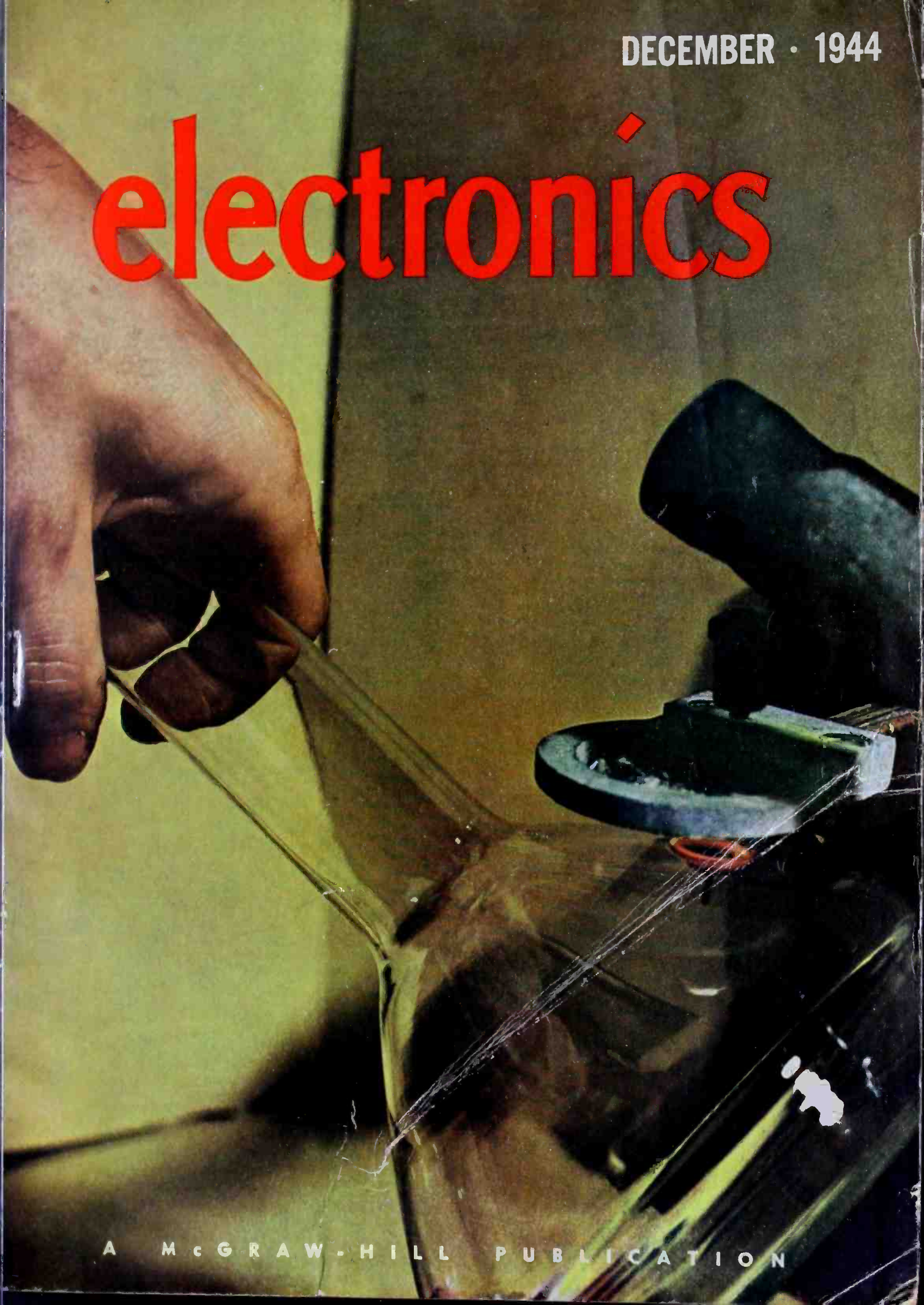
DECEMBER · 1944

electronics



A McGRAW-HILL PUBLICATION

...WHY

AMPEREX

WATER and AIR COOLED
TRANSMITTING and RECTIFYING TUBES

AMPEREX

... the high performance tube

Amperex engineers have made many important contributions to the refinement of electron tubes. One **"Amper-extra"** of note is the development of a means of assuring positive contact between the plate and wire support. Varying and unreliable high resistance contacts have been eliminated by **clinching and riveting.** And it is this method of joining the plate and its supports that makes for a steady, constant flow of plate current.
The sum total of all **"Amperextras"** adds up to cost efficiency in broadcasting, industrial, electro-medical and amateur radio applications. An **Amperex** engineer is available for consultation on your present or postwar problems.

AMPEREX ELECTRONIC CORPORATION

ARMY E NAVY

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IN THIS WAR, YOU GIVE WHAT YOU'VE GOT...DONATE A PINT OF BLOOD TO THE RED CROSS TODAY

electronics

DECEMBER • 1944

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To ....

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Signed ....

Made in Japan*

A recent UTC analysis of Japanese components substantiates the conclusive superiority of products of American design and construction . . . for example, on transformer components . . .

JAPANESE unit weighs **8 oz.**
...failed on 15 minute submersion test
...very narrow frequency range.

UTC hermetic ouncer weighs **1 oz.**
...takes full hermetic sealing tests
...has twice the frequency range.

* Japanese components illustrated obtained from the Pacific war theatre for the UTC Research Laboratory

MAY WE COOPERATE WITH YOU ON DESIGN SAVINGS FOR YOUR APPLICATION . . . WAR OR POSTWAR

United Transformer Co.

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Westinghouse
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PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Stalwart *against* Time

THE REPUTATION of Tobe Capacitors for *long life* rests on a record of practically no "returns". Ratings are always conservative. Constant research . . . manufacturing skill born of long, specialized experience . . . frequent, rigid inspections—these are the "secrets" of Tobe's ability to master difficult specifications, like those of the new American War Standards. The "DP" Molded Paper Capacitor shown below is an example. It is made of high grade Kraft tissue paper and aluminum foil —mineral oil impregnated and molded in low-loss Bakelite. Leads are tin copper wire. Whatever *your* capacitor problems, Tobe engineers will gladly work with you. Inquiries and requests for samples will receive prompt attention.

Norseman's Tower in Newport, R. I. One of Americas oldest structures, said to have been built by the Vikings about 1040 A.D.

LONG LIFE ASSURED

SPECIFICATIONS "DP" MOLDED PAPER CAPACITORS

CAPACITANCE ....001 to .04 MFD
WORKING VOLTAGE.....................*See chart at right*
Flash test 3 times rated DC working voltage
SHUNT RESISTANCE . . . At 185°F— 1000 megohms or greater
At 72°F—50000 megohms or greater
WORKING TEMPERATURE RANGE . . . . Minus 50° F to plus 185° F
OPERATING FREQUENCY RANGE . . . . . Upper limit 40 megacycles
Q at one megacycle—average 20
POWER FACTOR...................At 1000 cycles .004 to .006
DIMENSIONS ....13/16" x 13/16" x 19/64"

Capacity in MMFD	DC Working Voltage Rating	TOBE & AMERICAN WAR STANDARDS DESIGNATIONS	
		"A" Characteristic	"B"
1000	600	CN35A102	CN35B102
1500	600	CN35A152	CN35B152
2000	600	CN35A202	CN35B202
2500	600	CN35A252	CN35B252
3000	600	CN35A302	CN35B302
4000	600	CN35A402	CN35B402
5000	600	CN35A502	CN35B502
6000	600	CN35A602	CN35B602
7000	600	CN35A702	CN35B702
8000	600	CN35A802	CN35B802
10000	400	CN35A103	CN35B103
20000	200	CN35A203	CN35B203
30000	150	CN35A303	CN35B303
40000	100	CN35A403	CN35B403

TOBE DEUTSCHMANN CORP.
TOBE
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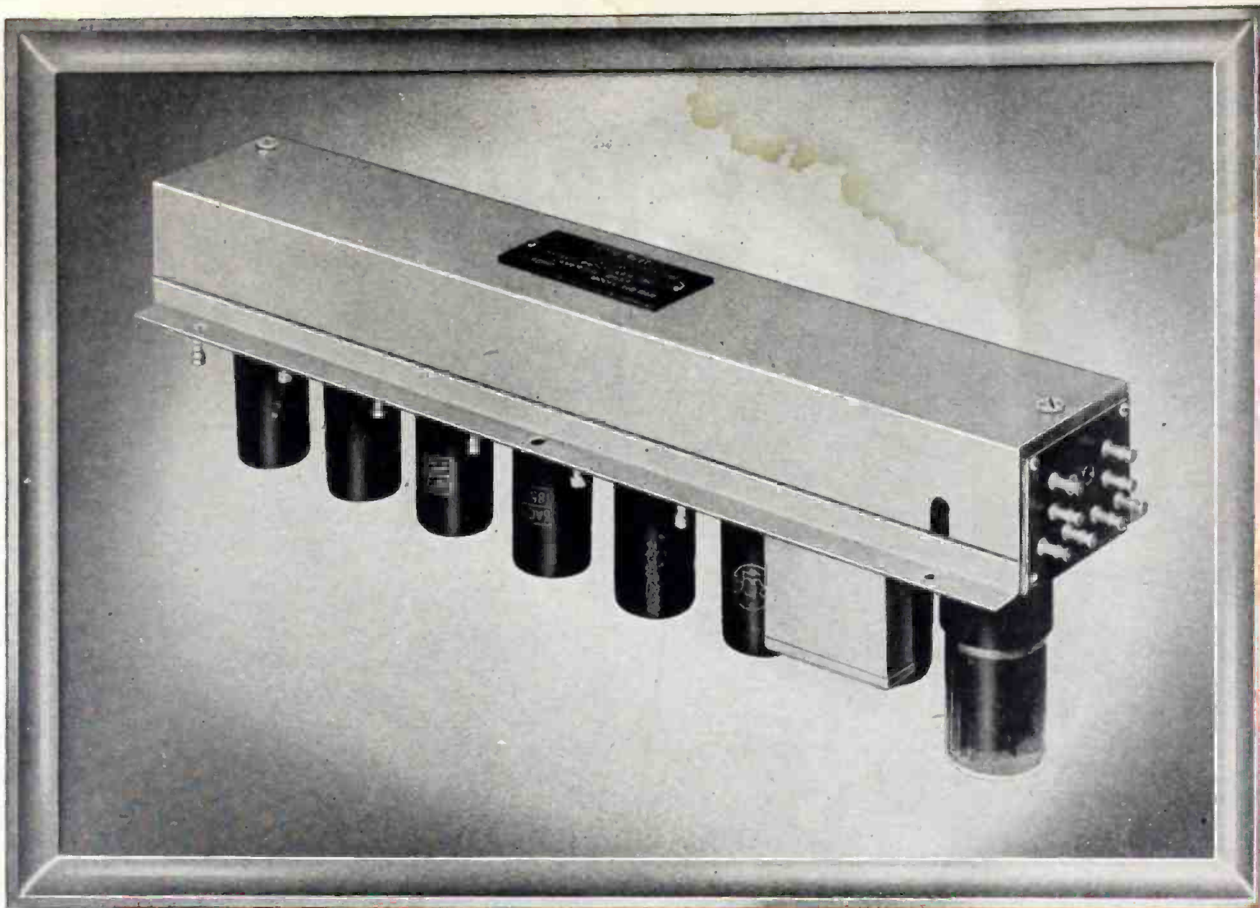
A SMALL PART IN VICTORY TODAY — A BIG PART IN INDUSTRY TOMORROW


PLATING
Constant checking of plating solutions and rigid quality control gives Hammarlund variable capacitors a finish that will last a lifetime under practically every operating condition.
THE SIGN OF QUALITY
ESTABLISHED 1910
HAMMARLUND
THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., N. Y. C.
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT



DOES THIS HARVEY "AMPLI-STRIP" *Fit Into Your Picture?*

It does if you need thoroughly dependable I-F and AUDIO Amplification. The HARVEY "AMPLI-STRIP" was designed and developed to provide a compact, convenient and practical Audio and I-F Amplifier. Custom-made to meet *your* electrical characteristics. This tested and proved "AMPLI-STRIP" will meet your most exacting performance standards.

The "AMPLI-STRIP" provides an excellent example of how the knowledge and experience gained by HARVEY through years of specialization in the radio-electronic field results in practical, efficient, reliable apparatus.

Why not let HARVEY of Cambridge help you to bring to a successful solution any of the present or projected radio-electronic problems that may be troubling you? Just get in touch with

HARVEY
OF CAMBRIDGE

HARVEY RADIO LABORATORIES, INC.
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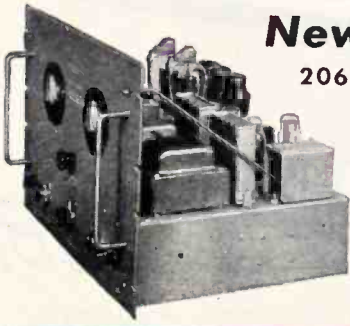
HARVEY UHX-25

A 25-Watt General Purpose Radio Telephone Transmitter

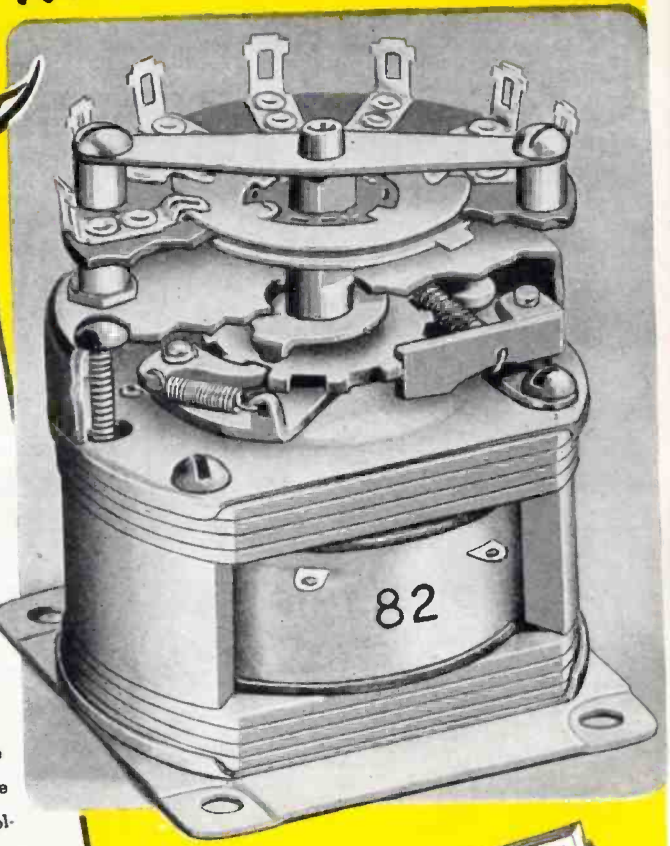
Available for operation between 1.5 M.C. and 30 M.C.



New HARVEY

206 PA REGULATED POWER SUPPLY
for Laboratory
D. C. Source—
RANGE 500 to 1000 VOLTS
500 to 700 at ¼ ampere
700 to 1000 at .2 ampere

Stepping out
with another member of our ROTARY RELAY family



The Rotary "Stepper" is another striking example of the unusual applications to which the ROTARY Relay can be adapted.

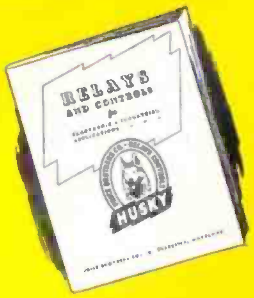
The Type 82 Rotary stepping unit is a compact twelve position driving mechanism which operates a shaft extension through 360° in twelve progressive steps.

When built up as shown above, the unit provides a twelve position selector switch, which indexes one position for each momentary current impulse. The unit will drive up to three wafer switches, or any other load not in excess of twelve ounce-inches torque. This unit can be made to operate clockwise or counter-clockwise.

The actuator can be furnished as a direct drive indexing the load with the current impulse, thus the switching operation is complete the moment the solenoid operates, or the actuator can be furnished as a spring drive, indexing the load following the current impulse. In this case, the switching operation is accomplished by spring action following each current impulse.

The current required to operate this unit will depend upon the torque required for a particular application. We will furnish a suitable coil if load is specified. For a twelve ounce-inch load a twelve Ohm coil drawing two amperes from a 24 volt D.C. supply would be required.

The unit is available for operation from Direct Current only.



PRICE BROTHERS CO. • RELAYS CONTROLS
HUSKY

Get Catalog E-12

Illustrates "ROTARY" adaptability to unusual and varied relay applications. Complete specifications and detail drawings. Also illustrates other Price Relays for Time Delays, Motor Starting, High Speed Keying, Antenna and Power Contactors. Write today for this Catalog.

ARMY E NAVY

PRICE Brothers Co. FREDERICK, MARYLAND

RELAYS, CONTROLS, AND MAGNETIC DEVICES FOR ELECTRONIC & INDUSTRIAL APPLICATION

The steel-jacketed sealed ignitron

. . . another G-E electronic FIRST!

The glass ignitron facilitated the application of electronic tubes to high-speed resistance welding and to the conversion of a-c to d-c without the use of rotating equipment. But it was General Electric's development of the sealed, water-cooled stainless-steel envelope or jacket that gave the ignitron the sturdiness that made it practical for industry's use.

Steel, instead of glass, not only gave the ignitron the ruggedness to avoid mishaps from external sources, but, more important, permitted water cooling which enabled tubes to be built that handle *ten* times the power for a given size of tube.

The present G-E steel-clad ignitron has the newly developed G-E low-current ignitor points that fire accurately and uniformly; that possess longer life and require less power. The G-E steel ignitron also incorporates a new type of anode seal with increased resistance to electrolysis.

As a result of these G-E developments, G-E steel ignitrons offer an exceptionally long life and dependable performance. Their operating costs are lower compared to motor-generator equipment, because of higher efficiency over the entire load range. This efficiency provides appreciable power savings.

Descriptive literature available. G-E electronic tube engineers will be glad to discuss the selection of G-E steel ignitrons for your products or manufacturing processes. Write for Bulletin ETI-12, a convenient listing of all G-E electronic tubes for industrial application. Address *Electronics Department, General Electric, Schenectady, N.Y.*

OTHER G-E TUBES ARE FIRST IN INDUSTRY, TOO! For example, General Electric developed the thyratron tube, which usually teams up with the ignitron where precision control is needed—as in "timing the shots" in high-speed spot welding. The G-E thyratron is also used to maintain constant speed in power tools regardless of variations in load.

Tune in "The World Today" every eve. except Sun. at 6:45 E.W.T., CBS. Sunday listen to G-E "All Girl Orchestra," 10 P.M. E.W.T., NBC.

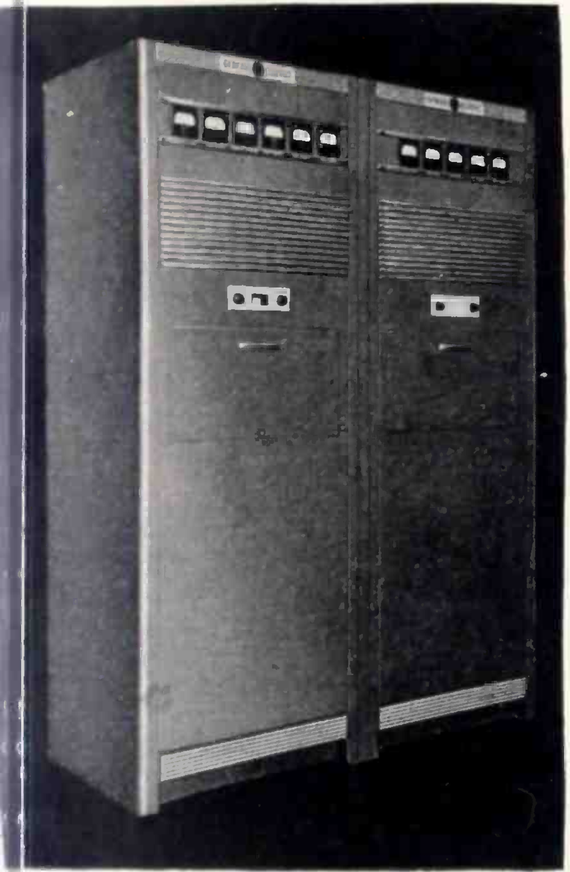
G. E. HAS MADE MORE BASIC ELECTRONIC-TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

161-C9—8850

day and night

5 times the coverage by day
35 times the coverage by night



THE PRE-WAR G-E 1-kw FM TRANSMITTER

General Electric's post-war FM equipment will include significant developments in circuits, components, and layout that will contribute directly to the quality and economy of your broadcasting system.

Regardless of your present power, if you face a coverage problem, if you share a crowded channel, consider FM. In nearly every case FM will provide better coverage of the *same* area at *less* cost, or better coverage of *more* area at the *same* cost.

Wherever station interference presents a problem, look to FM for better coverage. Consider, for example, the case of the 1400-kc channel in the broadcast band. Here, eighty-five AM stations share the same frequency. Eighty-one of them are rated at 250 watts and at night are capable of causing serious heterodyne interference up to 400 miles. This interference greatly reduces nighttime coverage. Engineering data indicate that under conditions of average ground conductivity (3×10^{-14} EMU) and with an antenna height of 331 feet, the effective range of these stations over flat country would be:

AM Service	*Range*	*Coverage*
Day	13 miles	530 square miles
Night	4.8 miles	72 square miles

Compare this with the coverage of a 250-watt FM station using a single-bay antenna 331 feet high broadcasting over the same terrain:

FM Service	*Range*	*Coverage*
Day *and* Night	29 miles	2640 square miles

Thus, FM gives five times the coverage by day; *thirty-five times the coverage by night!* To your audience this means improved service. To you, this means a larger audience and better service to advertisers.

When you plan your FM station, make full use of General Electric's vast background of experience in the FM field. G.E. is the one manufacturer with experience in designing and building complete FM systems—from transmitters to receivers. G.E. has designed and built more FM broadcast transmitters than any other manufacturer. G.E. has furnished a large percentage of today's half-million FM home receivers. G.E. has supplied six complete studio-transmitter FM relay links with thousands of hours of regular operation to their record. General Electric's experience in the FM broadcasting field includes more than three years of programming through its own FM proving-ground station WGFM at Schenectady, where every transmitter development is tested before it is offered to the industry.

Tune in General Electric's "The World Today" and hear the news from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS network. On Sunday evening listen to the G-E "All Girl Orchestra" at 10 E.W.T. over NBC.

ESTABLISH A POST-WAR PRIORITY ON DELIVERY OF YOUR FM EQUIPMENT. In order to enable you to obtain a post-war priority on delivery of transmitters and associated equipment, General Electric offers you the "G-E Equipment Reservation Plan." This plan will assure you of prompt post-war delivery of your transmitting equipment. Write for your copy of "The G-E Equipment Reservation Plan." *Electronics Department, General Electric, Schenectady, N. Y.*

ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

FM • TELEVISION • AM *See G.E. for all three!*

ELECTRONIC RESEARCH FOR INDUSTRY

The National Union Laboratories are now available to complete your established engineering facilities

There is no need to postpone your electronic research program, awaiting the day when competent engineers, costly equipment and scarce materials can be obtained. You can start right now and be far ahead by having National Union Laboratories take over this highly specialized part of your work, thus rounding out the development activities of your existing engineering group.

Whether you are interested in a single project or a complete service—we invite you to investigate National Union Electronic Research. Let's talk it over. There is no obligation whatever. Please address inquiries to Department E.

NATIONAL UNION RESEARCH LABORATORIES

National Union Radio Corporation **Newark 2, New Jersey**


ELECTRONIC HEATING
TUBES BY
UNITED
ARMY
NAVY
851
949 A
KU 23
311-CH
949 H
872 A
HV 27
HV 18
872
975 A
UX-973
967
FOR the widely varying conditions of load and frequency encountered in electronic heating "just any tube" is not good enough. Only specially designed tubes are capable of delivering a full life of efficient operation for this unusual function.
UNITED—a front line pioneer—has for many years been the leading supplier of tubes for the most widespread field of R-F heating . . . Diathermy.
Heavy Duty oscillators and power supply mercury rectifiers by UNITED are popular among users of H-F induction heating because they "stand up" under the fluctuating demands of this application.
To lower your operating costs, through increased life expectancy of your tubes, equip with the UNITED tubes, ideally designed for H-F heating . . . Write for technical data and tube interchange information.
UNITED ELECTRONICS COMPANY
NEWARK 2
NEW JERSEY
TRANSMITTING TUBES EXCLUSIVELY SINCE 1934

THE PICTURES MUST GET THROUGH!

Awarded to our Hicksville Long Island Plant for outstanding achievement in war production

A camera clicks in Moscow. Thirty minutes later, via Press Wireless radiophoto circuit, the picture is in Times Square, ready for the newspapers.

Today, swift, dependable and accurate radio transmission and reception of pictures, drawings, blueprints and other graphic material is of vital importance not only to the papers but to many other agencies as well. Mindful of this, Press Wireless is making constant improvements in its radiophoto technique and equipment.

An example is the trans-receiver shown here. It can send or receive a radiophoto, uses either amplitude or frequency modulation of the sub-carrier, is compact, easy to operate and reliable.

The trans-receiver is one of several advanced units Press Wireless has designed and is manufacturing chiefly for war today,—for peace tomorrow.

PRESS WIRELESS, INC. IS DEVELOPING OR MANUFACTURING

- HIGH POWER TRANSMITTERS
- DIVERSITY RECEIVERS
- AIRCRAFT AND AIRFIELD RADIO EQUIPMENT
- RADIO PRINTER SYSTEMS
- MODUPLEX UNITS "TRADEMARK"
- CHANNELING DEVICES
- RADIO PHOTO TERMINALS
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AND OTHER TYPES OF RADIO AND COMMUNICATIONS EQUIPMENT

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PRECISION MADE FOR PRECISE PERFORMANCE

and

PROVED IN USE!

There is no question about AAC crystals meeting the most exacting requirements under severe operating conditions. Their reliability has been tested and proved a thousand times over . . . in battlefront service to the armed forces . . . in helping to keep the communication systems of many leading airlines working efficiently . . . in meeting the quality demands of radio manufacturers. The list of users of AAC crystals shown below is a tribute to the engineering skill and fine manufacturing facilities behind AAC crystals.

Braniff Airways, Inc.
Chicago & Southern Air Lines, Inc.
National Airlines, Inc.
Northwest Airlines, Inc.
Pan American Airways System
Pan American-Grace Airways, Inc.
Pennsylvania-Central Airlines Corp.
Transcontinental & Western Air, Inc.

Colonial Radio Corp.
Columbia Broadcasting System, Inc.
Stewart-Warner Corporation
Western Electric Company, Inc.
Zenith Radio Corporation

Remember, crystal production is only one of AAC's services to the aviation and electronics industries. The production of airborne and ground radio equipment at the rate of more than 30 million dollars yearly for U. S. government and leading airlines demonstrates the wide scope and high rating of AAC manufacturing ability.

E-134

AIRCRAFT ACCESSORIES CORPORATION

ELECTRONICS • ENGINEERED POWER CONTROLS

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The TINYMITE
SMALLEST PAPER CAPACITOR - - -
yet 100%
MOISTUREPROOF
TYPE P5N
TYPE P4N
FEATURES
1. Bakelite Resinoid Ends. Lead wire cannot pull out, even under hot conditions.
2. Non-Inductive.
3. Excellent Temperature Coefficient.
4. Very high leakage Resistance.
5. Fine Power-Factor.
6. Range from 20 MMFD to .25 MFD. From 150 volts to 600 volts.
7. Types P4N, P5N for 100% humidity operation.
8. Types P4, P5 for 95% humidity operation.
Samples and price list on Request
BUY EXTRA WAR BONDS . . .
. . . 'TIL THE WAR IS OVER.
Pat. Pend.
DUMONT
ELECTRIC CO.
MFR'S OF
CAPACITORS FOR EVERY REQUIREMENT
34 HUBERT STREET NEW YORK, N. Y.

PRODUCTION *Flexibility*

ASSURES ONE STANDARD OF EXCELLENCE REGARDLESS OF QUANTITY

Unique production systems work side by side with a versatile engineering organization to build the utmost in efficiency into every TEMCO transmitter. Regardless of quantity, be it one, ten or a thousand units . . . every TEMCO-built transmitter receives the benefit of superb construction and engineering design.

Your expert eye will easily recognize the marks of finer craftsmanship evident in these TEMCO-built products, although only one special Power tube Life test rack was built in contrast to hundreds of these 150GS transmitters.

Delivered from the same production lines, all were endowed with every advantage of TEMCO'S advanced engineering skill.

Whether you need but one or many units of a particular design put TEMCO production flexibility to work for you. Write for a copy of our newest illustrated catalog.

TRANSMITTER EQUIPMENT MFG. CO., INC.
345 Hudson Street, New York 14, N. Y.

TEMCO

RADIO COMMUNICATION EQUIPMENT

HOW *Excellence*

NIMBLE FINGERS *Experienced Sangamo operators develop such a pronounced sense of touch that their handling of MICA in its initial state of preparation—that of splitting—is accomplished with the greatest dexterity and finesse. "Nimble fingers" inaugurate a quality control through ability that is maintained through each process of CAPACITOR production. Thus, faithful performance of the smallest to the largest unit has its beginning in the intricate art of MICA SPLITTING.*

SANGAMO ELECTRIC

ESTABLISHED 1898 • • • MICA CAPACITORS • • •

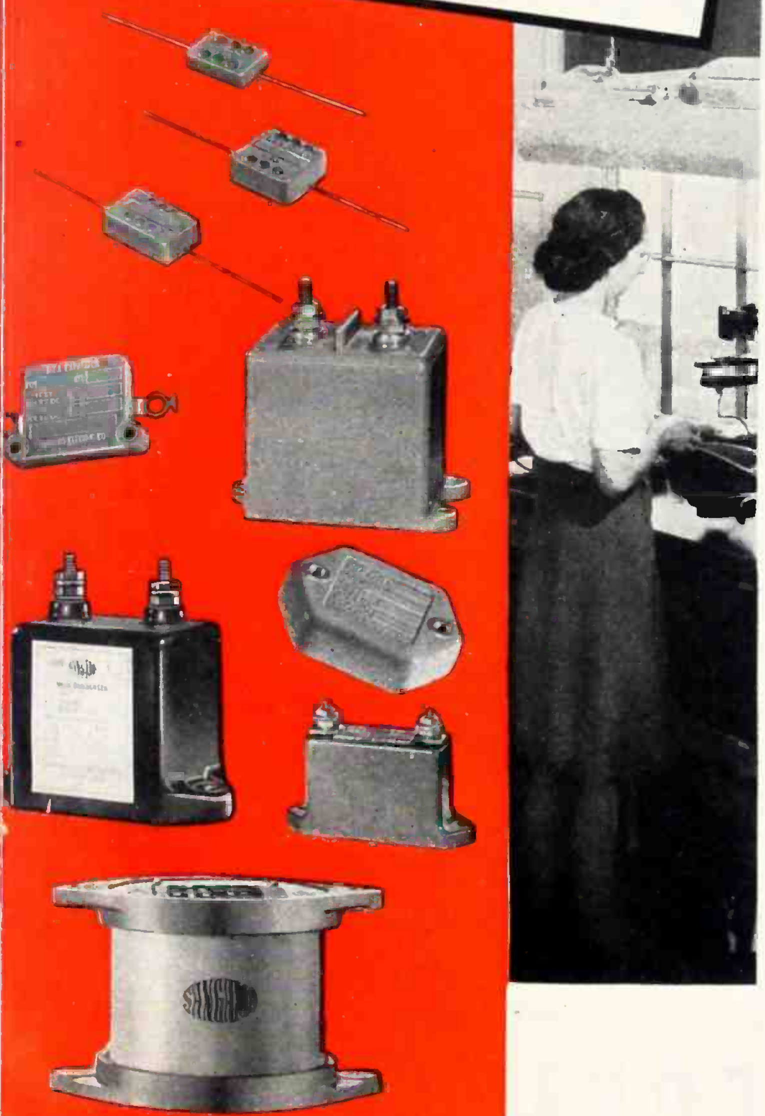
IS BUILT INTO . . .

SANGAMO
MICA CAPACITORS

★

Mica Splitting

The many processes that are required in producing Sangamo MICA CAPACITORS involve numerous critical operations. Some of these are MICA SPLITTING, MICA GAUGING, MICA PUNCHING, MICA INSPECTION, and CAPACITOR STACKING. The large photo shows a group of operators performing the highly specialized operation of splitting films from block Mica. Note the specially designed tables, the modern lighting, and the spacious layout to facilitate excellence of production.



Only the finest obtainable electrical MICA is used for the dielectric of Sangamo MICA CAPACITORS. The largest quantities of high grade block Mica (so called because it is still intact as a block and not split into individual laminations) come from India, although some Brazilian, Argentine, and domestic Micas are equally satisfactory.

For the manufacture of Capacitors, block Mica must be split into uniform, thin laminations. The voltage breakdown depends upon the thickness and quality of the Mica laminations, while the uniformity of the finished capacitors depends, in large measure, upon the uniformity of the thickness of laminations.

Even in these days of mass production and automatic processing machinery, Mica Splitting is still necessarily a hand operation, for no machines have been developed to split Mica satisfactorily. Deft fingers can usually split Mica into laminations to within 0.0005 inch of the required thickness.

There are many methods of splitting Mica. Some operators prefer to split Mica using a flat knife—others use a needle. In some cases the Mica is laid on a glass, plastic, or wooden plate and laminations are split from a flat surface—other operators hold the Mica in the air while splitting. But no matter which method is used, it is imperative that injuries, such as scratching of the surface, or fracturing of the edges, be avoided during the splitting operation.

NAVY

COMPANY SPRINGFIELD ILLINOIS

. . . WATT HOUR METERS . . . TIME SWITCHES . . .

SAVE WEIGHT

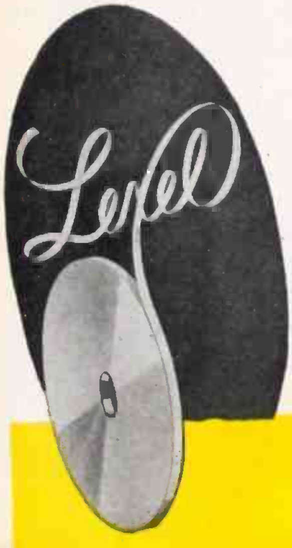
in low-tension circuits

with

Lexel Insulation

For a given conductor size, Lexel insulation weighs about 25% less than extruded insulation. That's a valuable saving in a wide variety of low-tension uses where weight is a factor. It's much less bulky, too, for a given voltage resistance. This permits compact design, usually important in instruments, controls and similar applications.

The main reason for this reduced weight is that the conductor is always perfectly centered. It is heat-sealed in a continuous helical tube of tape throughout every inch or mile of its length. No extra material is needed to insure sufficient insulation.



In spite of its light weight and low bulk, Lexel meets strict requirements of high dielectric strength, high insulation resistance, flame-retardant qualities and extremely low moisture absorption. This is proved by its wide acceptance in rigid military specifications.

These qualities of Lexel will extend its value to many peacetime products. If your designs call for low-tension circuits, be sure to consider Lexel. Ask for detailed information and samples of Lexel tape or insulated wire for your experimental use.

CUSTOM-MADE INSULATION

As a regular service, Dobeckmun engineers also develop laminated insulation products, custom-made to special purpose specifications, such as slot cell and phase insulation for motors, insulation for shipboard cables and other uses. If your requirements are unusual, call on us.

MADE BY THE MAKERS OF DOBAR LAMINATED PAPER INSULATION

"LEXEL" is a registered trade-mark of The Dobeckmun Company.

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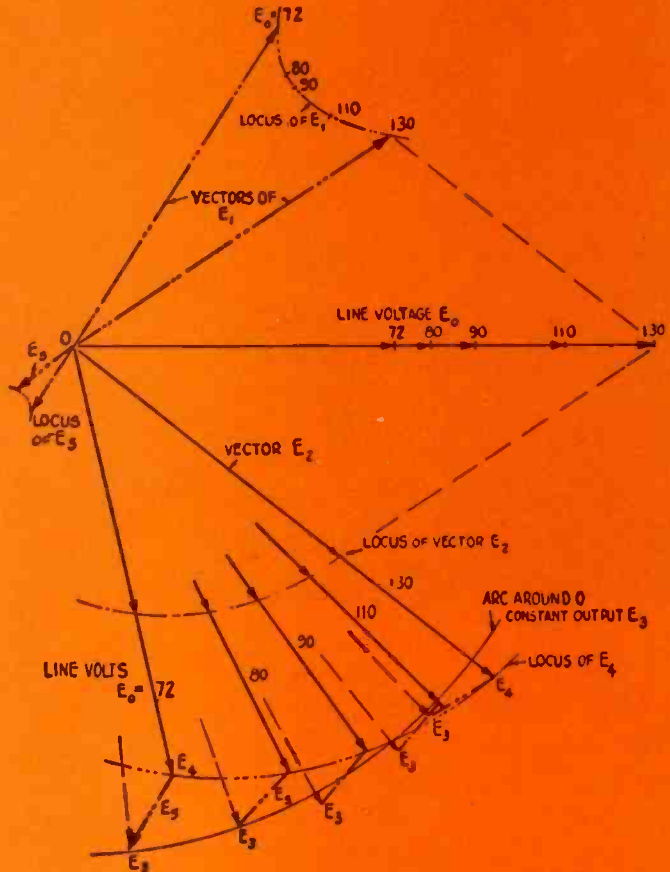
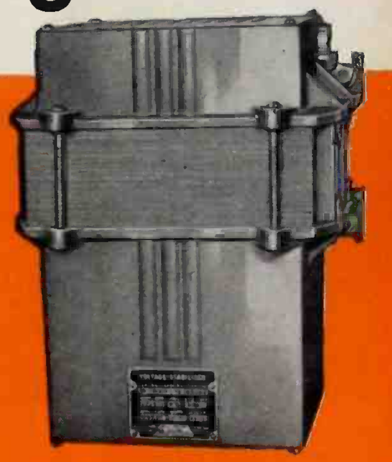
WESTERN SALES HEADQUARTERS • SAN FRANCISCO 4, CALIF.

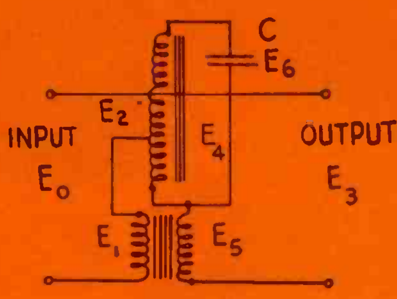
Raytheon Voltage Stabilizers CONTROL Output Voltage to ± ½%



VECTOR RELATIONS FOR FULL LOAD AND VARIABLE LINE VOLTAGE



Endbell Model



PRINCIPLES OF OPERATION

The stabilizer consists of two transformers with the primaries in series. One of these transformers operates at high magnetic density. This transformer with the higher saturation is partially resonated by means of a condenser. The secondary of the two transformers are connected in series opposed. Careful design results in the various voltages adding up vectorially producing the desired output changes compensating for differences of individual voltages. The resultant is a constant output voltage. This action is illustrated above in the chart of vector relations of voltage.

A Raytheon Voltage Stabilizer . . . built into new equipment or incorporated into apparatus not having voltage regulation . . . improves the performance and assures reliable, accurate operation of the equipment. It stabilizes varying line voltages from 95 to 130 volts to plus or minus ½ %. Entirely automatic in operation, the Raytheon Voltage Stabilizer has no moving parts, nothing to wear out. Simply connect it and forget it. Write for Bulletin DL48-537.

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190 WILLOW STREET, WALTHAM, MASS.

The coveted Army-Navy "E", for Excellence in the manufacture of war equipment and tubes, flies over all four Raytheon Plants where over 15,000 men and women are producing for VICTORY.

MANUFACTURERS OF VOLTAGE STABILIZERS, RECEIVING AND TRANSMITTING TUBES AND COMPLETE ELECTRONIC EQUIPMENT

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Mica Insulator Company offers to the electrical industry today a single supply source for a completely rounded line of insulations, both in standard form and made-to-specification. Branch offices, distributors and fabricators are strategically located in industrial centers from coast to coast, providing fast service on fabrication and delivery of special parts . . . as well as expert assistance for consultation on problems affecting insulating materials.

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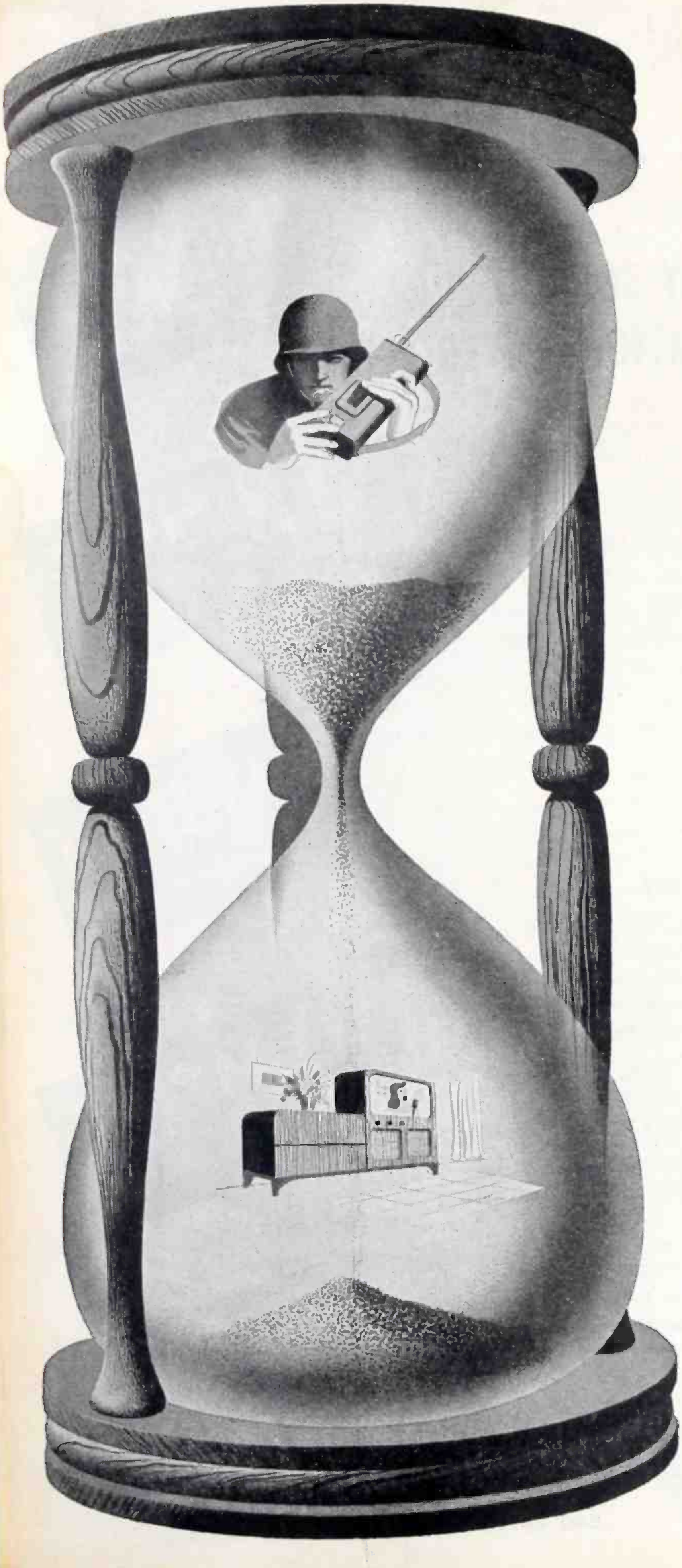

it's attention to details...

Human skill can't be scientifically tested. That's why it is always the unknown quantity in manufacturing. But experience is a reliable guide to measuring the true value of skill. In building C-D Capacitors precision work is backed by the accumulated experience of conscientious men and women, some of whom have been with Cornell-Dubilier for nearly the whole of our 34 years of existence; others for five, ten and twenty years of loyal service.

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Non-inductively wound, specially sealed and impregnated, small in size, with high safety factor. Type DT is uniform in electrical properties and has rigidly anchored wire leads. A specially-treated tube keeps out moisture.

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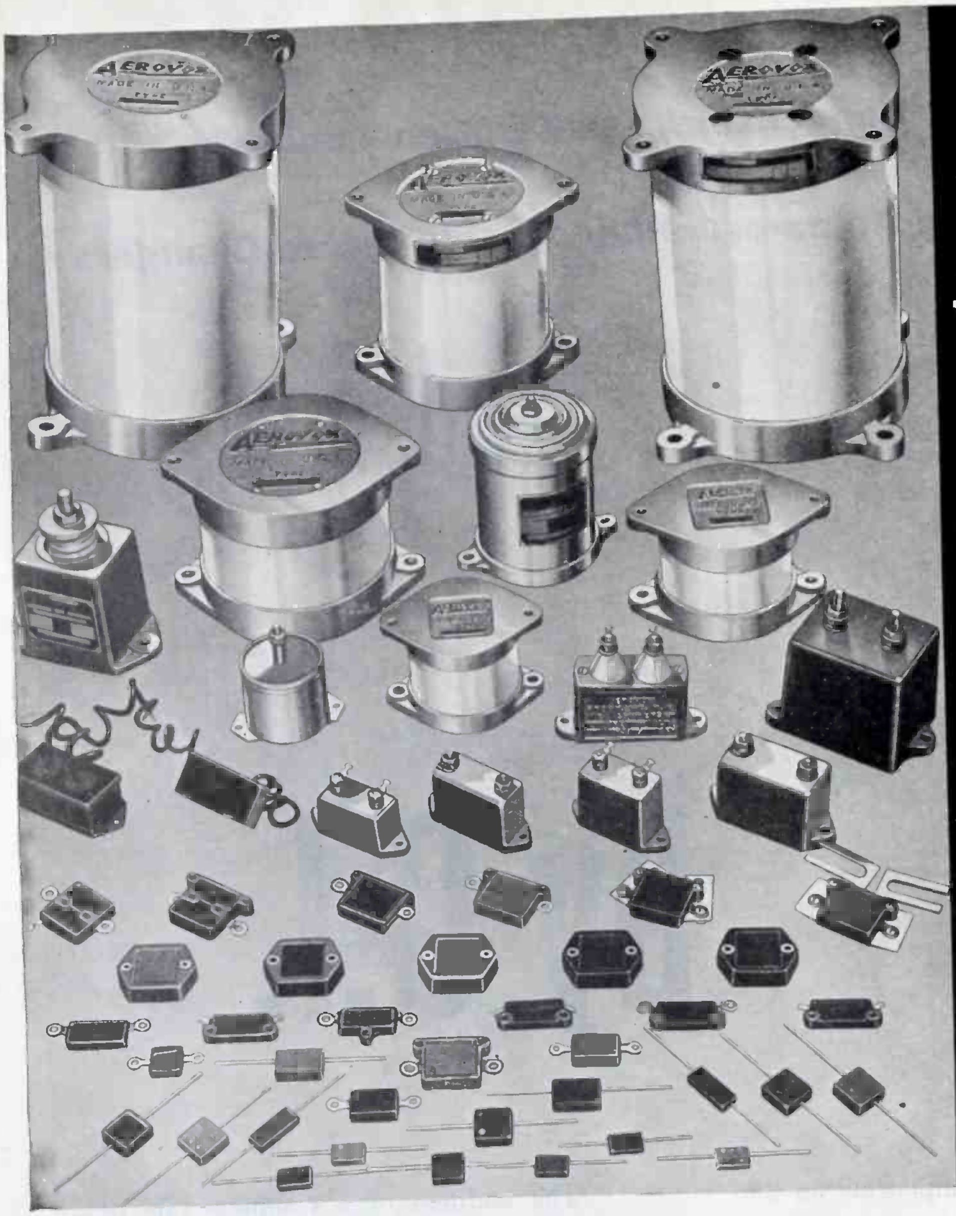

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Be sure you have the Aerovox Capacitor Manual in your working library, for general guidance. And for final insurance covering satisfactory results, just specify Aerovox Capacitors.

● Aerovox selection ranges from tiny "postage-stamp" molded-in-bakelite units to giant porcelain-cased stack-mounting units. These many varied types are standard with Aerovox—in daily production—available at quantity-production prices.

The following factors are suggested in guiding your selection:

Electrical: (a) Capacitance and tolerance; (b) D.C. voltage rating; (c) Current-carrying capacity and frequency characteristics; (d) Allowable temperature rise and maximum operating temperature; (e) Special characteristics such as temperature coefficient, retrace, etc.; (f) Special operating conditions such as high humidity, altitude, extreme temperatures, etc. *Mechanical:* (g) Basic type; (h) Terminals; (i) Case; (j) Mounting holes; (k) Nameplate data.

Yes, Aerovox expects you to *select* that type best fitting your particular requirements *in every way*. And Aerovox is ready to help you make the proper selection. Remember, *Aerovox Application Engineering*—that "know-how" second to none in the industry—can make all the difference between disastrous makeshifts and the most satisfactory results.

ARMY E NAVY

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COLONEL JOHN CASEY, *Manager, Chicago Municipal Airport . . .*

Colonel Casey said, "The growing complexities of airport traffic make it ever more important that private planes and regular operating passenger aircraft be equipped with up-to-date, reliable two-way radio, if high standards of safety are to be maintained. One important factor is . . ."

"A FOOLPROOF POWER SUPPLY FOR AIRCRAFT RADIO OPERATION"

Colonel Casey, Electronic Laboratories has long been aware of the need for reliable power supplies especially adapted for aircraft use. One of E-L's exclusive developments along this line involves vibrators operating in parallel which assures a reserve power source for extra protection. These Vibrator Power Supplies—both light and heavy duty—are specially designed for complete reliability at very high altitudes.

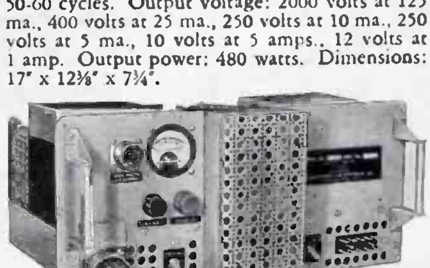
The life of E-L Vibrator Power Supplies is far beyond the customary overhaul requirement. With these units maintenance time is cut to a minimum—only a small fraction of the time previously required.

Other E-L developments for the aircraft field include units for flashing wing lights and for instrument panel illumination. This equipment has wide application for the light plane field as well as for large aircraft.

The economy and versatility of Vibrator Power Supplies are also available to the marine field—where units have been designed to provide fluorescent lighting, radio-telephone operation and electrical appliance use—as well as many other fields where it is necessary to convert current to specific voltage and type requirements . . . Let E-L engineers consult with you on your power supply problem.

STANDARD POWER SUPPLY
MODEL SC-1096

Model SC-1096 is a typical E-L Vibrator Power Supply which meets the requirements of aircraft radio use. This unit was designed for the Canadian Signal Corps to operate radio transmitters. Input voltage: 12 volts DC, or 110-117 volts AC at 50-60 cycles. Output voltage: 2000 volts at 125 ma., 400 volts at 25 ma., 250 volts at 10 ma., 250 volts at 5 ma., 10 volts at 5 amps., 12 volts at 1 amp. Output power: 480 watts. Dimensions: 17" x 12⅜" x 7¾".



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INDIANAPOLIS

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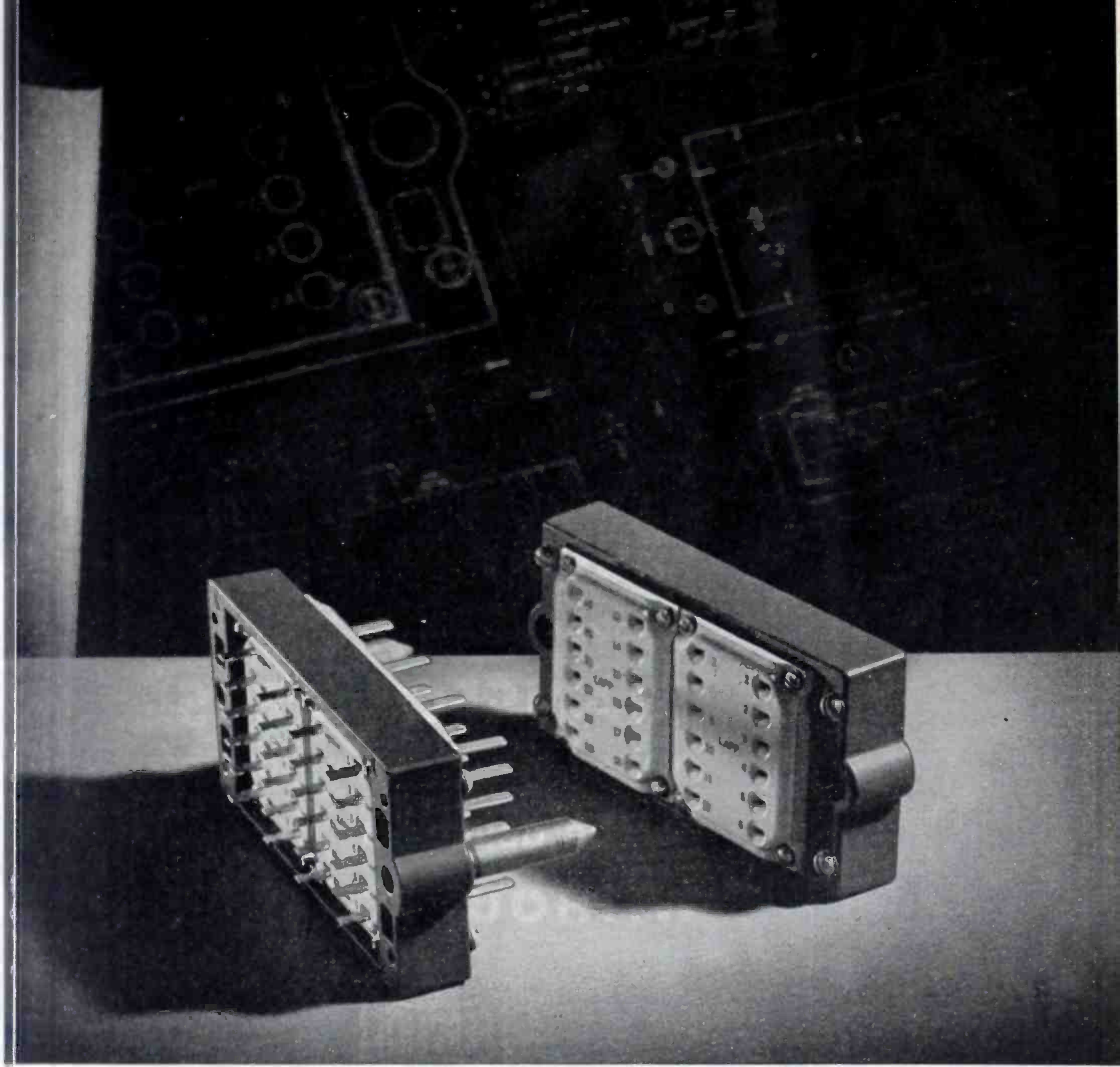

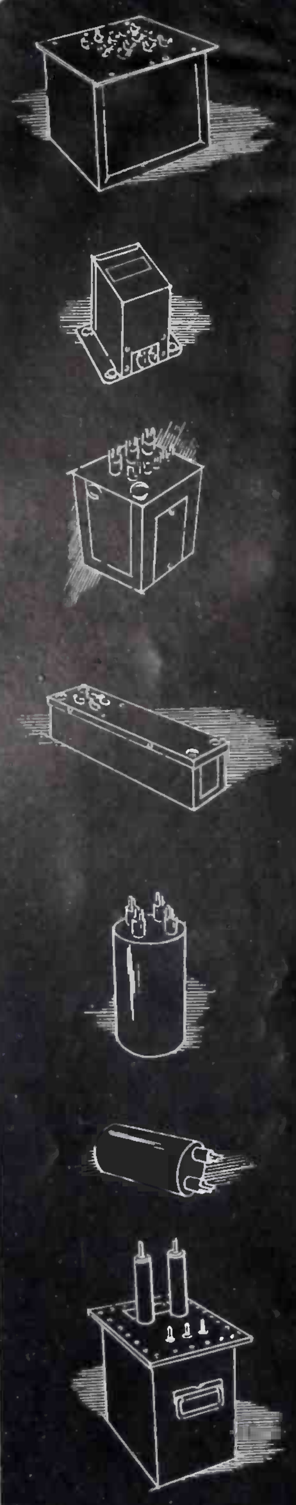

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Greater Accuracy Over Longer Periods

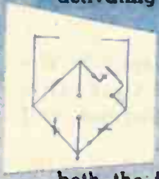
SHERRON NULL DETECTOR

The Sherron Null Detector is a necessary adjunct to all A. C. Bridge measurements, such as, A. C. resistance, impedance, capacity and others, and is used to indicate rapidly and accurately when that bridge is at balance or null point.

The standard Sherron Null Detector is designed to give an appreciable deflection with an input voltage of .01 volts. However, increased sensitivity can be readily obtained to any desired degree.

The Null Detector is so designed that while an input voltage of .01 volts will cause an appreciable deflection of the indicating meter, 32 volts across the input will not cause the meter to swing off scale.

All Null Detectors are equipped with a 1000 cycle tone source of sufficient level to operate any of the standard bridges, and a filter circuit resonated to that frequency to insure only that frequency activating the indicating meter.



Inasmuch as most of the standard bridges may be used at frequencies other than 1000 cycles per second, switching arrangements are provided to disconnect both the internal tone source and filter circuit.

By means of a conventional jack, a head set may be inserted to ascertain audibly if the meter is indicating the bridge frequency or any extraneous noises.

The substitution of a Cathode Ray Tube in place of a meter moves the test equipment upward from quantitative to qualitative.

Use of the Cathode Ray Tube permits the engineer or operator to note immediately and correct any distortion of wave shape, any displacement of phase or extraneous noise that may cause error.

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SHERRON ELECTRONICS COMPANY

Division of Sherron Metallic Corporation

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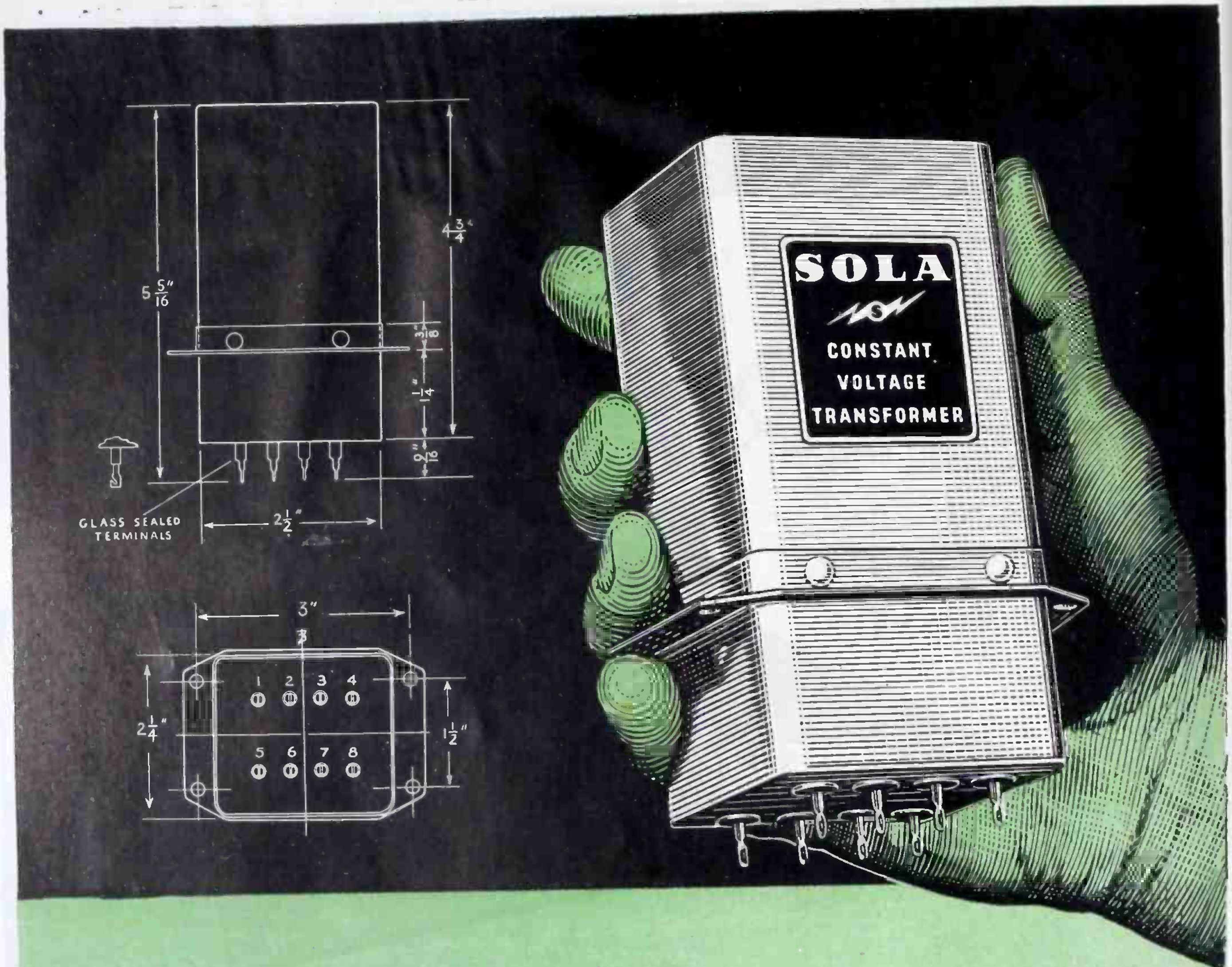
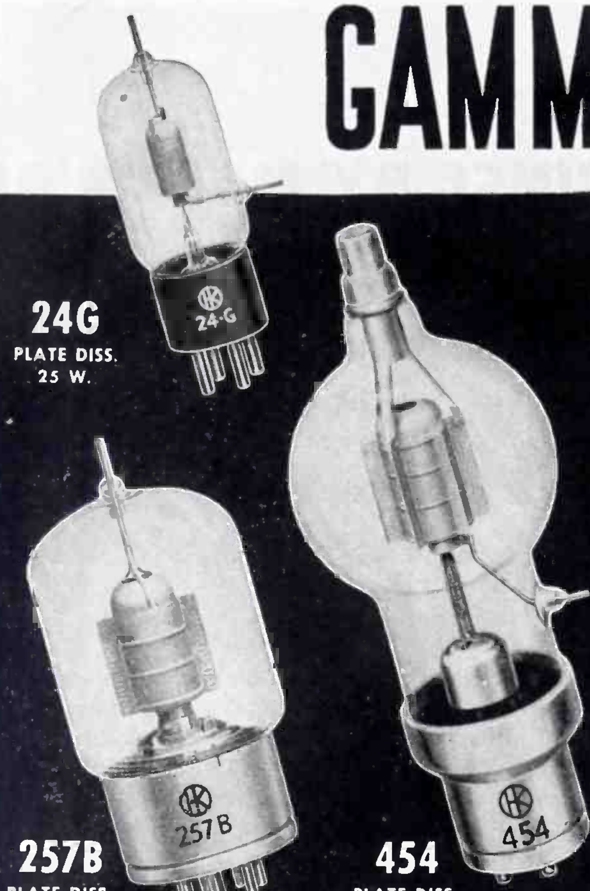
"Where the Ideal is the Standard, Sherron Units are Standard Equipment"


5 5/16"
4 3/4"
3/8"
1 1/4"
9/16"
GLASS SEALED TERMINALS
2 1/2"
3"
2 1/4"
1 1/2"
1 2 3 4
5 6 7 8
SOLA
CONSTANT
VOLTAGE
TRANSFORMER

GAMMATRON TUBES



24G
PLATE DISS.
25 W.

257B
PLATE DISS.
75 W.

454
PLATE DISS.
250 W.

This complete line, covering a power range of 50 to 5,000 watts, embodies 18 years of pioneering and experience in the design and manufacture of tantalum tubes.

Special plate, grid, and filament design, and new metal-to-glass seals, give Gammatrons remarkable VHF performance. Other features: ability to withstand high plate voltages, complete protection against tube failure due to overloading, and long, efficient operating life.

The Gammatron engineers responsible for these developments will be glad to help you with your special problems.

HEINTZ AND KAUFMAN LTD.
SOUTH SAN FRANCISCO CALIFORNIA U.S.A.

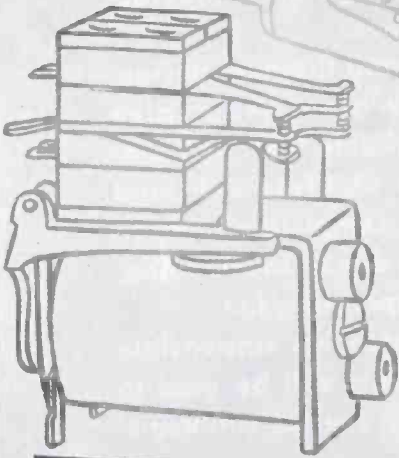
TYPE NO.	24	24G	54	254	257B*	304L	304H	354C	354E	454L	454H	654	854L	854H	1054L	1554	2054A	3054
MAX. POWER OUTPUT: Class 'C' R.F.	90	90	250	500	230	1220	1220	615	615	900	900	1400	1800	1820	3000	3600	2000	5300
PLATE DISSIPATION: Watts	25	25	50	100	75	300	300	150	150	250	250	300	450	450	750	1000	1200	1500
AVERAGE AMPLIFICATION FACTOR	25	25	27	25		10	19	14	35	14	30	22	14	30	13.5	14.5	10	20
MAX. RATINGS: Plate Volts	2000	2000	3000	4000	4000	3000	3000	4000	4000	5000	5000	4000	6000	6000	6000	5000	3000	5000
Plate M.A.	75	75	150	225	150	1000	1000	300	300	375	375	600	600	600	1000	1000	800	2000
Grid M.A.	25	25	30	40	25	150	150	60	70	60	85	100	80	110	125	250	200	500
MAX. FREQUENCY, Mc.: Power Amplifier	200	300	200	175	150	175	175	50	50	150	150	50	125	125	100	30	20	30
INTERELECTRODE CAP: C g—p u.u.f.	1.7	1.6	1.8	3.6	0.08	9	10.5	3.8	3.8	3.4	3.4	5.5	5	4	5	11	18	15
C g—f u.u.f.	2.5	1.8	2.1	3.3	10.5 In	12	14	4.5	4.5	4.6	4.6	6.2	6	8	8	15.5	15	25
C p—f u.u.f.	0.4	0.2	0.5	1.0	4.6 Ou	0.8	1.0	1.1	1.1	1.4	1.4	1.5	0.5	0.5	0.8	1.2	7	2.5
FILAMENT: Volts	6.3	6.3	5.0	5.0	5.0	5-10	5-10	5	5	5	5	7.5	7.5	7.5	7.5	11	10	14
Amperes	3	3	5	7.5	7.5	26.13	26.13	10	10	11	11	15	12	12	21	17.5	22	45
PHYSICAL: Length, Inches	4 1/4	4 1/4	5 7/16	7	5 15/16	7 3/4	7 3/4	9	9	10	10	10 1/16	12 1/2	12 5/8	16 5/8	18	21 1/4	30 3/4
Diameter, Inches	1 3/8	1 3/8	2	2 5/8	2 5/8	3 1/2	3 1/2	3 3/8	3 3/8	3 1/4	3 1/4	3 1/4	5	5	7	6	6	9
Weight, Oz.	1 1/2	1 1/2	2 1/2	6 1/2	6	9	9	6 1/2	6 1/2	7	7	14	14	14	42	56	66	200
Base	Small UX	Small UX	Std. UX	Std. 50 Watt	Giant 7 Pin	Johnson #213	Johnson #213	Std. 50 Watt	Std. 50 Watt	Std. 50 Watt	Std. 50 Watt	Std. 50 Watt	Std. 50 Watt	Std. 50 Watt	Johnson #214	HK 255	W.E. Co.	HK 255

*Beam Pentode.

WRITE FOR FULL DATA ON ALL **GAMMATRONS**

CHECKING RELAY REBOUNCE BY MEANS OF

DuMONT *Oscillography*



Parasitic oscillations caused by rebouncing relay contacts can prove mighty troublesome. However, *DuMont Oscillography* (oscillographic equipment plus the know-how) can be invaluable in determining the source of such difficulty as well as providing conclusive evidence that remedial measures have proved effective. For instance:

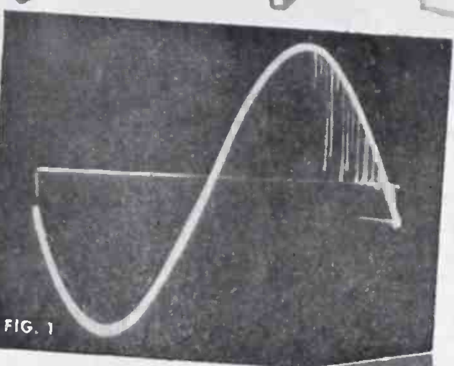


FIG. 1

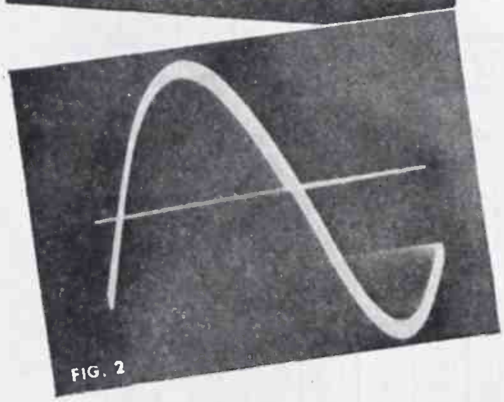


FIG. 2

A standard DuMont oscillograph with single-sweep feature is used. No additional accessories required. Relay is actuated by closing a switch. Relay contact applies 60-cycle wave to vertical deflection plates of cathode-ray tube. With sweep frequency set at 60 cycles, one complete sine wave period appears on screen.

If relay contact closes without rebounce, the transition from horizontal line to sine wave is a simple straight line and generally occurs so quickly that it is difficult to observe visually. However, if rebounce is present, the interruptions are indicated by a series of parallel vertical lines readily observed, as in Fig. 1.

If it is desired to determine the number of interruptions and duration of rebounce periods, photographic records are made. Since the frequency of the sine wave is known, the evaluation of results is simple. In this oscillogram there were over 20 rebounces before establishing definite contact. Total duration of series of rebounces is 1/250th second. Time between opening and closing of contact is about 50 microseconds. Greater accuracy may be had by using higher frequency wave generated by an external oscillator.

Fig. 2 oscillogram demonstrates that rebounce has been eliminated by cadmium plating the contacts, amalgamating with mercury, and finally dropping liquid mercury on them.

An illustration from hundreds of useful applications of DuMont Cathode-Ray Oscillographs. Perhaps your measurement technique can be simplified or improved upon by DuMont.

DUMONT *Precision Electronics & Television*

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Announcing

MYKROY #51

Glass-Bonded Mica Plastic High Frequency Insulation for INJECTION MOLDING

MYKROY

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THE perfection of MYKROY #51, glass-bonded mica ceramic insulation, which can be injection molded, and the processes developed for handling it rapidly and uniformly has opened a new field of applications. It is now possible to produce injection molded plastic ceramic parts of MYKROY having shrinkage characteristics of less than .001" per inch. In addition, parts molded from MYKROY #51 can be machined by grinding, drilling, tapping or cutting.

Electrical characteristics of MYKROY are of the highest order and do not shift under any normal conditions short of actual destruction of the material itself. This, plus chemical and physical stability—high resistance to oil, gas and water—resistance to acute temperature changes—high coefficient of thermal expansion and excellent metal bonding properties, make it one of the best insulating materials ever developed for general and high frequency applications.

MYKROY #51 is already being molded into a large variety of parts for use throughout the entire Electronic and Electrical engineering field. It may be the answer to your own insulation problems. So ask for detailed information. Request a copy of the special MYKROY INJECTION MOLDING BULLETIN #103.

WRITE FOR MYKROY INJECTION MOLDING BULLETIN #103

A comprehensive manual containing complete working data including mold designing criteria.

MYKROY SHEET BULLETIN #102

Contains full information about the largest size sheet (19¼" x 29¾") of perfected mica ceramic insulation now available.

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Chicago 47: 1917 NO. SPRINGFIELD AVENUE . . TEL. Albany 4310
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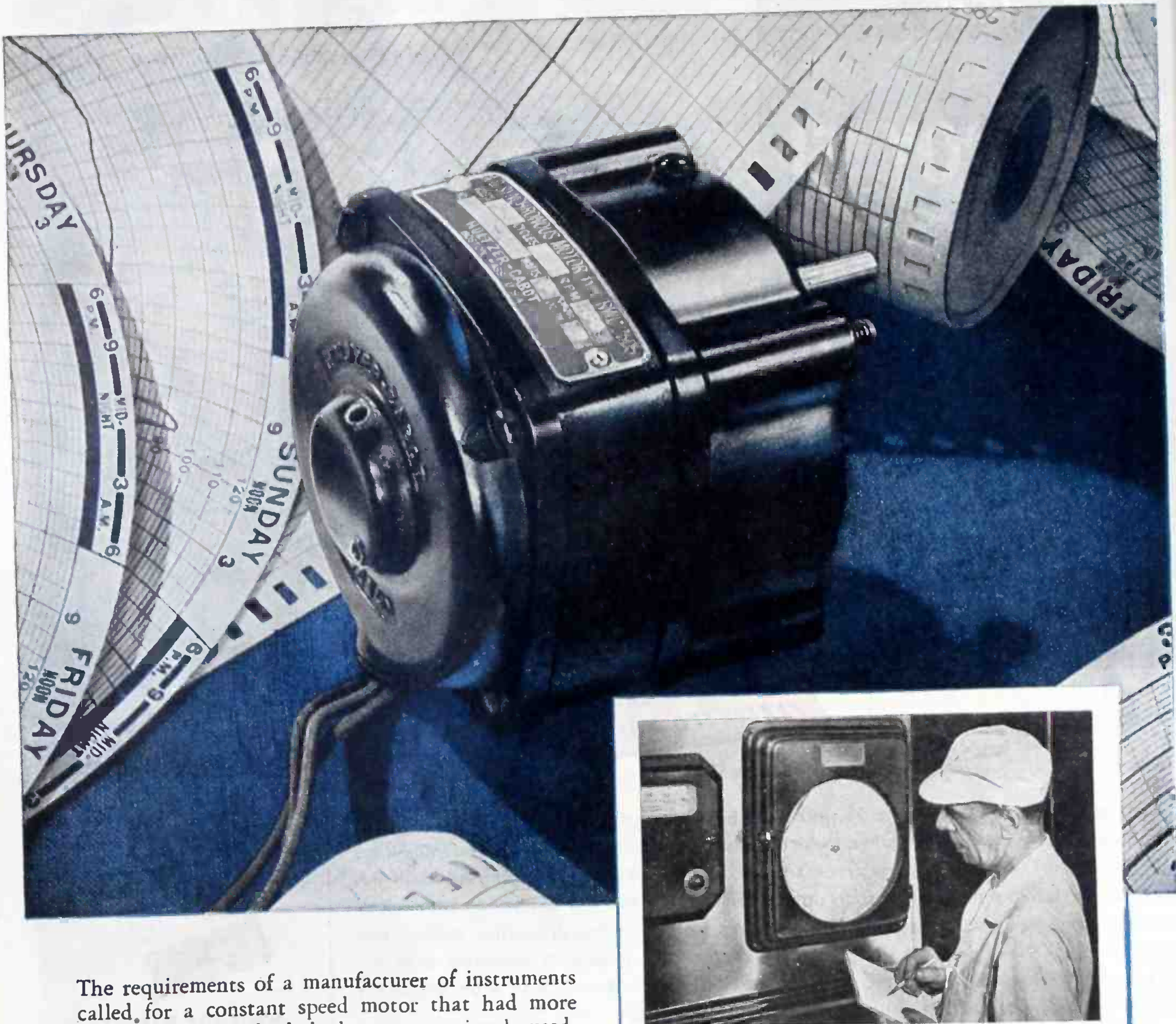
Increased Power and Constant Speed

...YET FITS MOTOR SPACE AVAILABLE



Typical Recorder Powered with Holtzer-Cabot Motor

The requirements of a manufacturer of instruments called for a constant speed motor that had more power than a standard clock motor previously used, yet still fitted the original space allowed.

Holtzer-Cabot designed the special synchronous motor, illustrated above, which not only filled the performance and space requirements, but saved the manufacturer the cost of redesigning and retooling to take a larger motor, and also made it possible to service instruments in customers' plants which had the old type of motor.

The specialized business of Holtzer-Cabot is the designing and building of special fractional H. P. motors to meet special requirements.

Although today our entire facilities are devoted to building special motors for military use, our motor development engineers will gladly discuss your post-war fractional H. P. motor requirements with you.

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HOLTZER-CABOT

Division of First Industrial Corporation

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Bushings for this G-E Temperature-Controlled Crystal Unit had to provide a high degree of electrical and thermal insulation. Yet they not only had to be small, but able to withstand great compressional stress.

Organic materials (phenolic, for example) could not be used for technical reasons. When ceramic and vitreous products were tried, the bushings broke under the strain.

Only G-E mycalex was found to be ideal on every count. In addition to showing small electrical loss and low thermal conductivity, it proved immune to fracture or crushing. In fact, when the bushings were tested for physical limits, G-E mycalex demonstrated no change whatever—even when screws broke off and compressing nuts were stripped of their threads!

G-E mycalex is the answer—often the *only* answer—to difficult electronic insulator requirements. These features explain a few of the reasons:

1. High mechanical and dielectric strength.
2. Low loss at high frequencies.
3. Arc resistance and heat resistance.
4. Easily subjected to drilling, filing, sawing, grinding, polishing.
5. Metal parts can be inserted or anchored during the process of molding.

Yes, General Electric specializes in producing fabricated parts as well as standard sheets, rods, and strips. For a free sample and detailed information about G-E mycalex mail the coupon at the right.

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GENERAL ELECTRIC

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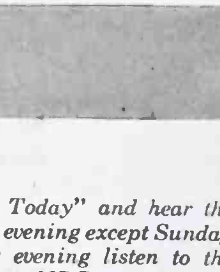

FREE—G-E MYCALEX BULLETIN

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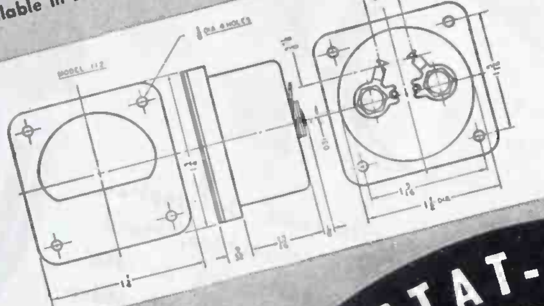
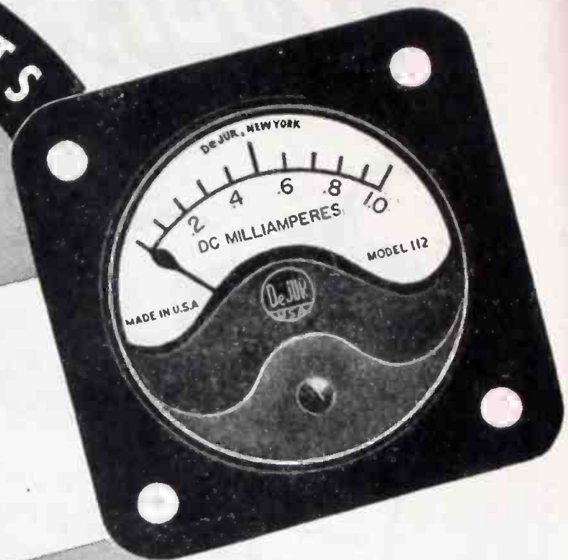
This miniature instrument may be successfully used in a variety of applications, and it is particularly useful where space is an important factor. The DeJur 112 measures only 1¾" square and 25/32" deep, and uses basically the same carefully designed components as our larger instruments. In order to conserve space, soldering lugs are used for the terminal connections instead of the conventional studs. Available in standard ranges.

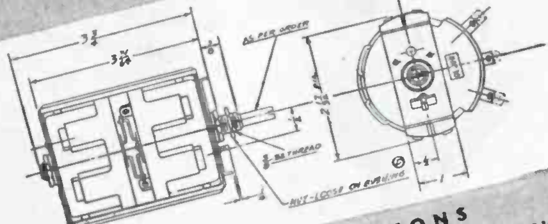




DeJUR RHEOSTAT-POTENTIOMETERS

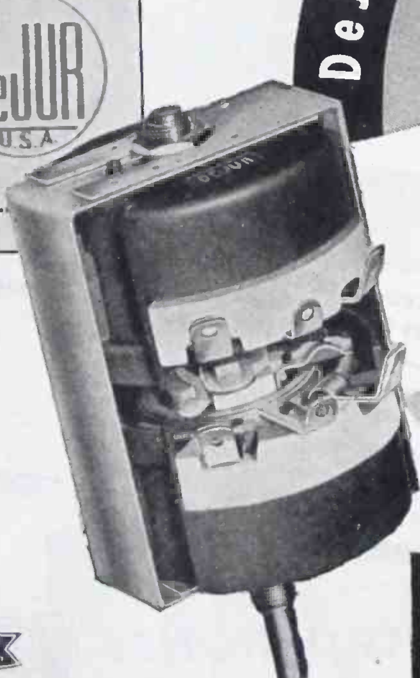
MODEL 241 D

A dual unit model, with both units mounted together. The Model 241 D is typical of the many types developed by DeJur engineers for special requirements. We are equipped to serve your needs, too.



SPECIFICATIONS

	RANGE IN OHMS	MODEL NO.
50 WATTS	0. 10	241 D
RANGES—10 to 10,000 Ohms	0. 50	241 D
MECH. ROTATION—300°	0. 100	241 D
ELEC. ROTATION—270°	0. 500	241 D
WEIGHT—7 Oz.	0. 1,000	241 D
	0. 5,000	241 D
	0. 10,000	241 D



Write for the NEW DeJur Catalog

Buy and Hold More WAR BONDS

DeJur-Amsco Corporation

GENERAL OFFICE: NORTHERN BLVD. AT 45th ST., LONG ISLAND CITY 1, N. Y.

CONSIDER PEDIGREE where QUALITY COUNTS

Nichrome

. . . the Quality resistance alloy made *ONLY* by Driver-Harris

45 years of continuous research devoted entirely to the perfection of the *World's finest resistance alloy* . . . that is the pedigree of NICHROME*.

For just as champions are created through selective scientific breeding, so do Driver-Harris Engineers, by means of perfected melting, hot rolling and cold finishing processes and exclusive quality controls, succeed in producing the champion of all heat and oxidation resisting alloys—NICHROME.

Although there are several excellent Nickel Chromium combinations, there is *only* one NICHROME and it is made *only* by Driver-Harris.

So put the "stamp of quality" on your post-war products by assuring dependable performance and longer life with NICHROME and other D-H resistance alloys.

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

D/H SPECIAL PURPOSE ALLOYS SINCE 1899

Driver-Harris
COMPANY
HARRISON, NEW JERSEY

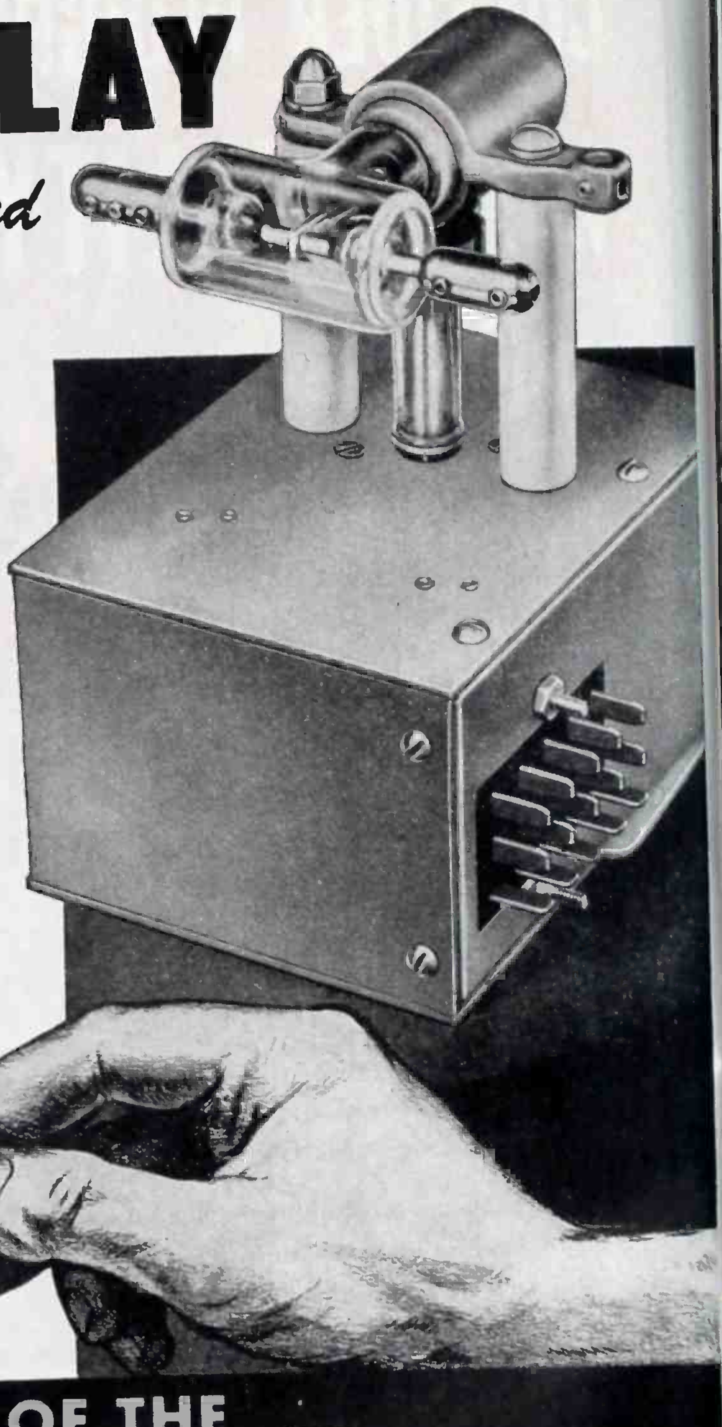
ARMY E NAVY

BRANCHES: CHICAGO • DETROIT • CLEVELAND • LOS ANGELES • SAN FRANCISCO • SEATTLE

A New Vacuum Switch

KEYING RELAY

. . . . for Aircraft and Other Applications



Here is convincing proof that a keying relay does not have to be complicated to be efficient. In fact, just the reverse! Actually, the extreme reliability with which Struthers-Dunn Type 78CCA100 Relay holds its adjustments is the direct result of its new simplified and rigid design which utilizes an absolute minimum of parts.

Originally made for aircraft use, it weighs little, is exceptionally sturdy, and has all parts readily accessible. Tests show a minimum life of five million operations.

The Relay has seven poles, including one double-throw pole which handles high-voltage radio frequency currents by means of a vacuum switch. All high-voltage parts are rounded to reduce corona.

Write for complete details, or get in touch with your nearest Struthers-Dunn Field Engineer.

STRUTHERS-DUNN, Inc.
1321 ARCH STREET PHILADELPHIA 7, PA.

ONE OF THE

STRUTHERS-DUNN

5,312 RELAY TYPES

DISTRICT ENGINEERING OFFICES: 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 . WASHINGTON

GI date for a phone call

This G. I. has an important call to make the instant he lands. For the next steps in the gigantic Air Invasion depend upon the reports he sends back . . . on the instructions he receives.

Fortunately, there will be no crowded circuits, no "busy" signals, for on his back this airborne trooper carries the means for instant, dependable Communications. In its way, it's as expertly designed and built as the huge Transport he has just left, as the automatic rifle that he clutches . . . designed and built to give the greatest possible measure of service under the most punishing conditions. It's one of the reasons why our troops are called the most superbly equipped in the world.

★ ★ ★

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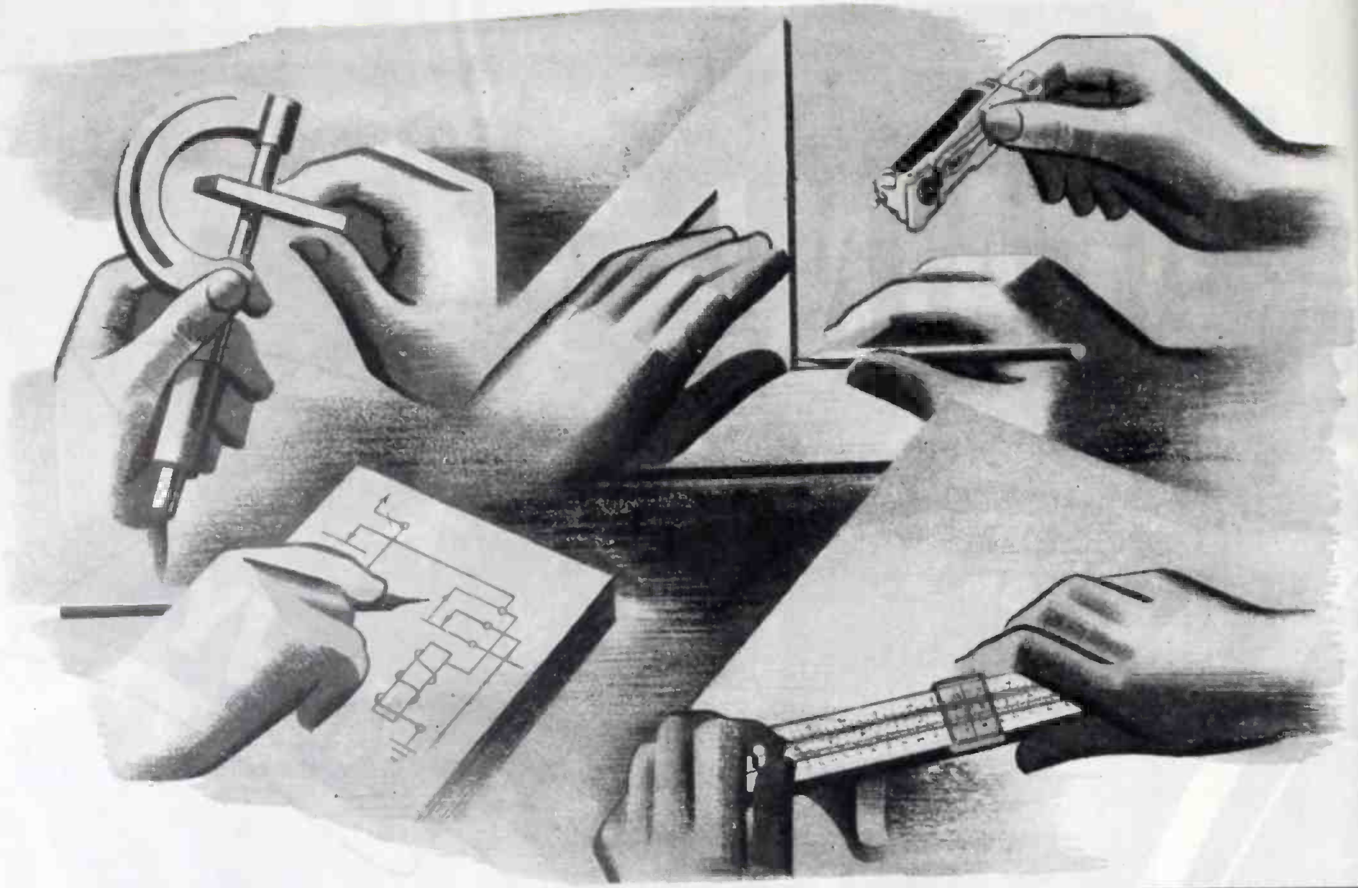
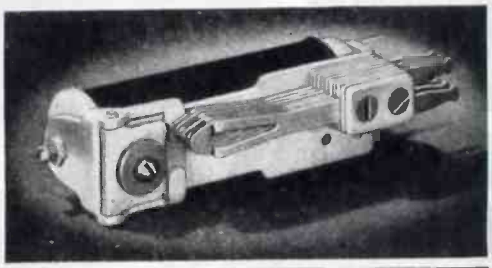
Builders of the famous SCR-299



Your New Product may need the Magic of Electrical Control



TAKE another look at that new product your designers are planning. It may be that Automatic Electric control devices can make it function better—at lower cost. It's worth checking into.

