lines

MICROWAVE radio relay systems with towers about 30 miles apart between the major cities of the United States will be installed during the next seven years by Western Union Telegraph Company. No lines will be removed from the present 2,300,000-mile telegraph network until the radio system along the route has proved satisfactory, government approval is obtained and existing contracts permit.

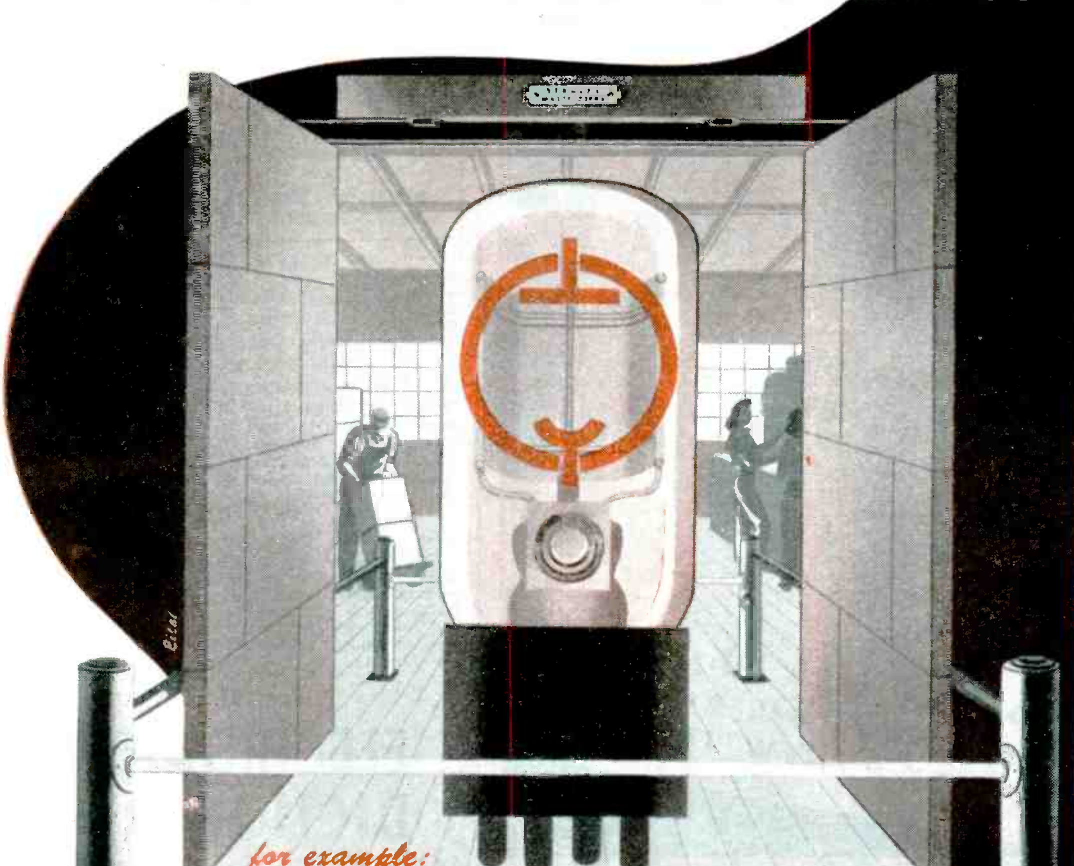
A test circuit was installed between New York and Camden, N. J. early this year by engineers of Radio Corporation of America who developed the system. Since March, this circuit has been used by Western Union on an experimental basis between their New York and Philadelphia offices.

Multiple Antennas

The illustration shows the 100-ft tower and two of the antennas at one of two intermediate relay stations used between New York and Philadelphia. These are located near Bordentown, N. J. and at 10-Mile Run near New Brunswick, N. J. The stations are unattended and operate automatically.

On top of each tower is an 8-ft

wherever a tube is used...



for example:

AUTOMATIC DOOR CONTROL

Doors that operate automatically save man-hours where plant traffic is heavy, cut heating costs, reduce breakage in restaurants, are a convenience to package laden shoppers. The electronic principle involved has hundreds of commercial and industrial applications.

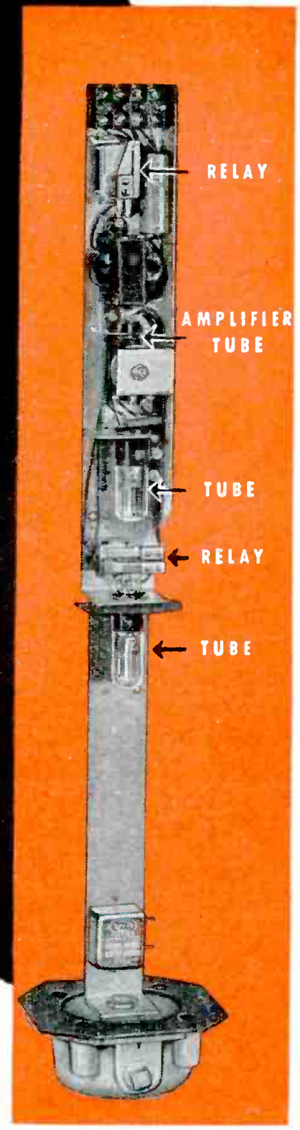


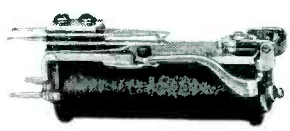
PHOTO-ELECTRIC DOOR CONTROL
Above unit manufactured by General Electric Co., is a part of STANLEY "MAGIC DOOR" CONTROLS.

THERE'S A JOB FOR *Relays* BY GUARDIAN

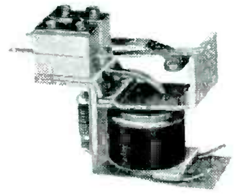
★ The "Magic Door" made by The Stanley Works of New Britain, Conn., uses a General Electric control unit which operates automatically at the approach of a pedestrian or vehicle. In this unit a beam of light focused on the cathode of a phototube causes a tiny current to flow. Enlarged through an amplifier tube this current operates a sensitive telephone type of relay such as the Guardian Series 405. Another phototube with an auxiliary relay, Guardian Series R-100, is employed to hold the doors open for anyone standing within the doorway.

The telephone type of relay is extremely sensitive and able to operate on the small current supplied through the electronic circuit. The auxiliary relay, Series R-100, is required to handle a greater current. It is a small, efficient relay having a contact capacity up to 1 KW at frequencies up to and including 28 megacycles. Contact combinations range up to double pole, double throw. Standard coils operate on 110 volts, 60 cycles, and draw approximately 7 V. A. Coils for other voltages are available. For further information write for Bulletin R-6.

Consult Guardian whenever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.



Series 405 Telephone Type Relay



Series R-100 H. F. Relay

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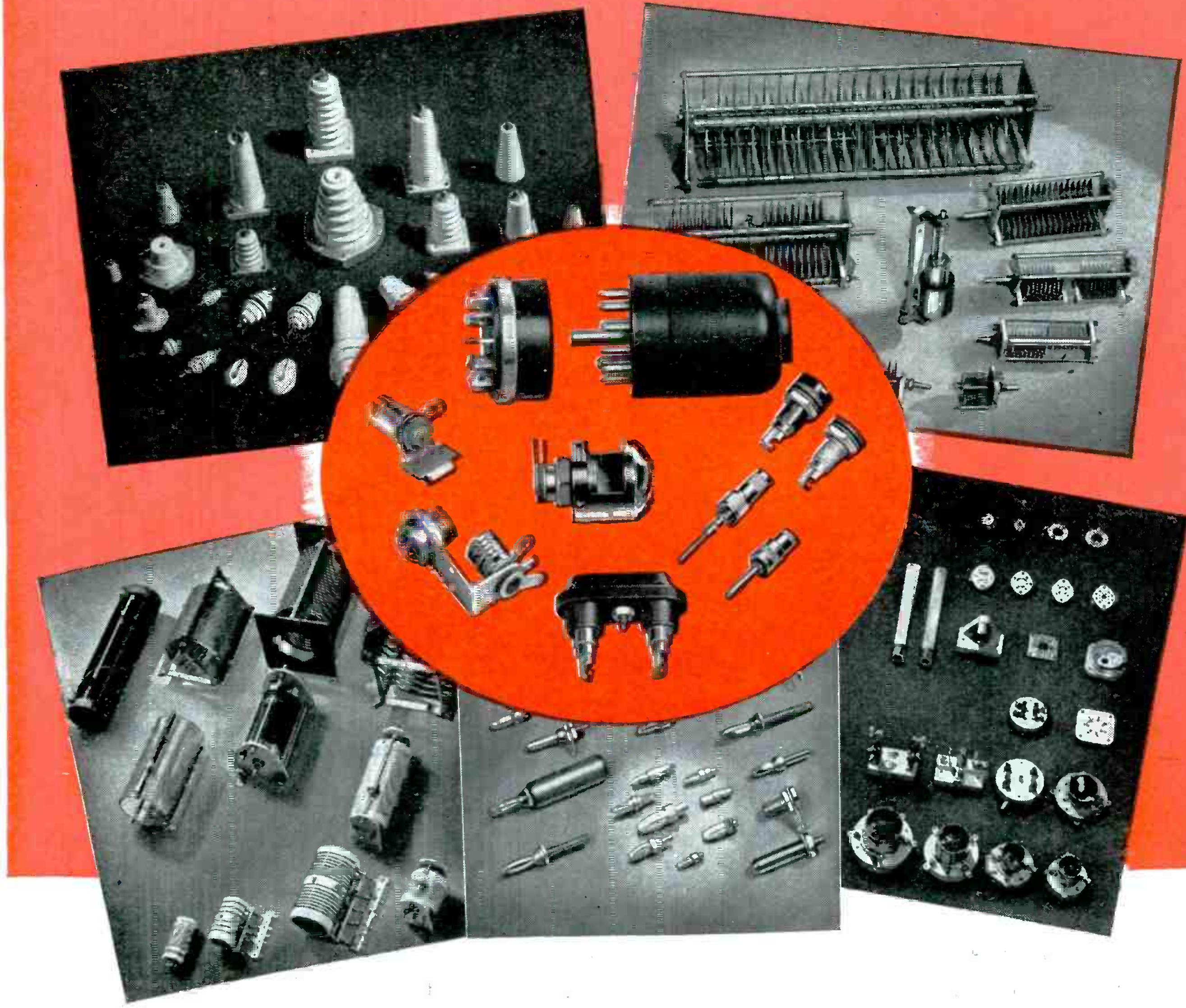

We are pleased to announce that the cable connectors, pilot light assemblies, tip plugs and tip jacks, former Mallory-Yaxley products, so highly regarded by the electronic industry for many years, will be manufactured and sold in the future solely by Johnson.

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Johnson products are stocked by leading radio-electronic parts jobbers.

Write for General Products Catalog 968

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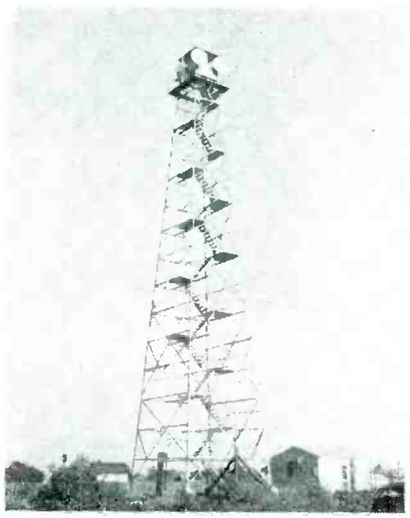
square enclosed cabin. Outside the cabin four antennas are mounted in parabolic reflectors. One antenna on the east side of the tower feeds the East-to-West receiver; the other is supplied by the West-to-East transmitter. Two other antennas on the West side of the tower are

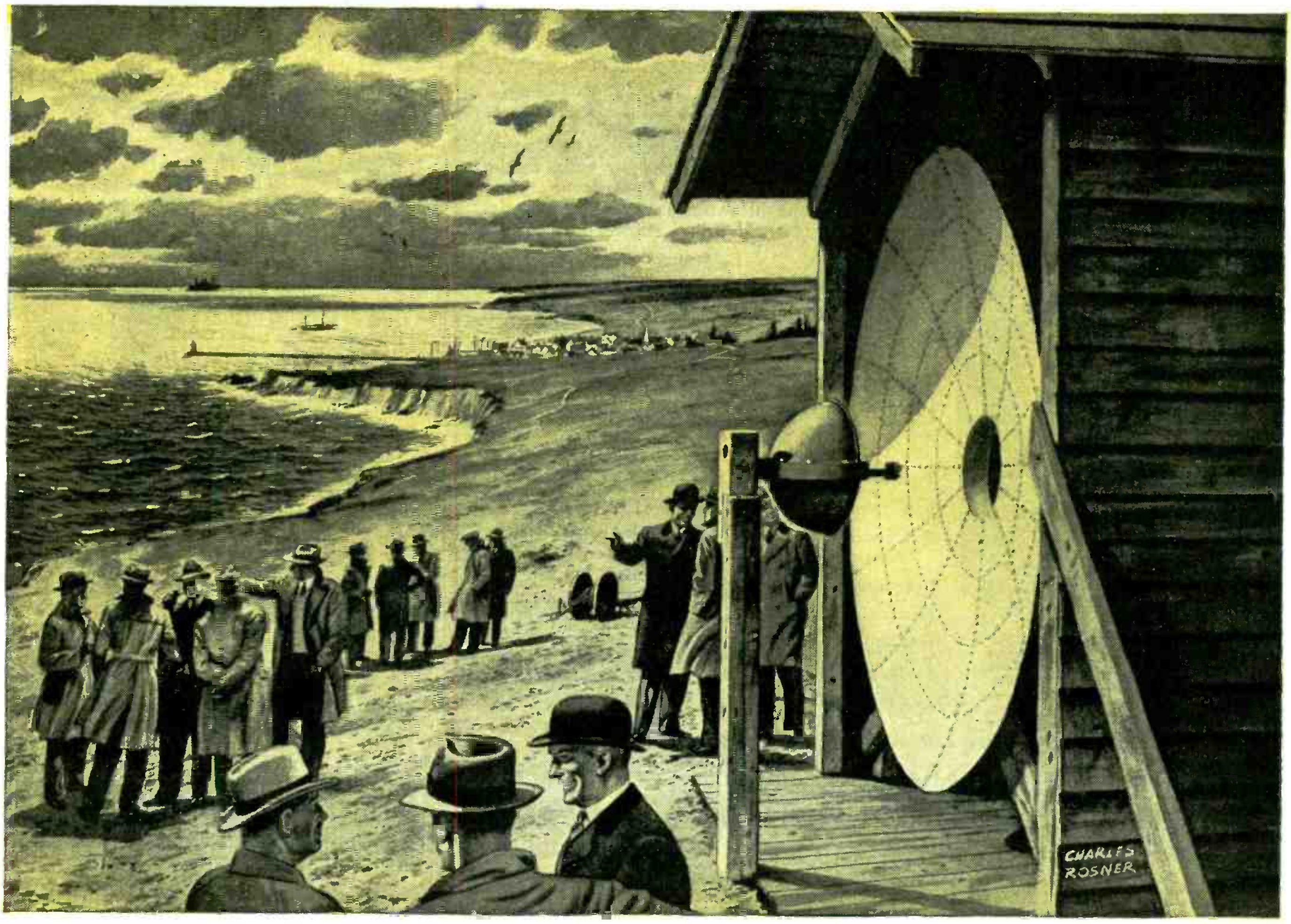


Four parabolic antennas and a cabin enclosing the transmitting and receiving equipment are mounted atop a 100-foot tower for use in the Western Union radio relay system

used on the West-to-East receiver and the East-to-West transmitter. The transmitters, receivers, demodulators and modulators are housed in the cabin.

The transmitters in the present system put out about one-tenth of a watt. However, the antennas have a power gain of 900 (so that the equivalent non-directive power is 81 kilowatts). This provides a transmitter-antenna to receiver-antenna gain of 810,000. Operation is being conducted on a frequency near 4,000 megacycles with a useful bandwidth of 150 kilocycles. It has been estimated that this is sufficient for 270 multiplex or 1080 single telegraph circuits. It could probably handle at least 25 ordinary telephone circuits, or if used for high-quality f-m broadcast service possibly eight channels. The present bandwidth is insufficient for television, but new equipment of higher power may be available soon to provide the necessary 6-mc television bandwidth.

As now used, the system provides



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On a gusty March day in 1931 . . . when man's voice was beamed across the English Channel from an antenna less than an inch long and powered by a mere half-watt . . . Microwave was born.

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Many of the scientists now at work in Federal laboratories participated in that triumph and helped in its developement through the years. Now they are engaged in extending its application, opening vast and striking possibilities for the future of communications.

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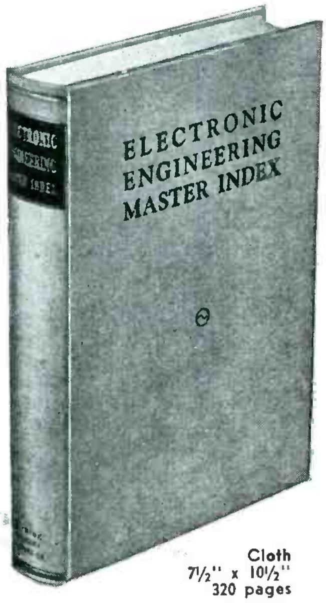

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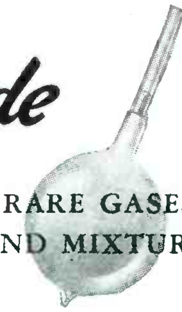

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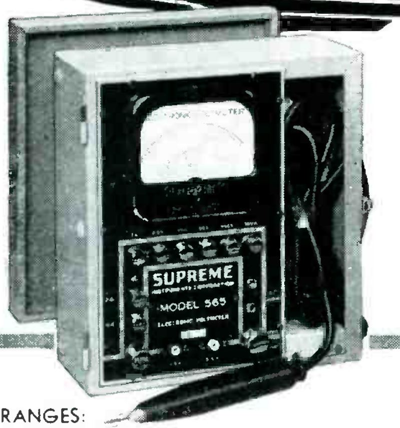

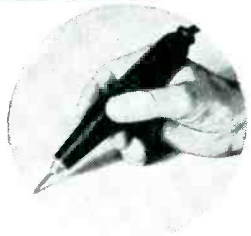

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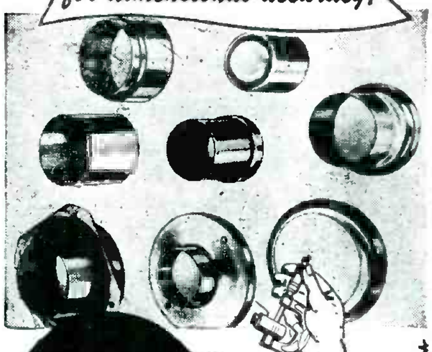

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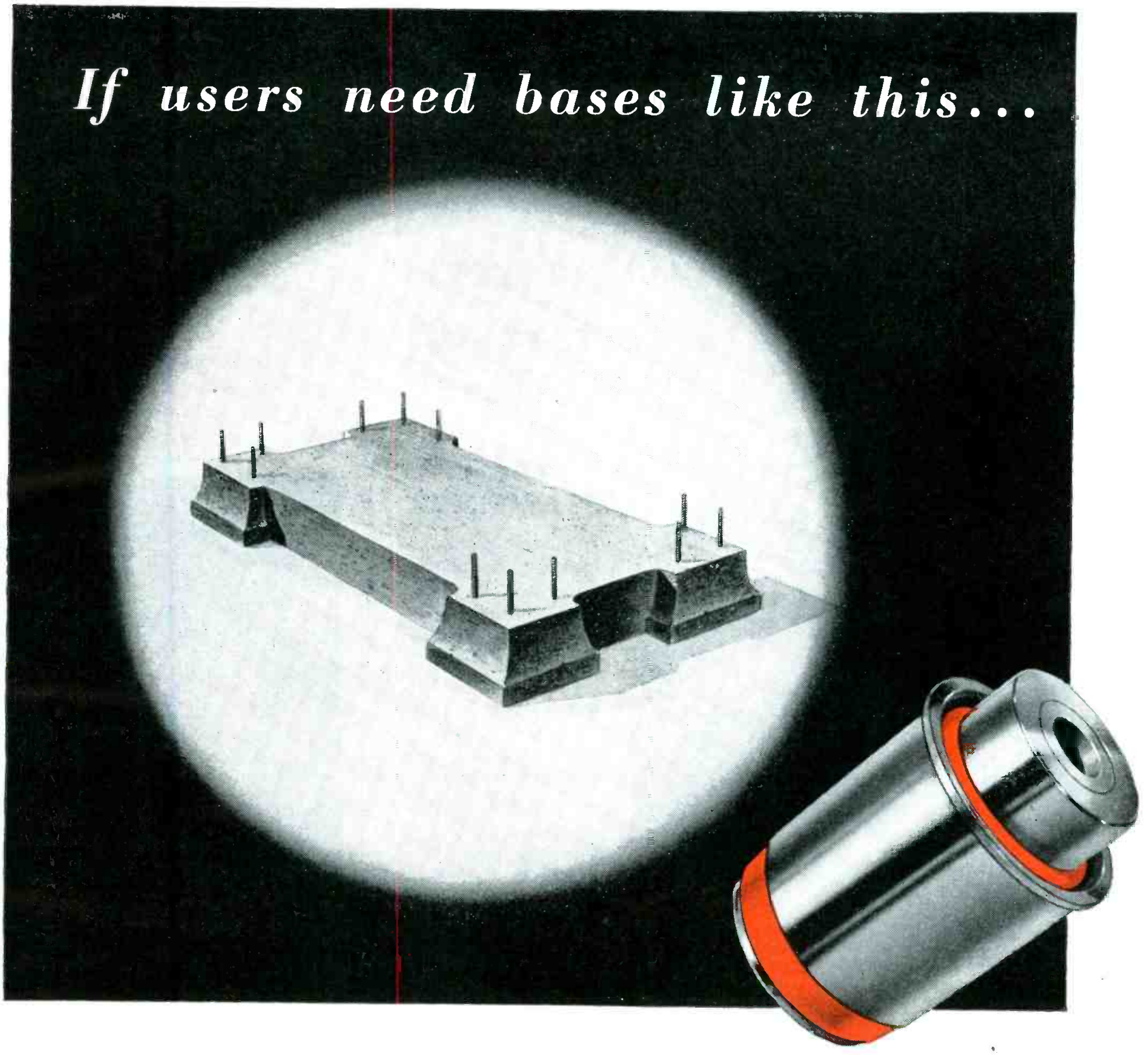

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a total of 40 telegraph channels, one two-way phone channel, and one two-way facsimile channel. Frequency modulation is used and each telegraph signal goes out as two frequencies; one is a marking impulse and the other a spacing pulse to the receiving printer. A 70 cycle swing of signals spaced 300 cycles apart is involved.

Progress

In its six months operation to date, the radio relay circuit has performed so well that Western Union has filed an application with

One of the 4,000-mc antennas is examined by H. P. Corwith, assistant chief engineer of Western Union

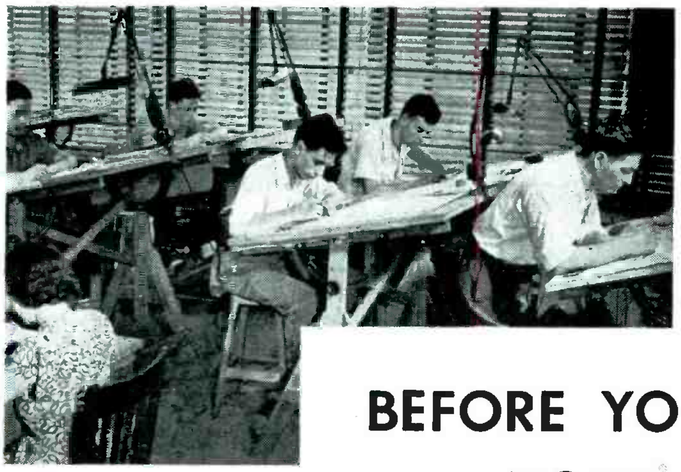
the FCC for permission to install equipment of a similar type from New York to Pittsburgh, Pittsburgh to Washington, Washington to New York, and New York to Philadelphia. Its establishment in time will permit the removal of about 2500 miles of pole lines with some 54,000 miles of wires and 180 miles of aerial and underground cable.

Besides terminal equipment in the four cities, 21 intermediate relay stations in towers on mountains ranging from 14 to 55 miles apart would be constructed. The sites for these have been acquired.

• • •

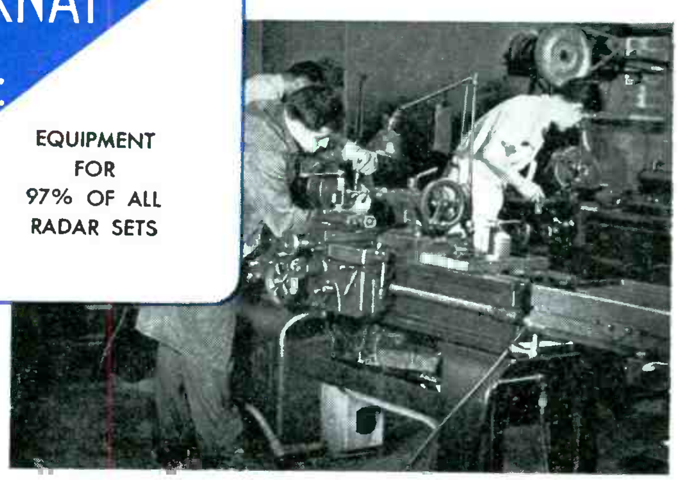
Tube for SCR 270 Radar

COOPERATIVE ACTIVITY between the Army Signal Corps and Westinghouse Electric Corp. produced the special radar tube shown in the







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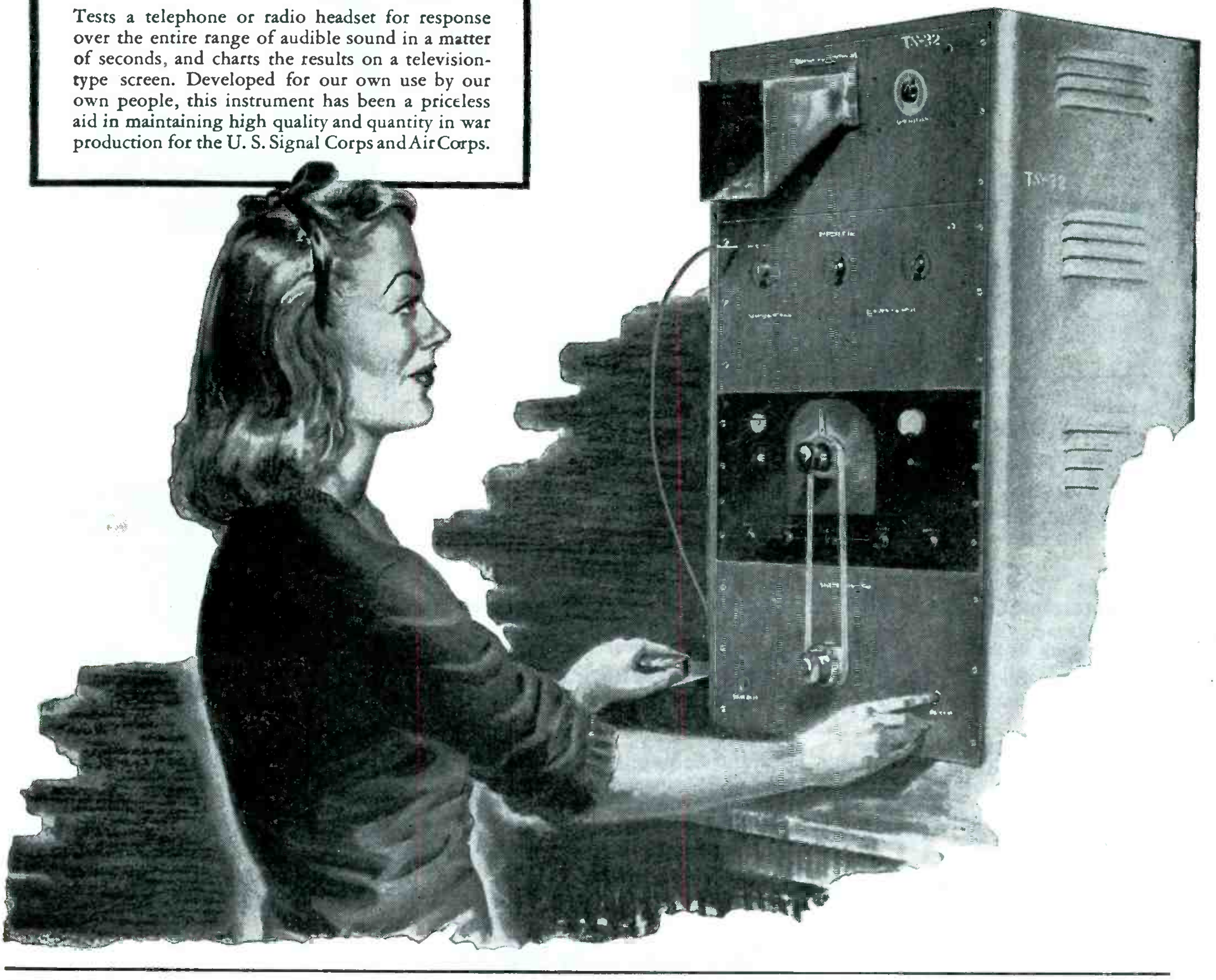

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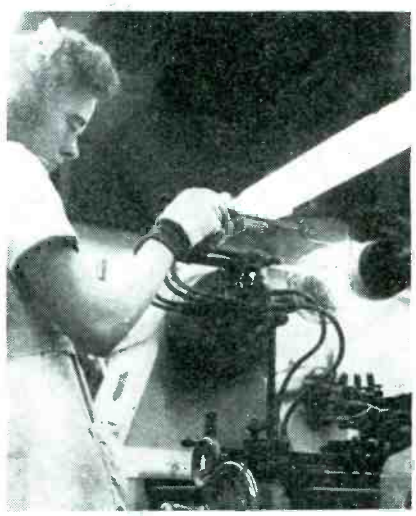
accompanying illustrations. It was used in long-range detection sets, one of which revealed the impending attack on Pearl Harbor and another guarded the Panama Canal a year before.

Of revolutionary design, the tube produced ten times the power of uhf tubes previously built and in-

Finished example of type WL 530 radar tube. This unit served in the famous SCR 270 which detected the approaching Japanese attackers of Pearl Harbor

Production of copper-to-glass seal was one of the difficult parts in development of the WL 530 radar tube. Here a worker in the Fairmont, W. Va., plant of Westinghouse molds the anode seal



volved manufacturing problems at first regarded as insurmountable. Besides geometrical and physical characteristics departing radically from known techniques, the tube called for extremely difficult copper-to-glass feather-edge seals and momentary peak currents which de-

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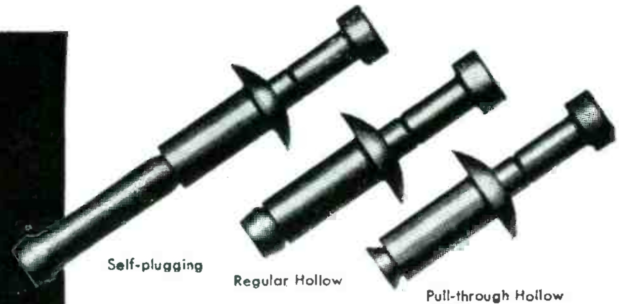

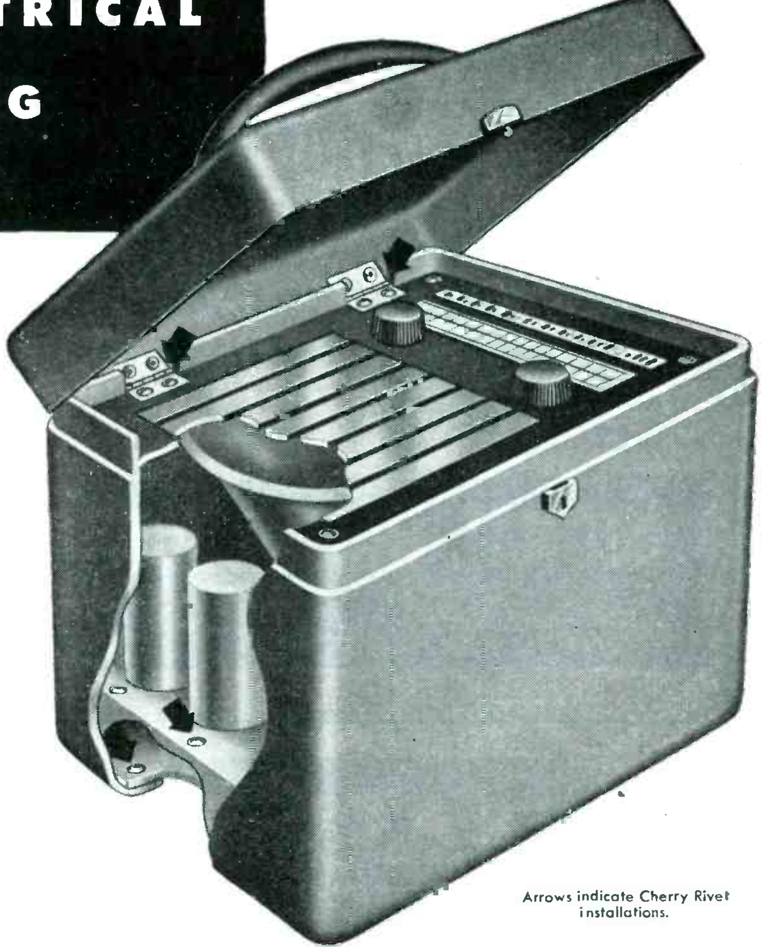

Arrows indicate Cherry Rivet installations.

CHERRY BLIND RIVETS are designed to meet the installation requirements of modern electrical fastening, as well as to simplify and speed up blind and hard-to-get-at rivet applications.

They are upset in a modern way—with a pull exerted by small, easy-to-handle Cherry Rivet pneumatic or hand guns. Installation can be made by one operator from one side of any location, blind or not, without bucking.

Cherry Rivets conform to modern contours; hold securely on curved surfaces, in tubes, bends and ducts; fasten double surface structures from one side.

Modern materials such as plastics, rubber, leather, fabrics, plywood, as well as all sheet metals can be fastened quickly, easily, and with complete success.

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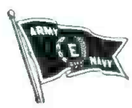
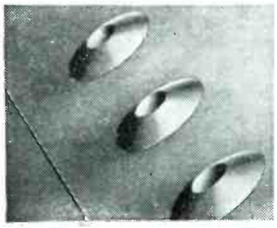
The installed appearance of Cherry Rivets is up-to-date, modern—enhances the appearance-value of the finished product. And their installed cost is low.

For more information, contact your nearest jobber or write now for illustrated Manual D-45, Dept. A-120, Cherry Rivet Company, 231 Winston Street, Los Angeles 13, California.



Hollow Cherry Rivets are best adapted for radio installations. They exert an exceptionally strong clinch—hold securely—can be easily removed for further servicing.



Small, one-hand G-25 gun shown below has head at right angles to gun axis to provide easy access to tight, crowded locations typical of radio installations.

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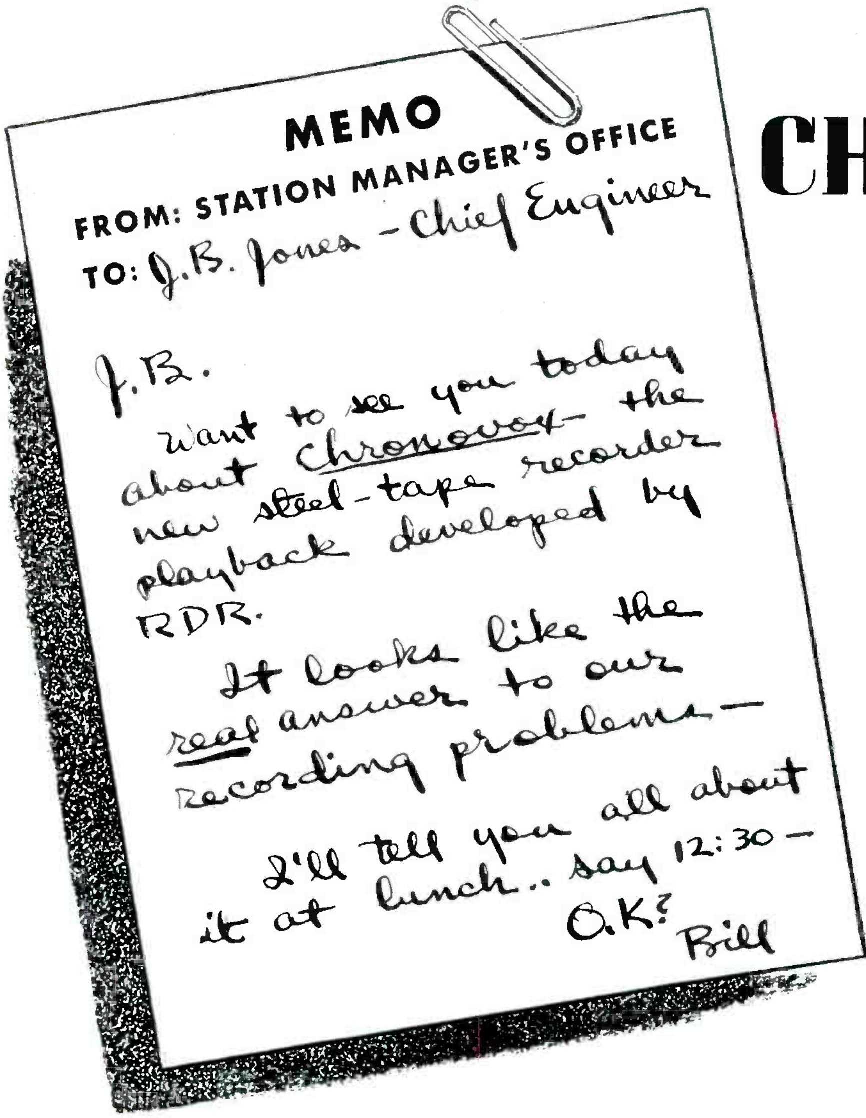

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manded a specially-treated tungsten filament able to withstand five times the voltages believed possible.

The project was taken over by Westinghouse electronic engineer Ilia E. Mouromtseff, who had, back in 1933, done line-of-sight transmission work which led to the detection of automobiles passing by on the highway outside the East Pittsburgh plant of the company. Tubes of similar construction are expected to contribute to the future advancement of f-m and television equipment.

• • •

Drafting Aids to Relay Profiling

By F. J. BINGLEY
Chief Television Engineer
Philco Radio & Television Corp.
Philadelphia, Pa.

PROFILING of the terrain along the line-of-sight television path recently built between Washington and Philadelphia (See ELECTRONICS, Oct. 1945) was necessary because it was desired to obtain at least 100 feet of ground clearance at all points on the transmission path. This clearance was to be provided by the use of two 100-foot antenna towers, one for receiving and the other for transmitting television signals at each relay site selected.

After a study of U. S. Coast and Geodetic Survey maps, four tentative hilltop sites for relay stations were chosen. Then a device, which has been named the Contourograph, was used to prepare profiles of the ground contour between each pair of sites to learn the exact ground clearance along each section of the proposed network.

The instrument is shown in the accompanying illustration. It consists of a double-ended T-square, actually an H-square, with an added cursor. The two vertical legs of the H are used to mark on the map the two end points of a path which is to be profiled, with one leg movable to permit adjustments in the length of the contour section.

Distance and Elevation

The slider which is moved along the horizontal leg of the H-square, is graduated in feet of altitude to an arbitrary scale. Thus as it is

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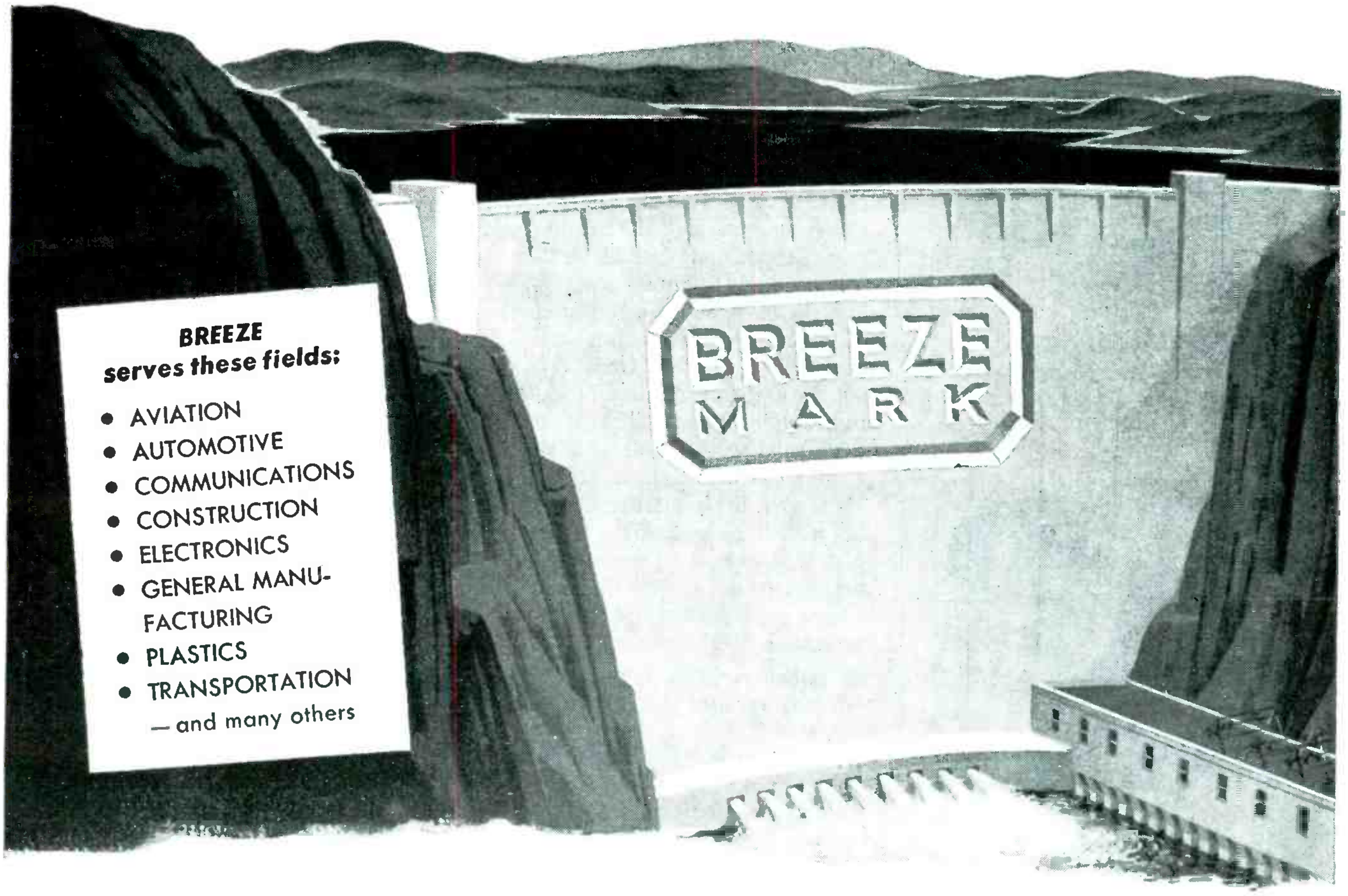

THROUGH diversified manufacturing operations covering a period of nearly two decades, Breeze has built up a vast reservoir of skills and facilities which now may be tapped by manufacturers faced with reconversion problems. Already Breeze has helped two producers of consumer goods to recapture pre-war markets . . . and turn a handsome profit while their competitors were still trying to figure out what to do about re-tooling for peacetime production. And in the same manner that it has helped others, Breeze may be able to help you.

Breeze has available, on a subcontracting basis, resources of versatile equipment and "know-how" ranging from the planning, engineering and production of intricate electronic devices . . . to the manufacture of hardened steel parts.

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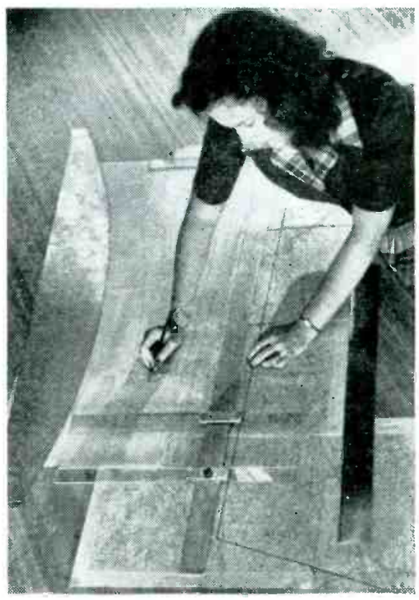
moved along the route between relay sites, the altitudes are read from the contour line intersections on the map and transferred directly as points to a sheet of paper placed above the map and between the ends of the H-square as shown. A series of points are plotted on this paper, and then connected to provide a profile of the ground contour between proposed relaying stations. Distances between transmitting sites are represented horizontally on this profile, while the ground elevation is shown by vertical distance from the base line.

Besides time saving, a second advantage of the Contourograph is that it greatly reduces the chances for error in locating profile points.

Additional Template

Since the curvature of the earth's surface is another factor important in profiling for line-of-sight television transmission it has been necessary to use an auxiliary piece of equipment. This is a curved template, cut on a scale corresponding to the altitude scale of the Contourograph cursor, with its radius of curvature representing the inverse of the earth's curvature. This template is placed so its curved edge passes through the



Profile charts for line-of-sight relay routes are plotted with the aid of this modified T-square. Template at left represents a straight line as affected by curvature of the earth

end points of the profile, and a curve is traced on the paper. If desired, an allowance can be made in this template for the refraction of television waves by the earth's atmosphere—usually accomplished by using as a base figure 4/3 the actual radius of the earth. However, by using the actual radius for this system, Philco was conservative in the matter of clearance on the profile drawing.

To make an instrument capable of simultaneously providing altitudes for profile points and curvature corresponding to the earth's, it is merely necessary to modify the Contourograph by making the upper edge of the horizontal leg curved to represent the earth's curvature. The cursor travels along this curved surface. Then both operations are combined into one simple plotting process.

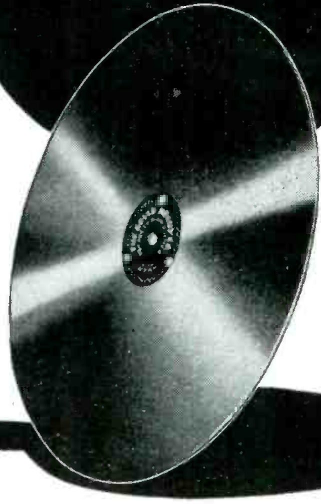
• • •

Measurement Applications of the Dynatron

By Wayne M. Ross
Wallace, Idaho

THE DYNATRON oscillator is a very interesting and useful circuit that seems to have been overlooked by many research and service engineers. As is commonly known, the operation of this type of oscillator results from secondary emission in certain types of tetrodes or screen grid tubes having no suppressor grid, notably the old 24A. When the plate voltage is less than that of the screen, a large amount of secondary-emission current flows from the plate to the screen grid. This causes the plate current to increase as the plate voltage is decreased and to decrease with an increase, in plate voltage, thus, in effect producing a negative resistance. If a resonant circuit is placed across this resistance and the resistance made sufficiently negative to overcome the losses of the circuit, it will oscillate with no other form of reaction or feed back.

As, in a resonant circuit, the greater the resistive losses the lower is the dynamic resistance, so the more damped circuit will require a lower negative resistance to produce oscillations. This value of negative resistance varies consid-



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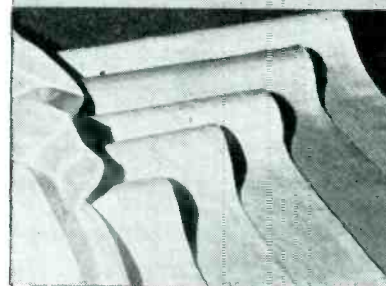

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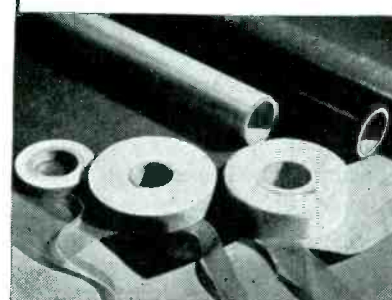

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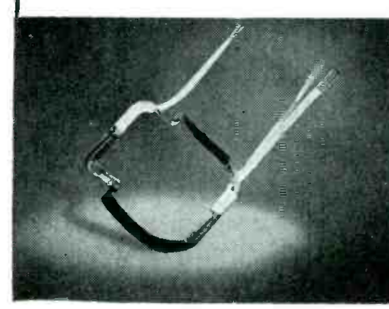

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erably with different tubes. Some of the early type 24A's will provide a resistance of approximately 5000 ohms. Almost any of them will provide 10,000 ohms which is sufficient for most work. The negative resistance is also directly controllable by means of the control-grid bias, being lowest in value when the bias is zero.

A dynatron circuit, arranged for convenience in doing experimental work, is shown in Fig. 1. In addition to the components shown, useful accessories are: a calibrated wavemeter, preferably a non-absorption type, a variety of coils and a capacitor calibrated over the desired frequency ranges, and a large slide-type dial. The 24A tube should be mounted horizontally so that the lead between the plate and external connection is short. The basis for dynatron measurement applications are the dynamic resistance of a tuned circuit and the resonant frequency or change in frequency.

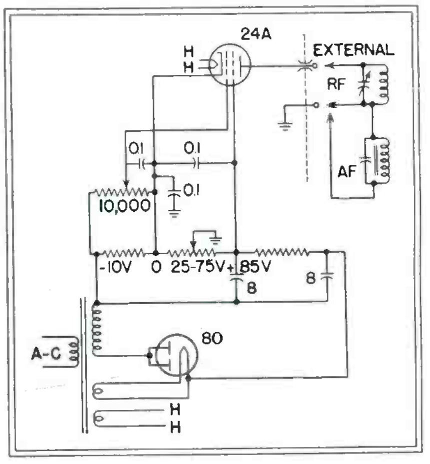

FIG. 1—Once popular in test oscillators, the dynatron circuit operates most efficiently with the early 22 and 24A-type tubes. The circuit above provides convenience in making many measurements

Grid Voltage as Indicator

The dynamic resistance is determined by the most negative control-grid voltage that will still maintain oscillation. This voltage may be controlled by a wire-wound potentiometer, the scale of which may be calibrated to read the negative resistance, or a voltmeter may be used to measure the bias voltage

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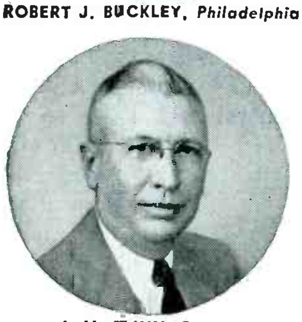

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and a chart made to read the negative resistance. The value of negative resistance may be computed from the E_PI_P curve at various bias voltages, or, if approximations are sufficient, standard coils whose dynamic resistance is known may be used. The negative resistance is equal to the dynamic resistance of the circuit when the bias control is set just at the point of oscillation.

The frequency or change of frequency is determined by the loosely coupled wavemeter or a nearby receiver. The wavemeter is also necessary to determine the point at which oscillations begin.

A parallel-resonant circuit may be tested directly by connecting it to the terminals shown in Fig. 1. The dynamic resistance will be indicated by the potentiometer setting at which oscillation begins and the frequency of the circuit will be shown by the wavemeter.

Capacitance and Inductance

Perhaps the more useful is the substitution test. In this case, a tuned circuit of known values is caused to oscillate. The component to be tested is then clipped across this circuit. Oscillation will probably cease but may be reestablished by decreasing the control-grid bias. This decrease in bias will correspond to the effective resistance of the component under test. If the component contains reactance, the frequency will be altered. The tuning capacitor may be adjusted to restore the original frequency. This adjustment may be calibrated to read capacitance in one direction and inductance in the other. This will not indicate true inductance or capacitance but the effective value at that frequency.

Signal Source

Additional uses to which a dynatron may be put include application as an a-f, r-f, or modulated r-f oscillator. When operated with sufficient control-grid bias so that oscillation is only just maintained, the frequency stability is excellent. Since the amplitude of oscillation may be controlled by the control-grid bias, this factor may be useful for automatic amplitude control. If a modulated oscillator is desired,

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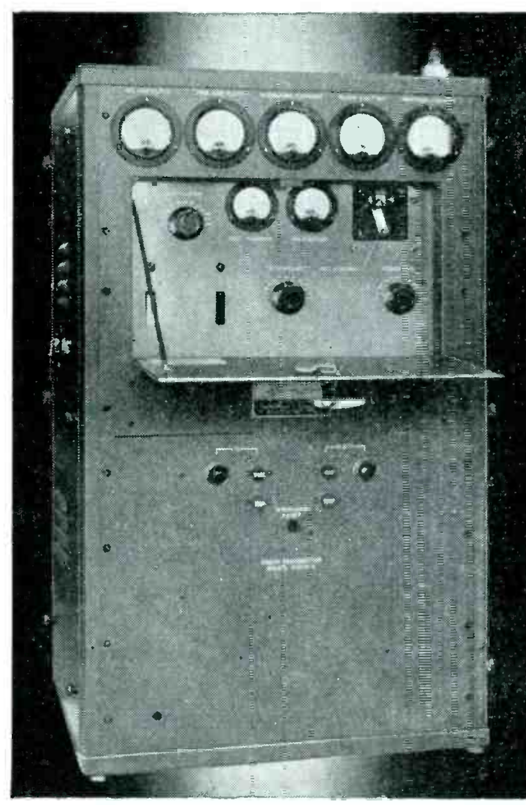

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Measuring effective inductance of small r-f coils can be done if the wavemeter is set to a predetermined setting, say 1000 kc the coil clipped on and the dynatron turned to the wavemeter setting. The dial can be calibrated to indicate the inductance directly in microhenries. This can be done using standard inductances with interpolation between available values.

Using a good quality, 365-$\mu\mu$f capacitor, the 1000-kc setting would provide a scale of approximately 75 to 200 microhenries. A frequency of 1500 kc would provide a scale of 25 to 75 microhenries; 500 kc, the scale of 200 to 1000; and 250 kc, the scale of 1000 to 500 microhenries. This may be carried to as low a frequency as desired, provided the coils are of sufficient Q.

Measurement of inductance in the a-f range may be obtained by providing the wavemeter with a resonant audio circuit and a small capacitive coupling to the grid of the wavemeter. A capacitor decade box is also useful. Using this as the variable capacitor, the coil is tuned to the wavemeter frequency. The amount of capacitance in the circuit may be charted to indicate inductance.

Greater Accuracy

A method for acquiring a more accurate reading of inductances may be worked out by computing changes of capacitance against changes in frequency. These measurements may be carried well into the high-frequency bands but here the value of the tube as a dynatron becomes critical.

Mica and paper capacitors may be measured in conjunction with a known inductance. The frequency of oscillation, when the capacitor is inserted, indicates the capacitance when calculated against the known inductance. Leakage or resistive losses will be indicated by the lower Q as compared to that when a good capacitor is used.

Resistance of Chokes

In testing r-f chokes, it is useful to provide a parallel resonant cir-

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cuit. A frequency is chosen, say 500 kc, and the coil is made to tune to this frequency with approximately ⅓ of the plate area of the tuning capacitor meshed. This point on the dial should be marked zero. If the choke is then clipped across the tuned circuit, the frequency will be altered. The capacitor is then increased until 500 kc is again obtained. This point on the dial can be calibrated to show the value of the added inductance of the choke.

When the choke is shunted across the circuit it will probably stop oscillating. It is necessary to lower the control-grid bias to reestablish oscillation. This will indicate a lower dynamic resistance the value of which will be that of the two coils in parallel.

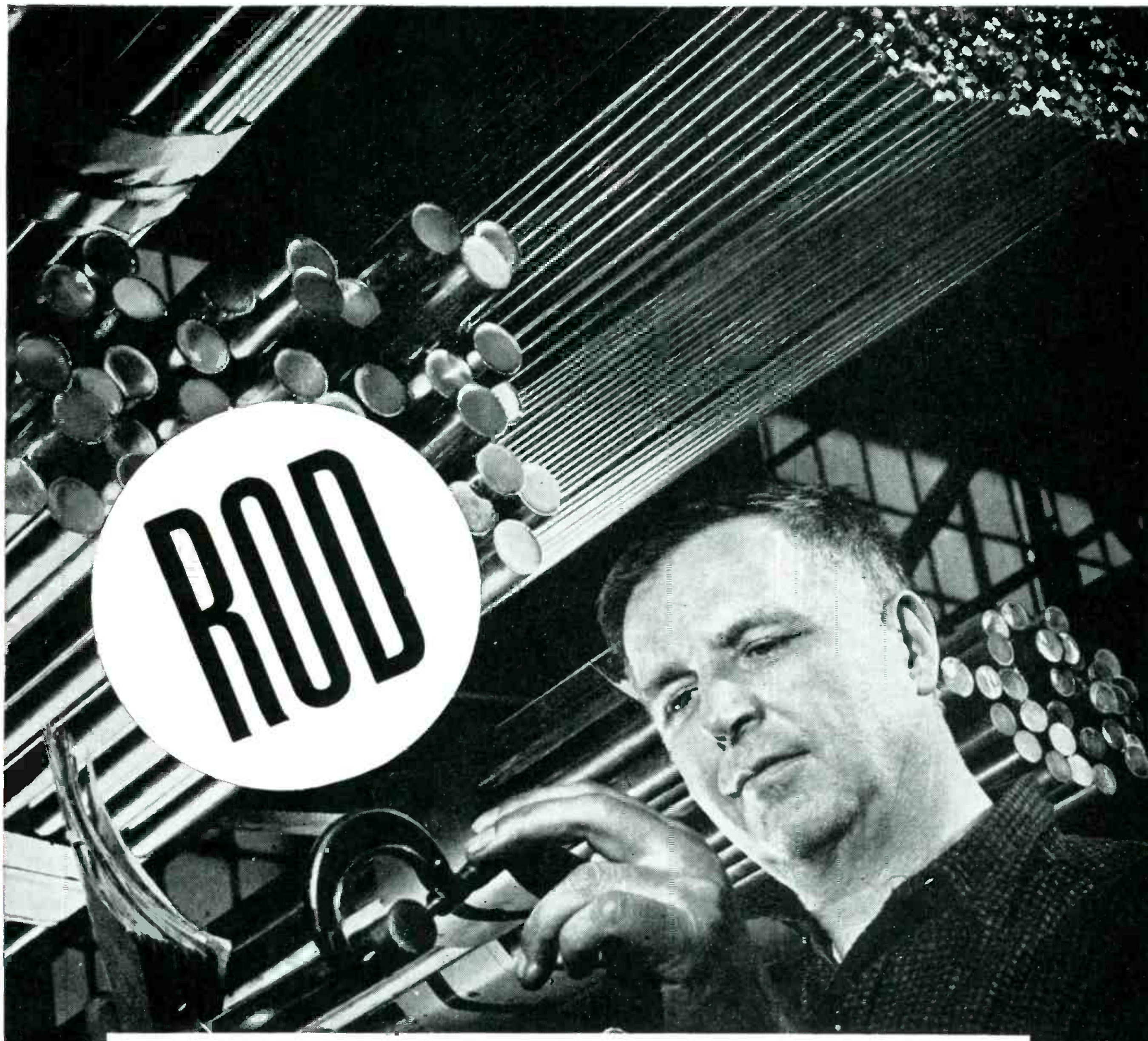
When the dynamic resistance of the coil alone is known, that of the choke may be computed. Or, different values of resistance may be shunted across the tuned circuit in place of the chokes. The value of resistance that requires the same setting of the control-grid potentiometer to produce oscillation will be equal to the effective resistance of the choke.

The instrument may also be used for matching coils using a fixed, standard capacitor and for comparing properties of insulating materials.

Operating Conditions

With the circuit shown, the plate voltage may be between 25 and 75 volts. Maximum efficiency is obtained by increasing the negative grid bias until oscillation just ceases, then oscillation is reestablished by varying the plate voltage. This operation should be repeated until an optimum condition is found.

Another method is to adjust the bias to a slightly negative value, then shunt the oscillating circuit with decreasing values of resistance until oscillations cease; then re-established, as before by varying the plate voltage. This operation should also be repeated to optimum conditions. The plate voltage should then be fixed and not varied after the control-grid potentiometer is calibrated.



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THE ELECTRON ART

Sensitive Television Camera Tube

THE IMAGE ORTHICON, pushed during the war from the developmental stage into practicality by the Radio Corporation of America, has such high sensitivity in converting the optical image into electrical impulses that it simplifies the lighting problems of producing television programs. In addition, the image orthicon makes it possible to obtain clearer television images under shifting light conditions than is possible with earlier pick-up tubes. This new tube is portable as well, making it suitable for field pickups. The tube itself is 15 inches long and three inches in diameter at its widest section.

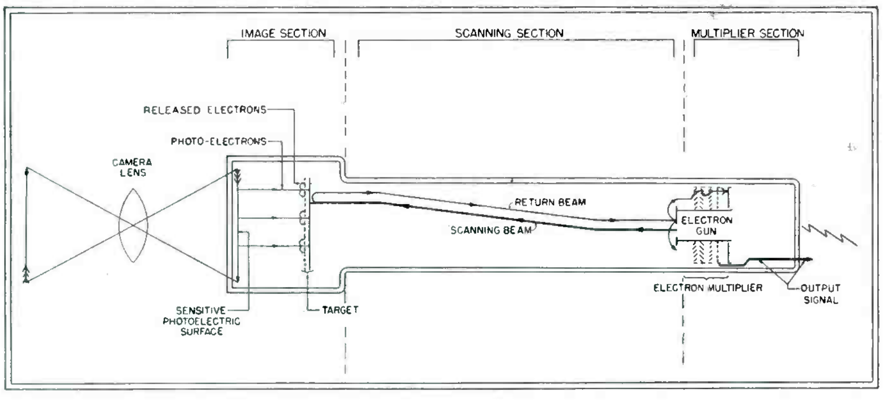

Image orthicon separates functions of photoelectric image conversion and scanning, and incorporates an amplifier

Operating Principle

As can be seen from the accompanying diagram, the image orthicon separates the functions of converting a light image into an electrical image, and of scanning the image. Because of this division of functions, each element can be designed for optimum performance thus giving maximum sensitivity.

The photosensitive surface which converts the optical image into an electrical image is chiefly cesium oxide from which it derives its chromatic-sensitivity characteristic. This photosensitive surface emits electrons in proportion to the photons falling on it. In effect, the surface converts incident photons into impelled electrons. These derivative electrons are translated by a magnetic field through the mosaic screen, which can be of any producable fineness, to the scanning plate. By requiring the photosensitive element to perform but one function, its sensitivity is increased several times over that of the Iconoscope because full utilization can be made of its photosensitive properties.

The scanning target is a semiconductor. The focused, derivative electrons that reach it set up charges. Because electrons are constantly reaching the scanning target, 100-percent image storage is obtained in this fundamentally orthicon-type tube. The target is scanned by a magnetically controlled beam. The target itself is at the same potential as the beam cathode, thus where the target has become charged from the image electrons, it reflects the electrons of the scanning beam in proportion to the image intensity. These reflected electrons are returned to a pick-up, annular-ring dynode surrounding the cathode. The conductivity and thickness of the semiconductive scanning target are the chief parameters that determine its efficiency.

The reflected electron stream is amplified in a cascade electron multiplier of variable gain. This automatically variable gain feature is such that at low levels the gain is high and at high levels it is low. The action prevents intense light from obliterating the entire image as in some earlier type tubes.

The over-all system has almost unity gamma and is operative in scenes illuminated with as low as 0.01 candles per square foot. The gain of the multiplier is about 100 at the 0.01 candle level, and decreases to about 10 at a 10 candle level. By placing an amplifier in the tube the image signal is amplified above the noise level before it is placed on outside conductors where interference will be picked up.

Non-Ferrous Magnetometer

A MERCURY JET MAGNETOMETER for measurement of magnetic field intensities in sharply localized regions is described by Alexander Kolin in the *Review of Scientific Instruments* for August 1945. Operation depends on potential being induced in a moving conductor placed in the magnetic field; the moving conductor in this case is a flowing stream of mercury.

The search channel consists of a narrow non-conducting tube carrying mercury at constant velocity. Two electrodes, at ends of a tube diameter, pick off the emf developed by the moving conductor (mercury) in the magnetic field under study. A ratio of 10 to 1 between channel length and diameter (0.2 mm by 2 mm) has been found satisfactory.

Induced emf is given by $e = \mu Hdv \times 10^{-8}$ volt, where d is the separation of electrodes (diameter of the tube), v is the average velocity of mercury flow (regardless of velocity distribution), and H in oersteds is the component of local magnetic field mutually perpendicular to the channel axis and the elec-

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trode diameter. Orientation of the magnetic field can be determined by locating the channel probe in the position that gives a maximum voltage, then flux direction can be determinated from the above perpendicularity relation.

The electrodes are connected to a millivoltmeter. Induced emf, mercury velocity and channel diameter can be measured accurately with readily available instruments, thus H can be determined with high precision. The instrument can make continuous field measurements, and is therefore valuable in transient field measurements.

In the equipment as developed for laboratory measurements, a magnetometer with permanent magnet is used as flow meter. The sensitivity of the flow-meter magnetometer is adjusted by rotating the permanent magnet; the cosine of the magnetic angle giving the multiplying factor.

The same principle is used for the mercury pump. Electrodes are made to pass current through the entire cross section of the mercury path. A permanent magnet provides flux over the same volume. Control of the electrode current governs the mercury flow.

• • •

High-Frequency Deflection System

By GUNTHER RUDENBERG
Harvard University
From Jour. of Applied Physics, May 1945

THEORETICAL DESIGN considerations for the deflection system of a cathode ray tube to be used at high frequencies include the driving amplifier output, the sensitivity of the deflection system, and the arrangement of the system.

Amplifier

High-frequency characteristics of wide-band oscilloscopes are chiefly limited by the amplifier stage that drive the deflection system. A figure of merit for this stage is $I/C = E\,\omega'$ where I is the maximum output current from the stage, which can be approximated by the average current drawn by the tube for class A operation, and C is the total shunt capacitance in-

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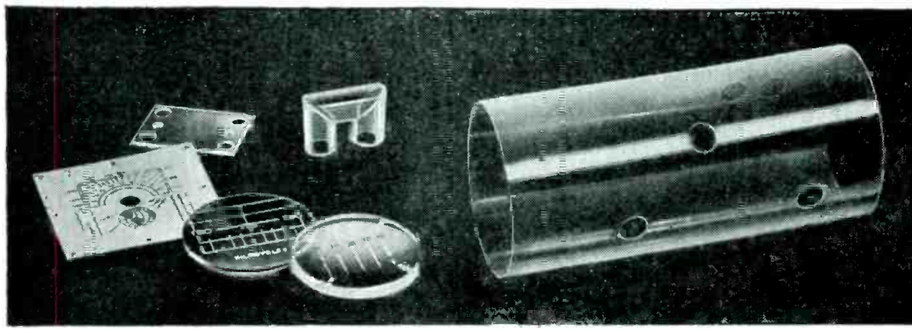

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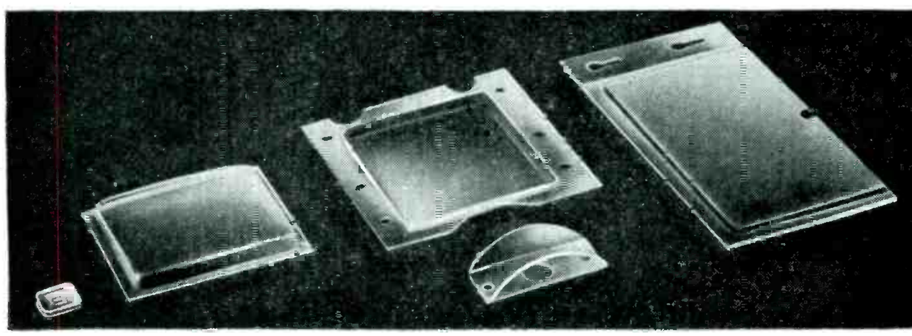

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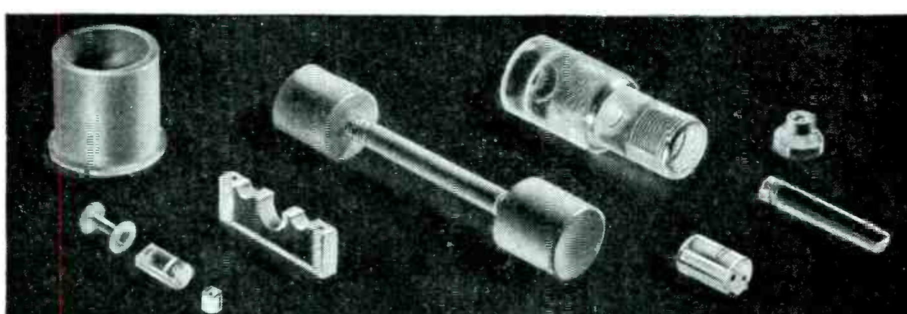

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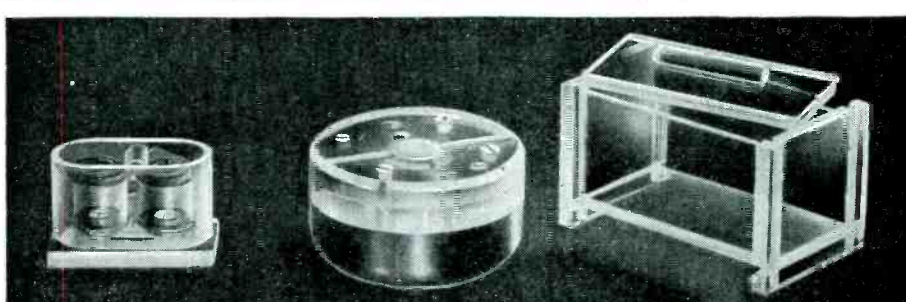

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cluding both that of the amplifier and of the deflection system, E is the peak output voltage, and ω' is the upper frequency limit of the amplifier; i.e., the half-power frequency.