To help designers perfect new developments—or improve old ones—Automatic Electric offers this unique three-point service:

1. Technical advice by experienced field engineers, who know the "how" and "why" of control technique.
2. A complete range of relays, stepping switches, and other control units—time-proved products readily adapted to your needs.
3. A design and manufacturing service for complete engineered assemblies.

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AND OTHER CONTROL DEVICES
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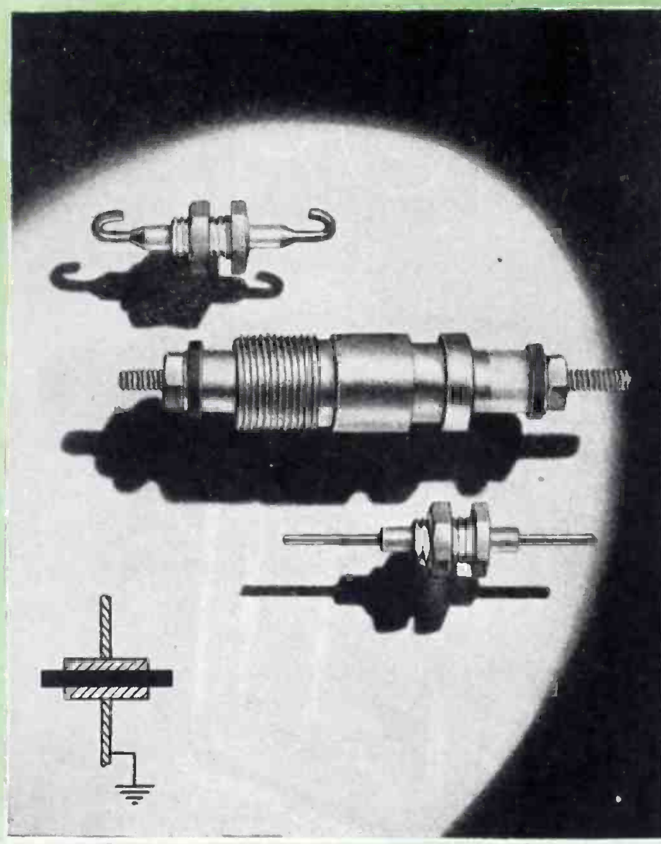
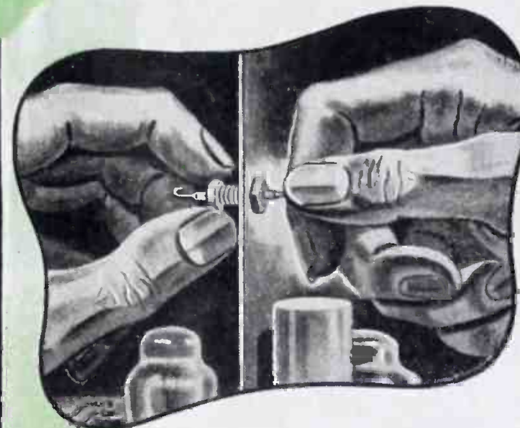




ERIE *Feed-Thru* CERAMICONS

REG. U. S. PAT. OFF.

For By-passing R. F. Currents to Ground

Erie Feed-Thru Ceramicons are sturdy, compact ceramic condensers of a rigid mounting type that perform the function of bypassing high frequency currents to ground through the shortest possible path. As shown in the illustration, lead inductance is practically eliminated, since the lead inductance is in series with the transmission line rather than in the path to ground.

Small sizes are made in capacities from 5 MMF through 75 MMF, and can be furnished with either straight or hooked wire leads, as shown in the photograph above. The larger size, Erie Part No. SP-110 represents a special design for high voltage applications, and is available in capacities from 20 MMF through 250 MMF.

The Erie Resistor Engineering Department is working on several other developments for high voltage, high altitude, and pressurized feed-thru applications.

ERIE PART No.	MIN. CAP. MMF	MAX. CAP. MMF	WORKING VOLTAGE D. C. SEA LEVEL	50,000 FT.	OVERALL LENGTH
357-000 (Hooked wire)	5	75	1,000	375	1-1/16"
SP-114 (Straight wire)	5	75	1,000	375	1-1/4"
SP-110	20	250	2,000	750	2-3/8"

ARMY E NAVY

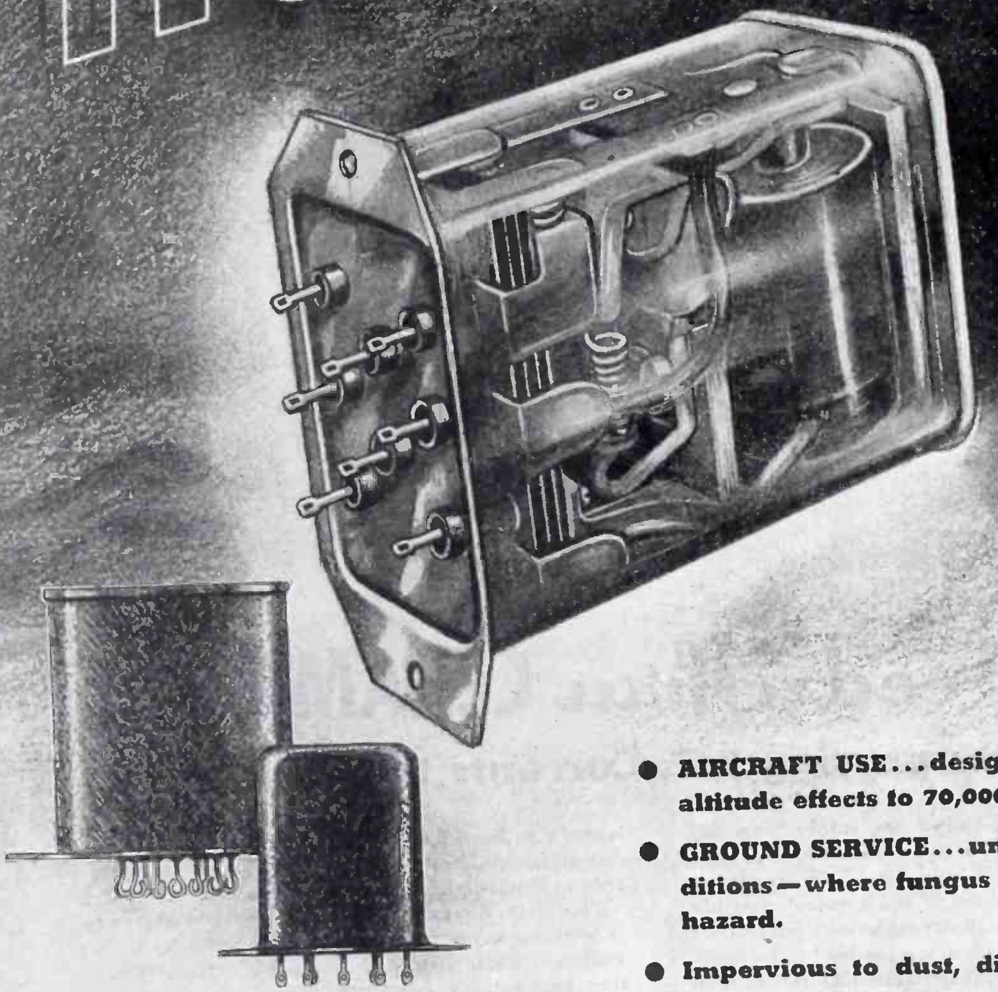
FOR HIGH ACHIEVEMENT IN WAR PRODUCTION

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • • TORONTO, CANADA

ALLIED Hermets*



* Hermetically sealed relays, —a new development by Allied.

- **AIRCRAFT USE... designed to overcome altitude effects to 70,000 feet.**
- **GROUND SERVICE... under tropical conditions—where fungus growth is serious hazard.**
- **Impervious to dust, dirt, oil and other foreign substances normally responsible for over 90% of all relay failures.**
- **Can be subjected to 100% humidity,—continuously.**

ALLIED CONTROL COMPANY, INC.

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Plugs FOR VICTORY

70 Types PLUGS & CONNECTORS

SIGNAL CORPS • NAVY SPECIFICATIONS

Types: PL

50-A	61	74	114	150
54	62	76	119	159
55	63	77	120	160
56	64	104	124	291-A
58	65	108	125	354
59	67	109	127	
60	68	112	149	

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

NAF

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Other Designs to Order

Remler is equipped for the mass production of many types of radio and electronic devices from humble plugs and connectors to complete sound amplifying and transmitting systems. Ingenious production techniques contribute to Remler precision, reduce costs and speed up deliveries. • The Axis is on the run and final Victory is in sight. Let us help you finish the job.

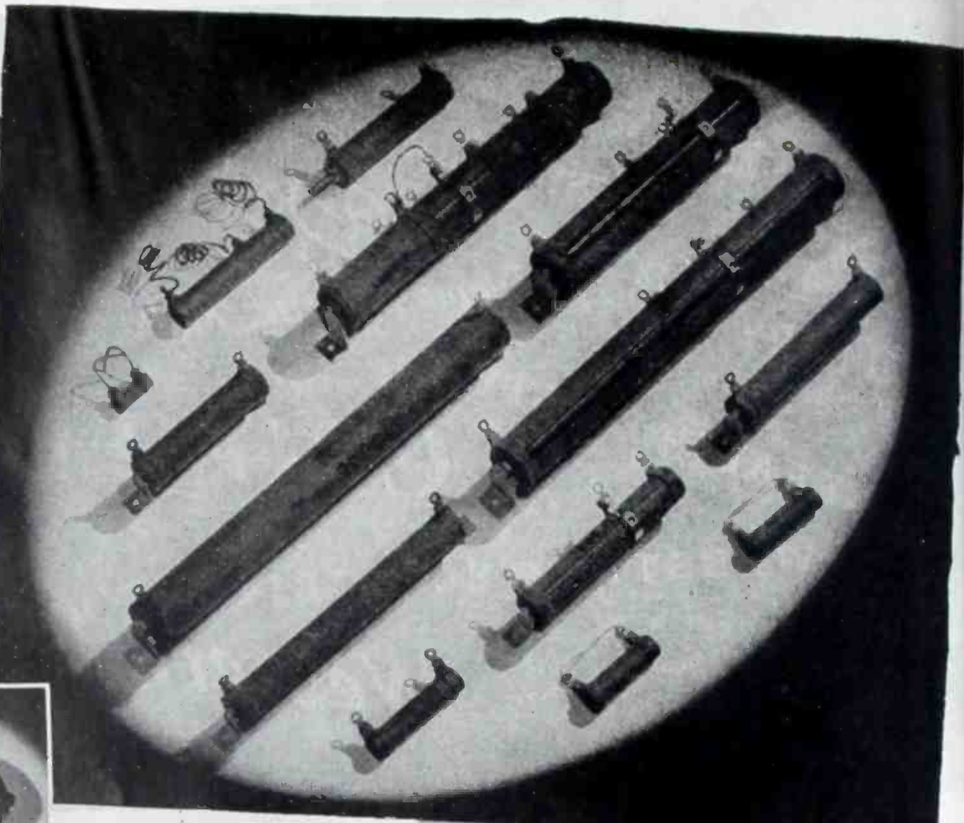
Wire or telephone if we can be of assistance

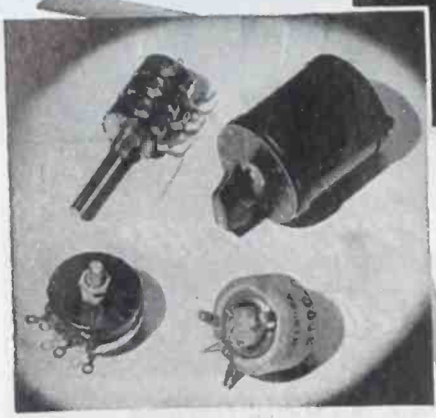
REMLER COMPANY, LTD. • 2101 Bryant St. • San Francisco, 10, Calif.

REMLER

SINCE 1918

Announcing & Communication Equipment





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Rheostats and potentiometers in wire-wound and composition-element types.

Midget controls in both types. Matched in external appearance and dimensions. Mechanically interchangeable.

Large line of controls for sound systems—constant-impedance attenuators, L-pads, T-pads, faders, mixers, etc.

25 and 50 watt power rheostats featuring exceptionally rugged construction.

Greenohms—well-known green-colored cement-coated power resistors found in the most rugged assemblies.

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Etc. etc.

★ Builders of rugged equipment specify CLAROSTAT for resistors, controls and resistance devices as a matter of habit. They know through years of experience, especially out in the field, that Clarostat components are *tough*—electrically and mechanically. Thus one more clause in their insurance against equipment failure and excessive servicing.

Today Clarostat is engaged 100% in the war effort. The facilities of two large plants are concentrated exclusively on meeting the requirements of our armed forces. But after Victory is won "The House of Resistors" will convert back to civilian production, with vastly increased capacity to meet the needs of its many business friends.

★ *Submit Your Problems . . .*

If they have to do with resistance—fixed, adjustable, or ballast—send them along for our engineering collaboration. We either have standard items in our extensive line that will meet your needs, or we can build special units. Let us quote on your requirements.

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Controls and Resistors

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Revolutionary in Range!

CML MODEL 1200

STROBOSCOPE

"FREEZES" MOTION IN RANGE OF 600 TO 600,000 RPM

Rotary speeds from 600 to 600,000 RPM—or vibrations from 10 to 10,000 CPS—can be "stopped" and studied with the Model 1200 Stroboscope. The light source is mounted in a small probe at the end of a five-foot flexible cable.

This makes it easy to examine small objects at close range. Provision is made to operate the unit from external tuning fork or crystal standards, where extreme accuracy is required. The motion of objects moving at irregular speeds may also be "stopped" with the Model 1200.

An accurate repetitive pulse rate is obtained, as the pulses are derived from a stable audio oscillator.

Not only does this eliminate the necessity for constant readjustment of the repetitive rate, but it also insures clearly defined images at high speeds.

For greater flexibility, a light intensity control switch is also provided. This enables the user to control both the intensity of the light and the duration of the pulse length.

SEND FOR COMPLETE DESCRIPTIVE BULLETIN

COMMUNICATION MEASUREMENTS LABORATORY

Rotobridge · Electronic Generators · Power Supply Units

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THE 20 KW RADIO FREQUENCY GENERATOR—This unit has a nominal output of 20 kw. Controls and meters are conveniently located on the front panel. The circuit breakers and relays are readily accessible through the lower door on left side of the cubicle. Dead-front construction provides maximum protection to operating personnel.

THE 2 KW RADIO FREQUENCY GENERATOR—This unit has a nominal output of 2 kw and is designed to take a minimum of floor space. Large, sturdy casters provide high mobility. The "table top" working surface eliminates the need for special worktables and all controls are centralized on the sloping panel.

WESTINGHOUSE RADIO FREQUENCY GENERATORS

Cut Heating Time

FROM HOURS TO MINUTES

Heating operations that used to take hours are now completed in *minutes* through radio frequency heating—with a uniformity and control of the heat never possible before. In fact, with Westinghouse Radio Frequency Heating, tricky heating jobs become simple "push button" jobs.

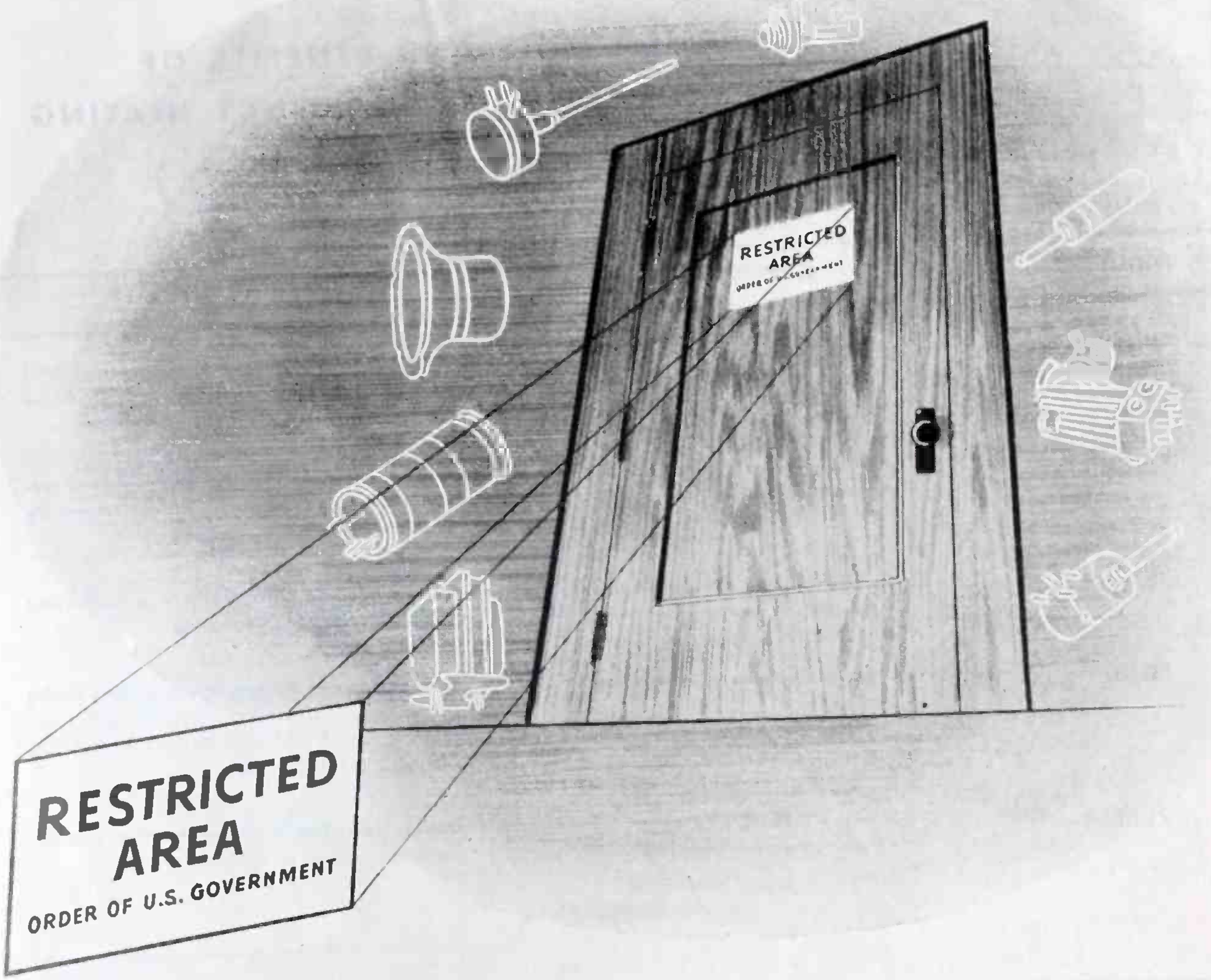
Westinghouse Radio Frequency Generators are designed for both induction and dielectric applications. With all the generating equipment and controls housed in a single cabinet, these units are literally radio frequency heating "packages" . . . simple to install and maintain. They are completely shielded to minimize radio communication interference.

The "long life" air-cooled tubes eliminate all the complications of water cooling. Air cooling also provides an extra margin of safety against failure and, at the same time, effects worth-while savings in both space and *initial* cost.

Westinghouse offers industry a complete line of radio frequency generators—1, 2, 5, 10, 20, 50, 100 and 200 kw units. The heavy-duty 50, 100 and 200 kw units employ water-cooled tubes. Ask for Bulletin B-3261-A and Descriptive Data 85-800. Or, for assistance on some specific application, send us an outline of your problem. Westinghouse Electric & Mfg. Co., P.O. Box 868, Pittsburgh 30, Pa. J-08074

Westinghouse RADIO FREQUENCY HEATING

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE



locked door . . .

• Forbidden to all but top government officials and Utah technicians . . . this room has been the birthplace of many miracles in radio, electronics and electricity. Behind this locked door, Utah has developed vital equipment . . . earmarked for military needs. Inevitably, the wartime secrets of this forbidden room will be adapted to commercial and consumer needs . . . assume a prominent role in the pursuits of peace.

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Every product made for the trade, by Utah, is thoroughly tested and approved

Keyed to "tomorrow's" demands: Utah transformers, speakers, vibrators, vitreous enamel resistors, wirewound controls, plugs, jacks, switches and small electric motors.

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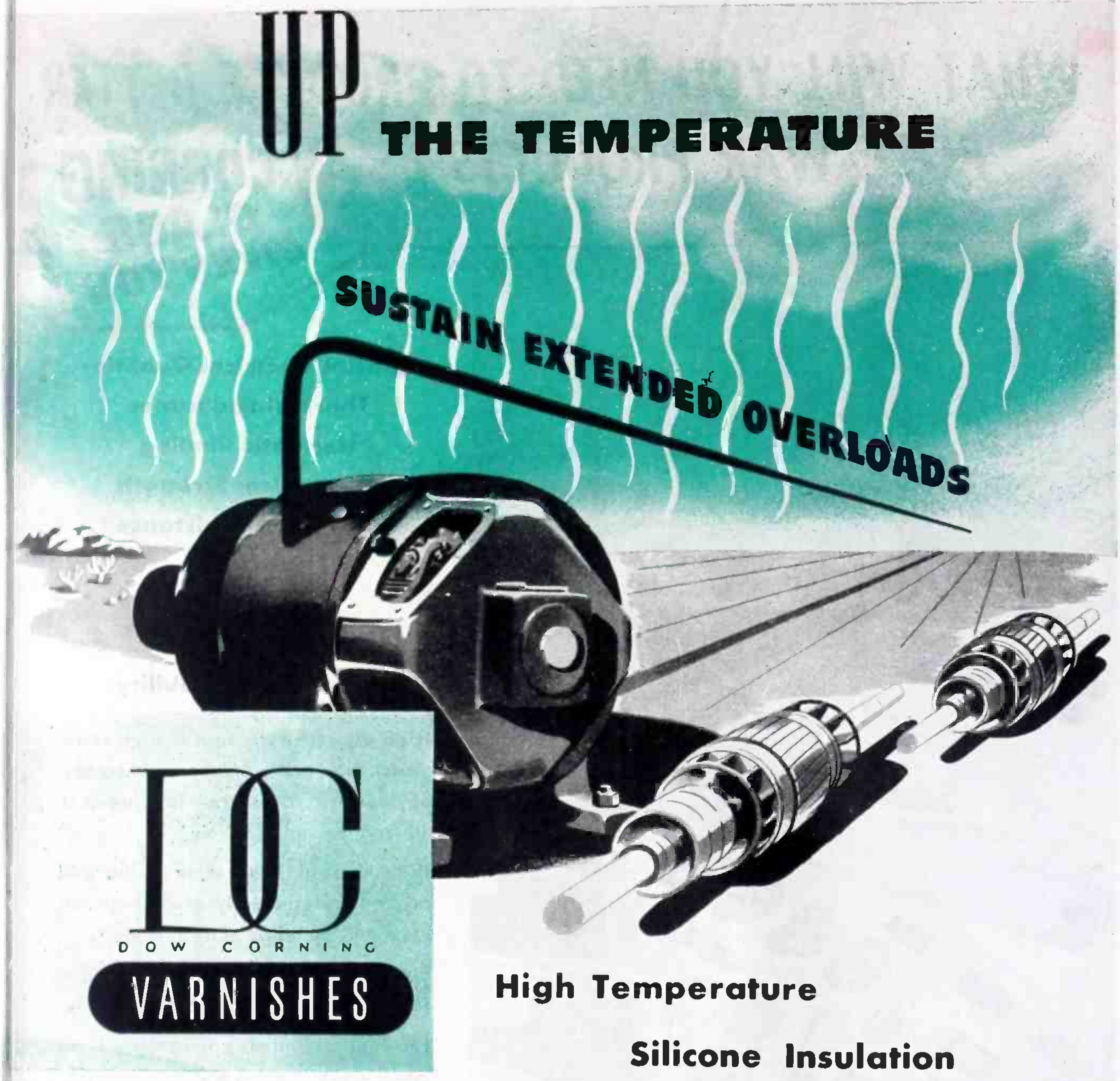
ARMY E NAVY

Utah Radio Products Company, 857 Orleans Street, Chicago 10, Ill.



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hey provide the bonding and filling me-
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DOW CORNING 993 . . available in commercial quantities, is a heat curing, high temperature stable silicone varnish for impregnating motor stators, transformer coils and other electrical equipment; for varnishing Fiberglas or asbestos served magnetic wire; for varnishing Fiberglas and asbestos electrical insulating cloths, tapes, tying cords and sleeving; for bonding Fiberglas and mica combinations.

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Artisans in sheet metal, Karp craftsmen produce a varied line of products . . . from a chassis small enough to be handled by two fingers to a heavy rack which requires a crane to lift. We save you time, cost and manpower. A Karp engineer will gladly consult with you.
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In QUARTZ CRYSTALS, the most significant advancements have been introduced by Bliley

This is a message from Bliley to the thousands of amateurs and professional engineers who are now serving their country in the armed forces and in essential communications industries. Bliley "grew up" with them.

To these men and women Bliley crystals are still a familiar sight. They recognize, in the military crystal units used by our armed forces, many basic features that were pioneered by Bliley for application in peacetime services.

When tremendous production was demanded by our armed forces Bliley had the engineering background, the facilities and the production experience to provide a firm corner stone on which this volume production of radio crystals was successfully built. And, from the ranks of talented amateurs and radio engineers came a host of long-time friends who knew exactly how to use them.

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To our old friends, amateurs and professional engineers, we say, "Look to Bliley for crystal units that embody every advanced development."

ARMY E NAVY

Bliley CRYSTALS

Do more than before . . .

buy extra War Bonds

BLILEY ELECTRIC COMPANY

UNION STATION BUILDING • ERIE, PENN.


pioneer for tomorrow
The world of tomorrow will be one of electronics. Pioneer for that world is the electronic engineer. His vitally important effort during this wartime period in devising electronic equipment is helping to defeat the enemy. Tomorrow, he devotes his specialized scientific knowledge to aid peacetime industries.
Raytheon is applying its efforts to the development of advanced electronic tubes and equipment for the war effort. When that job is done, the knowledge that has been gained will be used to guarantee that post-war radio, industrial and electronic equipment manufacturers will receive Raytheon tubes and equipment with even greater "Plus-Extra" quality.
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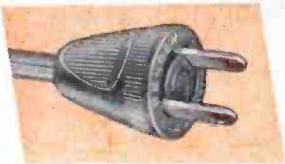
DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS

A Good Motor PLUS A Good Cord...



Unbreakable Plugs

...that's why it's running today

Unbreakable Connectors

Unbreakable Strain Relief

For years an identifying mark of a good tool or appliance, Belden electrical cords and plugs are an accepted token that the manufacturer was careful in the selection of the parts for his equipment. Belden cords have promised freedom from Corditis, and in this present emergency have proved their value on a host of electrical tools and appliances that are still giving good service.

After the war, customers will again look for nationally advertised Belden cords and plugs as a guide in purchasing electrical equipment. Take advantage of the plus value of Belden products when designing your postwar products; specify Belden Corditis-free cords.

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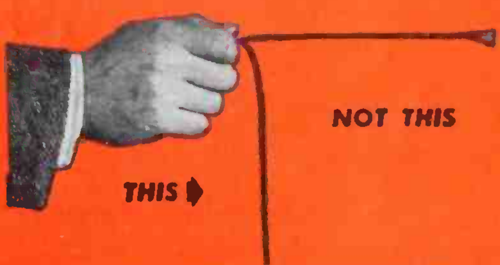
Corditis-free CORDS

BH NON-FRAYING FIBERGLAS SLEEVING

BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

2 WAYS BETTER

NON-FRAYING



NON-STIFFENING

ASSEMBLERS and electricians don't have to be contortionists when working with non-fraying BH *Extra Flexible* Fiberglas Sleeving. Remarkably resistant to stiffening, this always supple insulation won't crack or rot with age. Whether in tough, active service or dead storage, it remains "fresh" and easy to work, retaining its full insulating efficiency *indefinitely*.

This special-processed sleeving won't burn and is non-crystallizing at low temperature. It offers all the natural advantages of Fiberglas—high dielectric and tensile strength—chemical and moisture resistance—and many more—in addition to its own unusual properties.

You'll want to see for yourself the cleaner cutting, non-fraying and non-stiffening features of the sleeving that simplifies assembly, lasts longer and cuts repair costs. BH *Extra Flexible* Fiberglas Sleeving is available in all standard colors. Sizes from No. 20 to 5/8", inclusive. Write for *your* samples today and compare!

BH SPECIAL TREATED FIBERGLAS SLEEVING FLEXIBLE AS STRING!

Here's another high quality BH Fiberglas Sleeving. Due to the BH exclusive process no saturant is used, yet it will not fray out when cut and will withstand heat up to 1200°F. Made in natural color only—all standard sizes. Test it and try it!

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NON-BURNING IMPREGNATED MAGNETO TUBING • NON-BURNING FLEXIBLE VARNISHED TUBING • SATURATED AND NON-SATURATED SLEEVING

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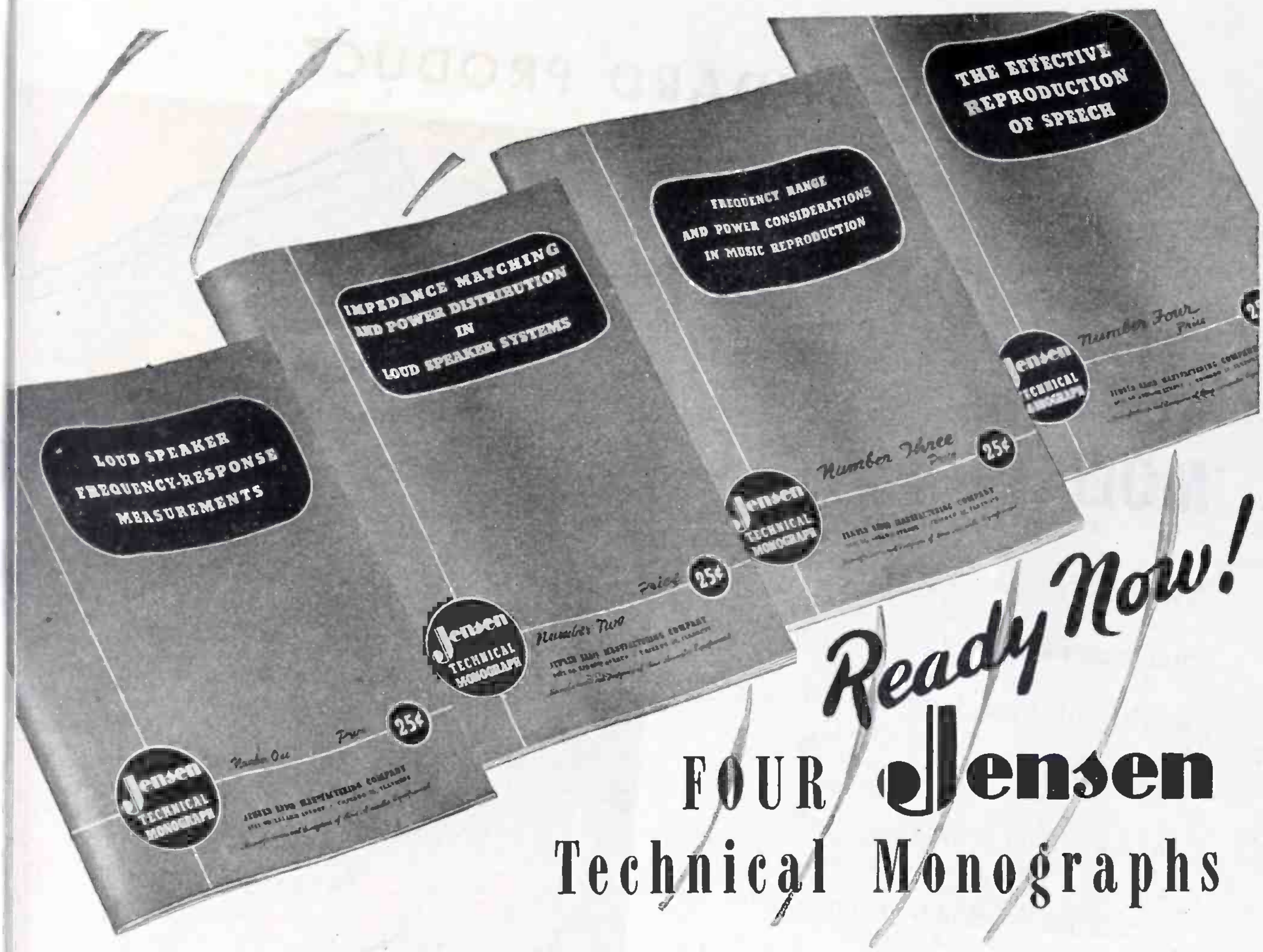

Ready Now!

FOUR Jensen Technical Monographs

'VERYONE interested in the reproduction of sound — engineer, tradesman, instructor, student or layman — should own these ur Monographs. Published by the Jensen Technical Service Department in the interest of improved sound reproduction, they are the st four numbers of a series. Up-to-date in factual information, replete with useful charts, graphs and tables, they supply a world of ita, heretofore unobtainable, to guide in the selection, installation id operation of loud speakers. You will want *not only these four* imbers *but the rest of the series* as announced from time to time.

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'ONOGRAPH No. 2: *"Impedance Matching and Power Disbution."* Discusses such subjects as multiple speaker connection, lume control, design of efficient transmission lines, and conversion volume levels to power and voltage. The text is supported by twenty-eight drawings and tables. More than a score of questions are described, illustrated and solved, including a comprehensive sound system for a military installation.

MONOGRAPH No. 3: *"Frequency Range in Music Reproduction."* What frequency range is needed for high fidelity reproduction? What are the maximum, useful audio frequency ranges under actual listening conditions? What are the practical limitations on high fidelity reproduction even if perfect transmission, reception and reproduction were possible? How much change in high frequency cut-off is required to be just noticeable to the listener? All these and many more questions are answered in this Jensen Monograph.

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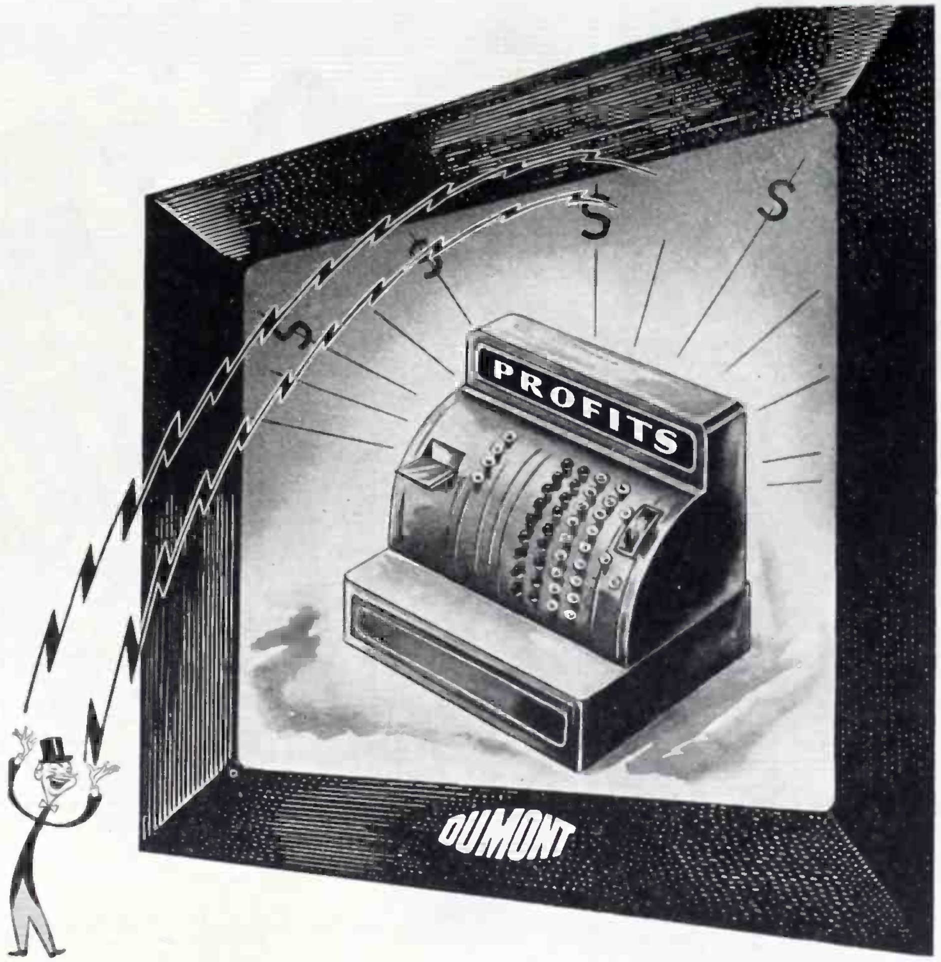

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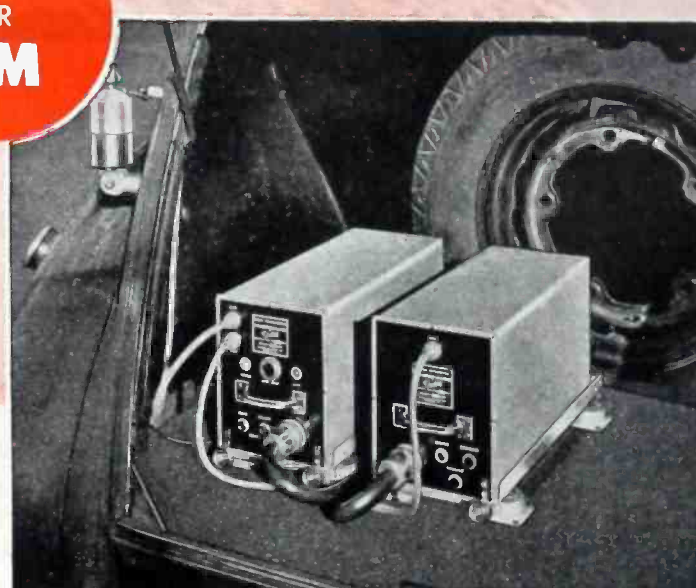

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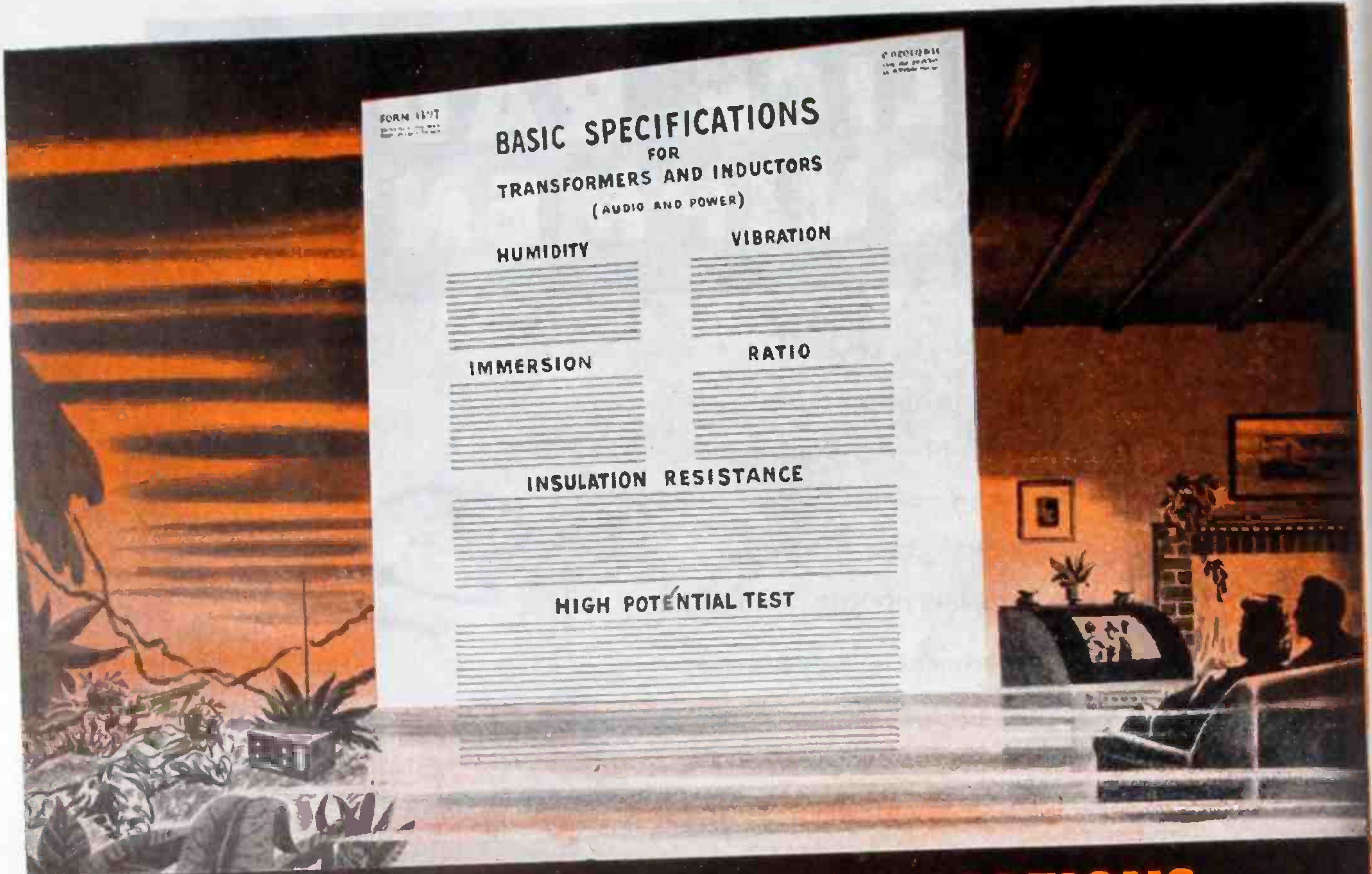

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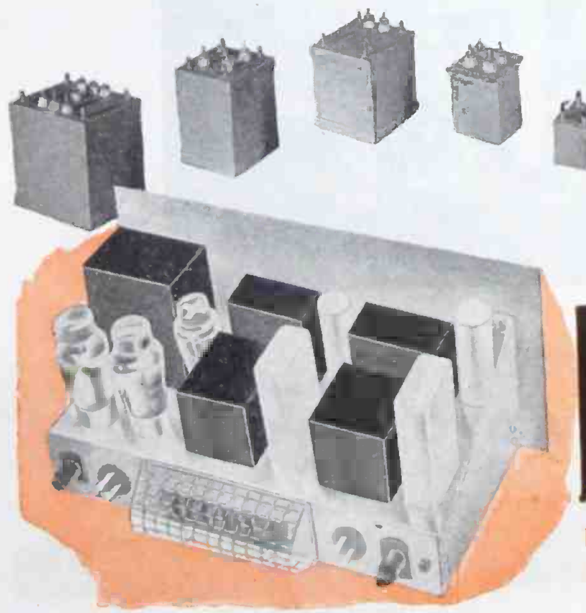

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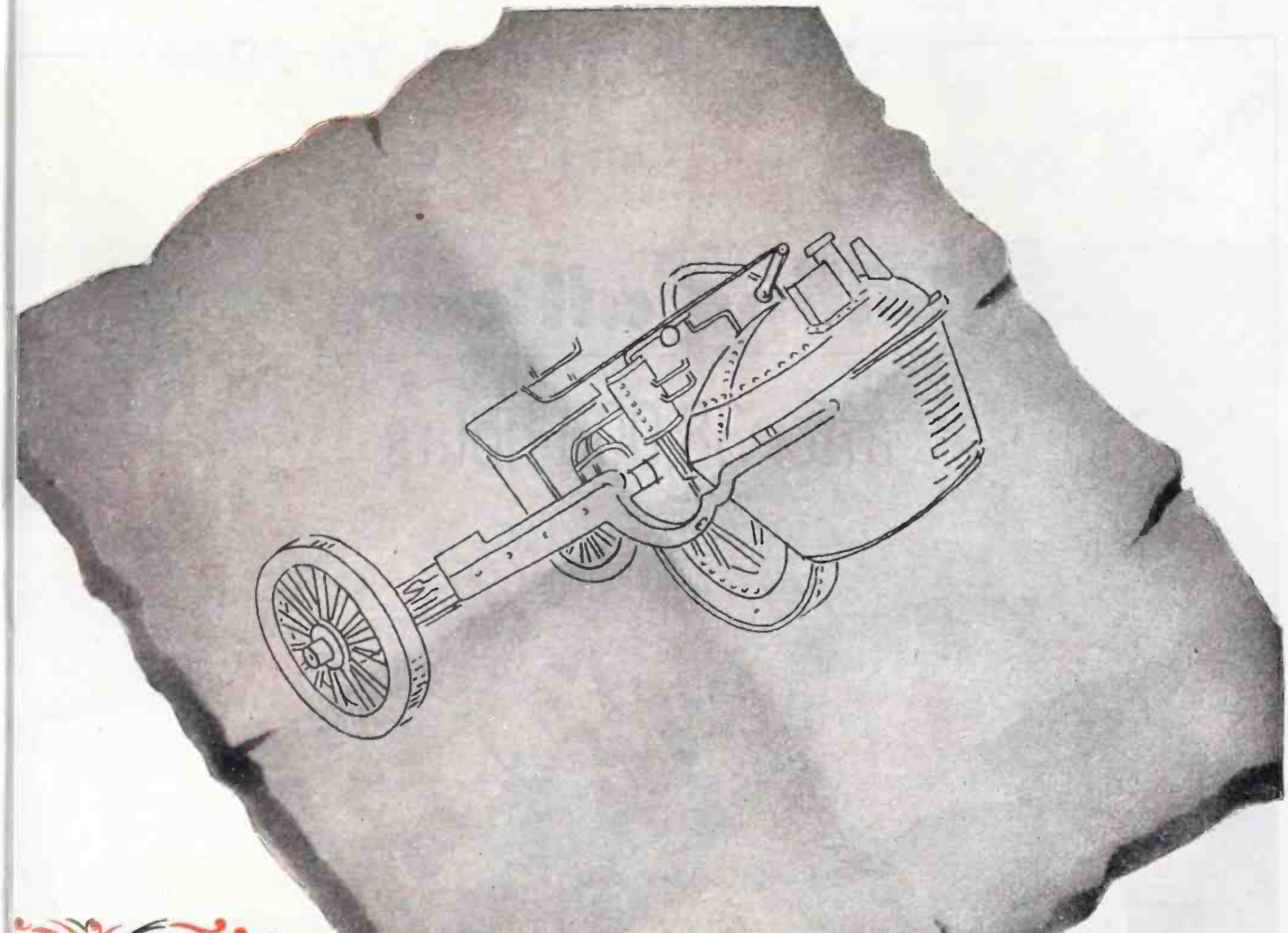

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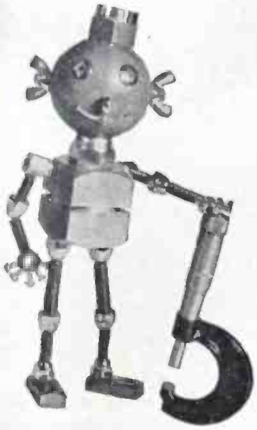

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MR. TROUBLE-SHOOTER

Thanks, Mr. G. I. You're close to our thoughts. All of us in radio know the world-wide job you're doing in the Signal Corps.

We know who you are. You're the radio ham across the street, the boy home from college who burned the midnight oil in the attic and rigged his aerial from the highest mast. You're the telephone man. You're the obliging young fellow from the lighting company. You're the serviceman who fixed our radio set the day before the World's Series. You're the radio engineer who added brains to that set.

We don't know where you're *seeing* action but we know that you are *helping* it. Crawling out ahead of artillery. Scrambling from one fox-hole to another. Rolling up telephone wire almost to the muzzles of enemy guns. Operating and servicing communication systems so that the attack may roll forward. Hunting booby traps. Saving lives.

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SOLAR

CAPACITORS AND RADIO NOISE-SUPPRESSION FILTERS

THE FAR EAST

Frontier for American Enterprise

IN THE great tradition of America, our frontier lies to the West. But for a United States that stretches from the Atlantic to the Pacific, to Go West is to arrive in the Far East. The feet of literally millions of our young men are now set upon that route.

Accomplishment of their objective—the defeat of Japan—will not end our responsibilities to the Orient any more than the defeat of Germany will end our responsibilities to Europe. This time we mean to see the venture through.

The first sketch of a political program for enlisting the strength of nations of good will to enforce the peace was drawn at Dumbarton Oaks. That is a good start. But those who participated know how much work remains before the blueprint becomes a fully matured plan, the plan becomes a structure, and the structure takes life and effective being in the living imagination and will of the peoples of the world.

No political accord, however high its purpose, can endure for long if it depends upon the loyalty and support of populations embittered by hopeless poverty that is offered no promise of relief. The poisonous dust of mass despair makes inevitable an ultimate explosion, whether it be sparked by a torch supplied from without or by its own internally generated heat. Much of the Far East is sufficiently close to that position to pose a grave problem to the Western world. It is of particular importance that American business men and workers alike recognize the nature of their responsibility in the matter, for to them the great area of the East presents also an opportunity and a challenge.

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The Orient—stretching in a vast semicircle from Manchuria and Japan to India and Ceylon—is the home of more than a billion people, the world's greatest potential market. In its mountains are the earth's richest stores of tin and mica; its deposits of iron ore, coal, and manganese rival those of France, Russia, and the United States. Its rice paddies are the most productive in the world, its coconut and rubber plantations the largest, and its cotton production is of major volume.

And yet, this fabulous region—with its riches of manpower and raw materials—suffers from living standards at the lowest rung of the world scale. With as much as 85 per cent of the populations of this great area devoted to the production of farm products, starvation has been an endemic plague to countless millions of its inhabitants, and will remain so until they graduate from the crudely primitive methods of the crooked stick and the bamboo plow to the use of the implements of a modern world in both agriculture and industry.

The improvement of agricultural methods and the burgeoning of industrial development depends upon tools—a preponderance of simple tools, no doubt, at the beginning, for modernization of economic processes is a development that cannot be forced at a rate faster than the ideas upon which they depend can be developed. If we, in the United States, are to hope to supply a major portion of the implements upon which the salvation of the East depends, we must be prepared to export also the skills and technologies which will make their effective use possible.

The possibility of a world market for machinery and manufactured products is a challenge that American industry cannot afford to ignore. The United States will emerge from the war with almost half of the world's industrial capacity within its borders, with much more than half of the heavy industries. Drastic and painful readjustments are inevitable; but they can be mitigated to the extent that we can find outside markets for the products for which we have excess capacity.

We shall find ourselves, at war's end, in a singularly favored position to compete in any equipment markets which are open. It is not merely that we shall have the productive capacities crying for outlets. Aside from Germany and Japan, which for some time will not be in a position to compete, our two major industrial Allies, Great Britain and Russia, will face enormous tasks in providing for their own rehabilitation. Neither of them is likely to be in a position to export more capital than they absorb; and although Canada, Sweden, and Switzerland will be, the United States will stand alone as the one major creditor nation in the world. If the potential advantages of this position are managed with wisdom and imagination, they will enormously enhance our opportunities for supplying a great share of the capital goods demand of undeveloped areas.

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What is the dimension of the Far East's potential demand? What are some of the difficulties standing in the way of its being realized?

If needs were the only measuring stick, the Far Eastern market would provide a bottomless pit into which even the great stores of our exportable capacity could be poured with room to spare.

China, alone, with its teeming population of 450 millions, has spelled out needs in dimensions large enough to stir the imaginations of the equipment producers of the world.

Business Week (February 5, 1944) supplements Dr. Sun Yat-Sen's spacious first estimates of the requirements for a thorough-going industrialization program with figures provided by current Chinese planners—25,000 locomotives; 300,000 freight cars; 20,000 passenger coaches; 20,000,000 tons of steel; and 90,000 power driven machine tools for the first five years of reconstruction. An American manufacturer of farm equipment, who recently surveyed the agricultural requirements of China, estimates an ultimate Chinese market for 20,000,000 tractors.

India's drawing-board plans are equally expansive. According to the bold pattern drawn up by a group of Bombay industrialists—some of whom are due to visit the United States early in 1945—India, after the war, will require a capital investment of $2,000,000,000 a year over the next 15 years, of which $250,000,000 per year for the first seven years will be in the form of imported capital goods.

Included on the huge import order list of the Bombay executives are mining, roadbuilding and power station equipment, heavy locomotives, metallurgical plants, agricultural machinery, and a long list of machine tools.

There can be no question of the need of these countries for the industrial equipment—and for many items of manufactured goods—which we are so eminently in a position to supply. But realism requires that we measure this demand against the Far East's probable capacity in the relatively near future to absorb industrial goods.

A Chinese economist has estimated that China, in 1937, had a total industrial capital investment of about $1,000,000,000 in American values, or something like $2.50 per capita of population. In contrast, the American investment, in manufacturing facilities alone, is now more than $600 per capita.

What it could mean in terms of capital goods requirements if China alone carries out this dream of modernizing, not to the utopian level of the United States but to the present modest level of the less developed Soviet Union, is typified by measuring just three lines: 500,000 tons of steel a year, for five years, to add 12,500 miles to the railroad system; 2,187,500 motor vehicles; 3,300,000 telephones.

But it is one thing to cite mountainous figures demonstrating needs. It is another, and far less optimistic exercise, to find assurance that practical opportunities for satisfying such needs can be made to materialize. Let us face some of the major difficulties and see if they are insurmountable.

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The first hurdle to be cleared is the question of whether or not we want to promote the industrialization of the Far East. The wisdom of doing so has been vigorously challenged. The negative argument, on the economic side, generally runs thus: If we provide industrial equipment to backward economic areas, we deprive ourselves of the greater long-run opportunity of selling them manufactured articles which our aid has enabled them to produce for themselves.

It is only fair to say that such a thing might happen—that it has happened in isolated instances in the past. But the overwhelming weight of economic history demonstrates that the broader attitude is also the profitable one.

The United States itself is the living refutation of the fear which now cramps the outlook of many of its own citizens.

From 1790 until 1850 the foreign trade of our new fledged Nation had many of the characteristics which pertain to the trades of China and India today. We imported manufactures and we exported raw materials, agricultural products, and newly mined gold. Our imports exceeded exports, the difference being made up partly by payments to us for shipping services and partly by industrial development loans. It is relevant to inquire how the trade of the lenders was affected by this policy of supplying us with industrial capital and machinery.

From 1850 through 1939 the pattern of America's foreign trade changed. Slowly at first, and then at accelerated pace, our import ledger showed a percentage decline in manufactured goods and a percentage rise in raw materials to feed our expanding industrial facilities. But while finished manufactures declined percentagewise in our import budget, so great was the increase in our total foreign trade operations in the century from 1830 to 1930 that our imports of manufactured goods increased more than twentyfold, and they more than doubled between 1900 and 1939.

Clearly industrial Europe gained rather than suffered from the industrialization of the United States, and it is equally clear that we, in turn, shall benefit from the industrialization of the world's undeveloped territories. Further evidence is provided by Canada which, with its high industrial development but only 12 million people, buys from us each year almost as much as the relatively unindustrialized 130 million people south of the Rio Grande.

If it be granted, as I believe it must, that the development of Far Eastern countries will be to our advantage as well as theirs, the second question that we should face is the speed with which it can be accomplished. Is there genuine promise in the proximate future of opportunities for American enterprise of the magnitude set forth in the estimates quoted above?

In all fairness, I am forced to state my conviction that the road is longer than is indicated by Chinese and Indian leaders. It is natural, and far from censurable, that their eyes should be focussed upon the urgency of national needs, rather than upon obstacles in the way of their fulfillment.

On the other hand, it is possible that our own long process of industrialization may lead us to conclusions of undue conservatism. Ideas, once they break the crust of resistance are the most contagious of bacteria, and the tempo of their infiltration seems to increase by geometrical progression in a world of swift communication.

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In an interesting recent study of The International Labor Office, it is suggested that the general economic level of the rest of Asia outside Japan in the late 1930's was not dissimilar to that of Japan in 1900. Between 1900 and 1936, Japan increased its total capital investment more than threefold devoting between 10 and 17 per cent of its annual income to capital outlays. A comparable tempo of development for China, India, and other Asiatic areas would result in a capital expansion that would dwarf to insignificance the most optimistic blueprints that have been put forth to date. I am not suggesting this as a likely possibility, but rather as a caution lest we, in the name of hard-headed realism, underestimate Asiatic potentials as much as their own nationals exaggerate them.

Finally, in appraising the outlook for American enterprise in Far Eastern markets, we collide, head-on, with the problem of how we are to be paid. Here, hard-headedness can be only a virtue, for the lack of it will breed inevitable disaster for the Asiatics as well as for us.

In the last analysis, the dimension of the American market in the Far Eastern countries will be determined by the dollar exchange at their command, obtained through the products, goods, and services which they are able to provide to us, with due allowance for multilateral trade arrangements. It is true that the balance temporarily can be distorted through the extension of developmental loans. There is little question but that such loans will be in order after the war, and if they are wisely made, for productive projects that eventually will increase the exporting capacities of the countries to which they are extended, they can be thoroughly justified. But the best loans provide only a temporary expedient. In the long run, the balance of current payments must be restored with sufficient margin to provide interest payments and finally amortization of principal.

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How, then, are we to attack the problem of increasing our imports from the Orient?

In 1937, the total exports of the Far East amounted to something over $5,000,000,000—a little less than $1,500,000,000 in foodstuffs, a little more than $2,500,000,000 in raw and partly manufactured materials, and better than $1,000,000,000 of manufactured articles. Of this total, the United States purchased only about 20 per cent—approximately 10 per cent each of the foodstuffs and manufactures, and 30 per cent of the materials.

Despite changes in our technologies which will probably reduce our future takings of such important items as rubber and silk, the achievement of a high level of economic activity in this country after the war will provide a basis for increasing our Eastern imports, but only if it is an accepted part of our national policy to do so.

This means an alert and aggressive exploration of two-way trade possibilities on the part of both American business and our governmental agencies. It cannot be done by either alone.

The war has dislocated many of the trade patterns that prevailed in the past. The East is hungry for the type of products which we, uniquely, are situated to supply, but it will make its bargains with those who will not only fill its needs but will also provide outlets for its produce. Even the prewar magnitude of the exports from this area provides ample margin for the most meticulous and imaginative shopping of Eastern markets with the aim of increasing the modest share of our prewar purchases. And a farsighted program of development loans can greatly increase the capacity of these countries to produce what we want.

In general, we can trust American enterprise to explore rigorously all likely export opportunities. But the equally vigorous investigation of import possibilities will require a break from past traditions on the part of American business and American government.

Both East and West must learn to think in new patterns for the successful opening of a new frontier.

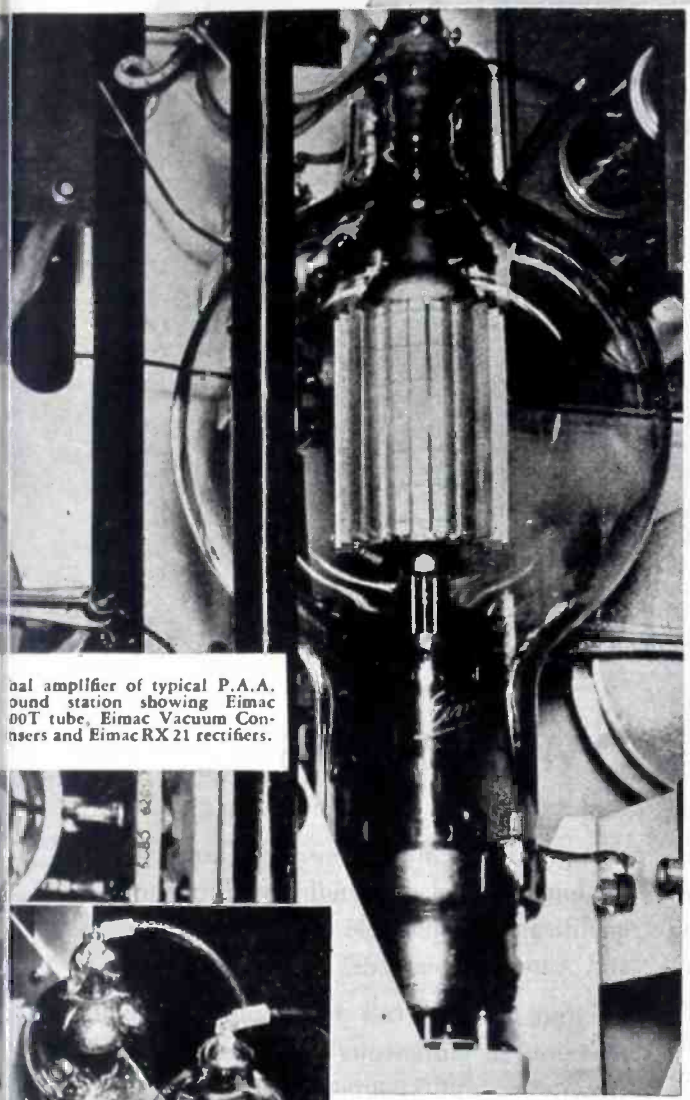
James H. McGraw, Jr.

President McGraw-Hill Publishing Co., Inc.

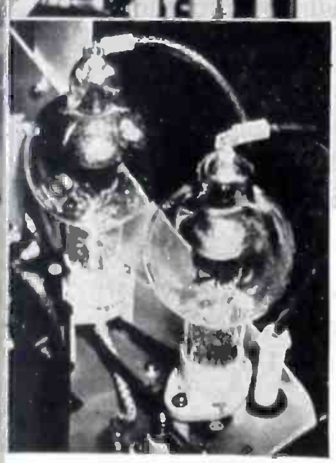
THIS IS THE 30TH OF A SERIES

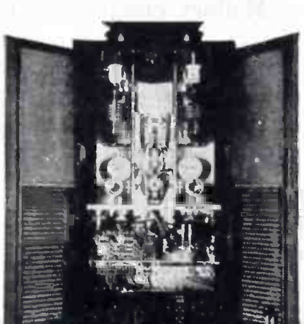
PAN AMERICAN USES EIMAC TUBES

Pan American World Airways, which has done so much to advance the war-time goals of the nation, has just announced a plan for a new service to South America. Employing a fleet of stratosphere planes, carrying 108 passengers, flying at more than three hundred miles an hour, Pan American proposes to take travelers from New York to Rio de Janiero in less than twenty hours instead of the present sixty-six hours, charging $175 for the trip, as against the current rate of $491.



nal amplifier of typical P.A.A. ound station showing Eimac 00T tube, Eimac Vacuum Connsers and Eimac RX 21 rectifiers.





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The fact that Eimac tubes are the number one favorite of the commercial airlines is important evidence to substantiate the oft repeated statement that "Eimac tubes are first choice of leading electronic engineers throughout the world."

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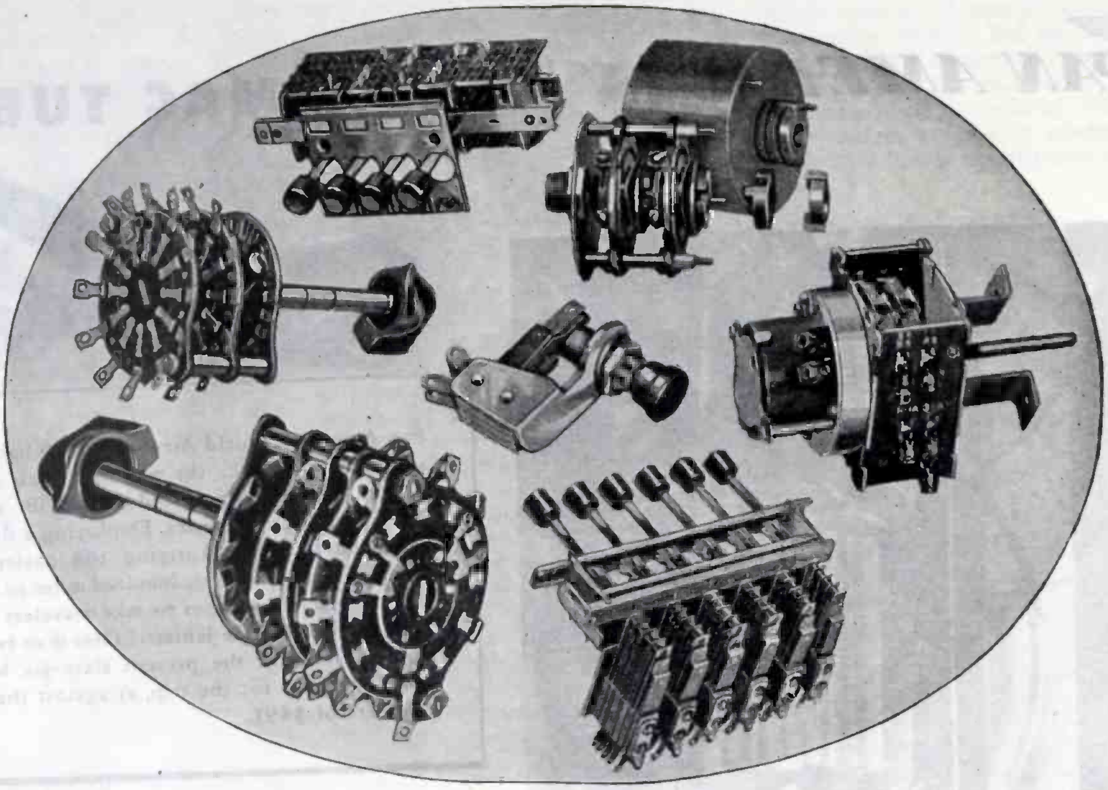

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MALLORY

Help Finish the Fight—Buy War Bonds

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CROSS TALK

▸ **LAST CHANCE . . .** One of the large broadcasting companies recently conducted a series of studio tests to determine the kind of tone fidelity the average radio listener wants. Invited guests were asked to vote their preference between a low-range and a wide-range setup. Care was taken to see that the wide-range transmission was clean, free of noise and distortion.

The vote was in favor of low fidelity.

This is not difficult to understand. The average radio listener has heard few real jazz bands or real symphonies at first hand; he has rarely heard music as it is played, but only radio or recorded versions of music. The average radio receiver is ridiculously defective in transmitting tones above 5000 cycles. In fact it is down 10 to 20 db at that frequency. Since the tests were conducted by a broadcast company, in a broadcast studio, to determine what broadcast listeners preferred in the way of radio tone fidelity, what else could one expect? Naturally the vote was for the thing that was familiar.

This question of band width is extremely important. So long as the radio industry floods the market with receivers that are practically deaf to tones above 5000 cycles, there is mighty little need to engineer transmitters and lines and repeaters and switching gear for frequencies higher than this. So long as stations are packed close together in the spectrum and so long as receivers must be engineered for extreme sensitivity, then selectivity and freedom from adjacent-channel interference are more important than mere tonal fidelity.

FM, however, poses a different and embarrassing question for the radio industry. Once more, and probably for the last time, the industry has a chance to produce a truly tone-faithful system. There are signs, however, that parts of the industry will kick and scream bloody murder before they will give in to the "idealistic goops" who wish for the broader bands.

One of the arguments against higher frequency transmission is that adults can't hear much above, say, 6000 cycles. It is certain that the higher frequencies become less and less apparent as one grows older. Of our total population, however, 41 percent is less than 25 years old; and while the trend is toward a population which is becoming successively older, the increased birth rate during the war may put a temporary plateau under this curve. Anyhow, why should the broadcasting industry be engineered for old duffers with failing ears; why not for the youth?

Another argument against high fidelity is that we will then hear needle scratch, violin rosin noises and soprano breathings. This, too, is merely a dodge. So long as we continue the old technique of ramming the microphone approximately down the throat of the violin (or of the soprano), we will hear such noises. But we won't if we develop new microphone techniques.

The broadcast system should always be better than the average listener can appreciate with his cheap little box of radio parts. From a purely selfish standpoint the radio industry should be interested in reloading the buyer of a cheap radio with a much more expensive set when and if he gets the money to buy it. Listeners should resist with every means at their command any attempt to cramp the new FM system with the same kind of thinking that has made such complete frauds out of so many radio receiver advertising copy writers who prate about the fine tone quality of their products.

A Report on the FCC FREQUENCY

Over a month was required for presentation of evidence regarding radio's future needs by the RTPB, the IRAC, the ARRL and others. Proposed assignments cover the spectrum from 10 kc to 30,000 Mc. Industrial electronic equipment channels suggested

DOCKET 6651 may well prove to be the most voluminous file in the history of the Federal Communications Commission. For it is under this number that the Commission considered, throughout the month of October, the future needs of various services in the radio spectrum from 10 kc (30,000 meters) to 30,000 Mc (1 centimeter).

That the inquiry was exhaustive is clear from the record, a transcript over a million words long. That the decisions based on this record will be of the utmost importance is equally clear, for on them will depend in large part the future activity of every communications engineer and technician in the business.

The ether spectrum obviously has been expanding under the impetus of war but the extent of the expansion is now for the first time a matter of public record. The spectrum extends upward to 30,000 Mc, whereas the last public allocation stopped at 300 Mc. Wavelengths between one meter and one centimeter are to be assigned channel-by-channel for the public use. The spectrum has been extended by some six octaves.

Of equal interest is the number and variety of services which are presently in competition for preferred positions in the spectrum. Panels of the Radio Technical Planning Board (RTPB) made up of men from industry, each panel representing a different group of services, presented requests for ether space and some of these requests conflict with those of other panels. The allocation plan of the Interdepartment Radio Advisory Committee (IRAC), representing government departments, was also introduced, agreeing with the RTPB plans in some respects but widely differing in others.

The volume of evidence presented before the FCC was so huge as to make this reporter despair of assimilating any but the major points in time to meet a December deadline. What follows, therefore, is an attempt to delineate the requests for ether space put forward by the various services through RTPB and IRAC and others, and to indicate in passing some of the technical implications involved.

Program of the Hearing

The hearing got under way on September 28, when Chairman Fly of the FCC explained its purpose and asked Dr. W. R. G. Baker, Chairman of the RTPB, to outline the functions and activities of this group. Dr. Baker pointed out that in 1942 Mr. Fly himself had suggested that such an organization be set up to assist in resolving the problems of frequency allocations and system standards.

The RTPB, said Dr. Baker, was patterned after the National Television System Committee, but its organization was broadened to include all non-government radio services, and to include representatives from all interested groups from commercial as well as scientific bodies within the industry. Moreover, since much pertinent information is classified as secret or confidential by military authority, it was necessary to rely on the knowledge and recommendations of Panel members to a considerable extent in formulating plans to avoid violation of

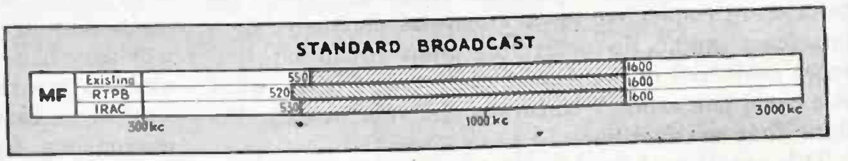


FIG. 1—Standard broadcasting would get three new channels on the low-frequency end, if the industry-sponsored RTPB had its way. The IRAC proposal representing the viewpoint of government departments would provide only two, keeping clearer of the SOS frequency

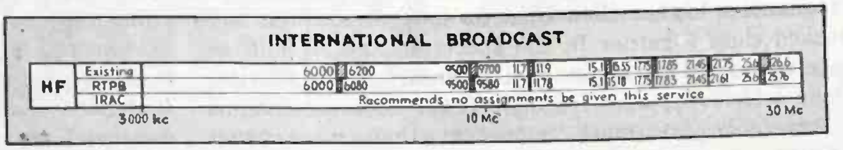


FIG. 2—International broadcasting would be continued on approximately the prewar basis by the RTPB. The IRAC would drop it entirely insofar as direct reception by the radio audience is concerned, substituting spot-frequency relaying and re-broadcasting by standard broadcast stations

ALLOCATION HEARING

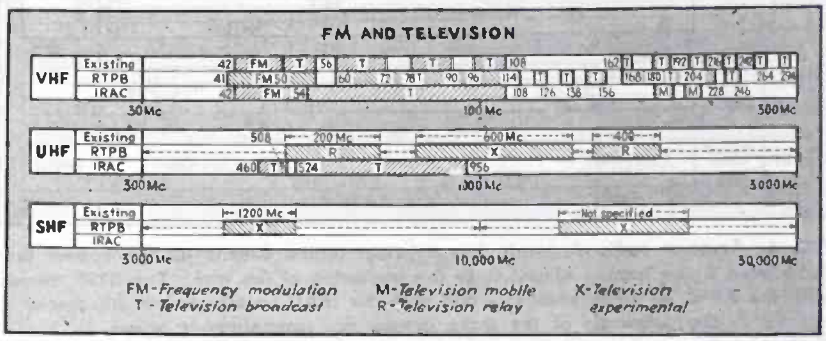


FIG. 3—FM and television frequency assignment clashes between RTPB Panels were compromised and solved before the FCC Hearings took place. Some differences, however, remained between RTPB and IRAC proposals

ur national security regulations.

Dr. Baker further stated that an nportant aspect of the RTPB's ork was to obtain agreement on requencies and standards for such ervices as would provide maximum mployment after the war. He aid that Panels reporting on two of e most important post-war serv-ces, frequency modulation and tele-ision, had agreed upon standards nd had resolved all conflicts on fre-uency allocations. Finally, he ointed out that many new serv-ces, not originally included in allo-ation discussions, now had to be onsidered. Among these were in-ustrial and scientific oscillators ot used for communication pur-oses, relay systems, and new ypes of mobile radio communica-on equipment for buses, railroads, axicabs and even the private citi-en.

Then followed reports from the aairmen of two RTPB Panels hav-ng a broad outlook on the whole pectrum, Panel 1 on Spectrum tilization, and Panel 2 on Fre-uency Allocation. The major ex-ibit of these two panels was a hart of the spectrum showing the resent allocations under FCC rules, nd the RTPB proposals in each ass of service. The "chart" is so oluminous that it takes 30 sheets, ach 10 by 30 inches, to cover the ange. The illustrations accompany-ng this report represent a sum-ary of the more important serv-es, and include also the allocations roposed by the IRAC and ARRL.

Following this presentation, tes-mony was taken by the FCC on ll phases of the art. The first eek was devoted to general ommunications services, includ-ng amateur and international roadcast. The second week was iven over to broadcasting in its arious forms; standard, FM, tele-ision, facsimile, and educational. ortable and mobile units used by police and other similar services, as well as by public utilities, were dis-cussed in the third week. The fourth week covered industrial, medical and scientific sources of in-terference and services intended to relay public and private communi-cations.

Finally, the chairman of RTPB Panel 2 again appeared and made recommendations based on all the evidence presented. Similar recom-mendations from all other inter-ested parties were invited, and the Commission then rested from its labors and retired to peruse the rec-ord in the quiet of its chambers. From such contemplation will come, and it is believed in the not-too-dis-tant future, a binding allocation of the spectrum to govern the indus-try for the next five years or more (the last allocation occurred in May, 1940).

The Broadcasting Services

The broadcasting services . . . standard, international, f-m and television . . . are of primary im-portance because they represent so large a part of the commercial activity in the electronics field. These services must, furthermore, assume the largest initial burden of production when military equip-ment is no longer needed in large quantities. The proposed alloca-tions for these services are shown in Fig. 1, 2 and 3.

Standard broadcasting (Fig. 1) was studied by the RTPB and Panel 4 recommended that the lower fre-quency edge of the band be extended downward from the existing 550 kc limit to 520 kc, thus providing three additional channels. This would bring the band edge within 15 kc of the distress frequency (SOS chan-nel) but it is argued that modern equipment provides plenty of selec-tivity to avoid interference. The IRAC proposal indicates greater caution in this regard but admits that the band should be extended to 530 kc. (The 540 kc channel is al-ready in use in Canada. Some evi-dence was brought forth purporting to show that interference was oc-casionally experienced from auto-alarm SOS devices on this fre-quency.)

Panel 4 pointed out that rural coverage in the standard band leaves much to be desired and said that this condition cannot always be remedied by providing vhf or uhf services. One third of the area of the United States is still outside the daytime range of any broadcast-ing station. Thus some 10,000,000 of our people can enjoy radio only at night, and then often only under adverse conditions. The RTPB pro-poses to ease this situation by set-

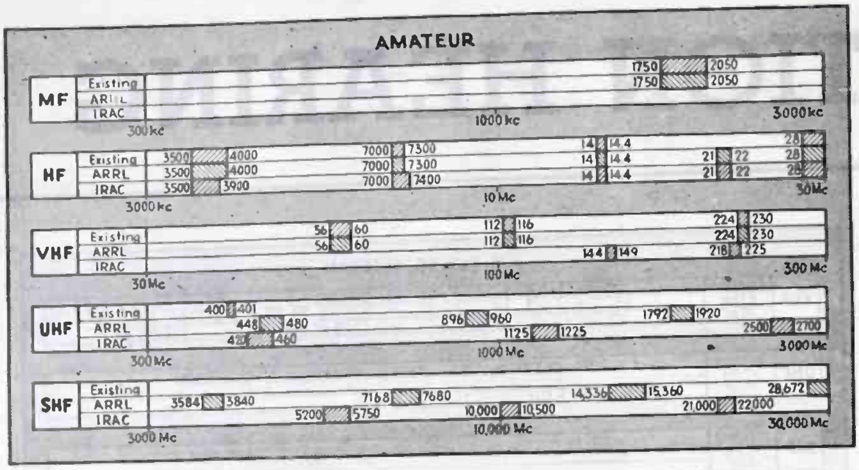


FIG. 4—Amateur radio obviously has a bright future, despite all the rumors that have been flying around almost since the beginning of the war. The RTPB agrees with the ARRL on some proposals and with the IRAC on others, but differences in the proposals of the three groups are comparatively minor

ting up satellite stations, operating on synchronized standard broadcast frequencies, to extend the range of existing stations into the rural areas. One of the reasons why such stations have not been employed more extensively in the past is the expense of program lines and synchronizing circuits. Satellite stations, it is proposed, can now be operated economically by the use of relay facilities in the uhf (300 to 3000 Mc) and shf (3000 to 30,000 Mc) bands.

A proposal to set up a new low-frequency broadcast service between 200 and 400 kc (similar to existing European service) has not been approved by the Panel but remains under study.

International broadcasting came in for a large share of attention. The IRAC plan proposes to eliminate international shortwave broadcasting entirely in its present form and to substitute a limited number of relay channels, giving point-to-point service. The relayed programs would be disseminated by domestic stations in a manner similar to the present overseas news broadcasts. This proposal found no favor whatever with industry. RTPB Panel 8, within whose province the subject lies, urged that 7 bands be set up, each consisting of 8 channels, for the exclusive use of U. S. stations (Fig. 2).

The chaotic condition of the international service was clearly revealed by the testimony of Curtis Plummer, FCC engineer. In January 1939, according to Mr. Plummer, there were 155 stations operating outside the bands authorized by the Cairo Conference. The U. S. A., adhering to the regulations, had no stations outside the bands. In August, 1944, on the other hand, 341 stations were operating outside the authorized bands, and 22 of these were U. S. stations. Which shows how treaty agreements fare in wartime.

FM Broadcasting

The recommendations of the RTPB FM Panel have already been reported in these pages (ELECTRONICS, November, p. 125). Briefly, they adhere to the previously existing standards, 200-kc bandwidth, 75-kc maximum deviation. The question debated at length at the hearings had to do with the position of the f-m band in the spectrum (Fig. 3).

The present f-m band extends from 42 to 50 Mc, the lower portion of which is reserved for educational stations. The RTPB proposal is that the band remain in the same general location but be extended downward to 41 Mc and upward to 56 Mc, providing 75 channels each 200 kc wide. It was revealed during the hearings that a contest between the FM and Television Panels for the space from 50 to 56 Mc had been resolved within the RTPB, the Television Panel agreeing to give up the space in return for space from 108 to 114 Mc. The IRAC plan also would enlarge the present f-m band but not to the extent proposed by RTPB. IRAC favors eliminating the five-meter amateur band (56 to 60 Mc) and turning this space over to television in return for the space from 50 to 54 Mc given to f-m broadcasting.

In contrast to these official recommendations, former Commissioner T.A.M. Craven urged that 400 f-m channels be provided between 60 and 100 Mc, and that television move upward to the region above 480 Mc. Mr. Craven urged that the width of each f-m channel be 100 kc, one half the present width. He also envisaged an ultimate demand for at least 2000 commercial f-m stations (at present there are 53 stations authorized and 255 applications for construction permits pending before the FCC).

Major E. H. Armstrong took the stand to urge that no reduction be

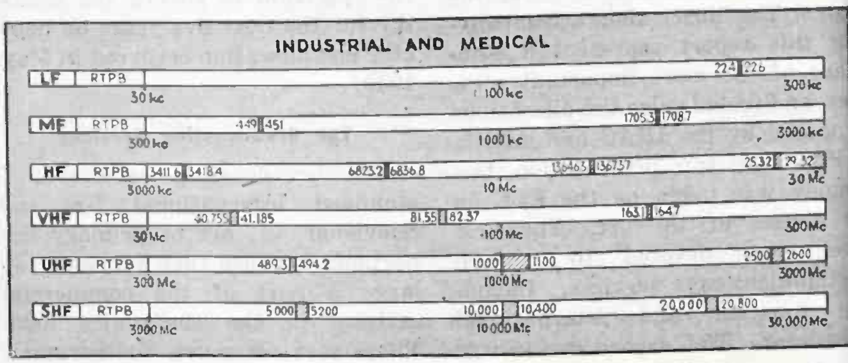


FIG. 5—Industrial and medical equipment radiating radio interference should, thinks the RTPB, be assigned specific frequencies. There is some question as to whether the Communications Act covers such gear, and obviously many clashes exist between the allocations suggested in this chart and other services

ermitted in the width of channels llocated, since such reduction vould impair the quality of the ervice and would also remove the ossibility of multiplexing facsimile n the same channel. He also ar- ued against limiting the power of -m outlets.

Paul Kesten, vice president of CBS, urged that practically unlim- ted competition be permitted on he f-m bands, with each outlet cov- ring a single market area. This, le said, would mean larger net- vorks, more extensive rural cover- ge, and general benefit to all radio isteners. The plan would mean lim- ting the power of stations. Mr. Kesten believes that a total of 4000 o 5000 f-m stations could be sup- orted in 10 national networks. He aid CBS engineers were not cer- ain as to the best region of the pectrum for f-m but said they oped the present region was the est habitat of the service.

Questions asked by the Commis- ioners and the FCC engineering taff indicated that there was much oubt in official quarters that the resent f-m band was the best for he service. These doubts have ap- arently arisen from measurements nade by the FCC on long-distance nterference effects in the region rom 40 to 100 Mc. Dr. L. P. Vheeler of the Commission's en- ineering staff presented a report n these measurements which in- icates the extent of tropospheric nd "burst" interference, sporadic E, and F_2 layer reflections from 'ebruary 1943 to the present date ver distances of from 100 to 1400 niles. Sporadic E-layer propaga- ion was prevalent in the summer nonths, producing field strengths n excess of 25 microvolts-per-meter 2 percent of the time in July 1944, t 900 miles on 44.3 Mc. In the vinter, on the other hand, such elds occurred less than one percent f the time. Such interference vould not, of course, be troublesome n the vicinity of the desired sta- ion, but would cut into the outer mits of the coverage area, where eld strengths are low. The burst- ype of interference was, incident- lly, definitely correlated with neteorite tracks by direct visual bservation, during these tests.

Dr. K. A. Norton, formerly with the FCC and now serving as a ci- vilian consultant to the Army, ap- peared for the FCC to reveal sim- ilar measurements made at the Interservice Radio Propagation Laboratory under the joint control of the Army and Navy. Information previously classified as confidential was released by the Joint Chiefs of Staff for the FCC hearing. Dr. Norton pointed out that F-layer re- flections, present at the longer dis- tances, can cause interference for several percent of the total time during sun-spot maxima, at fre- quencies lower than 60 Mc, and for

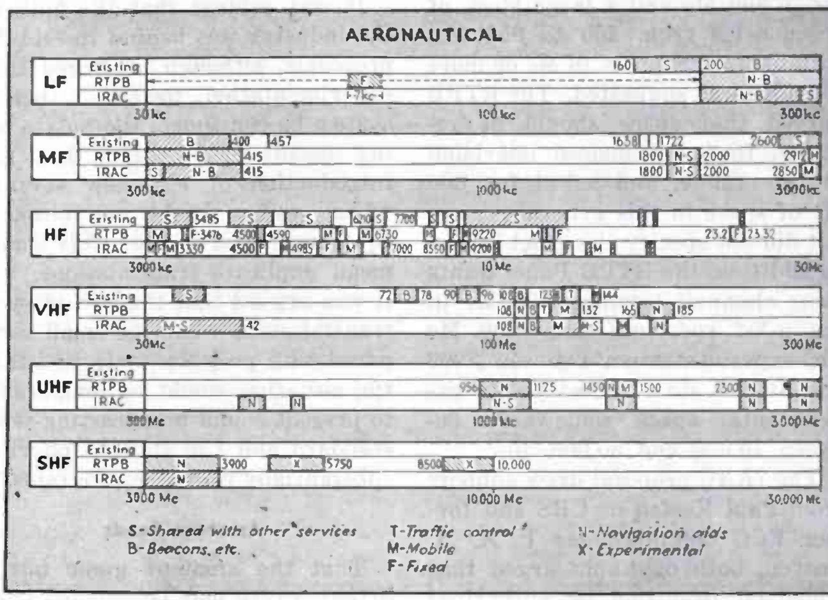


FIG. 6—Aeronautical progress in the post-war years will undoubtedly be rapid. So, spectrum-wise, proposed allocations are just about as broad as they come, with the basis for compromise evident when RTPB and IRAC proposals are compared

appreciable periods even up to 120 Mc. At 88 Mc, he believes that mutual interference between two widely separated stations would be limited to less than one hour per year. But frequencies from 40 to 60 Mc, now urged as the f-m band, are open to serious interference po- tentialities. This evidence has some bearing on television assignments as well, although television assign- ments are higher in frequency, be- cause the picture transmission uses amplitude modulation which is more susceptible to interference than f-m transmissions.

Major Armstrong questioned Dr. Norton concerning these measure- ments, particularly in view of the fact that the most serious interfer- ence effects were noted in an area outside the U. S. A. It was pointed out that the reduction in range of a desired f-m station due to these ef- fects might amount to a decrease from 120 miles range to 60 miles range in the case of a powerful transmitter but much less reduction in the case of lower power transmit- ters. It was also pointed out that the interference effects are serious only in the maximum sunspot years, and then in the middle of the day.

Television Broadcasting

Panel 6 of the RTPB, whose re- port has been discussed at length in these pages (ELECTRONICS, August, p. 92), recommended that the pres- ent television standards be changed only in one major respect, a reduc- tion of the maximum frequency deviation of the associated f-m sound signal. Again the discussion hinged on the extent of the televi- sion band and its position in the spectrum (Fig. 3).

Panel 6 requested nine commer- cial channels in a solid block from 60 to 114 Mc, and 17 additional channels in the range from 120 to 246 Mc. The IRAC urged that 9 channels be assigned from 54 to 108 Mc, but that this amount should suffice for television in the immedi-

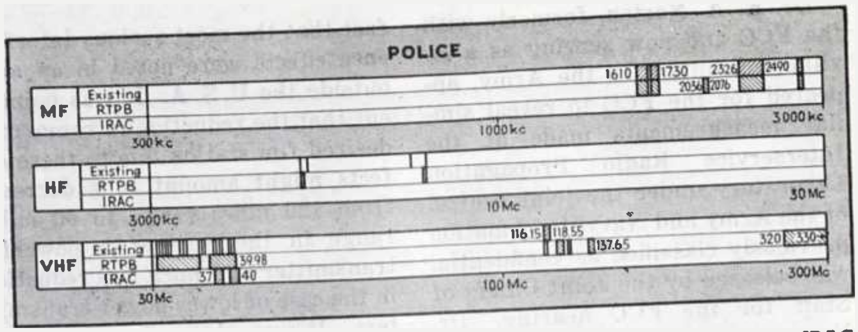


FIG. 7—Police channel assignments represent a bone of contention between IRAC and RTPB. The former would confine all such service to a narrow v-h-f band, the latter would continue existing m-f and h-f bands and open up the v-h-f too

ate future. It was, furthermore, recommended that television of the more distant future should reside above 400 Mc and a large block of frequencies from 460 to 956 Mc, suitable for channels 16 Mc or more in width was suggested. The RTPB agreed that space should be reserved for experimental television in this range, and asked for 600 Mc of space in this general region, but did not specify the exact limits. In addition, the RTPB Panel wants relay channels totalling 600 Mc in the u-h-f spectrum and 1200 Mc for experimentation between 3000 and 10,000 Mc. It also wants experimental space somewhere between 10,000 and 30,000 Mc.

The IRAC proposal drew support from Paul Kesten of CBS and former FCC Commissioner T. A. M. Craven, both of whom urged that wideband television be authorized now in channels in the vicinity of 500 to 1000 Mc. Mr. Kesten urged that the present service on channels up to 108 Mc be continued but that the public be warned that it is an interim service to be replaced as soon as possible by a higher definition service. To this point of view representatives of RCA, and others supporting the RTPB, took violent exception. It was pointed out that there was no equipment or system available, even in the laboratories, to use a channel substantially wider than 6 Mc, and it was argued that if the service were not established, without reservations, on channels from 60 to 114 Mc, television for the public would be put back at least five years. It was also pointed out that network connections involving a 16-Mc band were at present impossible and that such higher quality service could not be supported without syndicating the costs over a network.

It was evident that the bulk of the industry was behind the RTPB proposals, although all urged that experimentation toward a better system be continued, the public being meanwhile assured that the introduction of any new service, when ready, would not obsolete equipment then in use. This would mean duplicate transmissions, but it was argued that the cost of such transmissions would be small compared with program costs, and that the situation would be comparable to present sound broadcasting with standard and f-m stations offering substantially the same programs.

Amateur Bands

That the amateur game has a bright future may be guessed from the proposals shown in Fig. 4. The IRAC (and RTPB) recommends that the 160 meter band be eliminated in favor of a navigational service, still classified in nature, but evident to those who have monitored this band in recent months. The American Radio Relay League (ARRL) appears almost resigned to this loss, but officially requests that the band, or as much of it as possible, be reinstated at the close of the war.

ARRL proposes that the 80, 40, 20 and 10 meter bands remain unchanged, and the IRAC proposes only minor changes, including less space on 80 meters and more on 40 meters.

ARRL and IRAC urge a new band at 15 meters, space not widely useful to other services.

The IRAC urges that the five meter band be given to television and FM, but ARRL (and RTPB) urge it remain unchanged.

The real pie for the experimentally inclined amateurs lies above 400 Mc. Here the ARRL proposes a series of seven harmonically related bands which run clear up to 30,000 Mc (1-cm). IRAC agrees that the hams should have room in this region, offering six bands up to 22,000 Mc.

The ARRL revealed that surveys of postwar prospects indicate a ham population of over 100,000 at the conclusion of hostilities and 250,000 five years later. GI-Joes trained in electronics are going to wind up in a very dense crowd indeed!

Industrial, Medical, Scientific Service

The RTPB proposals shown in Fig. 5 are perhaps the most startling of all those presented at the Hearing.

It is urged that the interference caused by industrial heating equipment, diathermy machines, cyclotrons, etc. generating r-f power be recognized and that these sources of interference be herded into bands especially reserved for them. U-

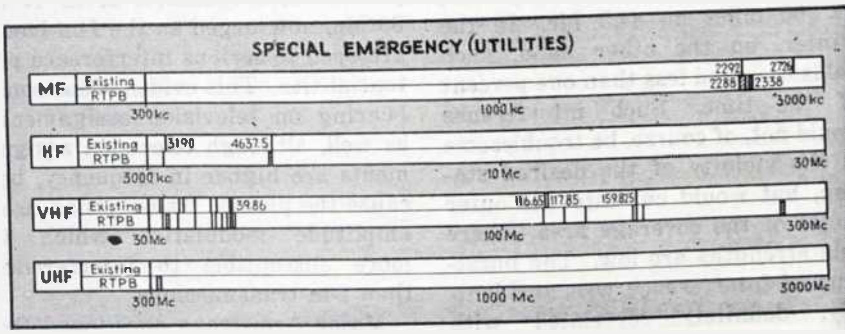


FIG. 8—Special emergency services such as those used by public utilities will gain a few frequencies, but nothing radical in this direction

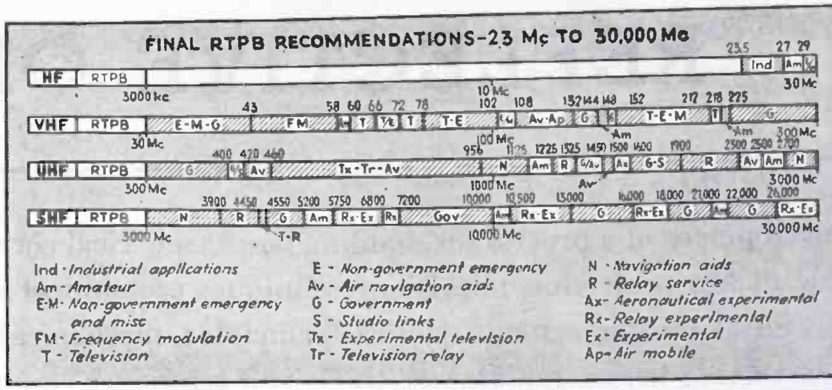


FIG. 9—Final RTPB recommendations relative to assignment of frequencies between 23 and 30,000 Mc, representing a compromise on certain conflicting proposals presented earlier, concluded the FCC Hearing

f·tunately, interference created h such devices covers the whole sectrum, and certain specific freqencies are needed for efficient qiipment operation. For example, a wide band from 25 to 30 Mc is rquired for self-excited oscillators o the diathermy type.

Since none of the services incded in this category is a radio s·vice per se, there remains a legal qestion as to whether the Communications Act covers them. That t͏e idea of considering allocation is a good one cannot be doubted, but t͏e conflict of the proposed allocaton with other services is only too eident.

Aeronautical Channels

In aviation, the radio business reets a partner whose post-war rospects are very similar to its on, that is, much down from warme levels but much up from prear levels.

To meet the needs of the expandg air services, Panel 11 of the TPB proposed the scheme shown i Fig. 6. Spectrum-wise, this allotion is just about as broad as they me, extending from below 200 kc 10,000 Mc. It would permit an rplane to be entirely filled with dio equipment to the exclusion of ssengers.

Specifically, RTPB and IRAC ree that the radio-range beacon nd from 200 to 400 kc be conued and extended to 415 kc. They th agree that the band from 1800 2000 kc, lately the province of the nateurs, should be reserved for a w navigation device. The region om 3000 kc to 30 Mc, now thorighly populated with air-toround and fixed point-to-point air rvice, is continued, with more ace reserved exclusively for avition.

IRAC asks for space from 30 to 2 Mc, but RTPB has other plans r this (police and similar serves). IRAC and RTPB Panel 11 gree that the region from 108 to 32 Mc now widely used for airport ontrol should be continued. Here, owever, a conflict exists with the TPB television plan.

Between 956 and 3900 Mc the RAC and RTPB have got together, for a variety of services euphemistically called "navigational."

Police and Special Emergency

The police were somewhat put out by the IRAC plan shown in Fig. 7, which proposes to liquidate the present police bands in favor of two narrow channels between 37 and 40 Mc. Apparently the Independent Radio Advisory people have had unfortunate experiences with parking tickets.

The RTPB, on the other hand, recognizes police radio service as essential, and proposes that the existing bands below 30 Mc be consolidated, and full bands from 30 to 40 Mc be assigned to mobile police to replace the present individual channels in that part of the spectrum. Larger groups of space are also requested between 116 and 118 Mc, and from 320 to 330 Mc.

The importance of special emergency service used by electric, gas, water and transport utilities was explained by RTPB Panel 13, but the requests for new space only slightly exceed existing facilities, as shown in Fig. 8. Two new bands near 300 Mc are requested. It was pointed out that v-h-f and u-h-f bands are not always useful for emergency service due to shadows thrown by buildings and hills, which may be circumvented by m-f and h-f assignments.

Other Communications Services

The broad subject of handling telegraphic and telephonic messages between fixed and mobile points was taken in hand by Panel 8 of RTPB. There is a considerable variety of services involved here, including coastal and ship telegraph and telephone, point-to-point telegraph and telephone, and, in the higher frequencies, special remote-controlled telephone service for rural regions.

The hearings ended November 3, following presentation by RTPB Panel 2 of final recommendations, based on all evidence presented, for allocations from 23.5 to 30,000 Mc. This allocation, shown in Fig. 9, is expected to have great influence on the final decisions of the Commission.

Time was not available to prepare a full digest of this latter report. However, the most prominent feature is the recommendation that television and non-government emergency services be placed on shared channels from 60 to 212 Mc, providing 18 six-megacycle television channels and also permitting emergency service to use this space in areas where no mutual interference would be caused. The five-meter amateur band is retained in abbreviated form, and f-m broadcasting is given the space from 43 to 58 Mc. The television band recommended by IRAC from 460 to 956 Mc is specified for television broadcasting, but on an experimental basis, in line with previous RTPB recommendations.

Comparisons between this allocation and the other proposals illustrated show a general trend of compromise, which is the only possible approach to a very complicated problem.—D.G.F.

REFLECTIVE OPTICS IN

Development of a process for molding large aspherical correcting lenses from clear plasti[c]
now makes projection television techniques economical and practical for home receiver[s]
as well as theater systems. Optical principles, mechanical mounting problems, design o[f]
correcting lenses, molding methods and a receiver console arrangement are presented

By I. G. MALOFF and D. W. EPSTEIN

RCA Victor Division
Radio Corp. of America
Camden, N. J.

RCA Laboratories
Princeton, N. J.

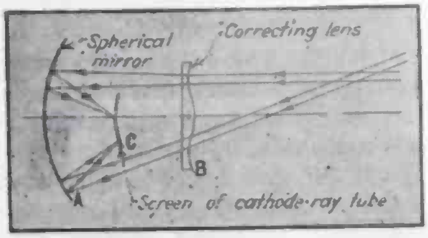
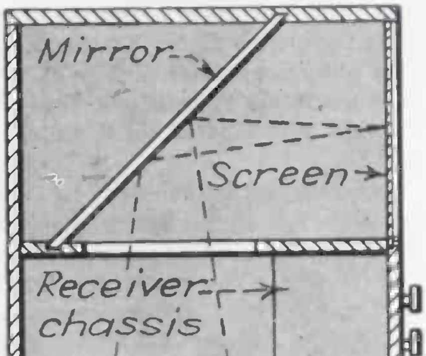


FIG. 1—Optical system of the so-called Schmidt astronomical camera, adapted by RCA for use in projection television systems



Arrangement of optical system for a home television receiver employing reflective optical principles. This design gives a large-screen picture with a console cabinet no deeper than that of an ordinary home radio receiver

IT has been known for a long time that aspherical surfaces in combination with either spherical or aspherical mirrors may be arranged into optical systems of high aperture and high definition. Astronomers made use of this principle in an arrangement consisting of a spherical mirror and an aspherical lens; however, high costs and difficulties in constructing such systems prevented their general utilization.

In searching for efficient optical systems for projecting television images originating on screens of cathode-ray tubes, the principle of reflective optical systems has been made a subject of concentrated study and experimentation. This has resulted in the development of a number of reflective optical systems suitable for projecting television images with diagonals ranging from 25 inches to 25 feet. RCA systems consist of a spherical front surface mirror and an aspherical lens, positive in the central portion and gradually changing into negative near its periphery. The gain in illumination on the viewing screen with the new systems is about six or seven to one when compared with a conventional $f/2$ lens. The quality of the images obtained is comparable with images produced by conventional projection lenses.

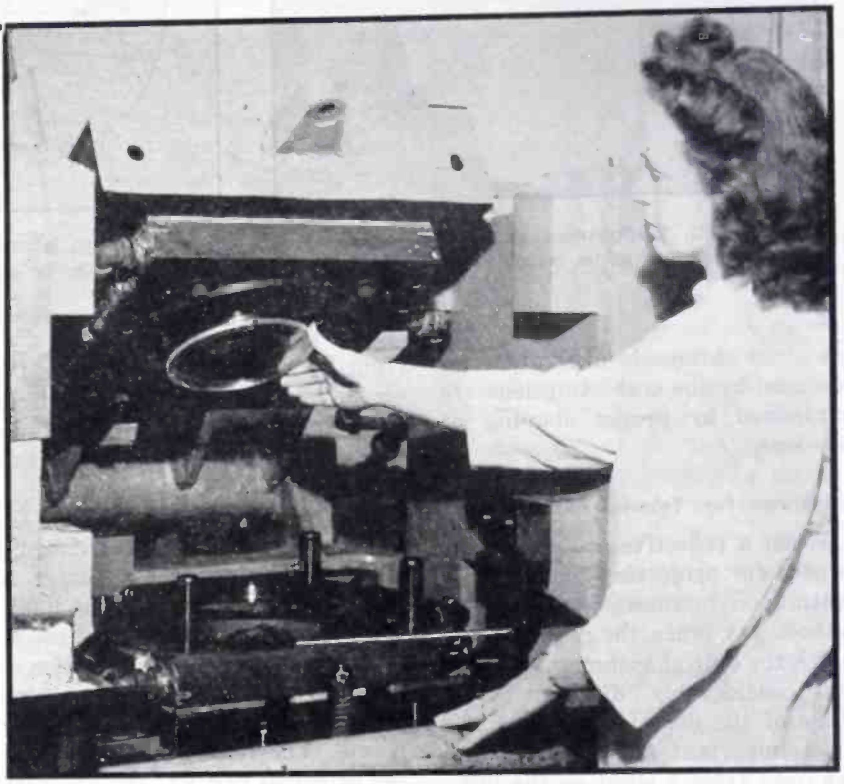
The main handicap of the new system, the high cost of the aspherical lens, has been overcome by the development of machines for mak[ing] aspherical molds and by devel[op]ment of a process for molding aspherical lenses from plastics. RCA reflective optical systems ar[e] designed for a fixed image distanc[e] and require cathode-ray tubes hav[ing] face-curvatures fixed in rela[tion] to the curvature of the mirror in the system. The last two factors while limiting the versatility of [a] given system, appear to be a smal[l] price to pay for the manifold gai[n] in light. The design, manufactur[ing], installation and servicing o[f] the RCA reflective optical system[s] have been improved and simplifie[d] to such a point that these system[s] can be considered as proven tool[s] in television and oscillographi[c] techniques. Reflective systems de[signed] for infinite throw have bee[n] already applied successfully to tele[vision] outdoor pickup cameras wit[h] the same manifold gain in light.

Analysis of the Problem

The problem of projecting im[ages] originating on the screens o[f] cathode-ray tubes has received [a] great deal of attention from in[vestigators] here and abroad over [a] period of years. It has been show[n] that the space distribution of ligh[t] emitted by the screen of a cathode ray tube follows very closely th[e] cosine or Lambert law of perfectl[y] diffusing surfaces. When a len[s]

From a paper presented at the Nationa[l] Electronics Conference, Chicago, 1944.

PROJECTION TELEVISION



Molding press used for producing plastic correcting lenses for projection television systems

ıch as the conventional motion-icture projection lens is used to roject a cathode-ray tube image nto a viewing screen, the overall fficiency of such a system is ex-remely low.

In motion-picture projection most f the light striking the film delivered to the viewing screen, xcept of course for the light ab-orbed by the darkened portions of ıe film, thus creating the picture self. However, when projecting ght from a perfectly diffusing sur-ace onto a viewing screen by ıeans of the same lens, much of the ght is lost. For large magnifica-ions the following relation holds:

$$\frac{\text{(lumens on viewing screen)}}{\text{(lumens on tube)}}\ 100\% = K\,\frac{1}{4f^2}\,100\%$$

vhere K is the transmission coef-icient of the lens and f is the f/umber of the lens[2]. Good, commer-ially available, treated projection enses having a relative aperture of /2 and a transmission coefficient f nearly 100 percent, collect from he tube and deliver at large mag-ification to the viewing screen nly 6.25 percent of the light gen-rated.[3]

The image on the face of the athode-ray tube is obtained at a elatively high cost in equipment, ffort and power. Any increase in he brightness of this image may be btained only at great cost from the tandpoint of design and operation. For this reason, the problem of roviding a more efficient optical rojection system has received a great deal of attention. Improve-ment of a few percent was of no interest. A manifold increase in the percentage of light delivered to the screen was sought. The answer was finally found in modifying a prin-ciple known to astronomers and adapting it to the problem on hand.

For quite a long time,[4,5,6] astronomers and opticians have known that optical systems combining spherical and aspherical mirrors and surfaces are capable of working at very high relative apertures and at the same time are remarkably free from optical defects. Schmidt[6] applied this principle to astrophotography. The so-called Schmidt camera is an optical system (Fig. 1) comprising a spherical mirror A and a weak aspherical lens B at the center of curvature of the mirror. Images of distant objects are formed on an image plate C, which in itself is part of a sphere of radius slightly larger than half the radius of the mirror and located at the focal point of the system.[7]

System Used in Astronomy

Of the outstanding defects of the images formed by optical systems (spherical and chromatic aberation, coma, astigmatism, curvature of the field and distortion), only spherical aberration is distributed uniformly over the whole image field; all other defects increase with the distance from the axis. A spherical mirror has no axis and is, of course, achromatic. If a small aperture is placed at the center of curvature of a spherical mirror, then any narrow beam of parallel light coming from any direction through this aperture onto the mirror will focus at a point located on a sphere whose radius is equal to half the radius of curvature of the mirror. If the aperture is increased, spherical aberration becomes apparent and the quality of the image deteriorates.

The correcting lens in the Schmidt arrangement (shown in Fig. 1) introduces into the incident beam an amount of spherical aberration which is equal to that introduced by the mirror but is opposite in sign. Thus, by placing a suitably shaped correcting lens at the center of curvature of the mirror the non-aberration condition for all rays arriving at the mirror from distant objects may be retained. The system is then free from the spherical aberration, while coma, astigma-

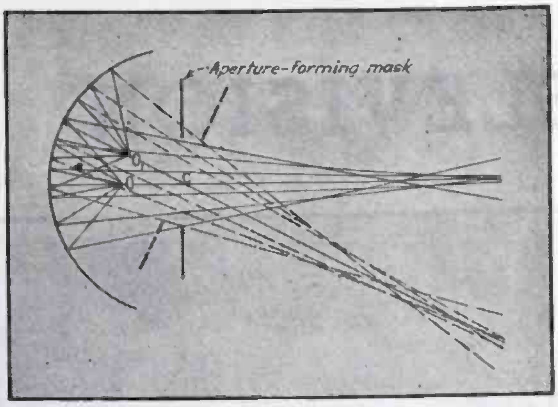


FIG. 2—Spherical mirror with an aperture at its center of curvature

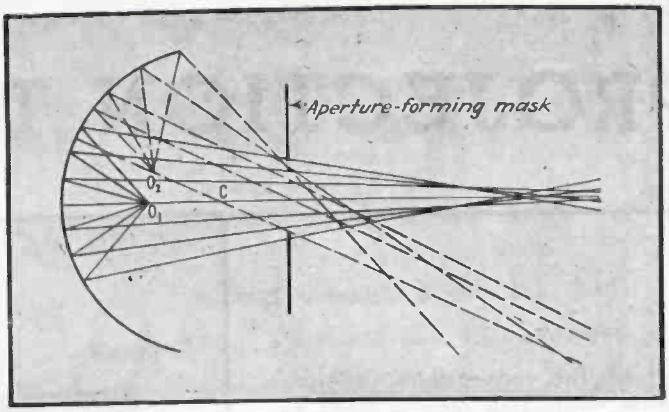


FIG. 3—Spherical mirror with an aperture that is not at the center of curvature

tism and chromatic aberration introduced by the correcting lens are minimized by proper shaping of this lens.

Systems for Television Projection

When a reflective optical system is used for projecting images originating on luminescent screens of cathode-ray tubes, the requirements which the optical system must fulfill are considerably different from those of the Schmidt camera. The most important difference is that the light from a point on the luminescent screen does not emerge from the optical system as a bundle of parallel light. On the contrary, it emerges as a bundle converging to a point or focus at a definite distance. This finite throw system is radically different from that of the infinite throw. The other difference is that the thickness of the glass face plate of the cathode-ray tube introduces a certain amount of spherical aberration, which has to be taken into account when balancing the spherical aberration of the correcting lens against that of the mirror.

The outstanding advantage of an optical system such as that shown in Fig. 1 over a more conventional optical system is its ability to focus a large field (large tube diameter) with a large relative aperture. As was mentioned already, such a system possesses this property primarily because a spherical mirror with an aperture located at the center of curvature of the mirror suffers from only two aberrations, spherical aberration which is uniform all over the field, and curvature of the field. This may be seen from Fig. 2 and 3, where C is the center of curvature of the mirror and O_1 and O_2 are object points located on the axis and off the axis respectively.

Figure 2 shows the ray paths for these two object points with the aperture located at the center of curvature. It is seen that the image or rather the circle of least confusion, since spherical aberration is present, is practically of the same size and symmetry for both object points. The reason for this is that the principal ray, i.e., the ray passing through the object point and center of the aperture also passes through the center of curvature of the mirror, and is therefore also an axis of symmetry for the sphere. The only difference is that the circular aperture mounted perpendicular to the principal axis and therefore symmetrically located with respect to the principal axis is non-symmetrically located with respect to the auxiliary axis. This causes some non-symmetry in the light distribution of the circle of least confusion but this non-symmetry becomes of importance only in the case of very large fields (large objects).

Figure 3 shows the imaging properties of a mirror with the aperture located not at the center of curvature. It is seen that there is barely any sign of image formation for the off-axis object point.

Purpose of Correcting Lens

The object of the correcting lens is to correct for the spherical aberration of the mirror without introducing any serious aberrations of itself. This is accomplished by making the correcting lens as weak as possible and locating it in the plane of the aperture at the center of curvature. In this way, the symmetry property of the spherical mirror is least disturbed. The curvature of the field is not corrected as it is actually used to good advantage in cathode-ray tube projection.

The spherical aberration of the mirror may be interpreted as focusing by means of zones, each zone having a different focal length. The correcting lens has to be such that each zone of the lens has a different focal length, compensating for the various focal lengths of the mirror and resulting in a focusing system with all zones of the same focal length.

The shape of the correcting lens will thus depend upon the zonal focal length of the mirror one chooses as the focal length of the optical system (mirror plus correcting lens). Since theoretically there are an infinite number of zones on the mirror, there are theoretically an infinite number of correcting lens shapes that will produce a system in which all zones have the same focal length.

Since the mirror with an aperture at the center of curvature has no extra-axial or chromatic aberrations, such aberrations are caused by the correcting lens itself, i.e., by the power or slopes on the correcting lens. From the standpoint of these aberrations, therefore, that shape should be chosen whose maximum slope is the least. Thus if the paraxial (central) focal length of the mirror is chosen as that of the system, then the central foca ngth of the correcting lens is in- nite and the shape of the curve is oncave. Alternatively, if a zonal ocal length of the mirror is chosen s that of the system there will be zonal focal length of the correct- ıg lens which is infinite and the ıape of the curve is convex at the enter and concave past this zone. f a peripheral focal length is ıosen, the required correcting lens convex. The maximum slope is ast for a convex-flat-concave ırve.

The shape and size of the cor- ecting lens depend upon the throw r magnification for which the sys- em is to be used. For a given focal ngth and relative aperture, the orrecting lens aperture decreases s the magnification decreases. hat this must be so, may be sur- ized from the fact that for unity ıagnification the plate aperture is ero, since object and image coin- de at the center of curvature.

Figure 4 shows the variation of orrecting lens aperture and mirror perture with magnification. Thus, different correcting lens is re- uired for each throw or magnifica- on. If a high relative aperture stronomical Schmidt camera is sed for projection at a throw only few times the focal length, the re- ulting image is of poor quality. he reason is that a high relative perture optical system can be well- orrected for only one position of bject and image. The throw or ıagnification tolerance for a given orrecting lens decreases with in- reased relative aperture for a iven resolution.

To obtain a flat image field, i.e., ocus on a flat viewing screen, it is ecessary that the object field or ıbe face be curved. Calculations how that in general the shape of ube face depends on the throw—a phere for infinite throw and an llipsoid for finite throw. The ec- entricity of the ellipsoid is suffi- iently small, however, so that even or finite throw the tube face may e made spherical with a radius of urvature equal to that of the focal ength of the system.

Design of Correcting Lens

The shape of the correcting lens nust be such that all rays emanat- ng from an object point O, and eflected by the mirror, shall meet at the image point I located at a distance S from the correcting lens. Figure 5 shows three rays emanating from O and striking the mirror at different apertures. Without the presence of the correcting lens, rays 1, 2, 3 would intersect the axis at distances q_1, q_2, and q_3 from the center of curvature. The slopes on the correcting lens have to be such (approximately as shown on Fig. 5) that all three rays intersect at I; hence, the correcting lens has a flat zone at the point where ray 2 passes, negative slope where ray 1 passes and positive slope where ray 3 passes.

Considered from the point of view of spherical aberration, if the zone where ray 2 strikes the mirror is taken as a reference, then the mirror has negative spherical aberration for smaller apertures and thus requires a positive lens for correction, and positive spherical aberration for larger apertures and thus requires a negative lens.

The shape of the curve of the correcting lens for any throw may be calculated to about the same accuracy as that obtained with the equation given by Hendrix and Christie[7] for infinite throw, from the formula

$$d = \frac{1}{N-1}\left[\frac{1}{4}\left(\frac{1-p}{p}\right)^2 x^4 - \frac{1}{2}\left(2+\frac{1}{s}-\frac{1}{p}\right)x^2\right] \qquad (1)$$

or from its equivalent

$$d = \frac{1}{N-1}\left[\frac{1}{4}\left(\frac{m-S}{S}\right)^2 x^4 - \frac{1}{2}\left(\frac{2S-m+1}{S}\right)x^2\right] \qquad (2)$$

where d is the depth of the curve at the zone of radius x, p is the distance between object (tube face) and center of curvature of the mirror, S is the distance between image (viewing screen) and center of curvature of the mirror, and m is the magnification. The relation between the quantities p, S, m and the focal length f of the system is given by

$$S = mp \qquad (3)$$

$$p = f\,(m-1)/m \qquad (4)$$

$$S = f\,(m-1) \qquad (5)$$

All distances in the above equations are measured in terms of the radius of curvature of the mirror, i.e., the radius of curvature is taken as the unit of length.

In applications such as projection television, the light emitted by the luminescent screen first passes through a thickness of glass constituting the tube face. Although the effect of the tube face is small in cases of high f/number, it becomes quite appreciable for a low f/number system. The fact that the tube face is curved endows it with some power and actually alters

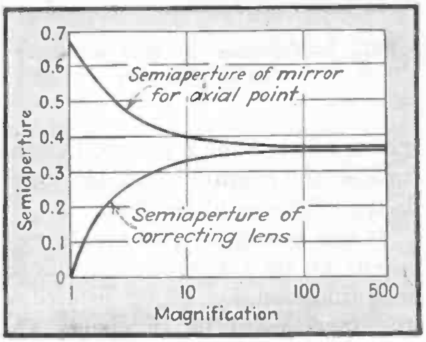


FIG. 4—Manner in which the semiapertures of the mirror and correcting lens vary with magnification

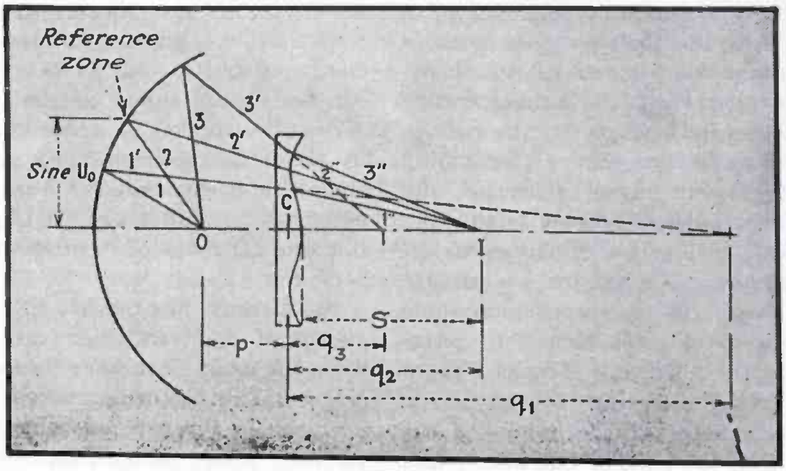


FIG. 5—Diagram illustrating how a suitably designed correcting lens makes the required corrections for spherical aberration

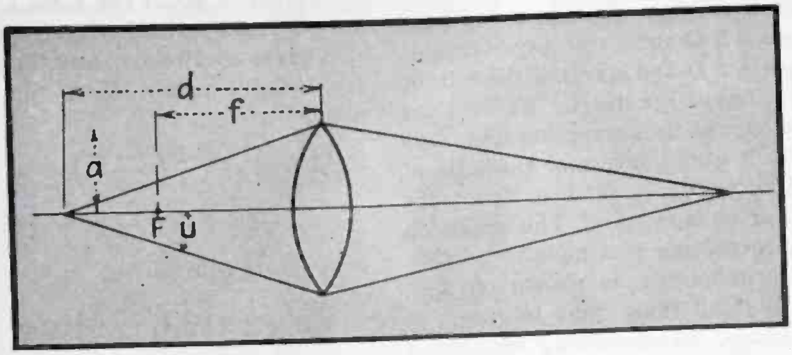


FIG. 6—Efficiency of a simple lens decreases as the lens is moved away from its source to decrease the magnification

the magnification of the system slightly. However, the largest effect of the tube face is caused by its spherical aberration. The presence of the tube face necessitates a change in the shape of the correcting lens. For a convex-concave correcting lens, the spherical aberration of the tube face calls for greater correction from the convex portion and smaller correction from the concave portion.

Equations (1) and (2) are not sufficiently accurate to determine the shape of the correcting lens for systems with high relative apertures. It was found that the best method of determining accurately the shape of the correcting lens is the old reliable and rather tedious, but very accurate method of tracing rays through the system consisting of the tube face, mirror and correcting lens.

Projection Efficiency

The projection efficiency of any optical system will be defined as the percentage of the total light flux, in lumens, emitted in a forward direction by an axial element of a perfectly disffusing source, such as a luminescent screen of a cathode-ray tube, which the optical system accepts and focuses on the corresponding image element, assuming 100 percent mirror reflection and 100 percent lens transmission.

The efficiency, e, in percent as defined above is given by: $e = 100 \sin^2 U$. where U is the semi-apex angle shown on Fig. 6. Hence, to determine the efficiency of a lens for a perfectly diffusing source, it is merely necessary to know the angle that the lens, or entrance pupil, subtends at the source. As may be seen from Fig. 6, the farther a given lens is from a source, i.e., the smaller the magnification, the lower is the efficiency of the lens.

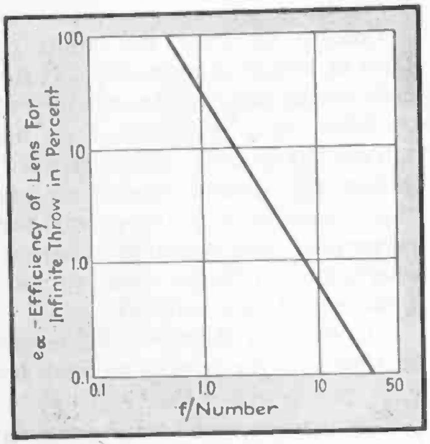


FIG. 7—Variation of lens efficiency with its f/number

It has become customary to rate a lens by its f/number for infinite magnification, i.e., object located at the focal point of the lens. The f/number is defined as

$$f/\text{number} = 0.5 \sin U = 0.5 \sqrt{e_\infty}$$

where e_∞ is the efficiency (a fraction, not percent) for infinite magnification. The smallest f/number possible is 0.5, since at 0.5 the efficiency is unity and all the light emitted by the object element in a forward direction is concentrated in the image element. Figure 7 shows the efficiency e_∞ of a lens as a function of f/number. It is seen that the efficiency of most lenses is very low.

As already mentioned, the efficiency of a given lens decreases when the magnification or throw decreases. This factor becomes of importance in the case of home projection, where magnifications as low as 5 may be used. Thus an ordinary $f/2$ lens having an e_∞ of 6.25 percent will have an efficiency of 4.6 percent when used for a magnification of 6.

Since the reflective optical systems under consideration are designed for a specific magnification and since the central part of the system is masked to maintain contrast, this part being blocked by the cathode-ray tube, it seems preferable to rate such systems by their efficiencies rather than f/number.

Let e_o be the efficiency of the system with no masking and e_1 the efficiency of the central part of the system that is masked. The efficiency e of the masked system is then simply

$$e = (e_o - e_1)\ 100\%.$$

Here e_o and e_1 (fractions, not percent) may be calculated approximately from the equations

$$e_0 = \frac{h_c^2}{p^2} = \frac{h_c^2}{f^2}\,\frac{m^2}{(m-1)^2}$$

$$e_1 = \frac{h_t^2}{f^2}\left(\frac{m^2}{m^2-1}\right)^2$$

where h_c is the semiaperture of the correcting lens and h_t is half the diameter of the tube face. For high-efficiency systems e_o will be above 40 percent and e_1 approximately 10 percent so e, the efficiency of the system with blocking, will be about 30 percent. Neglecting losses in the system, about 30 percent of the light emitted by an axial point will be focused into an image point. This corresponds to the efficiency of an $f/0.8$ lens used at a magnification of 6.

Alignment Requirements

The center of the correcting lens must be located at the center of curvature of the mirror and, for uniform illumination over the field, the axis of symmetry of the correcting lens should preferably coincide with the axis of symmetry of the periphery (circle) of the mirror. The tube face must be located so that the center of curvature of the tube face lies on the axis of symmetry of the correcting lens. For uniform illumination over the field, the axes of symmetry of periphery of tube face and correcting lens should preferably coincide. The tube face should, of course, be located at the correct axial distance from mirror or cor r-ting lens for focusing. The viewing screen should be normal to the axis and at the correct throw.

The most critical alignment items are: (1) Lateral displacement of the center of the correcting lens from an axis of symmetry of the mirror, i.e., a line passing through the center of curvature of the mirror; (2) Lateral displacement of the center of curvature of the tube from the axis of symmetry of the system. For good resolution these displacements should be kept within .001 R, where R is the radius of curvature of the mirror. The permissible tolerances on other alignments are about 10 times greater.

There are two distinct applications for projection television, namely, in theater television equipment and in television receivers for home use.

Projection Receivers for Home

In a self-contained projection television receiver[6] the optical system can be mounted near the floor with its axis vertical, projecting the image straight up and onto a flat mirror inclined at 45 deg to the incoming beam of light, and throwing the image on a translucent screen. Such an arrangement presents the advantages of compactness, relatively small depth of the cabinet and can be styled along the familiar lines of a radio console.

A number of such reflective projection systems suitable for home receivers of the type described have been designed, built and operated in actual receivers. The smallest of these was built for use with a cathode-ray tube having face diameter of 3 inches, and consists of a spherical mirror 9 inches in diameter and a correcting lens 6 inches in diameter. The largest has tube, mirror and lens diameters of 5, 14 and 9.5 inches respectively. A number of systems in sizes intermediate between the two just described have been built. The throw or distance between the correcting lens and the viewing screen varies between 36 and 54 inches and the optical efficiencies are between 18 and 35 percent. In resolution and contrast these systems compare favorably with well-corrected conventional projection lenses, and do not limit the performance of present television systems.

Systems for Theaters and Cameras

A description of the RCA theater television system was published several years ago.[3] The optical system consists of a 30-inch mirror, 22.5-inch correcting lens and operates with a cathode-ray tube 7.5 inches in diameter. Figure 8 shows the optical system with the cathode-ray tube in place. The control console may be seen in the background.

Reflective optical systems built for infinite throw find useful application in television pickup cameras under conditions of low illumination, such as during the last minutes of a football game or in direct pickup from a theater stage. The great light-gathering power of these optical systems is demonstrated in Fig. 9. An optical system with infinite throw was pointed from a window in Camden, N. J., toward the Philadelphia skyline. The bright image of the skyline can be seen inverted on the dummy tube face, undestroyed by the full daylight illumination.

An interesting modification, applicable to all systems described, is shown in Fig. 10. Here a flat mirror is inserted about half-way between the cathode-ray tube and the spherical mirror. Since the center of the mirror is blacked out to increase contrast, the opaque back of the flat mirror cuts very little of the useful light coming from the tube facing the spherical mirror, but the flat mirror permits placing another cathode-ray tube back of the spherical mirror and facing the flat mirror. Such an arrangement may be used in theater work since both tubes can operate singly with roughly the same optical efficiency. If one tube goes bad the other may be turned on by a flip of the switch. With some technical difficulty both tubes may be operated at the same time, the problem arising in the

FIG. 8—RCA theater television projector, with control console in background

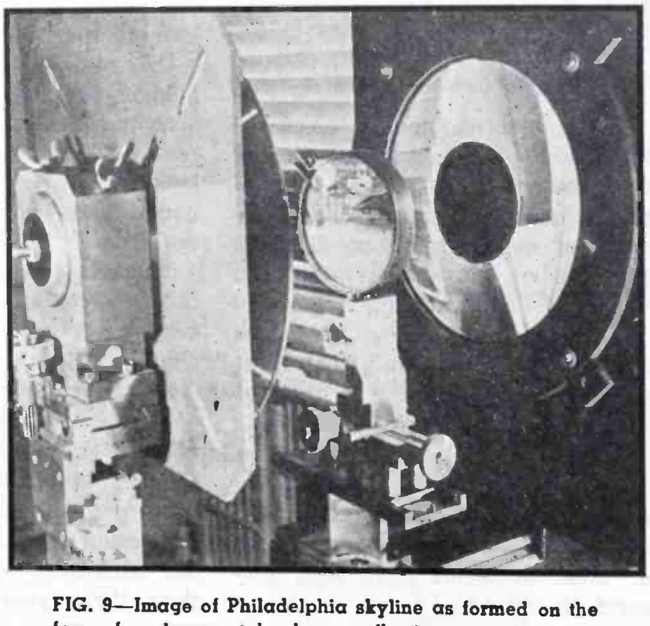


FIG. 9—Image of Philadelphia skyline as formed on the face of a dummy tube by a reflective optical system

exact super-position of two scanning patterns.

Cost Factors in Reflective Optics

The major objection to the use of reflective optics in television receivers has been the high cost of the aspherical correcting lens. The spherical mirror, while quite large, is an old and familiar item to the well-established optical industry, as most of the conventional optical surfaces are spherical and are easily made. The aspherical correcting lens, similar to a figure of revolution developed by rotating a shallow letter S around one of its ends, presents an altogether different problem. Unlike the spherical mirror, such a figure is not a naturally-generated surface and there are no machines on the market for straightforward production of such surfaces. True enough, astronomers, with their traditional patience and lack of hurry, produced excellent aspherical lenses on machines used for making astronomical instruments, but only by tedious step-by-step methods.

In the early stages of the development, RCA used methods and machines based upon astronomical technique. Exceedingly high cost of experimental reflective optics resulted. The gain in light over the conventional projection lens was very attractive, but the cost of such individually produced lenses was prohibitive. The apparent solution to the cost problem was that of molding the aspherical lenses from a suitable transparent material.

Plastic Correcting Lenses

A special development project was undertaken and soon concentrated on investigation of a clear thermoplastic material known under the name of methyl methacrylate, and sold under the registered trade names of Lucite and Plexiglas.

A new set of difficult problems came to the foreground. The most formidable of these was that of making molding surfaces of metal in shapes of the negative replicas of aspherical lenses. Almost as serious was the problem of obtaining optical finishes on metals. Both of these problems have been successfully solved.

A flat disk of hardenable stainless steel is first profiled with the aid of a template. The template itself is filed according to a theoretically calculated curve. The profiling machine has a five-to-one lever action which calls for a template five times deeper than the final curve.

Profiling is done by diamond wheels. The resultant curve is tested on a precision curvemeter, and final adjustments of the curve are done by fine grinding and polishing on a precision polishing machine. The final optical finish of the surface is the result of proper choice of metal, proper hardening and tempering, proper choice of abrasives and polishing agents, and most of all, patience and perserverence.

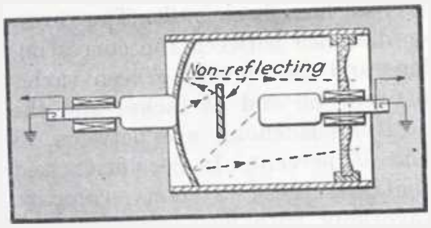


FIG. 10—Bi-reflective optical system, employing two projection television cathode-ray tubes

The molding process is essentially that of applying very high pressure to heated plastic material confined in a heated mold and cooling it under pressure until it reaches room temperature. The mold is then opened and the lens extracted. The only operation which remains is that of boring a hole in the center of the lens for accommodating the protruding neck of the cathode-ray tube. The lens is then ready for use, with no polishing or finishing of any sort required.

Molded correcting lenses for reflective optical systems possess very good optical properties, including slightly better transmission and slightly lesser scattering of light than glass. They do not possess the surface hardness and scratch resistance of glass, but even without any special care or protection they have stood up under laboratory operation for more than three years. The cold flow under operating conditions of three years was found to be negligible. The cold flow depends on the operating temperature, which for the plastic lens of a television receiver is not far from room temperature. Should design considerations call for higher operating temperatures, the new boilable methyl methacrylates can be used.

Mounting Problems

From a practical standpoint, the use of reflective optics in television receivers calls for careful consideration in the mechanical construction of the mounting which supports the optical system and the cathode-ray tube. This mounting, combining "the barrel" and "tube support," has to fulfill a number of requirements: (1) Since the position of the correcting lens with respect to the mirror is rather critical, the mount must provide for positive and simple alignment at the factory; (2) It must be dust-proof, since accumulation of dust on the mirror and correcting lens reduces both the contrast and the illumination, while frequent dusting would be detrimental to the plastic lens and the front surface mirror; (3) It must be electrically shock-proof since in some cases final optical focusing of the picture on the viewing screen must be done with a picture and consequently with high voltage on the cathode-ray tube; (4) The barrel should preferably be made of metal, to cut off x-rays generated by the cathode-ray tube. These rays are very soft and weak; nevertheless, they are measurable and should be screened in; (5) It must provide for positive and convenient initial adjustments of the tube face position along three rectangular coordinates, one of which coincides with the optical axis of the system. These initial adjustments may be carried out by the factory and by experienced servicemen; (6) It must provide for easy tube replacement by people unfamiliar with optics, such as the average serviceman and the customer himself; (7) It must provide for easy and safe focusing after tube replacement; (8) It must be designed to lend itself to such inexpensive manufacturing processes as stamping or die casting, involving a minimum of machining; (9) It must not deform in transportation and during years of service.

Typical Mounting

A layout of a mounting satisfying the requirements discussed is shown in Fig. 11. Here the correcting lens fits into a recess on the top of a metal barrel, this recess being counterbored for a snug fit with the correcting lens. The spherical mirror is mounted on the bottom cover of the barrel by means of a collar and nut through the center hole in the mirror.

The tube support consists of an arm of insulating material anchored on the side of the barrel and a metal ring supporting the face edges of the cathode-ray tube. The tube face is held tight against this ring by suitable springs. The high voltage is brought to the second anode of the tube through a dust-tight hole in the wall of the barrel. The metal ring holding the tube is at high potential, and several inches of Micalex insulate it from ground. The high-voltage cable has a grounded shield on the outside and the barrel itself is grounded.

The tube support arm is arranged to slide back and forth, providing for tube adjustment in a direction perpendicular to the optical axis of the system, say, along a rectangular coordinate x. The support of the arm is arranged to slide along an intermediate supporting plate in a direction y, perpendicular to both the x coordinate and the axis of the optical system. The intermediate supporting plate is made to slide up and down the barrel by means of a screw, providing a focusing means along the axis of the optical system or coordinate z.

The deflecting yoke is supported by the neck of the cathode-ray tube and is equipped with dust-proof gaskets. The top of the barrel may be equipped with a cardboard shield reaching to the upper part of the television cabinet and preventing dust from settling on the upper side of the correcting lens.

The arrangement described satisfies the requirements enumerated more or less completely and allows for variations governed by the individual preference of the designer.

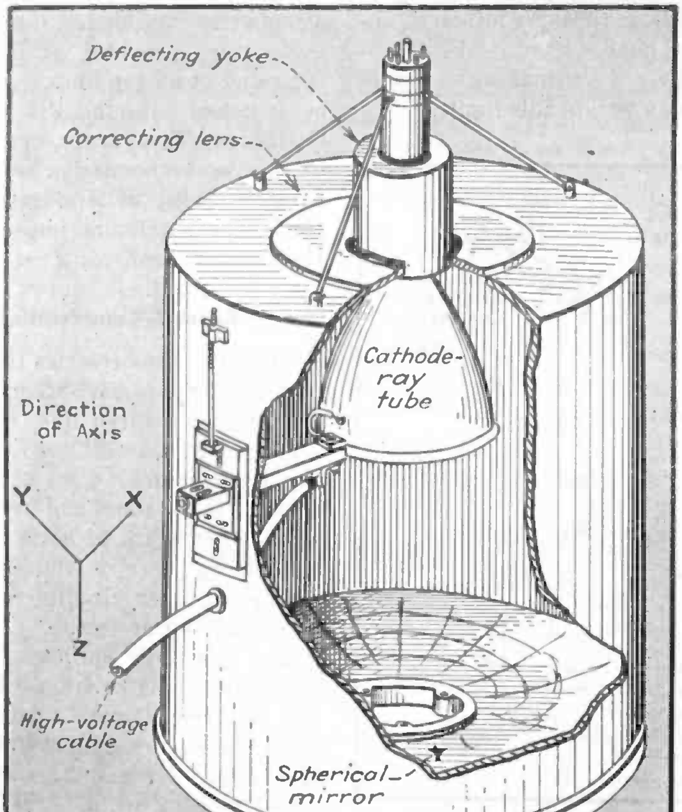


FIG. 11—Method of mounting optical components of a projection television system to give rigidity while permitting adjustments when required

Apparent Detail

If one wants to place an enlargement of a given picture on the wall of a room of a given size, he can find by experiment a size of enlargement that will give an "optimum effect." This size will give a picture that is not unduly blurred and does not require squinting to see the detail. In television with its intrinsic or absolute detail governed by the bandwidth of the channel of the transmitter or the wire channel, the subject of optimum size for a given application is of major importance.

The amount of apparent detail needed for a pleasing television picture will determine how much magnification the picture will stand in any particular application. For a given amount of absolute detail the picture size will be larger for hotel lobby applications than it will be for home use, still larger for auditorium use and much larger for theater use. The exact sizes may vary somewhat but it is believed that the buying public will soon find out what value of apparent detail is the most acceptable for a given use. Consequently, the apparent detail will determine the size of the projected television picture to be preferred for each application.

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F-M CARRIER TELEPHONY FOR 230-KV LINES

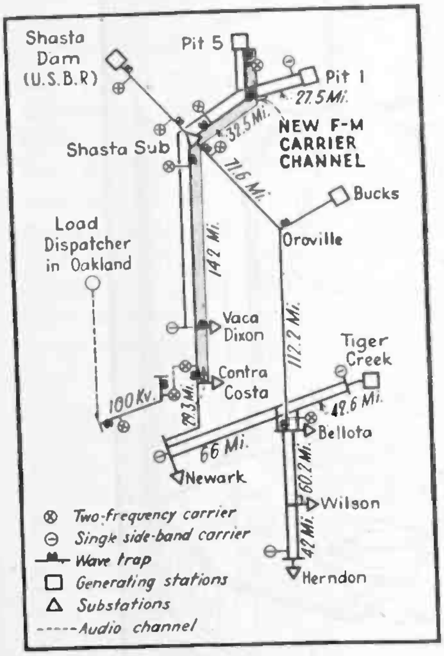
First f-m power line application, on 218-mile Pacific Gas and Electric line between Pit river power house and Contra Costa substation in California, uses 85 kc and 125 kc carriers with one-to-one deviation ration and 6-kc total band width. Signal-to-noise ratio of 32 db is obtained despite inherent noise level due to corona on conductors

THE installation of a frequency-modulated carrier telephone channel on a 230-kilovolt power line of Pacific Gas and Electric Co. constitutes a pioneering step in the field of power line carrier communication. This new channel forms an important link in the company's dispatching system between Oakland, California and the Pit River hydroelectric plant, and is part of a coordinated communication system that will consist largely of transmission line carrier circuits.

When it became necesary to provide additional communication facilities from the dispatching office to Pit 5 and the government's Shasta Dam plant which now feeds into the PG&E system, consideration was given to the three types of carrier thus far developed, namely the single side-band and double side-band a-m systems and the more recently developed f-m system.

It had been demonstrated by E. W. Kenefake, engineer in the electronics department of General Electric Co., that an f-m system operating within the power line carrier band of 50 to 150 kc, rather than in the 42 to 50-Mc band of f-m space radio possessed desirable signal-to-noise levels for power line carrier applications, particularly on lines having high noise level due to corona and other causes.

In developing an f-m system for transmission-line carrier, the problem was not alone that of dropping in frequency, which was comparatively simple, but also of limiting the bandwidth so as not to exceed that used for a-m carrier equipment, in order that an equal number of f-m channels could be accommodated in the most useful frequency range of 50 to 150 kc. A further consideration was the desirability, if not necessity, of using available line traps, coupling capacitors and line tuning equipment designed to handle bandwidths of approximately 6 kc, making it desirable to stay within this limit.



Map showing carrier telephone channels on the Pacific Gas and Electric Co. 230-kv system linking five generating stations in the California mountains with the load dispatcher in Oakland. The new f-m carrier link between Contra Costa substation and the Pit 5 generating station is described in this article

The line from Contra Costa to Pit 5 has been in existence for a number of years, and the conductor has a rough rope-lay surface which gives considerable corona and high noise level. Interphase coupling, which uses two-phase conductors of a transmission line, as a pair of wires, was used to minimize line attenuation and noise level. Line traps were provided at both stations and at all tap lines that might be switched onto the Pit 5-Contra Costa line. These traps, one in each of the two transmission conductors at each point of application, are tuned for maximum impedance at the frequencies used.

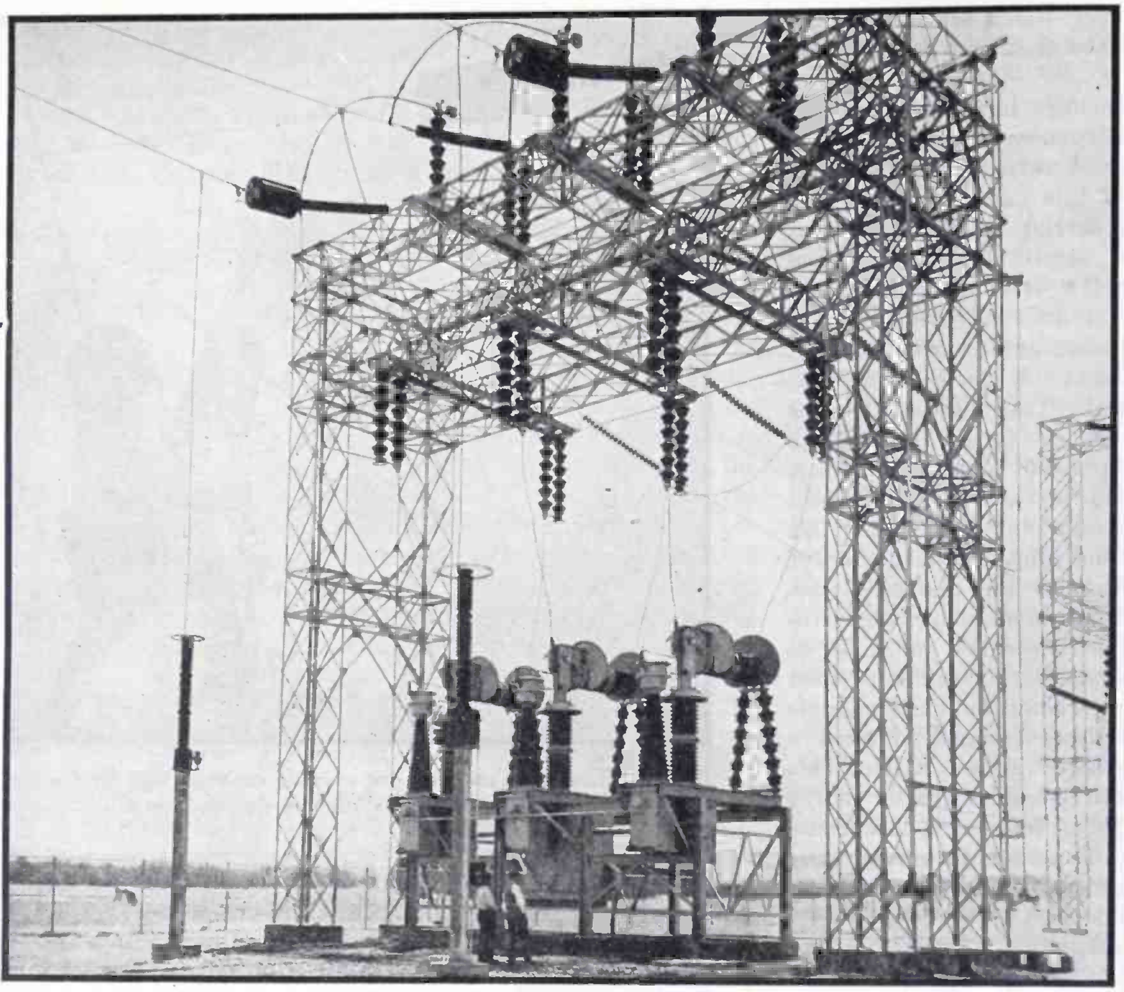
Channel Considerations

The line traps restrict the major portion of the carrier-frequency energy to the desired line, eliminate serious reflection difficulties resulting from switching on other portions of the system, and greatly reduce the strength of noise or other interfering carrier signals originating on other circuits connected to the 230-kv system.

The new f-m equipment is adjusted to use 85 kc from Pit 5, and 125 kc from Contra Costa, these being chosen to coordinate with the eight other frequencies soon to be added, six of which are for a-m equipment and two for additional f-m equipment.

Deviation Ratio

The choice of a one-to-one deviation ratio for 100-percent modula-



Standard coupling capacitors and line traps used at the Contra Costa 230-kv substation for the f-m carrier telephone channel. Traps direct the carrier energy over the desired line, and reduce interfering signals or noise that might enter from other lines. This permits closer spacing of carrier channels on the system as a whole, making more channels available for communication service

ion met both the bandwidth and ne trap requirements. With the w carrier frequency, however, his deviation gives a frequency hift that is a larger percentage f the carrier frequency than is sed in present f-m broadcast practice. Thus, a 3000-cycle shift is 6 ercent of a 50-kc power line carier, whereas the standard 75-kc hift of a broadcast transmitter at 0 Mc is only 0.2 percent. The percent shift gives readily attainble bandwidth requirements for ne receiver and coupling apparatus, along with a high degree of odulation.

A picture of what a one-to-one eviation ratio produces in the way f side bands can be obtained by onventional mathematical analyis. For a modulating frequency of 000 cycles, this shows that most f the side bands are confined to a andwidth of ±3000 cycles. Of ourse, if the utmost in fidelity is desired, some of the side bands extending beyond 3000 cycles would have to be transmitted and received, but actually the elimination of these extreme side bands constitutes a loss of only about four percent of the total energy in the modulated wave. This elimination of the extreme side bands produces a small amplitude modulation of the carrier, but the limiter in the receiver restores the carrier to a constant amplitude. The distortion resulting from elimination of higher side bands is entirely negligible for a commercial channel designed for use with standard telephone instruments and facilities.

Power-Line Noise

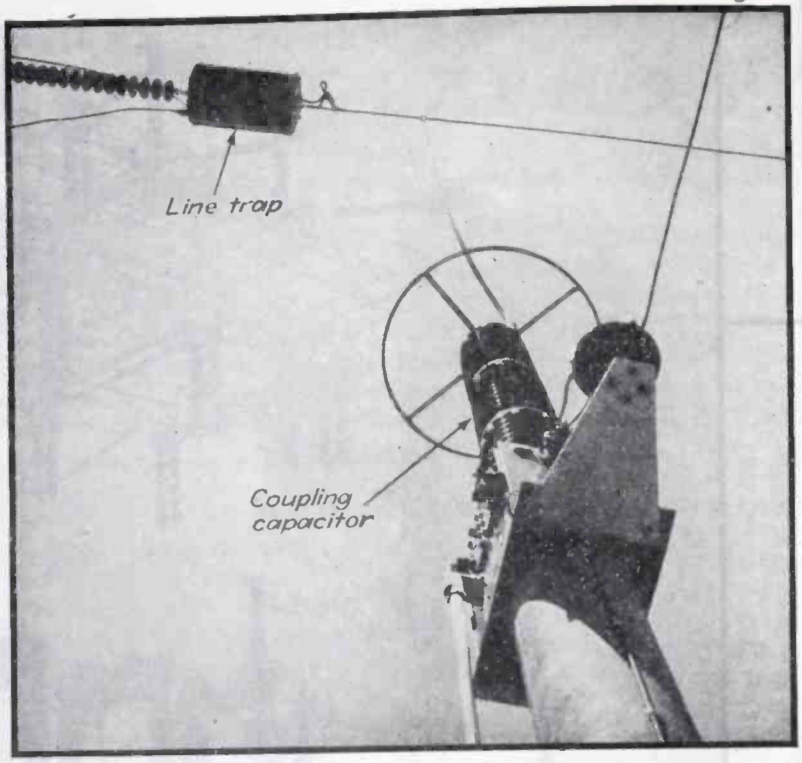
There are two basic kinds of noise on power lines, the r-f disturbances arising from electrical disturbances such as corona, leakage and switching; and corona modulation, which is amplitude modulation of the carrier due to a variable attenuation phenomena caused by corona. The major portion of the noise on the line in question was of the former type. With corona modulation predominating, superiority of f-m equipment would be greater.

With varying magnitudes of noise, an f-m carrier system has the characteristic of keeping the interference well rejected until the magnitude of the noise bears a certain ratio to the strength of the desired signal. The noise is then accepted and the desired signal rejected. In wide-swing f-m systems this threshold is abrupt, and occurs when the signal-to-noise ratio becomes about two. In a small-deviation system this threshold is not as abrupt and occurs at a lower signal-to-noise ratio, so that usable intelligence can be obtained from a signal whose signal-to-noise ratio is less than two. This is a definite advantage when the primary function of a service is to get intelligence from one point to another.

Power lines have a fairly high level of random noise, caused by corona and various types of arcs. Noise of this nature added to the desired carrier causes a complex type of amplitude variation and phase shift. It is possible for the limiter in an f-m receiver to remove the amplitude modulation, but it is impossible to eliminate the phase shift. This phase shift is the source of noise for an f-m channel.

It is possible in an a-m system for noise to cause a 100-percent modulation of the carrier, and this is also the limit to the degree of modulation by the desired signal. In the f-m system under consideration, it is impossible for noise to cause a phase shift of more than about one radian but it is possible for the desired signal to cause a much greater phase shift. This phase shift becomes greater as the modulating frequency decreases, and is the reason for more noise interference at the higher modulating frequencies.

By assuming a random type noise, the noise reduction theoretically possible by means of f-m over a-m is 6 db. This is computed from the fact that noise in a-m is the same over the entire audio spectrum, while in f-m the noise is zero at zero audio frequency and increases linearly to the same value as in a-m at the highest audio frequency. Hence, when the noise is integrated over the audio range, it is just half as great in f-m systems as in a-m systems.



Closeup of standard line trap and coupling capacitor used for the f-m carrier channel on the 230-kv line from Contra Costa to Pit 5

Characteristics of Corona Noise

Corona modulation is apparently a result of corona producing an impedance change affecting the flow of the carrier-current signal. If only this type of noise is present, an increase in transmitter power to surmount the noise does not help because the percent modulation due to the noise stays the same. This modulation is a function of the total attenuation between the transmitter and the receiver and the amount of corona present on the lines. If the transmitter is turned off when listening to signals in a carrier receiver having no automatic volume control, this type of noise will decrease or completely disappear, indicating that it comes in as modulation of the carrier signal. The noise is carried by symmetrical side bands about the carrier. In an f-m receiver that contains a balanced discriminator, these side bands are balanced out since a discriminator is a slope filter whose output is proportional to the frequency deviation from normal. Because an a-m signal has amplitude variations but no phase or frequency variations, the output of the discriminator in this case would be zero. Herein is the outstanding advantage of frequency modulation for power-line carrier, because it provides the only real solution to the above type of noise.

Comparative Tests

After installation of the f-m system and tuning of the line traps, carrier sets and coupling circuits, comparative tests of various systems were made. A single side-band a-m system was found to have 4.4 db better signal-to-noise ratio than a comparable double side-band a-m system. Comparisons of f-m and a-m systems on an equal power basis indicated that the f-m system was about 12 db better than the a-m system, with the average signal-to-noise ratio for the f-m system being about 32 db.

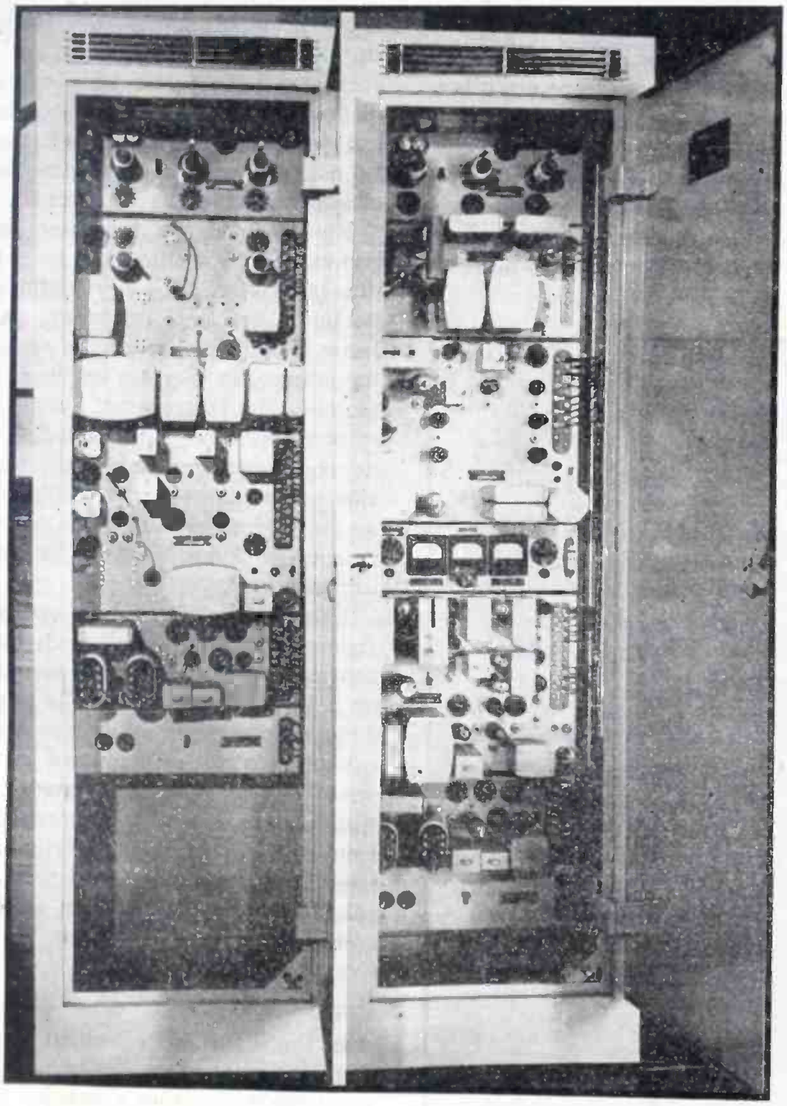
Further improvement in the discrimination against interference can be obtained by pre-emphasis of the higher audio frequencies at the transmitter, to take advantage of the concentration of voice energy in the lower audio frequencies. It is possible to pre-emphasize the higher audio frequencies in the transmitter without exceeding the modulation capabilities of the transmitter, and use a de-emphasis circuit in the receiver. This gives the greatest possible frequency shift for any modulating frequency without exceeding the bandwidth of any particular channel. Noise measurements made in the General Electric laboratory with an arc-noise generator show that to provide a given signal-to-noise ratio in a receiver, an un-emphasized f-m system requires a transmitter power of 8 watts and a pre-emphasized f-m system only 2 watts for the same signal-to-noise ratio obtained with a 100-watt a-m system. This indicates the possibility of greater transmission ranges with medium power, permitting a reduction in power or the solution of long-distance communication problems without repeating stations.

The presence of a limiter in an -m receiver is analogous to a fast nd flat type of automatic volume ontrol. The avc system used in -m receivers is comparatively lower and is not so flat. A flat vc action is advantageous in two-requency duplex, where one fre-uency is used to transmit in ne direction and the other fre-uency is for the other direction. 'he transmitter and receiver audio ircuits must then connect to a hy-rid circuit and can be set closer to ıe critical point if the audio out-ut of the receiver is quite con-tant. Since the limiter in an f-m eceiver can hold the output ex-remely constant, a two-frequency oice channel can be operated with higher audio gains from terminal to terminal.

The other type of communication commonly used is single-frequency duplex or automatic simplex, where the voice starts the transmitter and blocks the receiver on outgoing speech. To avoid noticeable clipping of words, it is desirable to accomplish the switching of the transmitter and receiver in as short a time as possible. One inherent limitation in an a-m system for fast switching of a channel is the surge of rectified carrier in the detector of a receiver when the transmitter starts. For smooth operation it is necessary to hold the receiver inoperative until this surge dies down. When an f-m carrier is used, the detector in the receiver is insensitive to amplitude variations, and responds only to the very small phase variations associated with starting and stopping of the transmitter.

In avc circuits of an a-m receiver, transients change the gain of the receiver, causing distortion. On the other hand, a limiter in an f-m receiver is practically instantaneous in action, and the receiver can be switched on and off very rapidly without distortion.

Two broadcast f-m stations operating on the same carrier frequency have considerably more interference-free operating area than two a-m broadcast stations on the same frequency. This holds true for f-m power line carrier systems also, though to a lesser degree since the deviation ratio is one-to-one instead of five-to-one. With increased installation of carrier-current apparatus throughout the country, there are many places where frequency congestion in the carrier band is becoming a problem. The use of f-m carrier offers a partial solution, because a given frequency could be repeated throughout a system more often than with amplitude modulation.



At right is the f-m carrier current assembly that provides a telephone channel between Contra Costa substation and Pit 5 power house 218 miles away. At left is a similar assembly of a-m carrier telephone equipment operating over a 110-kv line from Contra Costa to the load dispatcher in Oakland. Both assemblies are made by General Electric Co.

More F-M Channels Planned

Future plans for carrier communication on the PG&E system call for two-frequency duplex carrier equipment between Contra Costa and Shasta substation, Bellota and Shasta sub, Pit 5 and Shasta sub, Shasta Dam and Shasta sub, Bellota and Shasta sub, and between Contra Costa and Newark. It will be possible to connect these carrier channels to the company's physical telephone lines at any of these points. Two of the f-m channels will be operated on the 230-kv lines which have high corona loss.—J.M.

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tenuation ratio in the probe as a result of a necessary compromise between probe input capacitance and cable length. Input impedance of the probe is five megohms in parallel with 10 $\mu\mu$f. A 0.01 μf, 1000 volt capacitor prevents d-c loading of the circuit under observation. Insulated clips permit safe use on peak voltages up to the rating of the input capacitor.

Immediately following the input terminal and probe socket is an isolating capacitor and a three-position *RC* attenuator having ratios of 1:1, 10:1, and 100:1. This attenuator, as well as the one in the test probe, is compensated for high frequencies and introduces negligible distortion within the frequency range of the amplifier.

A continuously variable attenuator is necessary in an instrument of this type, but here compensation is impossible because the resistances are not fixed. Sources of distortion and methods of compensation are discussed later. Stray capacitances must be rendered ineffective by a relatively low-resistance potentiometer (1000 ohms).

The problem of matching this low-impedance control to the high-impedance stepped attenuator is solved very conveniently by the insertion of a cathode follower, shown in Fig. 2, as an impedance transformer, with the additional advantages of extremely low input capacitance and the ability to handle large signals. To take full advantage of the three-position decade-attenuator, the gain control is limited to a maximum attenuation of ten to one. This feature also prevents overloading of the input stage by strong signals, as long as the resulting deflection on the cathode-ray tube screen is less than three inches peak to peak.

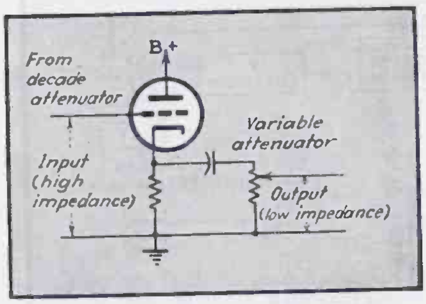


FIG. 2—Cathode-follower circuit acts as an impedance transformer between the high-impedance decade attenuator and the low-impedance continuously variable attenuator

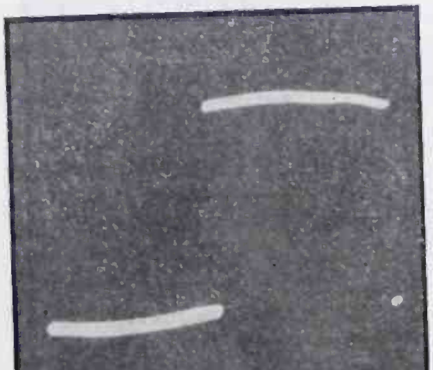


FIG. 3—A 30-cps square wave, as reproduced by the vertical axis amplifier

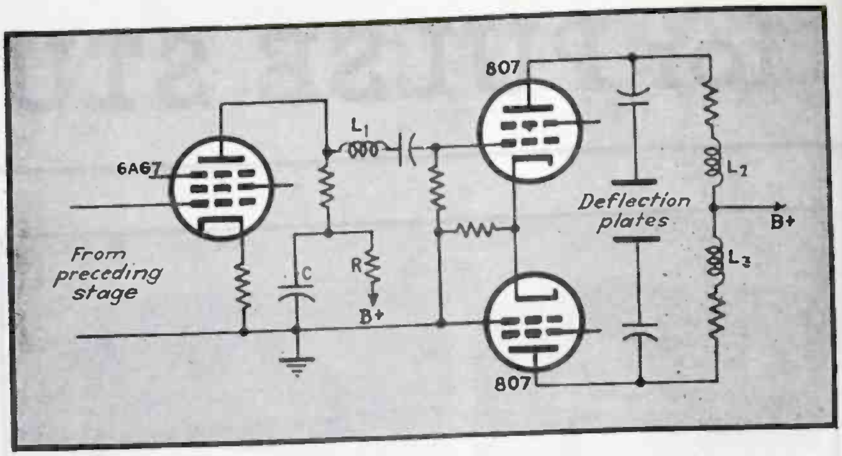


FIG. 4—Y-Axis amplifier is low-frequency compensated by the *RC* network, and high-frequency compensated by the series inductor L_1 and the shunt inductors L_2 and L_3. The X-axis amplifier is similar

Vertical Amplifier

Immediately following the variable attenuator are two amplifying stages, the first employing a 6AC7 pentode, the second, a 6AG7. Both plate circuits include compensating filters for low frequencies which, with slight individual adjustment to take care of component variations, make it possible for the amplifier as a whole to pass a 30-cycle square wave with only the slight distortion shown in Fig. 3. High frequency compensation is also provided, shunt peaking being used with the 1000-ohm plate load of the Type 6AC7 stage and series peaking with the 1300-ohm load resistor of the Type 6AG7. A type of compensation allowing a larger plate load for the desired frequency range is used in the latter stage in order that the maximum possible output can be obtained from the deflection amplifier which it drives. Transient response is equal to that of the shunt peaked stage.

The deflection amplifier consists of two 807's, cathode-coupled to give a balanced output. Because of low output capacitance it was found possible to use 1500-ohm plate loads and shunt peaking without reducing frequency response below that of previous stages. The last two stages of the vertical amplifier are shown in Fig. 4. Over three inches of undistorted deflection is available with 4000 volts accelerating potential on the cathode-ray tube.

Response of the Y-axis amplifier is down less than ten percent at five Mc, and is ten percent of the mid-frequency gain at ten Mc. Compensation is adjusted to give faithful reproduction of high frequency pulses without overshoot or oscillation. The oscilloscope input deflection factor is approximately 0.07 volts rms per inch of peak to peak deflection, with the higher accelerating potential.

High gain is not required in the X-axis or horizontal amplifier, so a cathode follower and gain control driving a balanced deflection amplifier similar to that of the Y-axis is all that is necessary. Response is down about 25 percent at two Mc, and the deflection factor is 2.5 volts rms per inch.

Signal Time-Delay

When using a driven or start-stop type of sweep, it is often necessary to trigger the time-base by means of the signal which is to be observed. Although sweep circuits such as the one used in this oscil-

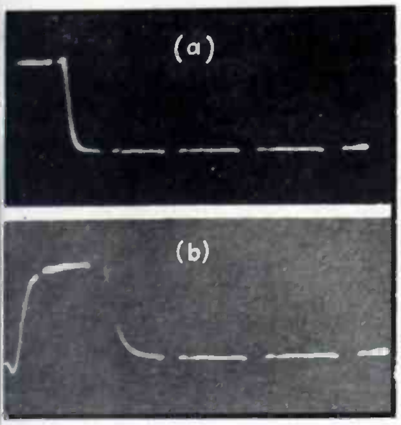


FIG. 5—Pulse reproduced with (a) and without (b) time delay for the signal. Marking spaces are 1 μ sec apart

scope get under way in a small :action of a micrgsecond, part of .e wavefront is obliterated as iown in Fig. 5(a) unless there is short time-interval before the ignal appears at the vertical de- lection plates.

A delay of about one-half micro- cond can be obtained by switch- g in a delay network ahead of the riable attenuator. This network the low-pass filter type has a aracteristic impedance of 200 ms to match the output of the thode-follower, and a cutoff fre- ency of twelve megacycles in or- r that it will be essentially dis- rtionless up to approximately six egacycles. With the signal de- yed by this network, the trace is shown in Fig. 5(b).

Time Bases

Two linear time-bases are pro- ded. One, providing the usual ntinuous sweep, is shown in Fig. and is a modified form of the gh-vacuum circuit first described Puckle. It has a range of 15 cps 150 kc when running free and is ceptional in its ability to syn- ronize steadily at high signal-to- eep frequency-ratios. Stable op- ation with more than 100 cycles the signal on the screen can be tained at medium frequencies. Operating frequencies as high as 300 kc or more are attained by moderate synchronizing with high frequency signals.

The second time-base incorporated in this oscilloscope is of the driven or start-stop type. Each stroke must be initiated by an external signal. Its great usefulness is in detailed inspection of waves occurring at relatively long and inconstant intervals, and having short durations. Any one of four sweep durations (5, 25, 100, or 1000 microseconds) may be selected by means of a switch on the front panel. This sweep can be triggered repeatedly at rates up to approximately the frequency corresponding to the sweep period. The previously mentioned delay network greatly increases the utility of this time-base (Fig. 5).

A stage of amplification following a phase-selector stage, (Fig. 1), in the synchronizing circuit insures that the foregoing time-bases can be synchronized or initiated by small signals of either polarity. One volt peak will trigger the driven sweep.

Generally, driven sweeps of short duration and low repetition rate are limited to one-half of the horizontal deflection distance that is available to the continuous sawtooth sweeps or other symmetrical signals. However, when this instrument employs driven sweeps, the operating points of the X deflection amplifiers are shifted along their dynamic characteristics to allow full deflection.

Beam Modulation

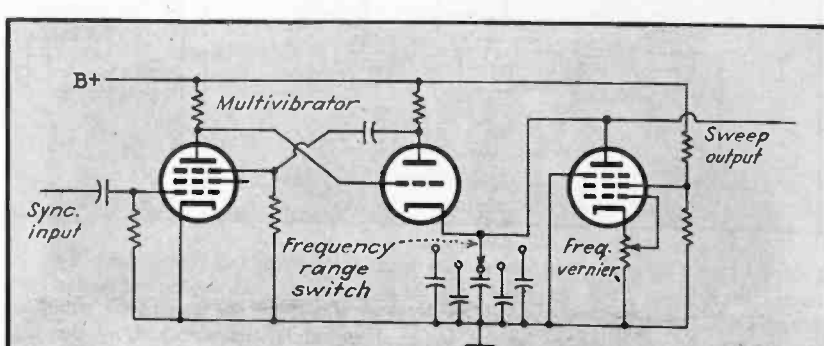
The Z-axis or beam modulation amplifier, illustrated in Fig. 7, makes use of a phase-selector as its input stage, thus making possible blanking or intensifying of the beam by either a positive or negative signal. This amplifier, together with the time-bases, acts as a beam control circuit serving to blank the return trace of continuous sweeps, and to drive the beam from cut-off during stand-by to full intensity during sweep when the driven time base is in use.

It is very necessary that adequate beam brightening be provided on short-duration strokes if the image is to be photographed, otherwise the beam intensity must be increased to a high level to make an infrequently repeated trace visible. As a result, the beam rest position will be so bright as to obscure the remainder of the trace. The cut-off of the beam during stand-by avoids this difficulty.

To allow for the use of the Z-axis with video frequency signals, the response of the amplifier was made uniform to four megacycles.

For use in conjunction with the Z-axis there is provided an oscillator and pulse-forming circuit which together furnish sharp pulses at intervals of one, ten, or 100 microseconds. Figure 8 is a block diagram of this marker circuit. The oscillator is synchronized with driven sweeps, and is used to indicate elapsed time along the X-axis by introducing brightening or blanking markers (Fig. 5) into the trace. Direct application of the signal to be investigated to the vertical deflection plates in no way affects the use of this timing circuit. The transitron oscillator is designed to be keyed on by the initiation of the driven sweep, but it is also useful over most of the continuous-sweep frequency range.

An unusual feature of this instrument is the inclusion of a pulse generator for use in triggering and testing other equipment. There are



IG. 6—Simplified wiring diagram of e vacuum-tube sweep circuit indicates e principle of operation. The tri- de of the multivibrator periodically harges one of the frequency-range ca- acitors. The constant-current pentode, hich includes the frequency-vernier ontrol, linearly discharges the fre- quency-range capacitor

available at terminals on the front panel positive and negative pulses of about 100 volts peak amplitude and less than a microsecond duration, at a rate continuously variable between 200 and 3000 pulses per second.

Attenuator Distortion

Initial deformation of the signal takes place when it is reduced from its original value by the test probe or the stepped attenuator. Both of these voltage dividers are compensated at the high frequencies by means of adjustable capacitors shunting the fixed resistors. These capacitors are adjusted for minimum distortion of a 10 kc square wave, this frequency usually being the most sensitive to attenuator misadjustment. Even at the best possible setting, however, there will be a slight but noticeable rounding of the leading corners of square waves at 100 kc and higher. This distortion is probably caused by phase shift at frequencies above one megacycle. While generally negligible, this effect cannot be entirely eliminated. Equal attenuation at all frequencies is an engineering ideal that can be approached only at the expense of input impedance.

Additional distortion takes place in the delay network, mainly because of the more rapid transmission of the frequency components above approximately two megacycles, and because of resistive and dielectric losses. Fortunately, this deformation in a well designed and correctly matched lumped-constant delay network is of the same order as that occurring in the attenuators, and can usually be neglected at frequencies below one-half the theoretical cut-off of the delay network.

Amplifier Compensation

The amplifiers themselves cause little or no frequency and phase distortion within their range of uncompensated, flat response. By proper compensation this range can be greatly extended at each end, but over-compensation must be avoided. The low-frequency and high-frequency equalizing circuits correct both gain and phase characteristics, but the most extended region of uniform gain and the most linear phase-shift characteristic cannot be attained with the same circuit constants. If a wide-band amplifier is adjusted for minimum distortion of square waves at both ends of its frequency range, it will generally be found that the correction made is a compromise between that necessary for optimum gain and for optimum phase characteristic, but much closer to the latter than to the former. This will be the case at both low and high frequencies. Linear phase-shift at low frequencies requires more compensation than is needed for flat gain. The reverse is true at high frequencies.

Phase and frequency distortion in under-compensated amplifiers will appear respectively as sawtooth and concave bowing of the top and bottom portions of low-frequency square waves, and as rounding of the corners of high-frequency square waves. An over-compensated amplifier shows the even less desirable symptoms of upward slope and convex bowing of low-frequency square waves, and over-shoot, or even a train of oscillations, following the wave front of a high-frequency wave or pulse.

The Y-axis of this instrument will pass a thirty cps square wave with only slight convex bowing (Fig. 3) and compensation is so adjusted that there is no over-shoot on even the most abrupt wave fronts.

Amplitude distortion is always present in oscilloscopes, but seldom to an objectionable extent, as such distortion does not change the wave form in a manner that is very obvious to the eye. Interaction, or cross-coupling, between amplifiers is a serious problem. However, it can be solved by careful component and wiring layout, the provision of metallic shields where necessary, and the use of low output-impedance power supplies.

Oscilloscope amplifier performance is too often specified only in terms of sinusoidal frequency response, but this tells only part of the story of the actual fidelity of reproduction. The phase characteristics of the amplifier are of at least equal importance and should be given full consideration. For example by specifying the square wave response.

The authors wish to acknowledge the valuable contributions of Mr. Bernard Amos and Mr. Charles Puckette to the development of this instrument, particularly with regard to the mechanical design.

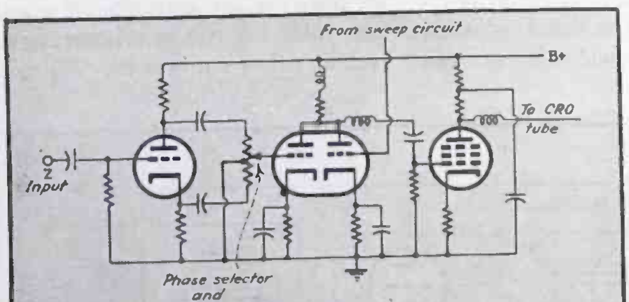


FIG. 7—The Z-axis or beam modulation amplifier blanks the return trace by means of a pulse from the sweep circuit (see Fig. 1). This blanking pulse is superimposed upon any external modulation signal by the dual-triode mixing stage. Phase selection of the external signal is accomplished by the balanced phase-inverter and potentiometer preceding the mixer stage. Both shunt and series high-frequency compensation are used in the final stage

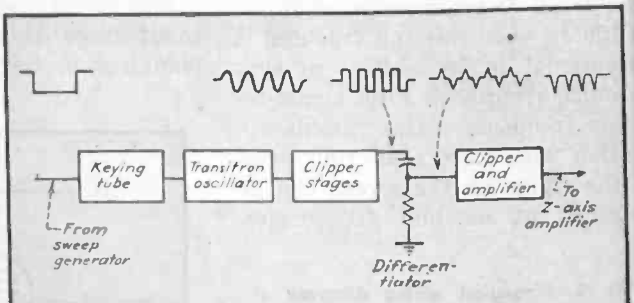


FIG. 8—The oscillator of the time-interval marker circuit is keyed on for the duration of each driven sweep. Wave shapes show the manner by which the oscillations are converted to marker pulses

Automatic Tuning System for PREHEATING PLASTICS

\ small, reversible electric motor moves the top electrode away from the plastic pre-orm during the heating cycle in response to an electronic control circuit, to keep the out-›ut circuit of the h-f generator in tune despite changes in power factor and swelling

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THE utilization of dielectric electronic heating in pre-heating lastic molding materials, partic-larly the thermosetting mate-ials, has proved to be a defi-ite asset in plastic molding pro-esses.[1,2] Production of sufficient igh-frequency power at a suitable requency is a relatively simple ngineering problem, but the aver-ge molding shop is generally too rowded for location of the neces-arily bulky generating equipment djacent to the molding presses. lso, the generally high ambient mperatures, excessive dust, oc-asional steam and water leaks, nd the heavy work involved in old-handling all constitute an un-avorable environment for elec-ronic equipment.

These conditions led to an as-umption that the generating quipment should be located in a emote and more satisfactory loca-on, and the r-f power fed through tandard transmission lines to rela-vely small and simple heating eads located at the presses. Fur-hermore, such an installation ystem offers flexibility in the re-cation of presses and heating nits, and simplifies maintenance y confining mechanical damage to readily replaceable unit. Ulti-ately, all of the high-frequency hop heating power could be dis-ributed from a central air-condi-oned generating room through ermanently installed rigid high-requency transmission lines, with emovable droplines to the indi-idual heating heads.

Application of such a system is traightforward except for the problem of coupling the material to be heated to the load end of a matched transmission line, in the face of variables during the heating cycle and between heats. Two experimental installations were made in the Boonton Molding Co. plant at Boonton, New Jersey, wherein an automatic tuning system is employed to stabilize these variables.

Tuning Problem

The molding material to be preheated is generally batched and briqueted into a preform having the right weight of material to fill the mold. The preform is then placed between plates, high-frequency heating voltage is applied until the material becomes plastic, and the preform is transferred immediately to the mold and molded before polymerization can take place. Heating must be rapid, usually to a temperature of about 320 degrees F in a minute or less, to avoid polymerization before the mold can be closed.

The preform with its associated electrode plates constitutes a discouragingly low capacitance requiring a rather high applied voltage for a suitable heating rate. Also, the dielectric constant of the material changes greatly during the heating cycle because of tempera-

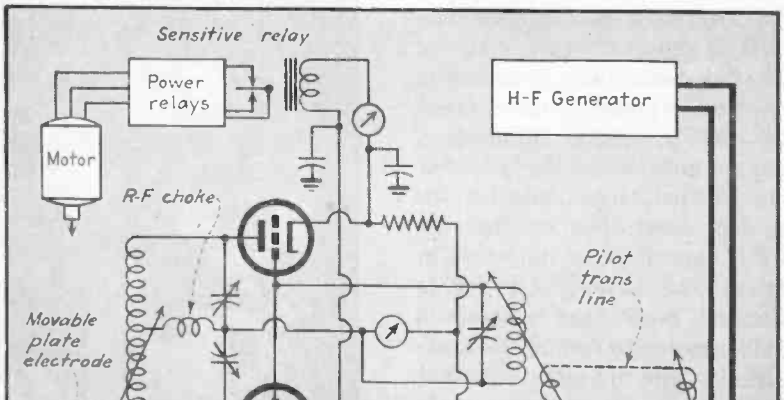


FIG. 1—Automatic tuning circuit used with h-f generator to keep the output tank circuit in tune during the heating cycle

ture coefficient and the chemical changes attendant upon plasticization.

The relatively low capacitance presented by the dielectric load, together with the necessity for maintaining a proper transmission line termination, dictate that the heating head be in the form of a resonant circuit with a maximum portion of the total tank capacitance lumped in the material being heated, automatically maintained in resonance during the heating cycle. In the present design, tuning of the circuit is varied by raising or lowering the top electrode plate through a motor-driven screw feed, thus readjusting to a constant tank capacitance in the face of varying dielectric constant in the material. The motor is in turn controlled by a circuit responsive to the direction, capacitive or inductive, of detuning of the resonant circuit.

Automatic Tuning System

The tuning circuit is illustrated in Fig. 1. Two triodes connected as a phase-sensitive bridge rectifier are coupled to the heating tank and to the driver output. Coupling to the driver is made through a separate line to include phase shifts through the power transmission line caused by detuning of the heating circuit. The circuits are adjusted so that the bridge d-c output is zero when the heating tank is in resonance with the driver. As the heating tank circuit detunes during the heating cycle, the characteristic shift in phase of the current in the heating head tank inductance, relative to the phase of the current in the driver output inductance, causes an unbalanced d-c rectifier output. The polarity of this d-c output is dependent upon whether detuning is capacitive or inductive in direction. The d-c output is fed to a polarized relay that controls a reversible motor to retune the heating circuit. The dielectric constant increases during the heating cycle and the plate spacing thus increases, which accommodates a tendency of the preforms to swell as they become plastic.

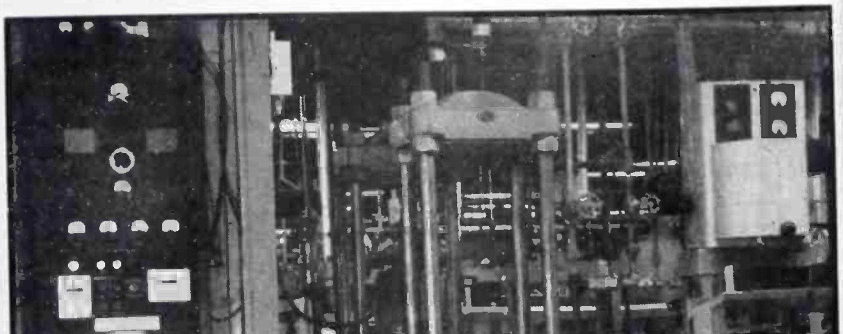
Automatic tuning has the additional advantage of adjusting itself to the normal random differences between preforms. In practice, differences have been noted that would represent a frequency deviation approaching ten percent from the nominal frequency, due mostly to moisture variations that are within acceptable limits from the molder's standpoint.

Meters and Limit Switches

Two indicating instruments are connected in the tuning bridge to assist in adjustment. A milliammeter in the common cathode return indicates the total level of grid and plate inputs to the bridge, and a zero-center microammeter in the polarized sensitive relay circuit indicates the differential bridge output, serving to check the overall operation of the bridge and assure sufficient margin of current in each direction for operation of the relay. In practice, the plate and grid circuit couplings and capacitances are adjusted primarily for symmetrical operation of the zero-center meter rather than exact resonance; slight detuning of one or both circuits may be desirable to compensate for residual phase differences between the power and pilot transmission line terminations.

To avoid mechanical jamming of the tuning plate, the plate drive is equipped with a disengaging gear to disengage the motor if the plate comes down into contact with the preform, and limit switches are arranged to stop the motor near the extreme limits of plate travel. The limit switches are connected to stop the motor only in the direction of overtravel, still allowing the motor to return the plate to its normal position without manual resetting. To facilitate manual operation of the plates during adjustment of the tuning bridge or determination of the resonant spacing for an unknown preform, a two-position switch disconnects the automatic tuning motor relay and connects run-up and run-down pushbuttons for manual operation of the tuning motor.

The total change in dielectric constant is apparently considerable because without the automatic tuning feature typical preforms change the resonant frequency of the heating tank circuit from ten to eighteen percent. In practice this requires a total excursion of the top plate of approximately one tenth the preform thickness during the heating cycle, and a plate speed of two to four inches per minute has been found satisfactory for preforms up to four inches in thickness. The air space between the top plate and the preform has only a negligible effect upon efficiency, but in general is not allowed to exceed one-fifth of the preform thickness to avoid excessive field fringing and uneven preform heating.



Experimental installation for dielectric preheating of plastic preforms at plant of Boonton Molding Co. The electronic generator cabinet, at the left of the molding presses, is normally closed and force-ventilated through filter screens. The heating head may be seen to the right of the molding presses

It is interesting to note that the dielectric constant change in all the thermosetting materials tested is only partly due to positive temperature coefficient; about half the increase is a permanent change accompanying polymerization. Also, the power factor of the material approximately doubles during heating, increasing the generator loading and the heating rate toward the end of the heating cycle.

Overload Problems

In operation, when a heated preform is removed, a new one put in place and the power applied, the top plate must run down to its starting position. During this period the heating tank is off resonance, mismatching the transmission line and running the generator virtually unloaded. Also, the danger of accidental operation of the equipment without a preform in place must be considered. These conditions require that the generator and transmission line be somewhat overdesigned to withstand voltage and current maximums of at least short duration. In practice, generator tank capacitor flashovers and transmission line overheating have been by far the greatest source of trouble because straightforward radio design factors were applied without initial regard for the factors peculiar to this application.