From this figure of merit we see that to obtain high-frequency response, capacitance C should be made small. Also, the available a-c from the tube should be made large by either using tube and operating conditions which draw a large current or using negative feedback. Another possibility is to reduce the required E by increasing the sensitivity of the deflection system which may prove advantageous despite the accompanying increase in capacitance. For fixed-frequency operation, input and output of the amplifier can be tuned.

Deflection Sensitivity

If, for small transit times, the deflection field is uniform across its width, and the acceleration potential V with which the electron beam enters the deflection field is constant, the deflection angle θ of the beam produced by the deflection field is, from electron ballistics,

$$\theta = (1/2V) \int_{Z_1}^{Z_2} \epsilon dz \qquad (1)$$

where Z_1 is the position of the beginning and Z_2 the ending of the deflection field as seen by the electron beam, and ϵ is the perpendicular component of the electric field along the path of the beam.

From Gauss's theorem applied to the plane of the path of the beam within the deflection field area, we obtain

$$\rho/\epsilon_0 = \int_{Z_1}^{Z_2} \epsilon dz \qquad (2)$$

in which ρ is the charge per unit width of the plates and ϵ_0 is the permittivity of the space between the plates. If E is the voltage between the plates, and c is their capacitance per unit width related to that portion of the electrostatic field that the beam traverses, then

$$\theta = Ec/2V\epsilon_0 \qquad (3)$$

This equation shows that, instead of the equivalent length of an idealized deflection system without fringing fields giving the same deflection as the actual system, it is a system having the same apparent capacitance per unit width that

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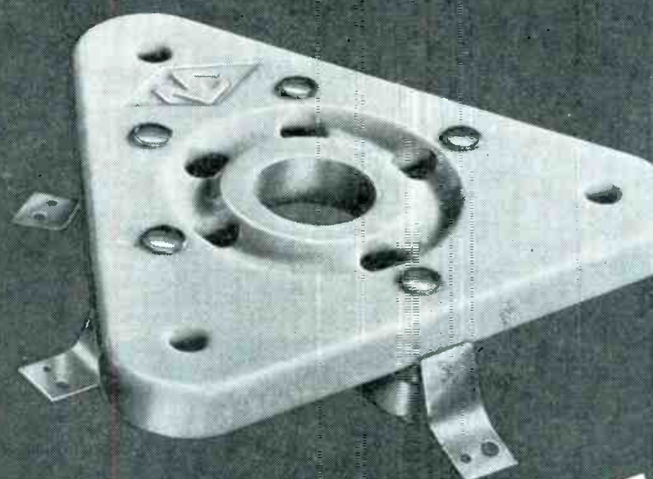

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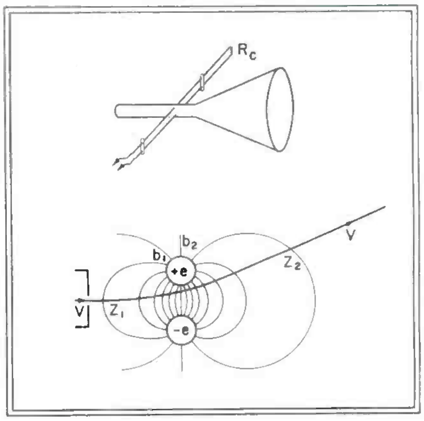
gives the same deflection. This capacitance takes into consideration the fringe effects in the path of the beam.

From Eq. 1 and 2 we find that $\theta = \rho/2V\epsilon_0$. This result shows that the deflection angle depends on the internal charge per unit width that can be placed on the system, and upon the axial accelerating potential, regardless of the configuration or potential of the deflecting system. The aims in designing either a deflection system or its amplifier are thus to decrease the



At the top is a parallel-wire line used as the deflection system of a cathode-ray tube. The line can be terminated in its characteristic resistance thereby giving a system having an inpedance independent of frequency. At the bottom is the deflection field established by the line. The length of the field is comparable to the wire spacing

beam accelerating potential at the deflection system and to increase the internal charge per unit width of the system.

For a given total charge, the deflection angle can be increased by making c large compared to the total circuit capacitance. Instead of making the deflection plates as small as possible as has heretofore been suggested, they should be designed to have large capacitance especially if the cathode-ray tube is to be connected to an amplifier which has some capacitance and can supply only a limited charge for the deflection system.

Parallel-Wire Line for Deflection

The factor c/ϵ_0 in Eq. 3 is a dimensionless quantity. Thus once the shape of the deflection system has been determined, its sensitivity

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—as long as transit-time effects do not enter—has been determined. However, because the axial length of deflection systems that use pairs of plates flared at their ends and the inductance and capacitance of their leads enter at high frequencies, the deflection is reduced.

Both transit time and lead effects can be reduced by using a closely spaced, parallel-wire line as illustrated in the accompanying figure. The capacitance per unit length of such a line is

$$c = \pi\epsilon_0/\cosh^{-1}(d/2r)$$

where r is the radius of the wires and d is their spacing. From Eq. 3 their deflection is

$$\theta = \frac{E}{2V}\,\frac{\pi}{\cosh^{-1}(d/2r)} \simeq \frac{E}{2V}\,\frac{\pi}{\ln(d/r)}.$$

the approximation being valid for large (d/r).

The electrostatic field is mainly concentrated within a distance equal to the wire spacing. Thus the significant part of the transit time is that time required for the beam to cross a space of the same order of magnitude as the wire spacing.

Use of Parallel-Wire Deflection System

For measurements at fixed, high frequencies the parallel wires can be tuned, and by proper adjustment of the tuning a voltage maximum can be located at the point where the beam travels between them. Owing to the low losses of such a line, very high maximum of charge and voltage can be obtained thus ensuring a maximum deflection.

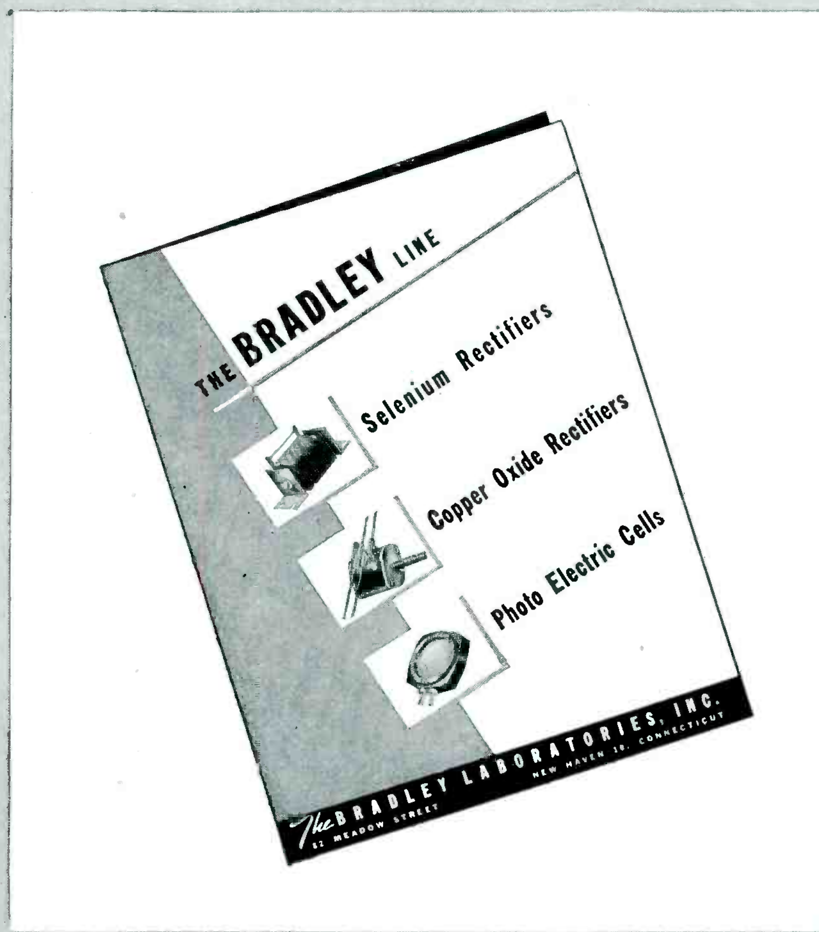
For wide-band operation, the deflection system should be terminated in its characteristic impedance. A greater power input to the deflection system than for the tuned condition will be required, but the system will present a pure resistance load at all frequencies. The surge resistance of a nonresonant line is

$$R_c = 120\cosh^{-1}(d/2r)\text{ ohms}$$

Thus the deflection angle in terms of the input current $I = E/R^c$ to the line is

$$\theta = 60\,\pi I/V$$

We see that this deflection is independent of the relative line spacing and is primarily determined by the



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current or charge on the deflection system.

The driving power for the nonresonant system is mainly dissipated in the terminating resistance and will be least when that resistance is smallest. This requirement indicates thick wires closely spaced. Where the wire diameter is too thick to be sealed into the glass walls of the cathode-ray tube, their cross section can be reduced thus offsetting the effect of the added dielectric of the glass on the characteristic impedance.

Contrasted to the conventional deflection-plate system in which a reactive power proportional to frequency is required, the parallel-wire system requires a resistive power that is independent of frequency. In the study of transients this advantage plus the absence of resonances make the parallel-wire deflection system very useful. If closely spaced wires are used, the low transit time enables absolute voltage measurements to be made at high frequencies.

• • •

Microanalytic Measurement of Oxygen Production

By PETER PRINGSHEIM
Ray Control Company
Pasadena, California

A METHOD FOR MEASURING the production of very small quantities of oxygen has been developed in collaboration with J. Franck and Dolores Terwood in the laboratory of the Fels Foundation in the Department of Chemistry of the University of Chicago.[1] The method is based on a phenomenon discovered by Kautsky[2] and permits measuring quantitatively the production of 10^{-6} cc per second of O_2 at atmospheric pressure.

Preparation of Posphor

Kautsky found that if a dye such as trypoflavine (acriflavine) is absorbed on silica gel and the gel is highly evacuated, the dye becomes phosphorescent when irradiated with light from an incandescent lamp, the afterglow being visible for about 10 seconds after the end of the irradiation. This phosphorescence is not affected by the presence of very pure N_2, H_2, CO_2, CO

or a rare gas, but it is very strongly quenched by the presence of the smallest quantities of O_2.

The phosphor, the phosphorescent gel with adsorbed dye, is prepared by immersing carefully purified silica gel in a dilute aqueous solution (0.5 normal) of the dye during a period of a few hours, keeping the solution in the dark. The grains of the gel should have a diameter of about 1 mm. After being dried superfically, a small quantity of the phosphor is inserted into a glass tube and evacuated during several hours to the highest attainable vacuum, while it is heated to 350°C. From there on, the phosphor must be protected against contamination with oxygen at high pressure. If it should come into contact with atmospheric air, the high temperature, vacuum treatment must be repeated.

Phosphoroscope

For quantitative measurements the tube containing the phosphor is placed between the discs of a Becquerel phosphoroscope the arrangement of which is shown in Fig. 1. The phosphor fills a tube of 4 mm

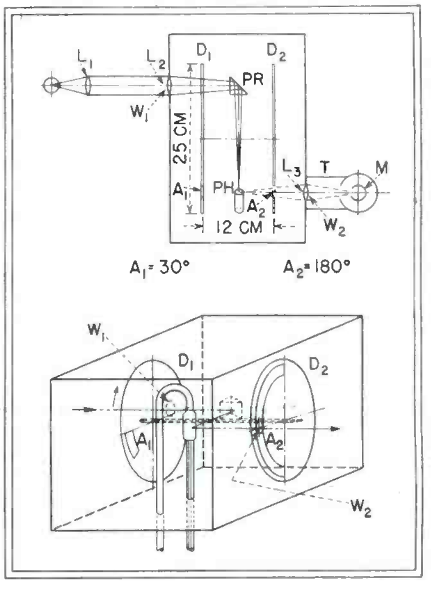

Fig. 1—Phosphoroscope in which oxygen sensitive phosphorescent dye is illuminated, the illumination shut off, and the reradiation directed to a photo tube

inner diameter and a length of 20 mm and is held in position by nickel gauze.

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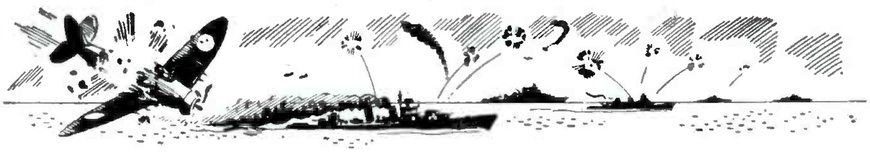

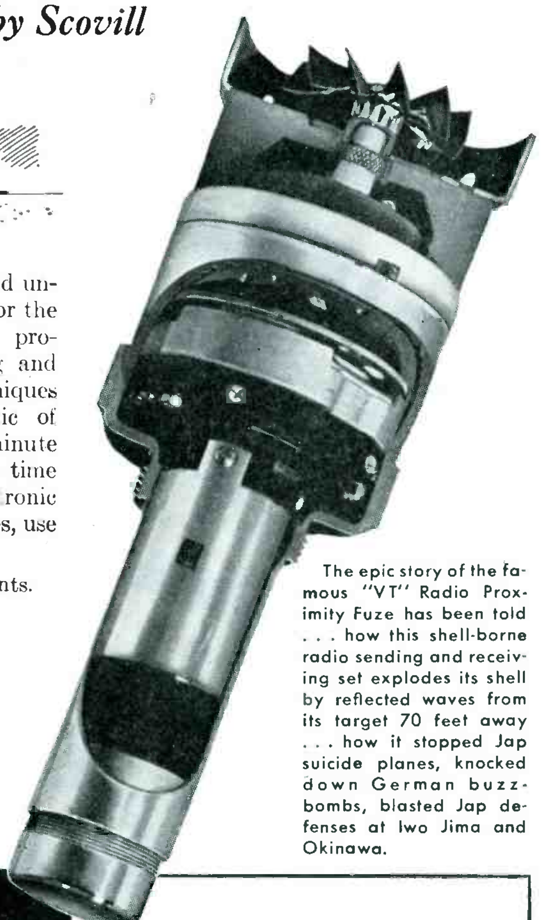

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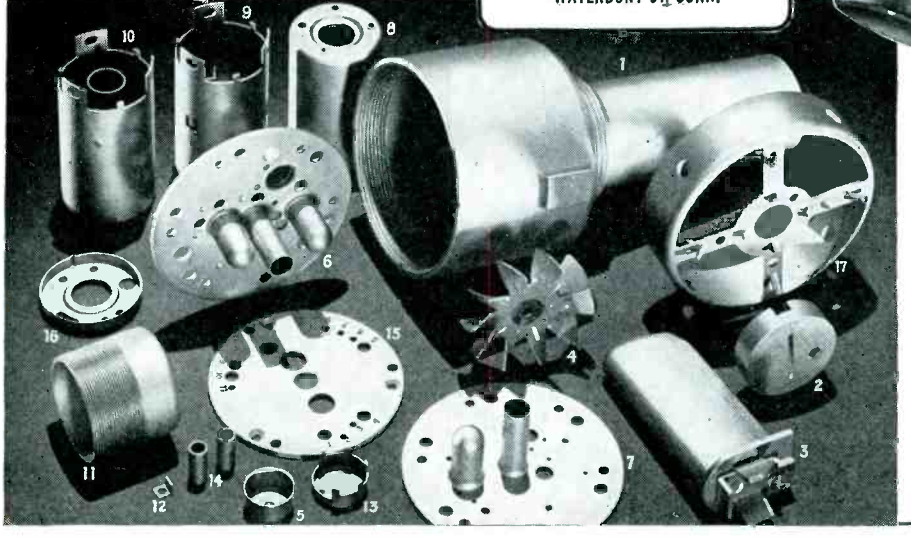

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the phosphoroscope through a window W_1 and the aperture A_1 in the first rotating disk D_1; the phosphorescent light is transmitted through window W_2 and aperture A_2 in the second rotating disk D_2. Apertures A_1 and A_2 are adjusted so that W_1 is completely screened by D_1 before A_2 opens window W_2. No light can fall on the phosphor except the radiation transmitted through W_1 and A_1.

The phosphor is excited by the radiation of a General Electric Mazda Projection lamp (6 v, 18 a) the current of which is supplied by a transformer connected to the houseline through a voltage regulator. The light is made parallel by a lens L_1 of small focal length so

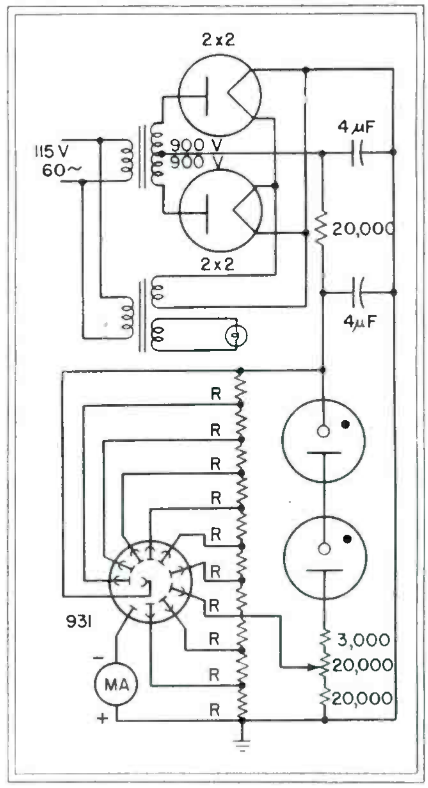
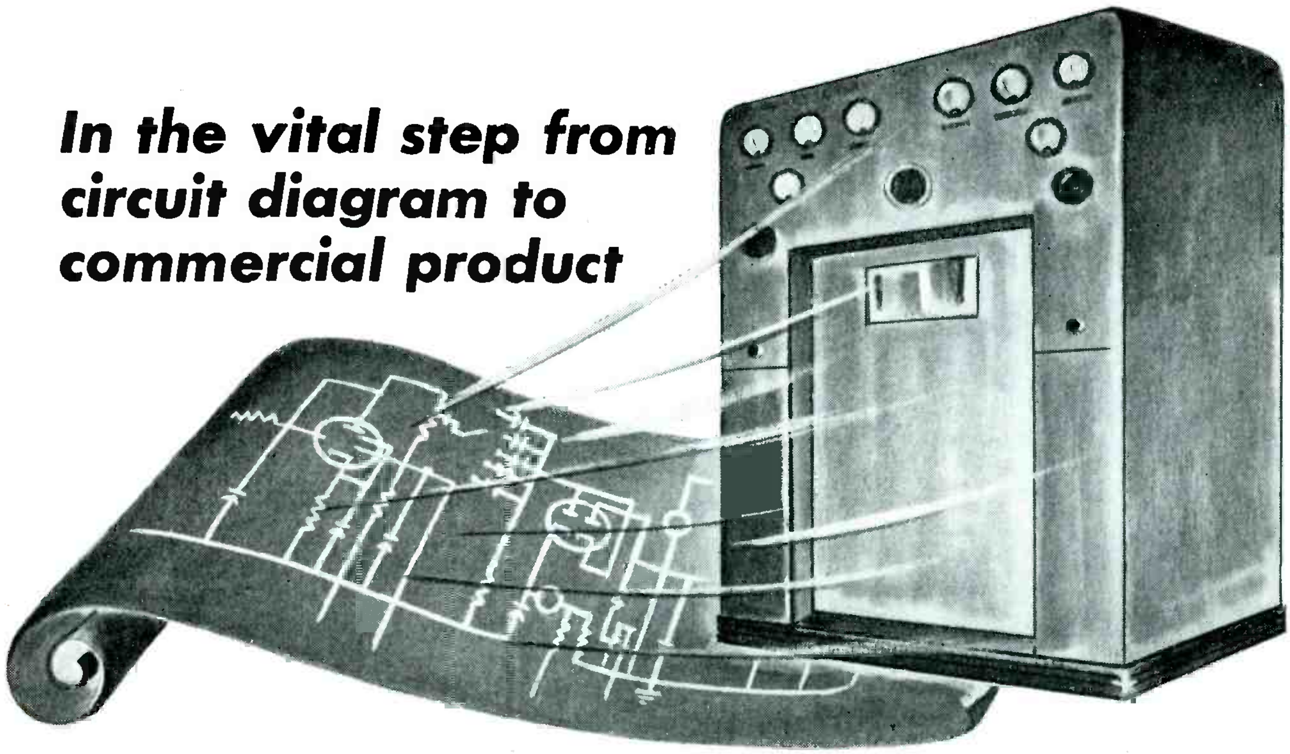


Fig. 2—Multiplier photo tube is used to operate indicating instrument

that the lamp can be located at a great distance from the phosphor and does not interfere with other parts of the apparatus. A lens L_2 is placed in front of the window W_1 and focuses the reduced image of the lamp filament on the phosphor; the totally reflecting prism PR is adjusted so that the light beam impinges on the phosphor container nearly at a grazing angle; the im-

In the vital step from circuit diagram to commercial product



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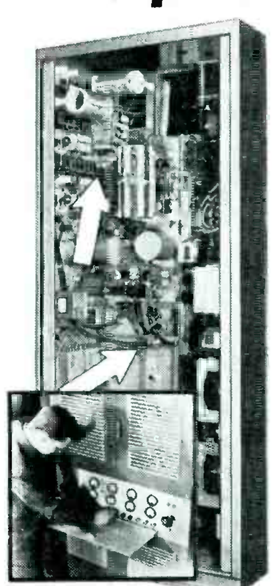

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Electronic Circuit

The self compensating circuit used in connection with the photomultiplier and shown in Fig. 2 is of the type reproduced in "Experimental Electronics" by R. H. Muller, R. L. Garman and M. E. Droz (Prentice Hall, N. Y., 1943).

A part of the voltage divider consists of two VR 150 tubes. With a fluctuating line voltage the variations in the voltage of dynode 7 are, therefore, larger than those in the voltage of the other dynodes and can be used to counterbalance any changes in the latter.

The anode current was measured without further amplification by means of a Rubicon galvanometer of a sensitivity of 4.10^{-9} amp per mm. The inertia of the instrument was sufficient to give steady deflections if the frequency of the phosphoroscope was 6 flashes per second.

A photo-multiplier tube of the earlier type (R.C.A. 931) was at our disposal. Even with this tube we obtained sufficient amplification of the photoccurrents produced by the phosphorescence by using 75 volts between adjacent dynodes, or 900 volts over-all. With the maximum voltage of 120 volts per step the anode output could have been increased more than tenfold. A similar high output could be obtained with the new 931-A tube at the normal 100 volts per step. Thus, either a galvanometer of lower sensitivity or a lower intensity of the exciting light could be used; the latter has some advantages because, after long and strong irradiation in the presence of O_2, the phosphor begins to deteriorate.

Measurements were made by tak-

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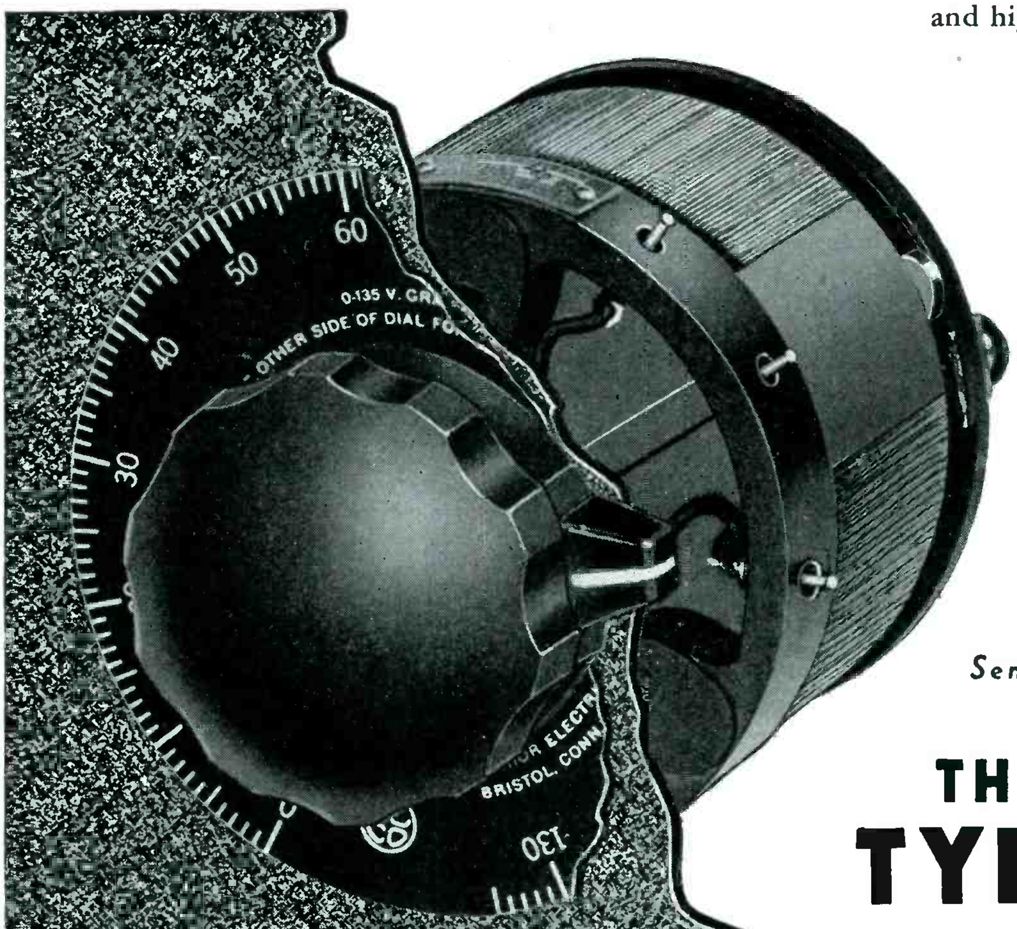

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ing a reading of the galvanometer deviation every two seconds and inserting the points in a diagram of galvanometer readings versus time. Since then a Esterline-Angus recorder has replaced the galvanometer. These points correspond to phosphorescence intensity which is a nonlinear function of the O_2 pressure. The dependence of phosphorescence intensity on oxygen pressure can be determined by introducing small quantities of oxygen into the highly evacuated apparatus and measuring their pressure by means of a McLeod gauge. The quenching efficiency of oxygen of a given partial pressure is practically unaffected by the presence of nitrogen. Fig. 3 shows a calibration curve.

Operating Technique

When not used for actual measurements, the phosphor was always kept in the dark. Under these conditions it could be used during many weeks. If, after a lapse of

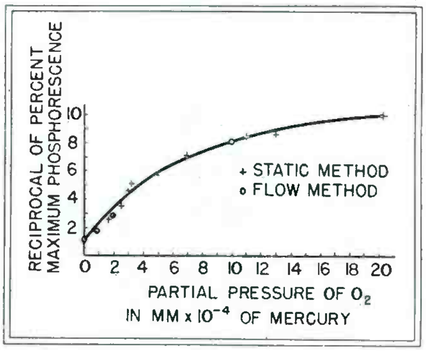


Fig. 3—Data from the phosphoroscope is converted from luminescence to partial pressure of oxygen by calibration curves similar to this one

time, it began to be less active, the height of the whole phosphoroscope with respect to the phosphor could be altered by a few millimeters, and a fresh spot of the phosphor gave again the former maximum phosphorescence.

The tube with the phosphor formed a part of a system which could be either connected to a diffusion pump or be flushed with N_2 or some other gas transporting small amounts of oxygen. Water vapor in the carrier gas must be frozen out in a trap cooled with liquid nitrogen before the gas reaches the phosphor. The carrier

gas itself, e.g. N_2 or H_2, must be of the very highest purity.

The method loses its sensitivity with increasing oxygen pressure; at pressures above 10^{-3} mm the phosphorescence is already quenched so much that a further increase in oxygen concentration has only a relatively small effect.

The quantity of oxygen produced per minute can be calculated from the partial pressure of oxygen measured during a certain period and the rate of flow, which in our experiments was only 3 cc per minute as controlled by a bubble counter. Because of this small rate of flow, the method becomes exceedingly sensitive as far as the rate of oxygen production is concerned.

It must be conceded that the quenching of the trypaflavine phosphorescence by oxygen does not yield absolute quantitative values with an accuracy of more than about ± 50 percent if the calibration curve is not frequently controlled, because the sensitivity of the phosphor is not constant. However, in many cases the order of magnitude of the oxygen production and its relative changes during a series of experiments will be all that is desired and, at any rate, no other method is available that could yield similar results with comparable ease and in as short a time.

References

(1) Franck, J. and Pringsheim, P., *J. Chem. Phys.* 11, 21, 1943; Pollack, M., Pringsheim, P. and Terwoord, D., *J. Chem. Phys.* 12, 295, 1944.

(2) Kautsky, H. and Hirsch, A., *Zs. f. anorg allgem. Chem.* 222, 126, 1935.

• • •

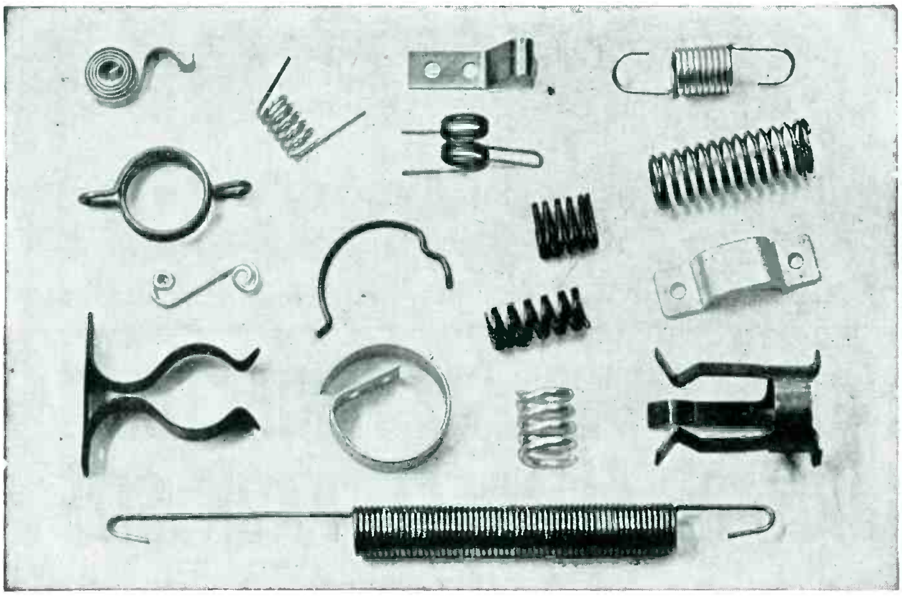
Low Frequency Multivibrators

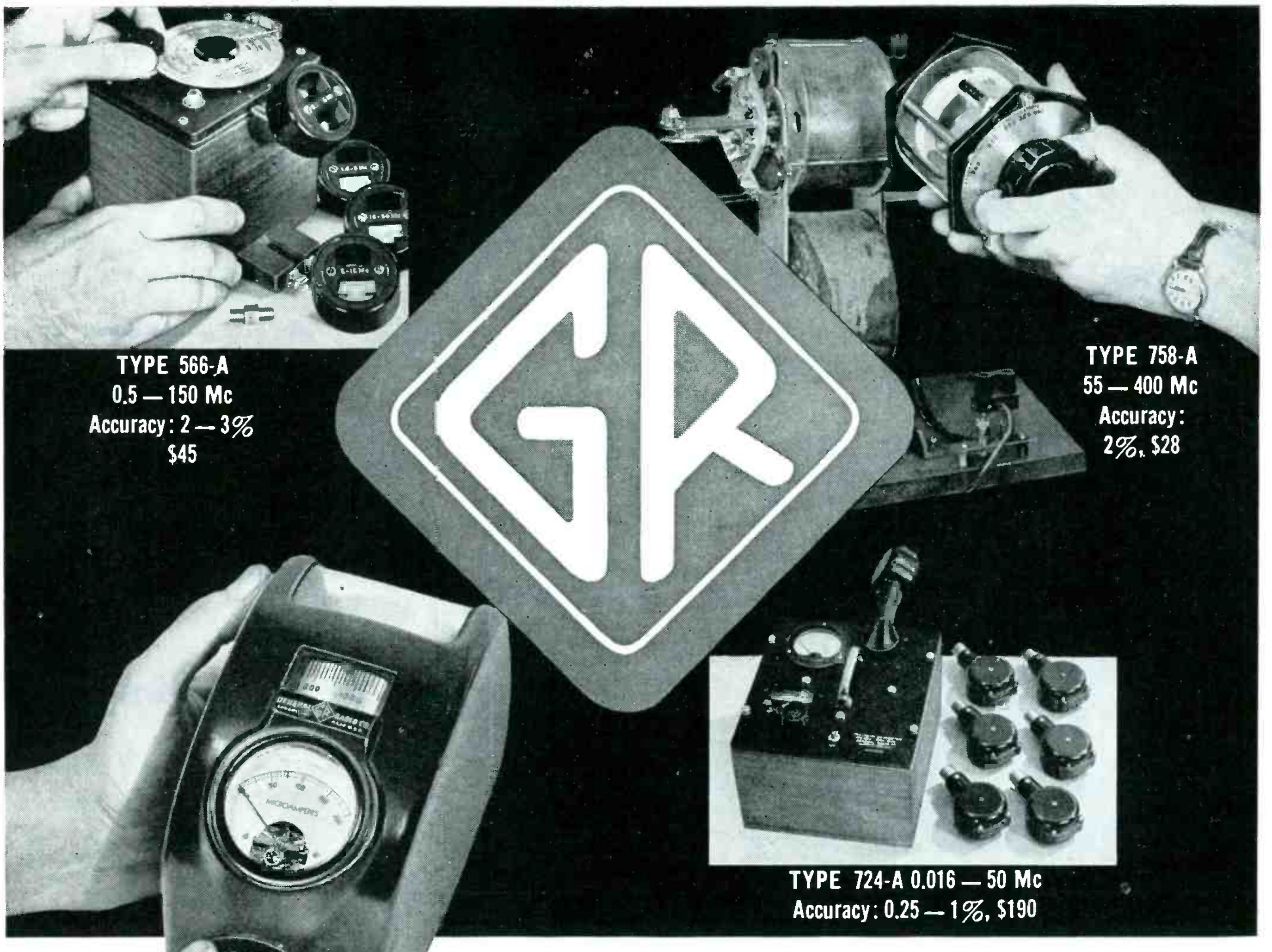
By Carl J. Quirk
Signal Corps

The lowest frequency at which a multivibrator will operate is determined by capacitor leakage. To determine the stability of such low-frequency circuits and their lowest possible frequency, an investigation using standard parts selected at random was conducted.

Basic Circuit

A simple free-running multivibrator shown in the accompanying illustration was used as the start-





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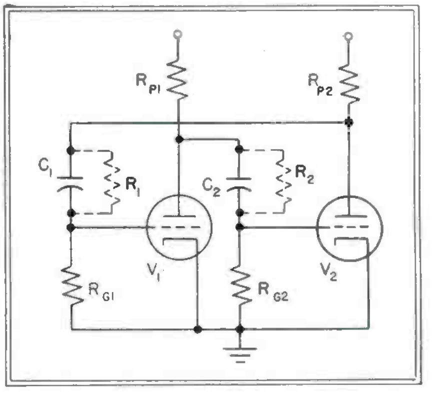
ing point. Disregarding for the present the capacitor leakage resistance shown dashed, the duration of a cycle is expressed by $T = R_{G1} \cdot C_1 R_{G2} \cdot C_2$, if $R_{G1} \gg R_{P2} \cdot R_{V2}/ (R_{P2} + R_{V2})$ and $R_{G2} \gg R_{P1} \cdot R_{V1} (R_{P1} + R_{V1})$ where R_{V1} and R_{V2} are the d-c resistance of V_1 and V_2 respectively. If resistances are given in megohms and capacitances in microfarads, the period will be in seconds.

Because these conditions are usually satisfied in multivibrators, this order of magnitude equation can be used. As will be shown later, results calculated by this equation will not always be accurate, but for the purpose of this discussion they will be close enough.

Multivibrator Operation

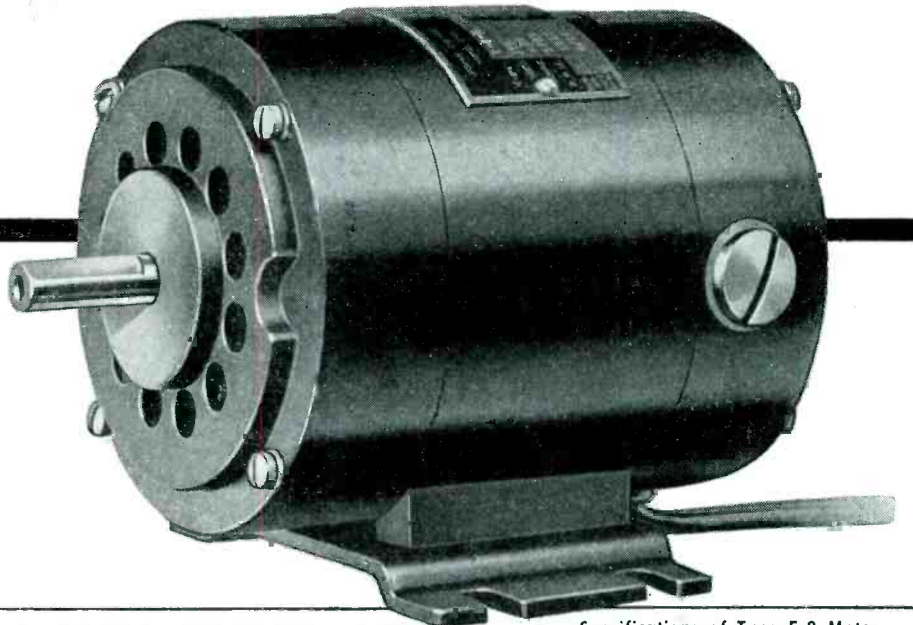
To illustrate the manner in which the leakage of the coupling capacitors limits the lowest frequency of operation, the function of the circuit is reviewed. An increase of



In the multivibrator used to determine the lowest frequency of operation, grid resistors were finally omitted and the leakage of the capacitors used to perform their function

current in V_2 lowers its plate voltage. This reduction in plate voltage is coupled through C_1 to the grid of V_1 thereby reducing the current in V_1 and causing an increase in the plate voltage which in turn is coupled to the grid of V_2 through C_2 causing the plate current of V_2 to further increase. This series of events continues until V_1 is cutoff, at which time V_2 will be drawing a large plate current. A very short time compared to the complete cycle is required for this action.

The effect is a sudden change in voltage across C_1 from the full



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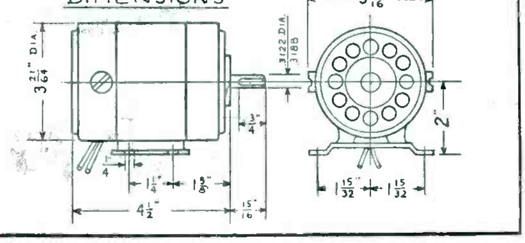
Starting Torque in % of F. L. Torque	200 min.	200 min.	200 min.	200 min.	200 min.

Specifications of Type E-8 Motor



Your new product will perform *better* and have *additional* sales appeal . . . with a dependable Oster motor

MADE IN U. S. A.

A modern, scientifically engineered motor, such as any one of many different sizes and styles made by Oster, is of prime importance in making your product perform satisfactorily.

The model E-8 Oster Motor illustrated above gives you the advantages of light weight, compactness, and dependable, trouble-free performance. Here are the details:

HOUSING — Die cast, open or totally enclosed.

FINISH — Black, baked enamel.

BEARINGS — Single or shielded ball bearings, or sleeve bearings.

BRUSHES — Furnished with metal graphite or electro graphite brushes of ample size to assure unusually long brush life. Phosphor bronze or beryllium copper brush springs.

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MOUNTINGS — Available for either base or flange mounting.

MODIFICATIONS — Motors can be furnished with special shaft extensions, finishes, leads, etc. Motors can also be furnished for operation in high ambient temperatures and high altitudes.

All ratings and data are approximate.

Let us help you fit this and other famous Oster Motors to your requirements.

John Oster Manufacturing Co.

DEPARTMENT L-29 • RACINE, WISCONSIN

M-29

plate supply voltage to a much lower value. But this reduction in voltage across C_1 cannot occur instantly, thus the voltage drop across R_{G1} due to the discharging current of C_1 causes V_1 to go rapidly to cutoff and remain cut off until the discharge current becomes low enough so that the voltage across R_{G1} is equal to the cutoff bias of the tube, at which time the circuit will again switch and cause V_2 to become cut off and V_1 to conduct.

The period during which V_1 will be at cut off will be designated as T_1 and determined by the product $R_{G1}.C_1$. This condition will hold true if R_{G1} is much greater than the parallel resistance of R_{P2} and R_{P2} (as mentioned above) and much less than the leakage resistance of the capacitor C_1 itself. In most low frequency multivibrators the first condition will be satisfied but the second will have to be determined by trial and error. Likewise the period during which V_2 will be at cutoff will be designated as T_2 and determined by the product $R_{G2}.C_2$.

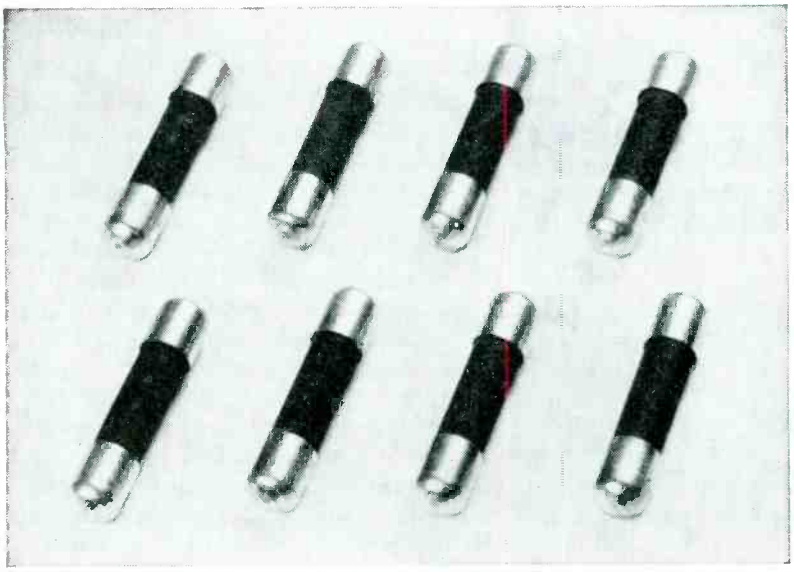
Effect of Capacitor Leakage

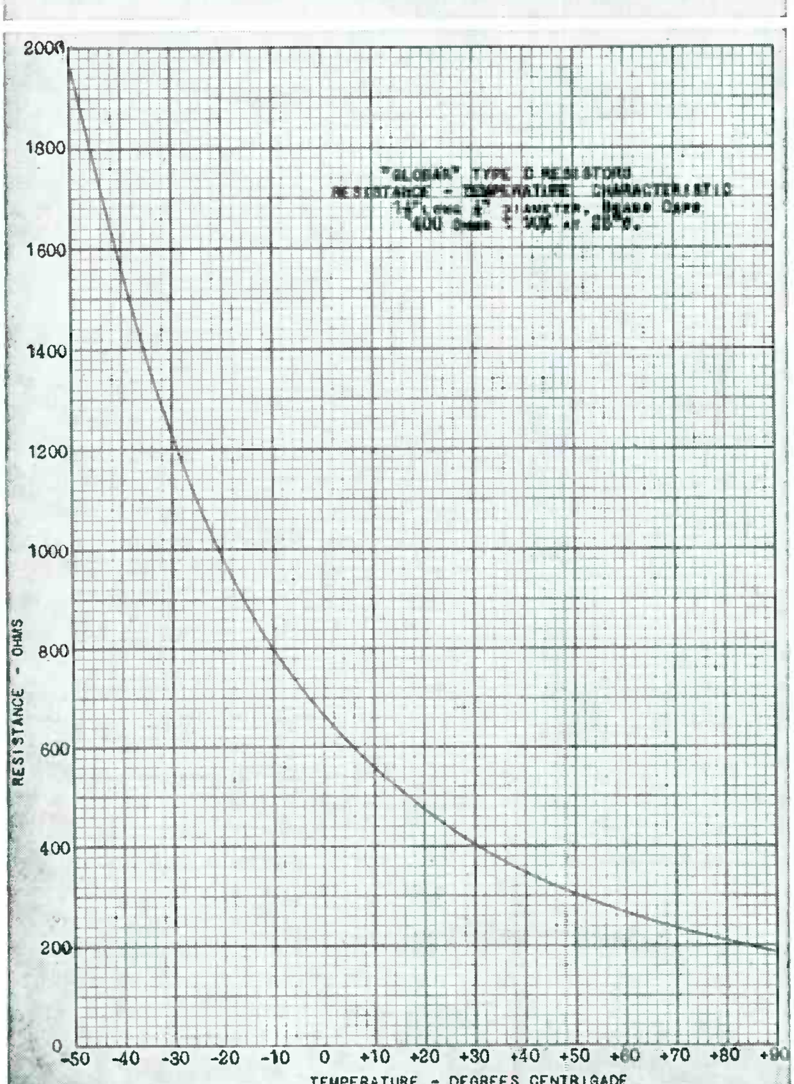
Referring to the illustration, note the resistance R_1 and R_2 which represent the leakage resistances of the associated capacitors. Because means to measure leakage resistances of capacitors is not available to most experimenters, the only way one can be sure whether this leakage is going to affect the operation or not is to actually build the circuit and test it. A number of combinations were tried and the results presented in Table I. In all combinations R_{P1} and R_{P2} are 0.5 meg, the plate supply to the 6SL7 tube is 250 volts.

In the first six tests it was decided to determine how large R_{G1}

Table I—Measured periods of long time-constant multivibrators

$C_1=C_2$ in μf	$RG_1=RG_2$ in megohms	T_1 in seconds	T_2 in seconds
0.5	1	1.5	1.5
0.5	3	4.5	4.5
0.5	5	8	7
0.5	10	15	15
0.5	15	24	19
0.5	18	27	24
1.0	18	50	50
8.0	18	170	153
16.0	18	345	235
16.0	56	1020	1140





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"GLOBAR" Type D Resistors have an extreme negative Resistance-Temperature characteristic which means that they will do a wide variety of jobs, accurately and economically. For example, one manufacturer uses them as Resistance Thermometers while another uses them as Temperature Compensators. They also perform a wide variety of useful functions in many electronic devices.

Light-weight—compact—efficient—reliable—"GLOBAR" Type D Resistors never get out of adjustment, because their function is purely electrical instead of mechanical. They may be used on A. C. or D. C. circuits.

These resistors are manufactured to meet the specific needs of each application, so be sure to include full information about your circuit when writing. We will be glad to provide working samples on request.

By the way, if your engineers haven't yet investigated "GLOBAR" Ceramic Resistors we invite them to do so without obligation. Write to The Carborundum Company, Globar Division, Niagara Falls, New York.

"Globar" Ceramic Resistors by CARBORUNDUM

TRADE MARK

("CARBORUNDUM" and "GLOBAR" are registered trade marks of and indicate manufacture by The Carborundum Company) could be made before the leakage of 0.5 μf capacitors would affect operation. However, as can be seen from Table I, the leakage resistance of the capacitors is much greater than 18 meg because the period increases linearly with resistance.

Increasing the capacitors to 1 μf with the same grid resistors increased T to twice its previous value. However increasing the capacitors to 8 μf only increased T five times (instead of eight), but increasing the capacitance in the next test to 16 μf doubled the time as the equations predict. It should be noted at this point that these long time-constant circuits are not stable and will vary as much as 30 percent over short periods of time.

Grid leaks were increased to 56 meg. Tabulated results show that T is approximately 6 minutes longer than calculated.

Long Period Multivibrator

At this point it was decided to design a multivibrator with a period of a few hours. Assuming that the capacitors would have a leakage resistance much higher than the resistors, very large resistances and capacitances would have to be used. For example, to build a multivibrator with a T of two hours, R_{G1} and R_{G2} would have to be 225 meg each if C_1 and C_2 were 16 μf each. Because these resistances are difficult to obtain, it was decided to omit the grid resistors and rely on the leakage resistances of the capacitors to provide capacitor discharge paths.

The resulting circuit is very simple and requires a minimum of parts. Results of using various capacitors in this circuit are presented in Table II. The circuit used the same plate supply, plate loads, and tube as that from which the data of Table I were obtained.

Leakage Resistances

With R_{G1} and R_{G2} omitted from the circuit, it is relatively simple to determine the leakage resistances of the capacitors. Because the time involved in charging or discharging either capacitor is a function of both capacitance and the leakage resistance, $R_1 = T_1/C_1$, and $R_2 = T_2/C_2$. Values obtained will not

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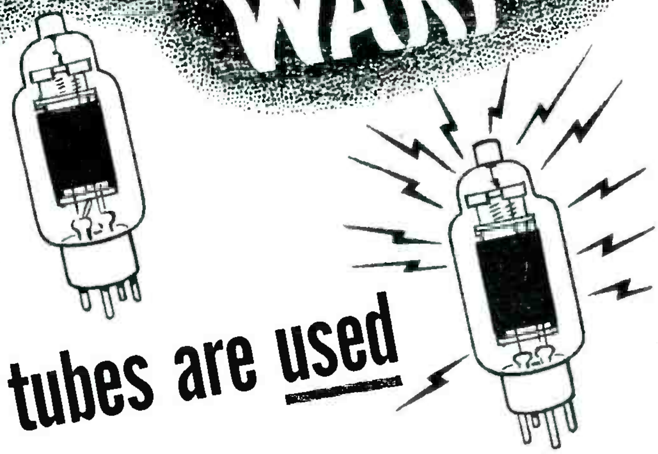

SPEER Graphite Anodes help tube manufacturers produce closely matched tubes that give closely matched performance — *because SPEER Graphite Anodes defy warping.*

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SPEER Anodes are made of a specially processed, highly pure, heat-dissipating, homogeneous graphite. They minimize envelope darkening, prevent hot-spots, improve degassing qualities, allow wide latitude of anode design.

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1. *Increase allowable plate power dissipation*
2. *Lower temperatures of associated tube parts*
3. *Withstand severe overloads*
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5. *Prevent hot spots or fused holes*
6. *Minimize bulb darkening and insulator leakage*
7. *Improve degassing qualities*
8. *Decrease gas troubles*
9. *Enhance tube appearance*
10. *Provide precise anode dimensions*
11. *Produce uniform tube characteristics*
12. *Retain original dimensions in service*
13. *Maintain normal tube characteristics*
14. *Allow wide latitude of anode design*

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be too accurate, but because in practical design of a very low-frequency multivibrator it is sufficient to know the approximate value of leakage resistance of the capacitors to be used, the measured results shown in Table II suffice.

Although in a conventional multivibrator designed for operation at very low frequency a 0.001 μf capacitor would not be used, capacitors of this value were checked to determine how closely the leakage of each checked with the others. As mentioned before, any long time-constant circuit will vary considerably from cycle to cycle, therefore it was difficult to decide how different the leakage values of these capacitors actually were. However, readings were taken at random and the results tabulated. The period of each combination runs fairly close to the others.

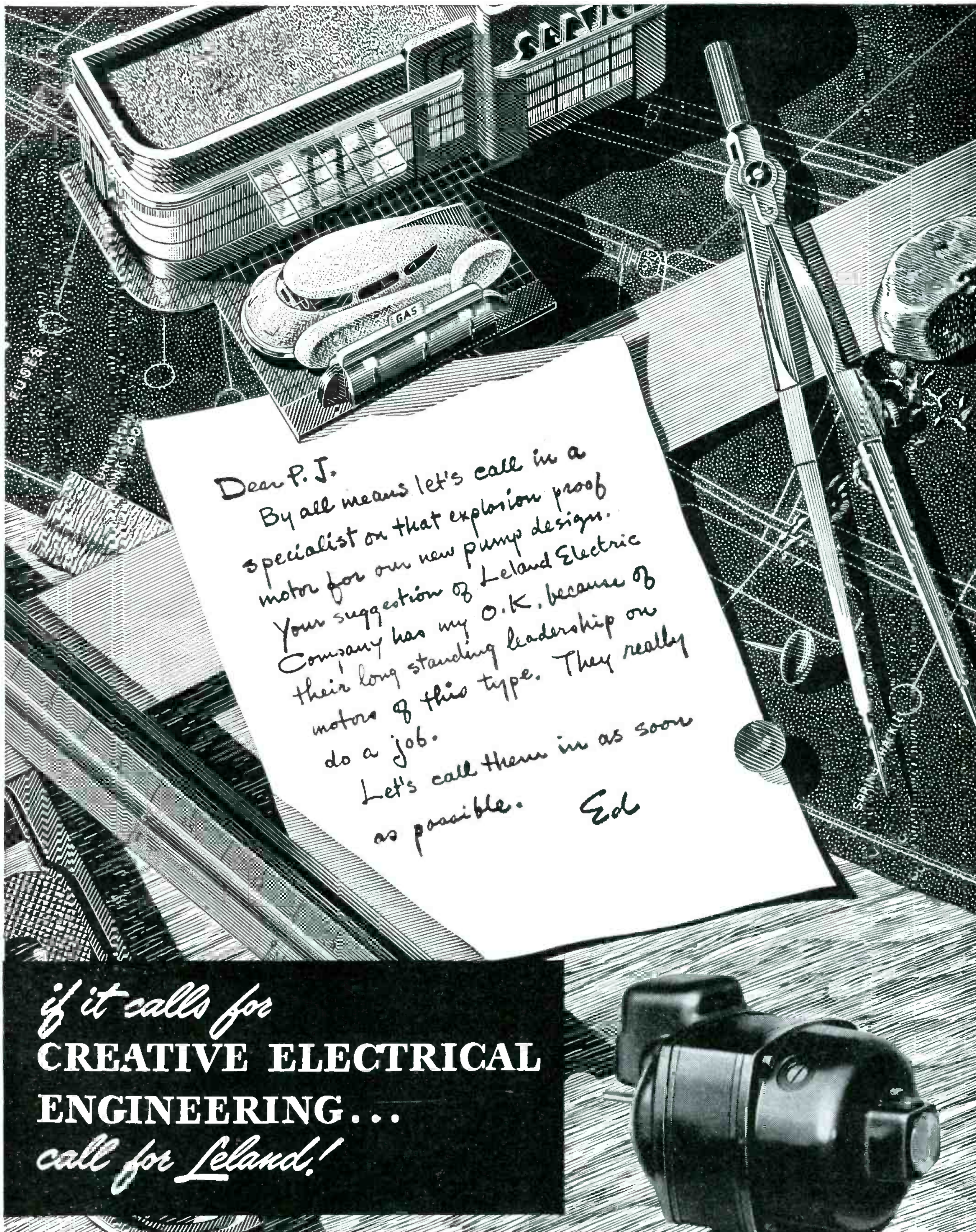
In test 4 the 0.001 mica capacitors were rated at 1200 d-c working volts which probably accounts for their higher resistance. In tests 5 and 6 the capacitors were increased five times but T did not increase five times because, as it is to be expected, as capacitance increases for the same voltage rating capacitors, the leakage resistance decreases. However, using higher capacitance capacitors increases the period somewhat. In test 11 the 0.5 μf capacitors were rated at 400 volts and were an inferior grade. This fact undoubtedly accounts for the much lower resistance of these units. All other capacitors were rated at 600 volts and were of good quality.

In several of the tests one capacitor of a combination had much greater leakage than the other. This phenomena is to be expected because any variation will appear as a greater percent of the period than it would with smaller capacitances.

Practical Circuit

With relatively small capacitors, fairly low frequency multivibrators can be easily built by omitting the grid resistors. This circuit fulfills the requirement of having a very low frequency and using small capacitors. With two 8.0 μf capacitors, a period of three hours can be realized.

It may be argued that a multivi-



THE Leland ELECTRIC COMPANY

DAYTON, OHIO • IN CANADA, LELAND ELECTRIC CANADA, LTD.... GUELPH, ONTARIO brator in which the grid resistors are omitted will not be very stable in frequency. This is granted, but it is also true that if a multivibrator is designed with a period of one hour using capacitors of 16 μf and grid leaks of approximately 112 meg, it will be no more stable than one using two 0.1 μf capacitors without grid leaks. In either case if we desire a very stable multivibrator for low frequencies it will have to be synchronized.

There is a current path from the grid sides of the capacitors to the negative side of the power supply through the tube base and socket. If the leakage of this path is of the same order as that of the capacitors, it has as much to do in determining time constant as do the capacitor leakages.

Table II—Periods of Multivibrators Using Capacitor Leakage Paths

$C_1 = C_2$ in μf	Type*	R_1 in megohms	R_2 in megohms	T_1 in min & sec	T_2 in min & sec
0.001	tube	145,000	83,000	2:25	1:23
0.001	"	65,000	60,000	1:05	1:00
0.001	"	95,000	145,000	1:35	2:25
0.001	mica	197,000	126,000	3:17	2:06
0.005	"	27,600	24,000	2:18	2:00
0.005	"	20,600	52,000	1:43	4:20
0.01	"	30,000	125,000	5:00	10:25
0.1	tube	32,600	6,350	54:20	10:35
0.25	tube	10,080	1,080	42:00	4:30
0.25	"	308	2,440	1:17	10:10
0.5	"	100	136	0:50	1:08
8.0	can	375	1,222	50:	163:
8.0	"	990	562	132:	75:

* All capacitors are paper insulated unless otherwise stated

During measurements for Table II a change was made from a bakelite tube socket to a Steatite socket and no difference was noted.

• • •

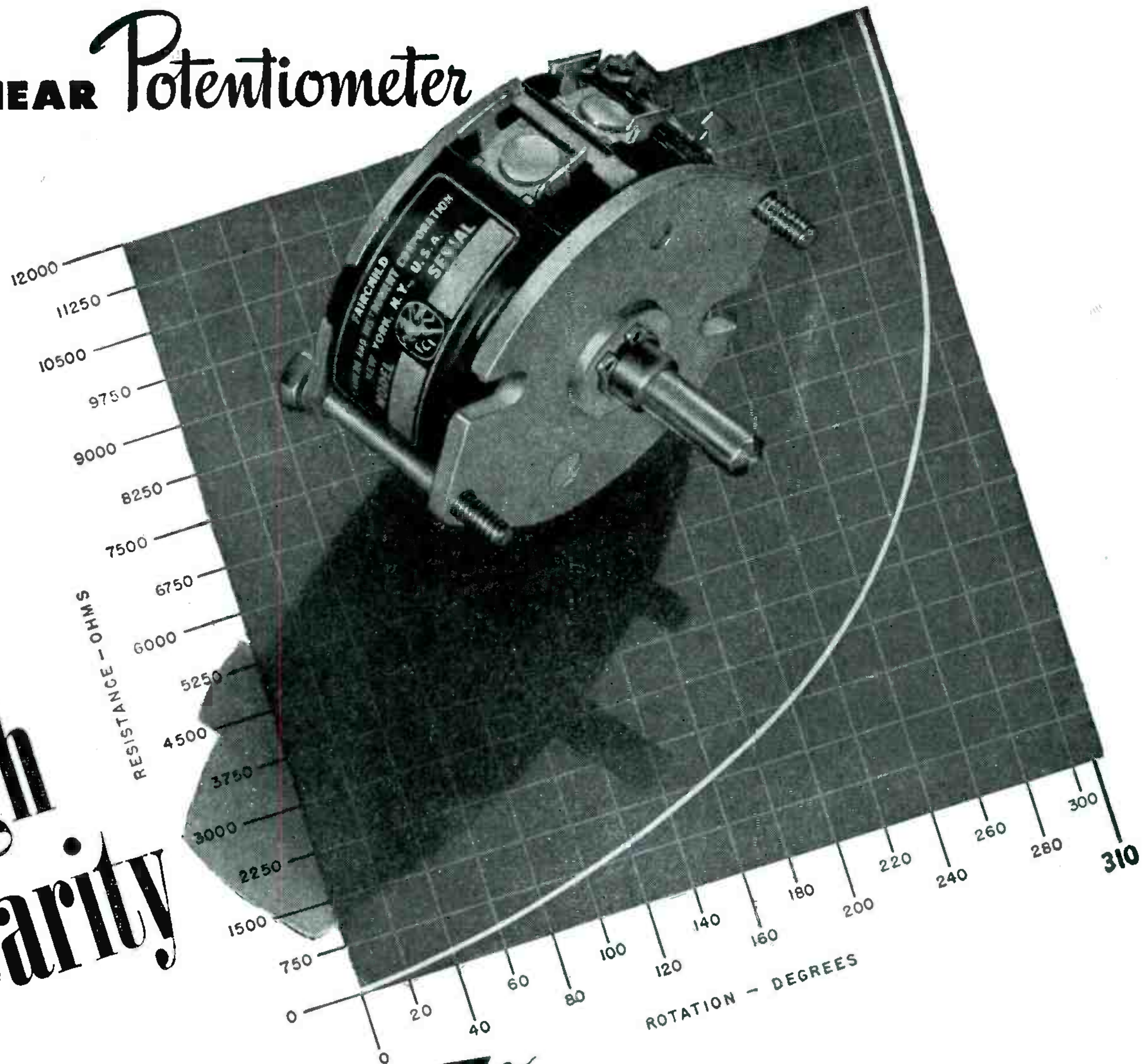
Modulation by Feedback

By ROBERT C. SHAW
Bell Telephone Labs., Inc.
Patented June 26, 1945, No. 2,379,042

MODULATION is accomplished by controlling the amount of negative feedback. The accompanying figure illustrates the general principle. The carrier is amplified in a low-distortion, stabilized, negative-feedback amplifier. The loss in the carrier feedback loop is varied in accordance with a modulating potential applied within the feedback loop, thereby producing a modulated wave in the output of the carrier amplifier.

Where the output voltage is represented by E, the carrier input to

NON-LINEAR Potentiometer



High Linearity

Performance within 1% of the plotted curve

Look to the Fairchild *non-linear* Potentiometer for unexcelled accuracy. War born — to meet the never-before-attained accuracy required of T attenuators in airborne, electronic lead computing gunsights — it proved its accuracy in battle.

Industry is now offered the full advantages of this war-time development. It eliminates intricate, space-consuming, expensive mechanical cams and linkages and electrical units — used with or without linear potentiometers.

Fairchild's non-linear Potentiometer offers these excellent design possibilities: Small size — being 1⅝″ in diameter, 25/32″ thick, with shaft diameter optional, but usually ¼″ . . . high linearity — ability to follow a plotted curve of resistance versus a maximum rotation of 310° within an error of 1% or less at any point on the curve . . . great flexibility for reproducing almost any desired curve — sine, cosine, tangent, hyperbole, square-root, logarithmic and special empirical relationships.

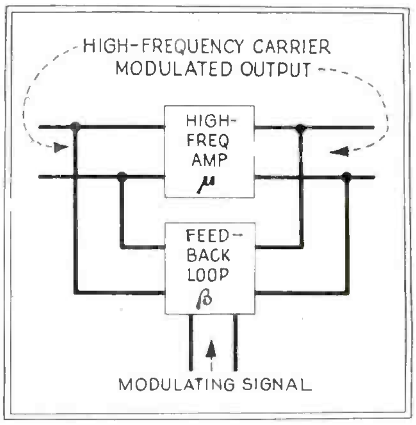
For further information address: *New York Office:* 475—10th Avenue, New York 18; *Plant:* 88-06 Van Wyck Boulevard, Jamaica 1, N. Y.

CONSIDER THESE APPLICATIONS

Fairchild non-linear Potentiometers can be adapted industrially to: instruments for process control, motor drives . . . computing and analyzing instruments and equipment . . . electronic heating . . . electro-medical equipment . . . aircraft and ship radio transmitter control rooms . . . AM, FM and television transmitter controls . . . recording, transcription and public address sound equipment . . . telephone long lines, etc.

Fairchild CAMERA AND INSTRUMENT CORPORATION

INSTRUMENTS — *precisionized* — **mechanically and electronically** — *for finer performance* the high frequency amplifier is E_c, and the complex feedback factor is β; the output is given by $E = E_c/(-\beta)$ provided $|\mu\beta| >> 1$. A variation in feedback factor from approximately 22 to 35 db for an amplifier having $\mu = -1{,}000$ results in the carrier being modulated 67 percent in one particular application. With feedbacks of this order, the nonlinearity introduced



Basic circuit consists of an amplifier, a feedback loop, and a means of controlling the loss in that loop

by assuming that $|\mu\beta| >> 1$ gives distortion of only a few percent.

Modulation can be introduced in series with the grid bias of a variable μ tube in the feedback loop. It may be desirable to introduce nonlinearity in the modulation signal circuit to counteract nonlinearity in the modulator if $|\mu\beta|$ is not much greater than unity.