Automatic Switching

Although any number of heating heads may be driven simultaneously from a generator capable of supplying sufficient power, the installation illustrated was designed to heat relatively large preforms using one head at a time, the presses being cycled and the heads operated in rotation for maximum use of the generator. It then becomes necessary to interlock the heating heads so that operation of one head will lock out all other heads. This is accomplished by a conventional interlocked contact system using the contacts on the heating cycle timers. Each head is equipped with its individual timer arranged for push-button starting and automatic cutoff. Green indicator lamps operate on all heads when none are in use and go out when any head is put in operation. A red indicator lamp lights individually on each head while the head is in operation, and goes out at the end of the heating period.

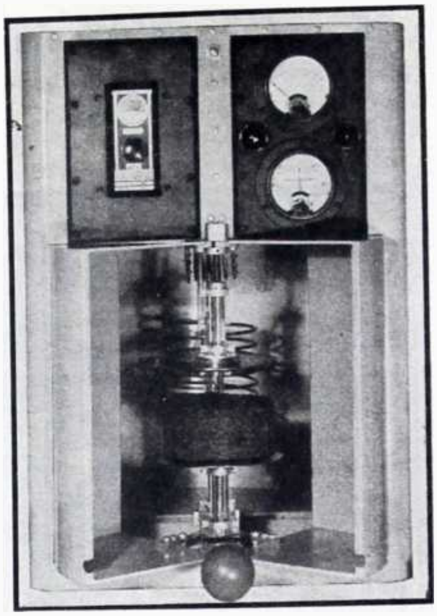
Operation of any one of the heads energizes a magnetic contactor in the generator plate supply, turning on the high-frequency power. In addition, operation of any head controls a motor-driven variable plate-input transformer to deliver a preselected generator output individually adjustable for each head. Different power inputs for each head could be obtained alternatively by individually coupling each transmission line to the generator with varying degrees of coupling, but the present method wherein the generator is fully loaded at all times seems the most efficient.

To avoid unused transmission lines acting as stub lines, each line is connected at the generator through a standard antenna switching relay that closes only when that particular head is operated. However, if the heads are in a group located some distance from the generator the transmission line distribution relays may be mounted in a distribution box centrally located with respect to the heads, with a common transmission line back to the generator. The pilot transmission lines for operation of the tuning circuits are relatively small and loosely coupled to the generator, and may be connected permanently in parallel without switching.

Operation of Heating Head

The level of high-frequency energy required to heat most preforms in a suitably short time period is sufficiently high to be dangerous to the operator. Also, the heating process is routine and the equipment is operated by personnel probably unfamiliar with the hazard involved. Consequently some suitable safety device, such as an access door switch, should be incorporated to make touching of a hot circuit impossible. In addition, grounding of the feed line or coupling loops to prevent accidental appearance of the driver plate voltage at the electrode plates is recommended. Hazard is then limited at least to high-frequency burns where the principal danger is infection.

The heating head must operate under rather adverse conditions of treatment, dust, temperature, humidity from steam leaks, etc. Plug connection of control, power and high-frequency lines to facilitate routine replacement for cleaning and adjustment is therefore advisable. The heating plates rather rapidly become coated with hardened resin from the molding material, and should be arranged for convenient frequent removal for cleaning or replacement by the operator.



Typical heating head, with preform in position. Knob at bottom center controls pivoted safety doors. By employing flexible coaxial cable, a heating head can be set up in a plant and quickly connected to the nearest convenient overhead rigid high-frequency line going to the electronic generator

Many variations from the particular experimental installation described are obvious. For example, it is possible to arrange the automatic tuner to adjust a variable-frequency generator to resonance with a fixed heating head tank circuit, although such a system does not appear as flexible. Where the heating heads are operated one at a time a single tuning bridge located in the generator can be arranged to tune all heads in turn. Individual bridge adjustment is considerably more reliable where the power demand between heads varies greatly, but in many cases could be eliminated for simplicity.

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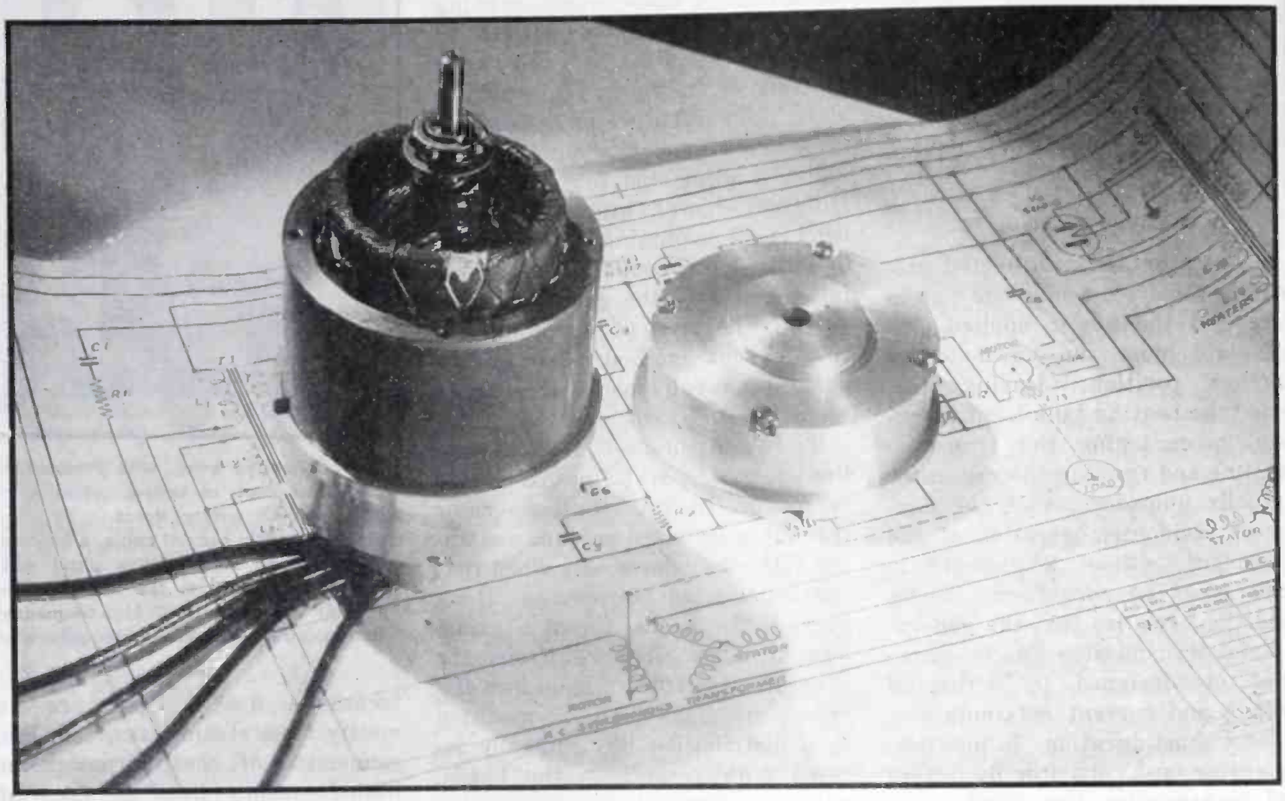
A Continuous-Control



Synchronous transformer used to translate mechanical position into electrical phase shift in electronically controlled servo systems. The rotor and stator are visible in this photograph

This continuous-control positioning system uses synchronous transformers, electronic anti-hunting circuits and electric damping, electronic error indication, saturable reactor control of motors and a dual gear system to increase the accuracy of the data system

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Servo mechanisms, although not basically new, are finding new and important applications. The development of servos has followed a demand imposed by the increasing complexity of modern machines. The need for servos has been recognized where it has been necessary to substitute a positive electro-mechanical control for a less positive and less certain manual control. Control problems wherein direct mechanical linkage between operator and machine is impossible make the servo a necessity. Moreover, where mechanical linking between an operator and a load is possible, servo mechanisms can be employed as torque amplifiers, thus permitting accurate control of the movement of large loads with a minimum of effort.

Applications of servo mechanisms are numerous. Rather than consider any specific case, general circuits and equipment will be discussed in a manner most likely to assist the engineer who is confronted with a problem which can be solved by a continuous-control servo. A mathematical analysis of servo mechanisms can be obtained from the references at the end of this article.

In general, servo mechanisms are devices for automatic control in which the output is proportional to the magnitude and direction of the input action. The input or control point in the system is the point at which the arbitrary or predetermined change is introduced. The output is the point in the system which constitutes the load.

Servo Systems

Servo mechanisms of all types may be divided into two general classes, namely, the stepping or on-off systems and the closed cycle or continuous-control systems. Their innumerable applications range from the solution of differential

SERVO SYSTEM

ɪuations to automatic control of ɪrcraft.

The system which will be disɪssed here is of the electronic conɪnuous-control type, which may be efined as a type in which a restorɪg force is approximately propor-ɪonal to the deviation of the output ɪith respect to the input and acts ɔntinuously on the output in both irection and magnitude until the eviation has been corrected. This ype of servo would be ideal if input nd output indications were equal t every instant. Since it is imprac-icable, if not impossible, to realize he ideal, a certain amount of error ɪust be accepted in such servo ap-lications. This type of servo ɪechanism is often referred to as a ollow-up system in which tolerable imits of error depend on the ɪmount the load can lag or lead its ndicated position at the control oint without seriously interfering vith efficient operation.

Fundamentally, the block diaɡram shown in Fig. 1 is representative of most closed-cycle electronic servo systems. There are usually two electrical devices which furnish displacement data. Their principle of operation is equivalent to that of a Wheatstone bridge. One unit is located at the point of direction (control point) and the other is associated with the load. The balance of the bridge can be disturbed or corrected at either location. If an unbalance is made at the control point, the output of the bridge, if of sufficient power, could be used directly to drive a motor that would automatically make the correction at the load. This in itself constitutes the operating principles of a servo system. For the particular servo being considered, power from the bridge is used to control a larger source of energy which in turn is supplied to a motor of sufficient size to perform the desired function in addition to balancing the bridge. The character of the load in every case will determine the necessary amount of

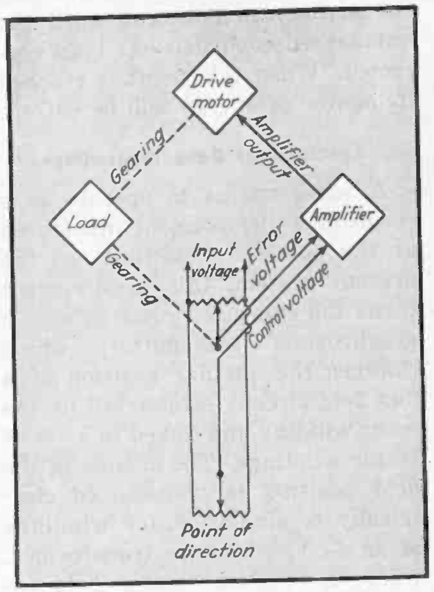
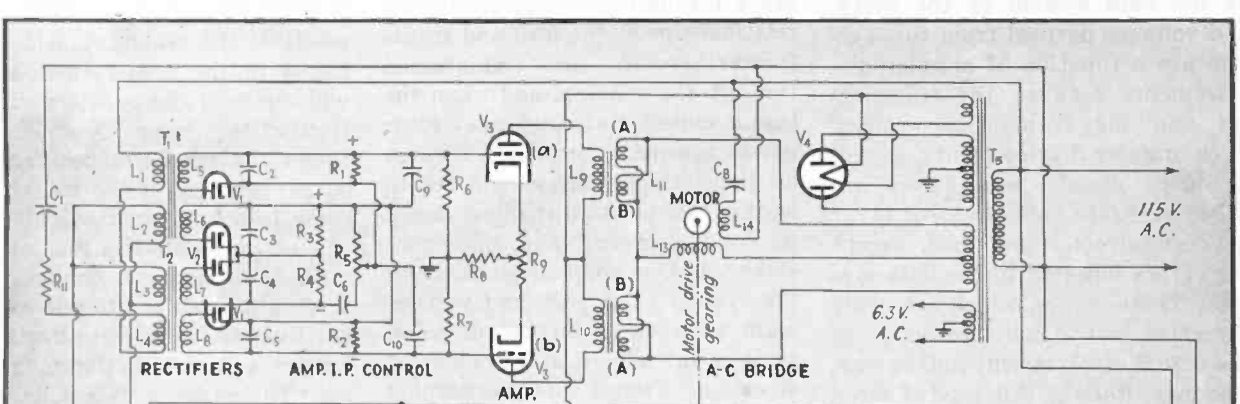


FIG. 1—A Wheatstone bridge, two arms of which are mechanical and two arms of which are electrical, constitutes the basic servo system

BELOW

FIG. 2—This complete servo circuit provides continuous adjustment of the load and also gives an indication of the error between the load position and the position set at the control point



power. In any event, the above principle will be carried out since the motor will only run until the unbalanced condition has been corrected. When this point is reached its source of energy will be cut off.

Synchronous Data Transmitter

A servo begins to operate as a result of a displacement introduced at the point of direction. In the present system, this displacement turns the energized rotor of an a-c synchronous transmitter, which changes the angular position of a flux field already established by the rotor winding and linked to a set of stator windings. The change in the field position is transmitted electrically to similar stator windings of an a-c synchronous transformer, where a resultant stator field assumes a new angular position with respect to the transformer rotor. A voltage called the displacement voltage is therefore induced in the transformer rotor.

The a-c synchronous transmitter is located and operated at the control point in the system and the a-c synchronous transformer is associated with the controlled load which may be at some distant location. A-C synchronous devices used in this manner may be referred to as the data system of the servo, and voltages derived from this system are a function of angular displacements between the transmitter and the transformer rotors. Such angular displacements, as will be more clearly seen later, are fairly accurate indications of error between director and load, except for errors inherent in the data system. These errors, which are often excessive, add to and subtract from the actual displacement indications. The magnitude of this type of error may vary from plus or minus a few tenths of a degree to several degrees in different synchronous units, and therefore their accuracy should be determined before the synchronous units are utilized in a system.

The displacement voltage assumes a direction and magnitude which, when amplified, exerts a control on the driving motor voltage corresponding to the rate and direction of change initially introduced at the input. The drive motor rotates the load in accordance with this control, and also turns the rotor of the transformer by means of gears through the load. Positional relationships of the load and transformer rotor are maintained through the gearing, and when the load is moved the transformer rotor moves toward a position at which no displacement voltage will result. In this new position the load ceases to receive energy and movement stops. At this point of equilibrium the system is at rest, and will remain so until a further displacement is introduced at the point of direction. Figure 2 is a schematic representation of this type of servo mechanism, which is to be described in some detail. It will be seen that this circuit contains a dual system of a-c synchronous devices.

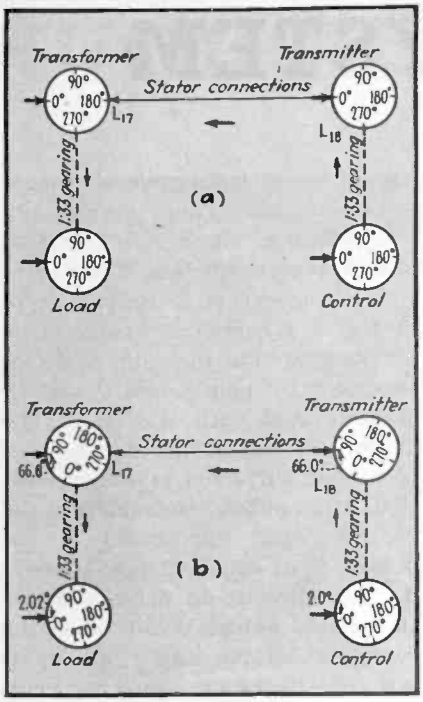


FIG. 3—At (a) is shown by means of dials the condition for all parts of the servo system in perfect alignment, while (b) illustrates how the gearing reduces errors which may appear in the transmitter network. There is only a slight misalignment between control and load

Motors and Gearing

The rotors of the transmitters, and likewise those of the transformers, are mechanically connected through 33:1 gearing, and the output of this system is coupled to an error-indicating circuit and phase-sensitive rectifiers. There is also a one-to-one gearing system whose output is coupled to a relay circuit. The rectified output is supplied to a vacuum tube and saturable reactor amplifying section through input signal control circuits. The saturable reactors form part of an a-c bridge that supplies power to the variable phase winding of a split-phase, low-inertia motor. The motor is connected through gearing to the load and also to the rotors of the synchronous transformers.

The two transmitter rotor windings are connected in parallel to a source of 115-volt, 60-cycle current. Their rotating members are geared to the positioning control at the point of direction. The two rotors serve as primary windings to a 1:1 data system and a 33:1 data system respectively. In each case there are three stator windings whose flux fields are angularly spaced 120 degrees. The angle between each stator winding and the rotor is continuously variable over 360 degrees. Individual stator potentials are accordingly a function of the sine of the displacement angle. The stator windings of the transmitter are connected to corresponding windings on the transformer.

Since current flow in each stator is a function of the primary rotor position, the resultant field established in the transformer stators will rotate in synchronism with the transmitter rotor. Coupling between the magnetic field and the output winding of the transformer rotor is zero when the coupling is at right angles, hence the output is zero. If the angle is changed from this right-angle position in either a positive or negative direction, a voltage is induced in the rotor winding. The phase of this voltage will differ by 180 degrees for either of these two directions. As the displacement angle is increased a sinusoidal voltage will be produced, reaching a maximum at 90 degrees and reducing to zero at 180 degrees, hence there are two zero positions 180 degrees apart.

Increased Data-System Accuracy

When the output voltage of the data system is zero, the angle of displacement between the primary and secondary rotors with respect to a common reference point may likewise be considered to be zero. If the primary rotor is given an angular displacement, the output voltage, which will be a function of the sine of this angle, will exert a control on the drive motor that will make it rotate the secondary rotor until it has approximately equaled the primary displacement and reduced the output voltage to zero. Since it is practically impossible to construct the synchronous units without some error, it can only be said that the displacement between the primary and secondary rotors is now zero within the accuracy limits of the data system.

When a servo application calls for accuracies that will not allow maximum overall system errors to exceed plus or minus 0.1 degree, but maximum errors in the synchronous units themselves measure approximately 0.6 degree, a data system similar to that shown in Fig. 2 may be used. The inherent errors of such a data system will have an apparent maximum value of 0.6/33, or approximately 0.02 degrees.

The a-c synchronous transmitter and transformer rotors, L_{17} and L_{18} of Fig. 2, are for illustrative purposes represented by dials in Fig. 3(a). According to both figures, L_{17} should make 33 revolutions to one revolution of the dial representing the load. The output voltage and all dials in the systems are set at zero, and therefore the indicated position of the load is correct.

The system is shown again in Fig. 3(b), but the position of the load as indicated by the control has been changed two degrees. Due to the gearing the transmitter rotor advances 66 degrees. Assuming that at this point in the data system there was an error of plus 0.6 degree, rotor L_{17} would advance 66.6 degrees to reduce the output voltage to zero, but because of the gearing between L_{17} and the load, the latter rotates approximately 2.02 degrees. The error between dial and load is thus only 0.01 percent.

Although errors in the data system vary from 0 to 0.6 degree in this illustration, they will not appear greater than 0.02 degree between the indicator dial and the load. In order to realize such reductions all gearing and mechanical couplings used between points must be free of backlash.

Director Misalignment

Whenever it becomes necessary to employ a gear train with larger than a one-to-one ratio between the transformer rotor and the mainshaft of the load, there will be a possibility of misalignment between the director and the load. In the present system there are 33 different angular positions at which the load could come to rest with respect to some common point on the indicator because at each position the output voltage of the data system would be zero.

To prevent this kind of misalignment, a second set of synchronous units is necessary. Their primary and secondary rotors are connected respectively to the indicator shaft and mainshaft of the load through a one-to-one gearing. The secondary winding L_{16} in Fig. 2 is coupled to a relay control circuit which causes a synchronizing relay to function when the displacement voltage reaches some predetermined value. Actually, the grid bias adjustment at R_{15} will allow the relay to be energized before the angular displacement of the one-to-one system exceeds four degrees. The 33:1 data system is then disconnected from the amplifier input circuits by the switching of S_1. Voltage from the one-to-one system will now furnish data to the amplifier until the displacement angle has become less than four degrees. This switching occurs when the angular difference between the primary and secondary rotors of the 33:1 system is approximately 132 degrees, with respect to a zero-angle point of reference.

There are two zero-voltage positions 180 degrees apart. One such position is referred to as the stable null and the other, the unstable null. When either of the synchronous systems is connected to the amplifier circuits, it is characteristic of the induction motor to respond to off-null voltages in a direction corresponding to their phase. Thus, the motor will always rotate the transformer rotor toward its stable null-point.

When the 33:1 synchronous system is loaded by the input impedance of the amplifier and error indicator circuit, it will produce 0.87 volt rms for the first degree of displacement between L_{17} and L_{18} in Fig. 2. Actually the displacement between the indicator and the load, as a result of the gearing, will be 0.03 degree. This indicates a gain of 33 when using a high and low

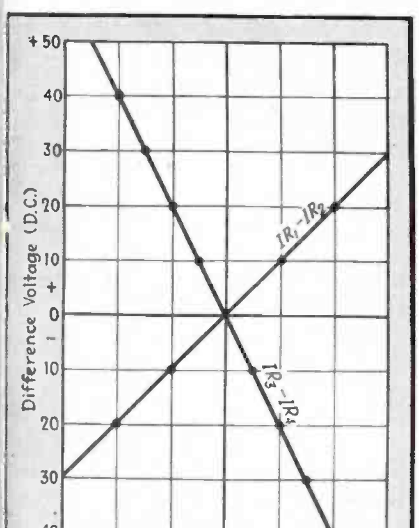


FIG. 4—The stabilizing and grid-control voltages developed by the phase-sensitive rectifier are in opposition

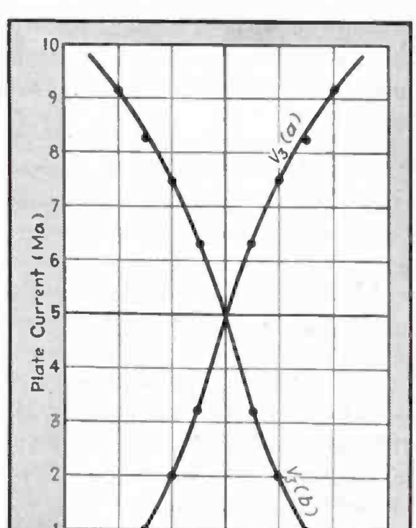


FIG. 5—When there is an error voltage, the balance in the motor control triodes is upset as indicated here

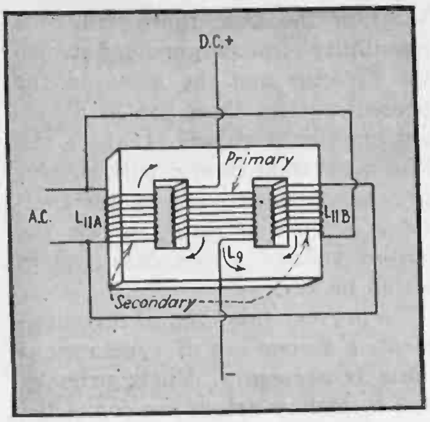


FIG. 6—As indicated by this drawing of one of the saturable reactors, the alternating component of flux is kept out of the primary leg, but the direct component of flux flows in both secondary legs

speed system in addition to effectively reducing system errors by the same amount.

Prevention of Hunting

Each input transformer, T_1 and T_2, has two primary windings, L_1, L_2, and L_3, L_4, which are designed for 60-volt, 60-cycle maximum input. The secondary windings L_5 and L_8 are rated at 360 volts and 0.002 ampere. Windings L_6 and L_7 have ratings of 720 volts at 0.002 ampere. Primaries L_1 and L_4 are connected in series with dropping resistor R_{11} and phasing capacitor C_1 across the 115-volt alternating source. Primaries L_2 and L_3 are connected in parallel and receive signal currents from the data system.

The signal current is combined with the reference current in each transformer. A resultant flux causes a current flow in secondaries L_5, L_6 and L_7, L_8 that is proportional to the magnitude and phase of the respective currents.

If an instantaneous primary current causes the plates of V_1 and V_2 to go positive while the displacement voltage is zero, equal voltages of opposite polarity will appear across R_1 and R_2. Similar voltages will appear across R_3 and R_4. Under these conditions no current will flow in R_6 and R_7, nor through R_5 and capacitor C_6. Capacitors C_2, C_3, C_4 and C_5, and shunting resistors R_1, R_2, R_3, and R_4 function as filters for the rectified half-wave currents.

When transmitter rotor L_{18} is displaced and a corresponding voltage is developed in transformer rotor L_{17}, it will be in phase with the 115-volt source, or reference voltage, in one transformer (T_1 for example), and 180 degrees out of phase with the reference voltage of the other transformer. Capacitor C_1, in combination with R_{11}, provides correct phasing of the displacement and reference voltages.

A displacement voltage of either phase will result in a difference in current flow through R_1 and R_2 as well as through R_3 and R_4. The algebraic difference between the current through R_1 and R_2 determines the direction of current flow through R_6 and R_7. Reference to Fig. 4 indicates that both $IR_1 - IR_2$ and $IR_3 - IR_4$ are functions of the displacement voltage, but are of opposite phase and because of the input transformer ratios the latter is double the former. That is, $IR_3 - IR_4 = -2(IR_1 - IR_2)$. The first half of this equation represents the stabilizing voltage and the second half represents the grid difference voltage.

A variation in the stabilizing voltage will result in a similar variation in the charge on capacitor C_6. The magnitude and sign of the voltage across resistor R_5 will be proportional to the current flowing in capacitor C_6. This voltage acts in phase opposition to signal currents flowing through R_6 and R_7, and as will be seen, prevents hunting, an undesirable servo characteristic when a high rate of response and small steady-state deviations are desired.

Electrical Damping

Capacitors C_9 and C_{10} serve as neutralizing capacitors to prevent low-frequency oscillation of the servo. The function of the stabilizing voltage across R_5 is to oppose changes in displacement voltages and its peak value is intended to be slightly greater than the $IR_1 - IR_2$ difference voltage. Without these capacitors in the circuit the following action would result.

During any change in displacement the action of the voltage across R_5 will be in phase with the change. Because it is of a greater potential than the signal, it causes a current flow through R_6 and R_7 in a direction opposite to that desired. The resulting grid difference voltage will cause an increase in displacement until it has reached 90 degrees. At this angle, the displacement voltage and the charge on C_6 reach a maximum, and the voltage across R_5 drops to zero. The $IR_1 - IR_2$ difference voltage is now able to correct this displacement, but after having been reduced to zero the above action is again repeated, this time in the opposite direction.

To prevent such oscillations, C_9 and C_{10} in combination with R_1 and R_2 function as a bridge across whose output are resistors R_6 and R_7. For a short period the drop across R_5 is greater than the $IR_1 - IR_2$ difference voltage for all practical purposes and the bridge will be balanced.

The function of the anti-hunt circuit is to superimpose a voltage on the signal to the amplifier. This superimposed voltage acts in opposition to potential changes in the signal. Since hunting or unstable conditions produce displacement voltages of an oscillatory character, either electrical or mechanical damping could be used to offset such action. The action of the present circuit is analogous to that of an inductance. It can be better understood if a step increment of displacement voltage is analyzed.

Illustration of Servo Circuit Response

Consider a 0.5 volt displacement which causes a step increment of an $IR_1 - IR_2$ voltage difference of 2.5 volts, of polarity shown in Fig. 2. At the same time this 0.5 volt displacement causes a step increment of an $IR_3 - IR_4$ voltage difference

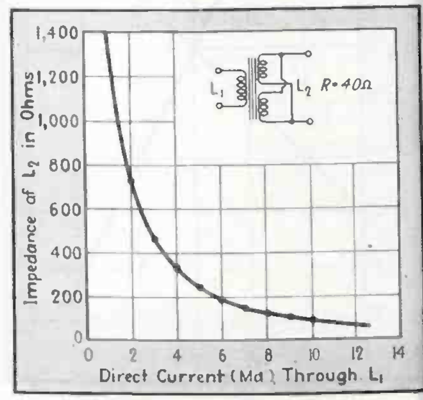


FIG. 7—The impedance of the saturable reactor secondary is controlled by the direct current in the primary

' 5.0 volts. During this step function, capacitor C_6 has the effect of a iort-circuit, causing an IR drop of 3 volts across R_5.

Currents from each source will nd to flow through R_6 and R_7 in pposite directions. By adjustment R_5 the current flow can be made ro for an instant, allowing the put voltage to the amplifier to iange with time. Neglecting the ctifier and transformer winding sistance, which are negligible, the me constant of the circuit is $= [R_5 + (R_3 + R_4)/2]C_6$. The me at which the amplifier input ltage begins to rise from zero is tually delayed by the adjustment R_5 to a point where the opposing ltage is greater than the input ltage, between 2.5 and 3.3 volts this illustration.

The charging time of C_6, in comnation with the adjustment of R_5, oduces a servo response that is oportional to an integral of the splacement voltage. After a time terval, the motor assumes a veloc- / that is proportional to the displacement. Thus violent action is evented and at the same time pid follow-up is permitted when storing forces make corrections displacements.

When the displacement is given constant velocity, the motor will so attain a constant velocity, bew a limit fixed by the rpm rating the motor. Unless the motor runs a speed that maintains exact nchronism between the transrmer and the transmitter rotor the data system, there will be nes when it will run alternately o slow and too fast. Such changes motor speeds will cause changes displacement voltage. A change in splacement voltage is at all times posed by potentials across R_5, d therefore the motor will be ider constant control.

A similar stabilizing action relts when a constant velocity dislacement is suddenly reduced to ro. Under such conditions, the pacitor C_6 will discharge through in a reverse direction, setting up voltage which causes the motor to ntinue its rotation in the same rection. Due to the inertia in the stem, which is also aided by the ltage across R_5, the displacement ltage goes through zero and rerses its phase. This results in a change in polarity of the grid difference voltage and the stabilizing voltage. The actual amplifier input voltage reaches a minimum value after the displacement voltage has passed through zero because of the discharge time of C_6, leaving an error still to be corrected. At this point the motor reverses its direction trying to correct the error. Since this action is likewise opposed, the motor will slowly reduce the error to zero.

The above is a theoretical description of the stabilizing action. It has been found in practice that when sudden changes in velocity are made, about two such cycles are required before the motor comes to rest. Various factors concerned with the servo application determine the correct adjustment of R_5, as well as resistor and capacitor values in the circuit.

Saturable Reactors

The signal is next amplified and used to control an a-c source to the drive motor. Each half of the amplifier tube, V_3, is biased for a normal plate current of 5 ma. The control windings, L_9 and L_{10}, of the saturable reactors are connected in the plate circuits of the dual-triode vacuum tube. The normal plate current of 5 ma sets the impedance of each winding, L_{11} and L_{12}, at approximately 250 ohms. Variations in the plate current of each half of V_3 as a function of displacement voltage are shown in Fig. 5. This current controls the impedance of the saturable reactors.

It may be well at this point to explain the action taking place in the saturable reactors, although they have been used in control circuits other than servos for many years. The field established by the flow of direct current through primary windings, L_9 and L_{10} in the plate circuit controls the permeability of the iron core. Permeability is the ratio of change in magnetic flux to change in magnetizing force.

There is a direct relationship between the permeability and the inductance which is given by the formula $L = 1.26N^2A\mu/10^8l$, where L is in henries, N is the number of coil turns, A is core area in square cm, μ is permeability and l is length of the magnetic circuit in cm. The reactive impedance is given by $X = 2\pi fL$. The total impedance of L_{11} and L_{12} will be $Z = \sqrt{R^2 + X_L^2}$. Variations in L are directly proportional to μ. Therefore variations in Z can be controlled by varying the flow of plate current in windings L_9 and L_{10}.

It may also be of some interest to know why secondaries L_{11} and L_{12} of the reactors are wound in two sections. With reference to Fig. 6, if a single winding were used there would be a flux impressed on the primary when alternating current flows in the secondary. By using a dual winding connected in parallel as shown, flux can flow around the outer legs of the core but not in the center leg which carries the primary. Flux from the two secondaries would be in opposite phase in the center leg and hence cancel. Direct-current flux from the center leg flows throughout the core.

The reactance windings, L_{11} and L_{12}, form two arms of an a-c bridge which is balanced when the displacement voltage is zero. Resistor

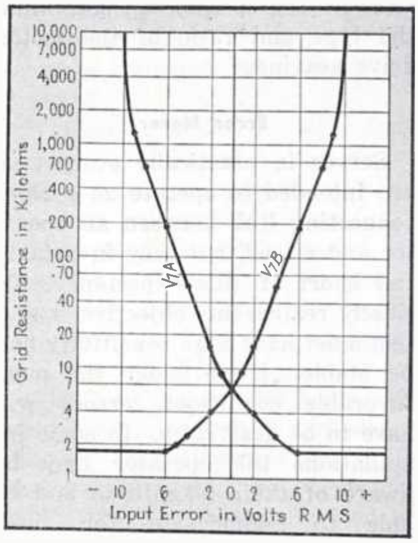


FIG. 8—The action of the error-meter tube depends on the change in grid-circuit resistance which is controlled by the plate voltage

R_9 is used to compensate for variations in circuit components which might contribute to an unbalanced condition. The impedance of the secondary as a function of direct current in the control winding is shown in Fig. 7. The zero displacement impedance, which is approximately 250 ohms, can be adjusted to match the impedance of the

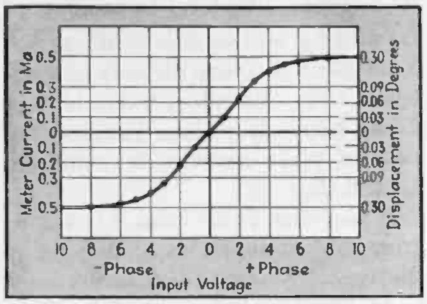


FIG. 9—To prevent damage to the meter the error tube saturates. This limits the amount of error that can be indicated, but in applications where close tolerances must be held this is no disadvantage. The meter can be calibrated in degrees displacement of the load as shown on the right

motor winding, L_{13}, by changing the value of the bias resistor R_6.

The motor represented in the schematic is a split-phase, low-inertia type. Each winding, L_{13} and L_{14}, is rated at 75 volts at 0.1 ampere; the motor has a normal speed of 3200 rpm. The size of the motor will largely depend on load characteristics. These facts, as well as operating speeds, will determine the type and ratio of the motor drive gearing.

Error Meter

Servos in practically every case are intended to operate as a rigid connecting link between an operator and a load, but they invariably fall short of this expectancy. To closely realize this objective, a system must have high sensitivity and be stable. Even under the most favorable conditions, errors will have to be dealt with. In some installations the operator may be aware of their magnitude and be able to compensate for them through proper correcting means. In the event that there are no direct indications of how well the load is following the director, auxiliary indicating equipment should be used in conjunction with the servo.

If necessary, a type of error-indicating circuit shown in Fig. 2 may be used. An input transformer, T_4, is coupled to the same source of data going to the amplifier, which may vary in potential from 0 to approximately 50 volts for displacements between 0 and 90 degrees in either a clockwise or counter-clockwise direction. Since the operator is particularly interested in errors not exceeding a few degrees in either direction, the indicator is zero centered and sufficiently sensitive to indicate small angular displacements.

Transformer T_1 couples the displacement input voltage to the plates of a 6SN7 tube, V_7. The desired performance could only be obtained by using the plates as control elements. They control the grid-to-cathode resistance of their respective tubes.

The cathode-grid resistance of each tube and resistors R_{20} and R_{22} comprise four arms of a half-wave, phase-sensitive bridge. The meter is connected across the output of the bridge. A reference voltage of 6.3 volts is supplied from the heater winding of transformer T_5. The potentiometer R_9 is used to balance the circuit.

When the 60-cycle error signal is supplied to the plates of the tube through the push-pull transformer, which incidently has a step-up ratio of 1:12, and a 60-cycle reference voltage is supplied to the parallel-connected grids, the grid voltage will be in phase with the plate voltage of one tube and 180 degrees out of phase with the plate voltage of the other. When the grids are positive for the duration of a half cycle, the direction of the servo error will determine the sign of the voltage on the respective plates during this period. A positive plate causes a decrease in grid resistance of one tube, which reaches a minimum of 1750 ohms, while a negative plate increases the grid resistance of the other tube to infinity.

Figure 8 represents changes in grid resistance of V_{7A} and V_{7B} as a function of input voltage. At zero voltage the grid resistance of each tube is 660 ohms. After the input signal has reached 10 volts, there is no further change in grid resistance of either tube.

The curve in Fig. 9 represents direction and magnitude of current flow in the meter as a function of error voltage. The curve shows that meter current reaches its limit of change when there is no further change in grid resistance.

The meter may be calibrated in degrees by converting the error voltage into angular displacement values. Since the maximum output of either the one-to-one or the 33:1 synchronous systems is 50 volts, the voltage for any angular displacement will be $E = 50 \sin \theta$.

At an angle of one degree of the 33:1 system to which the meter circuit is normally connected, $E = 50 \times 0.0174 = 0.87$ volts. By using the curve of Fig. 8, it will be found that 0.87 volts is equal to 0.087 ma on the meter scale. Since 0.87 volt is equal to one degree displacement of the 33:1 system, this represents an error of 0.033 degree between the positions of the indicator dial and the load.

Because there are no further changes in cathode-grid resistance after an input signal of ten volts, there will be no further increases in meter current between this voltage and the maximum data output of 50 volts. For this reason the cir-

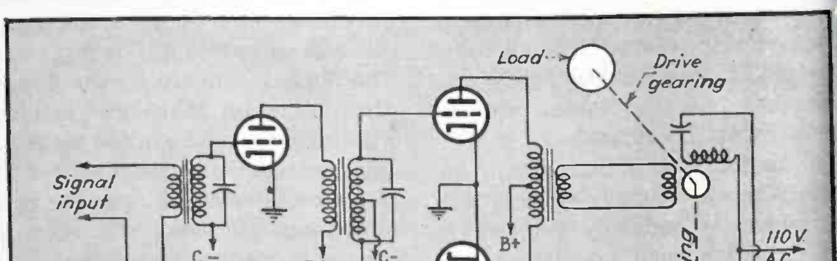


FIG. 10—Conventional servo amplifier, illustrating direct motor-control and feedback to prevent hunting

ıit protects the meter from possi- le overloads. Resistor R_{18} limits ıe current in the plate circuit to a ɜw microamperes. An spdt switch , is used to short-circuit the input hen balancing the meter after a ıbe change.

Other Amplifier Circuits

With reference to the servo sys- ɜm being discussed, the amplifier ıd control circuits described form ıly one of the various combina- ons generally used. The type ıosen depends largely on the size ıd kind of motor required to op- :ate the load and the circum- ances surrounding the servo ap- lication. Saturable reactors are ommonly used as power amplifiers ı a large variety of servo systems, ıt more in particular for the ontrol of fractional horsepower otors.

Figure 10 is a schematic of the ore conventional vacuum-tube nplier preferred for some servo plications. The 60-cycle output of ıe data system is amplified and ıed to drive the motor. A separ- ely generated 60-cycle source is ıupled back to the amplifier input ı an anti-hunt measure.

A generator G is driven by the otor through a one-to-one drive. he generator is similar in con- ruction to a split-phase, low-in- tia motor having two field wind- gs angularly spaced 90 degrees. he rotor is of soft iron construc- on covered with a copper shield. ne field, L_1, which is supplied from e 60-cycle source, serves as a pri- ary winding. When the motor is ot rotating there is no transfer of ltage from this field to the other. uring rotation, the 60-cycle flux tablished by the primary is dis- rted by the eddy currents in the pper shield. By this action a ltage is induced in secondary inding L_2 that is proportional to ıe speed of the rotor. The phase ' the induced voltage changes with ıe direction of rotation. This volt- ɜe is opposite in phase to the sig- ıl input to the amplifier.

During operation, a type of dyna- ic braking is produced. The sig- ıl normally overrides the feedback ltage beyond a small angular dis- acement. This excess voltage is fective in stabilizing the system ter a constant velocity error has

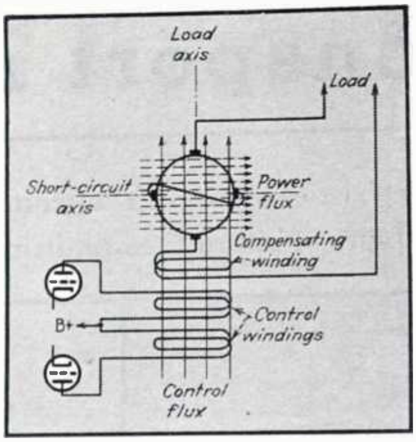


FIG. 11—Dynamo-electric amplifier-motor combines in one unit the saturable-reactor flux amplifier and the motor for servo applications

been reduced to zero. Under such conditions, an angle of displacement will be reached where the feedback voltage is equal to the signal. As time passes the motor begins to respond to the inverse feedback signal which tries to reverse its direction. This voltage only succeeds in slowing the motor because it decreases directly with the decrease in motor speed. The result is that the anti-hunt voltage and the signal are allowed to reach zero at the same time, preventing the undesired overshoot.

When closed-cycle servo mechanisms are employed in high-power-consuming operations, the amplifier may consist of grid-controlled gas-filled tubes. Generally only one stage of this type of amplification is required because of its extremely high gain. The low internal resistance of the tubes during ionization of the gas allows such a stage to function with high efficiency. This fact makes gas tubes desirable when supplying power to large machines.

Servo Motor-Generator

There are also the dynamo-electric amplifiers particularly adaptable to this type of servo. One such amplifier has two-stages combined in a single dynamo-electric machine, schematically shown in Fig. 11. The first stage comprises the control winding and a short-circuited section of the armature. The armature is rotated by means of a separately excited drive motor. A control flux established by the control winding is cut by the short-circuited armature windings, producing a power flux that may be 100 times stronger than the control flux. A second stage of amplification is from the short-circuited armature windings to that section of the armature connected by the load brushes. A gain of 100 can also be realized from this stage, giving the machine an overall gain of 10,000.

The control winding is center-tapped and connected in the plate circuit of a pair of amplifier tubes which in turn are supplied with a d-c signal. The operating characteristics of the pre-amplifier are similar to the unit shown in Fig. 2. The output of the machine is proportional to a difference in current flow through respective halves of the control winding. An input of one watt can produce an output of ten kilowatts.

The first stage of this machine is similar to a conventional d-c generator. The particular difference is that the usual armature circuit resistance is reduced to a short circuit, causing a high armature flux. This short-circuit axis armature flux can now serve as the field for the second generator made possible by the addition of the second set of brushes, referred to as load axis brushes.

Voltage produced at these brushes is supplied to the circuit resistance. Current flowing through the load will produce a load axis armature flux which would oppose the control flux. This field is completely neutralized by the load compensating field through which load current flows.

This type of amplifier has a comparatively high rate of response to changes in the control field. The short time-constant is chiefly due to the very low short-circuited armature resistance and the low control field requirements. Machines such as this which have a rapid response are particularly desirable for servo work.

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Transport Aircraft

Method of measuring the characteristics of aircraft antennas with a Q meter. Results of measurements on several types of aircraft transmitting antennas are presented

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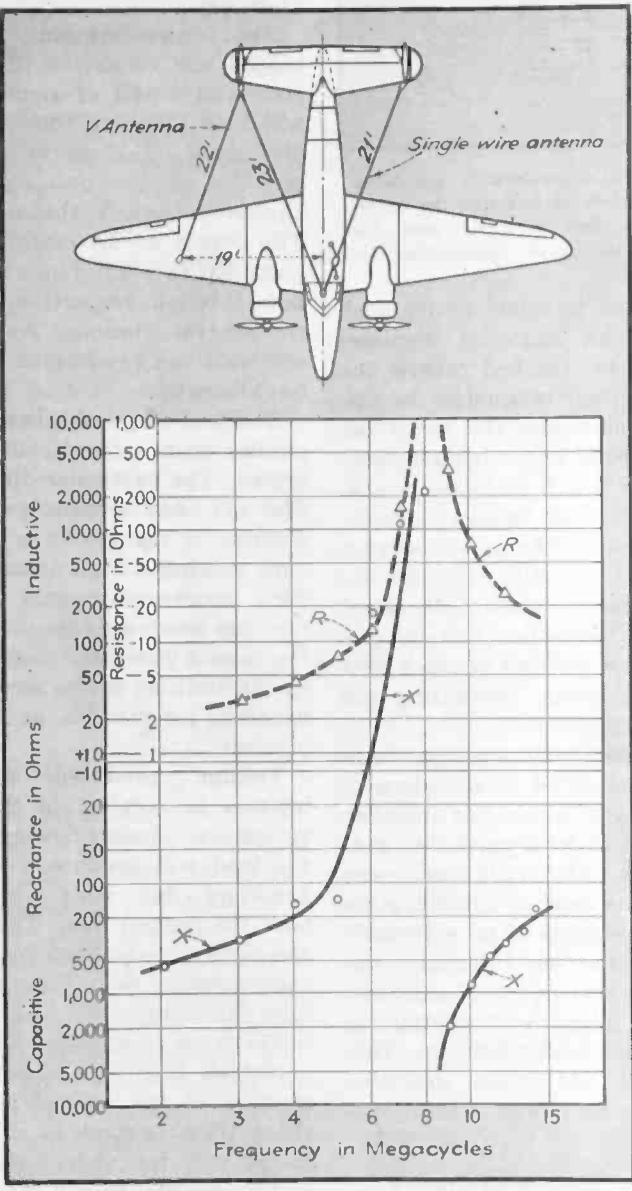


Position and characteristics of V antenna on Lockheed 14 transport. The reactive component of antenna impedance changes sign as the antenna passes through resonance

This discussion will be confined to methods and data taken from representative domestic transport aircraft equipped with antennas permanently attached above the fuselage.

Two methods may be used for obtaining antenna data. One involves an r-f bridge upon which values of resistance and reactance can be read directly. The bridges available at present are not particularly adapted to aircraft antenna measurements.

Q Meter Measurements

The other measuring method utilizes the Q meter, the data from which requires considerable computation to yield the desired constants. The data presented herein is based on Q meter measurements.

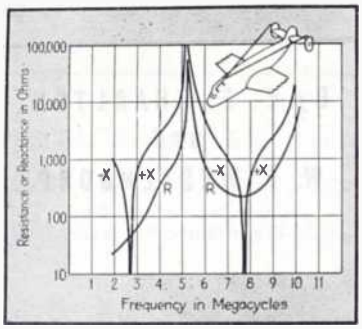
A Q meter consists essentially of a calibrated variable-frequency oscillator capable of inserting a known voltage in series with a resonant circuit, and a vacuum-tube voltmeter which measures the voltage across the resonant circuit. Then $Q = E/e$, where e is the inserted voltage and E is the voltage read by the v-t voltmeter. By maintaining e constant the v-t voltmeter can be calibrated directly in Q values. In the commercial instrument the components are housed in a cabinet including an a-c power supply, terminals, and a calibrated low-loss variable capacitor. Any suitable coil may be connected across the terminals to form, together with this calibrated capacitor, a tuned circuit. The impedance to be measured is inserted in the tuned circuit either in series or in parallel with the coil.

Two sets of readings are necessary: one to determine the impedance and Q of the coil, and one to determine the impedance and Q of the coil and unknown impedance together. Calculations are then made to determine the impedance and Q of the unknown impedance alone.

Measuring Aircraft Antenna

Precautions are necessary when applying the Q meter to aircraft antenna measurements. The plane should be as far from metallic structures as practical. Grounding wires, such as are used during gas tank filling operations, should be disconnected to minimize the earth's effect on the antenna. For the same

Antenna Characteristics



Impedance characteristic of the Douglas DC-4 V antenna

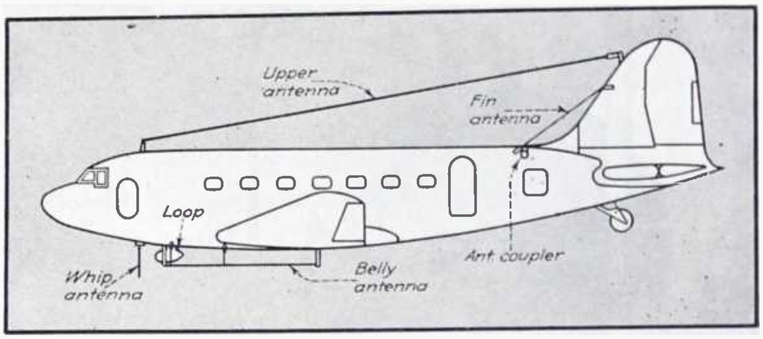


FIG. 1—Profile of Douglas DC-3, showing the various types of antennas used for communication and navigation purposes

eason it is undesirable to use an -c power line on the Q meter. A otary converter supplied from the lane battery or a battery cart is equired.

A number of coils are needed de- ending upon the frequency spec- rum over which measurements are ɔ be made. Several low-loss fixed apacitors may be needed to sup- lement the variable capacitor in he Q meter and to place in series rith the antenna when the Q read- ıgs fall below those conveniently ıade on the Q meter. In these ases it is necessary to make addi- ional calculations to obtain the an- ɜnna reactance. It is necessary to xercise care in adjusting the Q ıeter when the antenna is in the icinity of half-wave resonance, ecause the reactance and resis- ınce values change rapidly in this egion.

Table I gives data concerning the ɔp antenna on a Douglas DC-3, hown in Fig. 1. The data in the ırst seven columns was taken in ɩe field; that in the last five was omputed.

The readings C_1 and Q_1 are taken rith the antenna disconnected from he Q meter; C_2 and Q_2 with the ntenna connected. In the columns ıbelled C added, P indicates a paral- ɘl connection, and S a series con- ection. It should be noted that rhen using a series capacitor, if he value of $C_1 - C_2$ becomes larger han the series added capacitance, he antenna has become inductive. 'his also holds true when C_2 be- omes larger than C_1. The formulas sed in conjunction with the data re as follows:

$$Q_A = \frac{(C_1 - C_2)\,Q_1 Q_2}{C_1\,(Q_1 - Q_2)}$$

$$X_A = 1.59 \times 10^8/fC_A$$

$$R_A = X_A/Q_A$$

$$C_A = C_1 - C_2$$

$$C_A = \frac{(C_1 - C_2)C_S}{C_S + (C_1 - C_2)} \text{ (series capacitor)}$$

Q_A = antenna Q
X_A = antenna reactance in ohms
R_A = antenna resistance (effective), ohms
f = frequency in kilocycles
C_A = antenna capacitance in $\mu\mu f$
C_S = series capacitance in $\mu\mu f$
C_1 and C_2 = reading of variable capacitor in Q meter, in $\mu\mu f$

The quantity $(C_1 - C_2)$ is always taken as positive.

Aircraft Antenna Practice

It has become general practice to connect the aircraft antenna in series with the lumped C and L in the output circuit. Such an arrangement does away with coupling elements and allows a higher transfer efficiency. By providing a group of selectable fixed capacitors and a continuously variable inductor it is possible to reach resonance over a wide range of antenna constants. The system fails, however, at half-wave resonance where a slight change in the physical capacitance of the antenna may reflect a greatly magnified reactive component into the circuit. The simplest solution is to change the length of the antenna so as to shift the half-wave resonant condition away from the working frequency. The radiation efficiency of this extended tank circuit becomes very low when the antenna is a small fraction of a quarter-wavelength. This condition is not encountered on domestic air transports operating between 3000 and 6000 kc, but occurs on planes built for foreign service where bands between 300 and 600 kc are used. The short antenna becomes so highly reactive that voltages up to 30,000 volts may build up. Trailing antennas are then needed.

Dummy Aircraft Antenna

In addition to determining antenna characteristics at the various frequencies, an application of measurements such as these is in the design of dummy antennas. Such antennas are very useful when it is desired to bench-check transmitters under load conditions simulating those imposed by the aircraft antennas.

TABLE I. DATA ON DC-3 TOP ANTENNA

Freq. in kc	C_1	C added	C_2	C added	Q_1	Q_2	$C_1 - C_2$	$Q_1 - Q_2$	Q_A	X_A	R_A
2500	443	P141	290	P141	315	120	153	195	50.8	−j410	8.06
3000	406	....	233	....	347	157	173	190	122.0	−j310	2.5
3500	297	....	82	....	372	76	215	296	69.2	−j210	3.03
4000	226.5	....	130	S141	392	147	96.5	245	100.	−j130	4.1
5000	145	....	92.5	S50	424	148	52.5	276	84.	+j30	7.14
6000	210	....	194	S15	224	189	16	35	92.3	+j110	17.4
7000	155	....	134	S15	233	107	21	126	26.8	+j430	41.0
8000	381	P105	390.5	P105	141	89	9.5	52	4.72	+j2100	445.
9000	377	....	370	....	145	85	7.0	60	3.81	−j2520	663.
10000	305	....	286	....	152	76	19.0	76	9.5	−j810	87.
11000	252	....	227.5	S105	160	83	24.5	77	17.1	−j450	32.9
12000	213	....	188	S50	168	92	25.0	76	23.8	−j260	22.

Mobile

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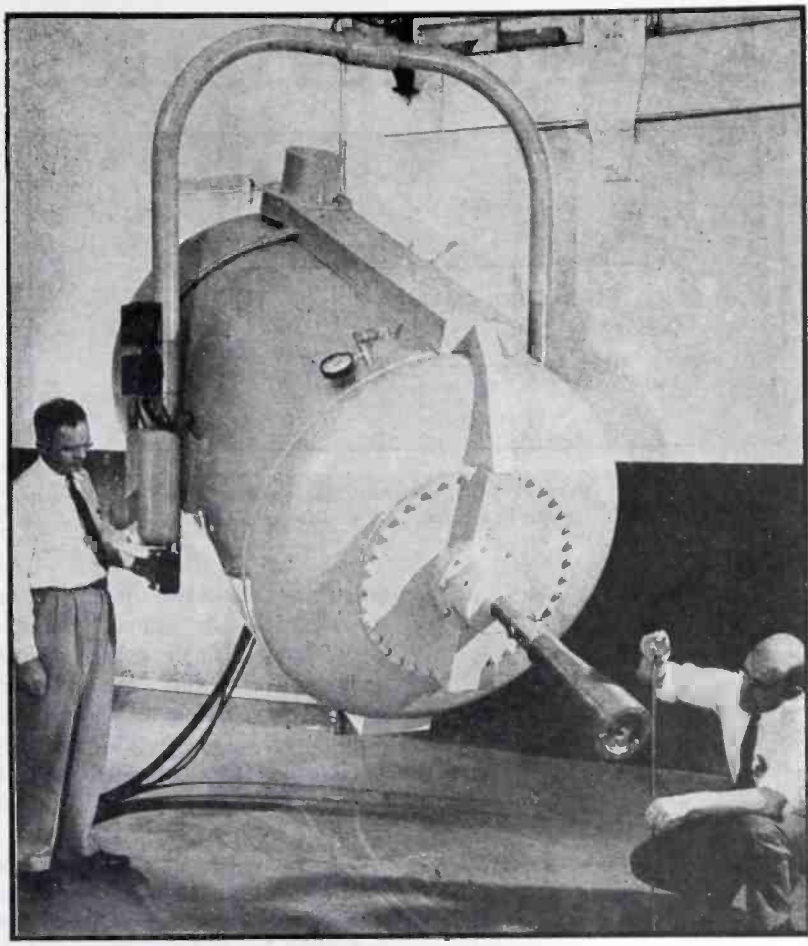


To show the mobility of the two-million volt x-ray unit built by General Electric X-Ray Corp., Dr. Charlton operates the positioning motor while Mr. Westendorp checks the height of the extended tube preparatory to moving in the sample to to be radiographed

To increase the utility of x-ray inspection, a two million volt mobile unit has been developed. X-rays produced at this high potential have far greater penetrating power than those produced at lower potentials. For example, foot-thick steel, which for practical purposes is opaque to x-rays produced at lower voltages, can be x-rayed in about two hours with this new unit.

In addition to increasing the thickness which can be x-rayed and decreasing the exposure time for thicknesses which could be penetrated by lower-voltage rays, the higher-voltage rays permit placing the x-ray source further from the sample being studied. This increases the area which can be radiographed in a given time and also reduces distortion of the image.

Most important of all is the fact that the higher-voltage x-rays can be used to study a sample having a wide range of thicknesses with a single exposure, because the exposure time for thick and thin sections are more nearly equal with the x-rays produced by this high-voltage instrument.

Design Features

The two million volt mobile x-ray unit described in this article is a further development of features embodied in the million-volt therapeutic x-ray unit developed for cancer treatment and the portable one million volt industrial x-ray unit. In this new equipment, the x-ray tube has been permanently vacuum sealed. All parts form a unit that is mobile in that it can be moved by crane and positioned for operation at any angle by push-button control of fractional-horsepower motors. Mobility increases the flexibility of this radiographic tool for industrial examination of metal structures.

This unit consists principally of a low-frequency resonance transformer with the multisection x-ray tube coaxially mounted within, and both contained in a steel tank and insulated with compressed gas. The x-rays are generated at a target mounted in the end of an extension chamber projecting from one end of the tank. This construction provides maneuverability, compactness, simplicity, reliability, freedom from exposed high voltage, and ready accessibility of the target end of the tube. The unit is five feet in diameter, eight feet in length and weighs 5000 lb.

Construction

The transformer shown in Fig. 1 and 2 has a low-voltage winding, consisting of two flat coils of rectangular wire and a high-voltage coil with 243 thin flat sections spaced apart for cooling. The upper coils are spaced more closely than the lower coils to provide a uniform potential gradient along the length of the coil stack. In this way radial spring taps to the x-ray tube can be used to supply the proper voltage to each tube electrode.

The resonance principle of operation makes an iron core unnecessary. The central space of the high-voltage coil is occupied by the x-ray tube, thus facilitating tube connections. In addition, the absence of the iron core eliminates space otherwise required for insulation between core and high-voltage winding. This resonant type transformer has a tank diameter only 62 percent of that of a comparable iron-core transformer.

The lower end of the high-voltage coil is grounded; the upper end is shielded by a rounded and radially slotted brass spinning.

From a paper presented before the National Electronics Conference, Chicago, 1944.

Industrial X-Ray Unit

esonant high-voltage transformer and gas insulation reduce the size and bulk of this two illion volt x-ray unit. Special alloy permits glass-to-metal seals so that the x-ray tube can e permanently evacuated, eliminating the need for vacuum pumping during operation

The natural frequency of oscilla-on of the high-voltage winding is 0 cps. The 180-cycle power is rived from the 60-cycle supply ne through a synchronous motor-nerator set which also eliminates e effect of line voltage fluctua-ons.

The coil is held under compres-on by spring-loaded drawn glass ds free of air lines and blow holes d with their surfaces sandblasted increase their resistance to sur-e creepage discharges. This type support makes it possible for the it to be operated in any position.

Since the tube is mounted in the s of the resonance transformer, is located in a uniform electric d and a weak magnetic field rallel to the tube axis. The mag-ic flux does not interfere with ctron focusing.

To avoid overheating of the sur-nding steel tank by eddy cur-ts there is an inner lining of rrow overlapping silicon steel ips spotwelded to the tank wall. ese steel strips guide the mag-ic flux of the transformer from top to the bottom. The bottom o is provided with a ring of simi- radially spotwelded strips.

Continuous operation at 120 de-es F ambient temperature is de possible by the coolers nted diametrically opposite each er near the top of the tank. A all fan circulates cooling gas ough ducts, through the trans-mer and over finned water-cooled per tubing mounted in each ler. For ambient temperatures ow 50 degrees F an electric ter raises the water tempera-e to maintain the gas pressure.

The tank of quarter-inch thick et steel is designed for an oper-ng pressure of 60 pounds per are inch gauge and has been tested hydrostatically to twice this pressure. The joints of the shell flange, the coolers and the x-ray tube flange are made gastight with rubber gaskets.

X-Ray Tube

A twenty four-section vacuum sealed x-ray tube for operation at two million volts was designed to go with the resonance transformer. It has an electron-emitting filamentary cathode, a copper backed tungsten target mounted in the lower end of an extension chamber, and cylindrical accelerating electrodes in each of the intermediate sections. Both target and chamber walls are watercooled.

The tube envelope consists of sections of molded borosilicate glass tubing joined to fernico rings which carry the intermediate electrodes of stainless steel. Fernico is a special alloy which has an expansion coefficient comparable with that of one of the borosilicate glasses. This property of the fernico alloy, permitting thick metal sections to be fused directly to glass, has allowed the tubes to be made much smaller than might otherwise be possible and has also permitted a rigorous exhaust of the

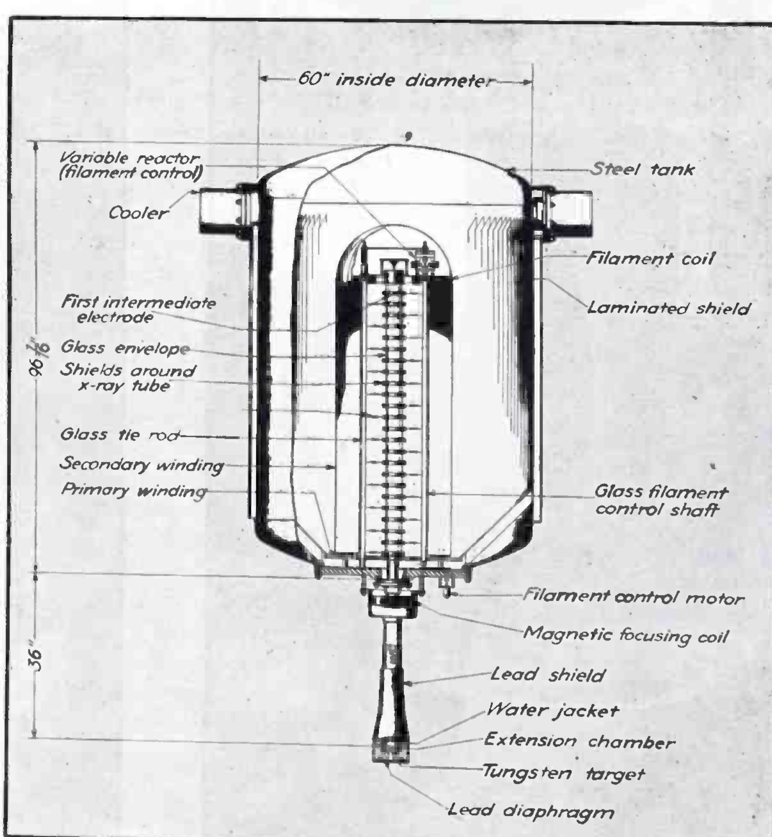


FIG. 1—This cutaway drawing shows the construction of the two million volt x-ray unit

tube. The inside glass walls of the tube are sandblasted to increase the voltages that can be applied to each section of the tube without the production of dangerous field current.

The cathode spiral of tungsten wire is mounted in an electrostatic focusing cup. The tube is supported by a metal flange bolted to the bottom of the grounded metal tank and soldered to the copper extension chamber. A magnetic focusing coil surrounds the x-ray tube extension chamber and controls the spot size of the electron beam on the target.

The tube is sealed after an evacuation process during which the glass envelope and metal parts are outgassed and all sections are aged at voltages twice the operating voltage. This process insures stability of operation and long life.

Gas Insulation

The insulating and cooling gas is derived from liquid dichloro-difluro methane, CCl_2F_2, known as Freon-12. This gas has a dielectric strength 2.5 times that of nitrogen at the same pressure. The gas pressure in the transformer tank is maintained at about 55 lb per sq in. A pressure-stat on the tank blocks operation of the transformer if the pressure drops below 50 lb per sq in. either because of leakage or abnormally low temperature. About 240 lb of gas is required, whereas to give the same insulation more than forty thousand pounds of transil oil would be required. Corona or an open flame decomposes Freon-12, liberating chlorine and fluorine. However, experience indicates that there is not enough decomposition inside the tank to cause troublesome deterioration of insulation or other components. Transformers without the x-ray tube were tested up to 2,500,000 volts without sparkover with Freon-12 at 50 lb per sq in. and 70 degrees F.

Figure 3 shows a schematic circuit diagram of the principal circuit elements. The push-button controls selector switches, control motor drives, interlocks, protective devices and indicator lights have been omitted for the sake of readability.

Electrical Circuit

The series reactor and the shunt capacitor serve to eliminate the effect of the small frequency fluctuations that occur on the power system.

When operated by itself on a constant primary current of adjustable frequency the transformer produces a secondary voltage that follows a resonance curve having a maximum at 180 cps. The transformer is purposely tuned at constant input current in order to produce a maximum of output voltage with a given primary current and also to operate at close to unity power factor. However, when operated at constant

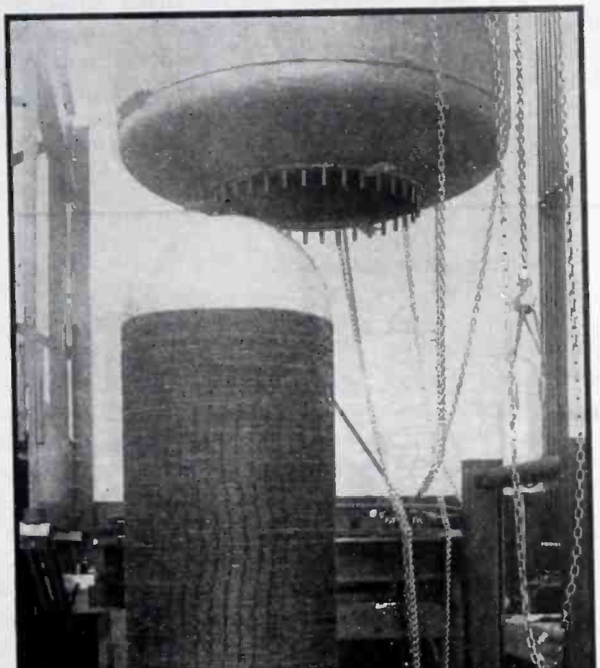
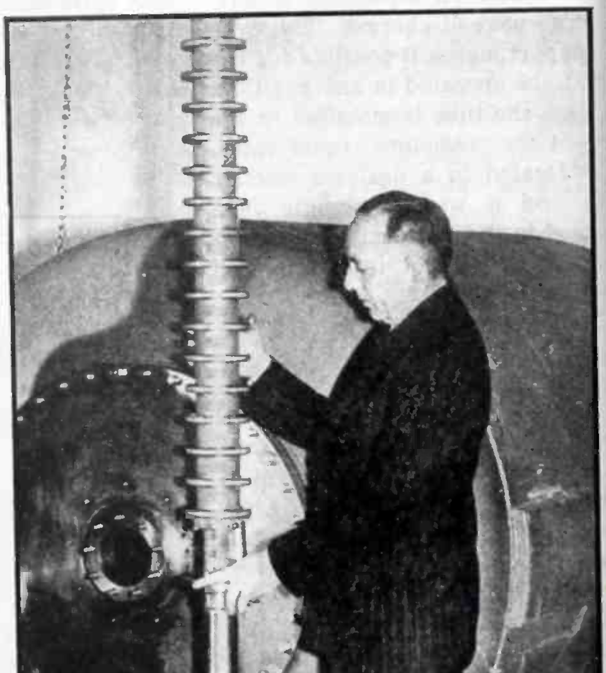


FIG. 2—The steel tank has been removed to show the transformer and the slotted brass shield at its upper end



Sealed-off two-million volt multi-section x-ray tube, held vertically in front of its steel housing

·imary voltage and variable fre-ıency, the transformer produces ; voltage maximum at 180 cps.

The series reactor and shunt ca-ıcitor so modify the constant-volt-ıe operation of the generator that ıe resonance transformer again ıs a maximum of voltage at 180 ccles. Small frequency variations (the order of one-tenth cycle can ıerefore occur at the flat top of the ısonance curve and will not show ıy effect on the output voltage.

The filament is operated from end ırns on top of the high-voltage coil ıd the filament current is adjusted ı a variable reactor driven through ı glass shaft by an external fila-ıent-control motor.

Metering Circuit

The metering circuit, connected ıtween the lower end of the high-ıltage winding and the grounded ık, consists of a d-c milliammeter ıth a reactor in series, and an a-c ılliammeter with a capacitor in ıries. The unidirectional x-ray ıbe electron current registers on ı d-c milliammeter; the secondary ıarging current (131 ma rms at ı 2,000,000-volt peak) passes ırough the capacitor and thus reg-ıers on the a-c milliammeter ıich is calibrated in megavolts ıak.

Auxiliary Circuits

The field of the generator is con-ıcted through a push-button oper-ıd relay to a motor-driven poten-ımeter which in turn is connected ıoss the exciter of the generator. ıe motor is operated from the con-ıl panel by a megavolt control ıer. Interlocking contacts are ıvided so that the unit cannot be ırted unless this potentiometer ın its lowest position, correspond-ı to approximately one million ıts. Another control lever on the ınel operates the filament-control ıtor.

A selector switch on the control ınel chooses one of four scales on ı tube current meter. The same ıitch simultaneously adjusts the ıect current through the mag-ıic focusing coil, thus setting ı spot size on the target for each ı the current ranges. This switch ıo switches various shunts on a ıbe-current operated relay which ıotects the x-ray unit and meters

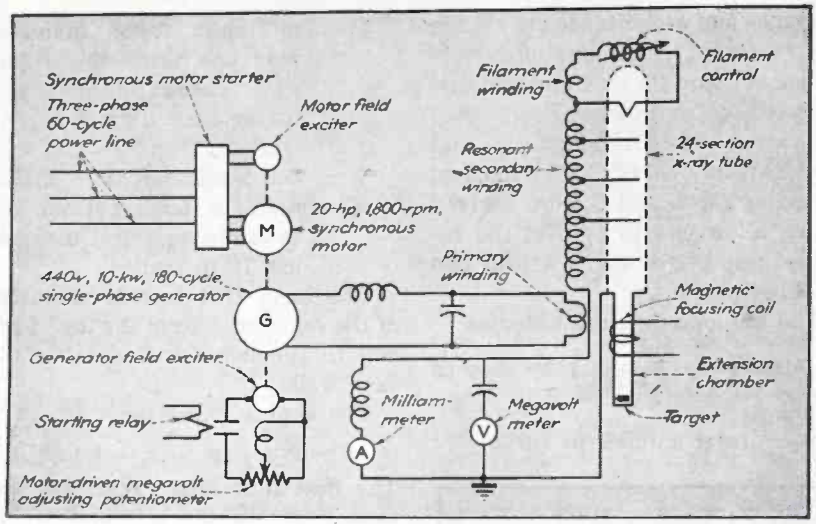


FIG. 3—Simplified schematic circuit diagram of 2,000,000-volt x-ray unit

against operation beyond the selected range.

A timer is provided which can be set from a few seconds to 55 minutes. It starts timing when the voltage passes the 1.8-megavolt point and opens the starting relay after the preadjusted interval has elapsed.

Table I shows typical electrical operating data of the unit.

Operating Sequence

A typical operating sequence will illustrate the simplicity of operation. Assume the operator plans to make the next exposure 1 minute at 1 ma and 2 megavolts.

He calls all people out of the x-ray room, closes the doors, selects the 3-ma range on the panel, starts the motor-generator set, pushes the x-ray-on button, lets the voltmeter come to 1 megavolt, then advances the voltage control. After reaching 2 megavolts he adjusts the filament control to give 1.5 ma, pushes the off button and goes into the x-ray room to place the film. For the exposure he repeats the foregoing except that he uses the timer which he adjusts for one minute. The current comes to 1.5 ma without adjustment.

TABLE I. OPERATING DATA

Tube Current in Ma	Transformer Input Volts	Amperes	Watts
0.00	418	8.2	3050
0.50	420	9.7	3825
1.00	425	11.1	4575
1.50	435	12.4	5300

Output constant at 2-megavolt peak

Resonance Transformer Design

There are several advantages to be derived from the use of the resonance type of transformer. Waveform in the high-voltage circuit is sinusoidal regardless of the input voltage. Furthermore, the oscillating current in the high-voltage winding is so large (131 ma rms at 2 megavolts) that the half-wave full-load tube current of 1.5 ma average does not produce any measurable difference between useful and inverse voltages.

In a resonance transformer where the oscillating power is 151 kva and the load, including losses, approximately 6 kw maximum, the voltage takes a few cycles to build up, even if the equipment is switched on suddenly. Therefore, switching surges or other disturbances do not raise the output voltage more than a fraction of one percent, whereas in iron-core transformers 50 percent or more over-voltage surges may occur in case of improper switching.

Since none of the thin flat coil elements sustains more than 10 kv peak and as they have a radial winding depth of several inches, random winding can be used. For convenience of assembly, start and finish wires of the coil elements are connected through flat phosphor-bronze terminal springs as the coils are stacked on top of one another.

In designing a resonance transformer the formula for the natural period of a tuned circuit,

$$T = 2\pi \sqrt{LC} \quad (1)$$

may be used provided values of inductance and capacitance are chosen to represent the non-uniformly loaded coil and its terminal and distributed capacitance. From consideration of the magnetic and electrostatic energy distribution, formulas for L and C were derived which allow one to predict the required number of turns within two or three percent.

The inductance is evaluated as

$$L = 25n^2 \left(\frac{D^2}{h + d + D/4} \right) 10^{-9} \text{ henry} \quad (2)$$

where

n = total number of turns

D = minimum turn diameter plus one third the difference between minimum and maximum diameters in inches

h = coil stack height in inches

d = distance from bottom coil to laminated steel disk below it, in inches

The term $D/4$ is representative of the reluctance from the top of the coil to the laminated shell on the tank wall.

The tuning capacitance is

$$C = C_1 + C_2 + C_3 + C_4 + C_5/3 \quad (3)$$

The first four terms represent the capacitance of the terminal cap in simplified terms that can be calculated either as concentric spheres, parallel planes, or concentric-cylinder capacitors. The last term is the capacitance of the concentric cylinders formed by outside copper turns and inside laminated shell. This term appears with the coefficient 1/3 because the energy stored in this space is only one third of what would be stored with uniform winding voltage.

For the mobile two million volt 180 cycle x-ray transformer these calculated values are $C = 67.1\ \mu\mu f$, $L = 11{,}700$ henrys.

Three times as much inductance would be required for resonance at 60 cps and the wire diameter for such a design would be impractically small. Higher frequencies than 180 cps could be used but are not desirable since the iron losses in the return magnetic shell would increase almost proportionally to the square of the frequency even if there were an increase in the weight of iron.

The stored energy of the tuning capacitance C at the peak of the voltage wave amounts to

$$\tfrac{1}{2}CV^2 = \tfrac{1}{2}(67.1 \times 10^{-12})\ (2 \times 10^6)^2 = 134 \text{ joules}$$

This stored energy corresponds to a power of $(1/2)\omega\ CV^2$, which in this case is 151 kilovoltamperes.

The tuning capacitance C must be distinguished from the charging capacitance C_c which is used in calculating the charging current of the transformer. Because the energy stored per unit volume in the cylindrical space between coil and tank varies with the square of the height, the fifth term in Eq. (3) appears with the coefficient 1/3. Because the dielectric displacemen current per unit height of the coi is proportional to the height, th term of C_5 will appear with th coefficient 1/2 in the expression fo C_c, thus

$$C_c = C_1 + C_2 + C_3 + C_4 + \tfrac{1}{2}C_5 \quad (4$$

The calculated value of C_c is 83 $\mu\mu$ with a reactance of 10.66 megohms drawing a charging current of 13 ma rms at 2 megavolts through th ground connection of the high-voltage coil. This calculated current i close to the 131 ma rms determine by measurement.

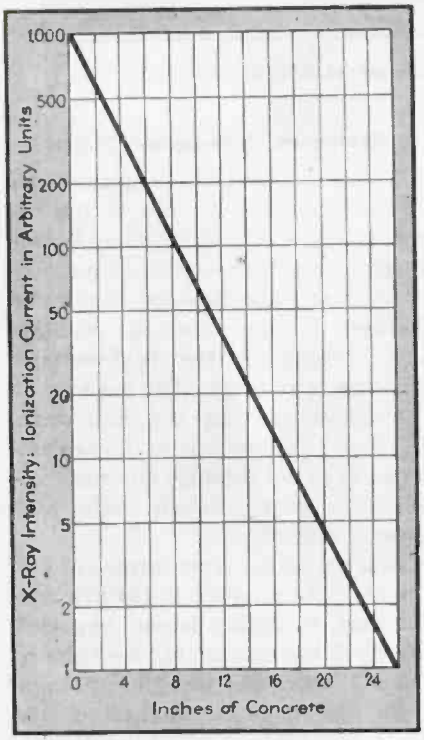


FIG. 4—This plot of the transmission of two million volt x-rays through concrete indicates the thickness necessary to provide safe shielding of the radiograph room

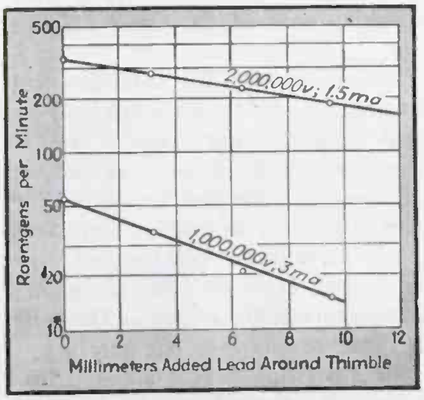
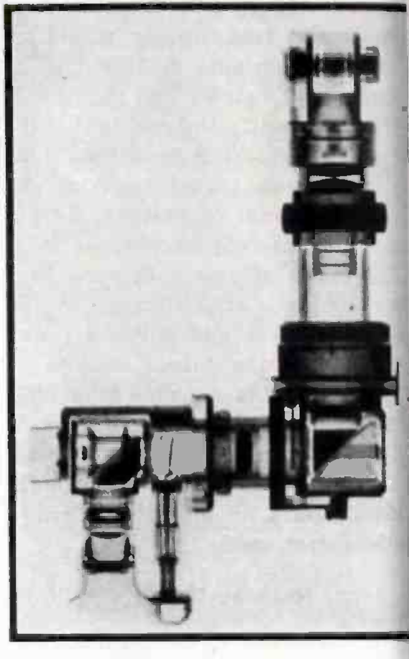


FIG. 5—Comparison of one and two million volt x-rays shows that the higher-voltage rays have relatively higher penetration for thick objects than do the lower-voltage rays



Radiograph of a German periscope, made with the 2,000,000-volt x-ray unit, illustrates how one exposure is sufficient at this high voltage to obtain a picture of several thicknesses and materials

Megavoltmeter Calibration

Calibration was done in air a atmospheric pressure with an ex ternal 12.5-cm sphere gap correcte and adjusted for 100 kilovolts peak The hemispherical brass termina cap of the transformer was con nected through one of the coole holes by a metal tube and a high voltage insulating bushing to th external sphere gap. The added ca pacitance threw the transforme out of tune and the charging cur rent read on the meter in th ground lead of the high-voltag winding was meaningless. However across the other hole in the tan diametrically opposite the bushin was temporarily mounted agains the inside wall of the tank a large nooth, insulated pick-up plate. A ad from this plate passed through e hole to a vacuum-tube rectifier ad d-c microammeter.

By operating the transformer at 0 cycles and raising the voltage ntil the spheres sparked, a reading as obtained on the pick-up plate icroammeter corresponding to 100 llovolts peak. After removal of the ishing and the sphere gap the ansformer was again in tune and e 100 kilovolts peak obtained by ading the pickup plate microammeter was used as the basis of the libration of the megavoltmeter on e control panel.

The insulating shaft for adjusting the filament current is also of ass similar to the transformer tie ds. This control shaft, mounted side the transformer stack and iven by a reversible motor, provdes remote control for the varile inductance in the filament circit. By controlling the filament curnt the x-ray tube electron beam rrent is made adjustable.

Electron Beam Control

Toroidal shields surrounding and cnnected to the various electrodes ectrostatically shield the electron am. The size of the beam is rgely determined by cathode geetry and by the ratio of the volte used in the first section to that the remaining sections. Without gnetic focusing the spot on the rget is about ⅜ in. in diameter. can be changed to any desired e by the magnetic focusing coil. r industrial radiography the size the focal spot is reduced as far as ssible without overloading the ngsten target and thereby shortng the life of the tube.

X-ray Protection

The x-ray protection for this unit ıst be supplied largely by build- the enclosure in which it is to used with thick walls of concrete lead. This becomes necessary beuse diversified radiographic techques with metal structures of difrent shapes demand that the exnsion chamber not be covered th a large and heavy protective ield.

A lead shield with two-inch thick lls and weighing 140 lb is placed ound the extension chamber. This ovides some protection, but its principal purpose is to improve the quality of the radiographs by reducing the scattered and stray x-radiation. This shield can be adjusted to change the diameter of the cone of radiation of either the reflected or the transmitted beam of x-rays.

Figure 4 gives the transmission of 2-megavolt radiation through poured concrete. These data in combination with the x-ray intensity measurements given in Roentgen units in Fig. 5 permit an estimate of the wall thickness required to provide any degree of x-ray protection.

X-Ray Radiation Measurements

This x-ray unit produces very penetrating x-rays of high intensity. Figure 5 gives the x-ray output of the 2,000,000-volt machine operating at 1.5 ma current, compared with a million-volt machine operating at 3.0 ma current. These intensity measurements were taken of the transmitted beam through the tungsten target with an inherent filtration of 1.5 mm tungsten and 5.0 mm copper and using a Victoreen Roentgen capacitor meter. The thimble type ionization chamber was placed 100 cm from the target in free air for the zero filter measurement and inclosed in lead cylinders for the added lead filter measurements.

Industrial Applications

Radiographs of thick sections of steel, ranging from 1 to 10 inches in wall thickness, can be obtained in short exposure times using 2,000,000-volt radiation. The comparative gain in radiographic speed of this machine over the million-volt unit becomes more pronounced for the thicker sections of metal. Figure 5 shows that the higher-voltage x-rays are less rapidly dissipated in traveling through thick sections than are the lower-voltage x-rays.

Figure 6 shows the decrease in exposure time required with the 2,000,000-volt machine rated at 1.5 ma over the million-volt until rated at 3.0 ma, for various thicknesses of steel at a fixed target-film distance. Figure 7 gives the exposure time required with the 2,000,000-volt unit through steel for various target-film distances.

Stereoscopic radiographs of metal sections of widely varying wall thickness can be obtained with definition of the order of one to two percent. It has been found that radiographs taken with two million volt x-rays will clearly define defects of less than one percent in steel structures which have walls with thicknesses which vary from one to ten inches. Two million volt x-rays have the added advantage of greater latitude in the range of metal thicknesses readable on one radiograph without the time-consuming complication of a blocking technique generally practiced in the lower voltage range.

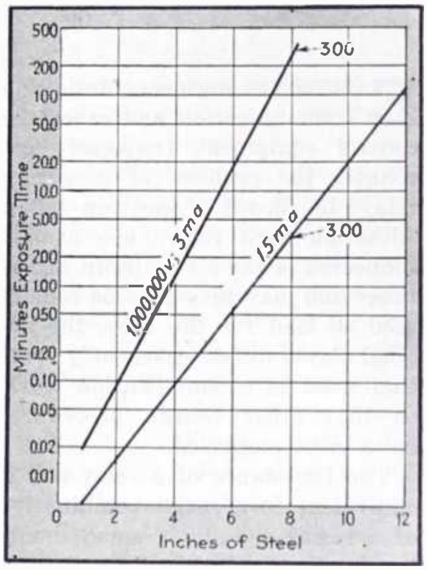


FIG. 6—The data for this graph was obtained with a three-foot target-to-film distance using 0.010-in. lead screens, type A x-ray film, density 1.5 and development at 68 degrees F for six minutes. With two million volt rays (1.5 ma curve), only one-hundredth the time required by million-volt rays is needed for radiographing 8 in. of steel

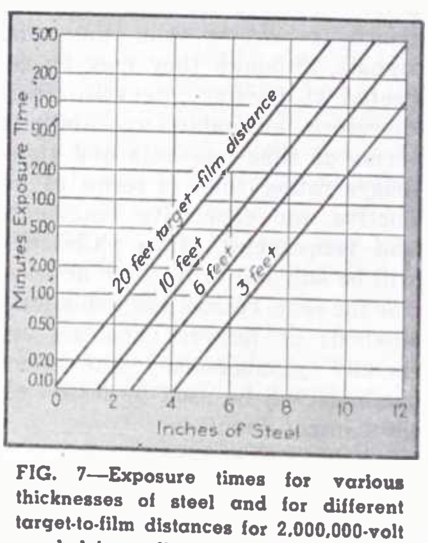


FIG. 7—Exposure times for various thicknesses of steel and for different target-to-film distances for 2,000,000-volt needed for radiographing 8 in. of steel

RELAYS IN Industrial Tube Circuits

Part I

Practical survey of available methods for using relays with diodes and triodes for on-off control applications. Ordinary d-c relays are best for both a-c and d-c operated circuits. Part II will cover relay circuits providing gradual control, and Part III will deal with relays in thyratron, multiplier phototube and other special industrial tube circuits

By **ULRICH R. FURST**
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ELECTRONIC engineers designing communication and especially control equipment frequently encounter the problem of operating relays by means of electron tubes. Although such relays are usually connected in the plate circuit of the tubes and may therefore be considered as load for the tube, the applied signal differs essentially from that used in communication work, so that other design procedures have to be employed.

The impedance of a relay coil is equivalent to a series combination of a resistance and a small inductance whose value is, like all iron-core inductors, dependent upon the coil current. In most cases this inductance can be neglected because the time of a cycle of operation is usually much greater than the time constant of the relay.

The signals used to control the action of relays are best treated as transients rather than sinusoidal signals, although they may be repeated at regular intervals. It is therefore advisable to think in terms of time-constants and time-delays rather than in terms of inductive and capacitive reactances and frequencies. This philosophy will be adhered to in these articles. For the same reason, the well-known methods of network analysis are usually cumbersome and other methods will be used to design relay control circuits.

Power Requirements

A well-filtered d-c supply voltage is not always necessary for the tube operation of relays. All that is required is that the relay pull in and drop out in the desired manner. It is therefore often convenient to operate relays and tubes directly from the a-c power line, thus saving considerable material, space and money. Use is made of the inherent property of all electron tubes wherein they conduct current in only one direction and therefore produce their own rectified voltage.

If d-c relays are to be used in such a circuit some kind of filtering must be provided, otherwise the relay current will consist of a series of current impulses at line frequency. The duration, shape and magnitude of these pulses depend on the type of tube, operating conditions of the tube, and the external plate circuit constants. In many cases, when the relay is used in self-rectifying tube circuits the armature of standard relays will chatter, a condition which must be avoided for reliable operation.

In some cases it is possible to select a relay coil having a long time-constant (resistance-inductance ratio) or one with a heavy armature which is so sluggish that it does not follow individual current pulses. At the same time, average relay current can be increased above that necessary to operate the relay. However, this arrangement not only imposes unnecessary limitations on the design of circuits, but also requires excessive currents through relay and tube. The use of electrical filters is a more desirable means of suppressing relay chatter.

A tube can act as a half-wave rectifier, with the relay coil as its load. Such a combination behaves like a half-wave rectifier with an inductive load. The actual differences between these two cases depend on the difference between the characteristic curve of a diode and the dynamic characteristic resulting from the manner of operation of the particular tube.

A-C Power Filtering

The simplest filter-circuit is a capacitor-input filter consisting of a large capacitor in parallel with the load, which in this case is the relay coil. Because the inductance of the relay coil is usually very small, it can be neglected, for a first approximation, without impairing the results. In such a filter the capacitor is charged to almost the peak value of the supply voltage, the difference being due to the voltage drop across the rectifier tube and the current limitation of the tube, the latter preventing a momentary full charging of the capacitor. Between charging impulses the capacitor discharges continuously through the load. The instantaneous and average currents can be easily calculated by the usual methods for determination of the behavior of half-wave rectifiers.

The average rectified current is always much larger than it would be without the capacitor, due to the

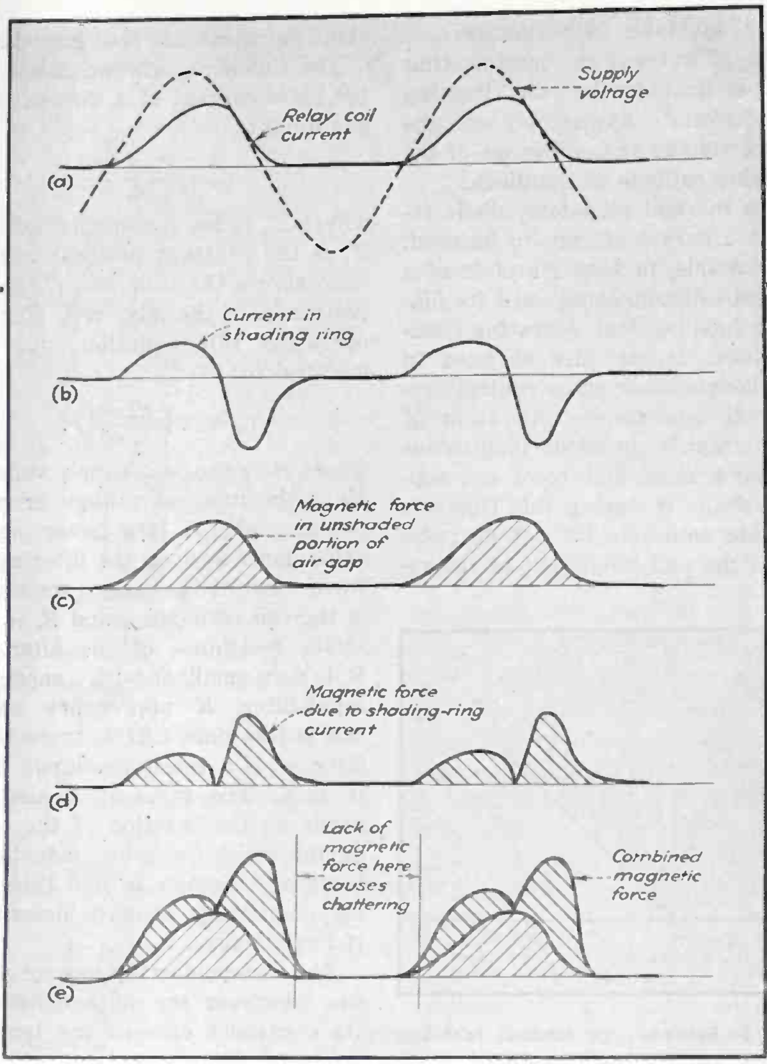


FIG. 1—The shading ring of an a-c relay operated in series with a half-wave rectifier will not prevent chattering

igher voltage across the capacitor. For most sensitive relays used in vacuum-tube circuits, 4 μf will provide adequate filtering; a larger capacitor will reduce ripple still further and therefore decrease the tendency of the relay to chatter, but operation will also become more sluggish. This results because the RC time-constant is increased and causes a delayed release of the relay. The current surge through the tube is also increased.

Care must be taken that this current surge does not exceed the maximum rated peak plate current. Failure to observe this precaution when using gas or vapor-filled tubes results in increased voltage drop across the tube, and the life of the cathode is considerably reduced. Current surges can be avoided by connecting a current-limiting resistor between the tube and capacitor. Although the tube is then protected, the voltage across the capacitor is reduced by the voltage drop across this resistor; this also reduces the average plate current.

An increase of this series resistance beyond the minimum value necessitated by the tube ratings further decreases the average current, or rather counteracts the effect of the capacitor in increasing tube current. When the series resistance approaches that of the relay coil, the capacitor action is fully compensated, and the average current through the relay coil is the same as if both the capacitor and resistor were omitted. However, instead of consisting of separate pulses the current is almost constant, except for a small ripple component. It should be noted that about half the voltage and therefore half the power is lost in the series resistor. Of course, chokes could be used instead of resistors, but the increase in cost, space and weight rarely compensates for the slight increased operating efficiency.

Relays designed for a-c operation are not recommended for use in tube circuits. These relays usually have a laminated core to decrease eddy-current losses. This core is split into two parts near the armature. A solid copper ring is fastened around one of these parts, and acts like a low-resistance secondary winding of a transformer the primary winding of which is the relay coil. Because the reactance of this shading ring is considerably larger than its resistance, the current flowing through the ring lags by 90 degrees the current through the relay coil. This shading current produces an additional magnetic force on the armature which reaches its maximum just when the flux due to the relay coil current decreases to zero. Therefore, at any time one of the two forces is acting on the armature and chattering is prevented.

Operation of A-C Relays

If an a-c relay is energized only by pulses during one half of a cycle and not energized during the remaining half, the current through the shading ring will not be continuous. It will consist of two pulses of opposite direction, one at the start and the other at the end of the conducting period. This current and therefore the forces acting on the armature will be proportional to the rate of change of the coil current. As can be seen from Fig. 1, practically no current will flow through the shading ring during the non-conducting period. Despite the use of the shading ring, the magnetic force is still zero through a considerable portion of the cycle and the relay will chatter. It is not possible to produce a phase difference of more than 90 degrees between the currents in the relay coil and in the shading ring so as to cover this gap in the magnetic force, and therefore these relays require as much filtering as d-c relays of similar dimensions.

Diodes for Relay Operation

A d-c relay can be connected in series with a diode to permit operation from an a-c power source. The problems encountered are essentially those of a half-wave rectifier furnishing pulsating direct current to the relay coil as its load. In addition to filtering considerations, the usual procedures of designing such rectifiers and their associated filter circuits should be followed. These considerations are equally valid for hot-cathode vacuum tubes as well as for cold-cathode and hot-cathode gas-filled tubes.

The difference in performance of these three tube types can be expressed in terms of their internal voltage drops. In hot-cathode vacuum diodes this voltage drop increases with current. Design data is published by tube manufacturers in the form of tube characteristic curves. In both hot and cold-cathode types of gas-filled diodes voltage drop is constant and dependent upon the particular type tube. In cold-cathode tubes the tube voltage drop is considerably larger than in hot-cathode tubes.

One type of cold-cathode vacuum diode is the phototube, which is mentioned here only for the sake of completeness. Its current output is small and it is not usually possible to operate relays from such tubes without additional amplification. This amplification can be either by a grid-controlled tube which in turn can operate the relay, or by using amplification due to secondary electron emission from additional electrodes in the same envelope with the photo electric cathode. This latter type cannot be considered a diode and will, therefore, be treated in the last section of this series.

Diodes as Time-Delay Element

Another possible application of diodes is as a time-delay relay. The diode heater is connected to its power supply. The relay operates when the emission current has reached the pull-in value of the relay. As no heating curves are published by tube manufacturers, a curve of current vs heating time must be made by the user. Heating time depends appreciably on the heater voltage and on the age of the emitting cathode of the diode.

The thermal time-delay diode relay is accurate enough to be used, for example, to keep the plate of a gas tube disconnected until its filament has reached operating temperature. It can also be used in burglar-alarm or other control systems to restore the operation of units which became inoperative during a short failure of the supply voltage if during this time the cathode emission did not decrease below the pull-in current of the relay. A false alarm is thus avoided.

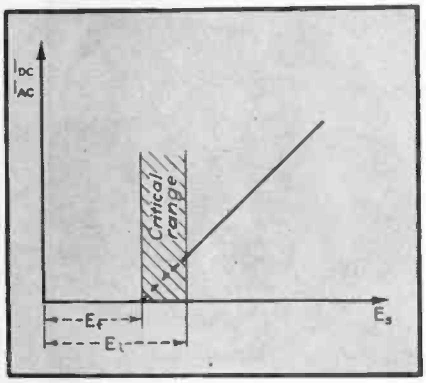


FIG. 2—Between the internal tube-drop voltage and the ignition potential of gas tubes there is an unstable operating region

To design such a time-delay relay, the cathode current which will flow after the desired time elapses is determined from the current vs heating-time curve. Load lines are drawn on the plate-current vs plate-voltage characteristic of the diode through the operating point to find the resistance or the required supply voltage for operation of the given type of relay. Obviously, gas diodes cannot be used for this purpose, because the plate load should be disconnected until the cathode has reached full emission.

Relay Control by Gas Diodes

A gas diode can be used if a variable control voltage is to operate a relay whenever the voltage exceeds a predetermined value. An amplifier or attenuator in combination with a suitable bias voltage is necessary to convert the critical value of control voltage to the ignition potential of the gas diode.

The following relation exists for the plate current of a d-c operated gas diode:

$$I_{dc} = \frac{E_s - E_t}{R_c} \quad (1)$$

where E_s is the d-c supply voltage, E_t is the constant internal voltage drop across the tube and R_c is the resistance of the relay coil. For a-c operation this equation must be modified to:

$$I_{ac} = K\left(\frac{E_s - E_t}{R_s + R_c}\right) \quad (2)$$

where E_s is the peak supply voltage, E_t is the internal voltage drop of the gas tube, K is a factor whose value depends upon the filtering or wave form of the relay current, R_c is the coil resistance, and R_s is the series resistance of the filter. If R_s is very small, as with a capacitor input-filter, K approaches unity, and is less than 0.31 if there is no filter or if a resistance-input filter is used. The value of K also depends on the fraction of the cycle during which the tube conducts. It is usually simpler to find this factor empirically than to determine it analytically.

The non-conducting gas tube will fire whenever the voltage between its electrodes exceeds the ignition potential E_i, which is usually between 5 and 30 volts higher than the internal voltage drop of the tube during conduction. Both the ignition potential and the internal voltage drop during conduction are unique for each particular tube type and can be found in manufacturers' tube data.

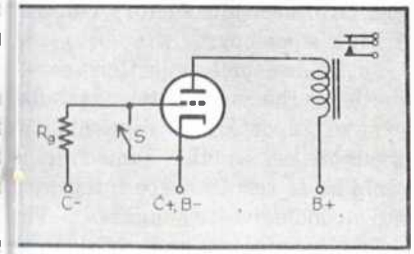
If a voltage that is higher than the tube drop but lower than the ignition potential is applied to the tube, the behavior of the tube depends upon its previous history. If this voltage is obtained by increasing a previously lower voltage, the tube stays non-conducting; if on the other hand it is obtained by decreasing a previously higher voltage, the tube having been fired by the higher voltage remains fired. Or in other words, a change of the conducting stage of the tube occurs at different values of control voltage depending upon whether the control voltage increases or decreases. Unless such a differential action is desired, this critical range should be avoided. It is shown as a haded portion in Fig. 2, which is a raphical representation of Eq. (1) nd (2).

To avoid damage to the gas di-de, a series resistor is needed. This esistor can be either the relay oil resistance or an additional eries resistor. The tube fires when s ignition potential is reached. If ie voltage across the tube remains t this high value, the cathode will e damaged. However, if there is esistance in series with the gas iode, the current will become such iat the *IR* drop across this resistor ill be the difference between E_i nd the applied control voltage, and ie tube will be protected. The eries resistance should be such iat the current that flows will be t least the pull-in current for the elay, but not greater than the iaximum allowable tube current.

ensitive Control With Vacuum Tubes

More important than diodes for elay operation are triodes and entodes. (Ordinary and beam etrodes have essentially the same ehavior as pentodes and shall e included in this group.) These ibes make operation of relays pos-ble with practically no power onsumption in the controlling or ilot circuit.

The simplest case is on-off con-ol of the relay. The tube may be ormally biased beyond cut-off; hen the relay is to be energized



:G. 3—This circuit illustrates the basic rangement for vacuum-tube relay con-ol. Closing the switch actuates the relay

ie grid is connected to the cathode that the full plate-current flows rough the relay in the plate-cir-iit, as shown in Fig. 3. If the bias supplied through a very high re-istance R_g the magnitude of which only limited by the grid-current iaracteristic, the current through witch *S* can be made extremely mall, so that the delicate contacts of a thermostatic or pressure switch or galvanometer-type relay can be used. The use of this circuit for electronic gages, liquid level control and similar applications is obvious.

The selection of the relay coil can be easily made. The full plate current of the tube with the grid tied to the cathode must be larger than the pull-in current of the relay by a suitable safety factor. The voltage drop across the tube and across the relay coil can be found from the tube characteristic curves on which the corresponding load-line has been drawn. A check can then be made to ascertain whether the power dissipated is within the ratings of the tube.

Vacuum-Tube Characteristics with A-C Plate Supply

To operate tube and relay directly from an a-c power supply there is again the problem of filtering the tube output. The tube with its grid tied to the cathode behaves exactly like a diode and should be treated as described in the previous section. Obviously, no filtering problem exists when the grid is biased beyond cut-off.

The cut-off bias can be either a constant direct voltage which is high enough to prevent current flow when plate or screen voltage reaches its peak value, or it can be an alternating voltage which is 180 degrees out of phase with the plate-supply voltage. A simple way to obtain this condition is to use a power-supply transformer with a tapped secondary winding as shown in Fig. 4. One end of the winding is connected to the grid and the other end to the plate circuit return; the cathode is connected to the tap of the winding. Another tap or a separate winding on the same transformer furnishes the heater voltage.

The instantaneous grid voltage should always be at least the cut-off value for the corresponding instantaneous plate voltage. This cut-off value is obtained from the tube characteristic curves, or may be approximated by dividing the plate voltage by the amplification factor. In the case of pentodes use the screen-control grid or "cut-off" amplification factor, which is approximately the one obtained from the characteristics of the tube con-

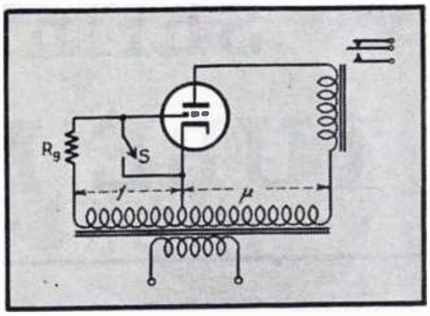


FIG. 4—For a-c operation, the power transformer is tapped approximately in the ratio of 1 to μ

nected as a triode. The grid voltage should then be multiplied by a safety factor.

The correct relay coil resistance cannot be found as easily from tube characteristics as in the case of d-c operation, but experience shows that under the same conditions the average current obtained from an rms voltage is about one half the current obtained from the same direct voltage.

Another method to be used only with pentodes is to measure the direct current (as read from a d'Arsonval type meter) as a function of the rms screen voltage while the grid is tied to the cathode. The plate voltage has very little influence on the plate current in pentodes, and it is therefore not important whether the plate is tied to the screen, or connected through the relay coil to the power supply. Load lines can then be drawn on the curves so obtained exactly as in the d-c case. Because the waveshape of the supply voltage has an influence on the plate current, too high a precision should not be expected from this curve. This method should not be used with triodes, because the plate current, and therefore the voltage drop in the relay coil and the actual plate voltage, are neither constant nor sinusoidal and the error made by using average values to draw the load-line is usually excessive.

To prevent possible overloading of the relay coil when pentodes are used, it is good practice to reduce the screen voltage so that the tube current is limited to the relay's pull-in current multiplied by a safety factor. This practice also reduces the required grid bias. With triodes this protection can be obtained only by careful selection of the relay characteristics.

Shrinkage Analysis in TUBE MANUFACTURE

Procedure for isolating the factors responsible for rejected tubes, with examples of routine followed by Shrinkage Analysis Department and samples of typical reports

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SUPPOSE 1000 stems for vacuum tubes are started in the mounting department and that only 800 actually became satisfactory tubes. Shrinkage analysis seeks to determine why 200 were lost en route. In contrast, quality control is concerned with variations in the performance of the 800 good tubes. Shrinkage analysis thus obtains information directly concerned with the reduction and removal of factors which cause industrial losses.

If the product is running close to a manufacturing limit, shrinkage analysis will never disclose that fact until the damage is done; quality control, however, observes the condition and reports to factory engineers who take steps to rectify the trouble. Should quality control warnings be ignored for one reason or another, shrinkage results. Shrinkage analysis, then, is the fact-finding procedure which informs factory engineering of the vital channels to be worked on to bring variables under control.

Operation of Shrinkage Analysis Department

In cases where the shrinkage is localized, a positive indication is available which points to an inefficient or improper operation. Let us say that 5 percent is the normal shrinkage expectancy for open filaments over the entire operation. If this 5 percent loss occurs in only one operation, it is imperative that factory engineers correct the situation quickly. Regardless of this fact, the point being made is that localization of the disturbance to a single operational area is most easily recognized by a preliminary analysis.

Suppose a poor material is used. If twenty different operations each lose 0.5 percent of their tubes due to open filaments, an overall filament shrinkage of 10 percent results. Here the trouble-localizing or "where" analysis is small, but the "what" analysis discloses the hidden truth.

Once it has been ascertained factually that trouble exists, a secondary analysis must be performed in order to isolate it. Is it confined to a certain operator or machine or to a certain combination of operators and machines? Does it occur on any specific day of the week? Does it occur only during or following certain atmospheric conditions? Does it manifest itself only on certain work shifts?

The causes for shrinkage belong more properly in the domain of engineering, but often the shrinkage analysis department can disclose or confirm facts concerning such troubles. Good analysts are fundamentally curious.

> **Other Articles on QUALITY ENGINEERING**
>
> Quality Engineering in Tube Manufacture
> NOVEMBER 1944 ELECTRONICS
>
> Quality Control in Tube Manufacture
> JANUARY 1945 ELECTRONICS

Here, then, is a method of operation:

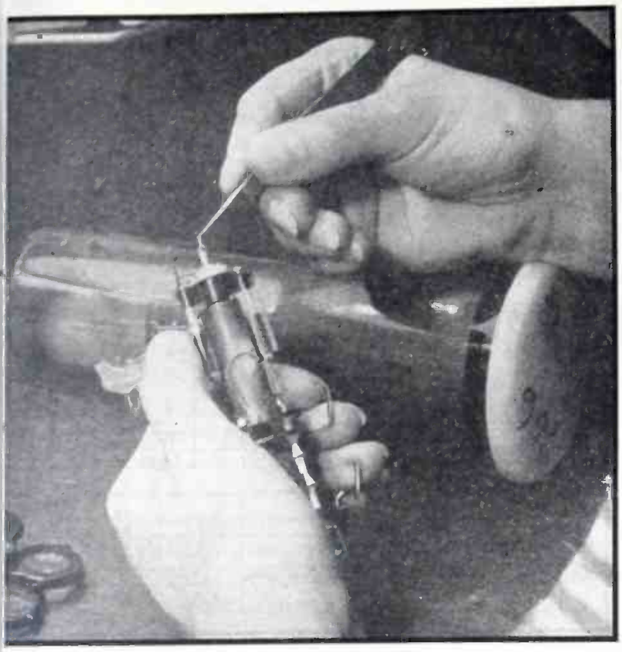
1. A primary or preliminary analysis is made for purposes of identification.
2. A secondary or detailed analysis is made for purposes of isolation. Summaries are made daily, weekly, and monthly in order to detect shrinkage trends. An isolating analysis follows any time that the situation demands it.

It is desirable that shrinkage analysis work be performed by a single specially trained group rather than by individuals from different departments. The Shrinkage Analysis Department is not concerned so much with reduction of shrinkage as it is with presenting accurate facts concerning the condition. This information is then turned over to factory engineers whose main concern is to keep the factory running at high efficiency.

There is some question as to whether the completely tabular form of report is as digestible or as emphatic as the same report would be if results were integrated into conclusive thoughts. The analyst's opinions and conclusions are important for several reasons, namely:

1. The analyst has time to draw a summary. Most (not all) other persons give tabular reports a quick reading and generally do not stop to summarize.
2. The analyst's summary is objective—thus, results are viewed impartially.
3. The analyst often draws upon the experience of many engineers to make or confirm his conclusions.

Report value depends on two



arinkage analyst removes a defective heater from a cathode-ray tube to determine why the tube was rejected

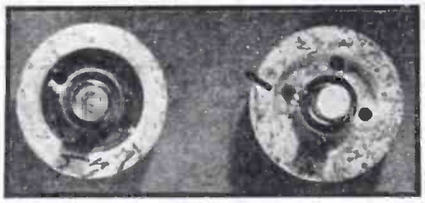
Shrinkage analyst uses a hot-wire glass cutter to open a defective cathode-ray tube for investigation

actors: 1. Factual content; 2. horough study of the findings. he first factor depends on the effi-iency of the analyst; the second actor depends on the engineering ersonnel of the sections involved.

Relation to Other Departments

Failure of production and engi-eering personnel to utilize the po-entialities of the Shrinkage Analy-is Department may be ascribed to ie natural reticence of anyone to are his errors, and to misunder-tanding concerning the function f the Shrinkage Analysis Depart-nent in the general scheme of fac-ory operation. Since reticence an be overcome only when misun-erstanding is clarified, it is im-erative to discuss the main prob-em: "What relationship does the hrinkage Analysis Department ave to general factory activity?"

Development engineers set up pecifications for making tubes, nd factory engineers watch manu-acturing procedure to be sure pecifications are followed. Natur-lly, all specifications cannot be ollowed exactly — the slight hanges that are necessary are ermed variables. The Quality Engineering Department gives a ynamic picture of production by bserving deviation of the vari-bles; when deviation gets out of



Top view of a cathode that has been bombarded with positive ions (left) and a normal good cathode (right)

control, shrinkage will then occur.

The Shrinkage Analysis Department examines rejected material to reveal the cause of shrinkage. This information is conveyed to factory engineers and production personnel, who use the additional information to put the variables under control. That is the reason—the sole reason—for circulating reports. Departmental activities are completely objective and are aimed at pointing out failure only for the purpose of lighting the road so engineering and production personnel may achieve success.

Technique of Shrinkage Analysis

As an example, let us assume that a transmitting tube fails because of low power output. The first step in performing a post mortem is to verify the failure in the following manner:

1. The test set must be checked with good tubes to show that it is operating properly.

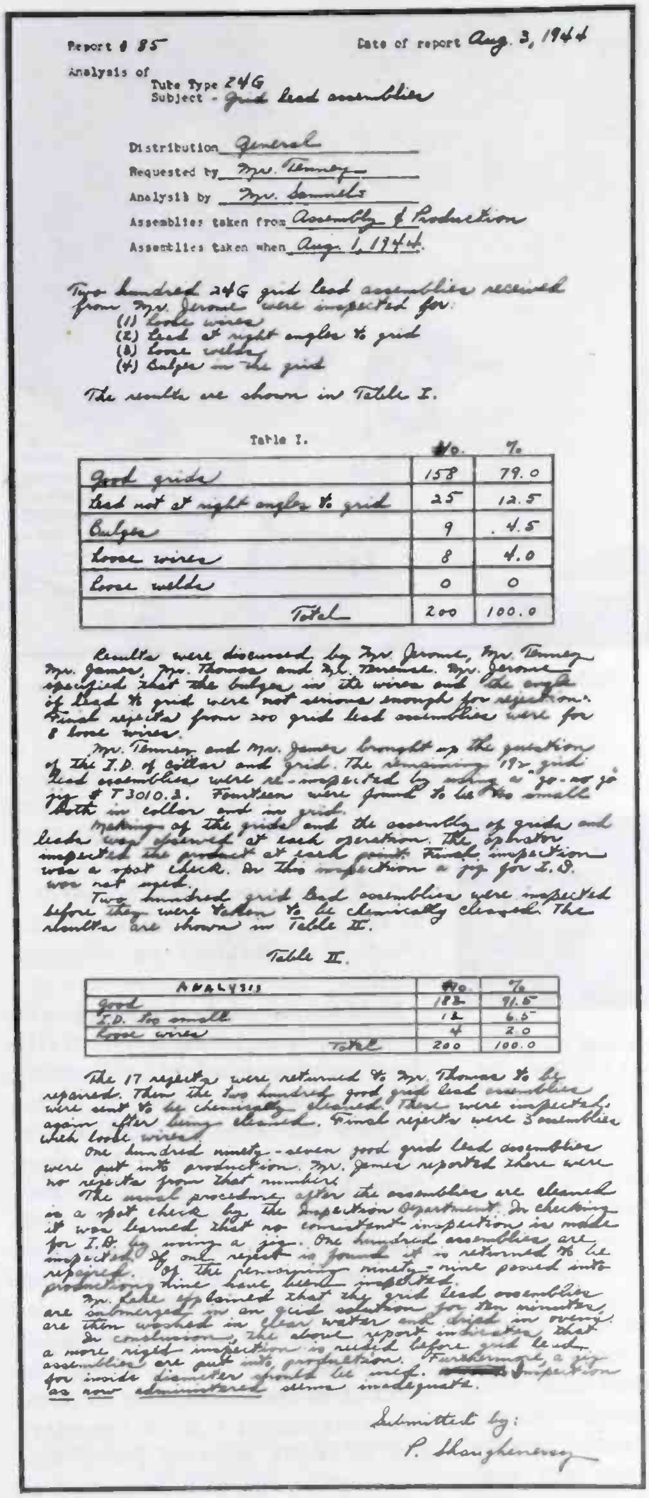
2. The meters should be verified to remove any question about the effect of calibration on observed results.

3. If the tube is tested as a power amplifier, it is necessary to verify the power input before condemning the tube for poor power output.

These are some of the preliminary steps which, though they seem quite obvious, are easily overlooked.

Once the failure has been verified, it is desirable to determine whether low power output is due to low emission or to faulty construction in the tube. If emission is adequate, the tube should be checked to see if the grid is properly constructed. It is necessary also to verify whether power output is measured at a frequency at which inter-element spacing may be at fault. Similarly, filament construction must be examined.

If emission is low, gas content of the tube should be measured and it is worthwhile to investigate carburization of the filament. When the filament is over-carburized, emission is reduced and in some cases power output suffers. This condition can be checked by "flashing" the tube at a temperature slightly higher than normal; thus, some of the carbon is removed and



Report # 85 Date of report Aug. 3, 1944

Analysis of
Tube Type 24G
Subject - grid lead assemblies

Distribution General
Requested by Mr. Tenney
Analysis by Mr. Samuels
Assemblies taken from Assembly & Production
Assemblies taken when Aug. 1, 1944.

Two hundred 24G grid lead assemblies received from Mr. Jerome were inspected for:
(1) loose wires
(2) lead at right angles to grid
(3) loose welds
(4) bulges in the grid

The results are shown in Table I.

Table I.

	No.	%
Good grids	158	79.0
Lead not at right angles to grid	25	12.5
Bulges	9	4.5
Loose wires	8	4.0
Loose welds	0	0
Total	200	100.0

Results were discussed by Mr. Jerome, Mr. Tenney, Mr. James, Mr. Thomas and Mr. [illegible]. Mr. Jerome specified that the bulges in the wires and the angle of lead to grid were not serious enough for rejection. Final rejects from 200 grid lead assemblies were for 8 loose wires.

Mr. Tenney and Mr. James brought up the question of the I.D. of collar and grid. The remaining 192 grid lead assemblies were re-inspected by using a "go-no go" jig # T3010.2. Fourteen were found to be too small both in collar and in grid.

Making of the grids and the assembly of grids and leads was observed at each operation. The operator inspected the product at each point. Final inspection was a spot check. In this inspection a jig for I.D. was not used.

Two hundred grid lead assemblies were inspected before they were taken to be chemically cleaned. The results are shown in Table II.

Table II.

ANALYSIS	No.	%
Good	183	91.5
I.D. too small	13	6.5
Loose wires	4	2.0
Total	200	100.0

The 17 rejects were returned to Mr. Thomas to be repaired. Then the two hundred good grid lead assemblies were sent to be chemically cleaned. These were inspected again after being cleaned. Final rejects were 3 assemblies with loose wires.

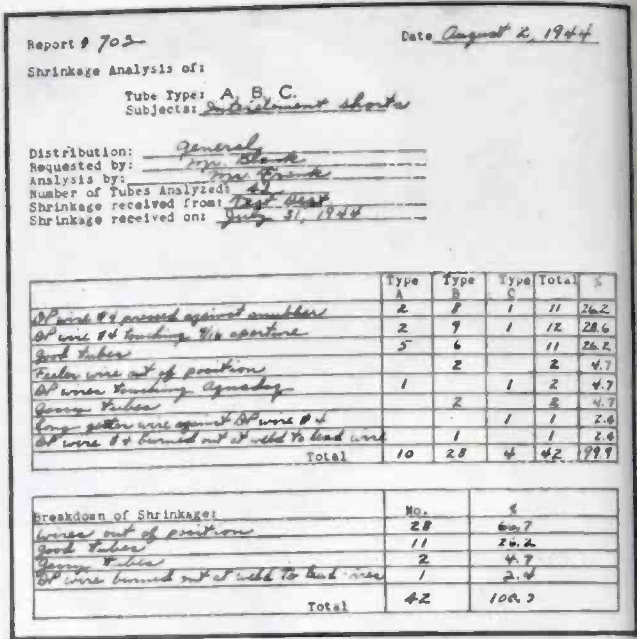
One hundred ninety-seven good grid lead assemblies were put into production. Mr. James reported there were no rejects from that number.

The usual procedure after the assemblies are cleaned is a spot check by the Inspection Department. In checking it was learned that no consistent inspection is made for I.D. by using a jig. One hundred assemblies are inspected. If one reject is found it is returned to be repaired. Of the remaining ninety-nine passed into production none have been inspected.

Mr. Lake explained that the grid lead assemblies are submerged in an acid solution for ten minutes, are then washed in clear water and dried in ovens.

In conclusion, the above report indicates that a more rigid inspection is needed before grid lead assemblies are put into production. Furthermore, a jig for inside diameter should be used. Inspection as now administered seems inadequate.

Submitted by:
P. Shaughnessy



Report # 702 Date August 2, 1944

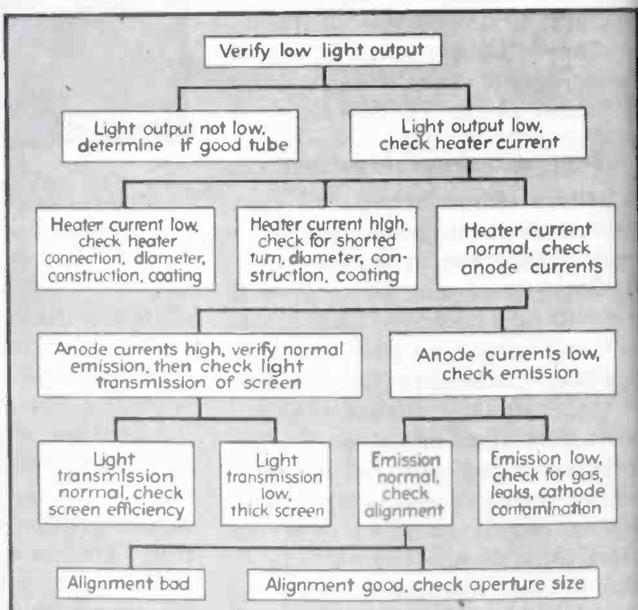
Shrinkage Analysis of:
Tube Type: A, B, C.
Subjects: Interelement shorts

Distribution: General
Requested by: Mr. Black
Analysis by: Mr. [illegible]
Number of Tubes Analyzed: 42
Shrinkage received from: Test Dept
Shrinkage received on: July 31, 1944

	Type A	Type B	Type C	Total	%
DP wire #4 pressed against [illegible]	2	8	1	11	26.2
DP wire #4 touching the aperture	2	9	1	12	28.6
Good tubes	5	6		11	26.2
Feeler wire out of position		2		2	4.7
DP wires touching [illegible]	1		1	2	4.7
Gassy tubes		2		2	4.7
Long getter wire against DP wire #4			1	1	2.4
DP wire #4 burned out at weld to lead wire		1		1	2.4
Total	10	28	4	42	99.9

Breakdown of Shrinkage:	No.	%
Wires out of position	28	66.7
Good tubes	11	26.2
Gassy tubes	2	4.7
DP wire burned out at weld to lead wire	1	2.4
Total	42	100.0

Sample shrinkage analysis report with breakdown, for three types of cathode-ray tubes having the same construction but differing in screen characteristics (above)
Sample shrinkage analysis report, showing detailed suggestions for improvement in processes and inspection (left)
Procedure for performing shrinkage analysis on an electrostatic focus and deflection type cathode-ray tube which failed for low light output (below)



power output can be redetermined. If power output comes up, the cause of failure is known. Should power output fail to come up, overcarburization is not at fault.

If the tube shows a slight gassy condition, the seals and beads should be carefully examined for wire leaks or faulty beads; metal-to-glass seals should be given special attention. Where tungsten is used as a lead, it should be examined for small fissures through use of a magnifying glass or microscope. In some cases it is desirable to use a fluorescent liquid penetrant which becomes visible under ultraviolet light.[1]

Where large volumes of gas cause the tube to be classed as an "air tube", the failure will generally be in the form of a large crack or fissure. Frequently, this can be discerned by eye with the aid of a bright light.

The above analysis does not pretend to be as complete or as detailed as might be desired. It does offer two advantages; it provides a simple pattern for new and untrained help, and it requires practically no expensive or elaborate test equipment.

hrinkage Analysis of Cathode-Ray Tubes

As a second example, consider a thode-ray tube which has been jected for low light output. Here ain, the rejection should be veri-d. One convenient method uses veral test sets for checking the ject against a standard tube. A andardized test set is preferred which heater current and anode ltages can be observed. The ater current can act as an index cathode temperature. By read-g second or third anode currents, required, intensity of the beam tting the screen can be checked. If anode currents are low, it is correct to assume that cathode nission is reduced. This value ust be checked separately with a w positive voltage on the grid. ace it has been definitely estab-hed that cathode emission is in-equate, various beads and wires ould be examined for cracks or ilures that permit entrance of s which destroys the emitting rface.

When the tube is opened, the thode should be examined for ion ots. If none are present, it ould be examined for other types contamination such as chloride oil, which also reduce emission.

Suppose, however, that emission adequate but second anode cur-nt is low. In that case, the geome-y of the electron gun should be amined for alignment and concentricity on the test set or by opening the tube if necessary; apertures should be checked for correct size. If emission and second anode current are adequate but light output is low, the tube should be opened to measure the light transmission of the screen. If the screen is too thick, then light intensity on the face of the tube will be materially less than on the inner surface of the screen. If light transmission is adequate, the screen may be inefficient for other chemical or physical reasons.

Basically, the luminescence of a phosphor is due to an unstable crystalline structure; this structure is disturbed by physical shock. When the phosphor comes from the oven during the manufacturing process, it is rather lumpy. Thus, it is necessary to reduce the diameter of particles to the order of 5 to 50 microns and this is generally done by ball milling. If ball milling continues over an extended period of time, the crystalline structure is disturbed by the physical shock. As a result, the phosphor becomes stable and loses its basic property of luminescence.

Impure chemicals used for synthesizing impair the efficiency and color of the phosphors. These characteristics may also be affected by improper crystallization temperatures. Now, all these things increase the amount of inert or non-luminescent material present in the phosphor and subsequently in the screen. Consequently, the efficiency of the entire screen is reduced because this inert material takes up space which normally would be occupied by luminescent material.

These are only a few of the factors which can cause low screen efficiency. Nothing has been said about reflectivity of the inner glass surface nor about glass thickness and bulb processing, which factors also affect the light output offered by the tube.

It is hoped that the material given so far in this series of articles will indicate the basic approach to these problems. It is more important to understand the approach than to understand the specific method, because the latter varies from problem to problem—the approach to shrinkage analysis problems generally remains the same.

The final article in this series will discuss problems involved in setting up a statistical method of controlling quality during manufacture, by testing scattered samples of tubes and placing the data on special process control charts that show promptly when production gets out of control. The best way to reduce shrinkage is to control the variables which produce it.

REFERENCE

(1) Kulin, S. A., Fluorescent Inspection of Tungsten, ELECTRONICS, July 1943, p. 95.

Report # 75

Shrinkage Analysis of:
Tube Type: 3BP1
Subject Alignment of mounts

Date July 27, 1944.

Distribution: Special
Requested by: Mr. Santee
Analysis by: Mr. Barton
Number of tubes analyzed: 135
Test made at: Final Assem., sealing, exhaust, basing, aging, test.
Test made on: July 25, 1944

Shrinkage due to:

Operation	# of tubes submitted	Out of Align.	Broken cathode fluores.	Cracked cathode fluoresc.	Cracked tip seal	Cracked bulb	Inter-element short	Missing Wire	Leaker	Cracked base	Foreign material in base	Poor seal	Foreign material in bulb	Low Light Output	Defective Anode Weld	Open Anode Connection	Burnt Screen	O.D.P.	Gas	Total Shrinkage	% Shrinkage
Final Assem.	135	30																		30	22.2
Sealing	105		33																	33	24.2
Exhaust	72			5	1	1	1													8	5.9
Basing	64							2	4	1	5	1	1							14	10.3
Aging	50								1		1		2							4	2.9
Test	46						1							16	1	1	1	1	3	24	17.8
Total shrinkage		30	33	5	1	1	2	2	5	1	6	1	3	16	1	1	1	1	3	113	83.3*
% of Tot. shrinkage		26.5	29.2	4.5	.8	.8	1.8	1.8	4.5	.8	5.3	.8	2.7	14.2	.8	.8	.8	.8	2.7	99.6	

* 22 or 16.3% tubes were good

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Note:
Upon removing "out of alignment" mounts there were no "spot off center" rejects to be found among the remaining 46 mounts which eventually came to the test set.
It is recommended that a "gage" be used at final mount inspection to check the alignment of mounts before they are sent to sealing.
It is suggested that a simple optical projection machine, which would show the alignment of the mount on a screen, be used. For a guide there should be a drawing of a mount within specifications of alignment on the screen.

Submitted by:
Henry Cook

Sample shrinkage analysis report having detailed analysis of factory efficiencies

Transmission-Line CONVERSION

Methods for joining a balanced two-wire line to a coaxial line are discussed. Conversion transformers which operate at a single frequency or over a band of frequencies are described. Constant impedance is possible over a one-to-three frequency range

By NATHAN MARCHAND
Federal Telephone and Radio Laboratories
New York, N. Y.

In high-frequency power transmission it is frequently necessary to use a balanced two-wire line over part of the system, and a coaxial transmission line over the remainder of the distribution system. The natures of the generator output and the load input will dictate the particular combination of balanced two-wire and coaxial transmission lines which must be used.

At the juncture of the two types of transmission line a conversion transformer is necessary to maintain the currents on the two types of line in their proper relations. The conversion from one line to the other can be made ideal only at one frequency, but methods will be described which provide satisfactory conversion over a range of frequencies.

In converting from a balanced two-wire transmission line to a coaxial line, it is necessary to understand what is meant by equilibrium conditions in a coaxial line and in a balanced two-wire shielded transmission line. The term unbalanced is often used for coaxial feed, but in this analysis it will be used for departure from the normal equilibrium conditions.

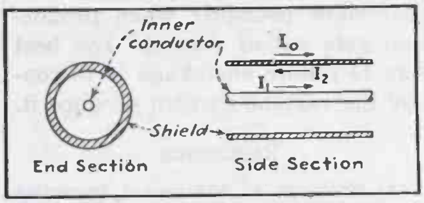

FIG. 1—Section of coaxial line, showing the currents which can flow

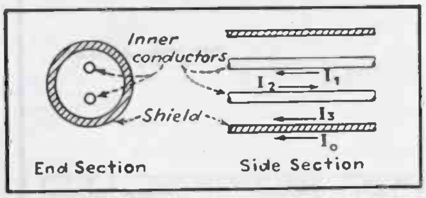

FIG. 2—Section of a balanced two-wire transmission line, showing the line and shield currents which can flow

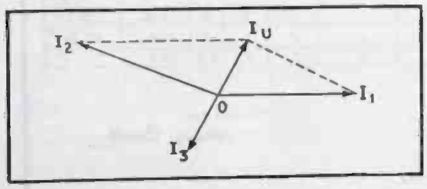

FIG. 3—If the currents of a two-wire line are not equal, an unbalance current I_3 flows. In this case the inequality of the line currents is in the nature of a small phase shift. The two line currents should be 180 degrees apart for balance

Currents on a Coaxial Line

A coaxial transmission line consists of a conducting wire concentrically disposed in a hollow conducting tube, the space between being filled with a dielectric which may be air. Figure 1 shows two sections of a coaxial transmission line. In the side section there are shown three currents, I_1, I_2, and I_0. When a transmission line of this type has a shield which is well constructed, and is used above 50 megacycles, it can be assumed without loss of generality that the shield is perfect. This does not mean that it is a perfect conductor, but rather that there is no coupling between the current I_2 on the inside of the shield and the current I_0 on the outside of the shield. This also means that the current I_2 on the inside of the shield must be exactly equal and opposite to the current I_1 on the inner conductor.

The problem in the coaxial line, as far as conversion is concerned, is to prevent any coupling between the true currents I_1 and I_2 and the interfering or unbalancing current I_0 that might be induced on the outside of the shield. It is also important from power considerations to maintain the surge impedance along the line constant.

Currents on a Two-Wire Line

Balanced two-wire transmission line consists of two parallel conductors in a dielectric which may or may not be surrounded symmetrically by a shield. Since for shielding purposes all balanced transmission lines should be enclosed in a shield, a shield will be included in the discussion.

Figure 2 shows an end and side section of a balanced transmission line. In the side section there are shown four currents, I_1, I_2, I_3, and I_0. I_3 is the total resultant current on the inside of the shield and I_0 is the total resultant current on the outside of the shield. In a perfectly balanced line I_1 would be equal and opposite to I_2, and I_3 would be zero.

If I_1 is not equal in amplitude and opposite in phase to I_2, then I_3 will be equal and opposite to the vector sum of I_1 and I_2. This is shown in Fig. 3, where I_1 and I_2 are not exactly 180 deg out of phase. Their sum is equal to the unbalanced current I_U. I_U behaves as though it were a current flowing in the same direction along both of the transmission lines. That is, the two wires are acting in parallel as the inner conductor of a coaxial line, the return current flowing on the inside of the shield. This return current is designated as I_3. Again I_0 is the

TRANSFORMERS

traneous current induced on the tside of the shield.

The first problem encountered in iintaining the normal equilibrium nditions in a balanced transmis-on line is to keep I_1 equal and op-site to I_2 so that I_3 will be zero; e second problem is to prevent from coupling into the transmis-on line at any point.

The problem is to convert from balanced transmission line to a axial transmission line by intro-cing some type of transmission ie transformer. First, in order to event I_0 from coupling into the ies the outside shields of both ies should be kept continuous so at there can be no way in which can get into the line. If this ethod is not possible, some other eans must be used to prevent I_0 om coupling into the line. Sec-dly, in order to maintain I_1 equal I_2 in the balanced transmission ie, the impedances from each nductor to the shield must be aintained equal. Any difference impedance will cause I_1 to differ om I_2. Third, the continuity of irge impedance, or impedance atching, should be maintained as ose as possible, to obtain maxi-um power transfer.

Single-Frequency Transformation

In Fig. 4 is shown one type of ansformer that can be used for ngle-frequency transformation. A large box, an expanded section of the shield, is used. This box must totally enclose the interior circuits to avoid coupling between I_0 and the inside currents. The coaxial line shield is extended a distance of one quarter wavelength inside the box; the dual line is brought in on the other side. One conductor of the dual line is connected to the inner conductor of the coaxial line and the other to the coaxial shield extension.

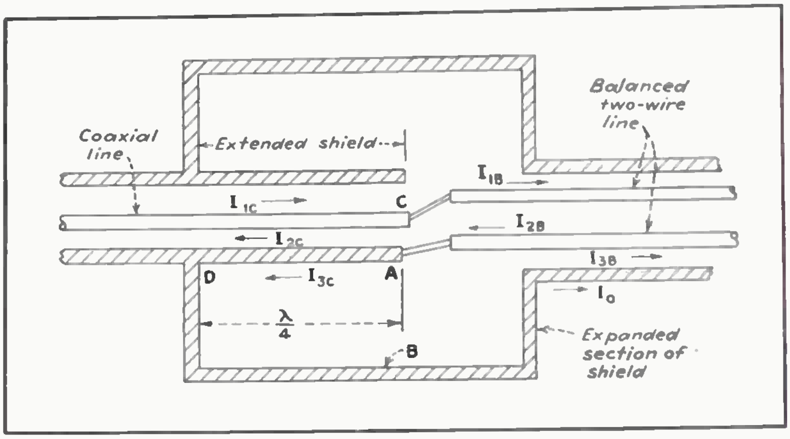

FIG. 4—Cross-section of a single-frequency conversion section, showing how the coaxial shield can be extended to reduce I_3 to zero at resonance

In order to determine the equivalent circuit of this conversion transformer, the current paths have to be traced. Current I_{1B} of Fig. 4 will flow directly from one side of the balanced two-wire line to the inner conductor of the coaxial line shown as I_{1C}. The current I_{2B} will flow from the other side of the balanced two-wire line and divide into two currents. One will flow along the inside surface of the coaxial shield (shown as I_{2C}), and the other will flow around the outside of the coaxial shield (shown as I_{3C}). In order to maintain the normal equilibrium conditions, I_{3C} should be zero. This is true since I_{1C} is always equal and opposite to I_{2C}; thus for I_{1B} to be equal and opposite to I_{2B}, I_{3C} must be zero. In this case it will be zero since the outer side of the coaxial shield AD and the inner side of the box B form a coaxial transmission line which is shorted at the end D and is one quarter wavelength long, resulting in an extremely high impedance between point A and the surface at B.

The equivalent circuit is shown in Fig. 5. The wire representing

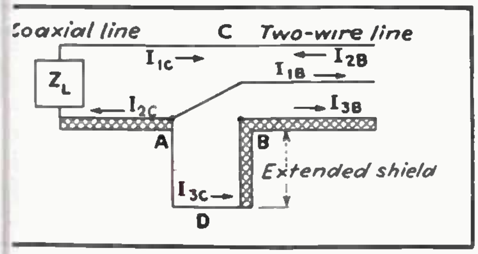

FIG. 5—In this equivalent circuit of the conversion section shown in Fig. 4 the shield is represented by cross-hatching

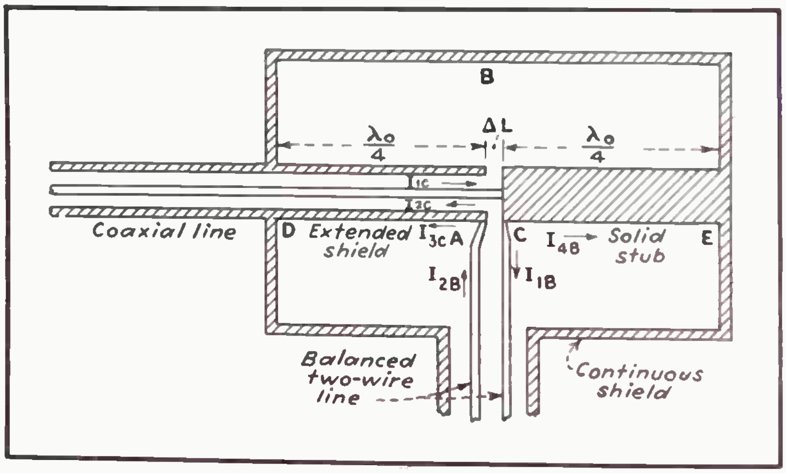

FIG. 6—The addition of a solid stub inside the conversion section improves the off-resonant action of the transformer

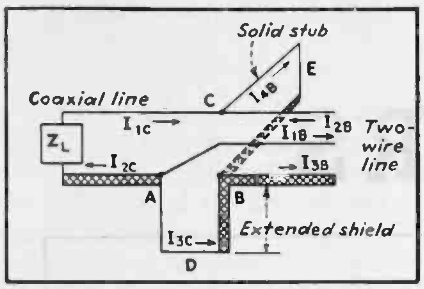

FIG. 7—The loop formed by the solid stub of Fig. 6 is shown on a plane extending into the page in this equivalent circuit

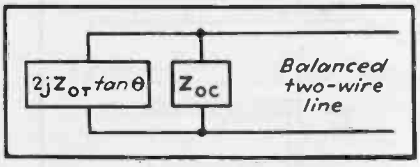

FIG. 8—The lumped constant equivalent of Fig. 6 shows a reactive impedance in parallel with the coaxial impedance. It is this reactive impedance which limits the frequency band over which the conversion section will operate

the inside of the shield is shown with shading. It can be seen here that I_{3C} is being fed into a shorted transmission line *ADB* which, if it is one quarter wavelength long, will result in an infinite impedance at *AB* so that I_{3C} will be zero. Whatever impedance is presented across *AC* looking into the coaxial line will be the load across the end of the balanced line. Thus, if both the coaxial line and the balanced line have the same surge impedances, and if Z_L is matched to the coaxial line, the balanced two-wire line will also be matched.

The one bad feature of this type of conversion transformer is that it will give good balance at only one frequency. As soon as the frequency is shifted so that *ADB* is no longer a quarter of a wavelength long, I_{3C} will no longer be zero, and hence I_{1B} will no longer equal I_{2B} and the line currents will no longer be balanced. I_{3B} will then no longer be zero, but rather will equal I_{3C}.

Wide-Band Conversion-Transformer

The next logical step is to put an impedance from *C* to *B* that will equal the impedance at *AB* so that even if the frequency is shifted, it will only introduce a phase mismatch, but will not disturb the current balance. This will be true because the voltage at *C* is equal and opposite to the voltage at *A*. In Fig. 6 is shown a wide-band conversion transformer. This is the same as the single-frequency transformer (Fig. 4) except that at point *C* where the inner conductor is directly connected to one side of the balanced line, a solid stub, equal in length and outside diameter to the extended shield, is connected as shown. Their electrical lengths are equal to $\lambda_0/4$ which would be one-quarter wavelength at the mean frequency if the stray capacitance between *A* and *C* were negligible. Because of this stray capacitance, the inner conductor of the coaxial line should be removed and the lengths of shield and stub so chosen that the impedance across *AC* is a maximum at the mean frequency for which the unit is to be used. ΔL should be kept as small as possible since it is an extra distance that I_{1C} must travel to reach *C* over that which I_{2C} must travel to reach *A*.

In Fig. 7 is shown the equivalent circuit for this type of conversion transformer or balance box. It can be seen that this is similar to the equivalent circuit of Fig. 5, except that a reactance *CEB*, equal to the reactance *ADB*, is inserted. If this transformer is detuned from its mean frequency, currents I_{4B} and I_{3C} will flow. However, because of the quarter-wave extended shield and solid stub construction, I_{4B} will equal I_{3C} in magnitude and they will cancel at *B*. This will result in I_{3B} being zero and I_{1B} being equal to I_{2B}. However, the transformer introduces a reactive component across the balanced transmission line that will result in a mismatch.

If the coaxial line is matched, its input impedance would be equal to

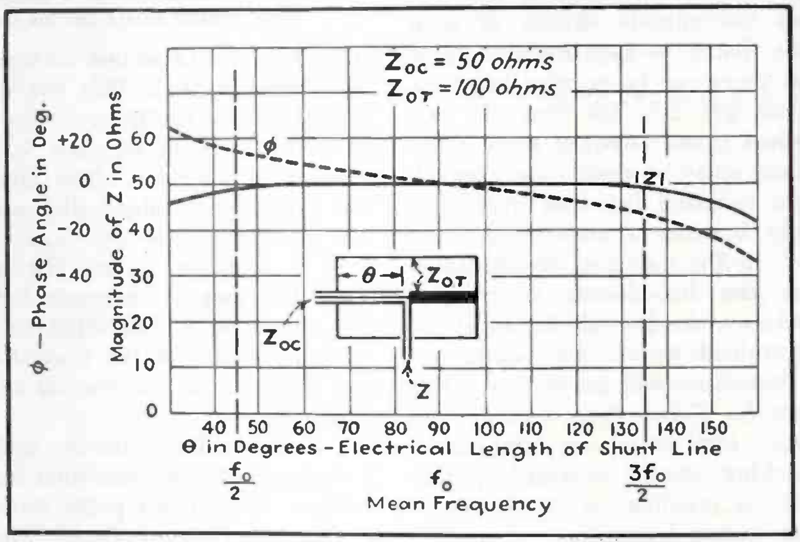

FIG. 9—Theoretical plot showing the variation in magnitude and angle of the impedance presented to the balanced two-wire line by the coaxial line and conversion transformer of Fig. 6 for conditions given in the text

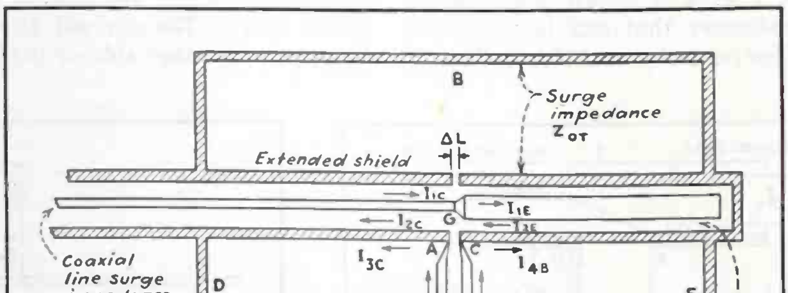

FIG. 10—To decrease the angular variation in impedance as seen by one of the lines being joined, the coaxial line is extended into the stub of Fig. 6.

$_{oc}$ where Z_{oc} is the surge impednce of the coaxial line. If the urge impedance of the transmision line, composed of the inside of ne conversion box and the outside f the extended inner conductor, is $_{oT}$ then the impedance across the alanced line is

$$Z = \frac{(Z_{oc})\,(2jZ_{oT}\tan\theta)}{Z_{oc} + 2jZ_{oT}\tan\theta} \qquad (1)$$

here θ is the electrical length AD hich is equal to CE. The lumped onstant equivalent circuit is shown 1 Fig. 8. θ of course will vary with requency. In Fig. 9 is shown the npedance characteristic presented t the end of the balanced tworire line in this type of transormer with an impedance Z_{oc} of 0 ohms and an impedance Z_{oT} of 00 ohms. Here θ is picked to be 0 deg at the mean frequency f_o. 'he balance remains very good over ne whole range. For a three-tone range in frequency the impedance will vary between the oints noted as $f_o/2$ to $3f_o/2$. The alue of the phase angle ϕ at these oints will be about 15 deg. This alculated curve neglects the capaciance between the edges of the exended shield and stub. This capacance will increase the impedance ariation slightly.

Phase-Shift Correction

It is now desirable to make the onversion transformer wideband rithout the shift in phase. This an be done by constructing the ransformer as shown in Fig. 10. 'he only difference between this ransformer and the transformer hown in Fig. 6 is that the coaxial ne is extended into the solid stub. 'his extended line has a surge impedance of Z_{oR} which is equal to

$$Z_{oR} = \frac{(Z_{oc})^2}{2Z_{oT}} \qquad (2)$$

rhere Z_{oc} is the coaxial line surge mpedance and Z_{oT} is the surge impedance of the coaxial shield and ox inside the transformer box. 'hus the inner conductor of the xtended line must be made large ince Z_{oT} is always larger than Z_{oc}. 'he length of the extended shield s resonant as a shorted quarter vavelength at the mean frequency $_o$. If the capacitance acros ΔL vere neglected, the length from the ox to the break would be 90 deg. The extended line is left open at the end and is made resonant as a quarter-wavelength open stub.

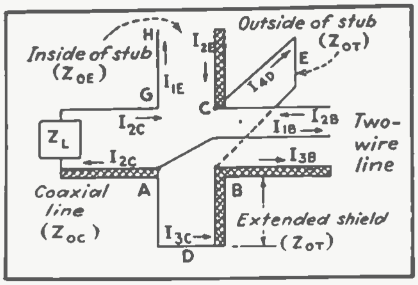

FIG. 11—As this three-dimensional equivalent circuit shows, the extension of the coaxial line into the stub is equivalent to adding an open quarter-wave line in series with the inner conductor of the coaxial line

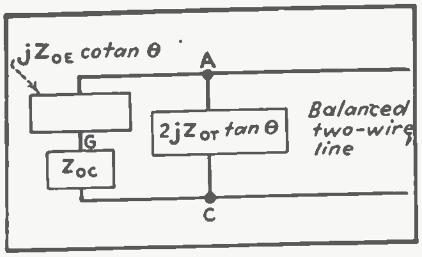

FIG. 12—The lumped-constant equivalent circuit of the conversion section shown in Fig. 10 shows how the addition of an open line in series with the coaxial line will correct the angular variation of impedance of the conversion section

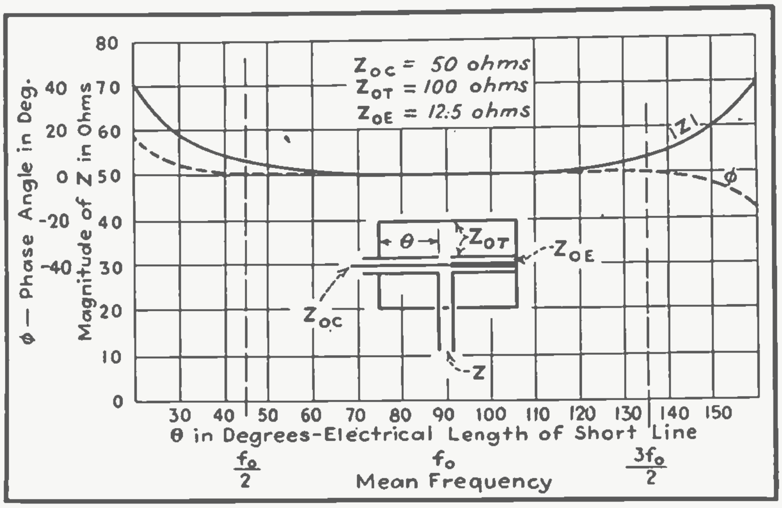

FIG. 13—The theoretical variation of impedance seen by the balanced two-wire line, when converted to a coaxial line by the transformer of Fig. 10, shows but slight change in magnitude and negligible change in angle over a one-to-three change in frequency

Calling the currents in the extended line I_{1B} and I_{2E}, I_{2B} is always equal and opposite to I_{1B}. From Fig. 10 it can be seen that I_{1B} is equal to I_{1C}, which will make I_{2B} equal and opposite to I_{2C}. Since the extended shield and stub have the same diameter, the circuit will be symmetrical, making I_{3C} equal and opposite to I_{4B}. This means that the balanced line currents I_{1B} and I_{2B} will also be equal and opposite, yielding balance. In Fig. 11 is shown the equivalent circuit of this type of transformer. This can be further modified to the lumped constant circuit of Fig. 12.

The input impedance from the balanced line across AC is

$$Z = \frac{(Z_{oc} - jZ_{oE}\cot\theta)\,(2jZ_{oT}\tan\theta)}{Z_{oc} - jZ_{oE}\cot\theta + 2jZ_{oT}\tan\theta} \qquad (3)$$

where θ is the electrical length of the extended line. This will also be equal to the length of the stub line inside the box when the capacitance across ΔL is neglected. The coaxial line is assumed to be matched so that the impedance presented at GA is the surge impedance. Simplifying Eq. (3),

$$Z = Z_{oc}\frac{1 - j(Z_{oR}/Z_{oc})\cot\theta}{1 - (Z_{oR}/2Z_{oT})\cot^2\theta - j(Z_{oc}/2Z_{oT})\cot\theta]} \qquad (4)$$

Substituting the value of Z_{oR} given in Eq. (2), Z becomes

$$Z = Z_{oc}\frac{1 - j(Z_{oc}/2Z_{oT})\cot\theta}{1 - [(Z_{oc}/2Z_{oT})\cot\theta]^2 - j(Z_{oc}/2Z_{oT})\cot\theta} \qquad (5)$$

As long as Z_{oT} is kept large this circuit is an excellent transformer.

The calculated impedance of a transformer where $Z_{oc} = 50$ ohms, $Z_{oT} = 100$ ohms and $Z_{oR} = 12.5$ ohms is shown in Fig. 13, where the capacitance across ΔL is neglected.

This type of transformer is excellent for a transfer from a stationary to a rotating member. Since the coaxial line does not make contact with anything, it can be kept stationary while the whole transformer and balanced two-wire line rotates around it.

Loaded Phase-Shifting

The loci of the output voltages with adjustments of the phase-shifting network are plotted for thyratrons or other loads across the output of the network. Three of the circuits illustrated give phase shifts that are continuously variable from zero to 180 deg

In thyratron control circuits and controlled rectifier circuits, phase-shifting networks are often required to change the phase angle between the grid and anode voltages.[1] Figure 1 shows such a network which is frequently used to perform the phase shifting. The network consists of two arms. One arm is a mid-tapped transformer or a single-phase, three-wire system, and the other is a series circuit of resistance R and reactance $\pm jX$ (which may either be capacitive or inductive). By varying the resistance or reactance, the phase angle between the input voltage E_i and the output voltage E_o can be varied.

When the load connected across E_o draws a negligibly small current, the locus of the terminal of the voltage vector E_o is a semicircle[2] as in Fig. 2. If the load Z_o draws current, the locus will no longer be a semicircle. However, the locus can be obtained by solving the two-mesh network using Kirchhoff's law directly and plotting the output vector E_o, but this method is lengthy and tedious.

Equivalent Circuits

The following method used to obtain the locus is based on Thevenin's Theorem[3], but is presented step-by-step so that those not familiar with the theorem can readily follow the procedure.

In Fig. 3(a), the transformer winding is replaced by two a-c voltages E each equal $E_i/2$. If the load branch Z_o is opened the voltage across the open-circuit will be E_{o1}. If the Z_o branch is closed by the insertion of a voltage equal and opposite to E_{o1} as shown in Fig. 3(b), there will be no current flowing through the Z_o branch. The open-circuit voltage will be cancelled by the inserted voltage, and therefore the two circuits in Fig. 3 are equivalent.

If all the circuit elements are linear, the principle of superposition[4] can be used to solve the circuit. The circuit of Fig. 1 is then equivalent to two circuits; that of Fig. 3(a) in which the Z_o branch draws no current, and a circuit in which only the voltage E_o in series with the Z_o branch acts with the polarity shown in Fig. 4. The locus of the voltage across Z_o of the first circuit is the semi-circle shown in Fig. 2. The locus of the voltage across Z_o of the circuit shown in Fig. 4 can be found quite readily. This correction voltage represents the voltage difference due to the loading path Z_o.

The locus of the load voltage across Z_o of the actual circuit (Fig. 1) can be obtained by superimposing the correction voltage of the second circuit on the voltage locus of the first circuit. Rather than combine the two voltages analytically it will be simpler to combine them vectorially. To the semicircle of Fig. 2 can be added the correction voltage of Fig. 4 for various types of loads.

This correction voltage can be

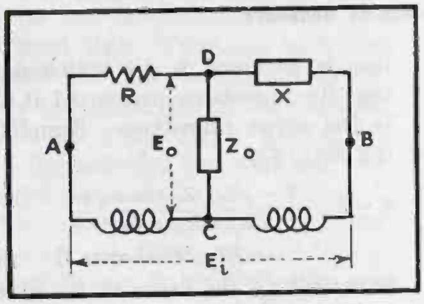

FIG. 1—Typical phase-shifting network in which the voltage applied is E_i and the shifted voltage is E_o. R and X constitute the shifting network. Z_o is the load across the shifted voltage.

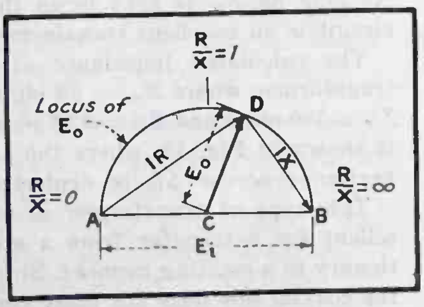

FIG. 2—When the load Z_o in Fig. 1 draws no current, E_o can be made to rotate on a semicircle by varying the ratio of R to X. If this ratio varies from zero to infinity, E_o rotates through 180 degrees

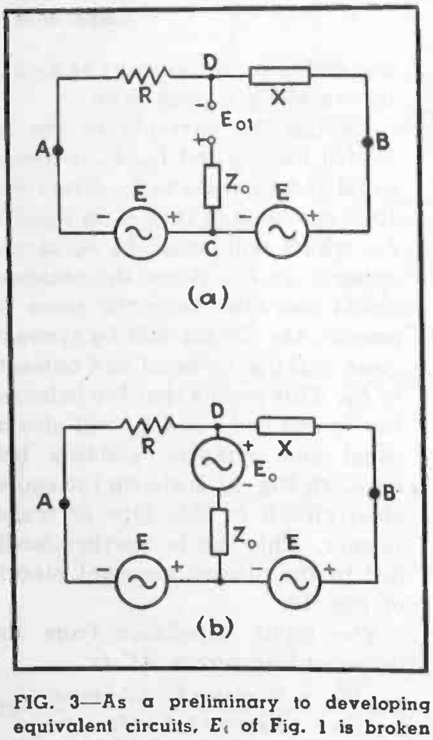

FIG. 3—As a preliminary to developing equivalent circuits, E_i of Fig. 1 is broken into two equal voltages E. If the center branch of Fig. 1 drew no current, it would be equivalent to an open circuit across which E_{o1} appeared as shown at (a), or to a circuit in which there operated an equal but opposite voltage as at (b)

Networks

By P. T. CHIN

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find easily by means of Ohm's Law. Referring to Fig. 4, the correction voltage V_R is

$$V_R = \frac{-E_{o1}\left(\dfrac{\pm jRX}{R \pm jX}\right)}{Z_o \pm j\dfrac{RX}{R \pm jX}} \qquad (1)$$

Simplifying,

$$V_R = \frac{-E_{o1}}{\dfrac{Z_o}{R} + \left(1 + \dfrac{Z_o}{\pm jX}\right)} \qquad (2)$$

From Eq. (2) it can be seen that the correction voltage V_R depends on Z_o, $\pm jX$ and on whether R or $\pm X$ is varied to obtain the phase shift.

Effects of Various Loads

In the following, the voltage loci of a circuit with $\pm jX = -jX$ (a capacitor), R the variable, and with different kinds of Z_o is discussed as an example of the application of this method.

When Z_o is purely resistive, $Z_o = R$ and Eq. (2) becomes, for this particular case,

$$V_R = \frac{-E_{o1}}{\dfrac{R_o}{R} + 1 + j\dfrac{R_o}{X}} \qquad (3)$$

To obtain the vector V_R, the terms of the denominator of Eq. (3) are added vectorially in Fig. 5(a). The variable term is R_o/R, in which R varies from zero to infinity. To obtain results for all values of this term by the fewest vector constructions, the constant vectors are plotted first, giving the vector $1 + j(R_o/X)$. To this is added the vector R_o/R. The resultant is proportional to the reciprocal of V_R. Therefore the reciprocal of the resultant is taken to give the required vector. It should be remembered that in taking vector reciprocals zero becomes infinity, and infinity becomes zero; also the sign of the angle of the vector is reversed.

The vector diagrams have been oriented so that the resultant V_R appears in the same sense on the first diagram of each figure as on the semicircle diagram of that figure. The resultant phase-shift vector for the foregoing example is plotted in Fig. 5(b). A small pair of vectors in each figure indicates the positive directions of the real and imaginary components. A zero indicates the origin in each diagram.

From Fig. 5(b) it can be seen that 180-degree phase shift cannot be obtained although R is varied from zero to infinity. Also, the output voltage E_o is not constant. The vector E_o has both phase and amplitude deviation from the vector which is obtained when the loading path is neglected. This deviation both in phase and amplitude is small in the vicinity of R equal to zero.

(2) When Z_o is purely inductive, $Z_o = jX_L$, and Eq. (2) becomes

$$V_R = \frac{-E_{o1}}{\dfrac{jX_L}{R} + \left(1 - \dfrac{X_L}{X}\right)} \qquad (4)$$

The locus depends upon whether X_L is greater than, equal to, or smaller than X. If $X_L > X$,

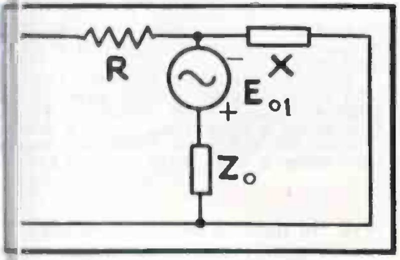

FIG. 4—To account for the current drawn by Z_o, the voltage developed across Z_o by the equivalent voltage E_{o1} must be added vectorially to the voltage whose locus is shown in Fig. 2

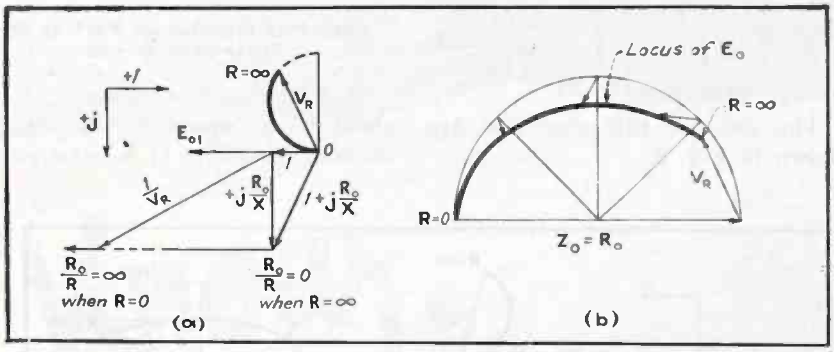

FIG. 5—(a) Vector operations give vector V_R which is the voltage correction to be applied to E_o because of current drawn by Z_o. In this case Z_o is a resistance. (b) V_R from (a) is added to semicircle of Fig. 2 to give locus of E_o

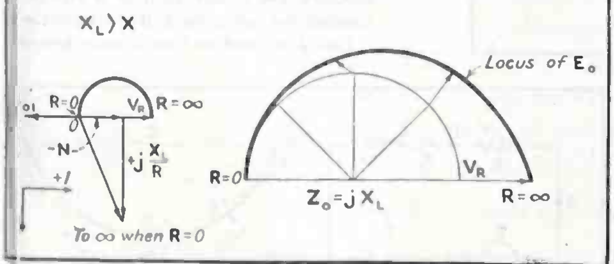

FIG. 6—Similar vector diagram to Fig. 5, but for the condition that Z_o is an inductance larger than X

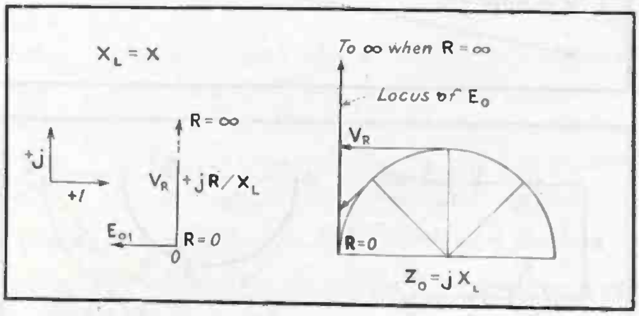

FIG. 7—This figure, Fig. 6 and 8 comprise a series showing effect of varying an inductive Z_o relative to a capacitive X

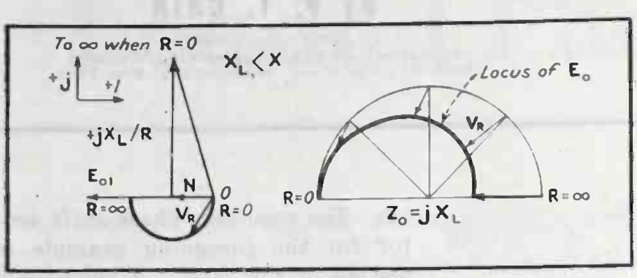

FIG. 8—In all the cases illustrated, X of Fig. 1 is a capacitance. The internal impedance of the driving voltage E_i is neglected

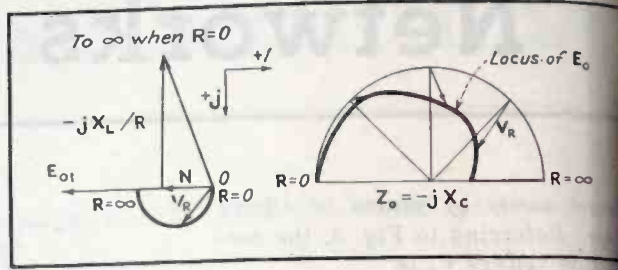

FIG. 9—If Z_o is a capacitance, complete 180-degree phase shift is possible, but there is amplitude variation

$$V_R = \frac{-E_{o1}}{\frac{jX_L}{R}+\left(1-\frac{X_L}{X}\right)} = \frac{-E_{o1}}{N+\frac{jX_L}{R}} \qquad (5)$$

where

$$N = 1 - X_L/X$$

The locus of V_R and the resultant locus of E_o are shown in Fig. 6.

If $X_L = X$

$$V_R = \frac{-E_{o1}}{\frac{jX_L}{R}+\left(1-\frac{X_L}{X}\right)} = \frac{-E_{o1}}{\frac{jX_L}{R}} = +jR\frac{E_{o1}}{X_L} \qquad (6)$$

The locus of V_R and the resultant locus of E_o are shown in Fig. 7. The locus of E_o, far from being a semicircle, is a straight line. That is, E_o is shifted 90 degrees from E_i for all values of R. Changing R merely changes the magnitude of E_o.

If $X_L < X$

$$V_R = \frac{-E_{o1}}{\frac{jX_L}{R}+\left(1-\frac{X_L}{X}\right)} = \frac{-E_{o1}}{N+\frac{jX_L}{R}} \qquad (7)$$

where $N = 1 - X_L/X$

The loci for this condition are shown in Fig. 8.

(3) When Z_o is purely capacitive, $Z_o = -jX_c$, and

$$V_R = \frac{-E_{o1}}{-\frac{jX_c}{R}+\left(1+\frac{X_c}{X}\right)} = \frac{-E_{o1}}{N-\frac{jX_c}{R}} \qquad (8)$$

where $N = 1 + \frac{X_c}{X}$

The loci are shown in Fig. 9.

(4) When an inductor of appreciable resistance is the load, $Z_o = R_o + jX_L$, and

$$V_R = \frac{-E_{o1}}{\frac{R_o+jX_L}{R}+\left(1+\frac{R_o+jX_L}{-jX}\right)} = \frac{-E_{o1}}{N+jM+\frac{R_o+jX_L}{R}} \qquad (9)$$

where $N = 1 - \frac{X_L}{X}$

and $M = \frac{R_o}{X}$

The vectors for this condition are shown in Fig. 10.

Imperfect Inductor as Part of the Phase-Shift Circuit

If X in Fig. 1 is an inductor instead of a capacitor, the voltage locus of D in Fig. 11 is not a semicircle (due to coil resistance) when there is no load between points C and D of Fig. 1. If the internal resistance R_x is separated from the reactance $+jX$ and combined with R, the locus of point E in Fig. 11 will fall on the original semicircle. If R and R_x are constant, and if the phase shifting is obtained by varying inductance, the voltage across AD and DE will be in the ratio of R: $(R + R_x)$. It can be seen that the diameter of D is $V_o R/(R + R_x)$ and its center is $V_o R_x/2(R + R_x)$ from C along AB. However, if the phase shift is obtained by varying R instead of the inductance, the locus of D will not be a semicircle, but will be as shown in Fig. 12 since the ratio R_x: R changes with different values of R.

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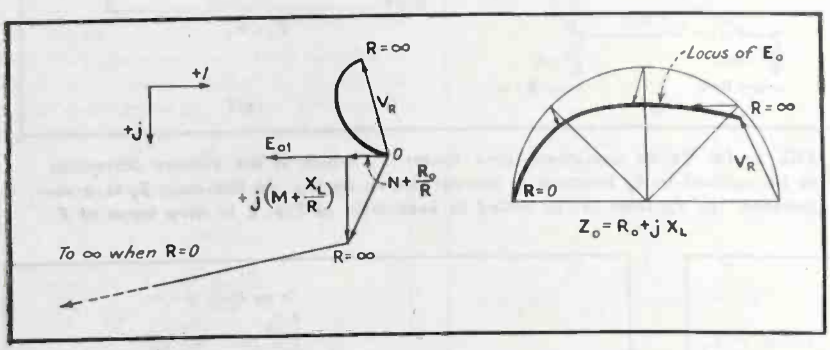
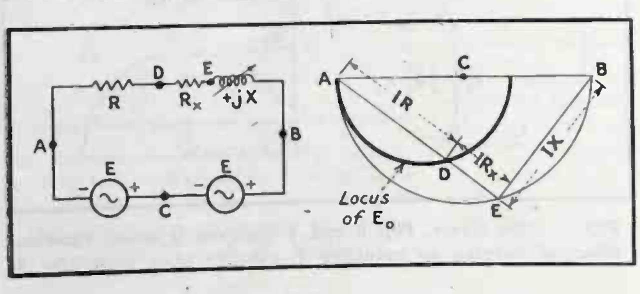
(3) M.I.T. E.E. Staff, "Electric Circuits," John Wiley & Sons, 1940, pp. 145, 469-47[illegible]
(4) M.I.T. E.E. Staff, "Electric Circuits," John Wiley & Sons, 1940, pp. 138-140.





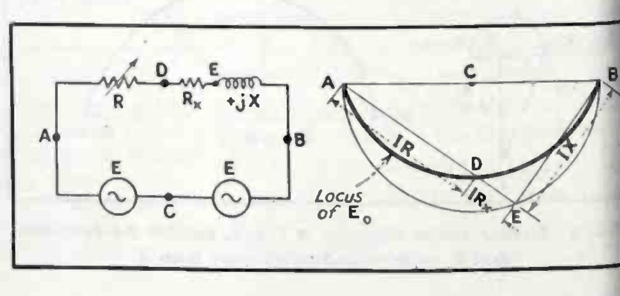


FIG. 10 (left)—Analysis of an inductor having internal resistance

FIG. 11 (lower left)—When X is an inductance with internal resistance the locus of Fig. 2 becomes that shown here if the inductance is varied to produce the phase shift

FIG. 12 (lower right)—If R is varied to produce the phase shift in a circuit including an inductance the semicircle of Fig. 2 is modified as shown below

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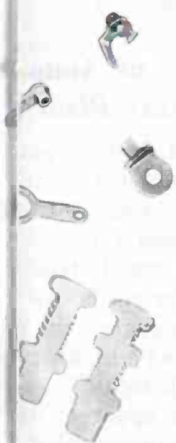

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INDUSTRIAL CONTROL

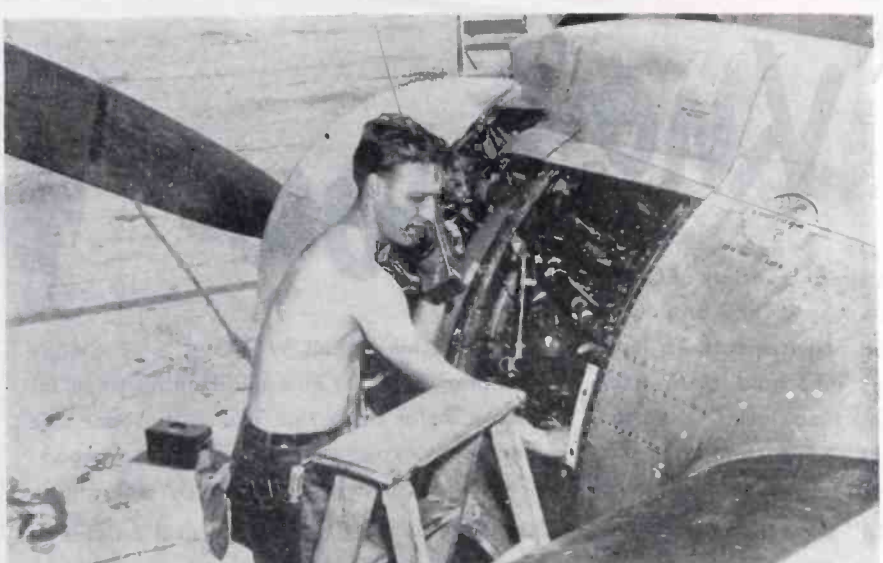
Handie-Talkies Replace Phones in Plane Plant

AFTER A FIRE destroyed all telephone lines and the administration building of the Douglas Aircraft Company plant in Chicago, Motorola handie-talkies, supplied by the U. S. Signal Corps, were used for communications between the remaining buildings, scattered over several miles. Production of planes was continued without interruption and for two and one half days, twenty-four hours per day, emergency communications were maintained between plants and plant officials with the portable units.

Marjorie Monnier, head of emergency messenger service established after a fire at Douglas Aircraft, received messages for routing over a Motorola portable radio transmitter-receiver

Outside telephone communications were provided by the Douglas f-m two-way Motorola police radiotelephone system. Messages were transmitted by radio over the police system to a Douglas patrol car, parked in front of the Park Ridge telephone exchange three miles away, then relayed over the regular telephone wires.

The original handie-talkie was developed by Donald Henry Mitchell, chief engineer of Galvin Mfg. Co., after observing army maneuvers at Camp McCoy, Sparta, Wisconsin in August, 1940. Since the equipment in use at that time was cumbersome and inefficient, he attempted design of a smaller compact transceiver. After three months work, he produced a five-tube unit in a die-cast aluminum box that weighed only five pounds with batteries. In recognition of his contribution to the war effort in the field of electronics, he recently received the *Chicago Tribune* War Workers Award.



At a Douglas hangar, N. Berkshire reports the condition of a plane motor with a Motorola handie-talkie borrowed from the Signal Corps

Standard for Industrial Control Equipment

A REVISED American Standard for industrial control apparatus in the heating, generating, and general machinery fields is available from the American Standards Association.

The new Standard is a working document of practical information concerning the manufacture, test, and performance of industrial control equipment. It represents standardized practice in the United States and covers industrial motor control, similar control used for industrial heating, and rheostats, including those for the generator field. Sections in the standard cover resistors, ratings, specifications for products, and performance.

Standardization of industrial control equipment was started by the Electric Power Club in 1915. In 1928, the first American Standard for Industrial Power Control Equipment was approved; and the present standard is a revision of that.

The American Standards for Industrial Control Apparatus (C19.1-1943) may be obtained for 50 cents per copy from the American Standards Association, 29 West 39th Street, New York 18, N. Y.

Industrial X-Ray of Ammunition in Ordnance Plant

THE EXPANDED USE of high-power industrial x-ray equipment in Army Ordnance plants throughout the country as a successful means of more complete and non-destructive testing procedure for shells has led ordnance officials to regard the use of x-ray equipment as a highly utilitarian and valuable tool.

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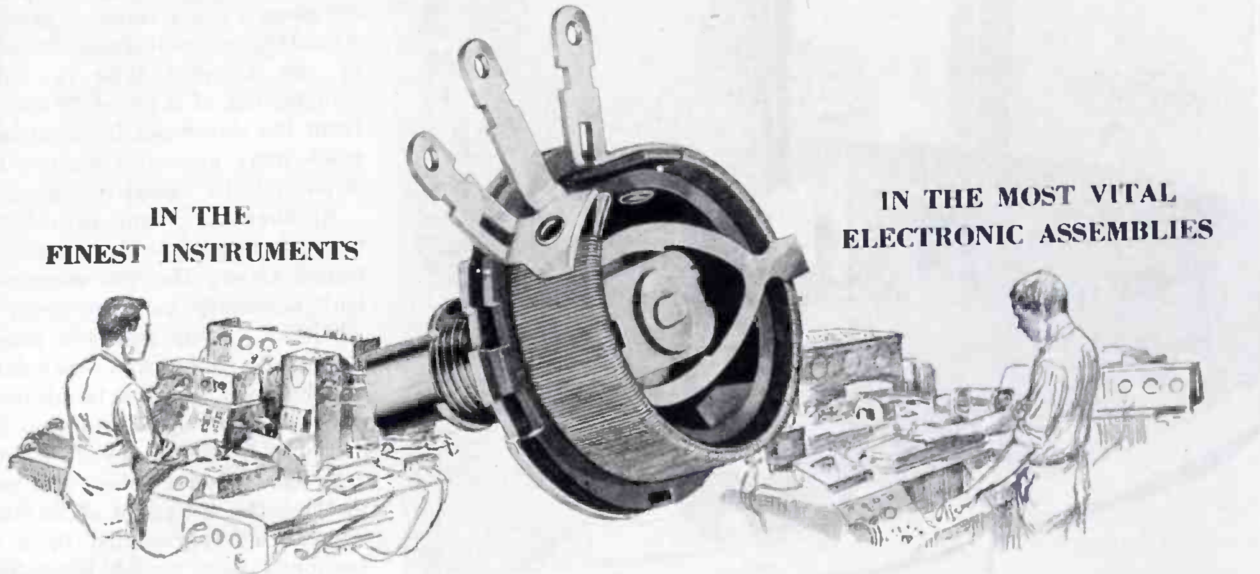
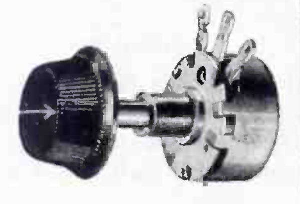


Mallory Fixed and Variable Resistors



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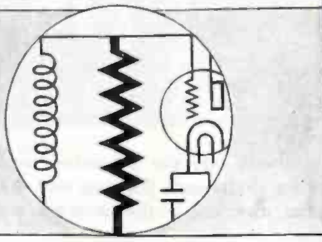

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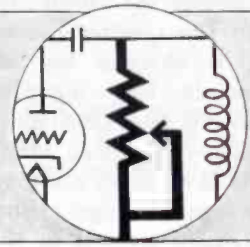
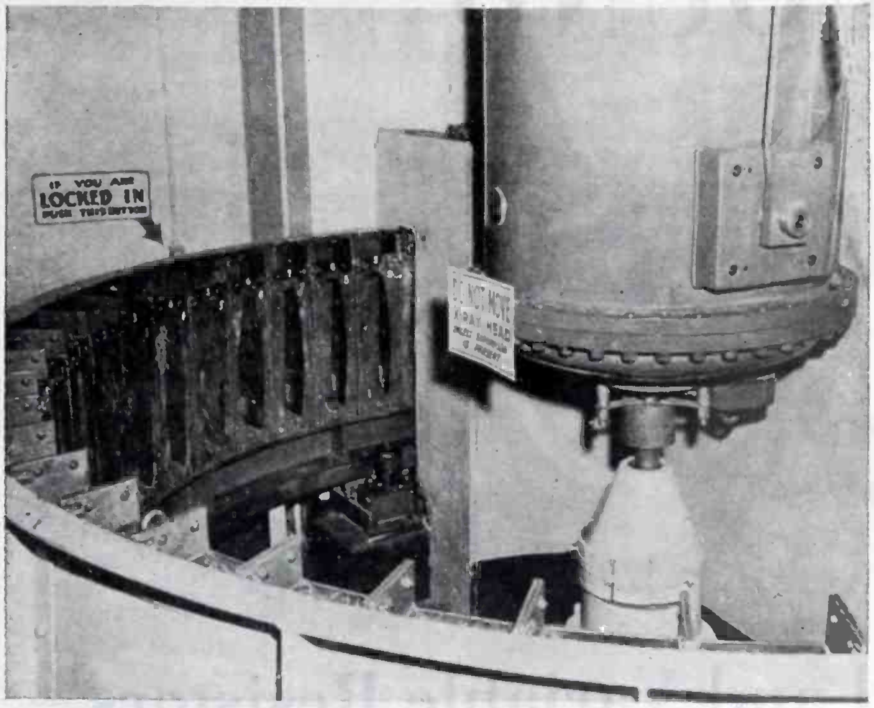




Inside the exposure room, where the shells are x-rayed by the million-volt industrial unit. The shells and cassettes containing the film are carried into the room on a motorized ring

ment through its St. Louis office. The first installation, almost entirely automatic, was made in cooperation with Proctor & Gamble Defense Corp. and the Ordnance Department by engineers of General Electric X-Ray Corp. and is used principally for the inspection of 155-mm shells.

The unit was installed at the Milan Ordnance Center, one of the most efficiently operated plants in the country, where all types of ammunition, including anti-tank and anti-aircraft shells, shells for field guns and trench mortars, and bombs of various sizes are turned out. At this plant, the most rigid and constant inspection is carried out all along the production line. Hundreds of different sub-assemblies and component parts are checked before they are ever assembled, and checked again at various points during the assembly.

The x-ray inspection job begins after the TNT is poured into shell casings at high temperature. In the cooling process that follows, it shrinks the same as many metals. Each operator must exercise extreme care in pouring the shell or cavitation may result. It is this cavitation, along with air bubbles and foreign substances, that is easily spotted in the TNT cast when the shells are radiographed.

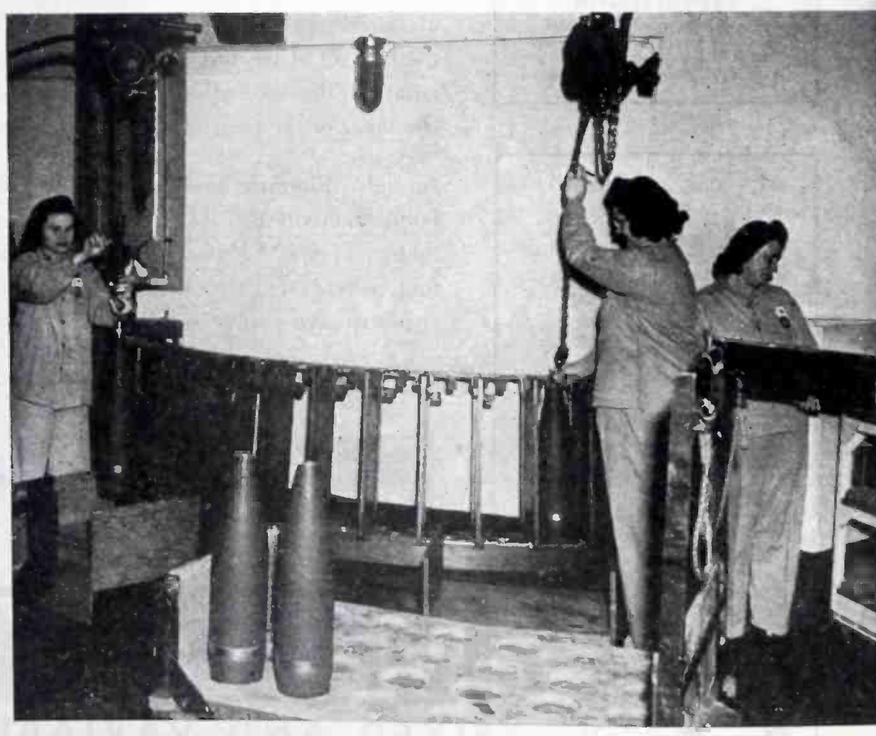
Advantages

With the x-ray technique, it is possible for the first time in history to inspect the shell without destroying it. In addition, the inspectors are given a wider range of sampling since they can radiograph 700 shells of the 155-mm type in sub-lot samples out of a lot of 20,000 and, from the developed films, obtain a much more accurate analysis than is possible by visual inspection.

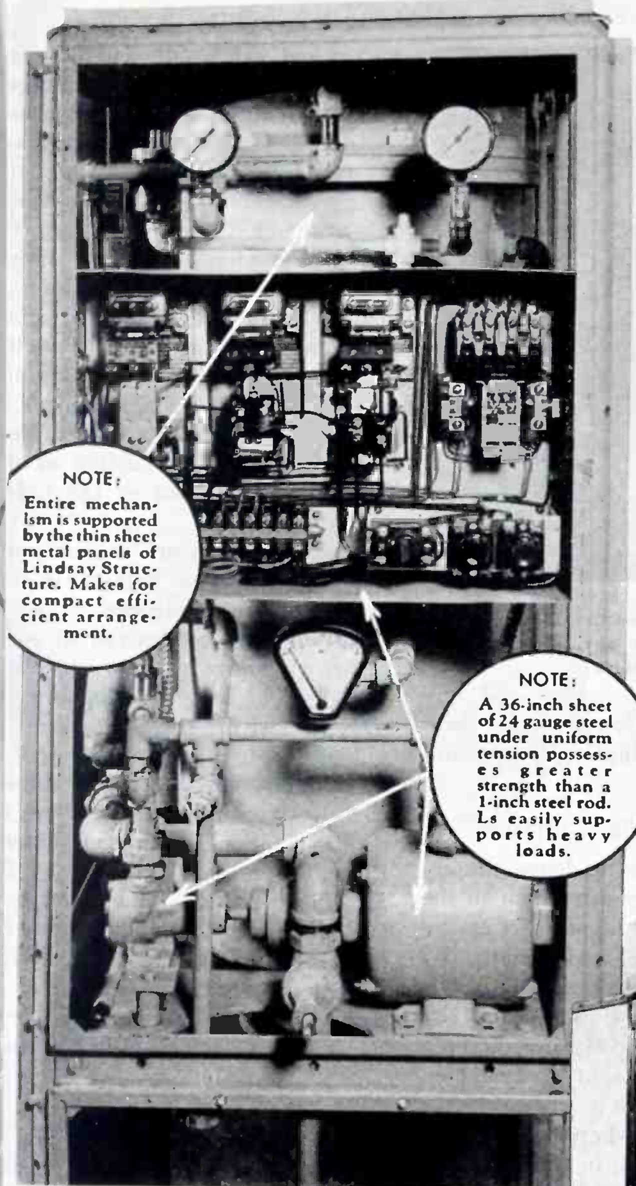
Another important advantage is that if any defective shells are found among the 700 samples, it isn't necessary to throw away the whole lot. X-ray makes it possible to speedily radiograph every doubtful shell and separate the defective ones from the good, thus no shell "acceptable" under specifications is rejected. Under the sectioning method, the entire lot of 20,000 or smaller lot represented by a bad sectioned cast would be rejected because there was no accurate way of picking out the good shells. A defective shell, found through x-ray, can be steamed out and a portion of the explosive and the entire casing reclaimed.

Procedure

At the Milan Ordnance Center, four girls work in front of the big exposure room which houses a million-volt x-ray unit. With the aid



View of the motorized ring that carries 155-mm shells into the adjoining room for x-raying of TNT cast. The girl at the left is loading shells onto the ring and the girl at right is removing them as they emerge from an aperture in the concrete wall of the exposure room



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It saves space—the second important feature of Lindsay Structure. No space lost for superstructure. Lindsay Structure cabinets are available in any desired dimension.