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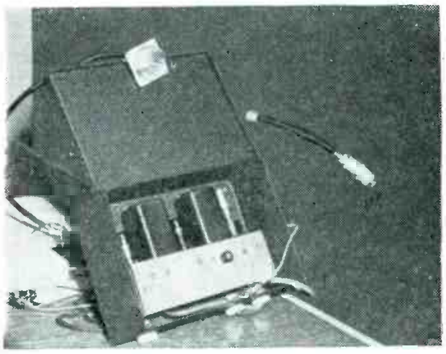
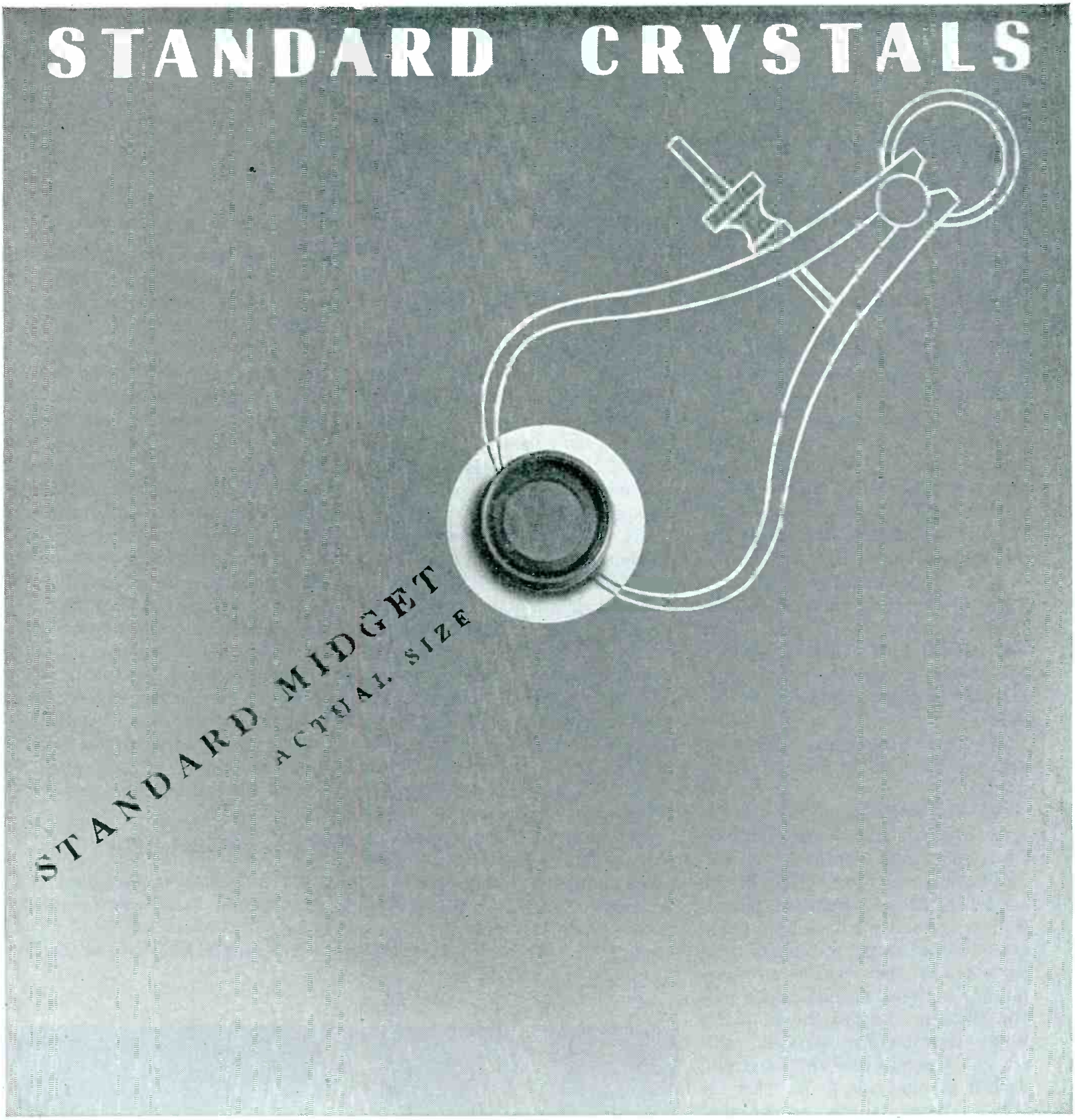
DOOR OPENER



Supersonic squealer actuated from car dashboard emits h-f sound from exhaust pipe that is picked up by a microphone to operate garage door opener. The system is made by Vendo Company of Kansas City



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NEWS OF THE INDUSTRY

Commercial radar progress; f-m receivers; reports on dielectric heating and wire recording; three lists of agents for surplus electronic equipment

CAA Radar for Airways is Approved by British

AT A RECENT British Empire Radio for Civil Aviation Conference held in London recently, several important points of agreement were reached which indicated complete accord with the Civil Aeronautics Administration on standards of airways aids and future developments. The U. S. delegation, headed by the Honorable Charles P. Taft and including representatives of the Army, Navy, Coast Guard, Radio Technical Commission and CAA, was invited to serve as observers but stayed to become active participants in the discussions and decisions.

The most important items of agreement reached at the conference were:

(1) The adoption of CAA-developed vhf static-free communications for airport and approach control. The frequencies used will be in the band 118-122 mc. Sufficient radio-frequency channels have been made available to accommodate all airports so that there will be no interference between airport traffic control stations. At present, only 278 kc is available for airport traffic control, whereas the vhf band will permit 20 channels to be used for this purpose. It was agreed that radiotelephone should be used in lieu of radiotelegraphy, thus speeding up operation of traffic in close proximity to terminal airports.

(2) The vhf two-course visual radio range developed by CAA was adopted as the primary short-range navigation device. This type of range produces two visual courses at 180 degrees which may be projected along an airway. Sector identification is also provided which advises the pilot of his position relative to the station and whether he is approaching or leaving the station. The course indications are shown on a right-left instrument on the instrument panel in the cockpit. Voice communication which provides weather and airway traffic control information is also obtained from the same facility. Several hundred of these facilities are now being installed on federal airways throughout the U. S.

(3) Radar techniques have been developed whereby a simple instrument on the panel of the airplane will provide a meter indication giving the number of miles to the radio range station or instrument landing localizer station to which the pilot is flying. CAA authorities regard this instrument as the most important use of radar in the cockpit to come out of the war.

(4) Use of radar search device to aid tower operators to monitor planes doing instrument approaches and to help in emergencies where plane equipment is not functioning or where the plane is not equipped with proper instruments. This is considered the most important ground application to come out of the war.

(5) Adoption of CAA three-element landing system consisting of glide path, localizer, and marker beacon.

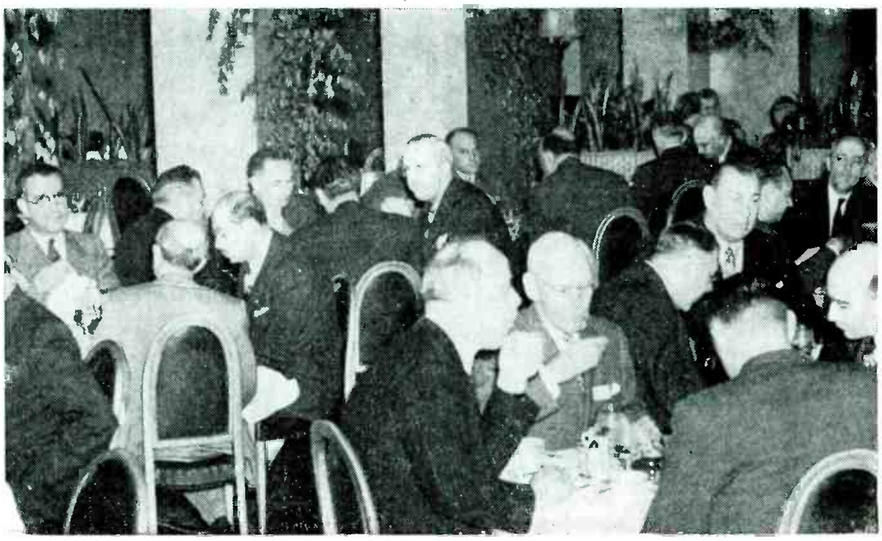
Electronic Weapons

TO CONTINUE RESEARCH and development of weapons like the proximity fuze, Army Ordnance has selected the National Bureau of Standards to establish such activities on a permanent basis. Several other devices have been in the works but details have not been revealed.

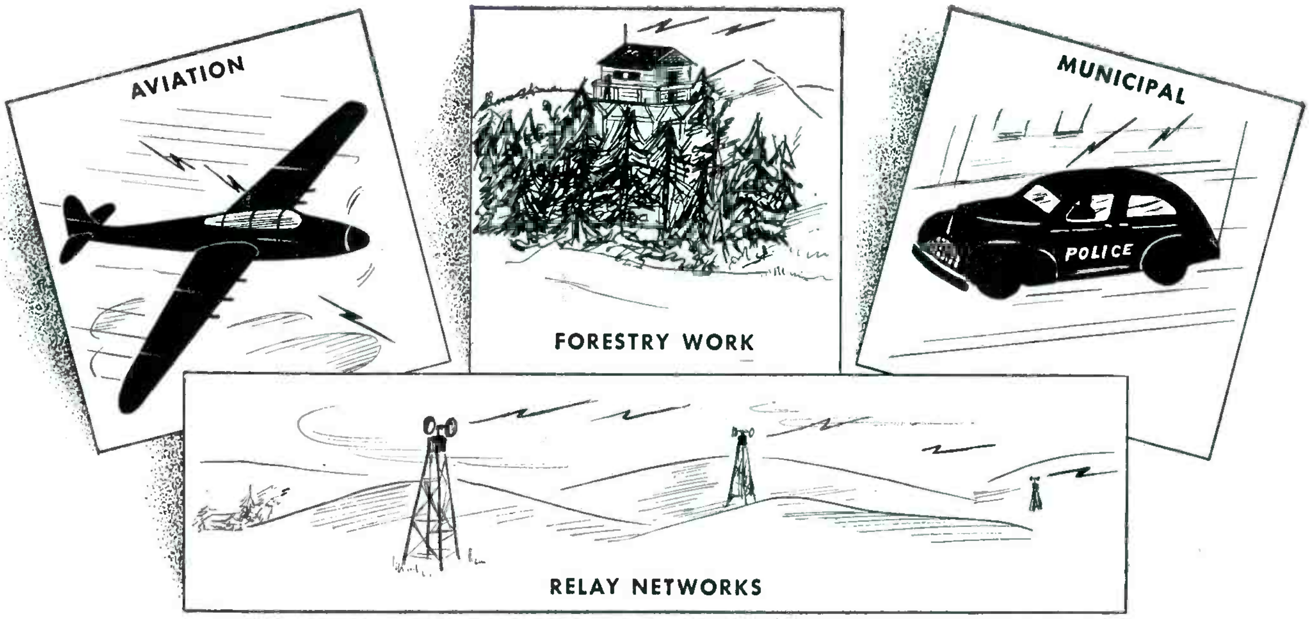
Not only will the bureau study the application of new scientific knowledge to war uses but it will also undertake to study peacetime uses for the knowledge gained in development of weapons. Located in a half-million dollar laboratory scheduled to be finished this year, the activities will center in the Ordnance Development Division headed by Harry Diamond. Several hundred physicists, engineers, and technicians will constitute the staff, set up to draw upon the facilities and experience of the entire National Bureau of Standards.

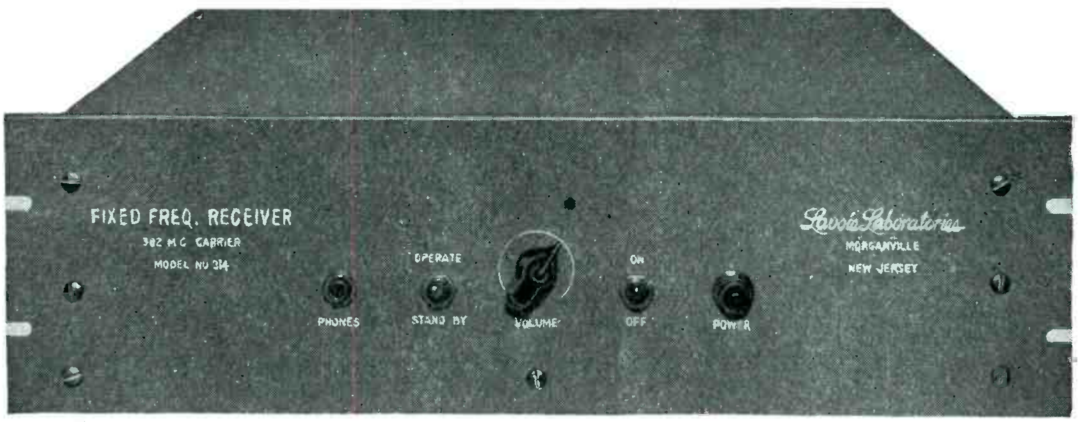
International RMA

MUTUAL PROBLEMS were discussed at the Second Joint Conference held recently between the U. S. and the Canadian RMA's. Held at the West-



Directors of the U.S. and Canadian RMA's get together at lunch during the recent Second Joint Conference in Rye, N. Y. See if you can find W. R. G. Baker of General Electric and George Lewis of IT&T





NEW! LAVOIE Fixed-Frequency Receiver for Applications Over 100 MC's

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RADIO ENGINEERS AND MANUFACTURERS

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Specialists in The Development of UHF Equipment *and in* The Manufacture of UHF Antennas

R. C. Cosgrove explains an outside loop to associates from American and Canadian RMA's at Rye, N. Y. Others are A. B. Oxley, Montreal; R. A. Hackbush, Toronto; R. M. Brophy, president of the Canadian association; Bond Geddes

chester Country Club, Rye, N. Y., the meeting featured a luncheon and a reception at both of which prominent people from the radio industries of the two countries became better acquainted as shown in the accompanying illustrations.

Experimental Radar Licenses

A LIMITED NUMBER of experimental Class 2 licenses will be issued by FCC for compilation of data on operation of navigational radar devices — particularly information which might be useful in formulating regulations governing the operation of radar stations.

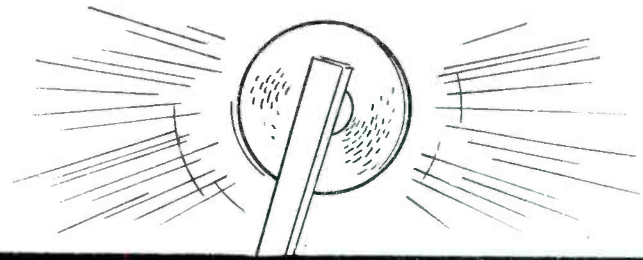
Channels have been designated above 25 mc specifically for radio aids to navigation but they are subject to change or modification necessitated by the results of the next World Telecommunications Conference. Applicants are being cautioned against this risk.

New F-M Circuit

COSTS FOR F-M receivers may be brought into line with those for a-m sets as a result of a new circuit revealed by Stuart M. Seeley of RCA Laboratories at a recent New York section meeting of IRE.

Insensitive to electrical interference of all kinds, the new circuit is a ratio detector. Not only is it free of a critical threshold signal level but its use in a receiver eliminates the need for special noise suppression stages which formerly increased costs of f-m receivers without adding anything tangible to their operation.

It was simultaneously announced



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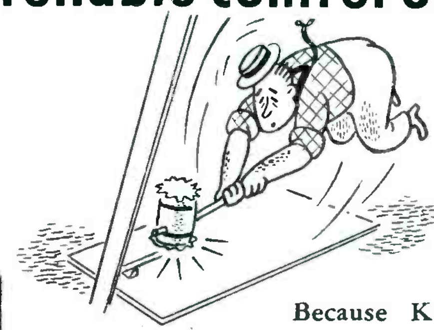

Type PM (NAF-1131) Circuit Breaker.

Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.

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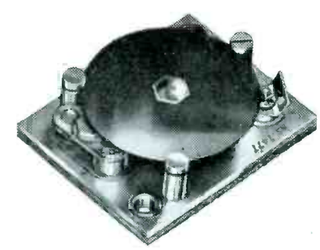
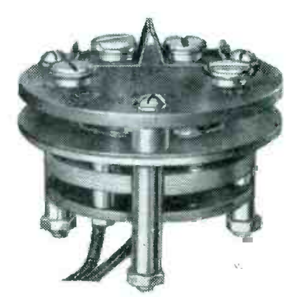
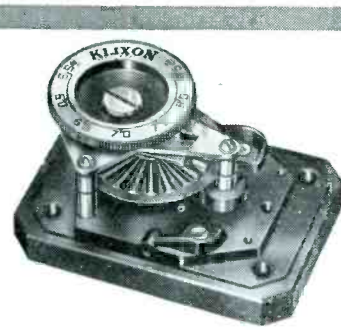


Type B-3120 Thermostat and Heater, Crystal Dew Point Control.



Type ER Series. Ambient Compensated Time Delay Relays.

Type C-7220 Precision Snap Switch 12 amps. 30 Volts D.C., 125 Volts A. C.



Type RT Thermostat. Adjustable Temperature Control.

Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

by RCA Victor division of RCA that the development would be embodied in future models of f-m receivers produced by the company.

Radar Specifications

THREE TYPES of radar are covered in specification briefs sent by the U. S. Coast Guard to makers of electronic gear. The types are designated A, B, and C. Class A is the highest-definition equipment capable of giving early warning of approaching vessels and the best navigational assistance co-ordinated with racon (radar control of navigation) and identification beacons.

Class B will have less resolution and will operate only with the identification beacons, while Class C will comprise that equipment with such low resolution that it can serve only as anti-collision gear.

RMA Divisions

SPEAKER MANUFACTURERS within RMA have been transferred from the amplifier and sound equipment division to the parts division where a new speaker section has been established. Its chairman is George R. Haase, Operadio Co. A new speaker parts section has been started in the same division with A. D. Plamondon Jr., Indiana Steel Products Co., as chairman.

In the transmitter division the following section chairmen have been appointed: transmitter tube section, E. H. Fritschel, General Electric Co., Schenectady; broadcast transmitter section, C. W. Miller, Westinghouse Electric Corp., Baltimore, reappointed; marine section, R. E. Samuelson, Hallicrafters Co., Chicago; aviation section, F. C. McMullen, Western Electric Co., New York; emergency service communications section, H. F. Mickel, RCA Victor Division, Camden, N. J.; piezoelectric quartz crystal section, George E. Wright, Bliley Electric Co., Erie, Pa., reappointed.

FCC Against Interference

RULES AND REGULATIONS are being considered for promulgation by FCC to govern the design and operation of gear utilizing r-f energy for non-communication purposes. Medical diathermy and industrial heating equipment would be the

primary target because they create serious interference particularly in congested city areas.

The commission has also announced its readiness to test for type approval, diathermy units designed to operate within the three frequency bands set aside for the purpose.

Industry Quadrupled

BECAUSE THE RADIO industry has grown to four times its size before the war it could satisfy the most extensive estimates of consumer demand within a year, believes James J. Nance, vice-president of Zenith Radio Corp. Speaking before the Sales Executives Club in New York recently he put the immediate pressing demand for receivers at 5 million and mentioned a normal replacement demand of 25 to 40 million. Production in the last prewar year was 14 million.

Snowbound Engineers

ATOP THE 11,485 ft. Mount Gorgonio in Southern California this winter, engineers from Raytheon Mfg. Co. will operate equipment for testing the feasibility of permanent tele and radio relay stations there. Suitable buildings have been erected and the party will hole up for the season, supplied with the necessities of life by packhorse.

Dielectrics at Cedar Rapids

AT A RECENT meeting the Cedar Rapids Section of IRE heard R. F. Field, General Radio Co., present a paper titled, The Behavior of Dielectrics Over Wide Ranges of Frequency, Temperature, and Humidity. Accompanying his talk with slides, Mr. Field outlined the theoretical and mathematical aspects of the subject, and demonstrated that such behavior can be predicted to a first approximation when only a few parameters are known.

While it might be said that raising the temperature increases both dielectric constant and dissipation factor, Mr. Field showed that the correct statement is that increasing the temperature moves the curves bodily up the frequency scale. For any one temperature, a curve plotted against frequency reveals that the inflection point of the curve for dielectric constant occurs at the

Southern New England...

BLUE BOOK OF AMERICAN INDUSTRY

GET out your directory of manufacturers . . . check with any credit rating service . . . and you'll discover more leading industries with headquarters—or branches—in Southern New England than in any other part of the country.

For example, while you probably associate the name of General Electric with Schenectady, General Electric also has large plants here in Massachusetts. So have Cluett, Peabody; Westinghouse; Pullman.

As for American Optical, Simonds saws, Whitney carriages, American Woolen, Pro-phy-lac-tic brushes, M. J. Whittall rugs, and many more . . . they were native born.

These manufacturers did not pick Southern New England by chance.

They chose Southern New England because it was the most highly-industrialized area in the whole United States . . . and always has been.

Also, because Southern New England is in the heart of the great mass of America's consuming public.

Inside a radius of 500 miles from the center of Southern New England are 58,000,000 people to use Southern New England's consumer goods and her vast output of producer commodities . . . the parts and tools upon which other industries depend to keep going.

And through her great seaports, Southern New England is only a step away from tidewater and easy access to the foreign markets that will develop now that the world is again at peace.

If your postwar plans are still in a state of flux, think hard about Southern New England . . . a great place to promote your new or expanding business . . . and a great place to live and play, too.

* * *

A full-color booklet is yours for the asking: *"Southern New England For Tomorrow's Industry"*. Get your copy by writing to P. E. Benjamin, Manager of Industrial Development, The New Haven Railroad, 80 Federal Street, Boston 10, Massachusetts.

This is one of a series of advertisements presenting the industrial advantages of Southern New England.

THE NEW HAVEN R.R.

Serving **SOUTHERN NEW ENGLAND** *with a network of rail and highway transportation that puts every manufacturer* "ON THE MAIN LINE".

same frequency at which the dissipation factor is a maximum.

A frequency range of sixteen decades will show that more than one such inflection point can occur. Different types of polarization are the explanation for this phenomenon, dipole polarization existing above 1 mc, and interfacial polarization at frequencies below 1 cps.

A plot of dielectric constant vs frequency for different temperatures reveals that there is no single dielectric with a zero temperature coefficient of dielectric constant and that no combination of dielectrics can yield a zero coefficient over a sufficiently extended frequency range. The temperature coefficient is negative at high and low frequencies, positive in the middle region, and zero where the curves cross.

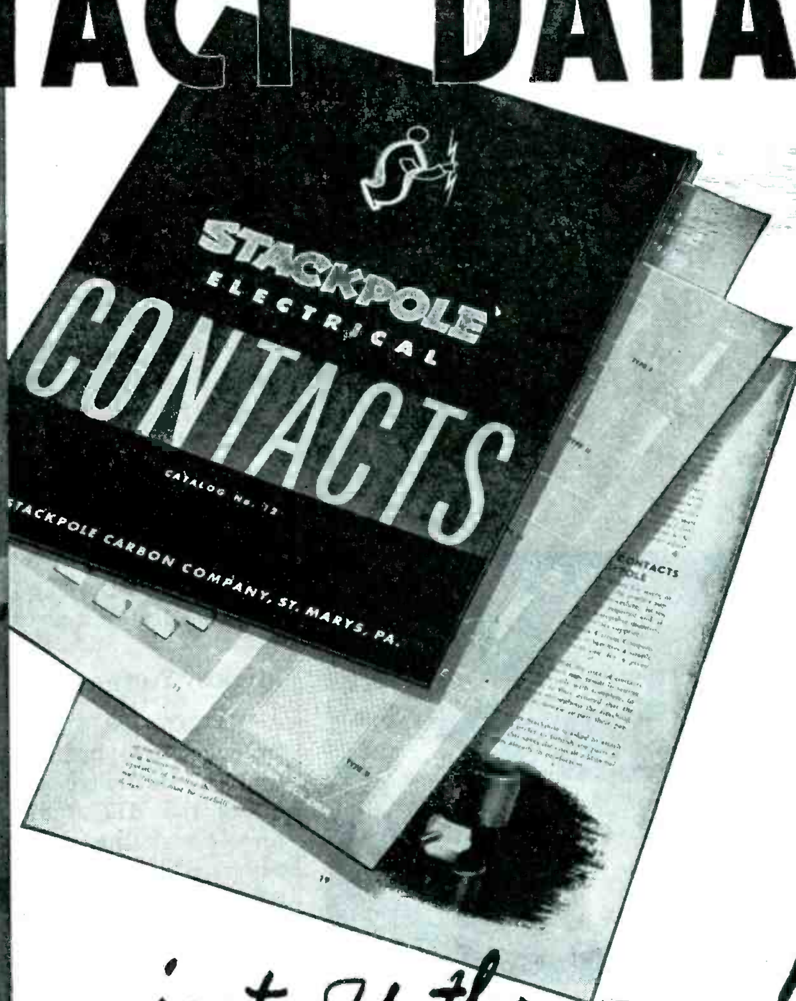
During a recent IRE meeting in Cedar Rapids this group of Navy students from Iowa State College looked on while Collins Radio Co. engineer Donald Jenkins demonstrated a communications transmitter

Placing a dielectric in high humidity causes the formation of an ionized conducting film of water on the surface. The surface resistance quickly drops to only a small fraction of its dry value. If the material is porous, water is absorbed which will maintain the surface film for long periods of time. The lowered insulation resistance increases the dissipation factor of a dielectric inversely with frequency.

In order to take measurements at frequencies in fractions of cycles per second, an indirect method is used which consists of measuring the charging current against time, with a steady applied voltage. Such a curve contains the same information as curves of dielectric constant and loss factor vs frequency.

Approximately fifty Navy and ci-

CONTACT DATA



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If your product uses contacts you'll find in this new Stackpole Contact Catalog a wealth of information designed to help you select units for maximum service under all conditions of use. New contact developments described will prove highly important in the design of smaller, better post-war electrical equipment. Write today!

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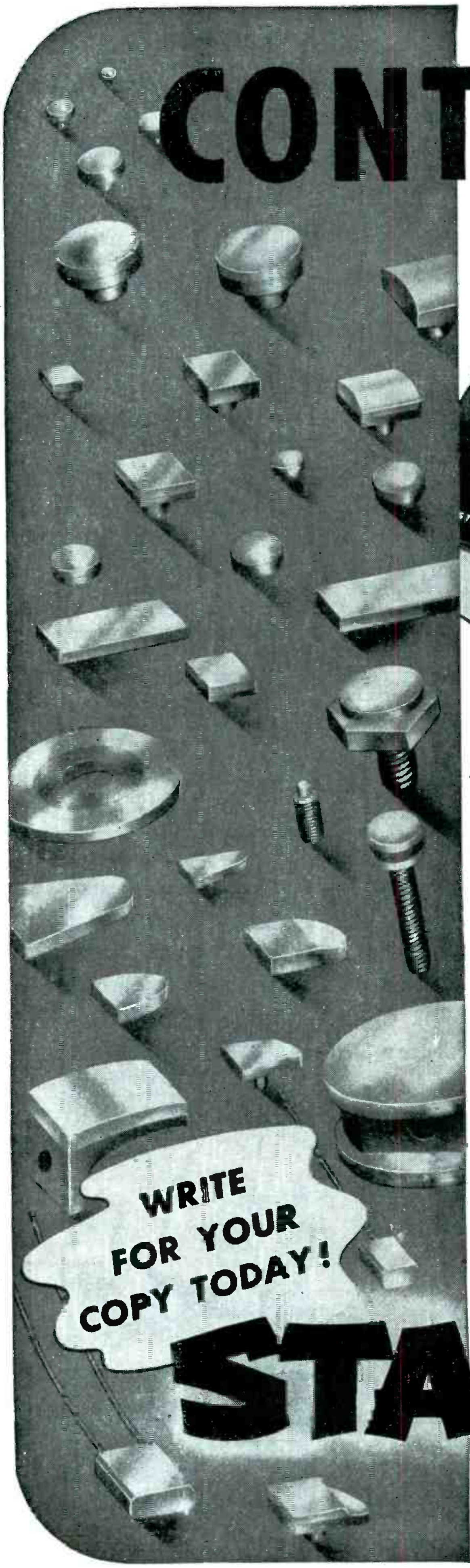

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BRUSHES and CONTACTS (*All carbon, graphite, metal and composition types*)
RARE METAL CONTACTS • IRON CORES • WELDING CARBON PRODUCTS
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vilian students at Iowa State College were guests at the meeting. During the day they were entertained by the Collins Radio Co., with a lunch and a tour of the plant. In small groups they were escorted on the tour by members of the Collins engineering staff who explained and demonstrated various Collins products.

New TBA Members

LATEST AFFILIATED member of TBA (Television Broadcasters Association) is Westinghouse Electric Corp., manufacturing division, Baltimore. C. J. Burnside is the official representative. Syracuse University and Western Reserve University have been added to the association's educational roster. They will be represented respectively by Kenneth Bartlett and Barclay S. Leathem. Yale and Rutgers already belong.

Mickey Network

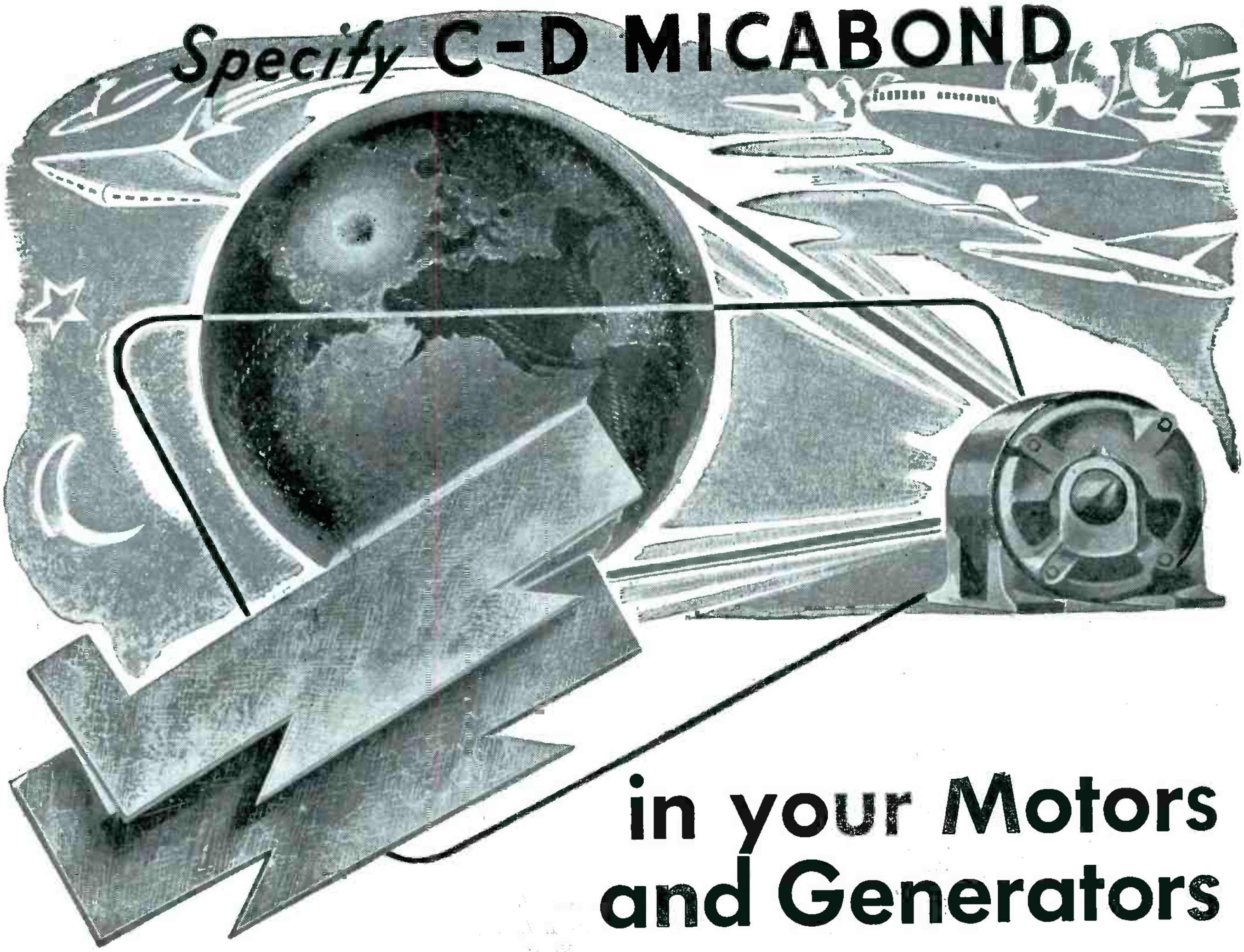
A NATIONWIDE SYSTEM of airway traffic control has been visualized by L. A. DuBridge, executive director of the MIT Radiation Laboratory. Consisting of 200 mickey-type radars the network would cost about $20 million.

Airways traffic controllers would be able under this arrangement to see all the planes in flight in their specified area—a 20- to 30-mile range. In the opinion of Dr. DuBridge, equipment of this type is well past the experimental stage.

Reviewed Wire Recording

DEVELOPMENTS IN WIRE recording were discussed by Hugh Davis of J. P. Seeburg Co. in a paper presented at the first fall meeting of the Chicago Section of the IRE. The subject is divided into three main heads: types of wire, recording heads, and mechanisms.

Round wires of stainless steel having diameters of 0.004 or 0.006 in. are in most common use; however, some recording is being done on flat tapes 0.002 by 0.008 in. In instances where cost is an item plated wires have been tried. Recording in parallel tracks on wide tape has been successful. Tape recordings, wound in pancakes, offer the advantage of indexing which is not possible with recordings on round wires. One German system



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Ever stop to think how important electric generators and motors have become to "our" World? Practically every convenience we enjoy . . . the effectiveness of our War Effort . . . the assurance of a fully employed postwar World . . . depend on electric generators and motors.

C-D MICABOND . . . mica electrical insulation . . . helps keep these generators and motors running.

Generator and Motor manufacturers specify C-D MICABOND because it provides them with the "perfect insulation"—MICA—in usable forms. C-D MICABOND sheets, tubes, rings, segments and other shapes are provided by bonding mica splittings with insulating resins. For complete technical and mechanical data send for Bulletin "M".

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HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

The NON-Metallics

DIAMOND Vulcanized FIBRE
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Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

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Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE made recordings on paper tape that had been sprayed with metal. A prime requisite of the wire or tape is that it be uniform.

For ease of loading, open type heads have been almost universally adopted. An improvement in fidelity is obtained by biasing the recording head with a high frequency current, usually about 50 kc. Biasing current is from 0.2 to 0.4 ma. Overbiasing has the effect of reducing the high frequencies and under biasing causes distortion. Erasing is done by increasing the biasing current to 20 ma.

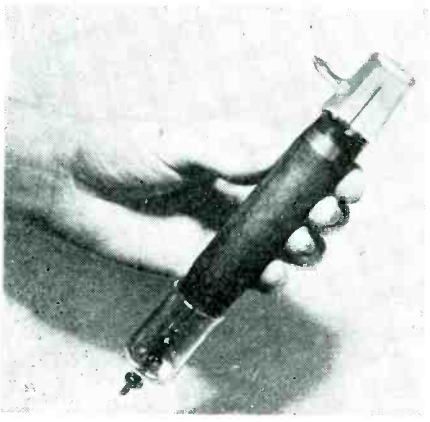
Drive problems encountered are similar to those peculiar to disk recording at 33⅓ rpm. Two feet per second for 0.004-in. round solid wire seems to be the minimum speed for good results. Stretching the wire either in recording or playback will modulate the recorded signal.

Behaviour of dielectrics over a wide range of frequency, temperature and humidity was discussed by Robert R. Field of General Radio.