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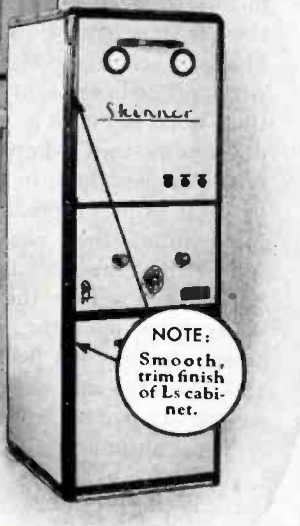
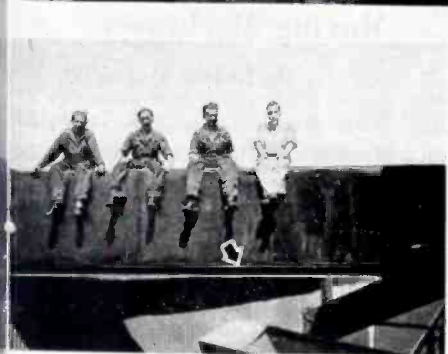
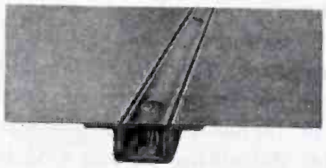




...strong and rigid is Ls that an I-... originally intended for support, ...lly sagged below this Ls housing ...though it bore the added weight ...ur men.



Easy to assemble

Ls

LINDSAY STRUCTURE

...Patents 2017629, 2263510, 2263511 ...nd Foreign Patents and Patents Pending of an air hoist, one girl takes the 155-mm shells from a truck and loads them into the 50 cubicles of a motorized ring. Each shell is 24 inches long and weighs about 90 pounds.

Another girl operator takes a special size cassette, previously loaded with x-ray film, and places it behind each shell as it is put on the ring. This operator also stamps the shell with the number corresponding to the lead number on the cassette and records the shell and film numbers so that pertinent information can be correlated later.

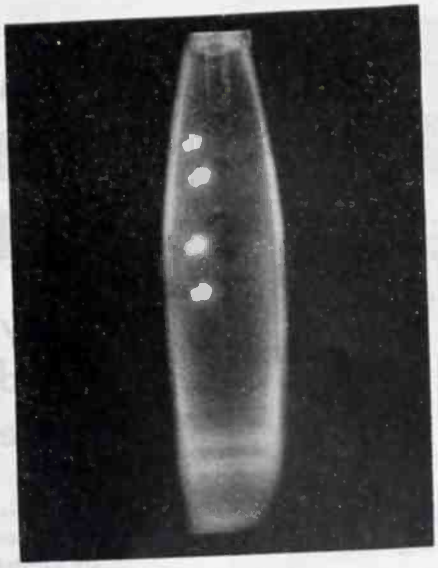
The shell and loaded cassette enter the exposure room on the motorized ring by passing through an aperture in the concrete wall. Within the room, the x-ray radiation produces a radiographic image of the shell and its contents on the film. With one-half of the ring extending outside the exposure room, the shells and films are exposed to the x-ray radiation only during one-half of the revolution.

A third operator then removes the cassette after the shell has passed through the exposure room, and marks the shell "x-rayed." The fourth girl, working with an air hoist, removes the shell from the ring. Each girl has approximately 20 seconds for her respective operation.

Since it takes the ring 18 minutes to make one revolution and there are 50 shell cages, each separated by a lead barrier, the shells are inspected at the rate of 50 every 18 minutes. Thus the equipment is capable of radiographing 3,300 shells every 24 hours of operation, allowing for down time and shift changes.

The exposure room, which is approximately 18 by 11 feet and 18-feet high, is protected on all sides by 18 inches of solid poured concrete. Adjoining on one side is the motor generator room, completely enclosed, and on the other is a small room which contains all controls for operating the million volt x-ray equipment.

The exposure room is designed so as to conform with the safety requirements so necessary because of the explosive danger ever present in plants of this type. Operators working outside of the exposure room are protected against



Radiograph of a defective 155-mm shell showing excessive cavitation or air bubbles

any stray radiation by solid lead barriers at the ring's entrance and exit.

Automatic Film Processing

After the cassettes leave the exposure room, they are taken to the darkroom nearby where girl operators remove the x-ray film. By means of a special loading board, they fasten two of the special size films on each developing hanger. An overhead conveyor system takes the loaded hangers to the automatic developing unit where another operator places them in the magazine of this film-processing machine. Meanwhile the cassettes, from which the films had been removed, are pushed across the table to another girl operator, who reloads them, changes the lead numbers on the cassettes and sends them back to the exposure position.

The automatic film-processing unit, which can handle 240 films per hour, picks up a loaded hanger from the magazine every 30 seconds and places it in the developing solution. From this point on, the hanger and film are automatically taken through the developing solution, the short stop, the fixing solutions and water rinse. The unit also delivers the processed films and hangers via a conveyor to the film viewing room, where a trained inspector views the films on an illuminator, and reports immediately any unusual shell condition or defect which she notes on the radiograph.

After the films are viewed, only those which show defects in the shells or other conditions on which a history may be desired at some future time, are permanently filed. The film not to be filed is immediately packed for salvage sale.

The Milan plant is operated on a 24-hour-day, six days-a-week basis. Two other units were installed at the Ravenna Ordnance Plant, Apco, Ohio, operated by Atlas Powder Co., and the Iowa Ordnance Plant at Burlington, operated by Day & Zimmerman, Inc. Additional x-ray units, similar in design and application, are on order for use in several other ammunition plants.

• • •

A Simple Stroboscope for Moving Machinery

By Robert C. Paine

The stroboscope is a very useful device for studying objects in rapid motion by making them apparently stand still. As in the name of many modern devices, the word "stro-

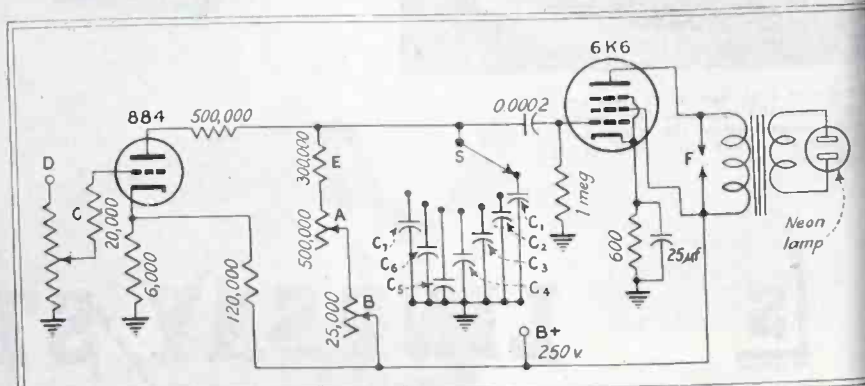


FIG. 1—Circuit diagram of a simple stroboscope using a neon lamp for the flashing element

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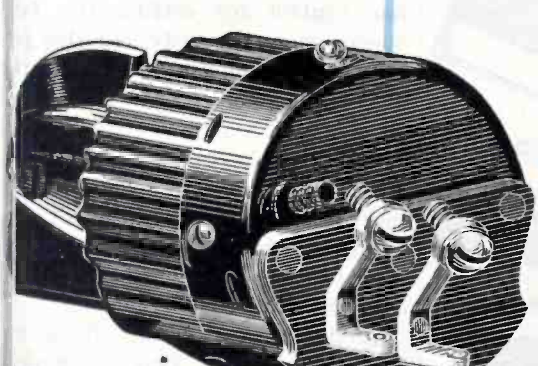
POWER RHEOSTAT

AN3155
50-watt



AN3155
25-watt; showing terminal positions

Here's a power rheostat with a *short* past but a *long* future. Rugged in construction, light in weight and neat in appearance, it conforms in every respect to Army-Navy AN3155 specifications. It embraces all the features of IRC's well-known PR25 and PR50 rheostats.

Both the winding core and housing, of this completely sealed unit, are of aluminum to effect greater heat dissipation. To still further aid this important characteristic the housing is coated with a special heat-radiating finish developed by the IRC Research Staff. As a result the AN3155 generates a maximum temperature rise of only 170° as against an allowable 300°. Another feature of interest is the fact that the AN3155 can be operated at full power load in as low as 25% rotation.

Available in 25 or 50 watt models with either linear or tapered windings, the IRC AN3155 should find many useful post-war applications.

Technical data and further information will be sent on request.

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boscope" is derived from the Greek, combining two words, meaning "to view" and "awhirling".

An inexpensive stroboscope, using materials commonly found in a radio workshop, is easily constructed. Figure 1 shows the circuit of the instrument. It contains a conventional power pack (not hown in diagram) using an 80-type tube, and a relaxation oscillator, using an 884 gas triode to generate a saw-toothed wave. The circuit is similar to that used for the sweep in some oscilloscopes.

In operation, one of the capacitors C_1, C_2 etc., charges slowly from the B+ voltage, through the resistances A, B, and E, to a voltage sufficiently high to cause the 884 tube to conduct. At this point of the cycle, the capacitor discharges very rapidly through the tube until the tube ceases to conduct, whereupon the cycle is repeated.

The frequency of these oscillations depends on the value of the capacitor switched into the circuit by the switch S and the charging resistance controlled by the rheostats, A and B. Rheostat A is the coarse control for setting the approximate frequency and B is the fine control for setting the frequency more precisely and also for shifting the phase. Potentiometer C is used when required for synchronizing the oscillator with an external control connected at D; such a control might be a circuit with a mechanical interrupter on a rotating machine or an a-c source used to drive a synchronous motor or machine under observation.

A differentiating circuit is included in Fig. 1. This contains a 6K6 tube for converting the steep front of the saw-tooth wave into a sharp pulse of voltage for operating some form of gaseous tube that deionizes quickly. The author has found a small neon lamp serviceable, such as the G. E. type S14, though other types of lamps may be brighter, if available. If a commercial neon lamp is used, it should be one which has no resistance in its base. To increase the brilliancy, the light may be concentrated by a condenser lens.

The lamp is coupled to the 6K6 tube by a stepdown transformer such as an interstage type of about 3 to 1 ratio. Since the operation of the circuit, with the neon lamp dis

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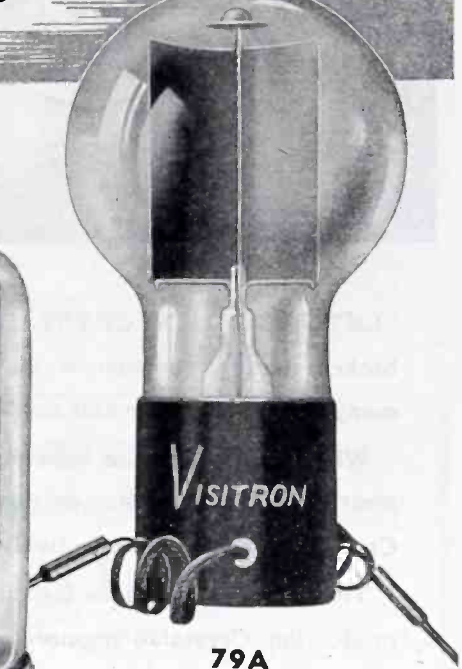
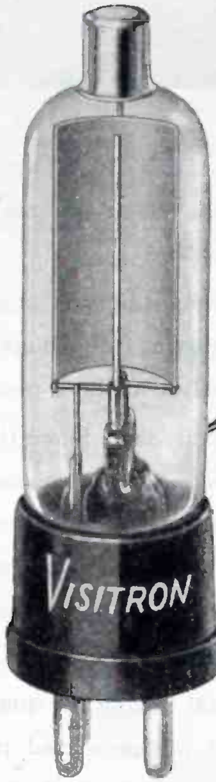


79A



59TA

51A

79A . . . designed for use in standard theatre projection equipment.

51A . . . universally used in portable 16 m. m. sound-on-film projection equipment.

59A . . . a popular model used in many makes of projectors. The 59TA is a special application of this tube, having a high dark resistance.

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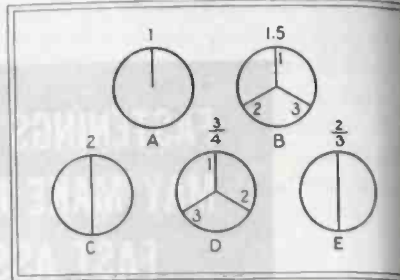

FIG. 2—Appearance of patterns of a single spoke painted on a rotating disk when illuminated by a stroboscope lamp at the indicated frequency ratios

two positions, as two flashes occur for each revolution. In Fig. 2(d), the frequency of flashes is slower than the speed of the disk and the spoke appears in three different positions again as the disk revolves $1\frac{1}{3}$ revolutions between flashes. In Fig. 2(e), the spokes appear in two positions as the disk revolves $1\frac{1}{2}$ revolutions between flashes.

Relative Brightness

Many other patterns of spokes appear at different flash frequencies. The spokes of these patterns vary in brightness directly as the number of times each spoke position is illuminated per second. To calculate relative brightness, let the apparent number of spokes seen be represented by S, the revolutions per arbitrary unit of time be represented by unity, the lamp flashes per unit of time by L, and the revolutions of the disk between reappearances of the spoke at a given position by R. Then stationary patterns of spokes appear whenever the ratio $S/R = L$ is formed by any integral numbers. However, these patterns are so dim as to be hardly noticeable except for those represented by the ratio of low numbers as given in the S/R column of the table in Fig. 3. The relative brightness of the spoke patterns equals $1/R = L/S$. For example, in Fig. 2 the relative brightness of patterns is as follows: $A - (1/1) = 1$, $B - (1.5/3) = 0.5$, $C - (2/2) = 1$, $D - (\frac{3}{4}/3) = 0.25$, $E - 2/3) = 0.33$.

For use with the stroboscope, it is convenient to have a table of possible patterns and their relative brightness as shown in Fig. 3. In this table six degrees of brightness from 1 to 0.167 are given (other dimmer patterns are possible but are not given in this table). For brightness of 1, $R = 1$ and each position of the spoke is illuminat

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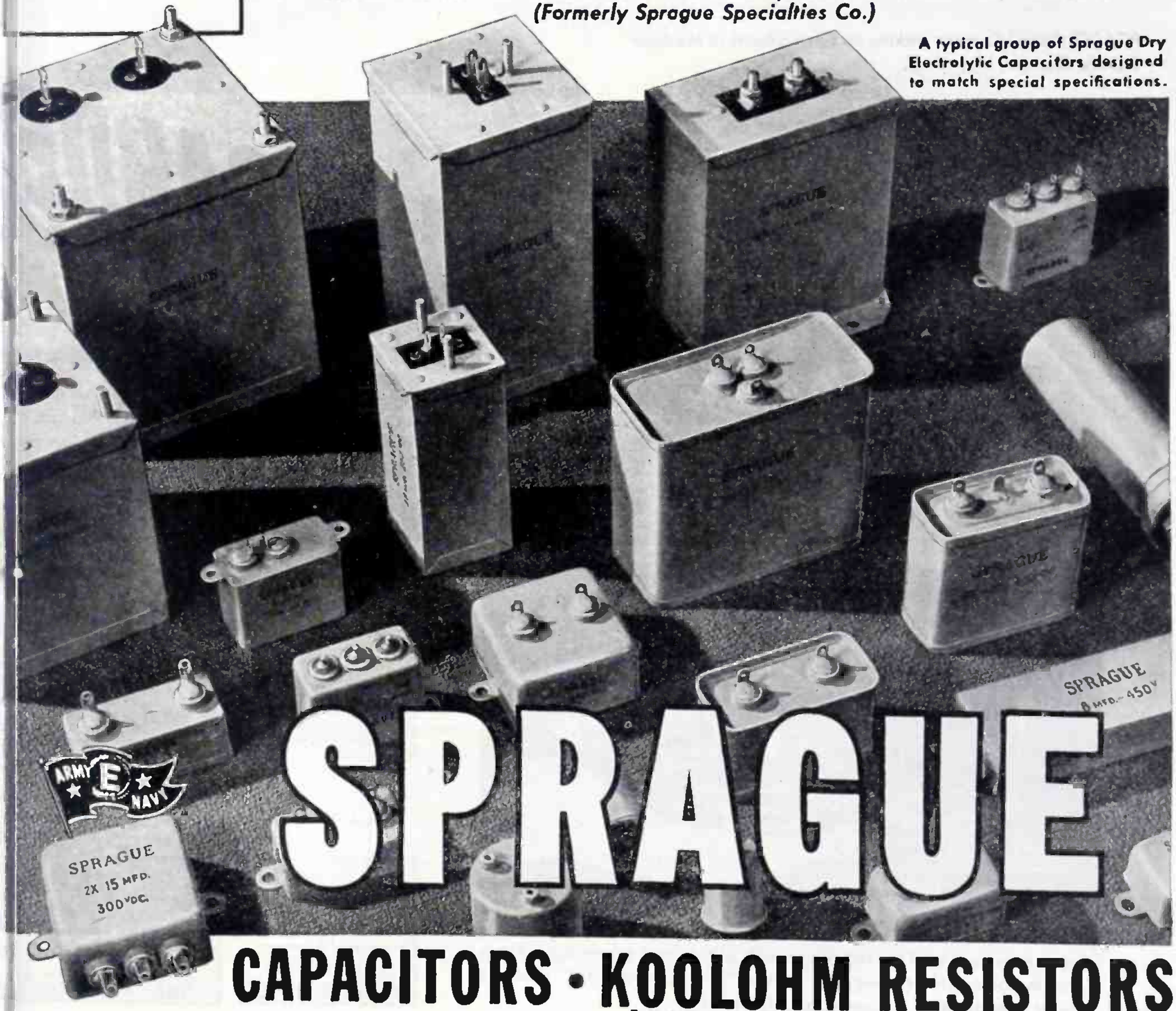

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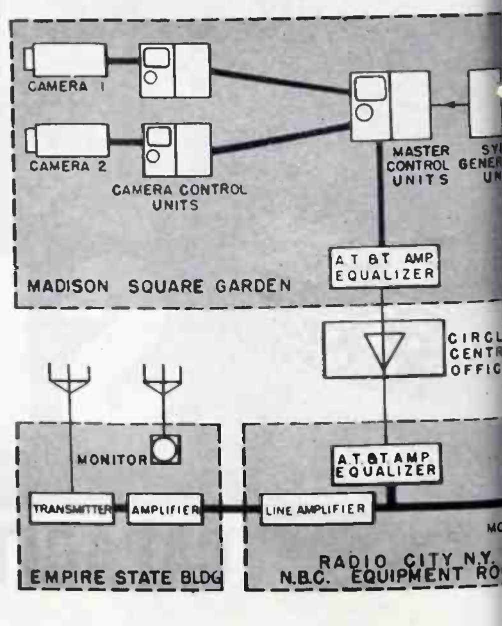
RCA "Orthicon" Camera picking up boxing bouts at Madison Square Garden, New York.

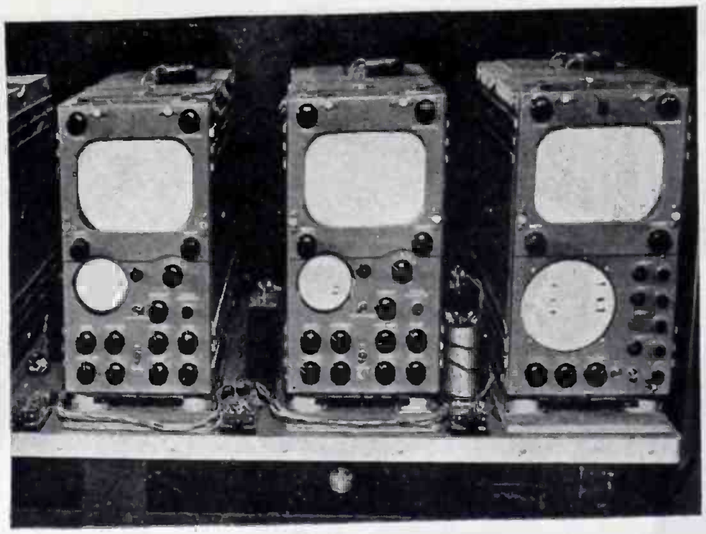
MADISON SQUARE GARDE

Using RCA Television Field Pickup Equipment is rela easy. Units are arranged as shown in diagram. Vide audio output are fed over an ordinary telephone (especially equalized) to Radio City, a mile away.



RCA control equipment used by NBC at Madison Square Garden. The audio control unit is at the left, video units at the right, power supply units beneath table. This corresponds to the "remote equipment" used by regular broadcasting stations in outside pickups.

Main units of the RCA Television Field Pickup Equipment. The two units at the left are "camera control" units. They provide monitoring of pictures picked up by each individual camera. At the right is the "master" monitoring and switching unit. Push-buttons allow operator to select, for transmission, the camera pickup desired.



TELEVISION!

RCA Portable Television Camera (below) which made outside pickups practical. Uses "Orthicon" pickup tube (an exclusive RCA development) which, because of its much higher sensitivity, makes possible operation with far less light than with other types of pickup tubes.

BOXING, basketball, radio, ice follies, circus—enjoyed at ease in your living room. In the New York area it has been a fact for the past year! Not just as an occasional experiment, but regularly, on a weekly schedule.

These broadcasts are picked up at Madison Square Garden by NBC, using RCA's standard Television Field Pickup Equipment, and are put on the air through NBC's Television Station WNBT. Some idea of the advanced design of this equipment and the ease with which it is used can be gained from a study of the accompanying illustrations. Not so obvious, but equally important is the experience behind this design. Before the war RCA built apparatus of this type for NBC, CBS, Don Lee and others. After the war RCA will introduce still further improvements—*based on actual experience in building commercial-type television equipment.*

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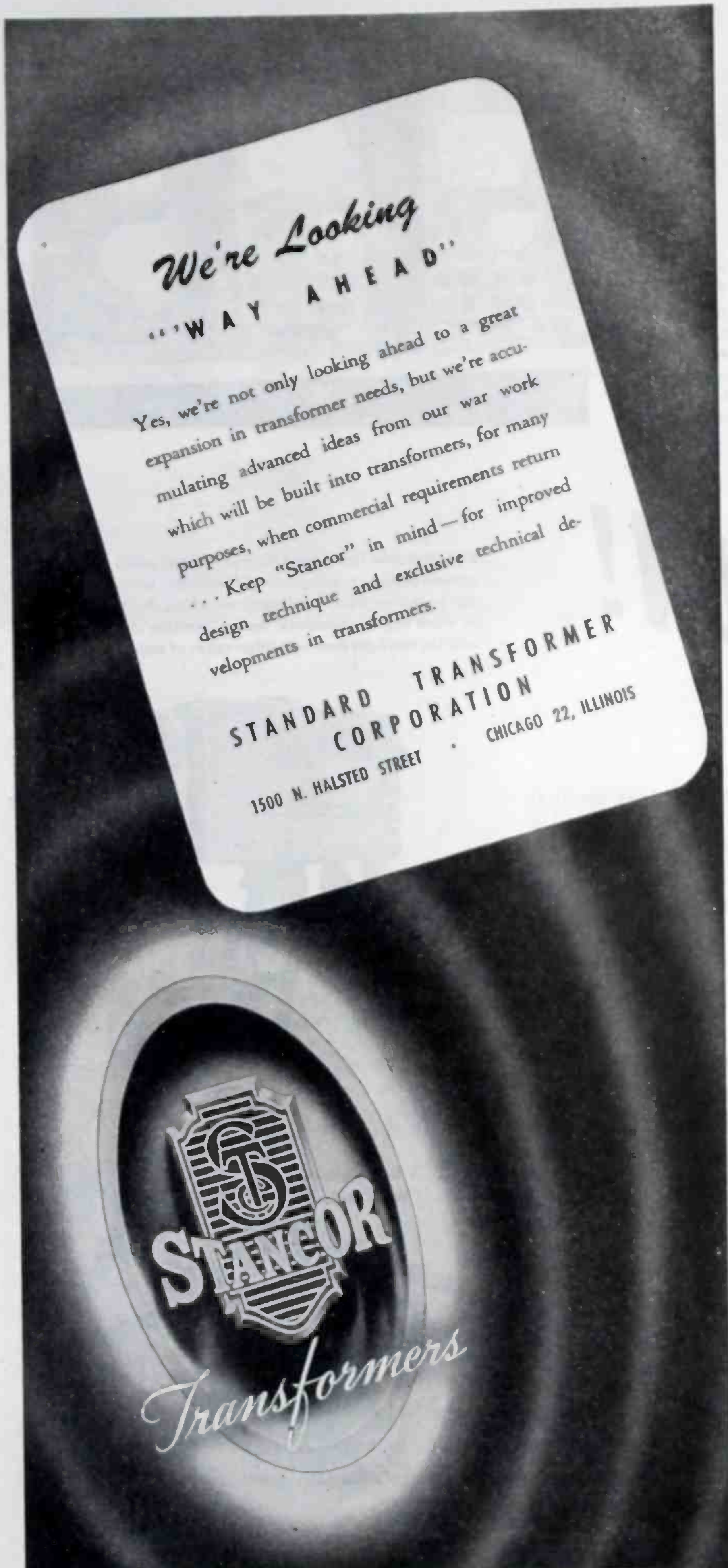

S/R	L	Relative Brightness (= 1/R) 1.	0.5	0.33	0.25	0.2	0.1
		pattern seen					
1/6	0.167						1
1/5	0.2					1	
1/4	0.25				1		
1/3	0.33			1			
2/5	0.4						
1/2	0.5		1				
3/5	0.6					3	
2/3	0.67			2			
3/4	0.75				3		
4/5	0.8					4	
5/6	0.83						5
1/1	1.	1					
7/6	1.17						
6/5	1.2					6	
5/4	1.25				5		
4/3	1.33			4			
7/5	1.4					7	
3/2	1.5		3				
8/5	1.6					8	
5/3	1.67			5			
7/4	1.75				7		
9/5	1.8					9	
11/6	1.83						11
2/1	2.	2					
13/7	2.17						13
11/5	2.2					11	
9/4	2.25				9		
7/3	2.33			7			
12/5	2.4					12	
5/2	2.5		5				
13/7	2.6					13	
8/3	2.67			8			13
11/4	2.75				11		
14/5	2.8					14	
17/6	2.83						17
3/1	3.	3					

FIG. 3—Table of possible patterns of apparent number of spokes on a rotating disk having only one actual spoke, at various flash frequencies of lamp L, and relative pattern brightness, $1/R$, where R is the number of revolutions of disk between appearances of the spoke at the same relative position

once for each revolution of the disk; for a brightness of 0.167, $R = 6$ and each position of the spoke is illuminated only once in six revolutions. Corresponding to each degree of brightness in the table is the number of spokes seen in the patterns at that brightness and on the same horizontal line is the ratio of flashes to revolutions, L, and S/R the ratio of spokes seen to the revolutions between recurrence, in small integral numbers. For example, when the rate of flashes is 1.25 times the revolutions, $L = 1.25$, $S/R = 5/4$ and five spokes will appear at a relative brightness of 0.25. Of interest is the symmetrical pattern which the figures form when laid out in this table.

Measuring Rotation Speed

This table can be used in determining the speed of revolution of a machine when it is not even known approximately. For example, when only one spoke is seen, the frequency per second at which the lamp

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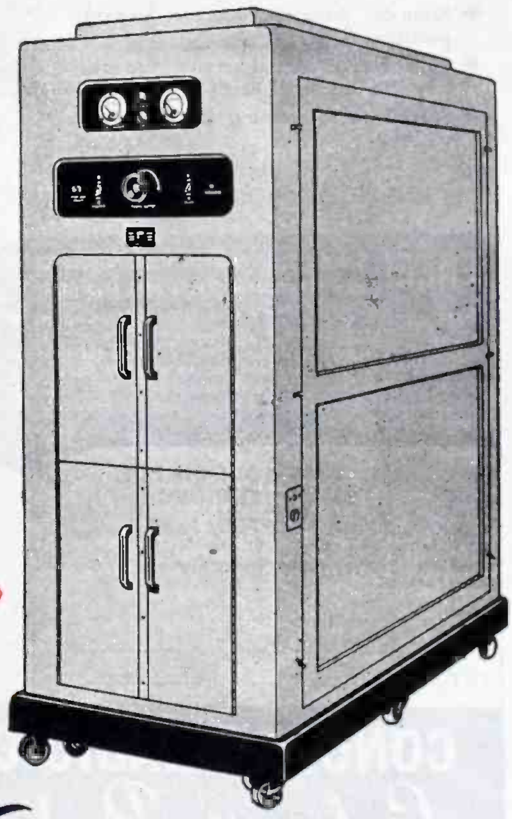

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is flashing may be equal to the revolutions per second or it may be only 0.5, 0.33, or 0.25 of this value (or even less, although such patterns will be quite dim). If the lamp frequency is equal to the revolutions, the pattern will be quite bright and an increase of flash frequency will cause dim patterns to appear consecutively in gradually increasing brightness of 7, 6, 5, 4, then a dim pattern of 7 followed by a bright pattern of 3 at a frequency ratio of 1.5 to 1. However, if the lamp frequency is half of the machine frequency, an increase of frequency will produce a dimmer pattern of 3 spokes then a brighter one of 2, followed by consecutively dimmer patterns of 3, 4, and 5 in the order given. Thus the sequence of patterns can be used to fix the ratio of flash frequency to revolutions of an observed machine for any ratio, by the use of this table.

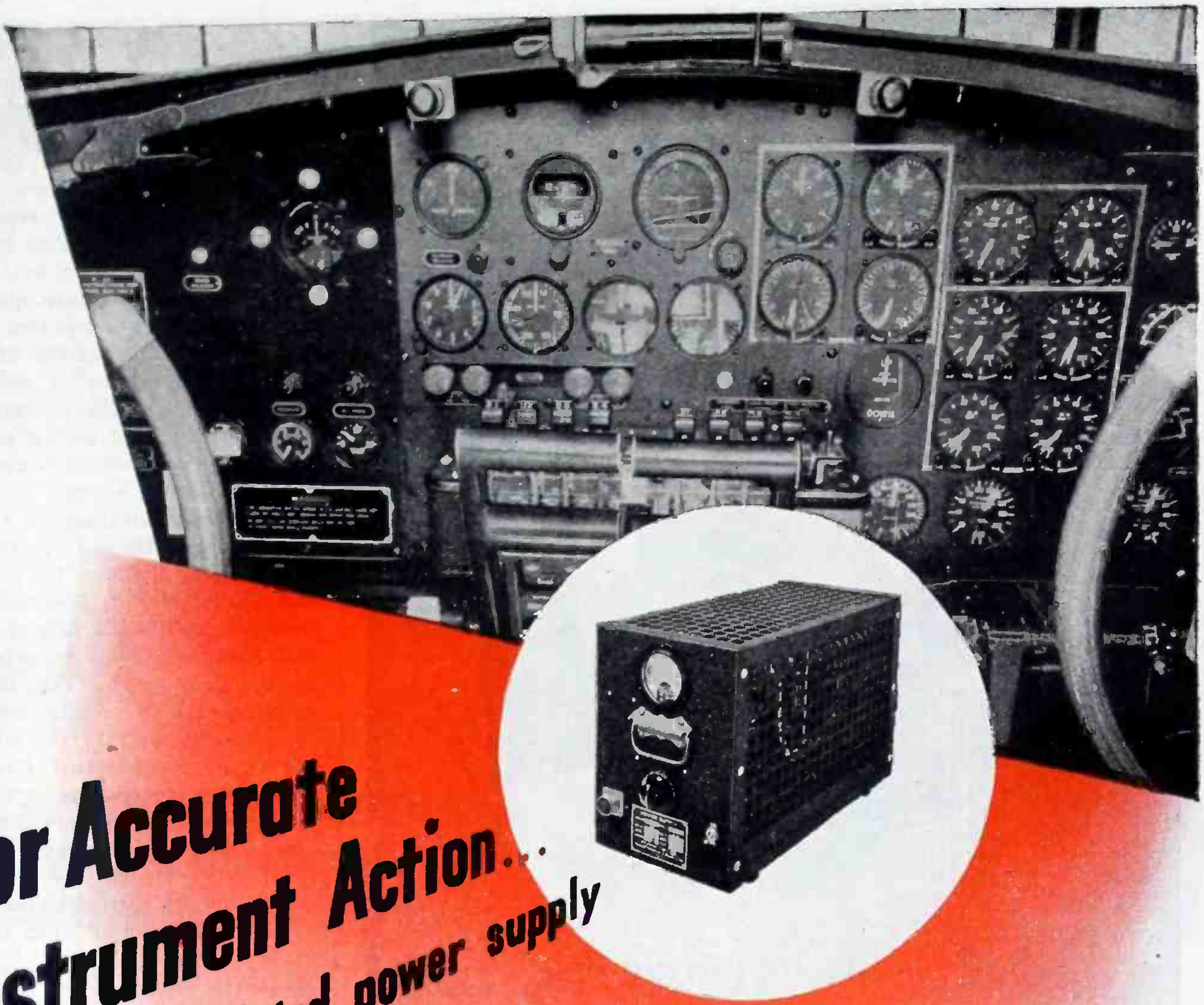
The same principle can be used in calibrating the frequency of lamp flashes against a disk driven at a known speed of revolution, as by a synchronous motor. For example, when, on the disk revolving at 60 rps, one bright spoke appears, the flashes are at a rate of 60 cps. As the flash frequency is reduced a dim pattern of 5 appears, at a frequency of 0.83 times 60, or 50 cps. It is followed by a brighter pattern of 4, indicating a frequency of 0.8 of 60 or 48 cps and so on.

• • •

Several Operations Controlled Over One Line

To CONTROL a number of operations in a variable sequence from a remote location, a number of control frequencies may be impressed on one pair of wires or radio carrier waves used as the control medium. This requires that selective control devices be used that possess fine sensitivity with critical response and high stability over a wide range of ambient temperature and pressure conditions.

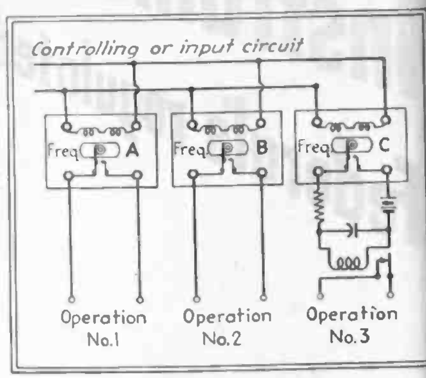
The torsional-type frequency-selective relay has been developed to fulfill this specific requirement. The required number of relays are connected in parallel across the controlling circuit. The contacts of the torsional relay are normally open and each relay is adjusted to a different resonant frequency. When



current pulses of constant amplitude and frequency are impressed upon the system, only that relay will respond which is adjusted to the corresponding frequency. In practice, the constant frequency at the control point is obtained from contactors which are operated by synchronously driven cams, any set of which may be placed into operation by means of a selector switch carrying the requisite number of positions. When employing radio remote control, a similar constant frequency generating device may be used either to interrupt or modulate the radio carrier wave.

As shown in the diagram, the two halves of the relay coil windings are wired in series across the controlling or input circuit. The oscillating member consists of a pair of astatically balanced magnets suspended on the main shaft. This shaft is counterweighted and oscillates against the spiral-type torsional spring at its adjusted frequency when current impulses at the corresponding frequency are impressed upon the relay winding.

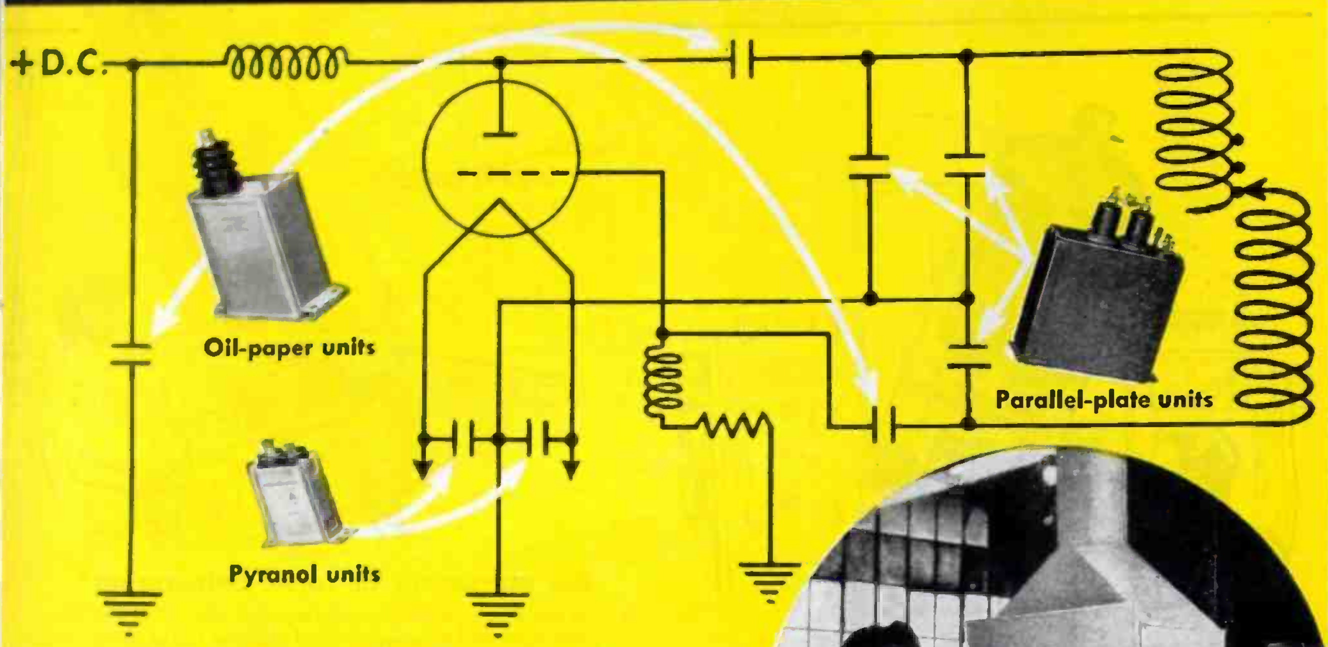
An eccentric on the oscillating shaft allows a pair of 50-ma capacity contacts to close when the am-



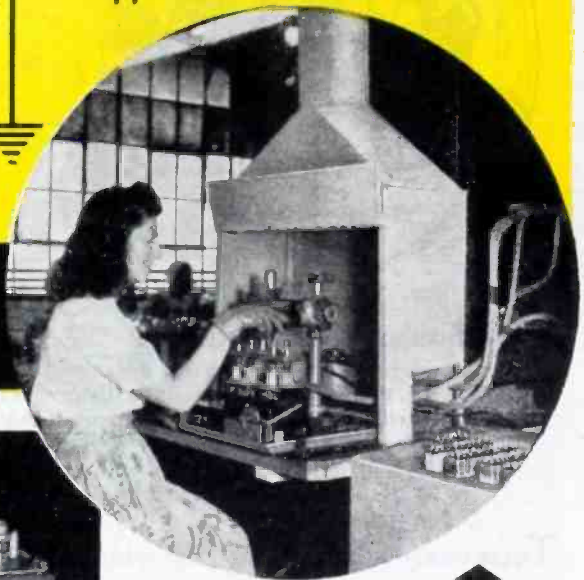
Circuit by which three a-c frequencies may be transmitted over a single pair of wires to perform three control operations. An auxiliary d-c relay is shown for constant contact in operation No. 3

plitude of the oscillation equals or exceeds 90 deg and is approximately equiangular 45 deg from the static position. As contact is periodic at the resonant frequency of the relay instead of continuous, it is necessary to use an auxiliary d-c relay of the slow-releasing (slug) type, or a d-c relay having a capacitor across its winding and a current limiting resistor in series with the torsional relay contacts to control

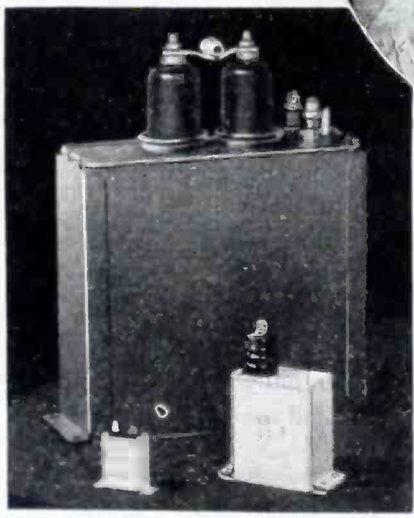
HOW G-E CAPACITORS are being used on new jobs



8 CAPACITORS NOW DO THE WORK OF 31 in this h-f oscillator circuit, and save space, weight, money



Electronic heater being used to solder on the covers of G-E capacitors. Four units are soldered simultaneously.



G-E capacitors designed for h-f oscillator circuits. Large unit: high-frequency, parallel-plate capacitor for the resonant circuit. The others: an oil-paper, high-frequency blocking capacitor, and (smallest) a Pyranol by-pass capacitor.

THE great number and wide diversity of capacitors required by today's electronic circuits make their selection an important factor in the design of the completed electronic device. Capacitors *designed for the job* can often appreciably reduce the over-all weight, size, and cost.

Take the simplified electronic-heater circuit shown above: The *original* circuit called for 31 capacitors. By selecting G-E high-frequency capacitors *designed for electronic-heater applications*, this number was reduced to eight.

Four mica capacitors were replaced with three G-E oil-paper blocking capacitors. This change alone saved more than $50.

In the resonant circuit, it originally took 25 mica units to do the job that three G-E high-frequency parallel-plate capacitors are now doing. These compact water-cooled units permitted an additional saving of more than $200, as well an appreciable reduction in the over-all dimensions of the electronic heater.

As a manufacturer of a wide variety of capacitors—including Pyranol*, oil-paper, high-frequency parallel-plate, and Lectrofilm units—G.E. is in a position to help you make savings like these in *your* electronic devices. Bulletins on our various lines are yours for the asking. See your nearest G-E representative, or write to General Electric Company, Schenectady 5, N. Y.

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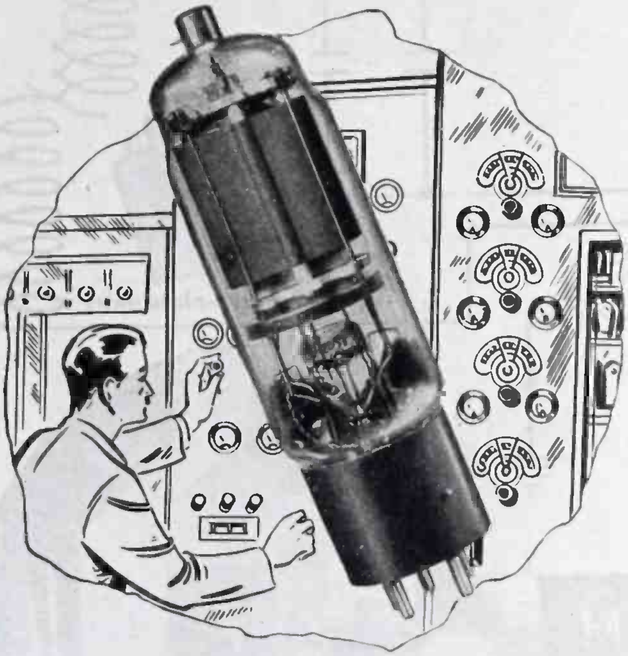
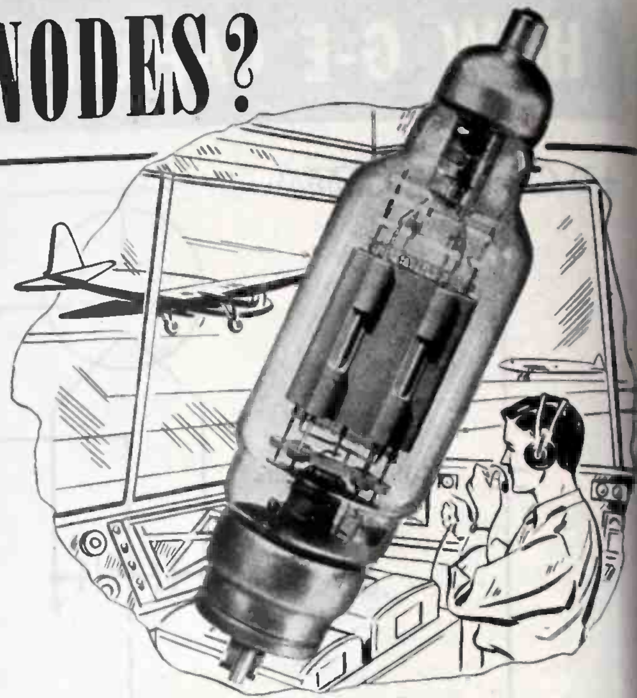
WHY GRAPHITE ANODES?



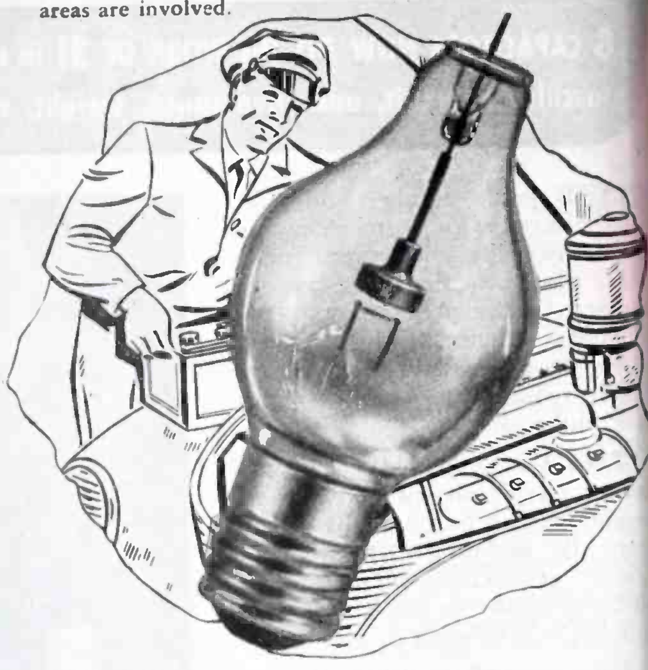
FOR DIMENSIONAL STABILITY

Three grids make it imperative that the anode in this air-cooled RF power amplifier and oscillator (WL-803) should not change shape, and hence the tube's characteristics, while operating. Graphite gives the anode this essential stability.



FOR PREVENTION OF LOCAL OVERHEATING

In the Pliotron modulator-amplifier (WL-849) for broadcast radio and aviation control stations, the graphite anode prevents local overheating and distortion where large areas are involved.



FOR DISSIPATION OF EXCESSIVE HEAT

This Rectigon 289416—workhorse rectifier tube for garage and home battery chargers for over 30 years—must get rid of a tremendous quantity of heat. Its graphite anode handles the heat with ease.

THESE PHYSICAL PROPERTIES of graphite—nearly perfect black body radiation, negligible coefficient of expansion, and excellent heat conductivity—dictate its use in the anodes of the three electronic tubes illustrated.

The tubes are but a few of the many in which "National" High Purity Graphite anodes and other tube components are specified. And the physical properties mentioned are but a few of those which make graphite a basic material for a wide variety of industrial and communications electronic tubes.

"National" electronic graphite of unmatched purity is available for your requirements. For information on electronic graphite and other "National" graphite products, write to our nearest Division Office.

Keep your eye on the infantry . . . the doughboy does it!

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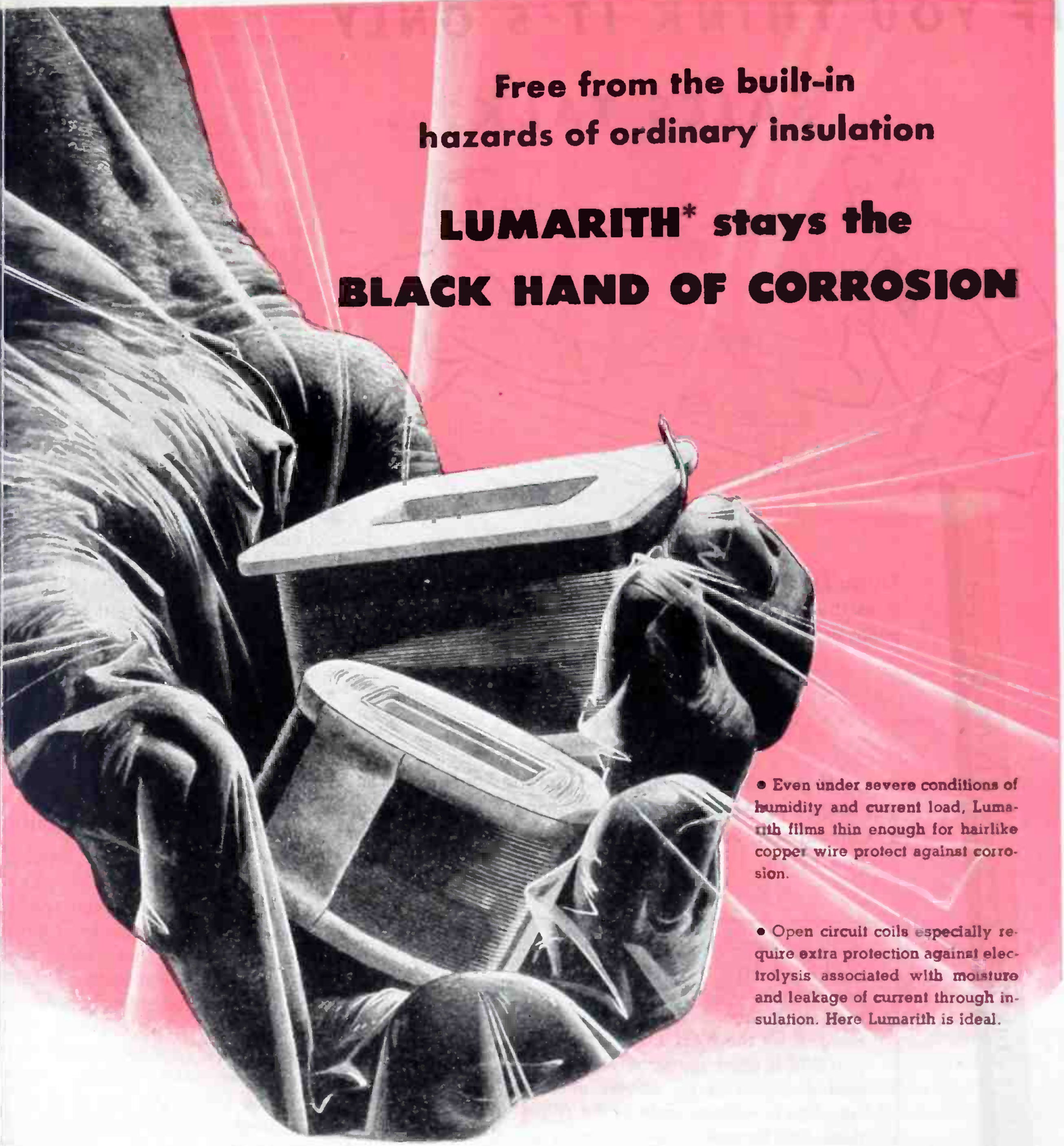

The best protection against electro-chemical corrosion is insulation that does not in itself promote decomposition when subjected to unfavorable conditions.

In electrical applications Lumarith is outstanding for chemical inertness. It does not combine with moisture to form free acids, nor is it subject to failure through oxidation. Even in direct current applications it protects against the usual sources of corrosion.

You can depend on Lumarith for high dielectric and tensile strength and freedom from cracking. It stands up under abrasion hazards while retaining necessary flexibility.

Supplied in films, sheets, rods, tubes and molding materials. Films available plain or in special mat finish for easier winding, reducing slippage and increasing visibility. "Lumarith for the Electrical Industry" is a reference booklet you'll want to keep handy. Send for it today. Celanese Celluloid Corporation, *a division of* Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

Celanese yarns and fabrics with the same basic electrical characteristics as Lumarith are especially manufactured for the electrical industry. For data, address Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

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the apparatus selected. Electronic means may also be employed.

A series of torsional relays is available from Wallace & Tiernan Products, Inc. of Belleville, N. J. that covers the frequency band of 10 to 20 cycles per second. The resonant frequency of each relay is adjustable within the limits of plus or minus one-half cycle per second. This adjustment is made by loosening two lock nuts and threading two counter-weights to a new position nearer or further away from the shaft on which they are mounted. Thus the natural period of oscillation of the relay is varied.

Sharp response of each relay is obtained at its resonant frequency plus or minus 2.5 percent when operating under a condition of constant amplitude and frequency of current pulses. The time of response for closure of the torsional relay contacts is within three seconds from the instant a 1.2-ma current at five volts is impressed upon the relay winding at its resonant frequency.

• • •

Inverted Triode for Industrial Measurements

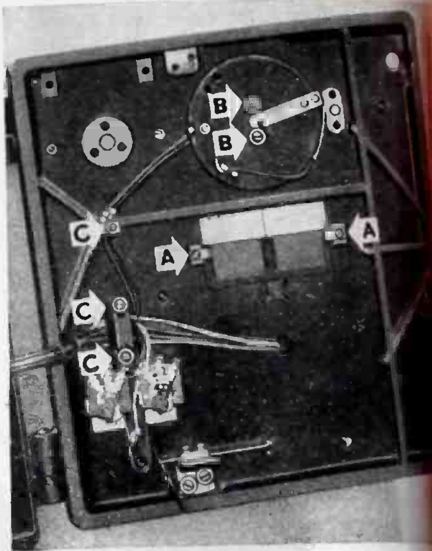
SEVERAL INDUSTRIAL OPERATIONS that were previously considered very difficult or impossible have been made practical by a new electronic tube that can measure hydrogen ion contents of chemicals (pH), minute currents produced by phototubes, ion current in mass spectrometer, alloying constituents of steel, and minute quantities which previously required an electrometer or its equivalent.

In this tube the outer electrode, which is normally the plate in an ordinary vacuum tube, is used as the control grid. This inversion minimizes the space charge effect, thereby making it possible to select a value of grid bias that will result in zero grid current.

With this tube, currents as low as 10^{-14} ampere can be measured and as low as 10^{-16} ampere can be indicated. Direct potentials can be measured to a sensitivity of 10^{-4} volt in circuits up to 10^{12} ohms in resistance.

The sensitivity of this tube is made possible by an extremely low grid current and a high grid-to-

CLEAR OUT THE "*Fastening Bugs*" BEFORE YOU SET UP FOR PEACETIME PRODUCTS



Will "Blind Fastenings" boost your parts breakage?

Heres' how Tagliabue licked this "bug" and speeded production

Difficulty in judging hole depth, when tapping blind holes for small machine screws, resulted in tap breaking through, ruining plasti parts at Tagliabue Mfg. Co., Brook-lyn, N. Y., makers of TAG pressu and temperature instruments.

Changeover to P-K Self-tappi Screws ended this trouble, stopp breakage, saved tapping time a tap expense.

P-K Type "Z" Screws are u (A) to attach steel clips fasteni window to plastic door; (B) to fa ten plastic rheostat disc to doo (C) to attach steel clamps holdi wire to door. The screws form the own strong threads as they a turned into plain holes. One ea operation makes a fastening.

Specify the SHORT CUT FASTENING METHOD and avoid later changes, expense, delays

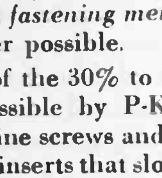
Don't wait until you resume manufacture of your peacetime product to find out that needless tapping, needless inserts in plastics, or other fastening "bugs" are slowing down assemblies and running up your costs.

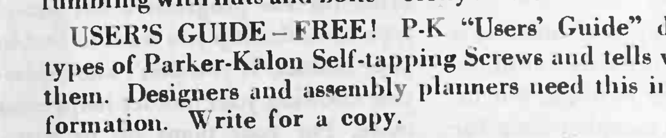
Check up *now*, while your plans are still in process. Choose fastenings as carefully as you settle any other factor of design. Make sure you are using the *short cut fastening method* – Parker-Kalon Self-tapping Screws – wherever possible.

Give your product the advantage of the 30% to 50% saving in assembly time and labor made possible by P-K Self-tapping Screws. Eliminate tapping for machine screws and tap expense – fumbling with nuts and bolts – costly inserts that slow up molding.

USER'S GUIDE – FREE! P-K "Users' Guide" describes all types of Parker-Kalon Self-tapping Screws and tells where to use them. Designers and assembly planners need this important information. Write for a copy.

ASK THIS EXPERT ON FASTENINGS how to simplify and strengthen assemblies, how to save time and lower costs. The P-K Assembly Engineer gives you unbiased advice, because P-K makes all types of Self-tapping Screws. Ask him to call . . . or, mail assembly details for recommendations. Parker-Kalon Corp., 208 Varick Street, New York 14, N. Y.





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cathode resistance. Due to the small magnitude of the current expected in the usual applications, it is absolutely necessary that none of the minute quantities of current be absorbed in surface leakage. Therefore, every precaution has been taken to design the tube so that unusually high resistance exists between each electrode.

Pant-Leg Leakage

The use of "glass pant-leg" supports has provided a maximum surface leakage path between electrodes. The pant-leg consists of a glass sleeve surrounding a wire which acts as support for mounting. This method of construction provides the insulation necessary between electrodes so that practically no energy is absorbed from the source being measured.

The tube is termed an inverted triode by Westinghouse engineers because the outer electrode, which is normally the plate in an ordinary vacuum tube, is used as the control electrode or grid in this tube. This places the control electrode at a maximum distance from the space charge region surrounding the filament, thus minimizing the amount of electrons collected by the control electrode. In this manner, the current to the control electrode is held at a minimum.

The mesh mounted between the filament and the control electrode is used as the anode. This construction provides more radiating surface to the grid, decreasing its temperature and possible thermionic emission. The control element or grid, being farthest from the filament, receives less heat and light from the filament, thus decreasing emission from the grid.

Operation

The filament is operated at a low temperature to minimize the emission of photoelectrons and primary electrons from the grid. All of the electrodes are operated at rather low voltages to reduce the possibility of ionizing residual gas in the tube, which would cause positive ion current in the grid circuit.

In taking measurements of extremely minute currents, the electrostatic charges which build up on the inside surface of the glass bulb produce a sufficiently high electric field to seriously affect the overall sensitivity of the tube. This elec-

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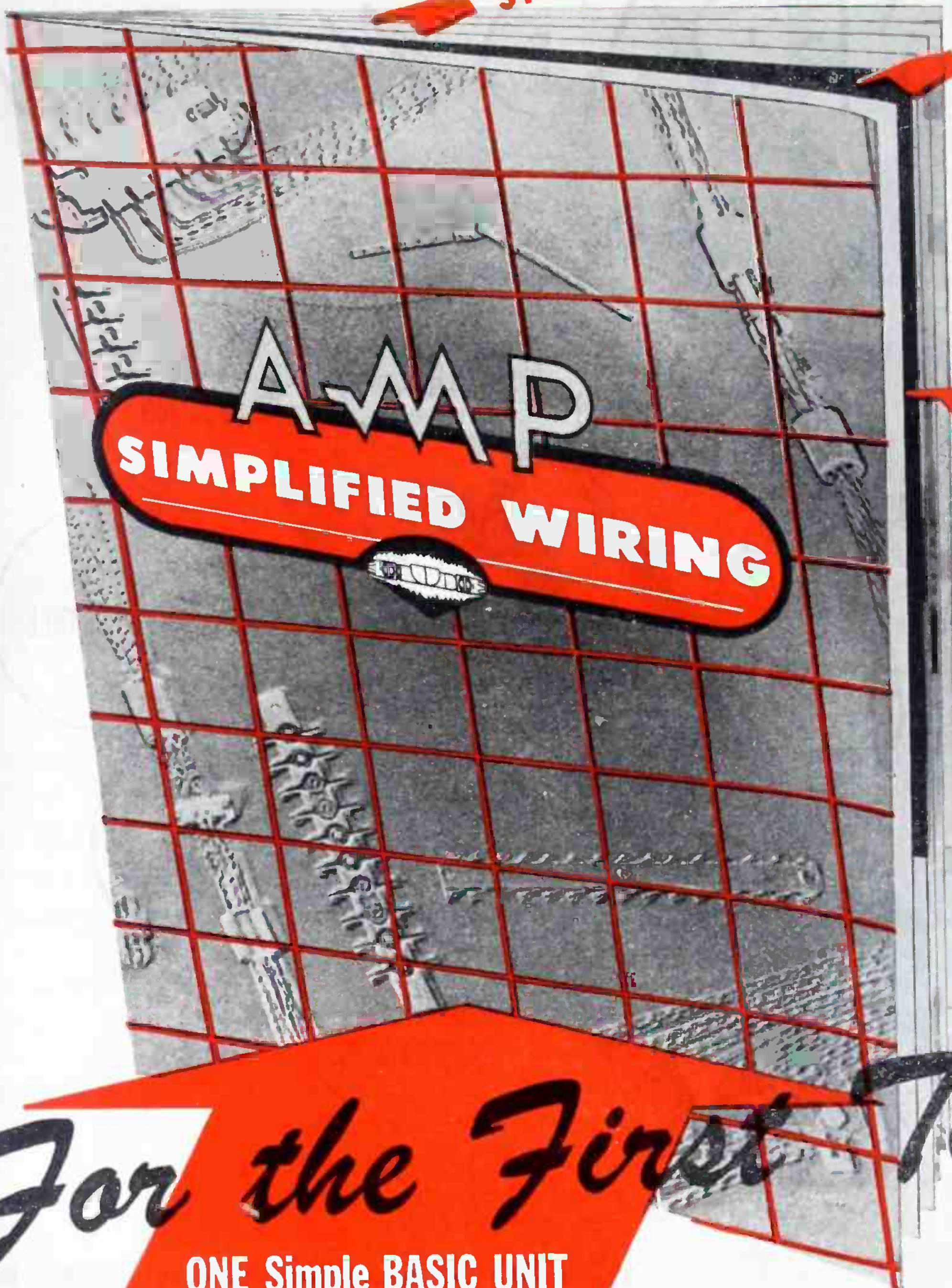

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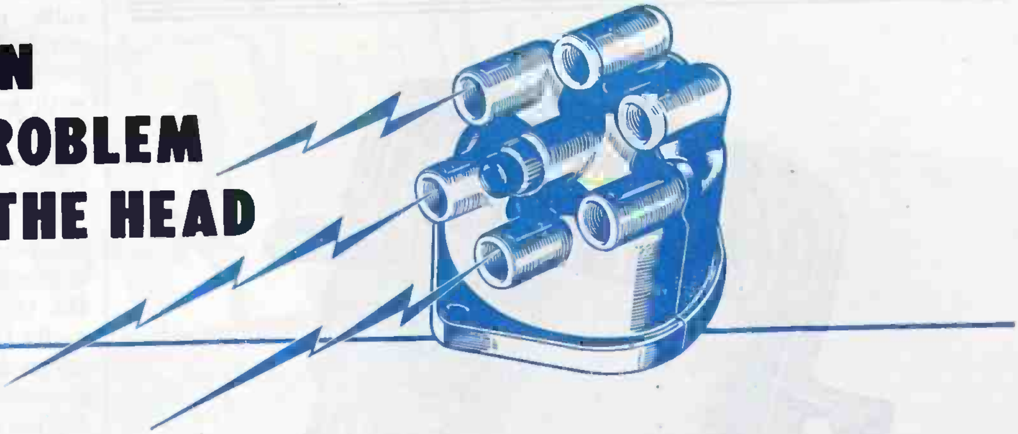
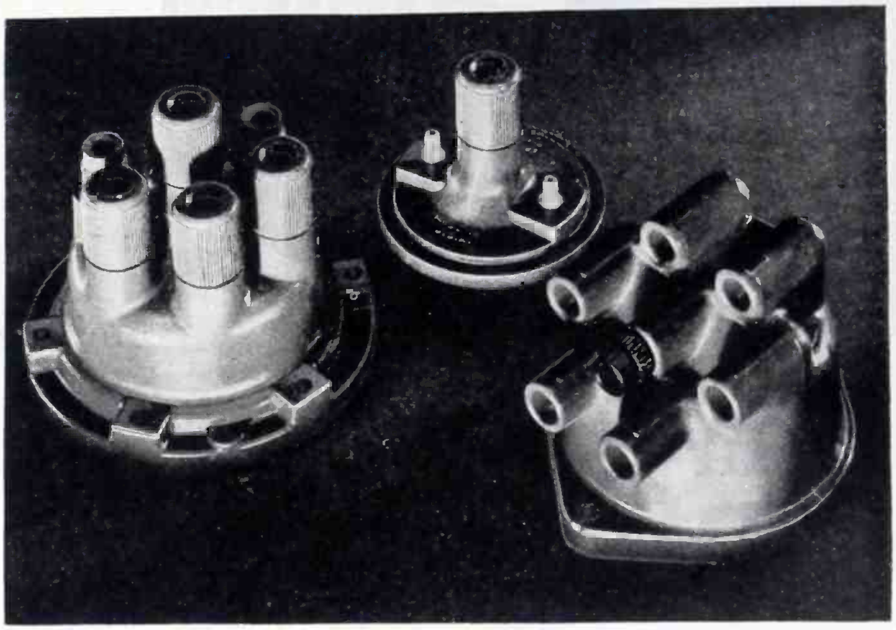
HITTING AN IGNITION PROBLEM ...ON THE HEAD





major problem confronting today's designer of electrical products is the proper selection of material for use where temperature variations occur frequently as in automotive ignition and radio parts. The unusually rigid requirements for dielectric strength and heat resistance in these items call for a plastic compound of extraordinary stability.

For the ignition parts illustrated at right, Durez technicians developed a phenolic plastic molding compound which not only more than meets the requirements for dielectric strength and heat resistance, but also has a low power factor, good moisture resistance and low shrinkage which reduces stress around inserts and renders the finished part less susceptible to cracking. *This particular compound is mineral-filled and possesses far better arcresisting qualities than the usual wood-flour-filled material*

The versatility of the more than 300 Durez phenolic molding compounds has made their use practically universal throughout industry. Such properties as highest dimensional stability under all types of climatic conditions, chemical resistance, impact strength, heat resistance, dielectric strength and moisture resistance... render them invaluable to the product designer.

Add to the product versatility of Durez compounds the many new molding methods and processes developed by your custom molder, and you can readily appreciate the scope which is offered to imaginative minds with post-victory markets in view

Many years' experience in successful product development has filled the Durez files with a wealth of valuable data. These data, plus the full co-operation of experienced Durez technicians, are available at all times towards the successful solution of any materials problem which you may have.

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PHENOLIC MOLDING COMPOUNDS AND RESINS

PLASTICS THAT FIT THE JOB

tric field also makes consistent results practically impossible. To eliminate this condition, a small piece of spring wire is mounted with a slight pressure against the inner wall of the glass bulb. The connection is then brought out to a base pin and connected to an electrical ground with respect to the other electrodes. If not thus neutralized, electric fields created by the charge on the glass bulb can easily be of sufficient magnitude to exert a greater control over the electron flow than is obtained from the control electrode.

Circuit

As low voltages are used on the electrodes, the anode current is low in comparison with ordinary triodes. Therefore, a microammeter or galvanometer must be used in the plate circuit to measure the small currents. The output may also be fed into a suitable voltage amplifier, in which case the RH-507 tube will serve as a coupling device between the source under measure-

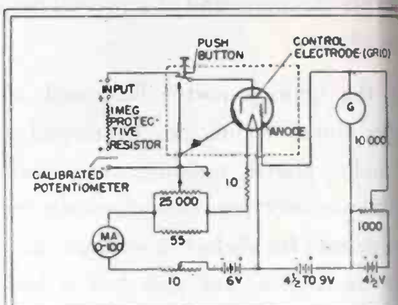

FIG. 1—Circuit of an electrometer using the inverted triode for high sensitivity

ment and the amplifier proper. Should the tube be used in this manner it is possible to use more rugged and cheaper instruments to obtain measurements previously requiring laboratory precision equipment. A typical electrometer circuit using a microammeter or galvanometer is shown in Fig. 1.

The tube and all leads from the voltage supply should be shielded very carefully from any stray magnetic or electrostatic fields. It is also necessary to shield the tube from light as there may be some photoelectric effects while sensitive readings are being taken. It is advisable to mount the tube in a reasonably tight shield can containing a drying agent such as calcium chloride or phosphorous pent-oxide to protect it from moisture in the

INSULATION

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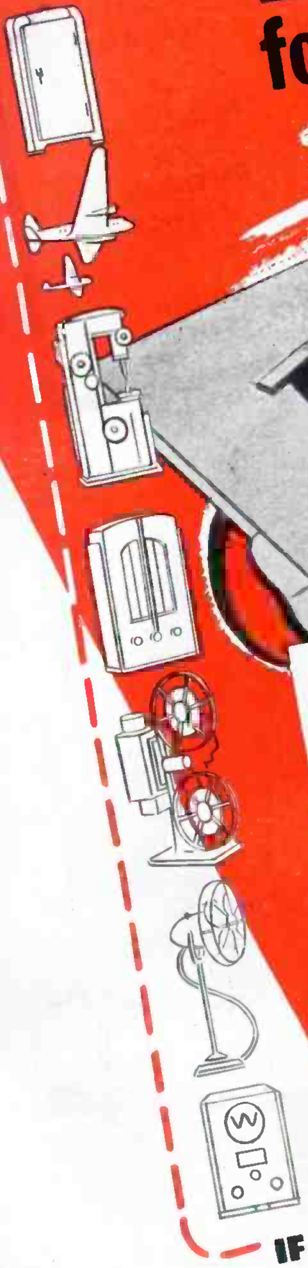

Analysts now investigating Mr. and Mrs. America's post-war pocketbook, little doubt its bulk. The size of the "spending spree" appears to be a moot question. Manufacturers, engineers and designers —at present "blueprinting" an electrical future, can write one form of product insurance by incorporating quality electrical insulation—TURBO.

Extensively specified by Army, Navy and Air Forces for unusually severe applications, TURBO can amply meet the requirements of post-war industrial and civilian manufacture. One of the various TURBO products—Flexible Varnished Tubing, Saturated Sleeving, Extruded Tubing, Varnished Glass Tubing, Wire Identification Markers, Cambrics, Composites, Mica-plate, etc. — will solve specific problems pertaining to temperature, operational or climatic hazards.

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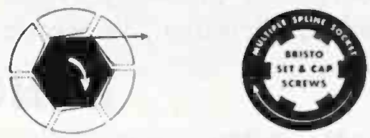
Bristol Multiple-Spline Socket Set Screws set tighter . . . even in hard-to-reach places . . . without rounding out or breaking.

Where a small screw is called for . . . where vibration will be a problem . . . where the fastening point is at an awkward place — think immediately of the *screw that's built like a gear.*

The Bristo Multiple-Spline Socket Set Screw is specified for aircraft parts, photographic equipment, electrical assemblies, because the multiple-spline design (the teeth in socket are geared to the key) provides much greater strength, permitting more tightening force even on screws as small as No. 4 wire size! The diagram shows why.



Hex: Key exerts *outward* pressure against socket wall; screw will round out or break.

Bristo: Key exerts *inward* pressure; no danger of rounding out or breaking socket wall.

So Bristo Multiple-Spline Screws can be set tight to hold against vibration, yet they can be loosened with a flick of the key! See THOMAS' REGISTER for more facts, list of product applications.

Here's What You Get from the Screw that is Geared to the Key

1. Easier transmission of rotary wrenching power; hence faster assembly.
2. Tight "meshing" with the spline-shaped key; hence no key slippage.
3. No rounding out or breaking socket wall; turning key does not spread the screw.
4. Quick removal — the gear principle acting to release the screw's strong hold.

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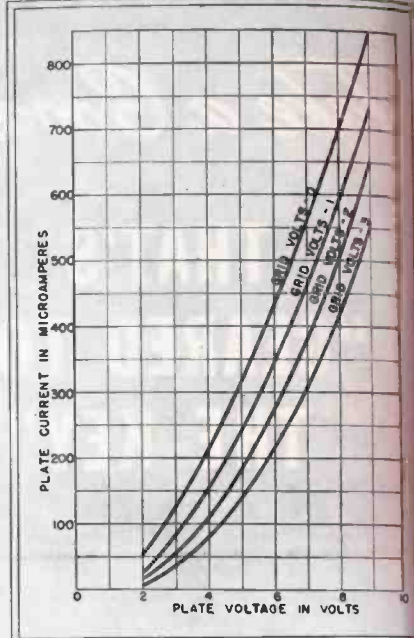

FIG. 2—Average characteristic plate current curves for the inverted triode

air condensing on the bulb surface.

Even a microscopic film of moisture, if allowed to form on the bulb surface, provides a leakage path between the control electrode and the cathode. If a leakage of current occurs through this moisture film, the change in resistance in the control circuit causes the control electrode voltage to vary widely, thus destroying the accuracy of measurements. The minute currents being measured are usually less than the leakage currents.

As added insurance against surface leakage, the outside surface of the bulb is sometimes treated with a solution such as Silicone resin or some other suitable material. This coating then helps to break up the possible formation of moisture into tiny droplets which do not contact each other. Thus a continuous leakage path through the moisture is not possible.

The filament current is very critical and must be held constant. If there is any drift due to battery or other changes the plate current will naturally shift, which will affect the constancy of the readings. It is therefore advisable to use only a battery which has been seasoned or has been stabilized so that its voltage has become practically constant.

Average Curves

The characteristic curves shown are taken from readings of several tubes. The plate current curves

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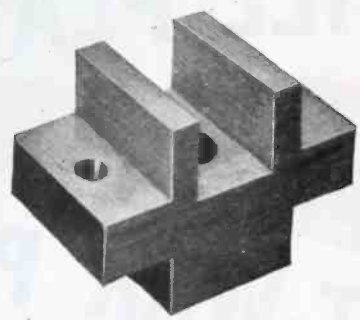

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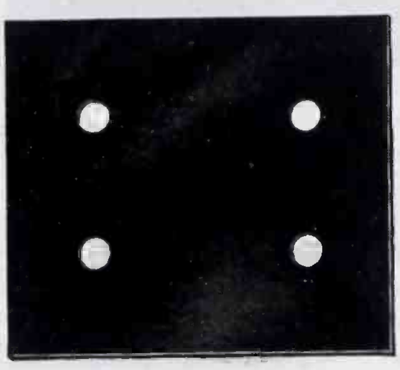

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Tensile Strength	8500 PSI	Dielectric Constant at 1000 KC	5.5
Compressive "	37000 PSI	Power Factor	0.045
Flexural "	19000 PSI	Dielectric Strength 1/8" thick	250 vpm

(Above Figures are NEMA average)

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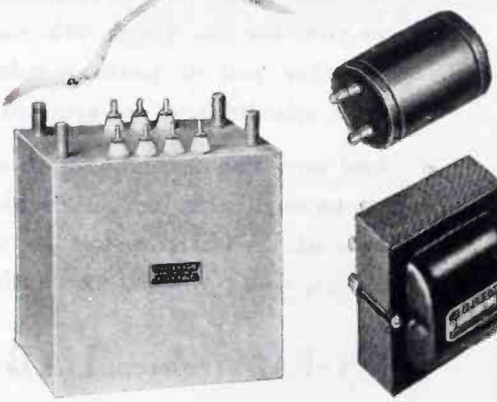

JEFFERSON ELECTRIC

TRANSFORMERS

shown in Fig. 2 represent average values, although individual tubes should not vary greatly from the average.

The grid current curves also represent average values taken on several tubes but the readings on individual tubes may vary considerably from the figures shown. The curve in Fig. 3, with 4.5 volts on the anode shows that the grid current passes through zero at minus 1.8 volts. The important feature to notice is that the grid current of every tube crosses zero at some bias voltage near this value. It is therefore possible to select a value of grid bias such that the grid current is

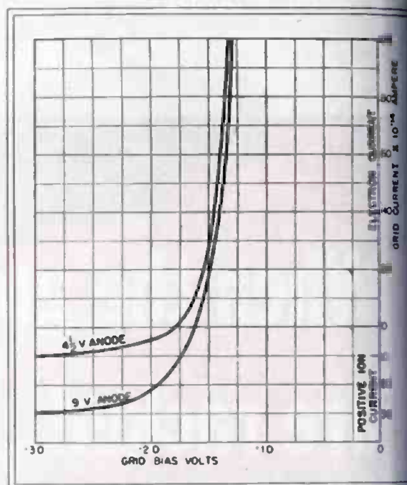

FIG. 3—Average characteristic grid current curves for the new tube show the possibility of selecting a value of grid bias that permits zero grid current

zero; hence, extremely minute currents can be measured accurately. By adjusting the grid bias so that the grid current is zero it has been found practical to measure grid currents as low as 10^{-14} ampere to obtain indications of grid currents as low as 10^{-18} ampere. By providing a bias adjustment on either side of the floating potential, reversal of control current is effected to advantage in electrochemical polarization studies.

Every precaution should be taken to insure that no electrical leakage is present in the circuit wiring. Wherever possible, all leads from the electrodes should be air insulated. Where construction requires feed-through insulators, quartz glass or other material which offers extremely high resistance to surface leakage should be used.

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TUBES AT WORK

New Oscillator Tube For 1200 Megacycles

AN ACORN TRIODE of the heater type has been announced by RCA and labeled type 6F4. Intended primarily as an oscillator, it operates at frequencies up to about 1200 Mc due to a closely spaced electrode structure and the use of a radial 7-pin base having two connections each for grid and plate. The close spacing provides high perveance and the double leads permit lower lead inductance than single leads.

A power output of 1.8 watt is available from a single tube at moderate frequencies with 150 volts on the plate. An output of about 45 milliwatts may be had at 1200 Mc with 100 plate volts.

Tubes Measure Cloud Ceilings for Pilots

CONSISTENTLY ACCURATE readings of cloud ceilings in daylight are provided by a pulsating light system using a phototube detector. Developed by Laurence W. Foskett, U. S. Weather Bureau, in conjunction with General Electric lighting engineers, the system measures the height of clouds two miles up in daylight for the first time in aviation history.

The complete equipment consists of a mercury-arc projector, a pickup unit known as a ceilometer, and a recorder which provides a continuous record of ceiling height and relative cloud density. A tiny super-high-intensity quartz mercury lamp is mounted at the focus point of a searchlight mirror to throw a 120-cps pulsating beam vertically into the sky.

Although not visible to the human eye in daylight, the beam is scanned readily by the ceilometer. This unit consists of a phototube pickup and amplifier feeding to an output meter. It is located 1000 feet from the projector and is tuned to the same frequency as the light pulse in order to distinguish the mercury light signal from background light. Scatter energy, produced on cloud layers dense enough to scatter the beam, is detected as the ceilometer scans the beam. A selsyn drive, between the ceilometer and the recorder, translates the position of the ceilometer into cloud heights on the recorder.

Since the tiny quartz lamp operates at an extremely high temperature, G-E engineers developed a high-pressure jet method of air blast cooling good for any temperature conditions normally encountered. The air cooling mechanism consists of a motor-driven compressor enclosed in a weather-proof housing.

Electronic equipment of the Novalux ceilometer. The scanning drum may be operated by a hand crank at the side

Television Station Design

A WORKING MODEL OF a new television station designed to provide flexible broadcasting studios was exhibited by The Austin Company, engineers and builders, at the NAB annual convention. The station includes one large studio with 44-foot movable stages, and two smaller studios which are served by a common set of controls on a pivoting control platform. Offices, dressing rooms, work shops and storage facilities are located on the ground floor surrounding the studios, while the second story is devoted to control rooms, broadcasting equipment and observation areas.

The large studio stage moves to right or left on a track for speedy change of scenes. Its control and observation facilities have been arranged in a manner similar to that in the Austin-designed master television studio, where a turntable stage and independent seating areas on either side of a central control room make possible rapid changes of both scenes and audiences. Sponsors and the public are accommodated in lounges on either side of the control room.

To avoid unnecessary duplication of costly broadcasting equipment the control rooms serving the large studio and the two small studios are located back to back, in a manner which permits centralized installation of cables and wiring. The first floor area below the observation rooms has been laid out to facilitate transfer of cameras and microphones from one studio to another so that a minimum of standby equipment will be required.

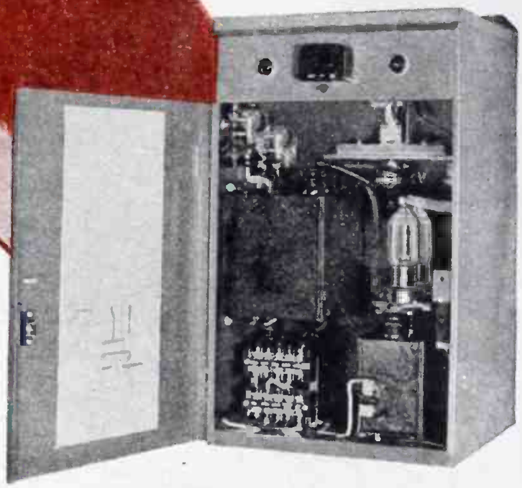
Austin engineers also exhibited their design for a two-studio f-m station developed in co-operation with the electronics department of General Electric. This station provides complete facilities for local f-m broadcasting, as well as for network relays. These are laid out on either side of one main control room having glazed areas affording a clear view of both studios. Acti

wherever a tube is used...

for example:

ELECTRONIC AIR CLEANING

Smoke, dust, and soot particles 100 times smaller than the eye can see are drawn out of the air electronically by an ingenious arrangement of positively and negatively charged plates. This device facilitates precision manufacturing of delicate instruments, guarantees purity and sanitation in food processing, promotes health and cleanliness in restaurants and hospitals.



POWER PACK

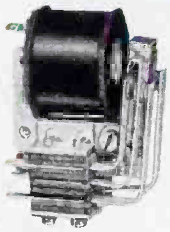
THERE'S A JOB FOR *Relays* BY GUARDIAN

Electronic air cleaners ionize dust particles and collect these particles on a series of positive and negative plates called "Collector Cells" which are arranged in a venetian blind fashion. Rectifier tubes in a power pack change the a-c secondary voltage into pulsating d-c voltage. This d-c voltage is smoothed out by a capacitor and charges the Ionizer and Collector cells.

Relays are built into the power pack to protect it against short circuits or other irregularities in circuit operation. Typical of such relays is the Guardian Series 40 a-c relay which has a laminated armature and field piece.

The Series 40 is well fitted for use in power packs such as illustrated, because it is designed to handle a maximum of control in minimum space. It has a switch capacity of double pole, double throw with 12½ ampere contacts (rated at 110 volts, 60 cycles, non-inductive load). Coils are available for standard voltages up to 220 volts, 60 cycles. Normal power requirements are 9 V. A.

For details on this and other Relays by Guardian write for General Relay Bulletin.



Series 40 A. C. Relay

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.

GUARDIAN ELECTRIC

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A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

Differences of Opinion

. . . provide the many functional advantages of E-E Electronic Tubes.

Quite another thing is to endeavor consistently to make a good product better. E-E engineers and research technicians—since the inception of the organization—have adopted a policy of round table discussions. Executive and employee alike have their say at these open forums.

Subject: You and your product or equipment, as it pertains to the versatility and performance of E-E vacuum tubes. Thus, by a thorough knowledge and understanding of the problems of particular applications, complete solutions are made available without a trial and error interval.

Every tube—Rectifier or Amplifier—is a studied outgrowth of these conferences and incorporates advantage-characteristics for every application.

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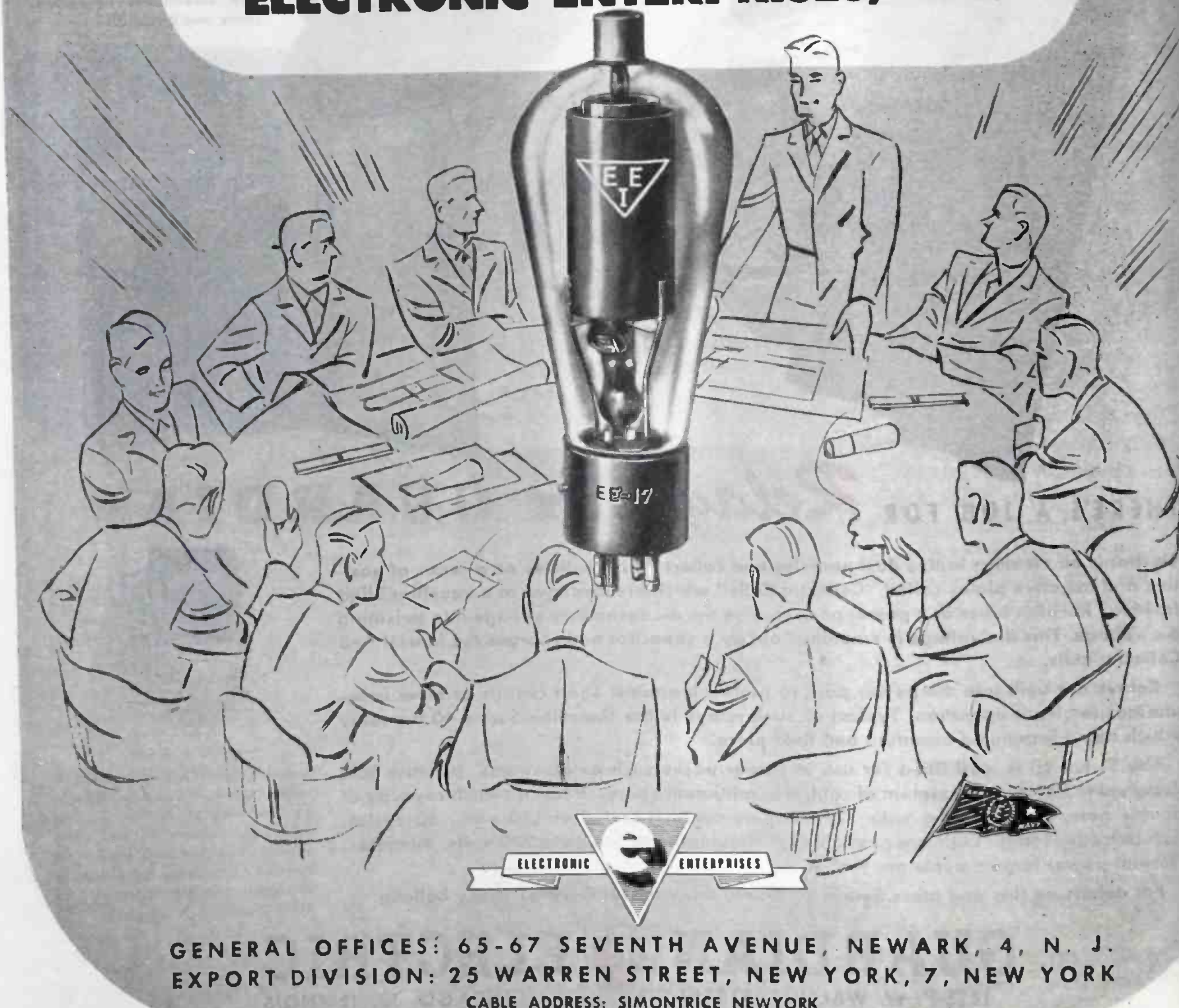

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EXPORT DIVISION: 25 WARREN STREET, NEW YORK, 7, NEW YORK
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According to the book-
Specifications
Jacks to meet the exacting specifications of battle communications in the air, on the surface and under the sea . . . Jacks are but one of the many precision made electronic essentials that National Fabricated Products will supply for your post war requirements.
NATIONAL
FABRICATED PRODUCTS
2650 WEST BELDEN AVENUE, CHICAGO 47, ILL.
Manufacturers of SOCKETS, TERMINAL ASSEMBLIES, JACKS AND CONNECTORS for use in every field of electronics.

ities in the two studios can be watched from a public observation corridor, which also commands a view of the control room through the glazed walls of a sound chamber connecting the two studios and the control room.

• • •

2,000,000-Volt X-Ray Tube

IF ALL THE RADIOGRAPHIC equipment previously in existence, plus all the radium mined to date, could be concentrated on the taking of a single radiograph through 12 in. of steel, it would require a longer exposure time for the job than would a two-million-volt x-ray tube recently introduced by Machlett Laboratories of Springdale, Conn. Besides high voltage, the new tube involves precision focusing of the electron beam to produce practically a point source of x-rays.

Doubling of previous top operating voltage for x-ray tubes is significant in industrial x-raying of heavy steel objects. The increase from one to two million volts reduces the exposure time in a particular instance from one week to less than an hour. With the new tube, it is possible to detect the

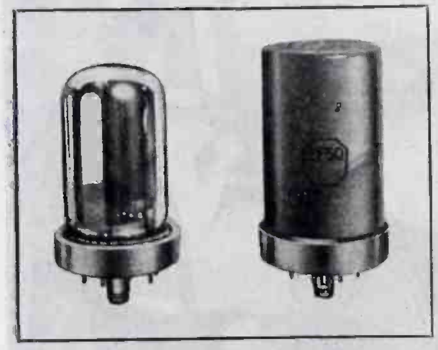
Operating with an applied potential of 2,000,000 volts, this new x-ray tube has reduced the exposure time in one particular application from a week with a million volts to less than an hour with two million. Raymond Machlett, president of Machlett Laboratories, holds the tube

SYLVANIA NEWS

ELECTRONIC EQUIPMENT EDITION

DECEMBER *Published in the Interests of Better Sight and Sound* 1944

Type EF-50 Pentode Found Useful at High Frequencies



Sylvania's Type EF-50 Amplifier Pentode, originally produced primarily for military purposes, has a number of unusual features that suggest many applications in postwar design.

The outstanding characteristic of the EF-50 is that it is designed to operate at 250 volts on both screen and plate, permitting operation at higher frequencies because of the resulting reduction in input loading.

Tube is provided with its own external shield, grounded through center lug, as well as internal shielding brought out on two terminals. Since suppressor and cathode are brought out separately, 9 pins are needed.

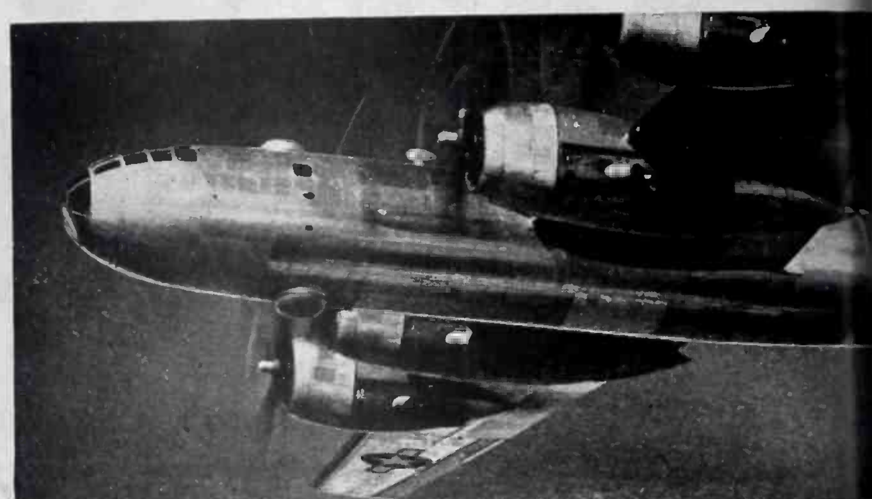
Full technical data on the EF-50 can be obtained from Sylvania.

"Next time you go bailing out, for heaven's sake grab a set with Sylvania Tubes!"

Sylvania Equipment Helps B-29s Report "Mission Accomplished"

Company's Tubes, Electronic Devices Extensively Used on Superfortresses

Radio communications equipment and electronic navigational aids have bee developed to a new pitch of perfection aboard the giant Boeing Superfortresse which have so convincingly demonstrated their ability to strike hard and effectively, deep within the enemy's territory, after flying from far-distant



Exterior view shows the B-29 bristling with 50-calibre machine guns and 20 mm. cannon. The Superfortress is powered by four 2200-hp. engines, rolls on double-wheeled landing gear, carries electronic equipment such as is manufactured by Sylvania and others. (Boeing Photo)

bases. The long operating range of th Superfortresses necessitates a complex ele tronic nerve system to assure close cont in flight, accuracy in reaching target, an safe return to base. Radio and electron equipment — estimated to total approx mately one ton for each Superfortress — includes the most modern navigation devices, in addition, of course, to th transmitters, receivers and other apparat necessary for communication between cre members, between aircraft in flight, an between planes and their distant bases.

Sylvania has made important contribu tions to the electronic equipment that help make possible—and ultimately transmits— the terse, stirring message, "Mission Accom plished." Not only are many Sylvania tube utilized in the various radio sets and contro devices carried by the Superfortresses, bu Sylvania is among the manufacturers sup plying electronic equipment for the B-29s.

DID YOU KNOW...

That many industries use Sylvania Pirani tubes to measure pressures ranging from 1/10 to 1/10,000 mm?

★ ★ ★

That newly defined life ratings for Sylvania Fluorescent lamps show that, in many applications, life expectancy is greater than previously indicated, when lamps are burned on long time-on cycles.?

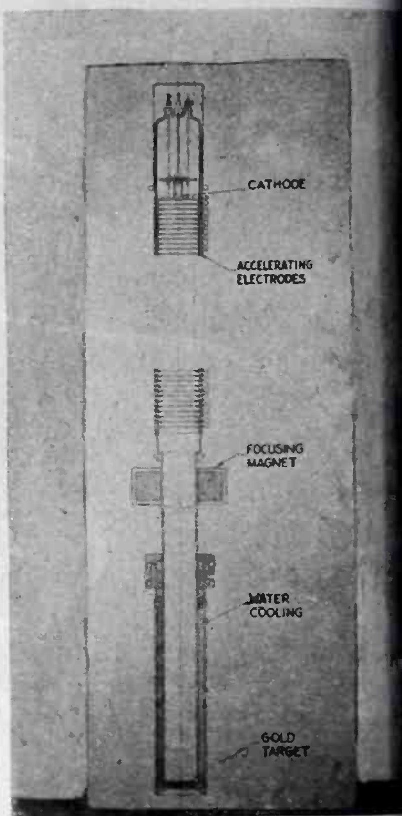
SYLVANIA ELECTRIC PRODUCTS INC.
Radio Division · Emporium, Pa.

MAKERS OF FLUORESCENT LAMPS, FIXTURES, ACCESSORIES, INCANDESCENT LAMPS, RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES


CREATIVE ELECTRICAL ENGINEERING
Industry is entering an era of electronics, marked by the keenest competition in business history. The rich rewards will surely go to those who employ *Creative Electrical Engineering* to best advantage.
In this highly technical field, LELAND Electric has solved many difficult electrical problems with skill and ingenuity. This valuable experience may be the key to your post-war plan. We invite your inquiry.
THE Leland ELECTRIC COMPANY
Dayton 1, Ohio. In Canada: Leland Electric Canada Ltd., Guelph, Ontario
MOTOR GENERATOR SET, NAVY TYPE 3 UNIT—A.C. or D.C. drive, and up to 2½ KW, A.C. or D.C. output —special frequencies, governor speed controlled.

presence of a piece of 0.014-in. foil laid on the surface of a piece of 16-in. thick steel.

Voltage for the tube is supplied from a Van de Graaff type electrostatic generator developed by MIT and Westinghouse and utilizing air under pressures between 200 and 400 psi. The tube must withstand the same pressures. Since rate of leakage goes up exponentially with pressure, this requires a particularly effective method of producing glass-to-metal seals, a fact complicated by the great length of interface-sealing involved in the design. Each tube



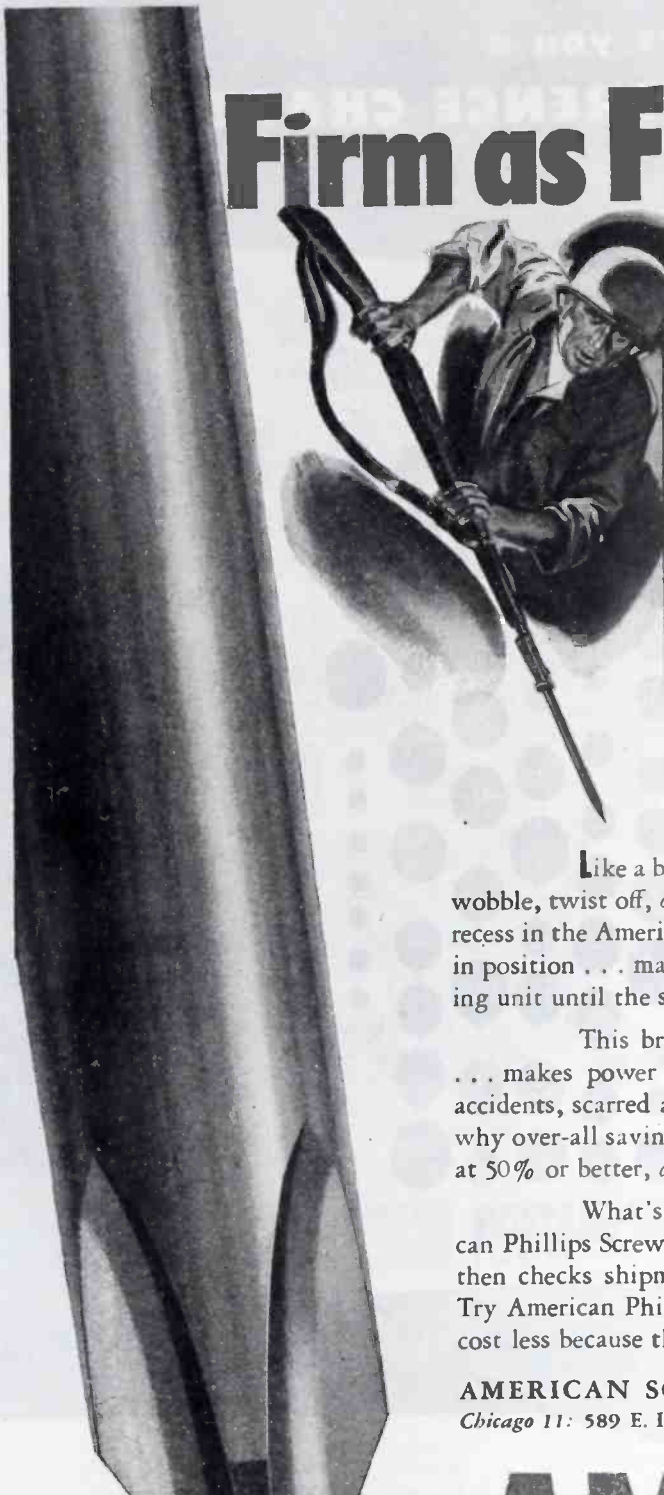
The new x-ray tube contains a column formed by a series of annular rings of glass and metal. To maintain a uniform field with minimum dispersion of the electron beam, 12.000 volts potential is applied between the metal rings of each section. A total of 182 sections are used

has about 300 ft of seal, or a thousand times that of the largest standard tube. Since rejections because of leaky seals customarily run above one per hundred tubes, a new technique was devised.

H-F Heating of Glass

The method developed consists of rotating a mandril with a slotted chuck to establish the precise spacing required of the Kovar rings. As the assembly revolves, a se-

Firm as Fixed Bayonets



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drive Faster . . . Straighter . . .

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Like a bayonet fixed on a gun, an American Phillips Screw can't wobble, twist off, *or drive any way but straight*. For the engineered, tapered recess in the American Phillips screw-head *fixes* the 4-winged driver firmly in position . . . makes screw and driver an inseparable, straight-line driving unit until the screw is set up flush and tight.

This brings new ease and speed to production screw-driving . . . makes power drivers practical for any type of work . . . prevents accidents, scarred and rejected work, loss from split screw-heads. That's why over-all savings, in plant after plant, score American Phillips Screws at 50% or better, *over any other type of screw fastening*.

What's more, American Screw Company inspects *every* American Phillips Screw . . . for physical fitness of head, thread, and point . . . then checks shipments by automatic weigh-count to assure full value. Try American Phillips Screws on your own assemblies. You'll find they cost less because they help you produce much more.

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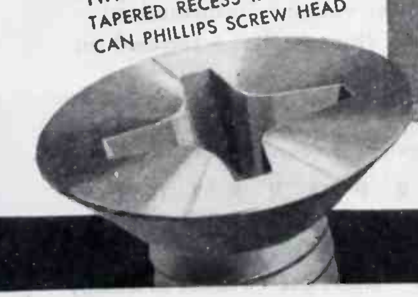
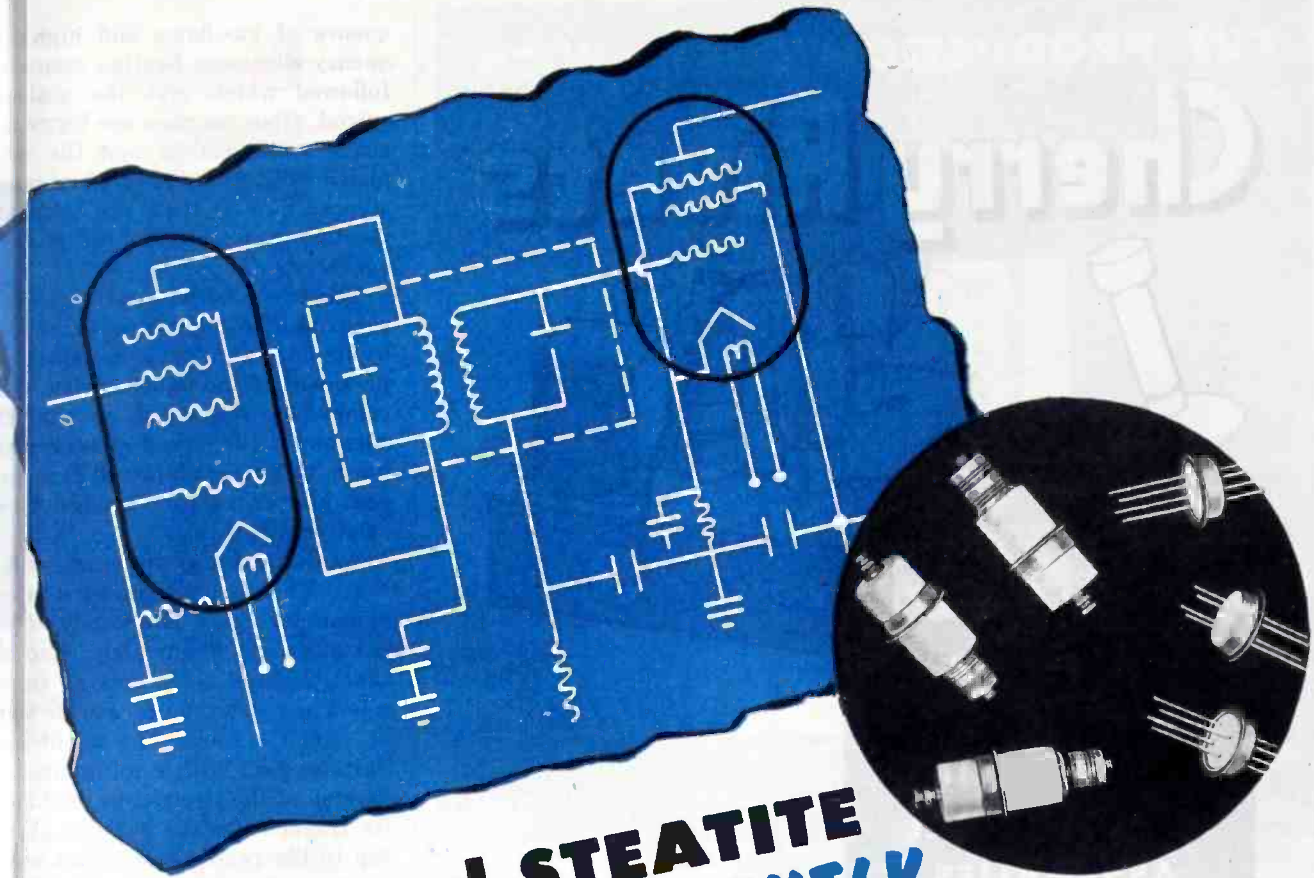
AMERICAN PHILLIPS *Screws*

4-WINGED DRIVER CAN'T TWIST OUT OF ENGINEERED TAPERED RECESS IN AMERICAN PHILLIPS SCREW HEAD



Put the Screws on the Japs . . . BUY BONDS!



quence of gas-flame and high-frequency electronic heating steps are followed which give the seal required. Glass sections are formed to shape while plastic and the completed column is lowered step by step as new sections are added at the top. Assembly and out-gassing operations follow.

The new tube is shown in the accompanying illustration, being held by its designer, Raymond Machlett, president of the Laboratories. It is completely sealed off so that its vacuum of 10^{-7} mm of mercury does not have to be maintained by pumping, and is compact enough to be relatively portable.

As the sectional drawing reveals, the column is made up of a series of annular rings, alternately of Pyrex glass and Kovar alloy. Each of the 182 metal rings acts as an accelerating electrode to provide steps of 12,000 v each. The result is a uniform field with a minimum dispersion of the electron beam during its travel from the cathode at the top to the region of the last accelerating electrode. At this latter point, the beam is focussed magnetically to strike the gold target at the bottom in a spot a few thousandths of an inch in diameter. Resulting x-rays pass through the target and the bottom housing for projection through the object being examined to the film beyond.

The reduction in exposure time made possible with the new tube permits examination of complete mechanical assemblies where the proper relation of parts within a housing can be determined. In the medical profession, better depth dosers are made possible for therapy of cancer. Using a 200,000-v tube, a therapist can obtain 32 percent of the skin dose at a depth of 10 cm. With a million-volt unit, the percentage goes up to 42. The two-million-volt tube gives 50 percent. Effectiveness of the treatment depends on obtaining the greatest possible depth dose with the least possible effect on superficial tissues.

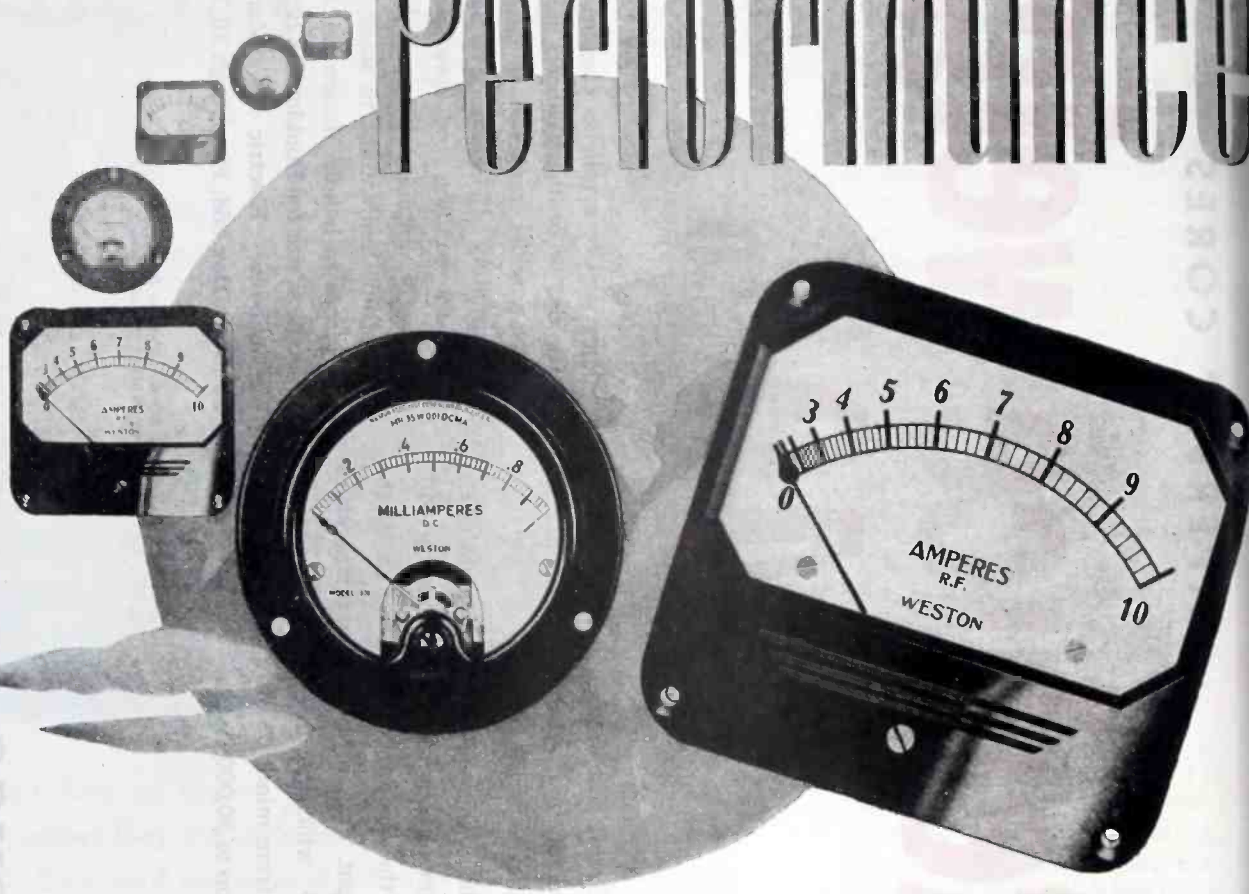
• • •

Experiments with Electronic Organs

By John H. Jupe

Experiences in the construction of various electronic organs are related by S. K. Lewer in *Electronic Engineering* for September, 1944.

known Performance



for destinations known or unknown

Today, our electrical equipment encircles the globe; some serving at Greenland's ice cap or in Kiska's fogs . . . others stewing in the swamps of a Pacific atoll.

With the destinations of war-products totally unknown, manufacturers logically have preferred "building-in" WESTONS on their control panels. They know that a WESTON will perform dependably *anywhere* . . . that there is sound reason behind WESTONS acceptance as the *international standard*.

And tomorrow, with equipment reaching known markets, instrument preferences will remain unchanged. For while human life no longer will be at stake, *reputations will*. So manufacturers will continue to "build-in" the instruments which consistently tell-the-truth . . . to build broader market acceptance and customer good-will, and assure highest efficiency from the machines which bear their name.

- Laboratory Standards
- Precision DC and AC Portables
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FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING EQUIPMENT

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PREGWOOD is a relatively new material possessing many unusual qualities that have adapted it to many uses—such as switch gear in heavy duty switches, picker sticks on textile looms, ski bottoms on military skis.

The test figures shown below indicate the remarkable strength of the material—which has a lower specific gravity than aluminum.

Pregwood has a certain measure of efficiency as an electrical insulator. It is non-absorbent and does not take up moisture. It is chemically inert and can be used for apparatus parts that will be exposed to acids and alkalies.

Changes in humidity have relatively little effect on dimensions; and a low co-efficient of thermal expansion holds the material stable under marked changes in temperature.

It has the quality of wearing smoothly without slivering or cracking. This makes it especially desirable for parts of textile machinery where it will not snag threads of fabrics.

Pregwood is built up by impregnating wood laminations with phenolic resins and pressing them together under heat and pressure. The laminations may be arranged with grain running one direction. This method produces high strength products such as Pregwood 1100.

THE FORMICA INSULATION COMPANY
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CINCINNATI 32, OHIO

PREGWOOD 1100

TENSILE STRENGTH
#/sq. in. 30,000

COMPRESSIVE
#/sq. in. 20,000

FLEXURAL
#/sq. in. 48,000

IZOD IMPACT
Ft. Lbs./In.
Notch Width

Flatwise	Edgewise
7.0	6.0

Test samples are available on request—

FORMICA

He was confronted by a choice of (a) complex waveforms, analyzed by the keyboard controls into the various tones required; or (b) sine waves, synthesized by the keyboard controls into the various tones.

He chose (a) and decided that an electrostatic method of generation was best for the amateur because cutting and shaping metal electrodes is easier than winding large numbers of electromagnets or setting up precision optical systems, and because time delay resistance-capacitance circuits provide easy means of controlling tone etc. This original choice has been confirmed by later experiments.

The first experimental generator was a gramaphone record with equi-spaced tinfoil waveforms pasted on it and using a fixed pickup electrode. Both this and a later all metal disc were discarded because of modulation or tone variation produced by mechanical defects. The system evidently required a high degree of mechanical precision. There were also difficulties concerning accuracy of frequency when a number of discs were driven from a common shaft.

Vibration Methods

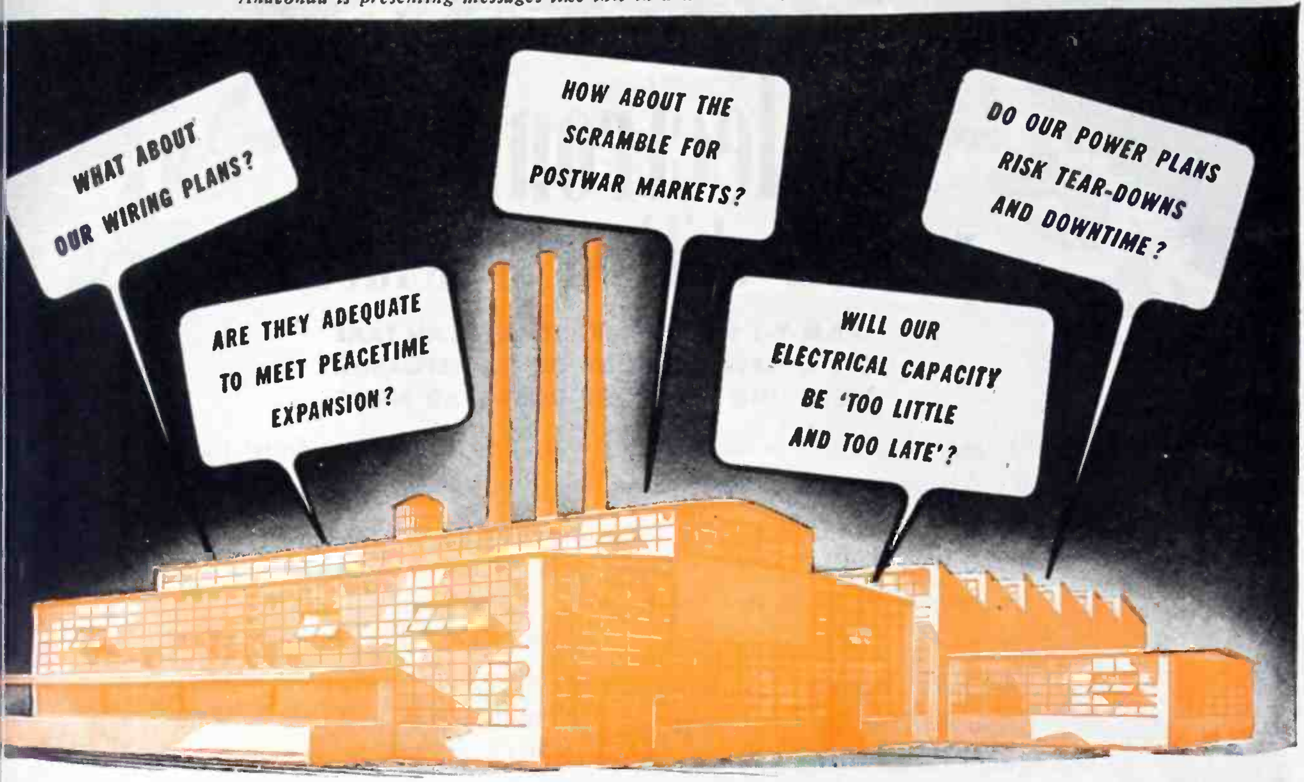
Vibratory systems were then examined and a start was made using stretched wires, where the vibrations produce variations of capacitance which are translated into oscillatory voltages across a high resistance. To generate sustained (organ) tones, the wires must be kept in continuous vibration. This was achieved in the first instance by feeding back some of the output from the final a-f amplifier into the string itself and arranging a magnetic field transversely to the string.

For selecting and converting the various tones, a second set of pickups was provided. Brass or phosphor bronze wires were found to be quite satisfactory and small bar magnets about two inches long were placed on each side of the wire to provide the magnetic fields.

Quite pure tones were obtained provided the maintaining electrode was at the center and the magnet ⅓ distant from the end of the wire. The chief difficulty was in maintaining absolutely constant amplitude of vibration, due to minute pickup and amplifier changes.

Later, a method of maintaining

Because of the basic importance of adequate wiring to the entire electrical industry, Anaconda is presenting messages like this in a wide list of national publications.



BE SAFE — BE CERTAIN

Wire Ahead!

If the facts below make sense, check up on your wiring plans *now!*

FUTURE MARKETS

Foresighted market surveys won't mean much if plant wiring and service equipment capacity don't back up potential volume.

NEW DEVICES

Do your plans anticipate the huge increase in the use of electricity—the power demands of new, complex electrical machines?

COSTLY TEAR-DOWNS

Figure the expense of possible downtime and labor costs for emergency wiring and equipment.

OBSOLESCENCE

What about your banker? He'll want to be sure that electrical efficiency is adequate to keep your plant a prime commercial risk.

POSTWAR EMPLOYMENT

You'll want to help assure places for the horde of returning men. Don't let inadequate wiring cramp your personnel.

Obviously unwired planning will cost a lot more than planned wiring. Wire Ahead! Have a talk with your electrical contractor, power engineer or utility power engineer. 41251

ANACONDA

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Well-Planned Power is Future Selling Power—Wire Ahead!


electronics..
problem child or benefactor?
THE N-Y-T SAMPLE DEPARTMENT CAN TAKE THE GUESSWORK OUT OF TRANSFORMER SPECIFYING FOR YOUR POST-WAR NEEDS
Placing the cart before the horse is to publicise in glowing terms, electronics of the future. Constructively, it's a job for engineers and designers with 'both feet on the ground'.
The N-Y-T Sample Department is helping to set the pace with research, engineering and development in the electronic field. Specially-built transformers, filters and solenoids—for every industrial and electronic requirement—are being produced to the highest degree of perfection ever attained.
Immediately that military needs taper, collaboration in the solution of transformer problems will be available to aid in the advancement of electronics . . . through product prestige and integrity.
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SEC.2
SEC.1

the strings with low pressure air jets was thought promising but it failed above about 800 cps.

Used Reeds

Attention was then given to vibrating reeds as variable capacitance elements, with reeds taken first from a harmonica and later from an American organ. Forty reeds, covering 32-2000 cps in five octaves, were assembled and at first direct acoustic output was difficult to silence, particularly at the higher frequencies. Cotton wool provided a reasonable solution to this problem. Key click filters were also necessary and by suitably choosing the values, could be made to provide "attack" controls as well.

Continuously operated reeds were satisfactory but there was a slight background roar, i.e. stray pickup from all reeds simultaneously. The war stopped experiments but there have been some later ones using an undulating change of capacitance to produce a frequency change in an oscillator instead of a current change in a resistance. In the opinion of Lewer, this system merits further careful consideration.

• • •

A New Electronic Compass for Aircraft

By David William Moore, Jr.
Fairchild Camera and Instrument Corp.
New York City

Use of the magnetized needle type of compass in aircraft showed that certain errors were introduced during turns and other maneuvers due to the accelerations imposed on the compass needle. To obviate this effect, a class of compasses known as earth inductors was developed. At first, these compasses used as a sensing element a rapidly rotating coil of wire which generated a minute voltage as it cut through the lines of force of the earth's field. The accelerations of the aircraft would not affect the voltage generated by this rotating coil, and as long as it was maintained in an upright position accurate direction indications could be obtained.

Certain defects were inherent in this type of earth inductor, though the most important being the necessity of employing brushes to collect this induced voltage from the coils. These brushes generated in themselves a noise voltage which many

CHECK TRANSMITTER FREQUENCY IN LESS THAN A MINUTE

THE BROWNING FREQUENCY METER, used by police and other emergency radio facilities for the past five years, is still the best meter for such services — because it was specifically designed for them. The design, which permits determination of any five frequencies from 1.5 to 120 Mc., makes for simplicity of operation which requires less than one minute to check one frequency. All Browning development work aims at specific, rather than broad, uses. Thus, all Browning equipment is best for its particular job. Furthermore, Browning Laboratory facilities are available for study and solution of your own, specific electronic engineering problems.

Write for data.

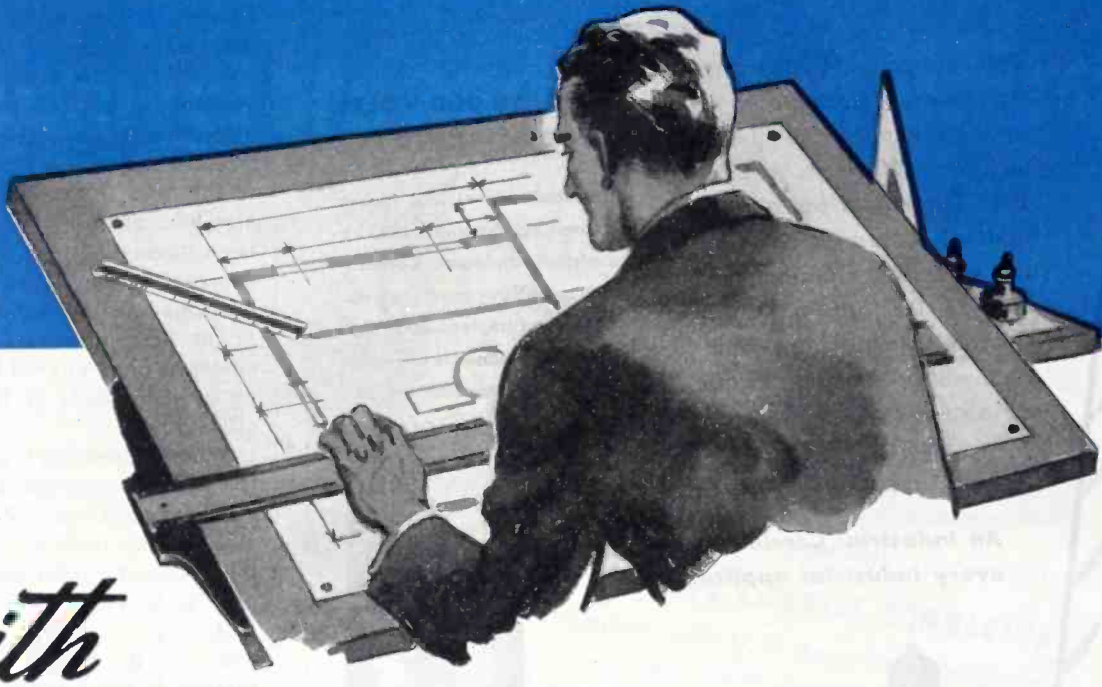
BROWNING

LABORATORIES, INCORPORATED
WINCHESTER, MASSACHUSETTS

Plan Now For

DEPENDABILITY

in your Postwar Radio-Phono Combinations



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WEBSTER RECORD CHANGERS

LOOK TO WEBSTER PRODUCTS

TODAY
Dynamotors and Voltage Regulators

TOMORROW
World Acclaimed Record Changers

In the selection of component parts for your models, you will be interested in the dependability of the unit and the ability of its manufacturer to carry through on any program undertaken. You will find satisfaction on both scores at Webster Products.

Webster Record Changers will have *all* the features you would expect from the pioneer manufacturer of record changers—with remarkable economies of space.

We will be glad to discuss with manufacturers now the ways we may serve you today and tomorrow.

WAR BONDS
are Top Value for TODAY and TOMORROW

WEBSTER PRODUCTS

3825 W. ARMITAGE AVE. CHICAGO 47, ILLINOIS

times approached the signal voltage in magnitude. In addition, the high-speed rotating coil in itself presented an undesirable maintenance problem. Later developments have produced earth inductors having no rotating coils, and in some instances no rotating parts at all.

New Type

In our laboratories, we have developed an entirely new type of magnetic field responsive device. This form of earth inductor, while inherently possessing no substantial advantages over those now available to our armed forces, does present an entirely new and novel approach to the problem, and one which we felt would be of interest to the field. Although rather extensive laboratory and flight tests have been made of this system with very successful results, no attempt has been made to market the device. It is, at present, merely a scientific curiosity, but one which may open up new channels of thought along other lines.

When permalloys are placed in the earth's magnetic field, they become magnetized inductively to a measurable degree. This fact is made use of in our earth inductor, as it is in many other systems.

As shown in the accompanying drawing, the permalloy sensing armature is surrounded by an exciting coil. The magnetic field of the exciting coil is normally at right angles to the longitudinal axis of the armature. In this position, there is no magnetic induction between the armature and the exciting coil along this axis. If, however, this armature is inductively magnetized by some outside field, it will no longer be neutral with respect to the magnetic field of the exciting coil and a magnetic couple will be formed between it and the armature.

In actual practice, an alternating current of suitable frequency is passed through the exciting coil to produce an alternating magnetic field at right angles to the longitudinal axis of the armature. Then, when the armature is inductively magnetized by the earth's field, an alternating couple will be produced between the armature and the coil. If the armature is free to move very slightly along an axis in the plane of the exciting coil, and at right angles to the longitudinal axis of

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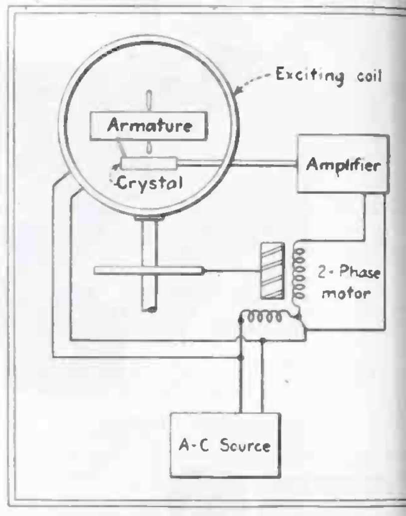
the armature, a mechanical vibration of the armature at the frequency of the alternating current in the exciting coil will result.

Rochelle Salt Crystal

This vibration of the armature is transferred to any suitable pickup which will convert mechanical motion to an electrical voltage. In our experiments, a standard phonograph crystal pickup was used.

The phase of the crystal output voltage with reference to the phase of the current in the exciting coil will be a function of the magnetic polarization of the armature. This



Essential components of the suggested earth-inductor compass for aircraft

magnetic polarization of the armature will in turn depend upon the orientation of it with respect to the earth's field. If the armature is placed in an east-west position, it will not be magnetized longitudinally by the earth's field and consequently no output will result from the vibration pickup. If the armature is rotated in either a clockwise or a counter-clockwise direction from the east-west position, the armature will become inductively magnetized and an output voltage will result.

The phase of the output voltage will shift 180 degrees as the armature passes through the east-west position and may be taken as a left-right type of indication. The magnitude of the voltage is, assuming linear output from the crystal pickup, proportional to the cosine of the angle between the longitudinal axis of the armature and the

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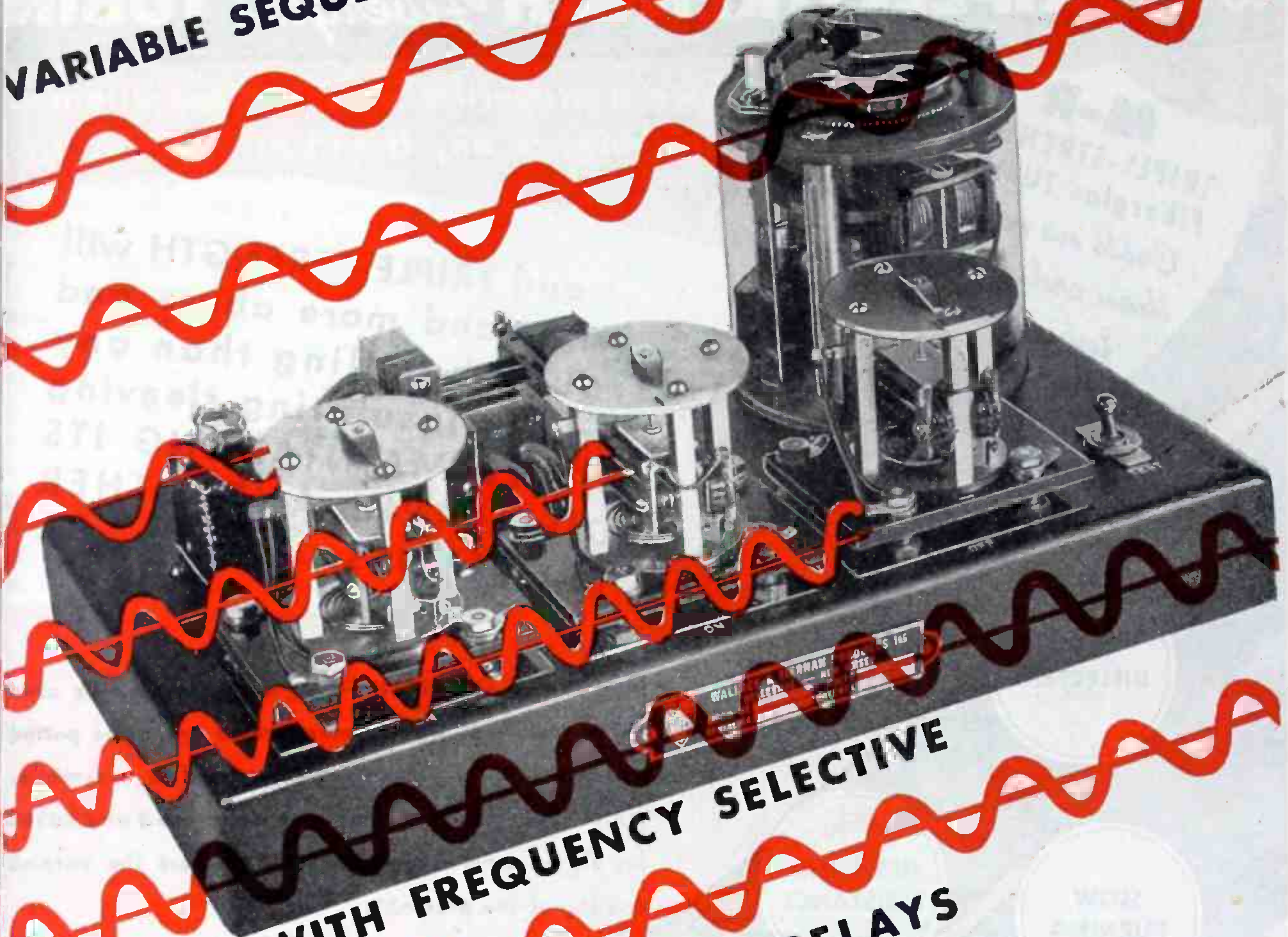

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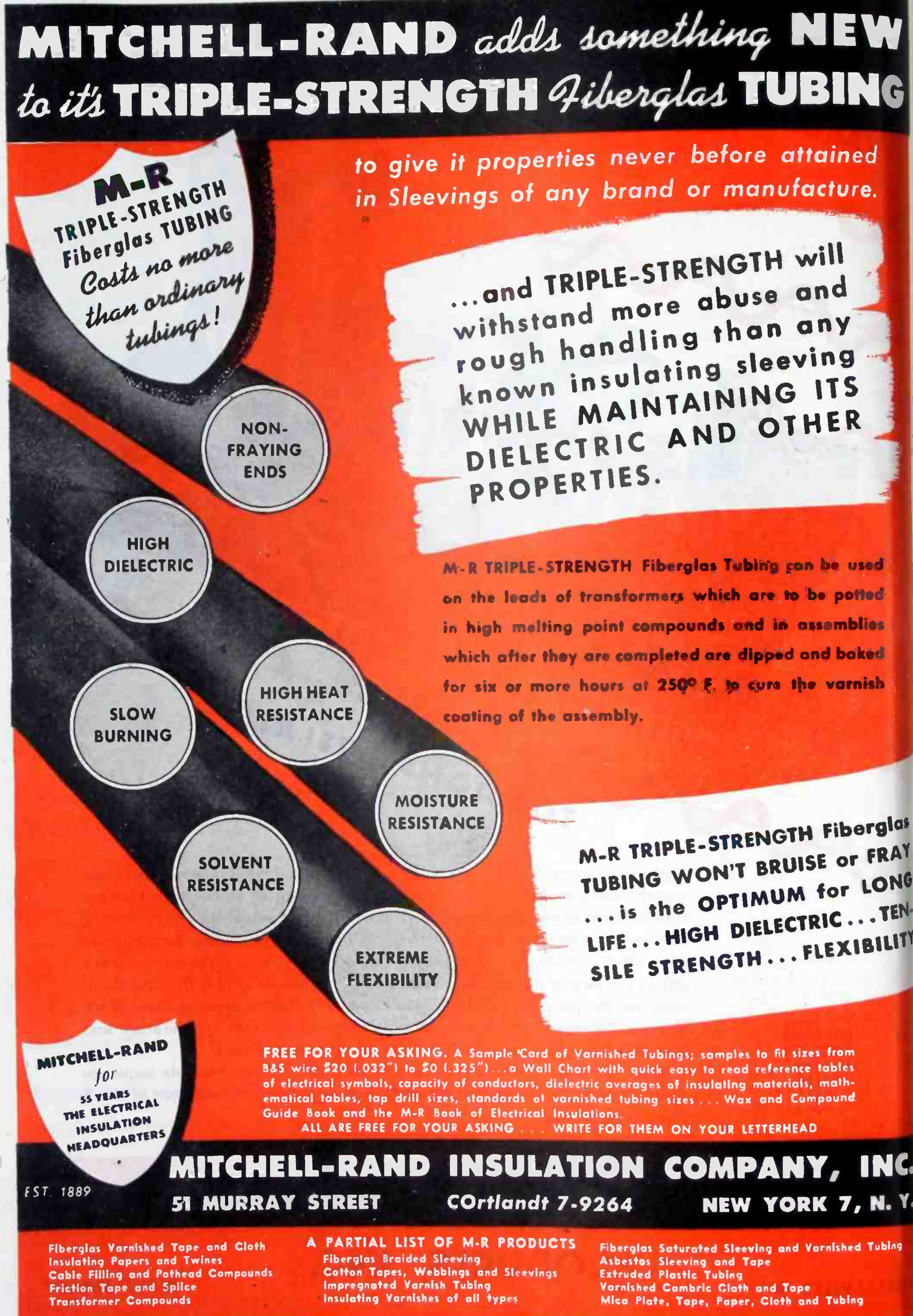
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horizontal component of the earth's magnetic field.

Test Model

In our tests, this device was constructed with an armature ten cm long surrounded by an exciting coil four inches in diameter. The output of the crystal pickup was amplified by a small amplifier having an amplification of approximately sixty db. The output of the amplifier and a portion of the current passing through the exciting coil were compared by a dynamometer type of left-right indicator of the type used on Fairchild radio compasses. With this arrangement, we were able consistently to obtain full-scale readings of the left-right indicator with deviations of the armature of only 1 deg from the balanced east-west position.

Mechanical vibrations transmitted to the armature from the outside were kept out of the amplifier by a suitable high-pass filter which suppressed the low-frequency vibrations and permitted the four-hundred cycle operating frequency to pass.

A model of this device was flown in our laboratory plane, and results approaching those obtained in the laboratory were obtained.

Additional information may be obtained by referring to United States Patent 2,331,617, or from the author at Fairchild Camera and Instrument Corp.

• • •

X-Ray Irradiation of Quartz Crystals

THE TECHNIQUE of permanently altering the frequency of quartz plates by subjecting them to x-ray irradiation and so changing the atomic properties of the quartz itself is described by Clifford Frondel, director of research at Reeves Sound Laboratories, in the October issue of *The Radio Engineers Digest*. Results of the experimental work accomplished and a discussion of the various factors involved are contained in the article, from which the following is abstracted.

When a BT quartz oscillator-plate is irradiated with x-rays, or by certain other radiations, it gradually becomes smoky in color and at the same time the oscillation frequency decreases. Similar effects are obtained with oscillator cuts

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other than the BT, and with substances other than quartz. The total frequency change that can be effected increases with increasing initial frequency of the plate, and can be roughly estimated for a given frequency on the basis of a decrease of approximately 0.02 percent in the frequency-thickness constant of irradiated quartz. There is, however, a considerable variation in response among different crystals of the same frequency; in an unsensitized 8-megacycle plate the observed total response varies between 500 and 3000 cycles, with an average change of about 1400 cycles. The rate of change of frequency is primarily determined by the intensity and wavelength of the x-radiation employed. The rate, like the total change, also increases with increasing initial frequency of the plate. Rates now achieved in production in the Reeves plant average about 40 cycles change per minute in 8-megacycle plates. A considerable increase over this rate can be expected from Philips x-ray equipment designed for the purpose. The change in frequency on irradiation is accompanied by little or no change in crystal activity.

Baking Reverses Action

The frequency change brought about by radiation can be reversed, and the plate restored to its original frequency, by baking at temperatures over about 175 deg. The rate of reversal increases with increasing temperature and is practically instantaneous above 400 deg C. Irradiated plates have been found to be stable below 175 deg C.

The fact that the frequency change is downwards from the original value permits the salvage of plates that have been overshot in frequency during manufacture, provided that the desired frequency change is within the range of the radiation technique. Similarly, plates that have gone over frequency due to ageing, re-cleaning, or under-plating may be recovered. At the present writing, roughly 1000 over-frequency plates are being recovered per week by x-rays in the Reeves plant.

Another advantage of the method arises in that the frequency of stabilized crystals can be adjusted without disturbing the surface condition of the quartz. Plates can

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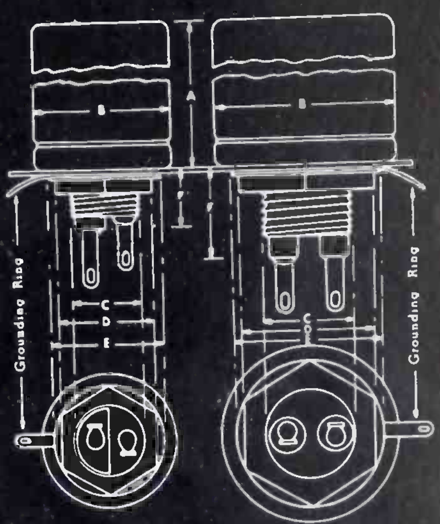

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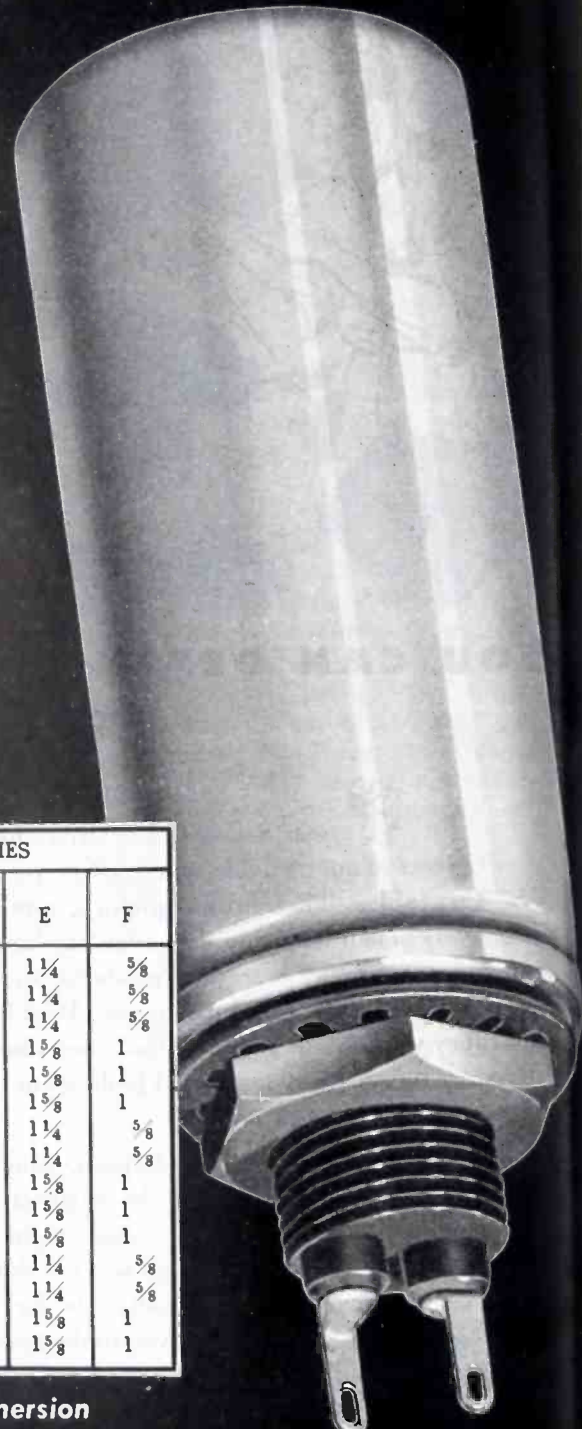

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6EC400	4.0	600	4½	1½	¾x16thd	1	1¼	⅝
6EC600	6.0	600	4	2	1x14thd	1 7/16	1⅝	1
6EC800	8.0	600	4½	2	1x14thd	1 7/16	1⅝	1
6EC1000	10.0	600	4	2½	1x14thd	1 7/16	1⅝	1
10EC100	1.0	1000	2¾	1½	¾x16thd	1	1¼	⅝
10EC200	2.0	1000	4½	1½	¾x16thd	1	1¼	⅝
10EC400	4.0	1000	4	2	1x14thd	1 7/16	1⅝	1
10EC600	6.0	1000	4	2½	1x14thd	1 7/16	1⅝	1
10EC800	8.0	1000	5	2½	1x14thd	1 7/16	1⅝	1
15EC50	.5	1500	2¾	1½	¾x16thd	1	1¼	⅝
15EC100	1.0	1500	4½	1½	¾x16thd	1	1¼	⅝
15EC200	2.0	1500	4	2	1x14thd	1 7/16	1⅝	1
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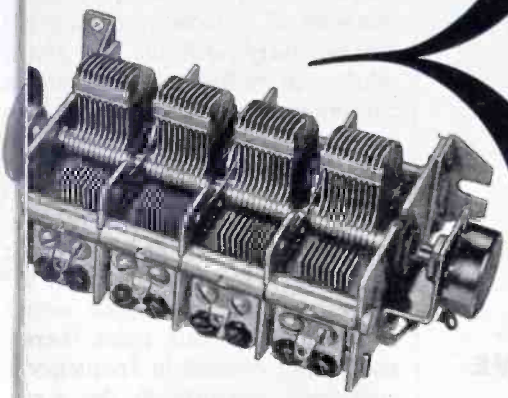

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also be finished to have a desired frequency at a specified temperature by irradiation to frequency while held at that temperature. The greatest advantage of the method, however, is that frequency adjustment can be brought under continuous, visual, control by oscillating the crystal in the x-ray beam until it reaches the desired frequency and then stopping the treatment. This can be accomplished while the crystal is mounted in its permanent holder, if the latter is suitably designed, or in a temporary holder so made as to permit entrance of the x-ray beam. Frequency adjustments of the highest precision can be attained in this way.

The irradiation-to-frequency technique is of special advantage in the manufacture of ultrahigh frequency plates, in the range over 15 megacycles, since the conventional methods of finishing crystals here become very difficult to control while the radiation technique, on the other hand, is at its maximum power.

Magnitude of Change

The rate of change of frequency of a quartz oscillator-plate during irradiation is rapid at first but then decreases and approaches zero at saturation. At this point there is no further change in frequency on continued exposure to the x-rays. The total change of frequency that can be effected is variable and depends on a number of factors. Among these are the type of cut of the plate, the treatment given to the plate prior to irradiation, the kind of radiation employed, and the initial frequency, or thickness, of the plate itself. There also is a considerable variation in response among different specimens of raw quartz and hence between different plates of the same frequency cut therefrom. The time needed to effect saturation appears to be constant for plates of a given frequency regardless of the total amount of change provided that the conditions of irradiation are identical. The observed variation in saturation value in 8000-kc, BT-cut, plates is roughly from 500 to 3000 cycles decrease, with an average change of approximately 1400 cycles decrease.

The *average* saturation value is a function of the initial frequency,

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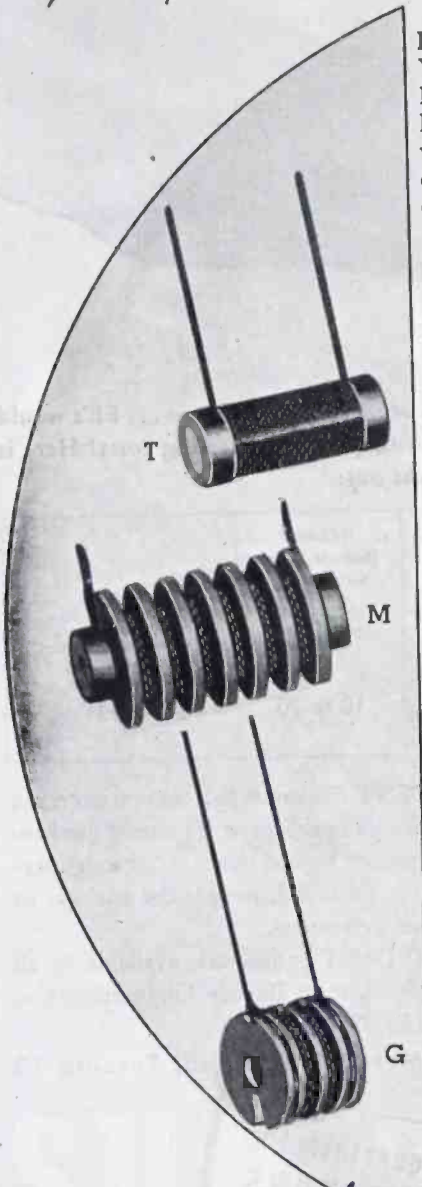

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"A-R"—Same as A-1, with leads reversed.

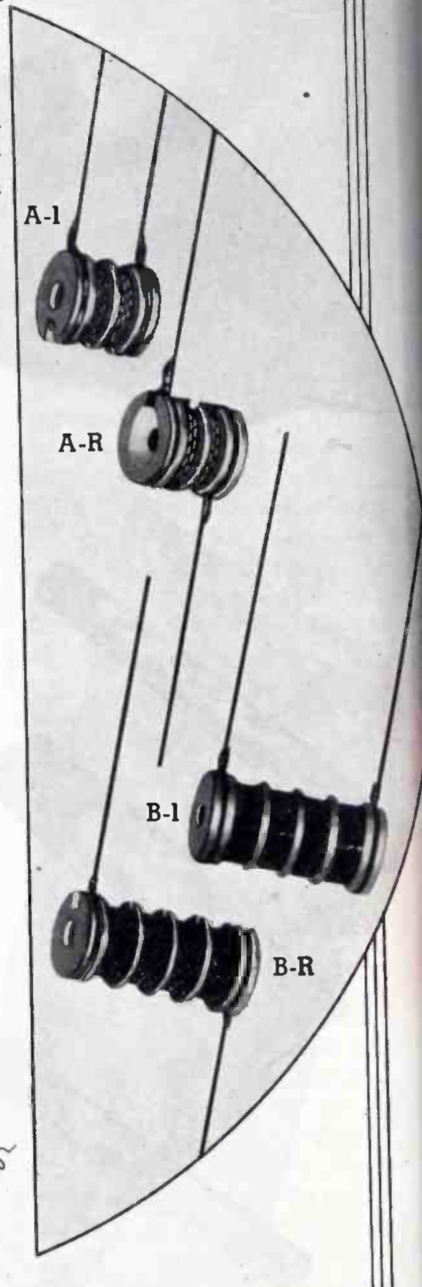
"B-1"—15/16 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—½% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—⅛ x .015 strap terminals—35 to 35,000 ohms—2 watts, 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x ¾" dia.—Mountable with 6-32 screw—⅛ x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy. Baked varnish finish.

"G"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. ½% standard accuracy—non inductive pie wound .8 watts, 30° temperature rise in free air. 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.



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or thickness, of the plate and increases with increasing frequency. Preliminary measurements indicate that the average change in BT plates of a particular frequency can be calculated on the assumption that the frequency-thickness constant of irradiated quartz is less by some constant amount than in ordinary quartz. It is seen that the average decrease in this constant is equivalent to a 1400 cycle average saturation value in an 8000-kc plate. Using the relation:

frequency in cycles = K/thickness of plate in thousandths of an inch where K for ordinary BT plates is $\sim 100 \times 10^6$ cycles per second per 0.001 inch, and the plate thickness is constant, the value of K for irradiated quartz is found to be 99.9825×10^6. In a table, are given the corresponding total frequency changes that can be effected over the range of BT frequencies from 3 to 50 megacycles. The table also includes total frequency changes over this range for values of K equivalent to various saturation values up to 12-kc plates.

A rough idea of the magnitude of the frequency change to be obtained between different pieces of quartz can be gained from the luminescence phenomena described in a later section and from the original color of the quartz. Generally speaking, colorless quartz shows a wide variation from specimen to specimen in the degree of response in color to radiation. On the other hand, deep smoky quartz and citrine uniformly show a relatively small response. Amethyst quartz is entirely unaffected. If amethyst is first decolorized by baking, irradiation restores the amethystine color. Rose quartz, which contains traces of titanium in solid solution, develops an extremely intense, almost black, smoky color. Chalcedony is weakly affected by x-rays and alternate bands in the mineral may become unequally colored. Opal is not affected. Tridymite, an orthorhombic polymorph of SiO_2, is deeply colored by x-rays.

Methods of Irradiating Plates

With the x-ray technique, the crystal must be placed as close as possible to the window of the x-ray tube, preferably within distance of one-half millimeter, and the x-ray beam should be made as intense as

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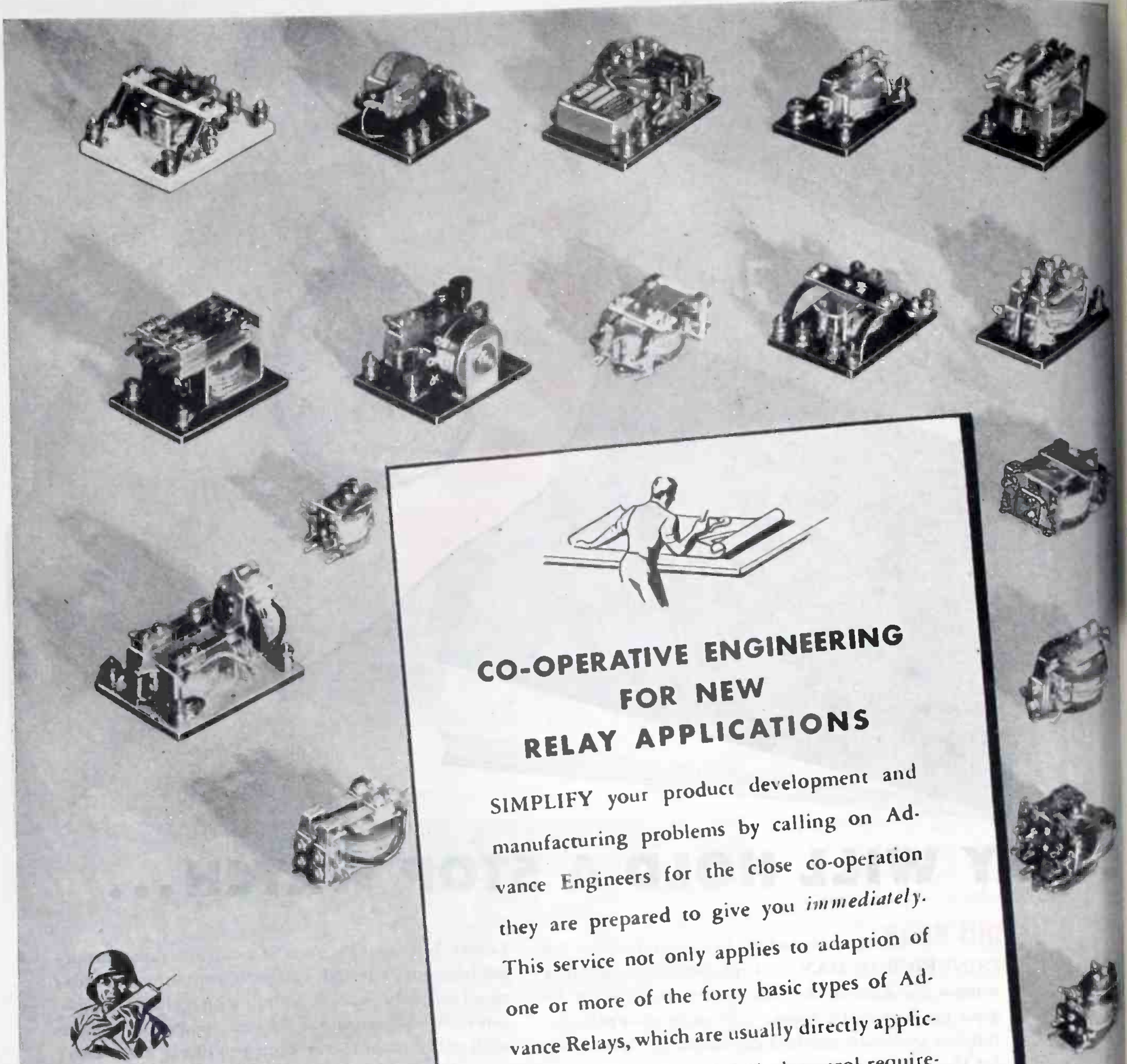
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possible, since the photo-electric response of the quartz appears to be directly proportional thereto.

The wave-length of the x-rays employed should be so selected as to yield maximum absorption in the total thickness of the quartz plate being irradiated. For example, soft x-rays are strongly absorbed and are relatively efficient in producing ionization, but their penetrating power is low and hence they may not penetrate through a thick crystal. On the other hand, hard x-rays penetrate deeply but their absorption and ionizing power is relatively low and hence the greater part of the energy in the x-ray beam might be transmitted through a relatively thin crystal. Considering the various factors involved, copper radiation is best for general use.

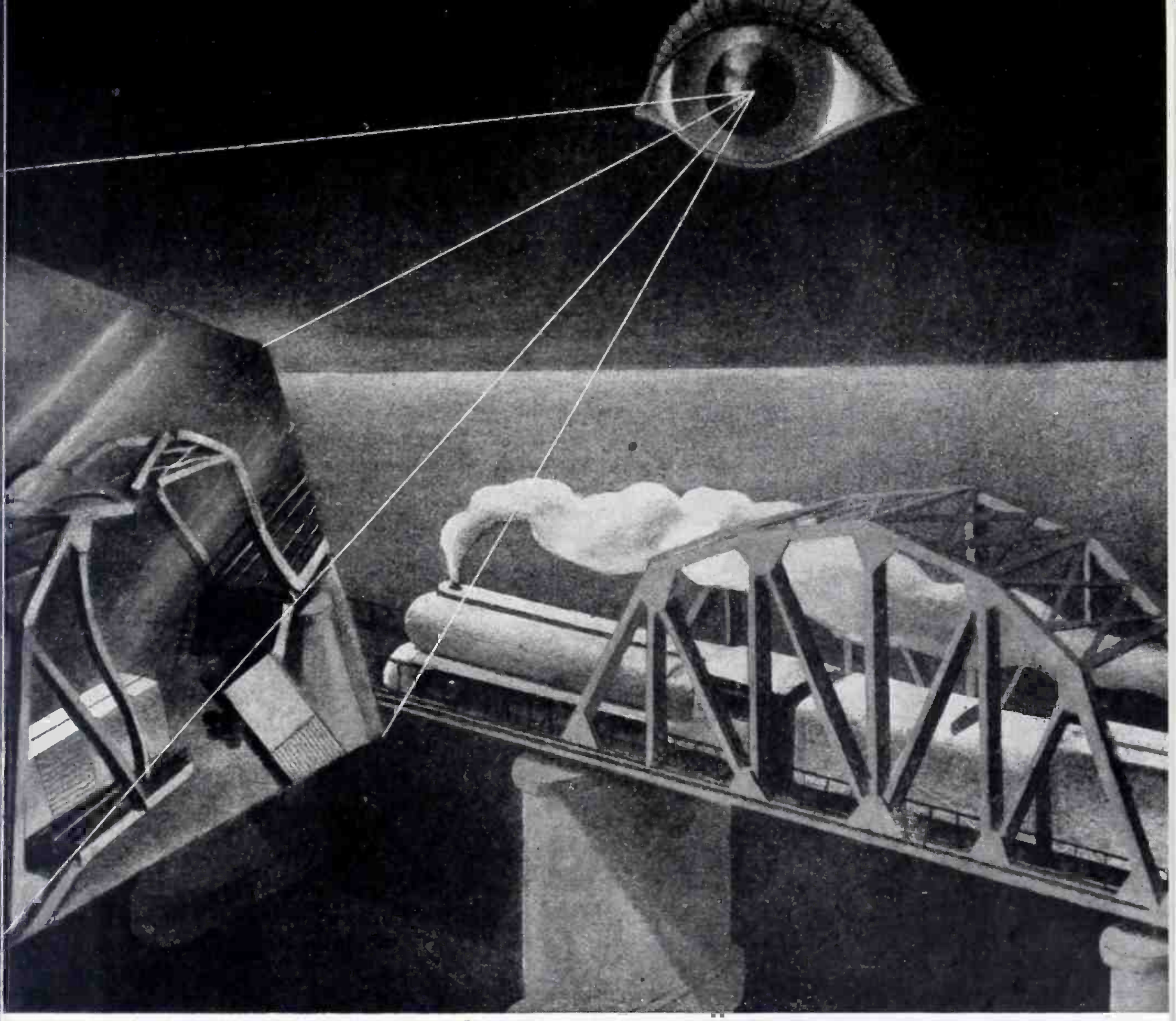
Foreign material such as metal, glass, or plastic sheets should not be placed in front of the crystal during irradiation since this will absorb part of the incident radiation, especially the relatively effective soft components, and thereby slow down the change in the quartz. X-rays used in irradiating oscillator-plates should not be filtered. If the crystal is irradiated while in a bakelite or other holder or if it is oscillated in a special holder on the tube during irradiation, every effort must be made to keep the shielding material as transparent to x-rays as possible, both by controlling the thickness and the composition of the material.

Advantage should be taken of the fact that quartz crystals can be markedly sensitized to the effect of x-rays by prior baking to 300°C to 570°C. Baking also is advantageous because of the stabilizing effect it has on the crystal. Attention should also be given to methods of increasing the efficiency of the radiation by coating or backing up the crystal with a highly scattering metal or substance. The plate that immediately supports the crystals in the irradiation jig should be made of nickel, since this metal will give the maximum amount of back-scattering in copper radiation.

Every care must be taken to shield the operator both from direct and scattered radiation. Irradiation jigs should be completely shielded by lead sheets not less than 1-mm in thickness.

Quartz crystals may acquire a


CONTROL
EAD



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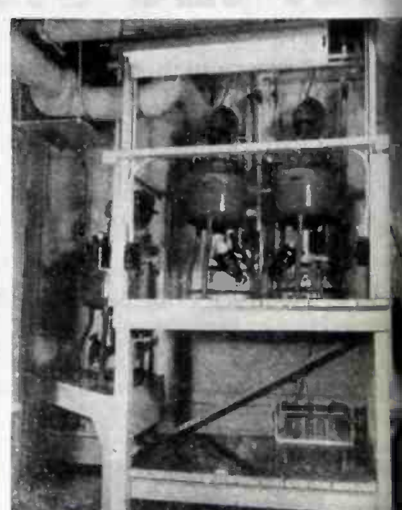
static electric charge during irradiation, especially if they are placed directly in contact with the window, and thereby may attract particles of dust to their surface. This dust can be blown off with compressed air—a much easier procedure than trying to remove the static charge. Under certain conditions the metal parts of water cooled tubes may sweat and moisture may deposit on the surface of the crystals. This can be overcome by proper design of the irradiation jig and the tube housing.

Silver plated crystals may darken during irradiation if ozone is developed in the x-ray tube housing. The ozone can be eliminated by proper insulation and shielding of the high tension thereby preventing corona and flash-overs. Gold, nickel and aluminum plated crystals have been observed to be affected in this way.

The x-ray beam where it hits the crystal should be large enough in cross section to completely cover the critical area. In most types of shear mode plates, less than 50 percent of the total area of the crystals has to be irradiated to gain maximum effect.

• • •

PHOSPHOR AUTOCLAVES



Hydrogen sulphide from the tank at lower right passes through six stages of gas purification before going to steam-jacketed, glass-lined autoclaves mounted at top of stand. The smelly gas is used in the manufacture of phosphors for cathode-ray tubes at the Dobbs Ferry plant of North American Philips

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"For the *main radio* in your home"—because there's nothing finer than a Stromberg-Carlson, and your *main radio* should be a *good* radio—a *quality* musical instrument in every respect!

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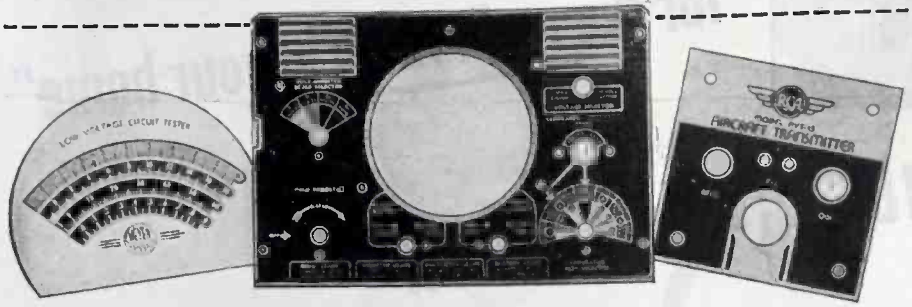

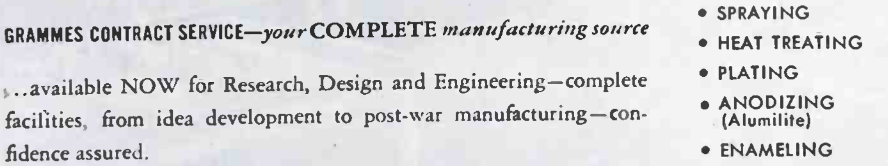

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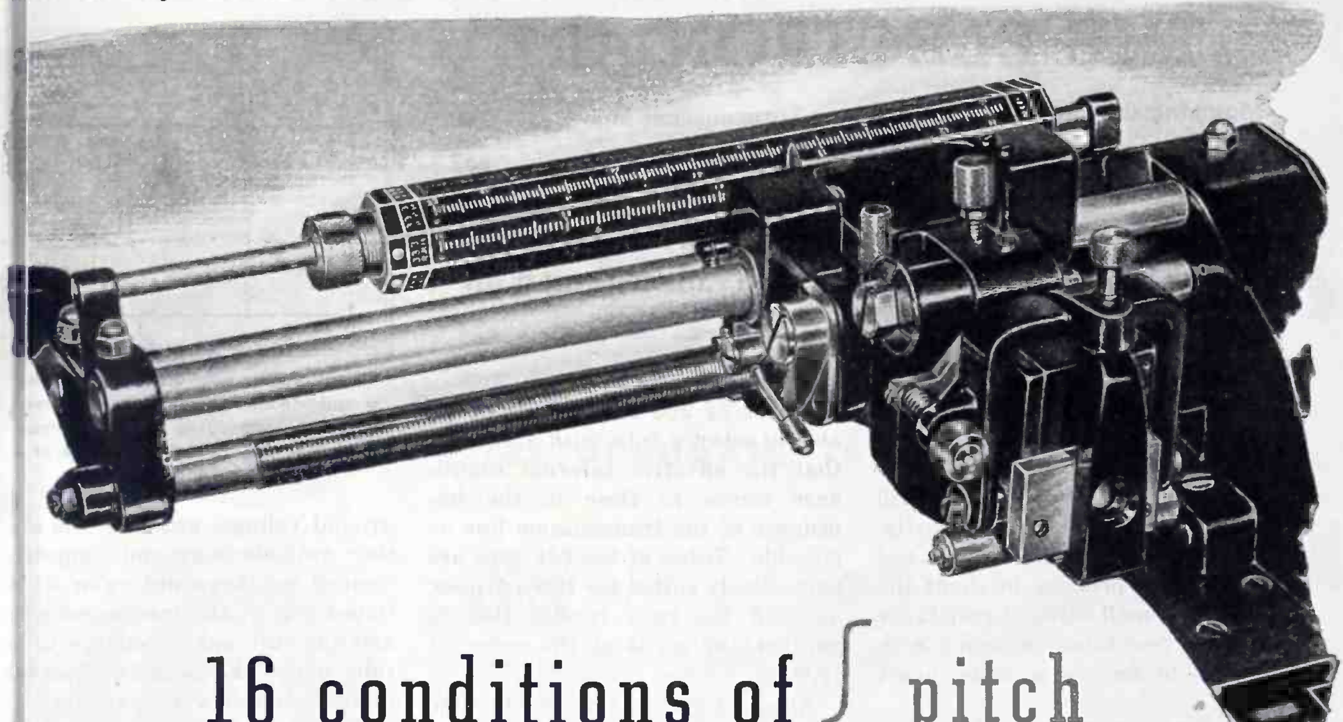

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THE ELECTRON ART

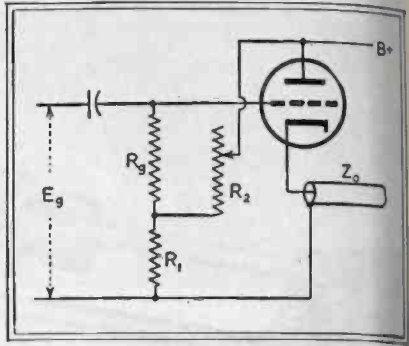
Matching Cathode Follower to Transmission Line

By L. R. MALLING
San Diego, Calif.

UNLESS SPECIAL PRECAUTIONS are observed, it is unlikely that the effective internal impedance of a tube used as a cathode follower will match a transmission line exactly. To overcome this condition, it has been common practice to shunt the line with a small value of resistance or to add resistance in series with the line to ensure a more exact match.

Due to the effect of feedback, the internal impedance of a cathode follower is reduced to a value which is equal to the reciprocal of the mutual conductance or $1/g_m$. Thus a tube with a mutual conductance of 5000 micromhos will have an internal impedance due to negative feedback of 200 ohms. It is desirable to select a tube with a g_m such that the effective internal impedance comes as close to the impedance of the transmission line as possible. Tubes of the 6J6 type are particularly suited for this purpose, as with the twin triodes tied in parallel, the g_m is of the order of 10,000.

An exact match is made when the alternating voltage across the cathode circuit is exactly half the grid to ground voltage, a measured check that can be quickly and conveniently made. The voltage across the cathode circuit is given by $E_c = E_g\, g_m\, R$, where E_c is the voltage across the cathode load, E_g is the grid to ground voltage, and R is the effective cathode-to-ground impedance formed by the shunt value of the impedance of the transmission line and the internal impedance of the tube under the negative feed-back or cathode-follower condition.



Circuit of suggested method of matching a cathode-follower tube to a transmission line by varying the grid potential to change the internal impedance of the tube

The g_m of a tube may be considered to be a factor dependent on the plate current, so that we have at once a useful method of controlling the effective internal impedance of the tube when used as a cathode follower. By making the grid potential variable it can thus be seen that a perfect match to a transmission line can be obtained.

Impedance Measurement

The internal impedance of the cathode follower can be measured as follows: The transmission line is replaced by a resistor of equivaalent impedance and the direct d-c voltage across this resistor noted. A small additional current is then applied from the positive plate potential through a known resistor and the new voltage across the cathode resistor noted. The effective plate current in the second test is the cathode current minus the bleeder current. We thus have a small plate-to-cathode voltage change with a small plate current change, from which the effective internal impedance R_{pe} of the tube may be determined from $R_{pe} = dE_c/dI_c$ where dI_c and dE_c are the incremental changes in the plate current and the plate-to-cathode voltage respectively. In the case of the cathode follower, it is convenient to consider voltages in relation to the fixed plate potential as a convenient reference point.

In the above discussion it is as-

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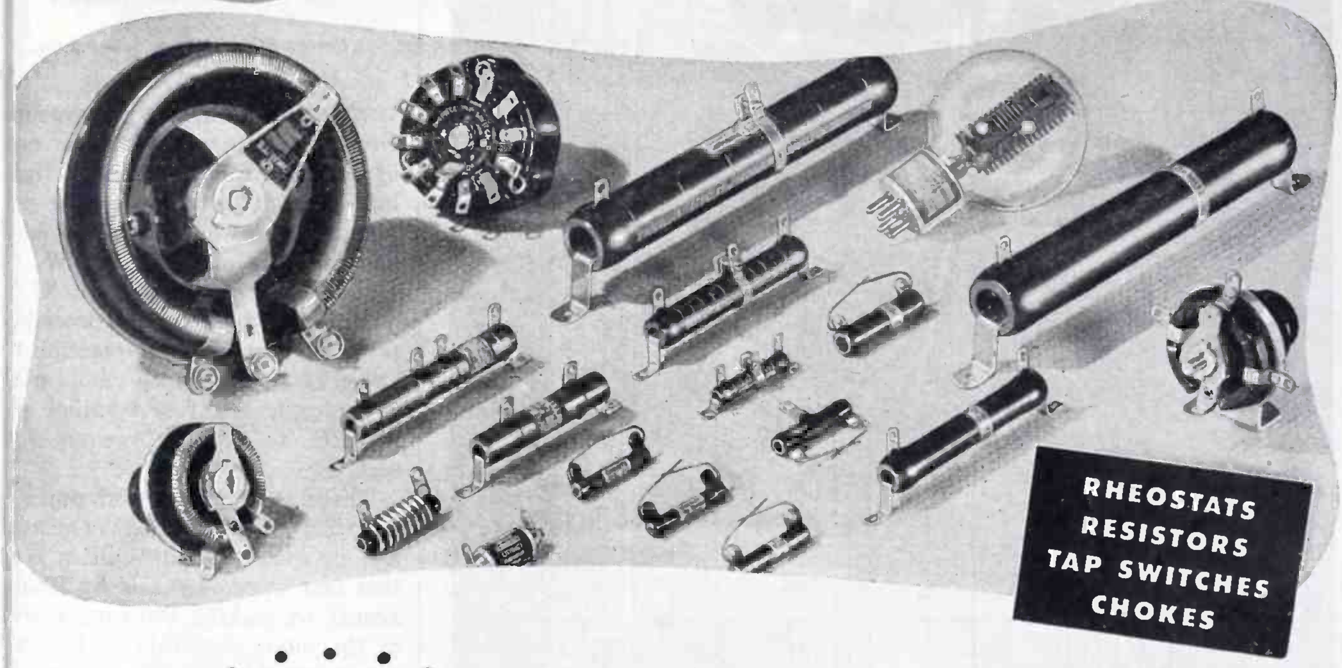

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sumed that the amplification factor is large compared to unity. In the case of pentode or screen grid tubes, this is always the case. The slight error introduced with the majority of triodes may be neglected. The effective impedance for the case of a triode with low amplification factor is given by $r_p/(\mu + 1)$ where r_p = normal plate resistance and μ = amplification factor.

• • •

Scaling Test of OFHC Copper for the Housekeeper Seal

BY ULRIC J. HOCHSCHILD

Metallographer
United States Metals Refining Co.
Carteret, N. J.

IN THE EARLY DAYS of high-vacuum electronic tube research, the need of a method for producing a tight, lapped joint between copper and glass tubes was encountered. A method was devised by W. G. Housekeeper which lent itself to quantity production. The procedure takes advantage of the reaction between cuprous oxide and glass whereby the two fuse together sufficiently to give a vacuum-tight seal.

There is a marked difference in the thermal expansion of copper and of glass, and difficulties from this fact were overcome by Housekeeper by making the copper wall, at the joint, very thin so that the copper could deform enough to compensate for the differential in the expansions. The copper therefore must not only have the property of forming a strongly adherent scale but also must be very tough to withstand the stresses during cooling of the joint. After considerable investigation, OFHC copper was selected for this work and has become the standard in the industry.

In order to be certain that the copper in stock is the correct type, it is tested before allowing it to go into production. Among the tests for establishing the suitability of any given lot of copper is the co-called "Scaling Test" which seems to be well adapted to determining the probable scale adherence in pratice.

This scaling test has assumed a formal status and it therefore seemed desirable to make an invest-

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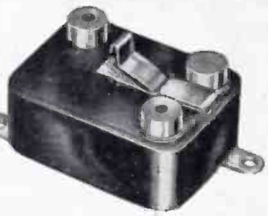

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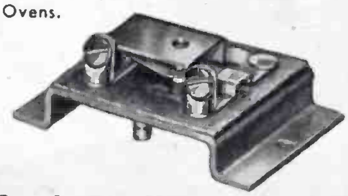

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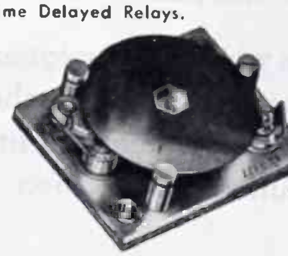

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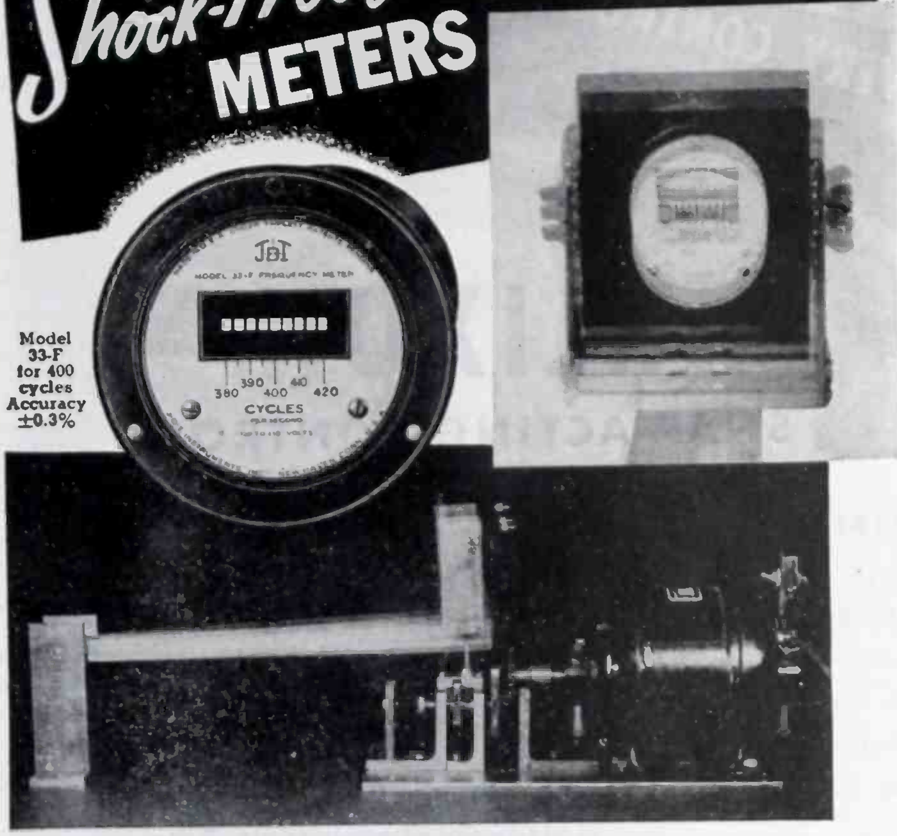

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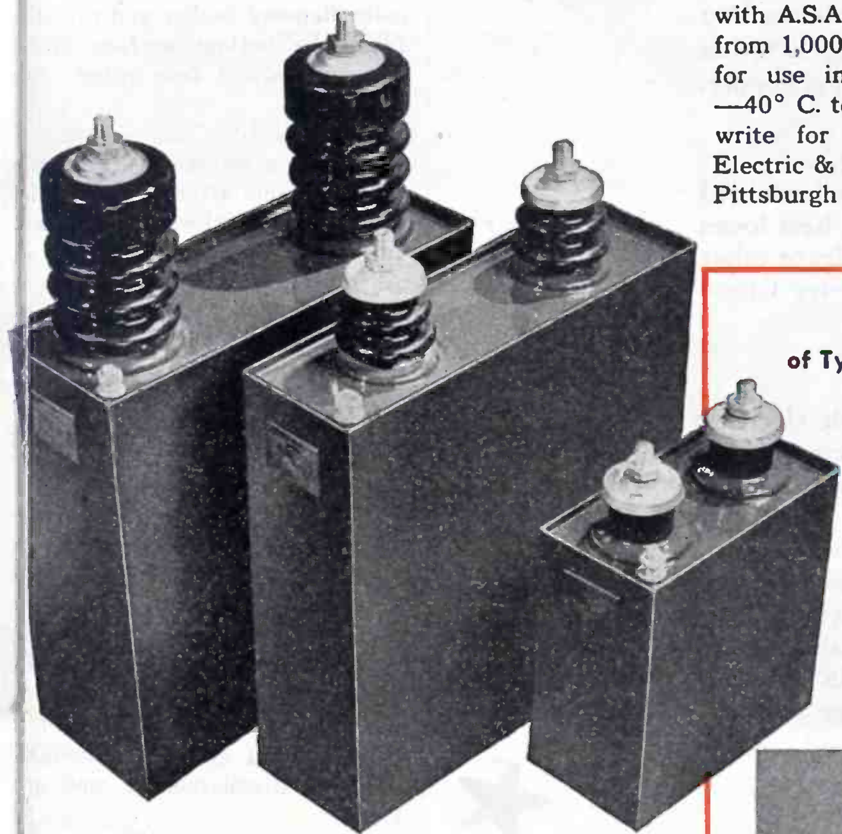

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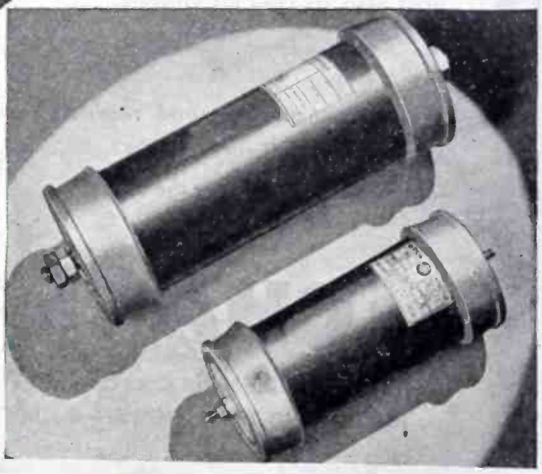

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igation of it to establish the optimum conditions for conducting it. The results obtained reveal that the tentative test procedure of heating at 850 deg C for 30 minutes was not far amiss, the only change indicated is to shorten the time of heating to 20 minutes.

Procedure

The recommended procedure for conducting this scaling test consists of heating a clean, smooth specimen of the cast or wrought copper in air, at 850 deg C for 30 minutes, in a clean muffle furnace.

The furnace used by us comprises a Sillimanite beaker heated electrically. Slow air circulation is induced through the beaker by a chimney effect produced by tubes: one of which reaches from the upper surface of the cover to a point near the bottom of the vertically disposed beaker and the other from the bottom surface of the cover upward a few inches above the cover.

After heating, the specimen is quenched in water. An inspection of the sample after this treatment reveals one of three conditions as far as the scale is concerned: (1) All the scale adheres. (2) All the scale has fallen off or is loose. (3) The scale adheres partially.

In condition (1), the copper has passed the test and is considered suitable for glass to copper seals.

In condition (2), the copper is definitely unusable for glass to copper seals. The action is unquestionably true scaling having the following characteristics: (a) The detached scale is in sheets or flakes, retaining the shape of the specimen surface. (b) The scale has parted from the copper at the copper-scale interface. (c) The surface of the copper is all exposed, although it may be discolored, or not quite clean.