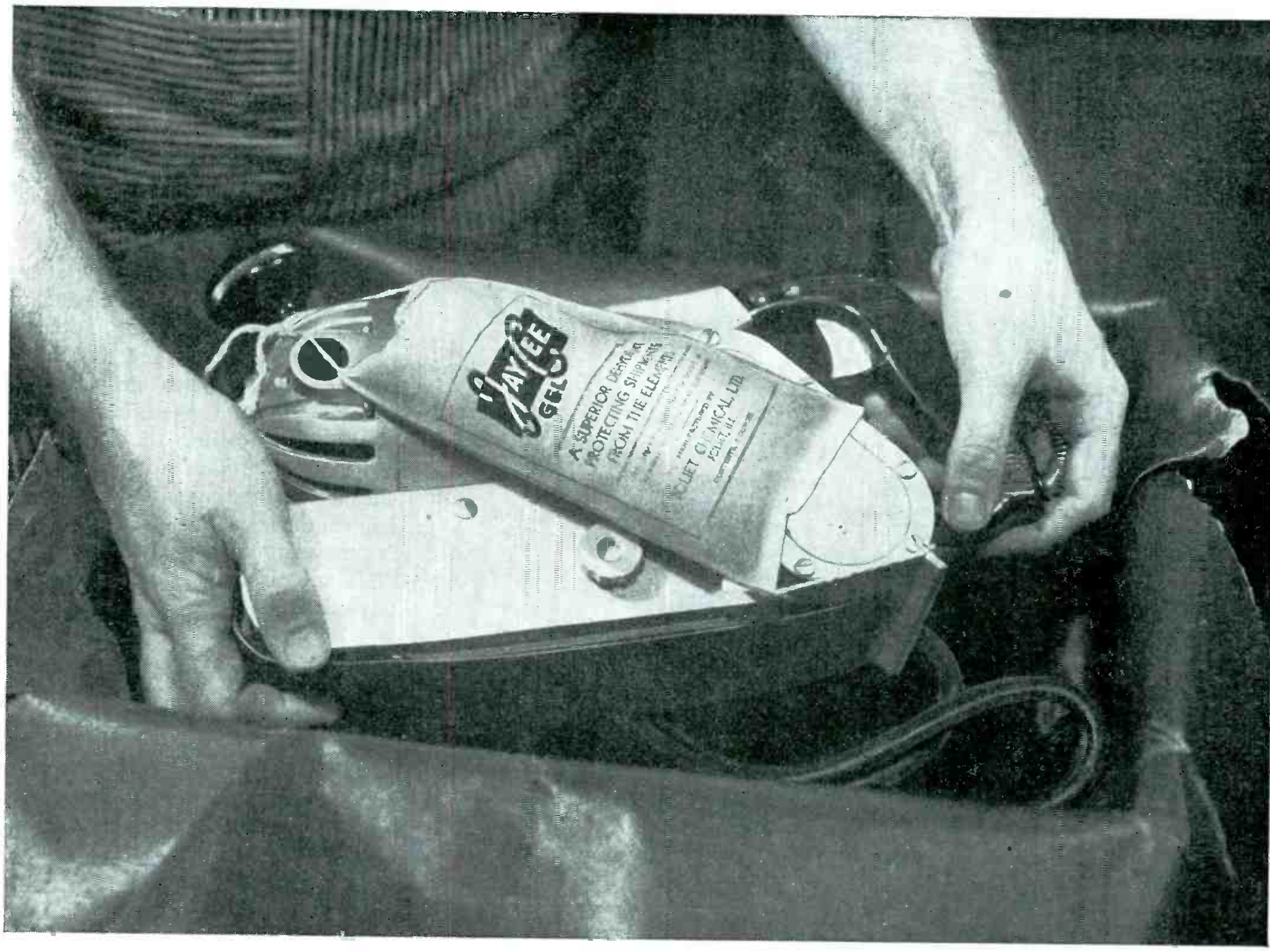
F-M Receiver Design

ONLY THE 88 TO 108 MC band should be included in new designs of f-m receivers, according to Paul A. Porter, chairman of FCC. Writing to R. C. Cosgrove, president of RMA, Mr. Porter indicated that postwar f-m receivers should not be burdened with the cost of tuning provisions in the 42 to 50 mc bands.

As he pointed out, receivers built to a duplex design might very well retard the changeover from old to



Closeup shows scale and conformation of Geiger-Muller tubes of a type made by North American Philips Co., Mount Vernon, N. Y. Units like these have been in the news recently as the testing elements of equipment used to check radiation at the craters of atom bomb explosions in New Mexico and Japan



How SKILSAW Protects Equipment "*in-the-Package*"

Moisture "in-the-package" causes vast damage to precision equipment.

Skilsaw, Inc. prevents this damage by means of Jay Cee Silica Gel, the ideal drying agent. A few small bags of the Jay Cee Gel are included within tightly sealed packages of electric hand-saws, drills, and other tools. The gel has amazing power to absorb and hold moisture. Thus the air in the package is kept thoroughly dry and damage from rust or corrosion is avoided.

This practice is being followed by more and more manufacturers of metal products. The cost of the gel is a mere trifle in comparison with the possible damage from rust or corrosion.

Jay Cee Silica Gel has wide application in the Air Conditioning, Refrigeration, and Chemical industries. It is clear white; passes a rigid section test; meets exacting Government specifications; is strictly a quality product.

A few excellent Jay Cee Silica Gel sales territories are still open to jobbers. Write for details.

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JAY CEE

SILICA GEL

A superior dehydrant

new band. The objective of FCC in allowing f-m stations to continue operation in the lower band was to prevent the loss of service to listeners who have not been able to convert or replace their receivers.

Conditional F-M Grants

BECAUSE MEN in the military service are confronted with particular difficulties in completing applications for broadcast facilities, FCC reminds that it has proposed to make conditional grants of f-m applications, affording the applicants a period of 90 days in which to file engineering details. However, since f-m channels cannot be reserved for future assignments, promptest possible submission of applications is advocated.

License Transfer

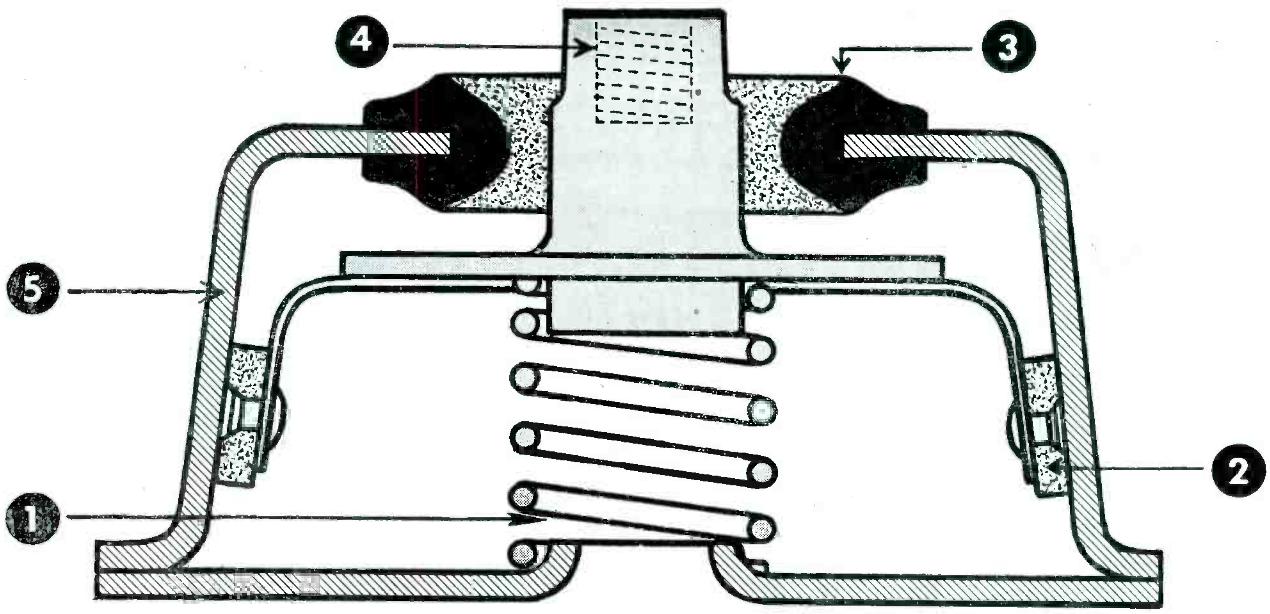
PUBLIC INTEREST underlies a new plan suggested by FCC for the transfer of licenses from one broadcaster to another. Under the plan the Commission and the seller would publish the terms and conditions of the proposed sale of broadcast facilities and the name of the prospective buyer who has met the seller's price. Other persons desiring to apply for the station would be invited to do so on the same terms and conditions. The Commission would consider all applications on their merits with a view to granting the transfer on the basis of public interest.

Another suggestion designed to improve FCC's transfer procedure will be recommended to Congress. This will be a yardstick for measuring the appropriate value of a station so the Commission's field of choice will not be unreasonably restricted because of sales of stations at artificially high prices.

MEETINGS TO COME

DEC. 12; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Mathematical Formulations for Linear Servomechanism Systems, by Charles F. Rehberg, New York University; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

JAN. 9; AMERICAN INSTITUTE OF



IT'S NEW

VIBRASHOCK* UNIT MOUNT

Amazingly Effective, Surprisingly Inexpensive

Robinson engineers offer a low-cost standardized Vibrashock unit mount that closely approaches the high operating efficiency of the famous custom-built Vibrashock Dual Suspension.

Without sacrificing the proven basic Robinson principle of three-way vibration absorption, the new unit mounts are simple, rugged and long-lived. Comparative tests show marked improvement in performance over conventional type unit mounts.

The use of stainless steel springs, instead of rubber or synthetic, eliminates drift or permanent set and vulnerability to cold, heat or humidity.

Check your equipment—airborne, vehicular, mechanical — on these triple action mounts. The results are startling. (On one such application, electronic tube life has been increased from ten days to ten months.)

Vibrashock unit mounts are available in three sizes, and in a wide range of load ratings. Designers, engineers and purchasing agents will find in our new catalog "Vibration Control Engineered by Robinson," the answer to most vibration problems. Send for your copy of this new publication today.

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CHECK THESE OUTSTANDING FEATURES OF THE VIBRASHOCK UNIT MOUNT

1. Stainless steel spring provides complete three-way freedom in a *single unit*. (Conventional units are resilient in only one direction and must be assembled in tandem for horizontal absorption, requiring twice the normal quantity of mounts.)
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4. Rugged, load carrying central stud tapped for standard machine screws.
5. Sturdy, light-weight, metal housing having standard attachment holes in its base.

This combination of features assures outstanding performance in the first *complete* unit mount offered to Industry.

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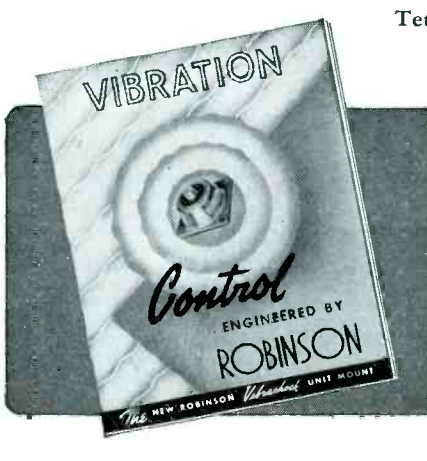

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ELECTRICAL ENGINEERS; Transient Analysis of Linear Servomechanisms, by John R. Ragazzini, professor, Columbia University; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

JAN. 18-FEB. 7; GARDNER DISPLAY CO., Products of Tomorrow Exposition; Coliseum Group, Chicago, Ill. Marcus Hinson, general manager planning department, Armory, 16th and Michigan, Chicago.

JAN. 23-26; INSTITUTE OF RADIO ENGINEERS, 33d Annual Winter Technical Meeting; Astor Hotel, New York, N. Y.; E. J. Content, chairman of meeting committee, WOR, 1440 Broadway, New York 18, N. Y.

FEB. 4-7; AMERICAN WELDING SOCIETY, National Meeting; Hotel Cleveland, Cleveland, Ohio; M. M. Kelly, secretary, 33 West 39 St., New York 18, N. Y.

FEB. 4-8; AMERICAN SOCIETY FOR METALS, National Metal Exposition; Public Auditorium, Cleveland, Ohio; W. H. Eisenman, secretary, 7301 Euclid Ave, Cleveland 3, Ohio.

FEB. 6-8; AMERICAN INDUSTRIAL RADIUM & X-RAY SOCIETY, Annual Convention; Hollenden Hotel, Cleveland, Ohio.

FEB. 13; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Frequency Spectrum Theory Applied to Servomechanisms, by E. B. Ferrell, Bell Telephone Laboratories; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St., New York 18, N. Y.

FEB. 25-MAR. 2; INTERNATIONAL EXPOSITION CO., 20th Exposition of Chemical Industries; Grand Central Palace, New York; Charles F. Roth, manager, Grand Central Palace, New York 17, N. Y.

FCC ACTS

To permit:	To do this:
U-Dryvit Auto Rental Co. Boston, Mass.	Install three portable and portable-mobile stations in vehicles to establish cost of service in use of rented radio-equipped trucks. Federal Telephone & Radio Corp. gear will be used on f-m at 50 w. Frequencies will be assigned.
RCA	Construct and operate four new experimental Class 2 portable radio

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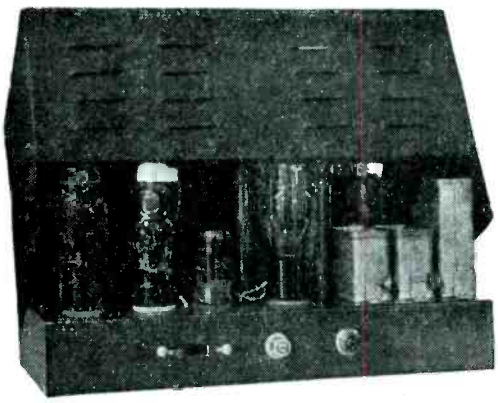
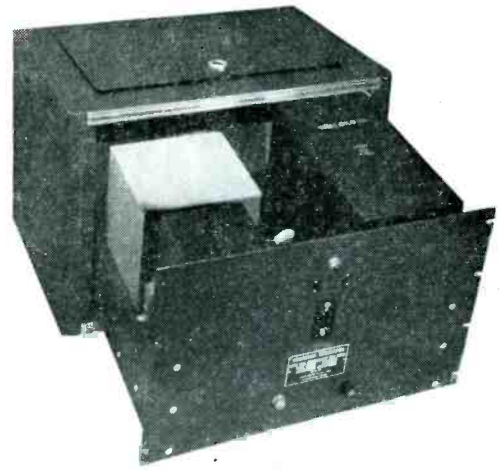


Model 250



Model 1750

AVAILABLE FOR IMMEDIATE DELIVERY:

Model No.	Load Range
250	25 to 250 V.A.
1000	200 to 1000 V.A.
1750	800 to 2000 V.A.
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NOTE THESE FEATURES:

- Output voltage maintained to within ± .2% (adjustable 110-120 volts) with input fluctuations 95 to 130
- Output voltage constant to .2% despite variations in load over entire rated range of unit
- Minimum wave form distortion—about 5% average
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- Quick response time—output voltage stabilized in SIX cycles maximum
- Built for long, trouble free service. Component parts conservatively rated—transformers, etc. hermetically sealed

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STAMFORD, CONN.

	stations for testing a system of wide-band multi-channel radio communication between Philadelphia or Camden, N. J. and New York City with intermediate relay stations to be located in Bordentown, N. J. and Tenmile Run, N. J. Frequencies will be assigned; power 1 w, and emission, A0, A1, A2, A3, A4 and Special.
University of Chicago Chicago, Ill.	Install a new experimental portable mobile radio station aboard a free balloon for operation within a 350-mile radius of Chicago. Objective is to transmit information on the nature of penetrating radiations in the stratosphere. Transmitters will be frequency modulated by impulses produced as a result of high-energy particles passing through a set of coincidence-counter tubes in a cosmic ray telescope. Frequencies will be assigned; power, 2 w; and emission special for radiosonde purposes.
Tanner Motor Livery, Ltd. Pasadena, Calif.	Temporarily operate one experimental Class 2 land station and two portable mobile stations in taxicabs. Frequencies will be assigned; power, 30 w; emissions A1, A2 and A3.
WIBU Poynette, Wis.	Install new vertical antenna and change ground system.
AT&T	Install an additional 339-mile link in the proposed New York to Los Angeles coaxial cable extending from Meridian, Miss. to Shreveport, La. at a cost of $7,056,000.

BUSINESS NEWS

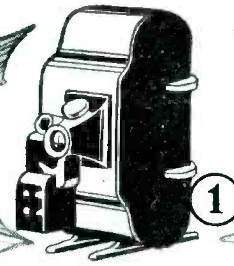
AMERICAN PHENOLIC CORP. in Chicago is erecting a three-story building to house their expanding manufacture of plastic items for the electronic trade and other industries.

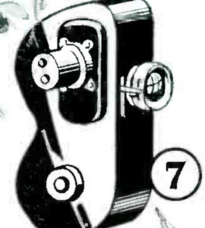
AIREON MFG. CORP. paid $400,000 for 100 percent of the stock in Oxford-Tartak Co. and Cinaudagraph Corp., Chicago, Ill.

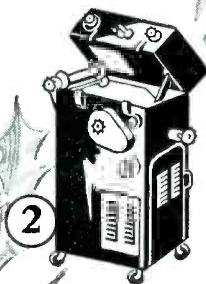
WILMOTTE LABORATORIES opens a branch laboratory at 236 W 65 St., New York 19, to provide complete engineering service in the application of electronics for industrial uses.

UTAH RADIO PRODUCTS CO., Chicago, and Universal Cooler Corp., Marion, Ohio, have merged into International Detrola Corp. The merger unites companies with a total of nine manufacturing plants in this country and two in Canada, making home and auto radio receivers, loudspeakers, other radio parts, refrigerators and furniture cabinets.

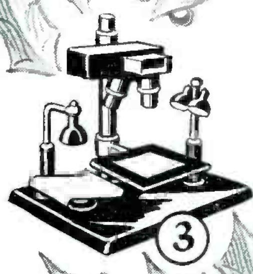
THE MUTER CO. of Chicago has acquired all capital stock of the Rola Co. in Cleveland. Larry King, formerly with Operadio, will be president and general manager of the Rola Co., to be operated as a division of the Muter Co. Ben Engholm,

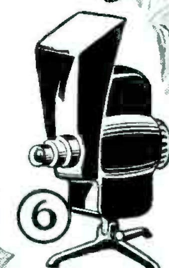






Good News for *Research Men*

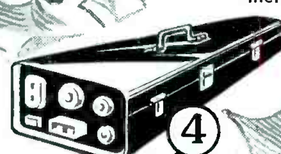


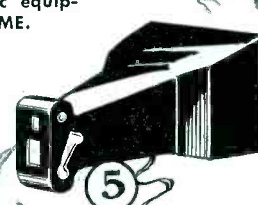


Research Departments of some of America's great industries have called upon Jerome Engineering Company to develop specialized photographic equipment. We are prepared to offer this same service in Design, Development and Production to your Engineering problems. Here illustrated are some of the units which we wish to present in present or modified form. These are:

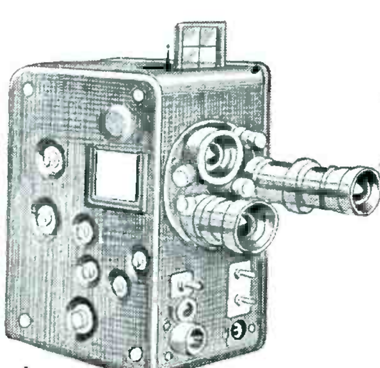
(1) **Automatic Impulse Camera,** 35 and 70 mm. for Electronic Research. Has many uses.
(2) **Automatic Photographic Processing Machine.**
(3) **Microfilm Filing Camera,** for reducing diagrams, drawings, and engineering data to a card filing system.
(4) **Portable Recording Camera** for removable instrument panels.
(5) **Low-Priced Copy Camera,** for engineering data and sketches. Takes copy up to 10" x 14". Has own built-in illumination.
(6) **Universal Projector,** for motion picture and still projection. Has remote control and viewing or editing screen.
(7) **Oscilloscope Camera,** for recording oscilloscope traces, etc.

In photographic research and design, experience counts as in other branches of engineering. If you have need for specialized photographic equipment—HAVE IT ENGINEERED BY JEROME.

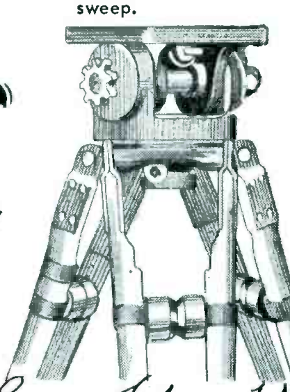




35 mm. Automatic Data Recording Interval Still and Motion Picture Camera, for time-lapse photography.



Heavy-Duty Professional Tripod — Built-in Heater for low-temperature work, if desired. Fast and controlled slow panoramic and elevation sweep.



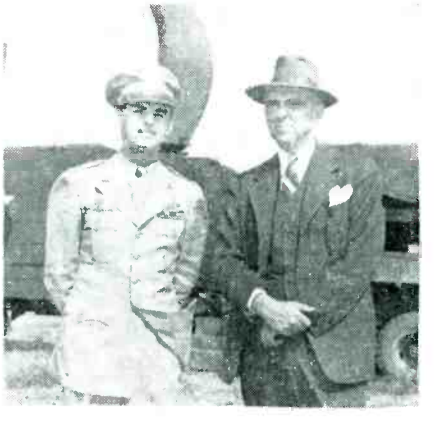
Jerome Engineering Company

Massapequa MERRICK & HICKSVILLE RDS. PHONE. MASSAPEQUA 2100 Long Island N.Y former president and principal stockholder of Rola, will remain in a consulting capacity.

WESTERN ELECTRIC CO. has purchased a 40-acre tract in Allentown, Pa., for a new electronic components plant that will provide employment for about 1,500 people. Present plans call for production of vacuum tubes, quartz crystals, temperature-sensitive devices, and other precision products for use in the Bell system and in other commercial applications. The manufacturing areas will be fully air conditioned.

HOFFMAN RADIO CORP., Los Angeles, has formed a new CAA Division that will develop material built to specifications of the Authority. In charge will be Elmer P. Gertsch, formerly manager of the Radio Division for Air Associates, Inc.

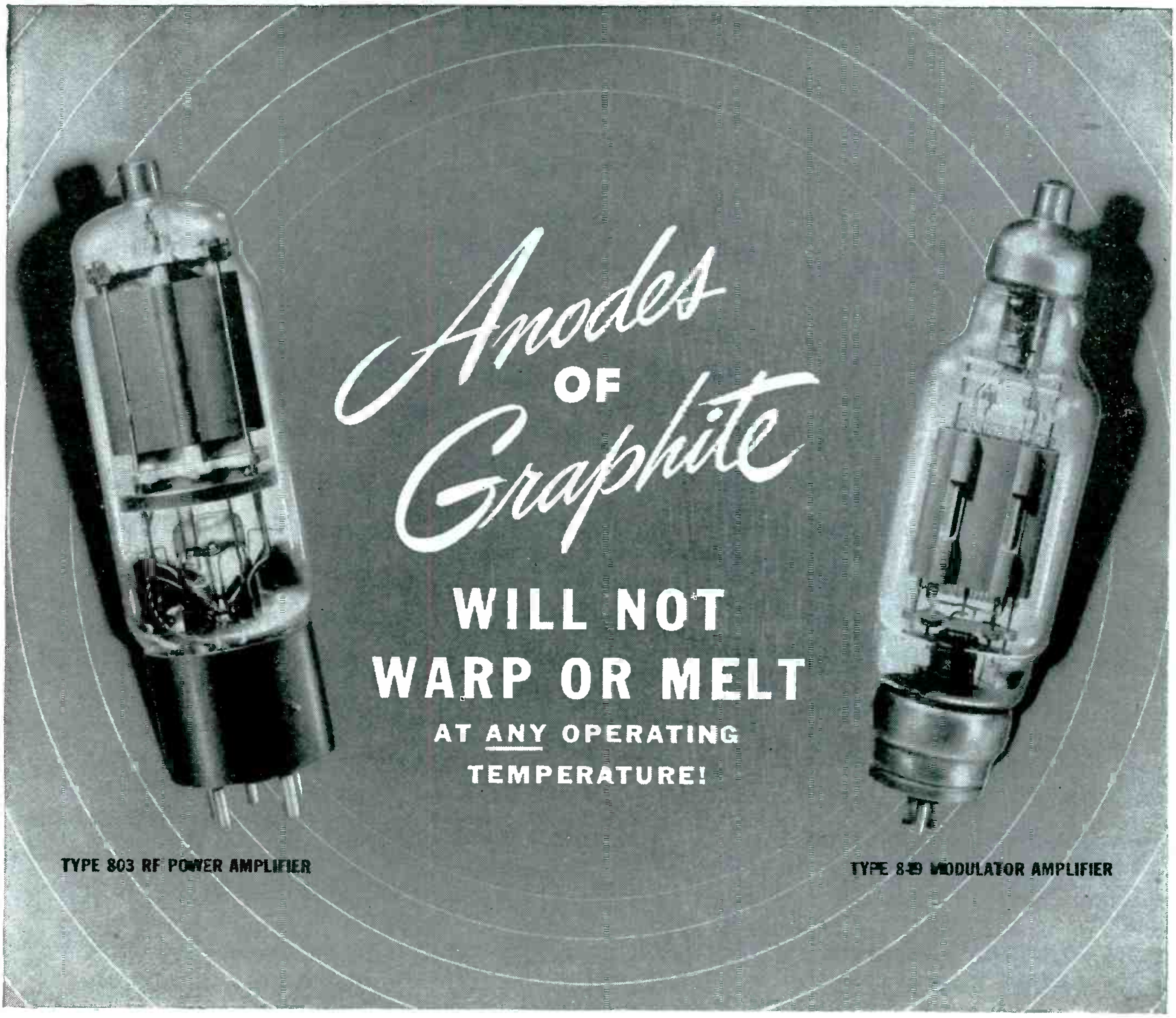
GILFILLAN BROS. INC., West Coast manufacturer and co-developer with MIT of the famed GCA (described in the Nov. 1945 ELECTRONICS, page 112) staged the first public demonstration, at Los Angeles Municipal Airport, of this radar system for



Lt. Col. Harry Downing, commanding officer, Mines Field, California, and S. W. Gilfillan, president of Gilfillan Bros. Inc., standing before the trailers housing the military version of GCA. The rotating radar antenna is mounted in the curved housing atop the trailer

guiding planes to safe landings through storm, fog and darkness. Gilfillan is now entering full-scale manufacture of GCA equipment as converted to civil uses for landing fields.

SENTINEL RADIO CORP. has broken ground for a modern plant at a location in Evanston, Ill., occupying over nine acres. It will have an estimated production capacity of 3,000 radio sets per day on a single-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TYPE 803 RF POWER AMPLIFIER
TYPE 849 MODULATOR AMPLIFIER

shift schedule. Production lines 300 ft long will be fed direct from the receiving department at the west end of the building and will turn out completely tested radio sets packed and ready for shipment at the east end of the building.

Architects' sketch of new Sentinel plant

COMMUNICATION PARTS recently purchased a new plant in Chicago having unique features. Each work bench is an illuminated and wired unit in itself yet all benches can be linked together in a few minutes for a line assembly operation.

WAVEGUIDE ELECTRONICS, 30 Church St., New York, is an organization of men who have been installing radio and radar gear on Navy vessels. The new company has facilities for fabrication and installation of waveguides and coaxial transmission lines, and plans to concentrate on installation and servicing of electronic radio and radar equipment on ships, in plants, at airports, etc.

SYLVANIA ELECTRIC PRODUCTS INC. produced more than 140 million tiny tubes and millions of fuzes for the Navy's secret VT proximity fuze program, also known as "Project A". The eight plants engaged in this work received 22 special awards from the Navy Bureau of Ordnance for efficient production.

PERSONNEL

WM. D. MACGEORGE, formerly chief of the Electronics Laboratory at Baldwin-Southwark, joins the staff of Automatic Temperature Control Co. in Philadelphia as technical consultant concerned with development of automatic control instruments.

J. WESLEY KOCH, until recently a captain with the office of the Chief Signal Officer in Baltimore, is now on the engineering staff of Mutual Broadcasting System. While in the Army, he served as technical adviser of the Radio Propagation Unit and as staff radio officer in North Africa and Italy.

EARL MINOR JOHNSON, radio propagation specialist with the War De-

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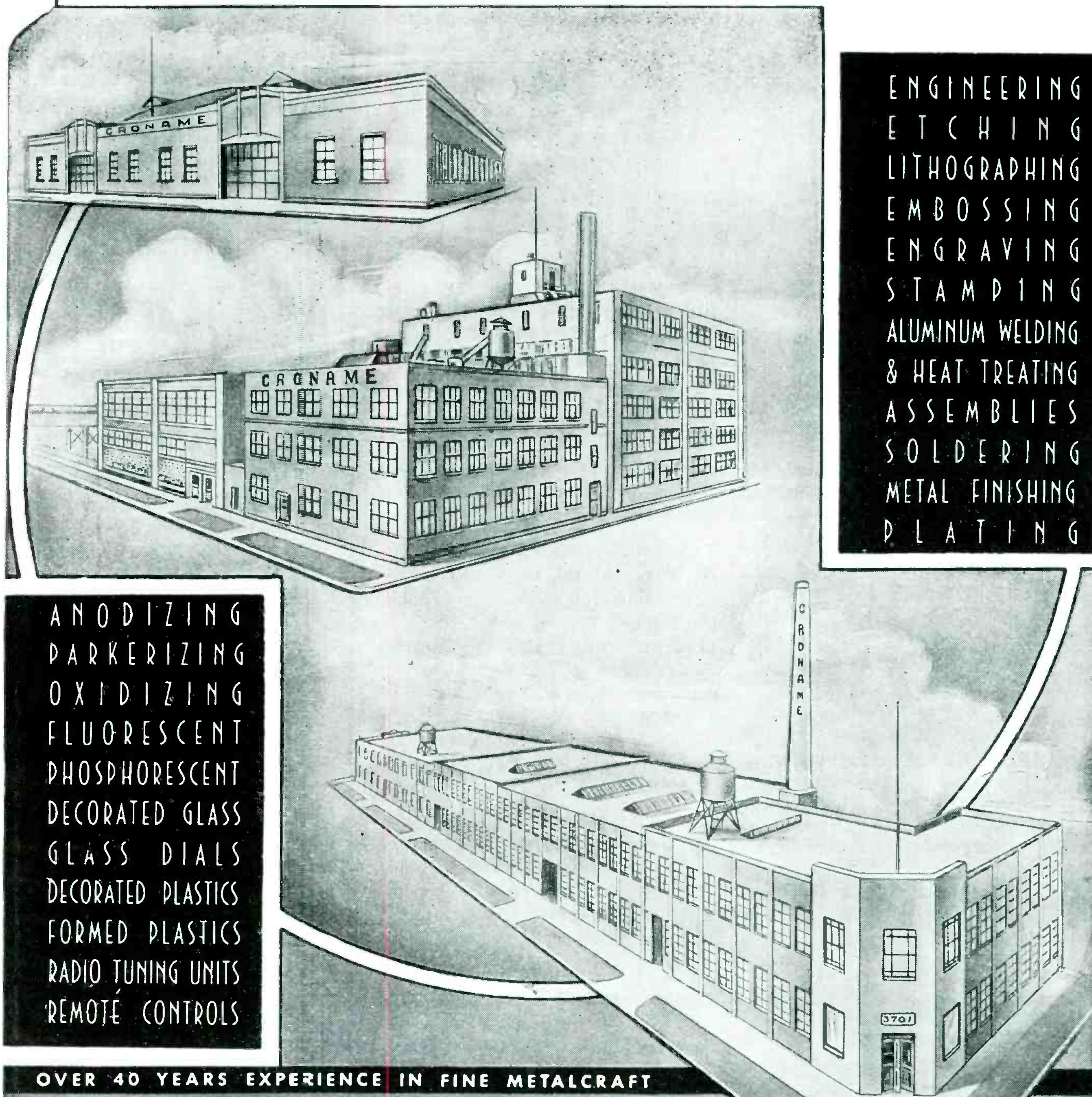
FOR ELECTRONIC COMPONENTS AND FINE METALCRAFT



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OVER 40 YEARS EXPERIENCE IN FINE METALCRAFT

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CRONAME INCORPORATED

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partment since June 1944, is now in the engineering department of Mutual Broadcasting System.

CLURE H. OWEN is allocations engineer with American Broadcasting Co., after serving with the FCC as assistant chief of their broadcast engineering division.

HENRY GROSSMAN, CBS director of technical operations, and JAMES SEWARD, director of operations, are now responsible for technical operations of CBS Television in addition to their regular network broadcast duties. Dr. P. C. Goldmark continues his responsibility for equipment design and installation, engineering standards, and tests.

Henry Grossman

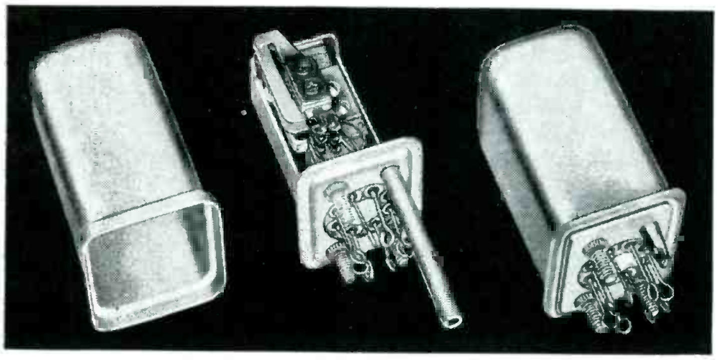
LOUIS G. PACENT, JR. becomes manager of production services department of Emerson Radio and Phonograph Corp., after a year of service as chief industrial engineer.

T. WANG and T. Y. WANG, representatives of the Chinese Government Communications Commission, interviewed Dr. Ray H. Manson, president of Stromberg-Carlson, during their nationwide tour of key communications centers in search of manufacturing methods and techniques applicable to China's industrial empire.

ERNEST A. MARX, who held the rank of Lieut. Commander in the Navy and the post of Senior Radar Officer of the Third Naval District, joined Allen B. DuMont Laboratories as general manager of their newly formed Television Division.

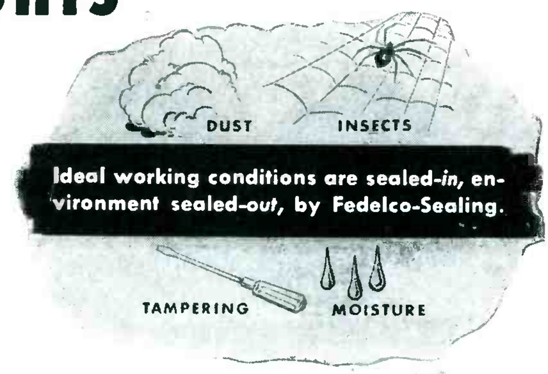
W. G. H. FINCH, Captain USNR, returns to inactive duty and assumes the presidency of Finch Telecommunications Inc., Passaic,

These environment-free products show how *Fedelco-Sealing* can meet Your requirements



A tiny relay is sealed into this rectangular housing. Photos show: 1, metal housing; 2, relay mounted on heavy bracket and base, with tube for exhausting air; 3, completed enclosure, with three 6-32 mounting screws and terminals for soldering on No. 14 stranded wire. Tube has been sealed off.

Larger relay, with specially designed anchor plate mounting to withstand shock and vibration up to 20Gs. Relay is bolted to heavy bracket and anchor plate (top left) and base plate. Completed enclosure (right) shows beads rolled into top and bottom of housing to grip both plates, and square base for bolting to frame. Lead wires have been soldered to octal plug.



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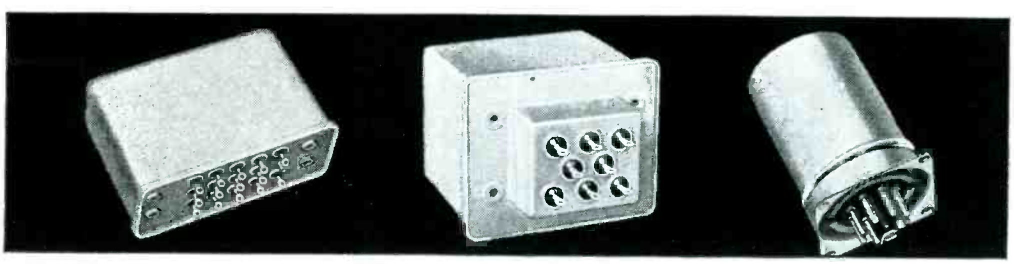
These enclosures are designed and engineered to fit your product and your specific requirements. Cases can be of any required shape, with various provisions for mounting. Terminals can be wired to an octal plug, or to solder terminals. Interior mounting and brackets are specially designed. Cases are exhausted and filled with nitrogen or other gas. Enclosures can be designed to withstand shock and vibration of any degree specified.

We Fedelco-Seal your product, or show you how to do it

Ship your product to us, and we will design the enclosures, and complete the Fedelco-Sealing job. Or, if your quantities justify, you can do your own Fedelco-Sealing, with equipment we will design for you.



Three other specially designed enclosures. 1. Oblong case for a large relay, with leads for soldering connection. Mounting sockets in base for 8-32 machine screws. 2. Rectangular case for aviation type transformer, specially designed to fit same mounting as transformer had before moisture trouble made Fedelco-Sealing necessary. 3. Small relay, arranged for plug-in.

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N. J. He also plans to resume construction on f-m station WGHF, New York.

AWARDS

Workers of the following concerns in the electronics field have been awarded Army-Navy burgees for excellence in production:

Eastern Amplifier Corp.
New York, N. Y.

National Union Radio Corp.
Robesonia, Pa.

The Workshop Associates
Newton Highlands, Mass.

The Bureau of Ordnance E has been awarded to the following firm for cooperation on the VT-fuze project:

International Resistance Co.
Philadelphia, Pa.

Surplus Parts and Equipment Agents

THREE LISTS handling government surplus electronic parts and equipment of manufacturer-agents have been released by RFC (Reconstruction Finance Corp.). They cover agents for component parts, agents for complete gear of their own make, and agents who will dispose of products of other concerns as well.

COMPONENT PARTS

Company	Address	Component
Advance Transformer	1161 W. Madison St. Chicago, Ill.	Transformers
Air Design & Fabrication, Inc.	241 Fairfield Ave. Upper Darby, Pa.	Transformers
American Phenolic Corp.	1830 So. 54th Ave. Chicago 50, Ill.	
American Transformer Corp.	178 Emmet St. Newark, N. J.	Transformers
Amperex Electronic Corp.	79 Washington St. Brooklyn, N. Y.	Power Tubes
Anco Products Co.	932 Market St. Paterson, N. J.	Transformers
Arco Transformer & Elec. Div. National Mill Supply Co.	207 E. Columbia St. Fort Wayne, Ind.	Transformers
Barker and Williamson Co.	235 Fairfield Ave. Upper Darby, Pa.	Capacitors, Coils
Best Mfg. Co.	1200 Grove St. Irvington, N. J.	Transformers, Coils, Speakers, Microphones, Head Sets
James G. Biddle Co.	1211 Arch St. Philadelphia 7, Pa.	Vibrating Reed Tachometers, Vibrating Reed Frequency Meters
Bogue Electric Co.	37 Kentucky Ave. Paterson, N. J.	Electronic Components and Equipments
Burlington Instrument Co.	106 N. 4th St. Burlington, Iowa	Panel Instruments, Meters
Capacitron Co.	849 No. Kedzie Ave. Chicago 51, Ill.	Capacitors

Company	Address	Componen
Carborundum Co. (Globar Div.)	Hyde Park Blvd. Niagara Falls, N. Y.	Resistors
Allen D. Cardwell Mfg. Co.	81 Prospect St. Brooklyn 1, N. Y.	Capacitors
Chatham Electronics	475 Washington St. Newark, N. J.	Radio Tubes
Chicago Condenser Corp.	3917 Fullerton Ave. Chicago, Ill.	Capacitors
Chicago Industrial Instrument Co.	219 W. Chicago Ave. Chicago, Ill.	Electronic and Associated Equip.
Chicago Transformer Div. Essex Wire Corp.	4216 W. Irving Park Rd. Chicago, Ill.	Transformers, Resistors
Cinch Mfg. Corp.	2335 West Van Buren St. Chicago 12, Ill.	Electronic Component Parts
C. P. Clare & Co.	4719 Sunnyside Ave. Chicago 30, Ill.	Switches, Relays
Cole Instrument Co. (Electric Products Service)	1320 So. Grand Ave. Los Angeles, Cal.	Meters, Test Equipment
Consolidated Radio Products Co.	350 W. Erie St. Chicago 10, Ill.	Head Sets, Transformers, Speakers
Continental Electric Co.	715 Hamilton St. Geneva, Ill.	
Control Corp.	600 Stinson Blvd. Minneapolis, Minn.	Coils, Transformers, Chokes
Cords Ltd., nc.	126 Orchard St. Newark, N. J.	Cord Sets, Electrical Components
Cosmic Radio Corp.	699 E. 135th St. New York 54, N. Y.	Capacitors
Daven Company	191 Central Ave. Newark, N. J.	Resistors
Dean W. Davis & Co., Inc.	Kentland, Indiana	Transformers, Coils, Solenoids
De Jur Amsco Corp.	Northern Blvd. at 45 St. Long Island City 1, N. Y.	Electric Meters, Potentiometers
Tobe Deutschmann Corp.	863 Washington St. Canton, Mass.	Capacitors, Filters, Noise Meters
Dumont Electric Company	34 Hubert St. New York, N. Y.	Capacitors
Thos. A. Edison, Inc.	51 Lakeside Ave. West Orange, N. J.	Panel Instruments
Eitel-McCullough, Inc.	525 West 13th St. Salt Lake City, Utah	Tubes, Capacitors, Relays
Electrical Reactance Corp	49 Elm St. Franklinville, N.Y.	Resistors, Capacitors, Choke Assemblies
Electrical Utilities Co.	La Salle, Ill.	Paper Capacitors
Electrical Windings, Inc.	2015 No. Kolmar Ave. Chicago, Ill.	Transformers, Coils
Electricoil Transformer Co.	421 Canal St. New York, N. Y.	Transformers, Reactors, Chokes, Coils, Rectifiers
Electro-Motive Mfg. Co.	So. Park & John Sts. Willimantic, Conn.	Capacitors
Electronic Development Co.	1336 N. Saddle Creek Rd. Omaha 3, Nebr.	Panel Instruments, Test Equipment, Noise Filters
Electronic Engineering Co.	733 W. Ohio St. Chicago, Ill.	Transformers, Chokes, Wave Filters
Electronic Enterprises, Inc.	67 Seventh Ave. Newark 4, N. J.	Transmitting Tubes
Electronic Transformer Co.	205 W. 25 St. New York, N. Y.	Transformers
Electro-Voice Corp.	1239 So. Bend Ave. South Bend, Ind.	Microphones

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S-20R	Sky Champion with built-in speaker...	60.00
S-22R	Skyrider Marine with built-in speaker..	74.50
SX-25	Super Defiant with crystal, less speaker	94.50
S-39	Sky Ranger portable, AC/DC and battery	110.00
SX-36	FM/AM receiver	415.00
S-37	V.H.F. FM/AM receiver............	591.75
	10" PM speaker in cabinet for use with SX-25, SX-28A	15.00

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HQ-129X (with tubes)............	$129.00
ASPC-210X	318.00
ASP-210SX	318.00

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NC-2-40C and speaker........... $240.00

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RME-45 and speaker.............. $166.00

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T-45556 or T-92R21	leads out of side, 778 V. C. T. at 200 MA. 115 V. 60 Cycle 6.3 V. C.T. at 5A. 5 V. at 30 amp. 9 lbs.	$5.29
T-13C30	8H. 150 MA. 200 ohm 1600 V. Insulation 2¼ lbs..................	1.41
T-4557 or T-74C29	leads out of side. 1 5-l. 150 MA. 200 ohm 2000 V. Insulation 5¼ lbs.	2.82

WESTERN ELECTRIC MICRO AMMETERS

Bakelite case fits 3¾" hole. Radium dial 150-0-150. Can be used with 0-200 micro and amp scale listed below. Excellent as a 5,000 ohm-per-volt meter or null, sound level and galvanometer indicator. Instructions included.

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0-200 paper scale for above....... .15

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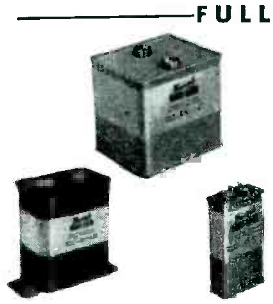

Capacity	Working Voltage	Height	Width	Depth	Wt.	Price
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17½ mfd.	1500 V. D.C.	3⅞	4⅞	3⅛	3 lbs.	2.75
11½ mfd.	1500 V. D.C.	5	3¾	1½	1 lb. 10 oz.	2.00
5 mfd.	1500 V. D.C.	4	2⅜	1¼	14 oz.	1.65
5 mfd.	2000 V. D.C.	4	3¾	1¼	1 lb. 4 oz.	2.15
8 mfd.*	2000 V. D.C.	4½	3¾	2½	2½ lbs.	2.75
.25 mfd.	2000 V. D.C.	3¾	1¾	1	6 oz.	.69
	Special Porcelain Insulators					
10 mfd.	3000 V. D.C.	4⅞	3¾	3¼	3 lbs. 8 oz.*	4.75
15 mfd.	3000 V. D.C.	4¾	4⅝	3⅞	5 lbs.	5.25
6 mfd.	3000 V. D.C.	6⅜	6½	3	5 lbs. 6 oz.	3.25
	with mounting feet, width includes mounting feet					
8 mfd.	3000 V. D.C.	7⅜	6½	3⅜	7 lbs. 4 oz.	3.95
2 mfd. & 4 mfd.	600 V. metal can	4⅞	2½	1¼	14 oz.	.80

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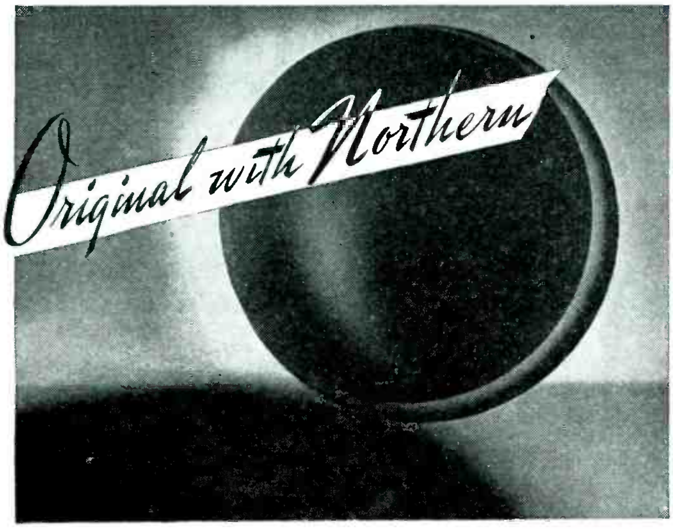

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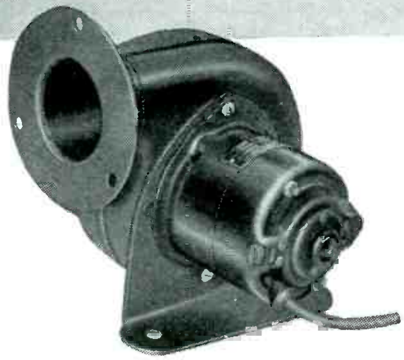
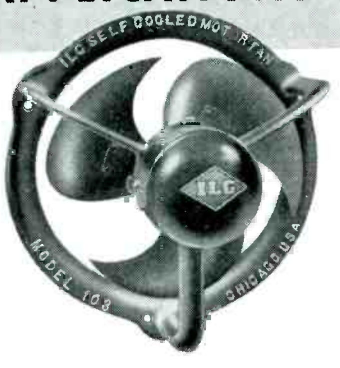


Model 6 S—6½" high



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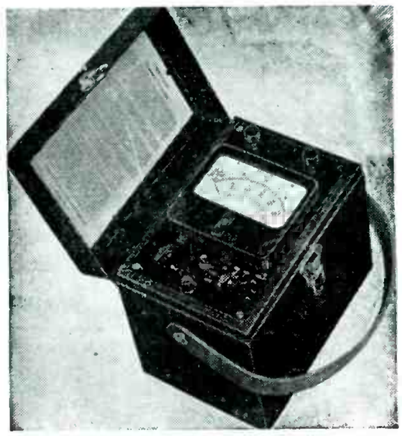

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Company	Address	Component
Erie Resistor Corp.	644 W. 12th St. Erie, Pa.	Resistors, Capacitors
John E. Fast & Co.	3123 No. Pulaski Rd. Chicago 41, Ill.	Capacitors, Choke Coils
Federal Telephone & Radio Corp.	591 Broad St. Newark, N. J.	Radio Component Parts
General Electric Co.	Bldg. 267, River Rd. Schenectady, N.Y.	Electron Tubes
General Electronics, Inc.	1819 Broadway New York 23, N. Y.	Power Tubes
Glenn-Roberts Co.	3100 E. 10 St. Oakland 1, Calif.	Transformers, Capacitors, Chokes
Gruen Watch Co.	Cincinnati, Ohio	Panel Indicating Instruments
Guardian Electric Mfg. Co.	1400 Washington Blvd. Chicago 7, Ill.	Relays, Solenoids
Hammarlund Mfg. Co.	460 W. 34 St. New York 1, N.Y.	Resistors, Capacitors
Hercules Electric & Mfg. Co., Inc.	2500 Atlantic Ave. Brooklyn 7, N. Y.	Transformers, Reactors, Choke Coils, Inductors
H.R.S. Radio Products	5707 W. Lake St. Chicago, Ill.	Capacitors
Hudson American Corp.	25 W. 43 St. New York 18, N. Y.	Transformers, Electronic Components
Hytron Radio & Electronics Corp.	76 Lafayette St. Salem, Mass.	Receiving and Transmitting Tubes
Illinois Condenser Co.	1160 No. Howe St. Chicago, Ill.	Capacitors
Industrial & Commercial Electronics	P.O. Box 296, Belmont, Calif.	Transmitting Tubes, Vacuum Condensers, Components
Industrial Condenser Corp.	3243—65 No. Calif. Ave. Chicago 18, Ill.	Capacitors
Industrial Transformer Corp.	2340 Belmont Ave. New York 58, N. Y.	Transformers
Insuline Corp. of America Inc.	3602 35 Ave. Long Island City, N. Y.	Various Electronic Products
International Resistance Co.	401 No. Broad St. Philadelphia, Pa.	Resistors
Jensen Radio Mfg. Co.	6601 So. Laramie Ave. Chicago 38, Ill.	Speakers, Transformers
E. F. Johnson Co.	206 Second Ave., S. W. Waseca, Minn.	Capacitors, Hardware, Inductors
Ken-Rad Div. General Electric Co.	3rd & St. Elizabeth Sts. Owensboro, Kentucky	Receiving and Transmitting Tubes
Lewis Electronics	16 Lyndon St. Los Gatos, Calif.	Transmitting Tubes
Light Electric Company	214 Lackawanna Ave. Newark 4, N. J.	Transformers
Madison Electrical Products Corp.	78 Main St. Madison, N. J.	Resistor
Maguire Industries	500 Fifth Ave. New York, N. Y.	Transformers
Micamold Radio Corp.	1087 Flushing Ave. Brooklyn, N. Y.	Capacitors, Resistors
August C. Miller Co.	9226 Hudson Blvd. N. Bergen, N. J.	Crystal Assemblies
Milwaukee Resistor Company	130-A West Pittsburgh Milwaukee, Wisc.	Resistors
Muter Company	1255 So. Michigan Ave. Chicago, Ill.	Resistors, Coils, Capacitors, Switches
National Scientific Products Co.	5013-25 No. Kedzie Ave. Chicago 25, Ill.	Crystal Oscillators, Headsets, Portable Electric Megaphones

Company	Address	Component
National Union Radio Corp.	15 Washington St. Newark, N. J.	Receiving and Transmitting Tubes
Newark Transformer Co.	17 Frelinghuysen Ave. Newark, N. J.	Transformers, Reactors
Newton Co.	244 W. 23 St. New York 11, N. Y.	Transformers
New York Transformer Co.	26 Waverly Pl. New York 3, N.Y.	Transformers
North American Philips Co., Inc.	100 E. 42nd St. New York, N. Y.	Electron Tubes
Ohio Carbon Co.	12508 Berea Rd. Cleveland, Ohio	Resistors
Oxford-Tartak Radio Corp.	3911 S. Michigan Ave. Chicago, Ill.	Speakers
Permoflux Corp.	4900 West Grand Ave. Chicago 39, Ill.	Headsets, Speakers
Precision Resistor Co.	334 Badger Ave. Newark 8, N. J.	Resistors
Premier Electronics Products, Inc.	4849 North Western Ave. Chicago, Ill.	Transformers
Presto Electric Co.	4511 New York Ave. Union City, N. J.	Resistors
Quam-Nichols Co.	33 Pl. & Cottage Grove Ave. Chicago 16, Ill.	Speakers
Radio Corporation of America RCA Victor Div.	Camden New Jersey	Electron Tubes
Radio Development & Research Corp.	233 W. 53 St. New York, N. Y.	Electronic Equipment
Radionic Controls	3758 W. Belmont Ave. Chicago 18, Ill.	Relays, Transformers
Raytheon Mfg. Co.	55 Chapel St. Newton 55, Mass.	Receiving and Transmitting Tubes, Transformers
R-B-M Mfg. Co. Div. Essex Wure Corp.	Logansport Indiana	Relays
Red Arrow Electric Corp.	132 Lincoln Pl. Irvington, N. J.	Transformers
Reimers Elec. Appl. Co., Inc.	596 56 St. West New York, N. J.	Wire Wound Resistors
Sangamo Electric Co.	11th & Converse St. Springfield, Ill.	Capacitors
Shallcross Mfg. Co.	Jackson & Pusey Ave. Collingdale, Pa.	Resistors
F. W. Sickles Co.	165 Front St. Chicopee, Mass.	Capacitors, Coils, Chokes, Subassemblies, Potentiometers
Simpson Electric Co.	5218 West Kinzie St. Chicago, Ill.	Palen Instruments, Test Equipment
Slater Mfg. Co.	728 Atlantic Ave. Brooklyn, N. Y.	Power Tubes
Sola Electric Co.	2525 Clybourn St. Chicago, Ill.	Transformers
Solar Mfg. Corp.	285 Madison Ave. New York 17, N. Y.	Capacitors
Sonotone Corporation	Elmsford, New York	Tubes, Head sets, Transformers
Speaker Corp. of Chicago	230 W. Superior St. Chicago, Ill.	Speakers
Sperti, Inc.	Beech & Kenilworth Ave. Cincinnati, Ohio	Electron Tubes
Standard Arcturus Corp.	30-34 Court St. Newark 2, N. J.	Receiving Tubes
Standard Coil Products Co.	2329 No. Pulaski Rd. Chicago, Ill.	Radio Coils, Crystals

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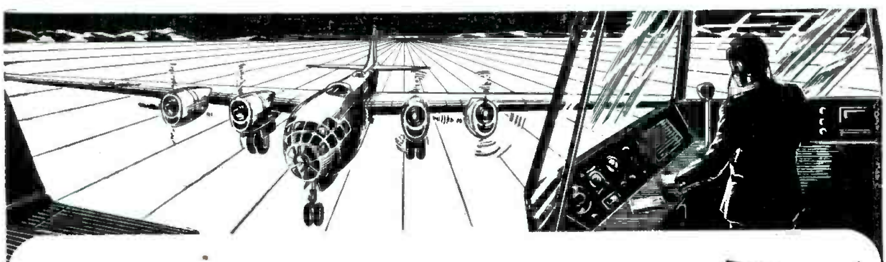

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Low contact resistance and non-welding when breaking surge currents are inherent properties of this unique combination of conductive silver and self-lubricating graphite.

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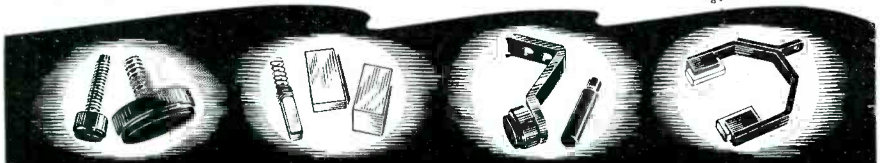

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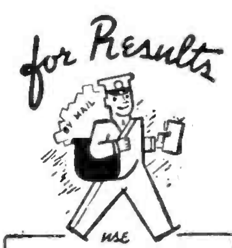

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NEW BOOKS

Table of Arc Sin X

By MATHEMATICAL TABLES PROJECT, *sponsored by National Bureau of Standards, Columbia University Press, New York, N. Y., 1945, 124 pages, $3.50.*

A 12-PLACE TABLE of values of arc sin x, in radian measure, prepared as a companion volume to the values of arc tan x published by the Mathematical Tables Project in 1942. Since, for the principal value, arc cos $x = \frac{1}{2}\pi -$ arc sin x, this volume may also be used for obtaining the inverse cosine. Specifically, the function is tabulated at intervals of 0.0001 in the range between 0 and 0.9890 and at intervals of 0.00001 in the range between 0.98900 and unity.

Also included are 15-place conversion tables for changing radians to degrees, degrees to radians, minutes to radians, and seconds to radians, along with a 15-place table of multiples of $\pi/2$ up to 100.—J.M.

• • •

Principles of Radio

By KEITH HENNEY, *Editor,* ELECTRONICS. *John Wiley & Sons, Inc., New York, 534 pages, $3.50.*

THIS FIFTH EDITION of a successful textbook shows promise of increasing its popularity which was well established by former editions over a period of fifteen years.

Although completely revised and brought up to date by the addition of new material on wave guides, microwaves, frequency-modulation broadcasting, klystron tubes, and other advances in the field the contents adhere to the original intention of the author, that of being written for the student who had little background in radio upon which to build and yet who wanted to know the basis on which radio communication existed. The omission in this edition of the chapters on Radio Frequency Amplifiers and Facsimile and Television in favor of new material does not detract from the continuity of the book.

While the contents are wide in scope, the various subjects have been presented in simple, understandable form. The majority of the explanations are followed by

practical examples and problems. The beginner should encounter little difficulty in gaining an understanding of the basic circuits employed in radio communication equipments.

It is noted that the author has been careful in adhering to a consistent form of abbreviation and notation. A minor objection is his refusal to make a clean break with the direction of "conventional current flow." Furthermore, it is considered unfortunate that inductors and capacitors continue to be called coils and condensers respectively. However, these do not measurably lessen the value of the book as a good basic radio textbook.—NELSON M. COOKE.

• • •

The Decibel Notation

By VEPA V. L. RAO, *Addison & Company, Ltd., Madras, India, 179 pages, $3.00.*

TODAY THE DECIBEL UNIT is widely used in radio engineering and acoustics. In 1924, when it was first used in telephone engineering, it was called a transmission unit. In the intervening twenty years, however, very few textbook authors and technical writers have devoted their efforts to the preparation of a thorough treatment of this important mathematical artifice. To fill this void in engineering literature, Vepa V. L. Rao, radio engineer, Government of Madras, has contributed this excellent monograph, the complete title of which is "The Decibel Notation and Its Applications to Radio Engineering and Acoustics."

As presented, the definitions, mathematical operations and procedures can be easily comprehended by anyone who has studied electrical engineering. The book should serve as a valuable reference work to all who are engaged in fields associated with telecommunications and acoustics.

To orient the reader, the author begins with an exposition contrasting the precision with which pressure, temperature, sound intensity, frequency change, and intensity of illumination can be measured, with the difficulties encountered in measuring the sensations of feeling, heat, loudness, pitch, and brightness. He next surveys the develop-

ment of the neper, bel, and decibel units, and then establishes their conversion relationships. The decibel notation and its formulas that relate to electrical quantities like power, voltage and current are explained.

Following a discussion and definition of the important terms used in acoustics, the phon or loudness unit is introduced and its development traced. For a plane progressive wave, comparative values are given in tabular form for the intensity level, phons, corresponding effective value of pressure fluctuations, and sound particle velocity. The zero phon loudness level is defined and a comparison made of the loudness levels in phons of the thresholds of hearing, feeling, and pain.

In showing how the decibel notation is used in radio engineering and acoustics, the author takes the opportunity to describe the principles underlying the use of many well known devices and their characteristics. The applications include the output power meter, audio amplifiers, radio receivers, audio transformers, gramophone record cutters and pickups, output tubes, microphones, loudspeakers, transmitters, transmission lines and feeders, antennas, studio acoustics, attenuators, equalizers, and filters.

An appendix is devoted to a description of the types of graphs used in radio and acoustic engineering, an explanation of the logarithmic notation and its limitations, a discussion of the differences between the British and American standard cables, and a statement of the laws of logarithms with tables of common logarithms and antilogarithms.—J.K.

• • •

The Electrolytic Capacitor

By ALEXANDER M. GEORGIEV, *Murray Hill Books, Inc., New York 16, N. Y., 191 pages, $3.00.*

ENGINEERS WHO DESIGN and develop electrical apparatus and products that make use of electrolytic capacitors will appreciate the broad scope of this book. The well-balanced presentation of fundamental principles and practical considerations is convincing evidence that the author is an authority in this field.

The author has drawn exten-

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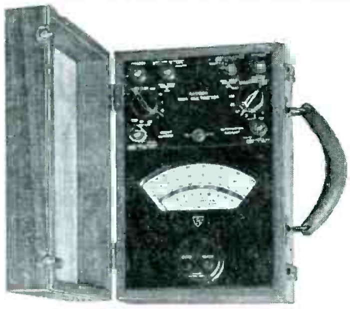

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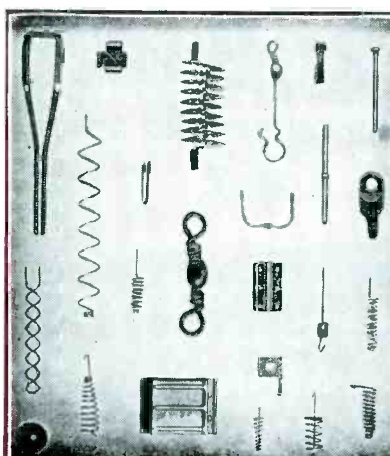

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sively from his observations and experiences acquired in the development and manufacture of capacitors. He describes the construction, manufacture, function, and testing of dry and wet electrolytic capacitors, explains the operating characteristics of the various types, and indicates both their useful applications and their limitations.

Several theories are outlined concerning the nature of the dielectric film, and the properties of the film treated in detail. Film-forming electrolytes that are generally used in the electrolytic capacitor industry are thoroughly surveyed as well as those employed in other branches of the anodizing process. The batch method and the continuous method, and associated equipment, used in the formation of capacitor anodes are set forth.

Much detailed and useful information is included in the chapters dealing with chemical and electrochemical methods of etching aluminum electrodes to increase capacitance, properties of papers suitable for electrode spacers in dry electrolytic capacitors, properties and requirements of materials used for the operating electrolyte, precautions and considerations that must be observed in winding capacitor sections and their connections if satisfactory performance is to be obtained, factors governing the effectiveness of the impregnation and precautions necessary to produce desired results, methods of impregnating dry capacitors and their respective advantages and drawbacks, and the requisites for an efficient container including a discussion on methods of venting the assembly.

For the laboratory technician and the maintenance man, chapters are included that cover electrical measurements, routine tests and special tests for electrolytic capacitors, causes and detection of troubles, emergency repairs, and replacements.

Of special interest to designers of electrical apparatus and assemblies are the sections devoted to the choice of type and design of electrolytic capacitors as governed by expected operating conditions, available space for mounting, permissible weight, cost, and similar factors, trends in the development of electrolytic capacitors during the

last twenty years, and applications and uses for electrolytic capacitors in radio receivers, electrical apparatus, and induction motors.

An informative glossary having eight pages of pertinent technical terms and nomenclature is included, along with an excellent bibliography of reference books and periodicals and a long list of United States and foreign patents.—J.K.

• • •

Willis Rodney Whitney

By JOHN T. BRODERICK. *Fort Orange Press, Inc., Albany, New York, 324 pages, $3.00.*

IN THE FOREWORD of this book, Karl T. Compton states "Few scientists have so impressed their ideals upon their contemporaries and followers as has Willis R. Whitney. He has largely set the pattern and philosphy of the modern industrial research laboratories, one of the unique achievements of this century. That Whitney was able to do this may be explained very simply; he was the right man at the right place at the right time.

"I am one of the many scientists to whom Dr. Whitney's intellectual stimulation, complete honesty and humility, abiding faith in the scientific method and unbounded interest in young men have been a continued inspiration. I am therefore glad that many others may come to know him through this biography."

Much of this interesting and fascinating biography is related in the dual form of narration—first telling the story of an individual and then letting him speak to the reader for himself in his own words—his own testimony concerning himself and his own interpretation, direct and in sidelights, of the work to which his life has been dedicated.

The author has not attempted to present an elaborate biography, but instead has produced a narrative sufficiently restrained to be in keeping with the character of its subject and yet extended enough to familiarize a reader with the career of a man who, as much as any other single individual, has made physical research both fascinating and fruitful.

Records of conversations and some typical Whitney writings supplement this picturesque volume. In these pages the doctor tells in his

own language the story of his life and activities, sometimes with homespun humor, sometimes with deep seriousness, but usually with a novel, inspiring and instructive message.

The narrative is not confined solely to the objectives of pure research and the values derived therefrom. It also deals with the relation of research to atoms and electrons, biology and physiology, education and religion, technological progress and industrial promotion, human life and turtle life, and the wide range of subjects that have engaged Dr. Whitney's attention as an assiduous student and original thinker.

This authentic record of Whitney's experiments, methods of work, ideas and practical accomplishments should be educational for readers, young or adult, who are ambitious to give their energies full and effective play but do not know what they are best fitted to do.

Mr. Broderick has contributed to our literature not only a vivid, graphic account of the activities and philosophy of one of the outstanding scientists of our time, but also a lucid explanation of the benefits that have been bestowed upon civilization by the research work conducted by modern men of science.—J.K.

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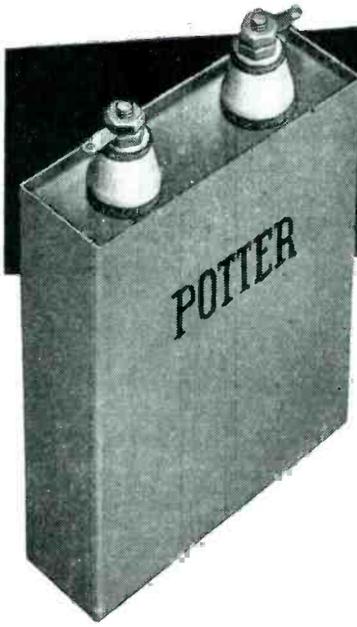

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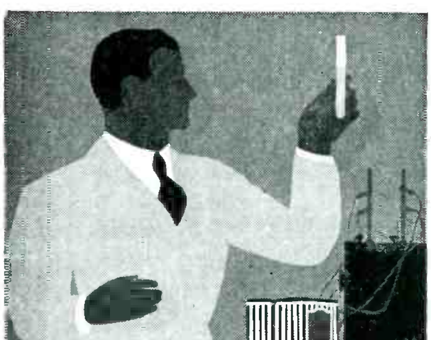

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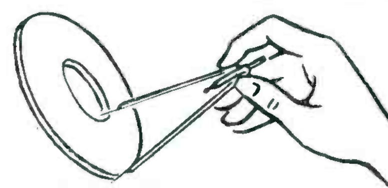

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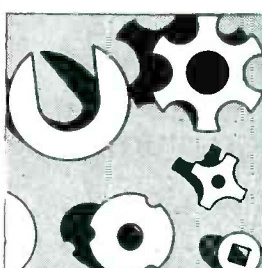

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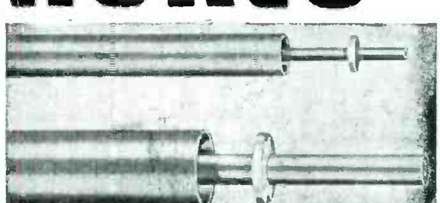

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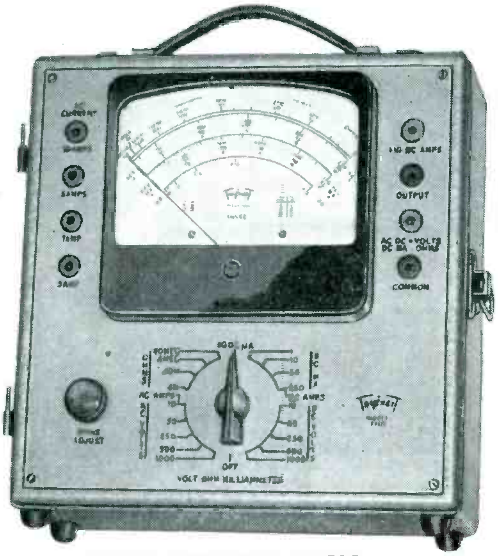


Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Slow-Motion Tele

DEAR MR. HENNEY:

IT SEEMS YOU just can't keep a dead dog buried. After everyone agrees to the fact that you can only transmit a given amount of intelligence by means of a system of a given bandwidth in a certain limited time, and while the fight is on as to whether or not to call it the Hartley Law, Palmer Craig pops up with a suspicion that it just ain't so.

I think that Mr. Craig's proposed exception can be shown to be quite invalid with a moment's thought. The television system that I think he describes has been put forward before, and has never been of any practical use. Let's consider just one out of the 240,000 elementary areas. The information determining the density of this area would have to be passed through a narrow-band filter; in the example given this filter is one-quarter cycle wide.

Now it is a well known fact that the amplitude of a wave passing through a band-pass filter can be changed at a maximum rate deter-

• • •

RADAR ANTENNAS

Now it can be told. Above, the forward detection antenna blister and one of the side blisters in the land-based patrol bomber, the Privateer PB4Y-2

mined by the bandwidth of the filter. "You can't get 20-kc audio signals out of a radio having an i-f bandwidth of 4 kc" is another way of saying the same thing. A band-pass filter having a bandwidth of about one-quarter cycle would require 8 to 10 seconds for the output to build up to a value approximating the final steady-state value if a suddenly changed voltage were applied to the input.

This means that if the picture at the transmitter were suddenly changed, the receiver would require 8 to 10 seconds to remove the old picture and reproduce the new one. In order to transmit a new picture each one-thirtieth of a second, the band-pass associated with each picture element would have to be approximately 60 cycles wide. Actually, according to present day practices, a bandwidth of 30 cycles would be sufficient. This would still require a total spectrum about 7 mc wide, or about the order of magnitude of present day practice.

The system described by Mr. Craig might be fine for a Hollywood clinch with a long fadeout at the end, but I'd hate to watch a boxing match or baseball game on it.

WM. H. UNGER
Philharmonic Radio Corp.
New York, N. Y.

[The motion is still before the house that the following statement be called the Hartley Law: "The total amount of information which can be transmitted over a system whose transmission is limited to frequencies lying in a restricted range is proportional to the product of the frequency-range which it transmits by the time during which it is available for transmission." Any further comments?—Ed]

• • •

INSTRUMENT FLYING

Wave Jean Gaum gives directions to a Naval officer shut in the Link trainer in the background

CONTACTS

FOR THE FIELD OF ELECTRONICS

Strip Insulated Wires
QUICKER . . . BETTER

with "Speedex" AUTOMATIC WIRE STRIPPER . . . Speeds Production

Strips insulation from all types of wire — instantly, easily, perfectly. Just press the handles and the job is done. Cuts wire too. Strips 800 to 1000 wires per hour. Available for all size solid or stranded wires — No. 8 to No. 30. List Price $6.00.

Write Dept. E for Full Particulars

GENERAL CEMENT MFG. CO.
Rockford, Illinois, U.S.A.

MORE RF KILOWATT HOURS PER DOLLAR WITH

F & O
TRANSMITTING TUBES

Inquiries Invited—Let us explain how Savings are effected and the F & O greater guarantee.

FREELAND & OLSCHNER PRODUCTS Inc.
611 Baronne St., New Orleans 13, La.
Raymond 4756

High Power Tube Specialists Exclusively
(5 KW To 100 KW)

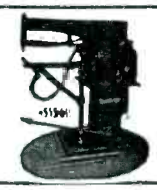
REX RHEOSTAT COMPANY, BALDWIN, L. I., N. Y.

PROTECTED & UNPROTECTED
RHEOSTATS
WITH LUBRICATED CONTACTS
ROTARY DRIVE RHEOSTATS
WITHOUT BACK LASH
PROTECTED & UNPROTECTED
ADJUSTABLE RESISTORS
UP TO 1000 WATT
PROMPT SHIPMENTS

We manufacture a complete line of equipment

SPOT WELDERS, electric from ¼ to 50KVA
TRANSFORMERS, special and standard types
INCANDESCENT LAMP manufacturing equipment
FLUORESCENT TUBE MAKING EQUIPMENT
ELECTRONIC EQUIPMENT, vacuum pumps, etc.
WET GLASS SLICING and cutting machines for laboratory use
GENERAL GLASS working machines and burners
COLLEGE GLASS working units for students and laboratory

AC ARC WELDERS from 100 to 400 Amps



EISLER ENGINEERING CO.
731 So. 13th St. (near Avon Ave.) Newark, New Jersey

FINE RIBBONS OF TUNGSTEN and MOLYBDENUM

Quality and accuracy in our fabrication of Tungsten & Molybdenum Ribbons have characterized our service to the Electronic industry.

A development of

H. CROSS CO.
15 Beekman St., New York 7, N.Y.

Electron Tube Machinery
of every type,—standard, and special design

Specialists in Equipment for the manufacture of Radio Tubes, Cathode Ray Tubes, Fluorescent Lamps, Incandescent Lamps, Neon Tubes, Photo Cells, X-ray Tubes and other glass or electronic products, on production or laboratory basis.

Kahle ENGINEERING COMPANY
1307-1309 Seventh St., North Bergen, N. J.

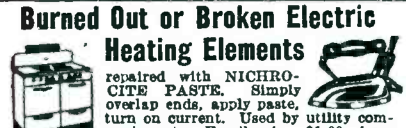
MICROMETER FREQUENCY METER for checking Transmitters from 1.5 to 56 mc., within 0.01 per cent

LAMPKIN LABORATORIES
Bradenton, Fla., U. S. A.

BRAZILIAN QUARTZ CRYSTALS

CRYSTAL TRADING COMPANY
Importers
118 Liberty St. New York 6, N. Y.

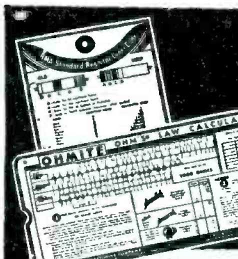
Burned Out or Broken Electric Heating Elements



repaired with NICHRO-CITE PASTE. Simply overlap ends, apply paste, turn on current. Used by utility companies, etc. Family size, $1.00, 4 oz. size $2.50. Satisfaction guaranteed.

Armstrong Mfg. Co., Box 861G Minneapolis, Minn.

FREE TO RADIO MEN



COLOR CODE and OHMS LAW CALCULATOR

Burstein-Applebee of Kansas City offers you this great convenience FREE. Easy to work. Solves many problems in a jiffy. FREE to radio men, electronic engineers and others in the business. Attach coupon to your letterhead.

MAIL COUPON NOW

BURSTEIN-APPLEBEE CO.
1012 McGEE, KANSAS CITY 6, MO.
Send me FREE Color Code and Ohms Law Calculator along with latest catalog.

I am ____________
STATE CONNECTION IN INDUSTRY

NAME ____________
ADDRESS ____________
TOWN ____________ STATE ____________

HETERODYNE ELIMINATORS

If you are troubled by heterodyne interference consult

J. L. A. McLaughlin
P. O. Box 529, La Jolla, Calif.

MINIATURE PRECISION BALL BEARINGS
(WORLD'S SMALLEST BALL BEARING)

For precision instruments, industrial laboratory equipment, radio and electronic devices, to minimize friction, space, weight and overcome starting torque. Radial and Pivot types.

Radial Series (5 Sizes) 1/8" to 5/16" O. D.
Pivot Series (6 Sizes) 2 mm to 10 mm O. D.
Write for data sheet and catalog E

MINIATURE Precision BEARINGS
KEENE, NEW HAMPSHIRE, U. S. A.

Make it a HABIT . . . to check this page—EACH ISSUE

THIS WHERE TO BUY SECTION supplements other advertising in this issue with these additional announcements of products and services essential to efficient and economical operation in the field of

ELECTRONICS.

SEARCHLIGHT SECTION

EMPLOYMENT • BUSINESS • OPPORTUNITIES • EQUIPMENT—USED or RESALE

UNDISPLAYED RATE:
15 cents a word, minimum charge $3.00.
(See ¶ on Box Numbers.)
POSITIONS WANTED (full or part-time salaried individual employment only), ½ above rates.
PROPOSALS, 50 cents a line an insertion.

INFORMATION:
BOX NUMBERS in care of any of our New York, Chicago or San Francisco offices count 10 words additional in undisplayed ads.
DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:
The advertising rate is $7.50 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.
AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. E.

NEW ADVERTISEMENTS received by 10 A. M. December 7th will appear in the January issue, subject to limitation of space available.

POSITIONS VACANT

(Additional Positions Vacant ads on pages 405 and 421)

WANTED: ENGINEERS with experience in Audio Circuit work for engineering development on hearing aids and associated devices. Experience on hearing aids not actually necessary. Apply to Chief Engineer Zenith Radio Corporation, 6001 W. Dickens Avenue, Chicago 39, Illinois, giving details of education, age and experience. These positions offer excellent opportunities for interested personnel.

WANTED: CAPABLE engineer in radio, television and tube design. Must be able to work in own home or shop. P-953, Electronics, 68 Post Street, San Francisco 4, Cal.

EMPLOYMENT SERVICE

SALARIED POSITIONS $2,500-$25,000. Reconversion is creating lifetime opportunities now. This thoroughly organized confidential service of 35 years' recognized standing and reputation carries on preliminary negotiations for supervisory, technical and executive positions of the calibre indicated, through a procedure individualized to each client's requirements. Retaining fee protected by refund provision. Identity covered and present position protected. Send only name and address for details. R. W. Fixby, Inc., 278 Delward Bldg., Buffalo 2, N. Y.

POSITIONS WANTED

RADIO ENGINEER. Interested in V.H.F. development, particularly multi-channel telegraph operation over V.H.F. radio links. (see page 237 August Electronics.) Recently returned from 3 years in charge of V.H.F. development section of British Admiralty. Desires position with company who might be interested in developing new ideas for V.H.F. communication. PW-936, Electronics, 68 Post Street, San Francisco 4, Cal.

ELECTRICAL ENGINEER: 6 years experience desires position in South in design and production small electric or electronic equipment possibly leading toward sales work. PW-954, Electronics, 330 W. 42nd St., New York 18, N. Y.

PHYSICIST, NOW head of research in large concern, desires responsible position as technical director in any research or manufacturing establishment. Age below forty. PW-955, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRONICS ENGINEER: M.A. in Physics, six years experience in the development and design of test equipment for radio and electronics manufacturers desires permanent position in electronic development in New England. PW-956, Electronics, 330 W. 42nd St., New York 18, N. Y.

E.E. COLLEGE graduate now employed in electronic industry desires permanent West Coast position. Five years varied experience in circuit development, organization, and public contact. Excellent references and records available. $5,000. PW-957, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRICAL ENGINEER

Graduate, age 35 with 12 years experience, seeks position as Quality Control Manager or Chief Engineer, electrical and radio fields. Past 5 years executive and production experience directing inspection organization of 600 employees for company producing aircraft accessory equipment. (Small motors, electrical controls, radio). Previous experience design, development with leading radio manufacturers.

PW-949, Electronics
520 North Michigan Ave., Chicago 11, Ill.

Curt E. Patton Personnel Engineers

53 W. Jackson Blvd. Chicago 4

offer Industry a confidential Personnel Service, selecting and presenting men for positions open—on either a fee or retainer basis.

Outstanding men in electronic and allied fields, with legitimate reasons for seeking a change, are invited to file applications at NO CHARGE, in confidence, so we may present their qualifications to our clients.

WANTED

PHYSICISTS AND ENGINEERS

Unusual opportunities are offered to technical men in advanced fields of exploration, geophysics, applied physics and industrial electronics who wish, to live in a town of 20,000 and maintain a stimulating contact with associates of widely diverse technical skills.

Excellent laboratory facilities including equipment for electron microscopy, x-ray diffraction, mass and optical spectroscopy are available to a small but expanding group.

Opportunities are offered to physicists and engineers of imagination to gain wide recognition for their contributions to the solution of advanced problems.

PHILLIPS PETROLEUM COMPANY
RESEARCH DEPARTMENT
BARTLESVILLE, OKLAHOMA

LOUDSPEAKER DESIGN ENGINEER AND PRODUCTION MAN

Excellent present and future opportunity for the qualified men. Profit sharing and participation in company stock. Must have proved performance and dependability; good judgment plus know-how for straight line economical production. Our organization knows of this ad. Your fully detailed answer held in strict confidence.

P-947, (Agency) Electronics
330 West 42nd St., New York 18, N. Y.

POSITIONS WANTED

ENGINEER, INDUSTRIAL or low-frequency electronics, wants permanent position commuting distance New Canaan, Conn. Some experience production, development, laboratory, but most satisfactory in sales, technical writing. Prefers work involving people more than things. Johnson O'Connor tested; results available to prospective employer. Reason for availability—present employer closing New York branch. J. B. Campbell, P.O. Box 834, New Canaan, Conn.

MAN INHERENTLY Lazy, no college graduate, no correspondence schooling, but 20 years in U. of H.K. (University of Hard Knocks), in installation, maintenance, service and trouble-shooting on wiring, motors and generators, radio and radar. Anything in electronics considered (particularly industrial electronic control equipment) where I stand around and watch the other fellow work. More money and less work desirable. Midwest location. Present salary $6,000 per year. Available within the next 60 or 90 days. Give complete details in first letter. PW-958, Electronics, 330 W. 42nd St., New York 18, N. Y.

RADIO ENGINEER, M.S., E.E. degrees, experience in practical design and development, desires to join manufacturers of electronic instruments, transmitters, receivers, heating, tubes, or parts as sales engineer and technical representative in China, many years radio business experience in China. PW-959, Electronics, 330 W. 42nd St., New York 18, N. Y.

(Continued on page 422)

Industrial designers!

Do you want to join a company which is out to give the buying public of the present and future the very best in product appearance? If you do, General Electric has a career job for you. The wide range of G-E products for the home offers fertile ground for imaginative, diversified designing. Industrial Designers on our payroll will therefore have an unprecedented opportunity to employ their talents in the creation of designs for G-E electrical appliances and apparatus and radio cabinets. Write now, giving your qualifications, to Mr. M. B. Tracy, Appliance & Merchandise Department, General Electric Co., Bridgeport, Conn.

ELECTRONIC ENGINEER

As research and design engineer with vacuum tube hearing aid company. Must be graduate E.E. Some electronic and acoustical experience desired. Unusual opportunity to progress with aggressive company. Compensation secondary to provable ability. Permanent position. Describe education, experience, aptitudes and age. State salary desired. Apply in complete confidence.

P-873, Electronics
330 West 42nd St., New York 18, N. Y.

for CAMERAS and PROJECTORS

Highly rated firm in the East manufacfacturing established line of amateur photographic equipment is interested in securing executive engineers or designers now commanding good salaries in camera goods or kindred type of work. Consideration given to original letters giving complete necessary details including home phone number, names of present or former employer, etc.

P-963, Electronics
330 West 42nd Street, New York 18, N. Y.

ENGINEER

HIGH QUALITY RADIO RECEIVERS

We need a high grade engineer who is thoroughly familiar with the design and production of radio receivers and has had several years experience. Knowledge of power and audio transformers also highly desirable. Small company located close to New York.

P. O. Box 430
Elizabeth, N. J.
or Elizabeth 2-1735

(Additional Positions Wanted & Selling Opportunity Advertising on Page 422)

Efficient Manufacturing Facilities Available

for sub-contracting

- ★ Sub-assembly and Complete Assembly Operations
- ★ Automatic - Screw Machines
- ★ Drilling, Tapping and Centerless Grinding
- ★ Electro-Plating

Facilities of three "E" Award manufacturing plants - conveniently located to insure "on schedule" production at the lowest costs - expert engineering service accustomed to precision manufacturing.

Company Representative will call to Discuss Details

John R. Wald Company

PHONE 682

HUNTINGDON, PENNSYLVANIA

POSITIONS WANTED

(Continued from page 420)

TRANSFORMER ENGINEER: long experience design, production radio—luminiscent tube and specialty transformers. Exp. design setup mass production equipment. PW-960, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRONIC ENG. 15 years experience in Europe, 3 years in U. S. manufacturing vac. cathode ray tubes etc. Exhaust, emission and glass working problems wants position as first assistant to chief eng. or technical adviser. PW-961, Electronics, 330 W. 42nd St., New York 18, N. Y.

SELLING OPPORTUNITY WANTED

ELECTRONIC ENGINEER: 14 years experience as executive research and installation. Maintenance engineer of airborne and ground equipment. Desire sales representation or installation and maintenance engineering position. Prefer Central or South America. Speaks Spanish fluently. SA-962, Electronics, 330 W. 42nd St., New York 18, N. Y.

Established electronic representative sales agency has

OPENING FOR A FIELD MAN

For Connecticut, Western Massachusetts and Vermont. Knowledge of and experience with radio-electronic parts helpful. A position with a future under contract for the qualified man.

RW-948, (Agency) Electronics
330 West 42nd St., New York 18, N. Y.

TECHNICAL SALES ENGINEER

Experienced in electronics, or preferably electronic physics. Permanent position and good opportunity for man who has technical qualifications and ability to establish firm lasting inter-company contacts. Salary open. In replying give full details of your experience.

SW-950, Electronics
520 North Michigan Ave., Chicago 11, Ill.

Export for Profit

Roburn Agencies, Inc. have represented leading manufacturers of radio and electrical equipment, parts and accessories, in world-wide markets since 1935. Extensive facilities relieve you of all export headaches – correspondence, advertising, sales, finance, packing and shipping. A few additional clients seeking experienced, reliable representation are invited. Write for information on Profits Through Exports.

Roburn Agencies, Inc.
115E Fulton Street New York 7, N. Y.

REPRESENTATION IN TURKEY

A well known turkish radio company desires to represent American manufacturers of transmitters, receivers, sound systems, recorders, test and measuring equipment, dynamotors, converters and other electronic products. Write details to:

Mors Telsiz Atelyesi
Sisli P. K. 66
Istanbul Turkey

SALES REPRESENTATION WEST COAST

If you are a manufacturer of electrical or electronic equipment for industrial applications, let our staff of experienced engineering consultants represent your products on the west coast. Address

RA-934, Electronics
68 Post St., San Francisco 4, Calif.

RADIO and TELEVISION

Leading Danish manufacturer of radio sets and parts wants connection with American manufacturers in the Radio, F.M., Television and Electrical Music industry, who would be interested in cooperating to exploit present potentialities of Denmark market.

A/S Rasmus Rudholt
Howitzvej 11—Copenhagen F.
Denmark

NATIONAL DISTRIBUTION AVAILABLE

For Manufacturers who make products suitable for sale to radio and electronic Jobbers. We have a complete sales staff for national and export distribution. Reply with samples or description of products.

RA-870, Electronics
330 West 42nd St., New York 18, N. Y.

MERKURIANA

is our cable address. *Wholesale Dealers* and large *Industry* consumers are our clients. We act as Manufacturers' Agent *on your behalf* against a small commission. Open to offers on all Electronic products.

T E K N O - M E R K U R
Industrial Agencies
Postbox 617 Stockholm I. Sweden

SALES REPRESENTATION EAST COAST

A group of experienced engineering consultants desire to represent manufacturers of Radio & Electronic products. Please reply with description of products.

RA-951, Electronics
330 West 42nd Street, New York 18, N. Y.

FOR SALE

Controlling Stock Interest

in well known transformer manufacture. Excellent opportunity to enter this active business

BO-876, Electronics
330 West 42nd St., New York 18, N. Y.

WRITE FOR 24 P. CATALOG OF

METERS

AND INSTRUMENTS

VOLTMETERS	BRIDGES (Wheatstone)
AMMETERS	MEGOHMMETERS
MICRO AMMETERS	RHEOSTATS
OHMMETERS	VARIABLE TRANSFORMERS
FREQ. METERS	RELAYS

ELECTRO-TECH Equipment Co.
329 CANAL ST., N. Y. 13, N. Y.

BEST QUALITY, USED ELECTRON TUBE MACHINERY

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., INC.
65-67 East 8th St. New York, N. Y.

FOR SALE

PAPER CONDENSER PLANT

Machinery, equipment and materials for manufacturing paper condensers. This is an opportunity for an experienced condenser man to start in business with limited capital.

BO-964, Electronics
520 North Michigan Ave., Chicago 11, Ill.

WANTED

Your Business

"ANYTHING containing IRON or STEEL"

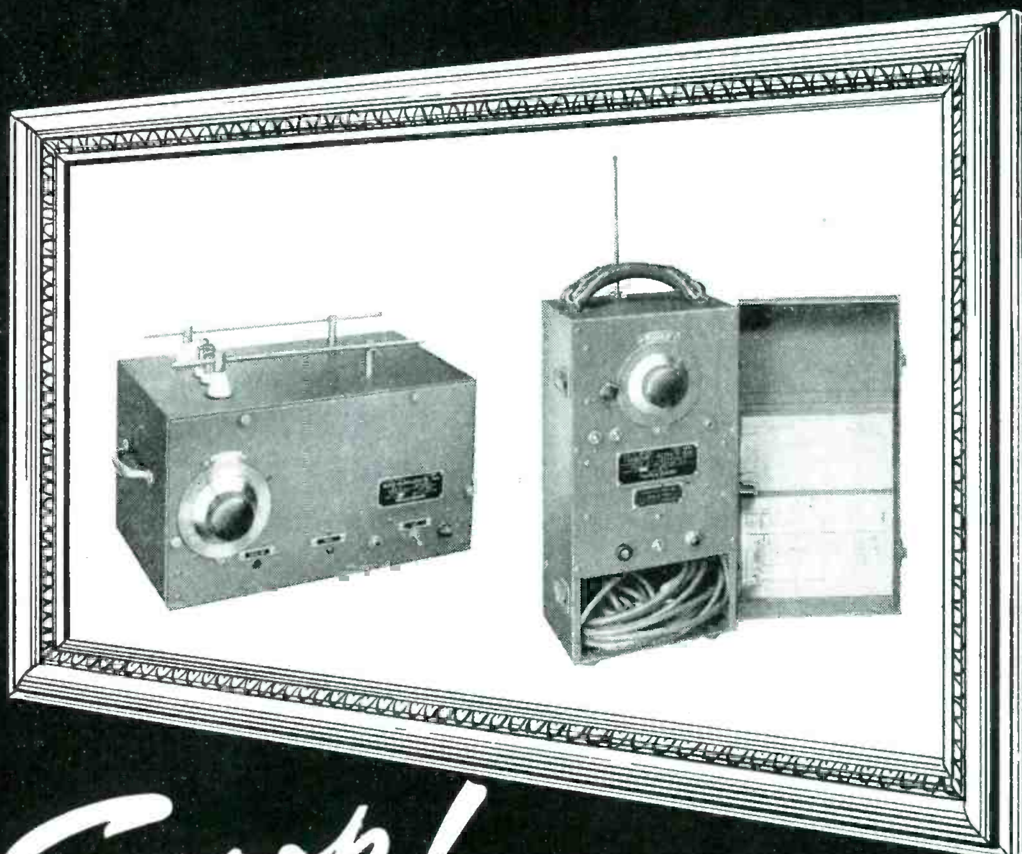
MORE FOR YOUR DOLLAR

IRON & STEEL PRODUCTS, INC.
40 years' experience
13422-A S. Brainard Ave., Chicago 33, Ill.

NAVAL OFFICER

Released from active duty desires to purchase interest in currently operating or proposed AM and/or FM Radio Station. Will also consider Mfg. or Distribution of Electronic Equipment.

BO-952, Electronics
330 West 42nd Street, New York 18, N. Y.



Scoop!

Left: Radio Modulator BC-423. High frequency signal generator operating from 195 to 205 mc., modulated at approximately 5000 cycles. Ruggedly built in steel case. Designed so that it can be re-adapted to many applications. Can be used as high frequency receiver, transceiver or frequency meter. Good for lab demonstrations requiring low power, ultra high frequency generator. Can be converted to 2½ or 1¼ meter receiver.

Right: Frequency Meter BC-438. Ultra-high frequency signal generator operating from 195 to 205 mc. with crystal calibration. Aluminum chassis in steel case. Removable nickel plated 19" telescopic antenna. Use as high frequency receiver or transmitter. Can be converted to cover any frequency range. Takes dry batteries for portable use. Precision tuning control make it ideal for "on the nose" ECO transmitter control unit.

hallicrafters RADIO

THE HALLICRAFTERS CO., AGENT FOR RFC UNDER CONTRACT SIA-3-24
MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT

THESE VALUABLE ITEMS *Available Now* or very soon. Write, wire or phone for further information • head phones • test equipment • component parts • marine transmitters and receivers • code practice equipment • sound detecting equipment • vehicular operation police and command sets • radio beacons and airborne landing equipment.

CLIP THIS COUPON NOW

RFC DEPARTMENT 417 HALLICRAFTERS
5025 West 65th Street • Chicago 38, Illinois

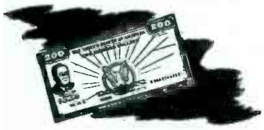
☐ Send further details on merchandise described above
☐ Send listings of other available items

Especially interested in ____________
STATE ____________
NAME ____________
CITY ____________ ZONE ______
ADDRESS ____________

Now – MATCH THEIR BEST WITH YOUR MOST IN THE VICTORY LOAN!

Top off your good work on your Payroll Savings Plan with an outstanding showing in the Victory Loan—our last all-out effort!

Help bring our boys back to the homes for which they fought—and give our wounded heroes the best of medical care—by backing the Victory Loan! You know your quota! You also know by past war-loan experience that your personal effort and plant solicitation are required to make your quota.



Sell the New F.D. Roosevelt Memorial $200 Bond through your PAYROLL SAVINGS PLAN!

In rallies, interdepartmental contests, and solicitations, promote the new Franklin Delano Roosevelt Memorial $200 Bond! Better than "cash in hand," Victory Bonds enable the buyers to build for the future—assure a needed nest egg for old age.

Keep on giving YOUR MOST to the Victory Loan! All Bond payroll deductions during November and December will be credited to your quota. Every Victory Bond is a "Thank You" to our battle-weary men overseas—also a definite aid in making their dreams of home come true! Get behind the Victory Loan to promote peacetime prosperity for our returning veterans, your nation, your employees—and your own industry!

The Treasury Department acknowledges with appreciation the publication of this message by

ELECTRONICS

VICTORY LOAN

n official U. S. Treasury advertisement prepared under auspices of Treasury Department and War Advertising Council

INDEX TO ADVERTISERS

INDEX TO ADVERTISERS

Continued

Index to electronics Volume XVIII

January to December issues, inclusive, 1945

Cumulative Index (April 1930—December 1944) available at 75 cents

McGraw-Hill Publishing Company

330 West 42nd St., New York City, 18

A

B

C

* Illustrated

D

E

First aid to hearing with wire insulation of Geon

Polyvinyl resins are superior materials for ALL types of wire and cable insulation

Many of the properties that make wire insulation of GEON a superior material for hearing aid cord are the same ones that have brought about its wide use in wiring of all kinds, public utilities, and in manufacturing, and fabrication in every field.

For example, it resists body oils—won't get gummy. (*It resists most other chemicals, too; oils, greases, acids, alkalis.*) It's long aging—resists the action of air, ozone, sun, heat, cold. (*Ideal for radio connector cord, switchboards, etc.*) It's light in weight—made possible by thin coatings. (*That means more conductors per conduit in domestic, industrial, or utility wiring.*) It's smooth and comfortable. (*Easy to handle, easy to install.*) It has high flexlife. (*Use it anywhere that there's vibration or frequent flexing.*) Of course, all of these are in addition to excellent electrical properties that make possible power cable without protective sheathing; buried service entrance wire, and many other severe—or routine—forms of service.

The next time you order wire or cable be sure to specify insulation made from GEON. That way you'll be sure to get the best. For further information write Department FF-12, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

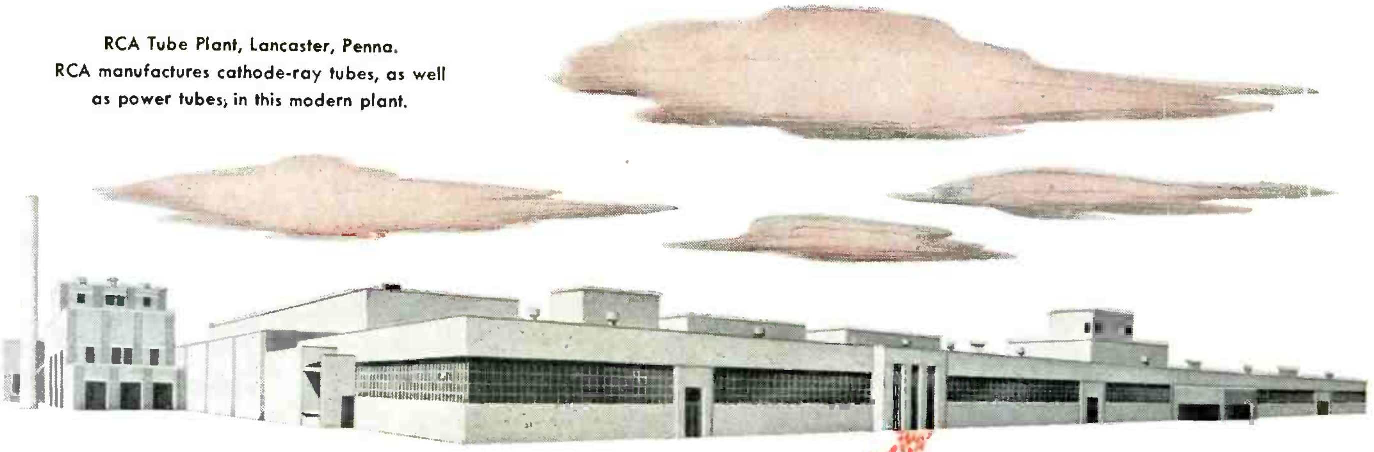
Geon
Polyvinyl Materials

B. F. Goodrich Chemical Company

A DIVISION OF
THE B. F. GOODRICH COMPANY

www.americanradiohistory.com

RCA Tube Plant, Lancaster, Penna.
RCA manufactures cathode-ray tubes, as well as power tubes, in this modern plant.



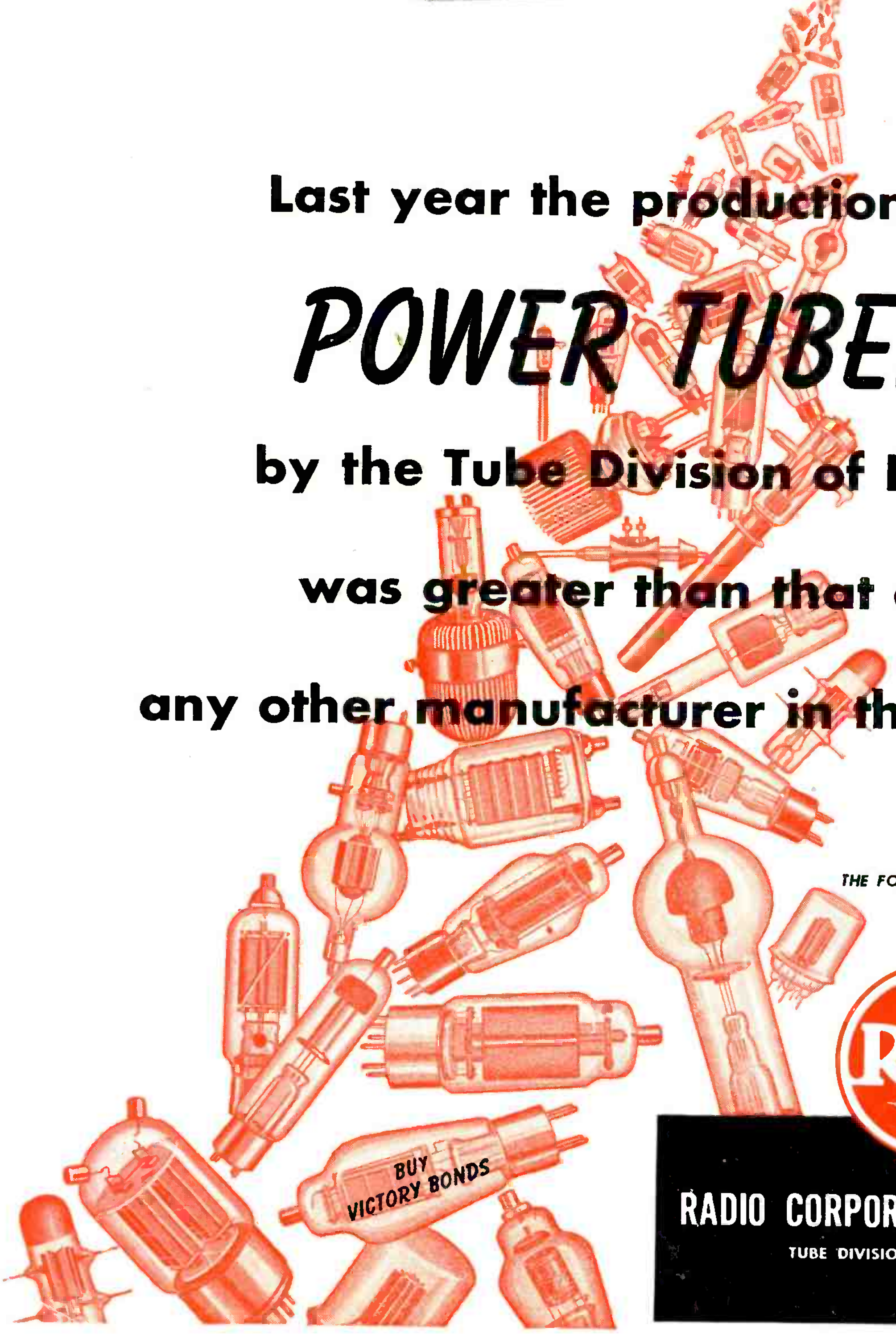
Last year the production of

POWER TUBES

by the Tube Division of RCA

was greater than that of

any other manufacturer in the world



THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

RCA

62-6136-37

RADIO CORPORATION OF AMERICA

TUBE DIVISION · HARRISON, N. J.