In condition 3, two types of shedding can occur. Either true scaling, but incomplete because the content of the contaminating element which causes scale shedding is very small (border-line case); or scale loss is caused by mechanical stresses set up in cooling. The latter type is characterized by chipping or fracturing of a conchoidal nature. It usually takes place at such favorable locations as sharp corners, deep scratches or stria-

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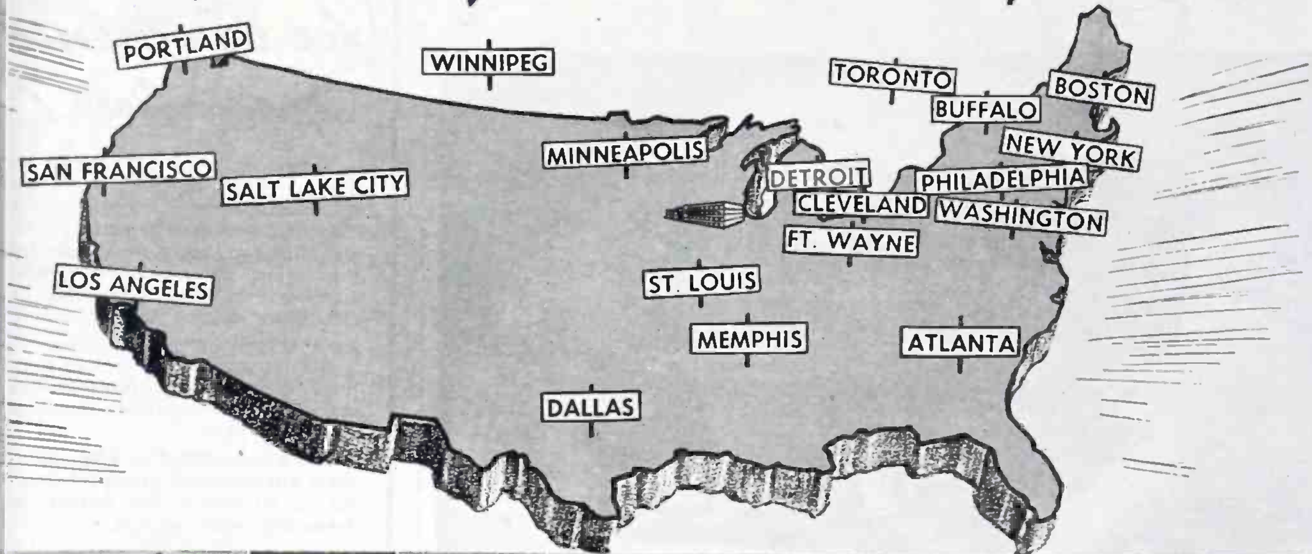

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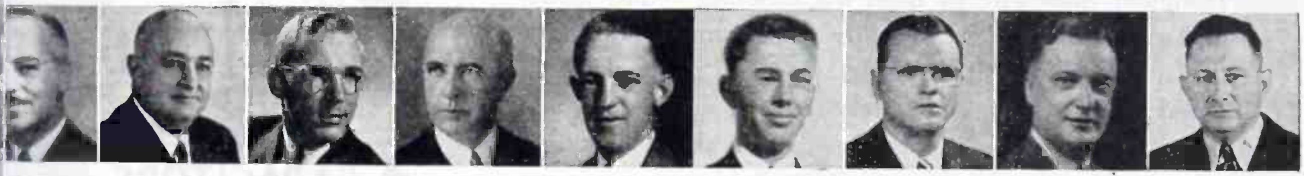

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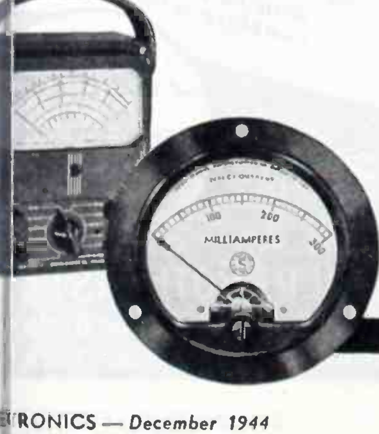

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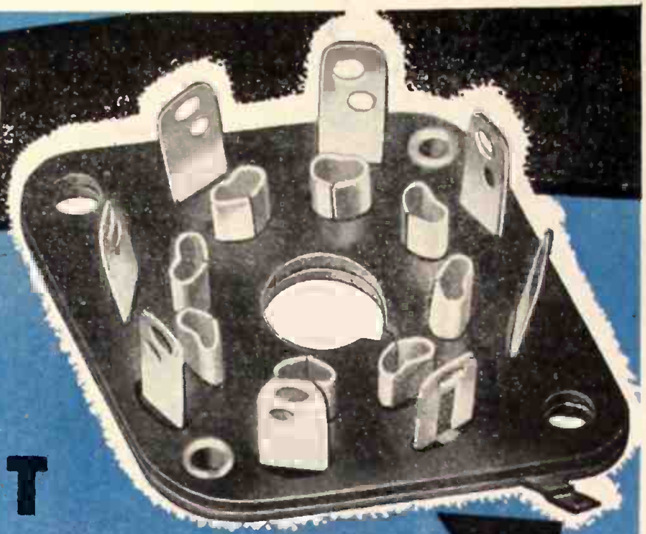

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tions and dents or bruises in the copper. Very little copper surface is exposed and the parting is in the scale itself. This kind of scaling is also recognized by the explosion-like nature with which the particles of scale fly off the specimen. This force is very great. When the specimen is left in the quench water, particles weighing only 1 milligram or less are thrown through several inches of water. We have never encountered any difficulty in distinguishing partial true scaling from the conchoidal type of scale detachment.

This test is simple and seems to be extremely sensitive to conditions unfavorable to scale adherence. Certain precautions must be observed to avoid misleading indications. For example, where several specimens are heated at the same time, one specimen containing phosphorus might affect the other specimens, so that they have the appearance of being phosphorized copper.

The furnace muffle must be free of such sublimations as are formed when copper is heated in hydrogen; otherwise erratic results will be obtained. The tools with which the specimens are handled should be clean; particularly must contact with phosphorus compounds of any kind be avoided.

Recent Investigation

When the matter of scaling tests first became of interest, we decided on heating at 850 deg c for 30 minutes because of the results described by Webster, Christie and Pratt in their paper "Comparative Properties of Oxygen-Free-High-Conductivity, Phosphorized and Tough-Pitch Coppers", A.I.M.E. Inst. Metals Div., 1933. The scaling test of different kinds of copper was first studied according to the procedure of these authors. However, the method of calculating the percentage loss of scale was changed to avoid negative values.

The tests were made on 12-gauge B&S (0.081-in. diam.) wire which had been annealed at 490 deg C for 30 minutes in a steam atmosphere. After annealing, the wire was pickled in dilute sulphuric acid washed and dried. The wire was then cut into 8-inch long pieces. These were coiled on a ½-in. mandrel and then washed free of grease

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and oil with carbon tetrachloride.

Each specimen coil was carefully weighed, and batches of 3 or 4 heated in a clean electric muffle furnace for 30 minutes at a definite temperature in a slow current of air. The coils were then quenched in water and any loose scale was rubbed off. After drying carefully, the specimens were again weighed. The scale was then pickled off with a solution of ammonium chloride, hydrochloric acid and water. After washing and drying, the specimens were again weighed.

Scale Loss

The percentage of scale loss is calculated according to the following method: Original weight = Wo, Weight after quenching = Wq, Weight after pickling = Wp. Then $Wo - Wp$ = Total Loss of Cu. This is almost all in the form of Cu_2O. Only a negligible amount of cupric oxide is formed. Average relative thickness of CuO in the total scale did not exceed 5 percent. It seems, therefore, permissible to neglect the presence of cupric oxide without appreciably affecting the accuracy of the results.

Contrary to the method of Web-

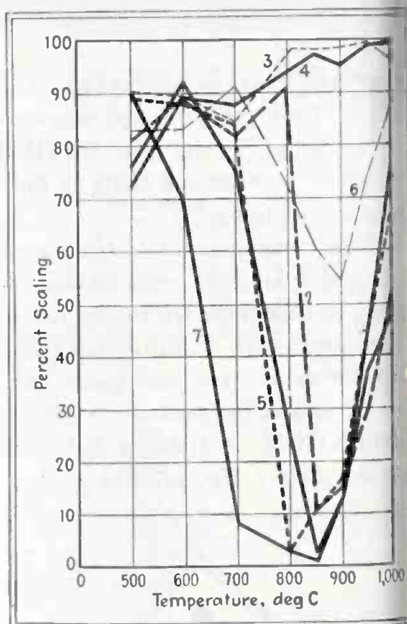

Fig. 1—Curves of percentage of scaling for several varieties of copper. Curve (1) is OFHC copper; (2) tough pitch; (3) tough-pitch deoxidized, 0.008 percent phosphorus; (4) tough-pitch deoxidized, 0.012 percent phosphorus; (5) cathode copper, plus 0.01 percent zinc; (6) cathode copper, plus 0.0015 percent phosphorus; (7) OFHC, plus 25-30 oz/ton silver

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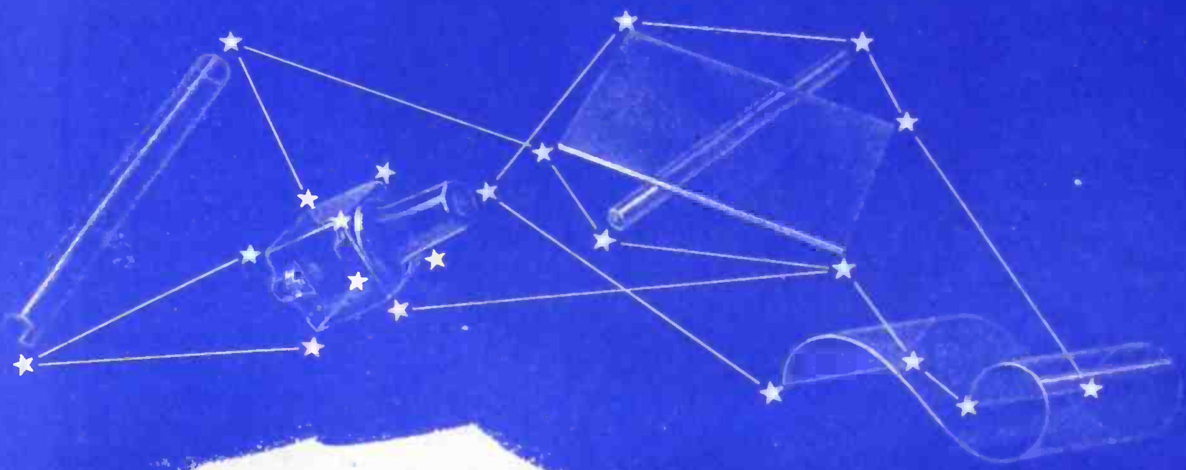

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ster, Christie and Pratt, who obtained negative values whenever Wq was greater than Wo, this method expresses perfect scale adherence by "zero percent Scaling".

Molecular Weight of Cu_2O = 127.14 + 16.00 = 143.14.

$\frac{143.14}{127.14} \times$ Total Loss of Cu = Total Cu_2O formed.

Wp + Weight of Total Cu_2O = Weight of Specimen after heating but before quenching = Wh

$W_h - W_q$ = Scale Loss.

$\frac{\text{Scale Loss}}{\text{Total } Cu_2O} \times 100 = \%$ Scaling.

The following varieties of copper were thus tested: (1) OFHC, (2) tough pitch, (3) tough pitch deoxidized, 0.008 percent phosphorus, (4) tough pitch deoxidized, 0.012 percent phosphorus, (5) cathode copper, plus 0.01 percent zinc, (6) cathode copper, plus 0.0015 percent phosphorus, (7) OFHC, plus 25 – 30 oz/ton silver.

Figure 1 shows the curves drawn from the data calculated from the tests. The plotted data are the averages obtained from the 3 or 4 specimens heated at the same time.

All the curves for copper containing no phosphorus dip to a minimum value between 800 and 900 deg C and then rise again. It is important to point out that the rise in percentage of scaling on the high temperature side of the dip is not true scaling (for instance, induced by the presence of phosphorus in the copper), but is of the conchoidal nature, caused by mechanical stresses set up in cooling. Since for a given duration the scale is thicker for higher temperatures, the rise in the curve beyond the dip may indicate that the thicker the scale the more the tendency to conchoidal shedding of the scale.

The scale formed at low temperatures on all the coppers studied is not very adherent. The change in character, as far as scale attachment is concerned, takes place over a small range of temperature and this range is probably narrower and at a lower temperature than the curves indicate. This critical range in which the change occurs is different for most of the non-scaling coppers used, with the result that there is a marked difference in the temperature range of good scale adherence between these

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coppers. For instance, OFHC plus 25–30 oz/ton silver seems to form a very adherent scale at temperatures from 700 deg to 900 deg C. Tough pitch copper, on the other hand, has a very narrow range of good scale adherence, and at no temperature reaches the degree of scale attachment of the other (oxygen-free) coppers.

Thickness of Scale -vs- Temperature

In order to ascertain the influence of thickness of scale alone and the effect of temperature only on the scale adherence, a time series was run at each of the following temperatures: 700, 750, 800, 850 and 900 deg C. The durations of heating were: 10, 20, 30, 45, 60, 90 and 120 minutes. The extent of scale formation, expressed in grams of copper that were converted to

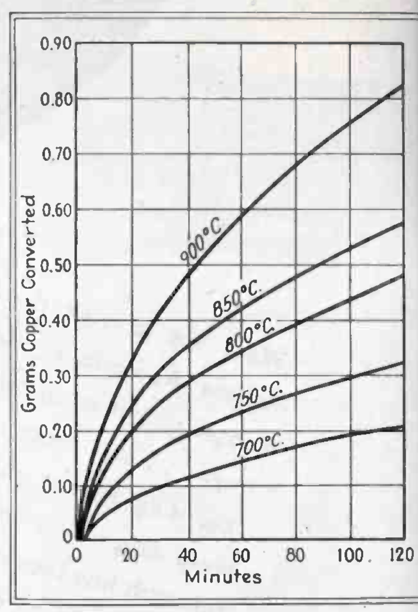

Fig. 2—These curves show the weight of copper converted to scale per sq in. of surface at various temperatures and heating times

scale, per square inch of surface, was determined in each test. It was found that for two kinds of copper tested, OFHC and tough pitch, the extents of scale formation for any particular temperature and duration were closely the same. The differences between corresponding samples of these two kinds of copper were usually less than ± 5 percent, and are due merely to experimental errors. Therefore, the data for the two kinds of copper were averaged and from the averages, the curves of Fig. 2 were plotted.

A series of scaling tests were

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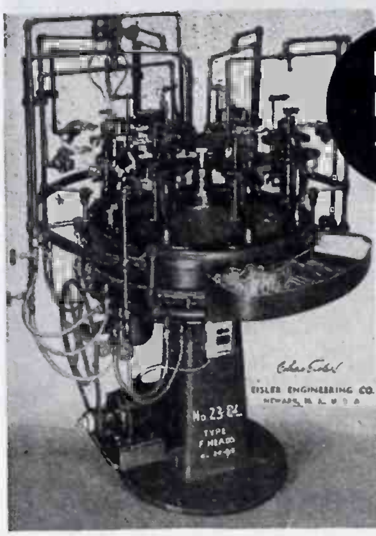

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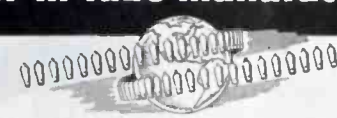

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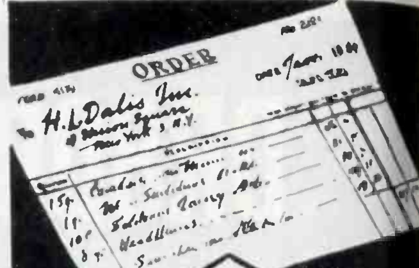

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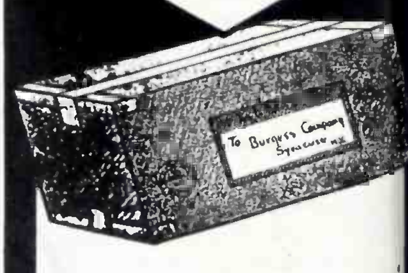

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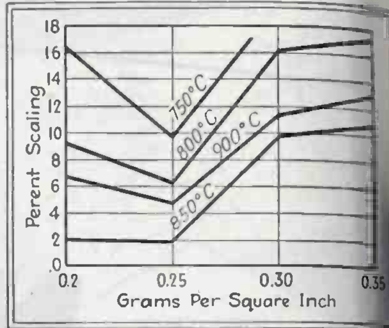

Fig. 3—Percent of scale versus weight of copper converted to scale for OFHC copper at four different temperatures

then conducted, in which specimens were heated at the proper time, for each of the temperatures, 700, 750, 800, 850 and 900 deg. C, which would form the same thickness of scale. The data obtained from these tests were plotted in two ways, percent scaling versus weight of copper that was converted to scale, and percent scaling versus the temperature. Only OFHC copper was so tested because phosphorus bearing copper showed at least 55 percent scaling for any heating period up to 2 hours and any temperature in the range 500–1000 deg C. The curves for OFHC are shown in Fig. 3 and 4.

In these curves, there is a decided dip to a minimum scaling-prcentage at 0.25 g/sq in. copper conversion (Fig. 3) and at 850 deg C—(Fig. 4). Referring to Fig. 2, the duration of heating at 850 deg C to convert that quantity of surface copper to oxide is 20 minutes.

From these findings we concluded

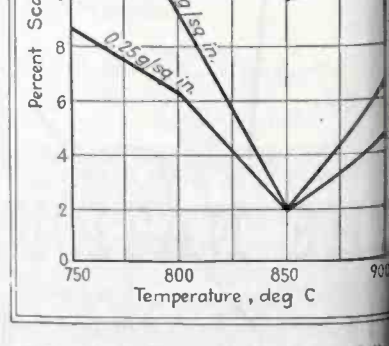

Fig. 4—Percent of scaling plotted against temperature for OFHC copper

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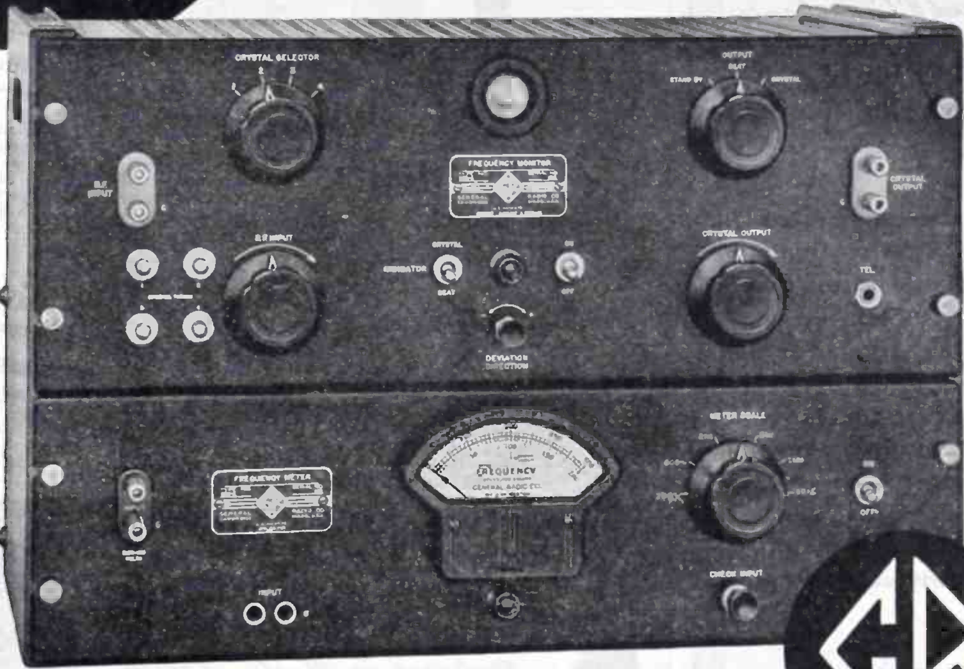

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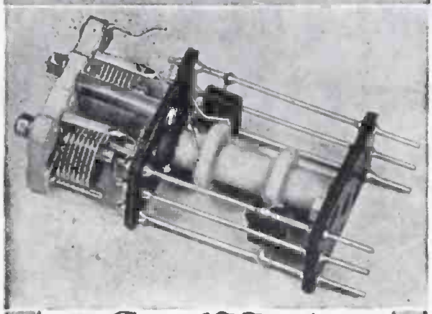

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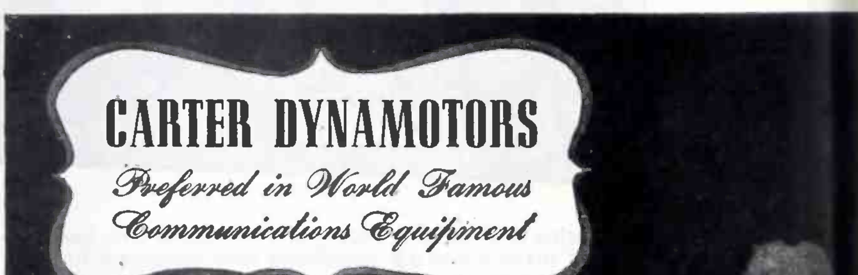

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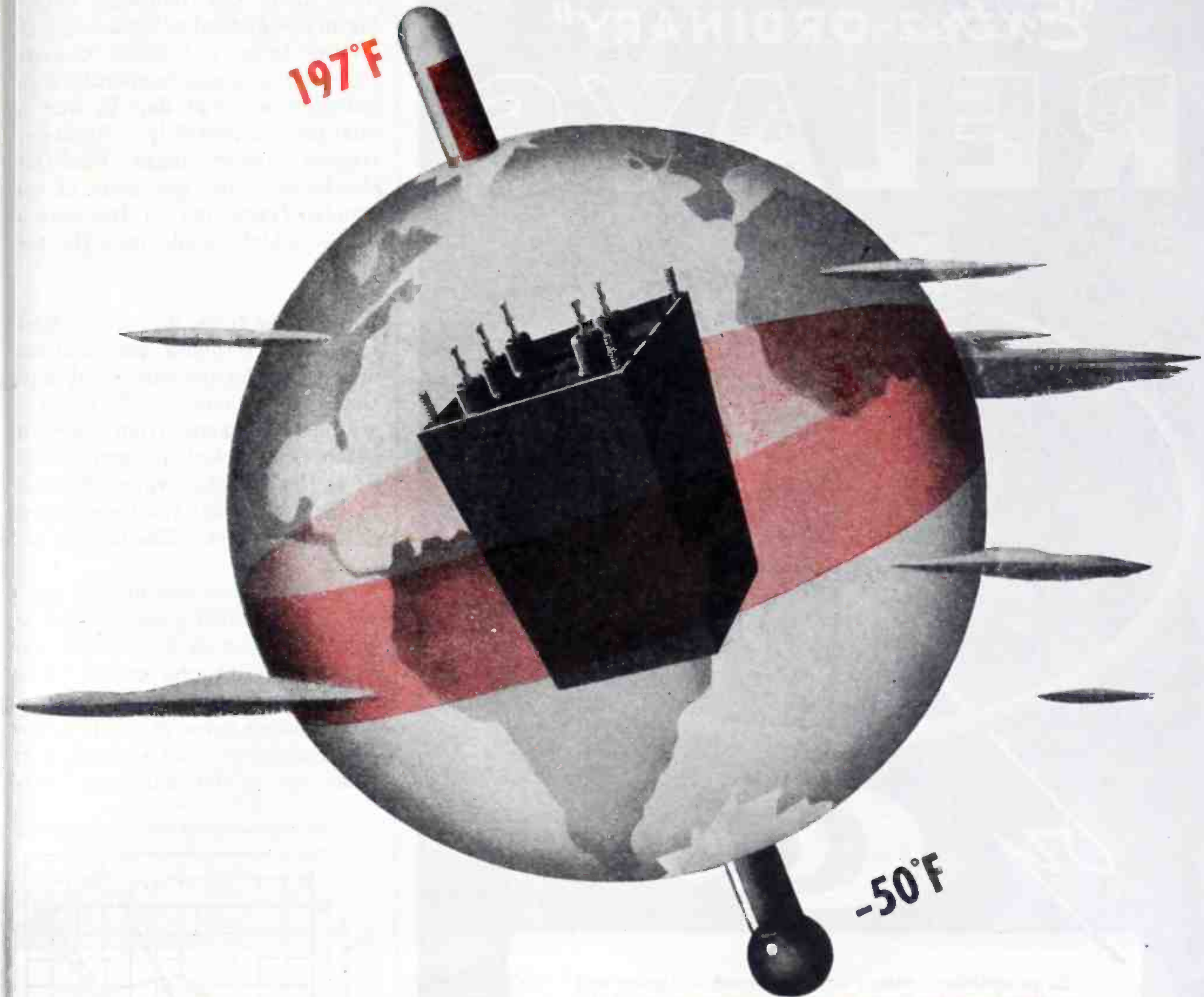

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that, under the conditions obtaining in our method of conducting the scaling tests, and using 12-gauge wire, the optimum temperature and duration are 850 deg C, and 20 minutes, respectively. Specimens treated under these conditions should show the minimum of conchoidal fracturing in the case of copper which should pass the test.

Conclusions

In all the tests, 3 or 4 specimens were treated under identical conditions of temperature and duration. Only small differences in scaling specimens from the same batch were noted at temperatures up to the dip and larger differences in the conchoidal fracturing range of temperatures. The plotted data are averages.

A duration series at 850 deg C was run on OFHC and tough-pitch coppers. The data obtained were plotted; giving the curves shown in Fig. 5. The differential in scale adherence in favor of OFHC copper was indicated in all tests at durations up to 60 minutes. After

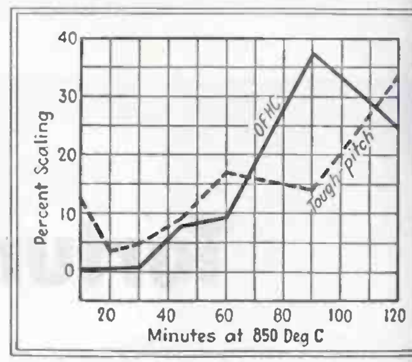

Fig. 5—Percent of scaling produced on OFHC and tough-pitch copper at 850 deg C for various heating times

longer heating periods, the curves cannot be considered reliable, as fairly large variations between specimens of the same test run occurred in this range. This is understandable if one considers the explosion-like nature of scale detachment when the thickness of the scale is heavy. It is a matter of chance whether scale particles detached in such a violent manner are small or large.

We have found that there is no essential difference in the results obtained with hard or soft copper in the scaling tests. Annealed copper of the various kinds tested were available when this investigation

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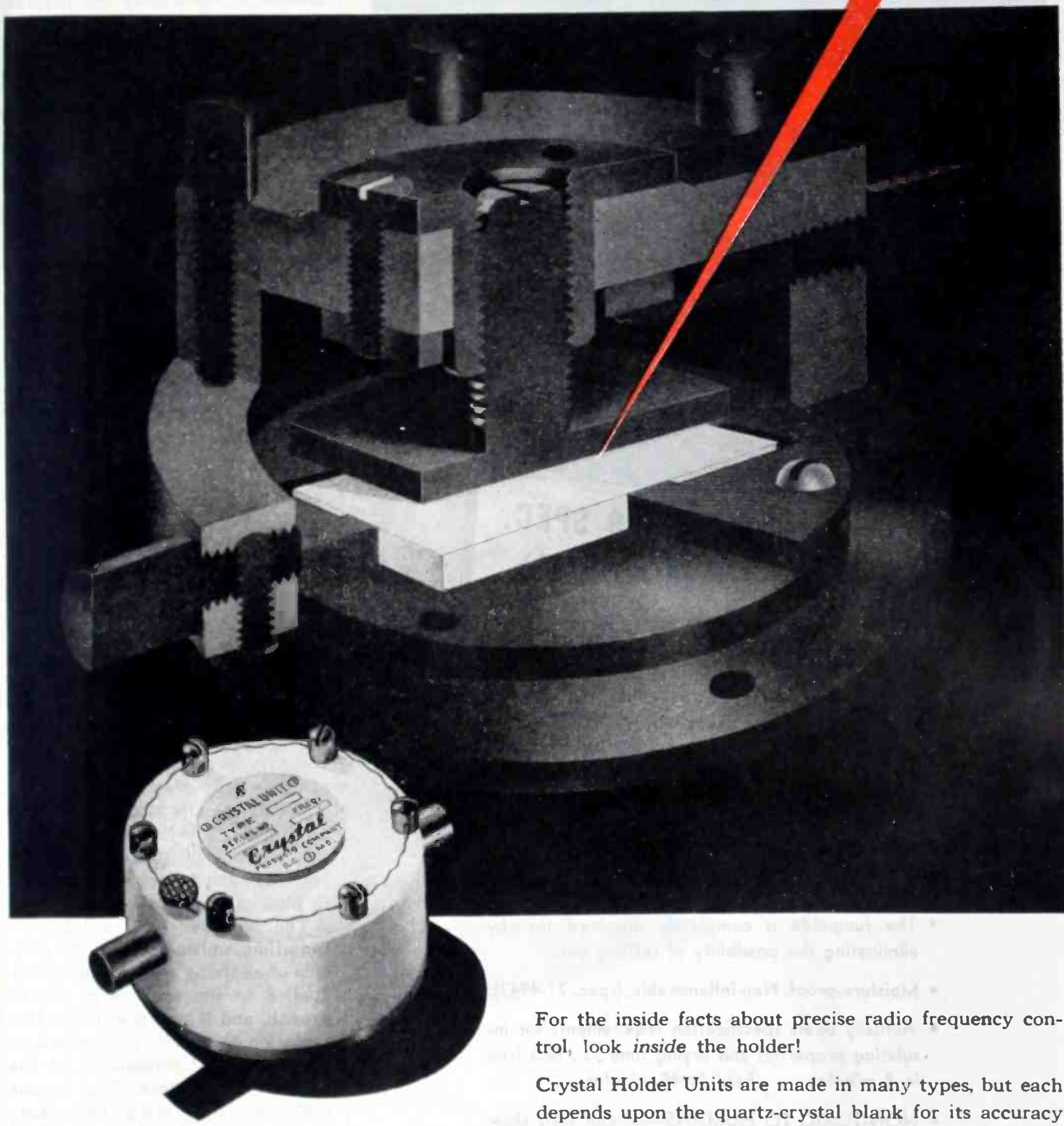

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We are well aware that the method of calculating the percentage of scaling ignores the penetration of oxygen into the copper, and that the scale is not pure cuprous oxide. However, there is little likelihood that anyone making scaling tests would be interested in any more than the indications derived from visual inspection. Small errors in calculating the data from these tests have no particular practical significance.

The writer wishes to express his indebtedness to the management of the United States Metals Refining Co. for permission to publish this paper, and to Messrs. H. M. Schleicher and Max Heberlein for their greatly appreciated help and advice given during the investigation.

• • •

A Neon-Counter for Medical Research

By O. CAMERON GRUNER

McGill University, Montreal, Canada

IT HAS LONG BEEN supposed that the blood is different in cases of cancer from that of other diseases, and from that of a healthy person. A reliable test for cancer has long been sought, and over one hundred and fifty have been devised. Some of these depend on chemical, some on biological, and a few on physical differences. The last named may be the best one because the chemical reactions can be traced ultimately to physical constitution.

The discovery of mitogenetic radiation, emitted during the division of all living cells, was naturally applied to the problem of cancer growth, and it was found that this radiation is definitely increased in the tissue, but diminished in the blood of the patient. That means that a person suffering from cancer has lost something from his blood which is present in health—something in the form of radiation.

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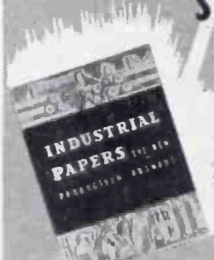

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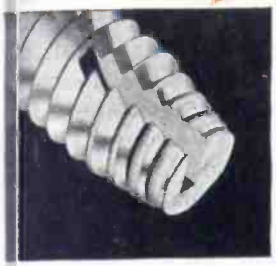

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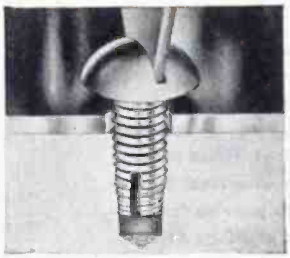
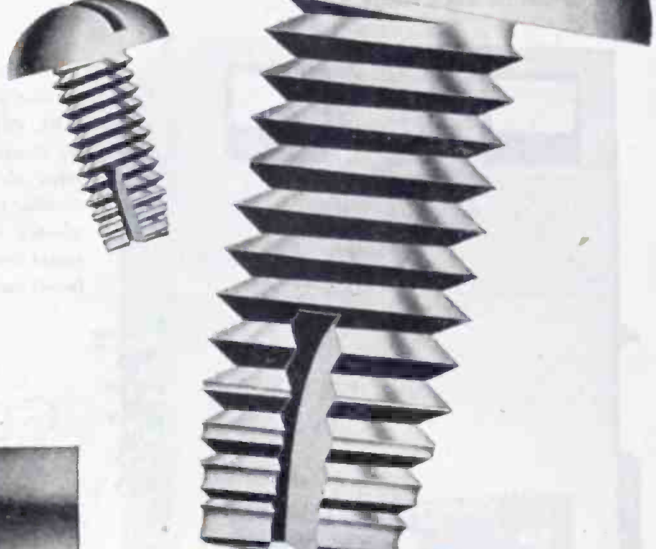
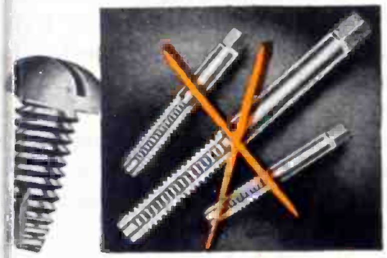


2 As each Type 1 is driven, it cuts its own perfect mating thread.





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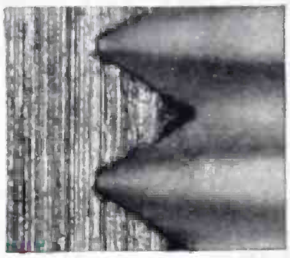
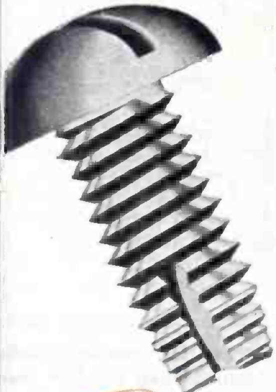
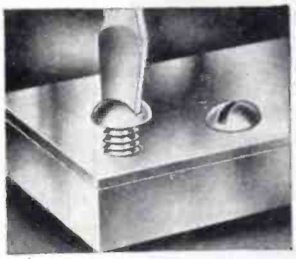


4 Snug, tight fit *always*, because each screw remains in the thread it has cut itself.





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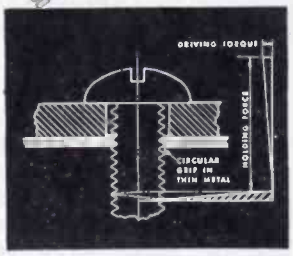

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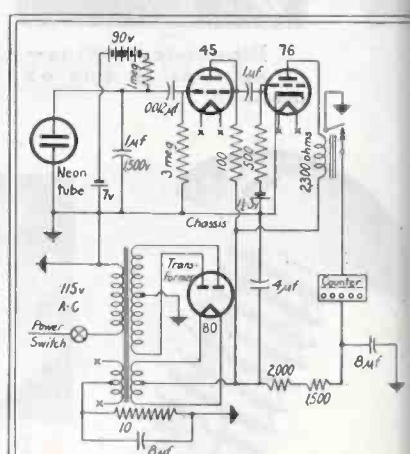
available for laboratory medicine—such as the electrocardiograph, the electro-encephalograph, audio-frequency measuring instruments, not forgetting the electron microscope, suggests that something might be devised for detecting radiations of the kind referred to above.

The Geiger counter has failed to reveal conclusive evidence of these radiations, but it was thought that a neon counter might serve the purpose. In ELECTRONICS for July, 1937, a short note by Stager was published, entitled "Relaxation Circuit Measures Radiant Energy", which suggested a device that might prove useful. In this circuit, the neon lamp charges and discharges as the potential accumulates. If the material to be studied emits a radiation which adds to the potential, the beats of discharge will become more frequent; if the material interferes with the accumulation of potential, the beats will slow down.

Technique

The accompanying diagram shows the circuit of the electronic equipment used in the experiments. The material to be studied was exposed to the neon lamp by arranging a small stage over the lamp so the specimens could be placed on the platform. The blood was usually



Electronic circuit for counting flashes of a neon lamp. When blood or tissue is exposed to the neon bulb, a change in the rate of flashing occurs

collected in moderately large drops on a microscope slide which, when dry, was inverted so that there was no screening action caused by the slide itself. A quartz slide was sometimes used, especially if a portion of an agar culture was to be studied. In this case, the microbes or mold

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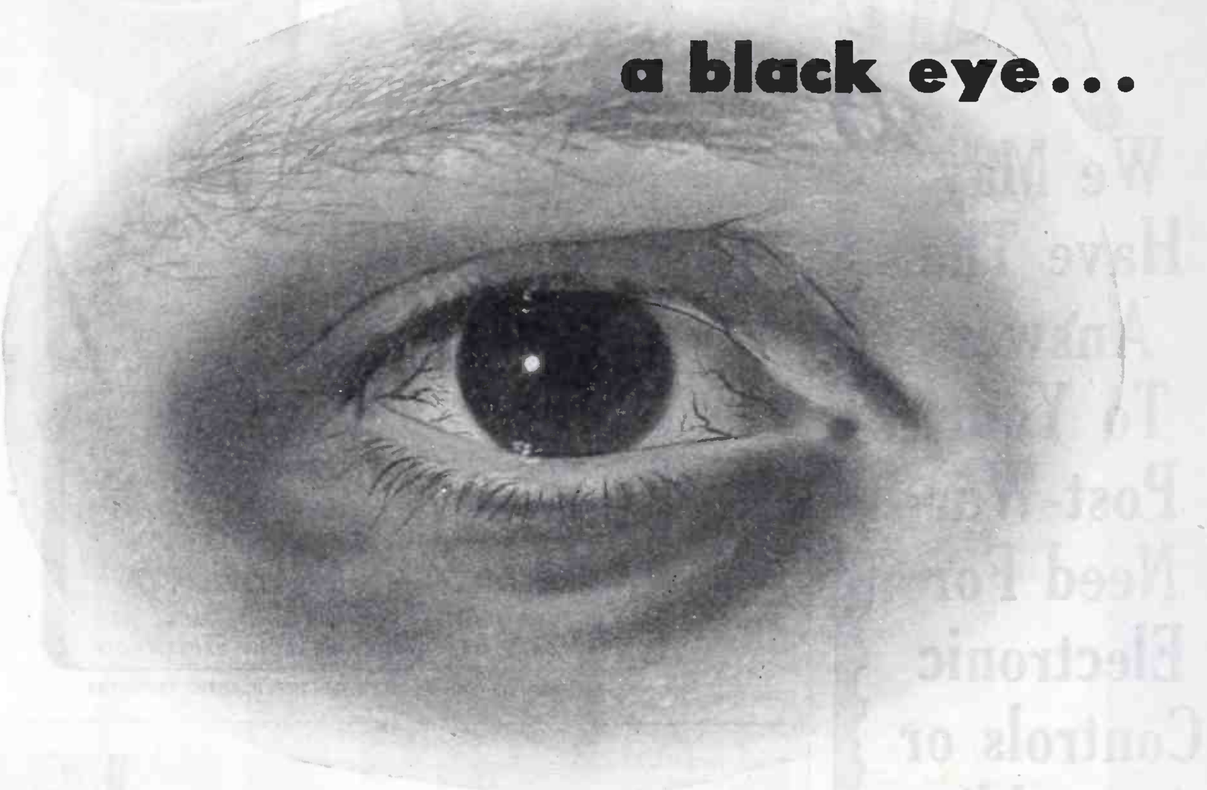

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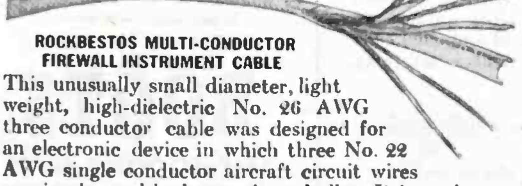

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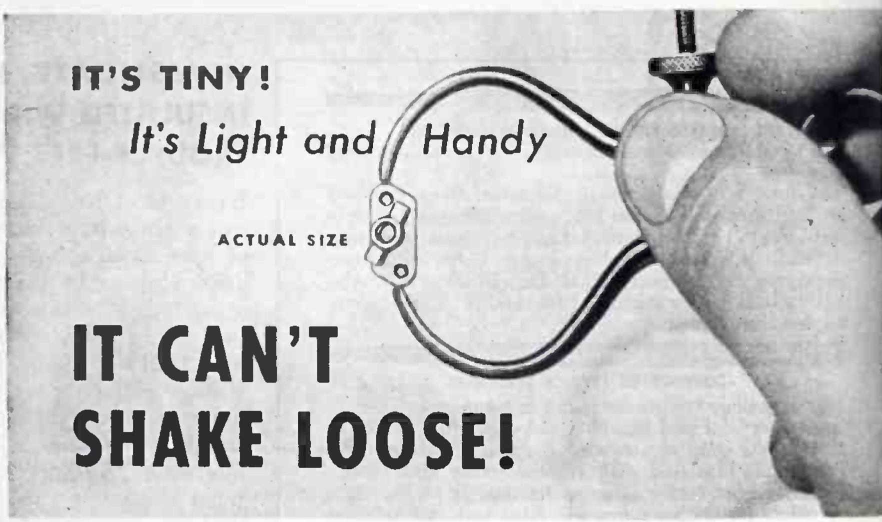

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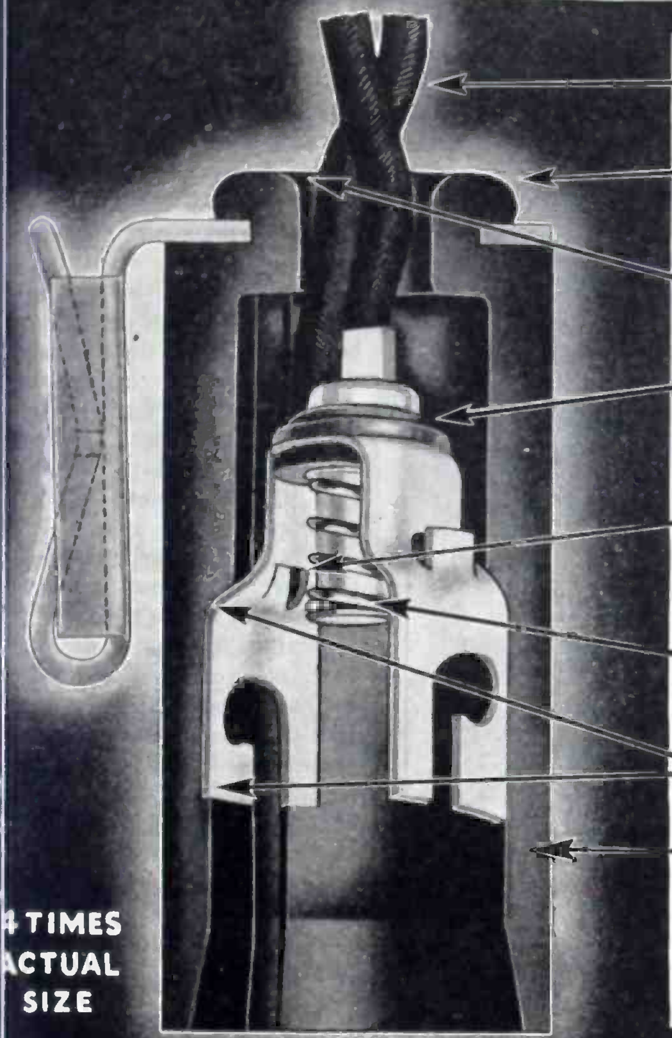

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was removed from an ordinary culture tube and placed on the slide.

Specimens of fluid blood were examined in the Kimble tube in which they were collected. Broth cultures of organisms in Pyrex-glass tubes could also be accommodated over the same stage. Mice, small rats and living tumor could be similarly placed. The neon lamp and stage assembly were enclosed by a lead cylinder topped by a lid of the same material.

The results of study have been of considerable interest. Healthy blood, and also blood from persons not suffering from cancer, slows down the number of beats per five minutes. The blood of cases with cancer increases the number of beats, and when the disease is under control (surgery, x-rays, radium), the number slows down again. Tumor tissue (experimental) raises the rate, which shows that the phenomenon is not in the same category as that of mitogenetic radiation, for with the neon-counter, the blood produces the same effect as the tissue.

Similar results are obtainable with blood-smears, and also with formalin-fixed cancer tissues, so that the phenomenon may be one of resonance—a change in potential being induced from a source of changing potential. This is in harmony with the discovery that Pfeiffer's crystallization test would materialize even if the specimen tested were at definite distances from the test-fluid.

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THE JAPANESE, at one stage of their war with China, paid a bounty of $2,000 for each captured Chinese Signal Corps officer and $500 for each enlisted signalman, according to Captain Hung-Yen Lo, of the Chinese Army Signal Corps, now on detached service at Camp Crowder, Mo.

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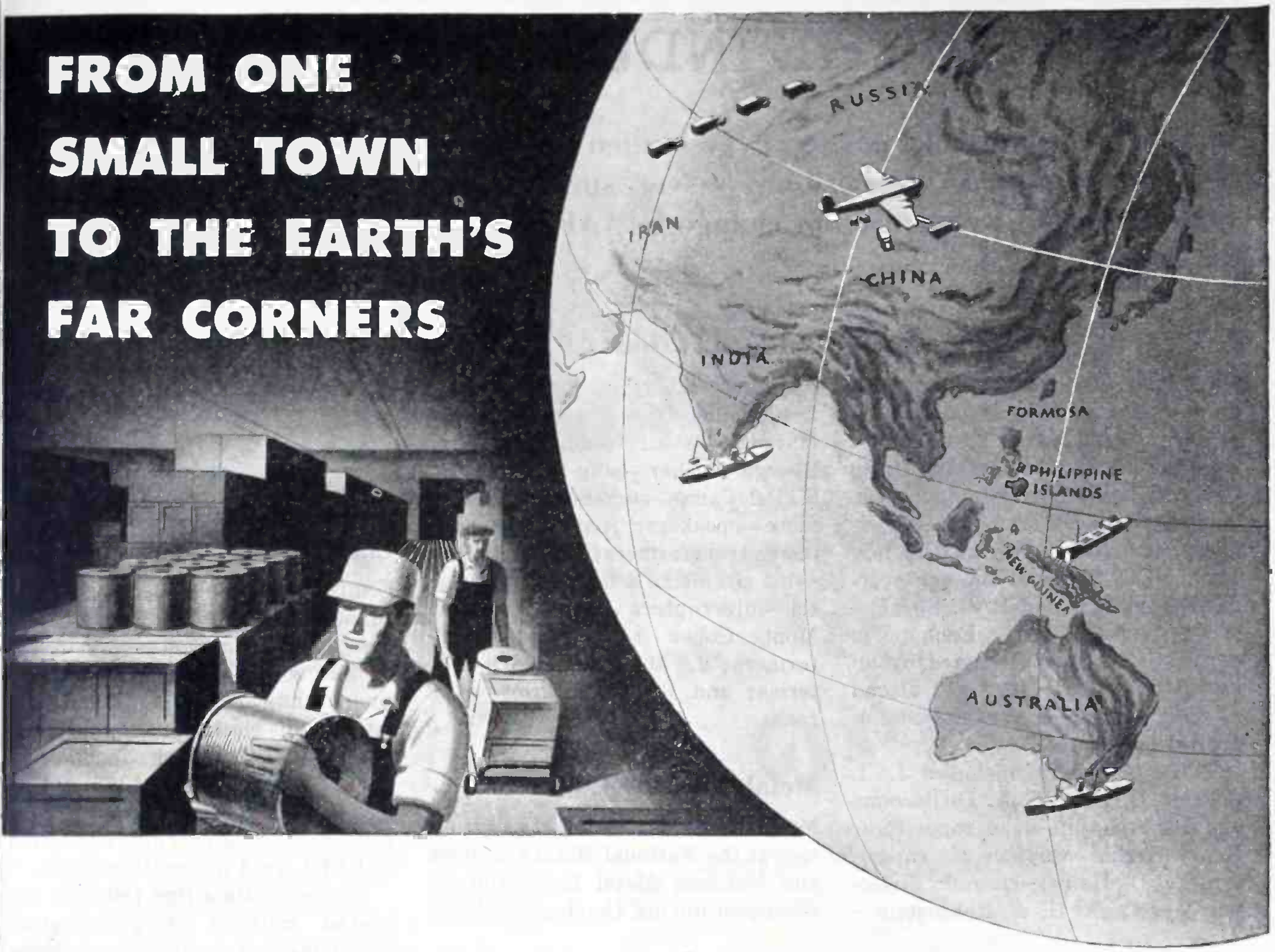

OUT to the Far East, to ports on the seven seas identified only in code on the packing cases, goes war material so vital that it is needed on every beachhead and before the beachhead is created—poured out of *one* shipping room in just *one* factory in just *one* small Connecticut town!

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Employment outlook postwar; Fessenden archives; conference notices; television receiver survey; f-m station for FCC; organization change in AAF; figures on output

Toward Parts Standardization

EXTENSIVE STANDARDIZATION of radio components for postwar civilian production is planned by the RMA Engineering Department and Parts Division. Arrangements have been made for cooperation between company executives under the direction of W. R. G. Baker of the engineering department and R. C. Sprague of the parts division. Each parts section is to be represented by an executive member who will attend meetings of the engineering standardization groups.

These members include: J. I. Cornell, H. E. Rice, A. DiGiacomo, and Louis Kahn—fixed capacitors; Henry Sarkis—variable air capacitors; J. D. Heibel—ceramic dielectric capacitors; H. W. Rubinstein—volume controls; D. S. W. Kelly—fixed composition resistors; Jesse Marsden — wire-wound resistors; George Mucher—plug-in resistors; S. Del Camp—sockets; W. A. Ellmore—speakers; Arni Helgason—power transformers; Henry Richter—h-f circuit switches; H. M. Dressel—interrupters and rectifiers; Monte Cohen—r-f and i-f transformers; L. M. Temple—dry batteries; and P. K. McElroy—relay racks.

Metal-Working Electronics

MORE THAN THIRTY of the exhibitors at the National Metal Congress and National Metal Exposition in Cleveland during October displayed various types of electronic apparatus related to the production, fabrication, and testing of metals and metal products. In addition, a number of technical papers on electronic subjects were presented at meetings of the sponsoring groups: American Society for Metals, American Institute of Mining and Metallurgical Engineers; American Welding Society, Society for Experimental Stress Analysis, American Industrial Radium and X-Ray Society, and the Metal Powder Association.

HAM SHACK DE LUXE

Curtains and all, this ham shack has been established in Chicago as a tribute to the 25,167 radio amateurs in the armed forces of the Nation. Formerly opened by sponsoring Hallicrafters Co., the shack was the scene of this ceremony as Cyrus T. Read of the company and ARRL, left, and Carol K. Witte, acting communications manager of ARRL, right, examine the service flag presented by Chet Horton, member of the Hamlesters Radio Club

For Engineering Curricula Changes

ENGINEERING COURSES are better adapted than those in liberal arts to give a broad understanding of the modern world. So said Allan Hazeltine, technical consultant and professor of electrical engineering, Stevens Institute of Technology, during a talk at the 52nd annual meeting of the Society for the Promotion of Engineering Education (SPEE) in Cincinnati recently.

Professor Hazeltine felt that improved methods of presentation might make it possible to condense the full equivalent of a four-year course in general engineering into three years and permit the addition of other courses of instruction not now given.

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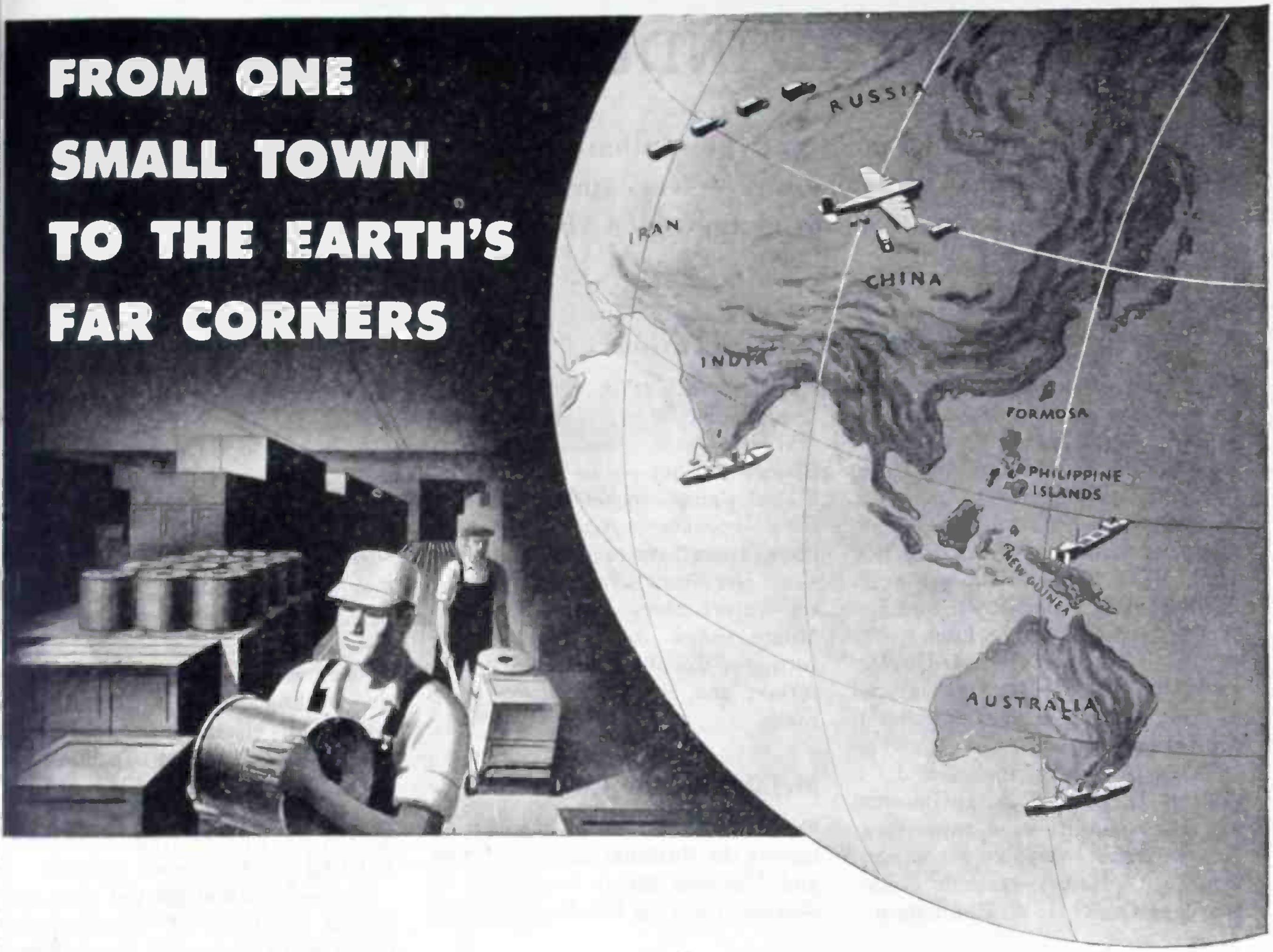

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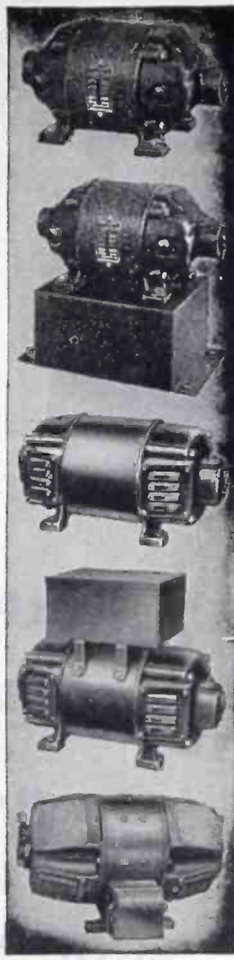

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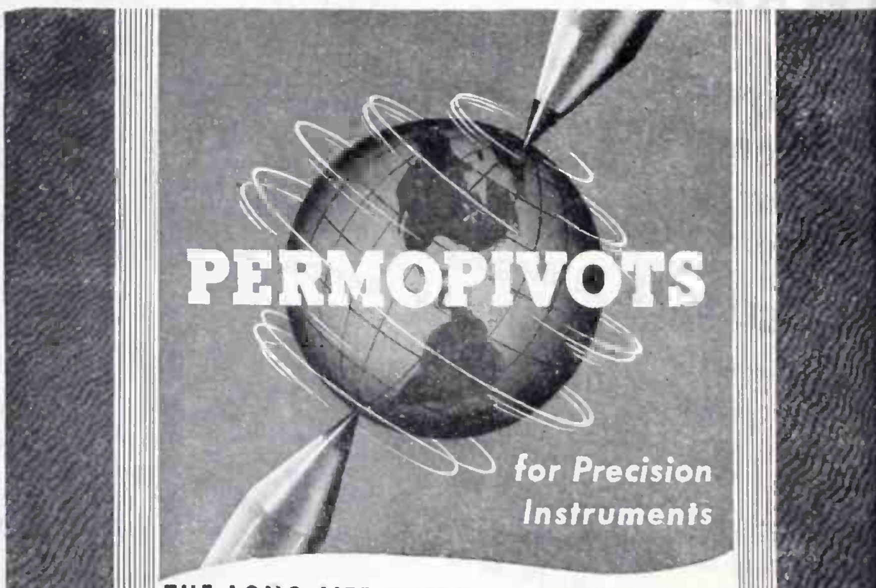

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Write Today for Complete Information

PRODUCTION "*Muscles*"...

FOR THE TASKS OF PEACE

WARTIME EXPERIENCES have developed production "muscles" for the communications industry that will be used to excellent advantage in the tasks of peace. With our customers, old and new, we have enjoyed a relationship that points clearly to the road to peacetime production. For instance:

1 **Our Old Customers Learned** that Sickles production facilities were flexible and versatile. Conversion from peacetime to wartime production was quick and effective. Quantity was stepped up rapidly. Quality was maintained.

2 **Our New Customers Learned** that it is practical to sub-contract parts and components to Sickles. To many of them, this was a new experience. We expect them to continue to profit from that experience in peacetime.

3 **Sickles Learned** that our foundation for such production was sound. In three years, we have gained additional experience that must be the equivalent to that of ten years. Reconversion to peacetime production will be smooth. Our facilities will help our customers to deliver the goods of peace as they did the weapons of war.

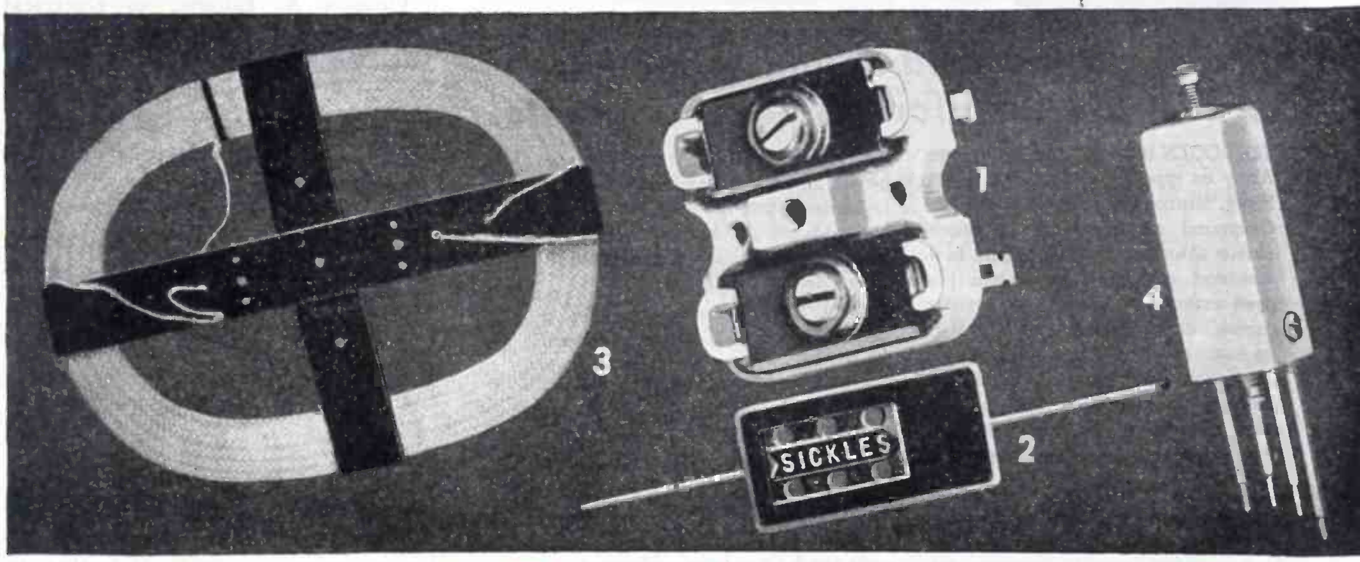
So our postwar plan is extremely simple. It is to continue to serve our customers in meeting their specialized needs for performance, quality, quantity and low cost. To us, that program seems sound. Can we help you now, to plan *your* postwar production "muscles"?

SOME SICKLES FIRSTS

1. 1933—Dual Mica Trimmers*
2. 1936—Silver Cap Condensers*
3. 1940—Low-loss "Ripple" Loops*
4. 1941—Midget I.F. Assemblies
5. 194V—More Coming

* *Patented*

THE F. W. SICKLES COMPANY • CHICOPEE, MASSACHUSETTS



SICKLES

Radio and Electronic Specialties for Today and Tomorrow given to circuit theory, Fourier theorem for steady and transient conditions, network synthesis, electron tube circuits, transmission lines, and wave guides.

Concerning the educational requirements for the production engineer, Dr. J. A. Hutcheson of Westinghouse Research Laboratory suggested that academic training is merely the first step in the development of a production engineer. After getting a foundation in the theory and application of electrical engineering, the production engineer-to-be must acquire a knowledge of properties of materials and gain the ability to design equipment which satisfies mechanical requirements. At Westinghouse, he pointed out, a single engineer is given the responsibility for design, production, and testing of the apparatus he develops. This makes it necessary for him to carry out or direct all of the operations which may be necessary in conception, design, engineering, manufacture, maintenance, and sale of the particular equipment.

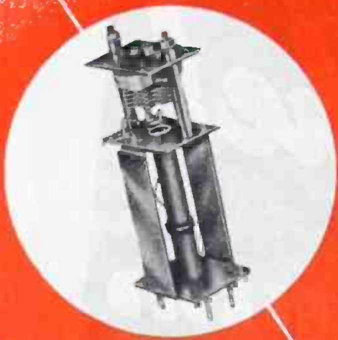
Fessenden's Papers Available

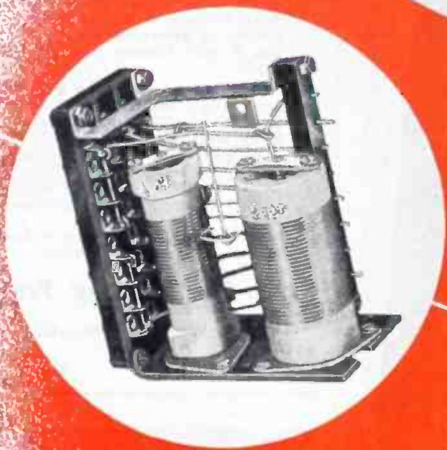
THROUGH A GIFT to the North Carolina State Department of Archives and History, papers of the late Professor Reginald A. Fessenden are made available for the first time for scholarly investigation. Fessenden, who served as head chemist with Thomas A. Edison, as electrical engineer with the United States Co., and was connected with the Stanley Company, has left data related to wireless telegraphy and signalling; position determining of vessels at sea; multiplex telegraphy; an invisible submarine periscope; sound detectors for aircraft; equipment for generating and storing power from the sun's rays and other subjects.

An Electronic Monument

INSTEAD OF AN UNFUNCTIONAL STATUE of a man on horseback, Brig. Gen. Frederick H. Kisch will be memorialized by the building of a laboratory in Haifa, Palestine, to house facilities for electronic investigation and instruction.

Gen. Kisch, who was killed in action in the Tunisian campaign, served as chief engineer in Mont-






A MIGHTY MITE is he!

RED-HEADED RUBBER FUSE BLOCK

MADE BY

JOHNSON

This wee bit of a redhead is our engineer's answer to another rubber problem — it is a rubber fuse block for Littlefuse Incorporated and a very important part of a plane. • Starting out as a regular piece of rubber, it acquires a bright red head, a head that is actually the same piece of rubber as its black body and will not fade or detach from it. • It holds two fuses, one on each end. When installed in a plane, the red end is inserted first, leaving the other end exposed to view. When number one fuse is burnt out, the pilot reverses the ends, thereby obtaining a new fuse, then the red end is exposed to view. • When plane lands this fuse block speaks for itself for the red end, a warning signal, indicates to all mechanics that a fuse is burnt out on the ship and needs a replacement. • It not only functions as a danger signal but carefully cushions the fuses, protecting them and absorbing the vibrations.

If you have a problem, let us have it; we welcome the difficult ones.

JOHNSON RUBBER CO.

Middlefield, Ohio U.S.A.

RAPID

METAL-COATING PROCESS

- FAST AND ECONOMICAL
- FOR HEAVIER COATINGS

REQUIRES ONLY RAPID ELECTROLYTE—RAPID METAL CLEANER—RAPID APPLICATOR

- Plating current is obtained from dry cells, storage battery, or any convenient source of direct current at 3 to 6 V., or use Rapid Plating Rectifier for heavy work.
- For silver surfacing bus bar connections, lugs, switch blades, etc. For plating or touching up miscellaneous surfaces with cadmium, nickel, zinc, copper and gold. Building up limited areas. Hard surfacing with nickel. Used in shop or field. Special applicators designed to speed up production line jobs.

Our laboratory is glad to cooperate. No obligation

Rapid Electroplating Process, Inc.

1414 S. Wabash Ave., Chicago 5, Ill.

621 Graybar Bldg. New York, N. Y.

237 Rialto Bldg. San Francisco, Calif.

STANDARD or SPECIALLY DESIGNED

CAPACITORS

For the past 15 years Girard-Hopkins have built standard and specially created capacitors, designed to meet the most exacting climatic and technical conditions. Our line includes every stock type of capacitor for normal needs —Increased manufacturing capacity and a highly trained engineering staff enable us to quickly build and deliver specially designed capacitors to your specifications. Consult us on your present and post-war capacitor problems for either wax or oil types.

GIRARD-HOPKINS

1000 40th Ave.

OAKLAND 1 CALIFORNIA

History of Communications. Number Nine of a Series

MILITARY COMMUNICATIONS BY TELEPHONE

During the Spanish-American War the telephone as a means of electronic voice communication met with favor and played a vital part in military action for the first time. Replacing men and horses, a telephone message could cross and recross enemy territory by wire without delay and cost of life.

Today, telephones in the office and home life of the average American have been an instrumental force in our higher standard of living.

Universal, manufacturing microphones and other voice communication components for the allied forces, will again after Victory is ours, stock dealers' shelves with the Universal components you have been waiting for. Until then — *Buy War Bonds.*

Model T-45, illustrated at left, is the new Lip Microphone being manufactured by Universal for the U. S. Army Signal Corps. Shortly, these microphones will be available to priority users through local Radio Jobbers.

UNIVERSAL MICROPHONE COMPANY

INGLEWOOD, CALIFORNIA

EIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA ·· CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA gomery's British Eighth Army. His monument is proposed as an addition to the Hebrew Institute of Technology, of which he was a trustee, and funds for the undertaking are being raised by the American Society for the Advancement of the Institute.

Backed by some of the most prominent people in the U. S. radio industry, the American group has planned to make the Institute into a leading technical school. During the war years alone, more than 1200 engineers and technicians, trained at Haifa, have distinguished themselves in the service of the United Nations.

Full Employment in Electronics

POSTWAR VOLUME in the electronics industry will be $3 billion, in the opinion of Benjamin Abrams, president of Emerson Radio & Phonograph Co., who compares it with a prewar standing of $350 million. Under these conditions he feels that not only will former employees back from the fronts have constructive jobs open to them, but there will also be a need for half a million more people.

Considering the training which has been given to men by the Signal Corps, every effort should be made to channel such qualified personnel into installation and servicing activities which will be contingent to a rapid expansion of production. In units, he points out that current demand for radios is in the 25 million set bracket with an additional normal requirement of 12 million. Large export quantities must be added to that. Before the war, the industry had a capacity of 16 million receivers a year.

Electronics Training Course

BASIC PRINCIPLES and applications of electronics in industry is the topic of a new training course which has been prepared by Westinghouse Electric & Manufacturing Co. Designed originally for company employees, the sound slide films, lesson books, quiz books, and instructor's manual are available to others at reproduction costs.

Subjects covered include: electronics and the electron theory of matter; electron movement during

current flow through metal conductors; emission of electrons and their controlled flow through vacuum and gases; theory of rectification by vacuum tubes; Kenotrons—high-voltage, low-current rectifiers; how gas in a tube neutralizes space charge; gaseous rectifier tubes; electronic amplification; electronic generation of high-frequency ac; electronic oscillators for radio and carrier-current transmission; basic circuits for electronic control; industrial applications of electronic regulation and control; electronic conversion of light into electricity and electricity into light.

West-Coast Conference

To DEMONSTRATE that Pacific-Coast electronic manufacturers are no longer assembly firms, but now engaged in actual manufacture, two days during August were devoted to the first annual Electronics Industry Show in Los Angeles. Sponsored by the West Coast Electronics Manufacturers' Association, the event featured an equal number of participants from both the San Francisco and Los Angeles councils of the organization. The roster of WCEMA has now reached 55 memberships.

New RMA Members

ADDITIONS TO THE MEMBERSHIP of Radio Manufacturers Association have been announced as: Arpin Mfg. Co., Airadio Inc., C. G. Conn Ltd., Fada Radio & Electric Co., Harvey Radio Labs, and Ohmite Mfg. Co.

Television Receiver Intentions

ACCORDING TO A SURVEY run off among several hundred metropolitan New Yorkers for Allen B. DuMont Laboratories, six out of every ten persons postponing the purchase of a television set say they will buy one within three years after the conclusion of the war.

Interviewees were shown two half-tone pictures with screen equivalents of present and suggested future television definitions. Six out of ten said the difference was immaterial and would not cause them to put off buying receivers in anticipation of such an

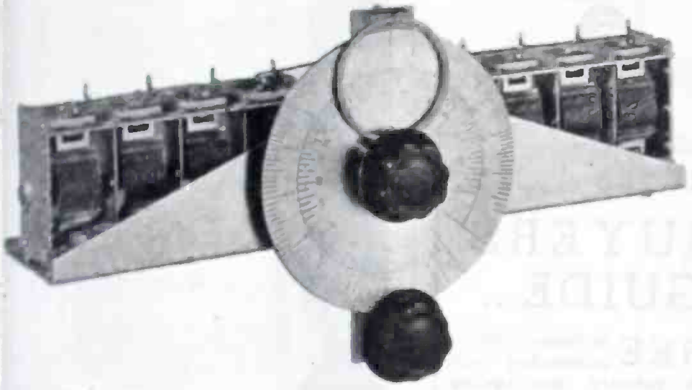
A NEW -*hp*- AUDIO OSCILLATOR

3 *OUTSTANDING NEW FEATURES:* 1. ACCURATE CONTROL DIAL

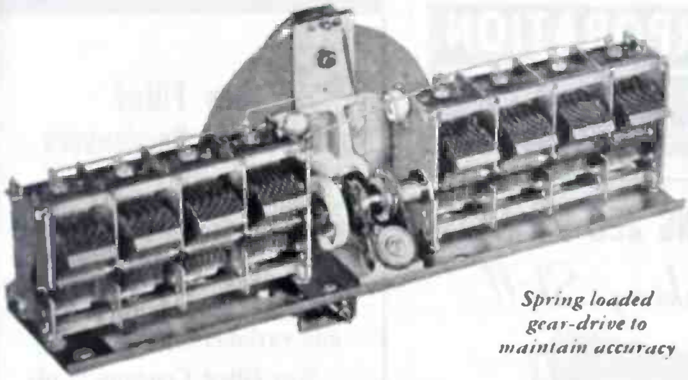
EASY TO READ • NO PARALLAX

2. RUGGED CONSTRUCTION

3. IMPROVED CIRCUIT



New friction driven dial provides hair-line accuracy



Spring loaded gear-drive to maintain accuracy

Rugged chassis construction on heavy cast frame

The Model 200-I is a resistance-tuned audio oscillator designed to provide high stability and accuracy for use in frequency measurements. It has a range from 6 cps to 6000 cps,* divided into six frequency ranges as follows: 6 to 20, 20 to 60, 60 to 200, 200 to 600, 600 to 2000 and 2000 to 6000 cps. Each of these ranges has an individual frequency adjustment so that the instrument may be set to a frequency standard such as the -*hp*- Model 100-B.

The large, 6-inch diameter, main frequency dial is calibrated over approximately 300 degrees, making possible a large number of calibrated points to cover the entire range. The dial itself rotates behind a fine wire locator which is visible through an opening in the panel. Parallax is completely eliminated and calibrations are spread over an effective scale length of nearly eight feet. Fast and extremely accurate settings are made easily with this dial. There are two manual controls: one direct action, and the second for vernier adjustments. An electronically regulated power supply is included to assure greatly improved stability.

The Model 200-I -*hp*- Audio Oscillator is but one among many new -*hp*- instruments which are to make public appearance as the cloak of military secrecy is removed. Preliminary technical information is available on this instrument now . . . write for it! And watch for the early release of other new -*hp*- instruments.

**This frequency coverage was selected for interpolation work. Other frequency ranges can be supplied from 6 cps to 100 kc on special order.*

HEWLETT-PACKARD COMPANY

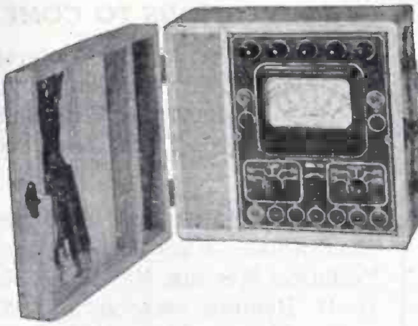
P. O. Box 930 A Station A, Palo Alto, California

930

ALL FOUR MODELS DESCRIBED ON THIS PAGE ARE NOW AVAILABLE FOR TEN-DAY DELIVERY ON PRIORITY OF AA-3 OR BETTER

THE MODEL 710

VOLT-OHM-MILLIAMMETER



* Sensitivity 1,000 ohms per volt on both A.C. and D.C. * Direct reading. * Completely self-contained. * No external source of current required.

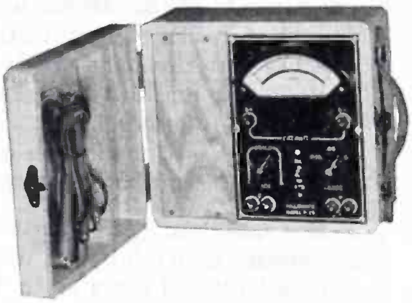
SPECIFICATIONS:

6 D.C. VOLTAGE RANGES: 0 to 15/60/150/300/600/1500 Volts
6 A.C. VOLTAGE RANGES: 0 to 15/60/150/300/600/1500 Volts
7 D.C. CURRENT RANGES: 0 to 3/15/50/150 Milliamperes
0 to 3/15/30 Amperes
A.C. CURRENT RANGE: 0 to 3 Amperes
5 RESISTANCE RANGES: 0 to 1,000/10,000/100,000 ohms
0 to 1 Megohm 0 to 10 Megohms

The MODEL 710 comes complete with cover, self-contained batteries, test leads and instructions. Size 6" x 10" x 10". Net weight 11 pounds. Price......... $34.50

THE NEW MODEL P-25

MEASURES: SWITCH RESISTANCE, CONTACT RESISTANCE, FRACTIONAL OHM STANDARDS, ETC. INDISPENSABLE IN THE QUANTITATIVE ANALYSIS OF ALLOYS BY THE RESISTANCE CHECK METHOD; INSURES RAPID ACCURATE BOND TESTING!!!



RANGE:
.00005 OHMS TO .5 OHMS

FEATURES:

- Operates on self-contained battery—no external source of current required.
- Mirror scale on meter eliminates paralax enabling extremely accurate readings.
- Linear scale.

SPECIFICATIONS:

- Accuracy—1% or better *at any point.*
- The built-in standard resistors are all of the 4 terminal type and are individually adjusted to an accuracy of ½ of 1%.
- Circuit employed is exclusive adaptation of the potentiometric method of low resistance measurement.

Model P-25 Milliohmer comes complete with battery, all test leads and instructions. Price $49.50

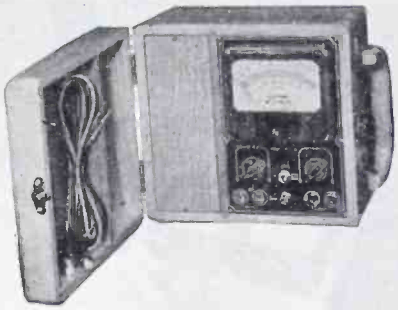
$49.50

THE MODEL 610-B

MEG-O-METER

A NEW BATTERY-OPERATED

INSULATION TESTER!!



INDICATES LEAKAGE UP TO 200 MEGOHMS AT A TEST POTENTIAL OF 500 VOLTS D.C.

NO HAND CRANKING:
The 500 Volt Test Potential is made instantly available by throwing the front panel toggle switch.

DIRECT READING:
All calibrations printed in large easy-to-read type enabling exact determination of leakages from 0 to 200 Megohms.

3 RESISTANCE RANGES:
In addition to the 0 to 200 Megohm Range which is used for insulation testing, two additional lower ranges are provided, 0 to 20,000 Ohms and 0 to 2 Megohms.

Model 610-B comes housed in hand-rubbed, rugged Oak Cabinet complete with cover, self-contained batteries, test leads and instructions. Only..... $62.50

THE MODEL 720

A.C. AMMETER

MEASURES A.C. CURRENT UP TO

200 AMPERES

4 RANGES: 0 to 10/50/100/200 Amperes
The Model 720 combines the two most efficient methods of measuring A.C. Current. Heavy-duty binding posts on front panel used for measuring low currents to 50 Amperes. Built-in torroid transformer permits measurement of currents up to 200 Amperes without breaking line. Necessary only to insert either leg of the line through front panel core opening.

Model 720 comes housed in heavy-duty, leatherette covered cabinet, complete with cover and instructions. Size 13" x 7" x 4½". Price.................... $49.50

SUPERIOR INSTRUMENTS CO.

Dept. E., 227 Fulton Street **New York 7, New York**

improvement. Seven out of ten would not delay the purchase of receivers because of the prospect of color over black and white. Eight out of every ten had already seen a television program on the screen of a receiver.

CONVENTIONS TO COME

Dec. 11-12. First Annual Conference New York, N. Y. TELEVISION BROADCASTERS ASSOCIATION, Will Baltin, secretary, 500 Fifth Ave., New York 18, N. Y.

Jan. 22-26. AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Winter Technical Meeting, New York, N. Y. H. H. Henline, secretary, 33 West 39 St., New York 18, N. Y.

Jan. 30-Feb. 1. INSTITUTE OF THE AERONAUTICAL SCIENCES. Thirteenth Annual Meeting, Pupin Physics Laboratory, Columbia University, New York, N. Y. Meetings Committee, 1505 RCA Building West, 30 Rockefeller Plaza, New York 20, N. Y.

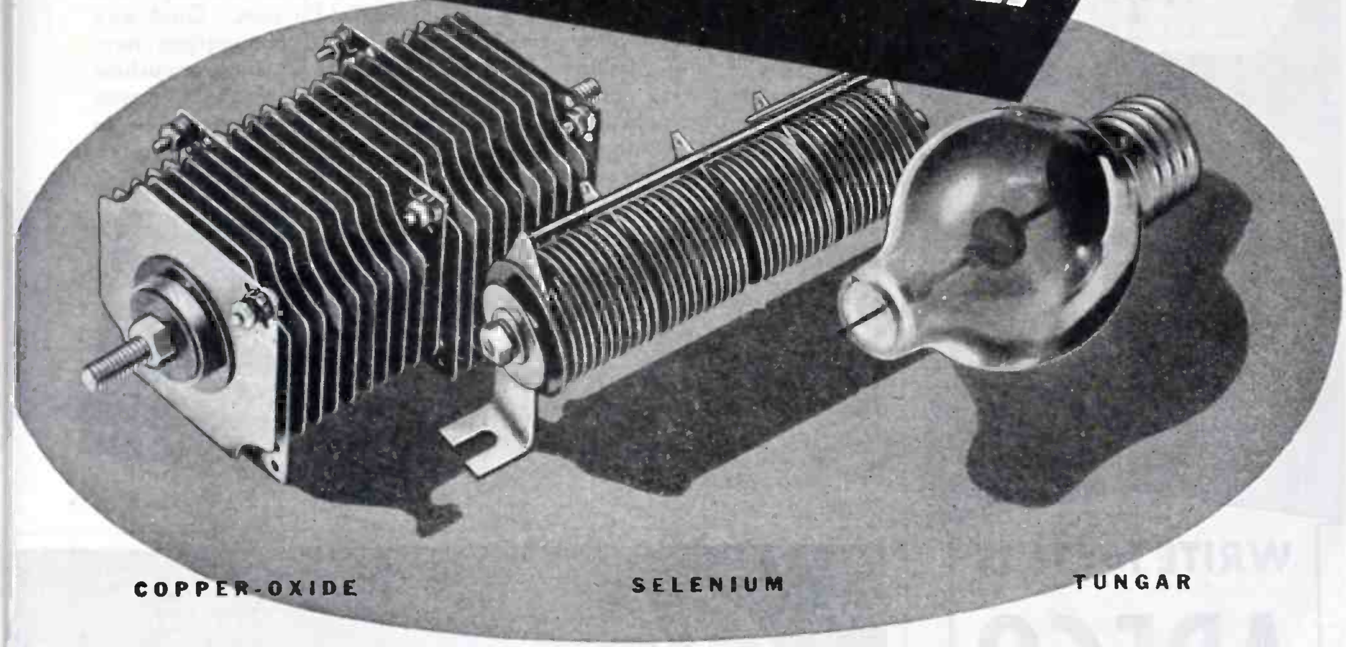
WASHINGTON NEWS

HEARING-AID BATTERIES. When Direction 2 of Limitation Order L-71 expired on October 1, production of B hearing-aid batteries was authorized on an industry-wide basis, according to WPB. It had become feasible for all five manufacturers of these batteries to return to production on a limited basis. Two of the five had formerly been cut to permit increased production of urgently needed military batteries.

F-M YARDSTICK. An experimental f-m station with call letters W3XFC will be built and operated by FCC. Idea is to get practical data on the operational characteristics of the system. Transmission will consist of records, transcriptions, and tone modulations. Power output will be approximately 50 watts while both wide- and narrow-band transmissions will be made on various frequencies between 42 and 50 Mc. The station will be operated at several locations in the Washington area.

AIR COMMUNICATIONS. Research and development functions of the Signal Corps relating to aviation radio, radar, and electronics have

DEPENDABLE RECTIFIERS FOR D-C POWER SUPPLY



ONLY G.E. BUILDS ALL THREE

Wherever d-c power supply is needed look to G.E. for the correct size and type rectifier to do the job. G.E. and *only* G.E. designs and builds the three types of low-voltage rectifiers most commonly used. Each type differs in characteristics, basic materials and construction.

Naturally, the conditions under which the rectifier is to operate and the results which are to be obtained determine which type will do the most economical, most efficient and most satisfactory job.

In some applications all three types serve equally well. However in most instances consideration must be given to space requirements, weight, cost differences, efficiency and life expectancy.

G-E engineers will analyze your rectifier needs and offer their recommendations. Whether they recommend copper-oxide, selenium or Tungar you can be sure that their selection is impartial because G.E. offers all three. For more information write to Section A1247-119, Appliance and Merchandise Dept., General Electric Co., Bridgeport, Conn.

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS.

BUY WAR BONDS AND KEEP THEM

GENERAL ELECTRIC

THIS SOLVES OUR PROBLEM ON POST-WAR PRECISION PARTS!

WRITE for THIS

ADECO

GUIDE - BOOK

It points the way to a dependable source of supply for precision parts and assemblies for your post-war requirements on a contract basis. As specialists in close-tolerance production, the Adeco organization offers complete facilities to meet your most exacting specifications—particularly in the field of hydraulics.

Send for this helpful book today.

ADECO

AIRCRAFT & DIESEL EQUIPMENT CORP.

4405 North Ravenswood Avenue

Chicago 40, Illinois

Your Partners in Precision

Cellusuede

FLOCK

HAS MANY USES IN RADIO

Practical, economical Cellusuede Flock is an excellent material for a variety of radio uses. Coat wire grills, cabinet bases, cabinet interiors and phonograph turntables with versatile Cellusuede and note its high acoustical value . . . low cost . . . flattering suede or velvet effect. Rayon or Cotton Flock is furnished in a wide assortment of colors. No rationing . . . no priorities . . . no delay.

Write for Color Card, Samples and Prices

CP

Cellusuede Products, Inc.

ROCKFORD, ILLINOIS

If you want

- CRYSTALS
- CABLES
- HARNESSES
- ELECTRONIC ASSEMBLIES
- CABINETS

Telephone Peru, Indiana

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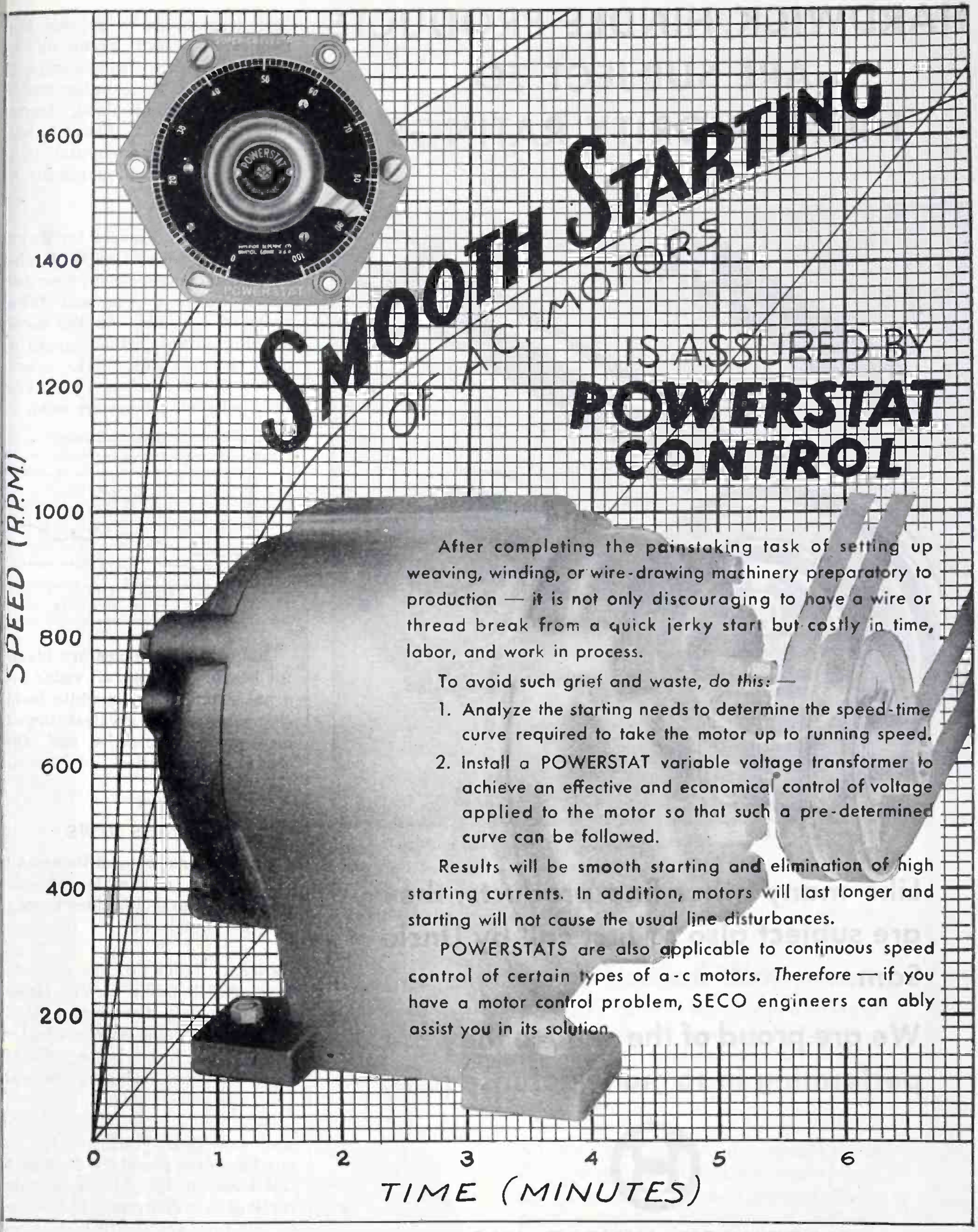
Serving the Radio and Electronic Industries with precision engineered products.

Wm. T. WALLACE MFG. CO.

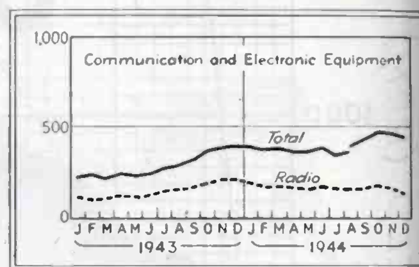
General Offices: PERU, INDIANA

Cable Assembly Division: ROCHESTER, INDIANA


SMOOTH STARTING
OF A.C. MOTORS
IS ASSURED BY
POWERSTAT CONTROL
After completing the painstaking task of setting up weaving, winding, or wire-drawing machinery preparatory to production — it is not only discouraging to have a wire or thread break from a quick jerky start but costly in time, labor, and work in process.
To avoid such grief and waste, do this: —
1. Analyze the starting needs to determine the speed-time curve required to take the motor up to running speed.
2. Install a POWERSTAT variable voltage transformer to achieve an effective and economical control of voltage applied to the motor so that such a pre-determined curve can be followed.
Results will be smooth starting and elimination of high starting currents. In addition, motors will last longer and starting will not cause the usual line disturbances.
POWERSTATS are also applicable to continuous speed control of certain types of a-c motors. Therefore — if you have a motor control problem, SECO engineers can ably assist you in its solution.
SPEED (R.P.M.)
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
TIME (MINUTES)
POWERSTAT

been transferred to the Air Communications staff group of the Army Air Forces Headquarters, Office of the Air Communications Officer. At Wright Field, Dayton, Ohio, the Aircraft Radio Laboratory is included in the switch. Other functions, such as procurement, are not affected.

OUTPUT IS UP. Figures for August production, released by WPB, show a 7-percent improvement over July, which leaves a 3-percent falling short of schedule. In the accompanying curves, actual figures are used through July, 1944. August figures are preliminary, and thereafter schedule figures are used.



Manpower shortages are blamed for keeping the aircraft radar program behind schedule while design changes are the greatest impediment to communication and other electronic production.

BUSINESS NEWS

LEAR AVIA has changed its name to Lear Inc. in anticipation of entry into other markets besides those of aviation equipment.

GENERAL RADIO CO. has opened a new office building at 275 Massachusetts Ave., Cambridge, Mass. This releases for war production office space formerly occupied in the main plant, bringing the total plant space to 112,000 sq ft.

RAULAND CORP., Chicago, Ill. has purchased the phototube division of GM Laboratories. The trade name involved is "Visitron." Phototubes of this type are now in production at Rauland.

WESTINGHOUSE ELECTRIC & MFG., Pittsburgh, Pa., has utilized 7,521 out of 20,545 war-production suggestions by its employees, and the war effort has thus been saved approximately $835,100, while the

"VARTEX" FIBERGLAS CLOTH SILICONE RESIN COATED

Sheet Insulation for NEW High Heat Applications

For the first time, a continuous fiber, soda-free Fiberglas Cloth . . . impregnated with special high-temperature Silicone Resin . . . is manufactured in quantities for commercial use as sheet insulation for high heat applications.

The new product's resistance to high, sustained heat is outstanding. Samples aged at 200° Centigrade were still very flexible after 400 hours exposure, while samples aged at 150° Centigrade showed little change after 2000 hours exposure.

In addition to its high heat resistance, Silicone Resin-Coated Fiberglas has good dielectric strength, low power factor, high mechanical strength, and exceptional low temperature flexibility.

It is recommended for applications to motors, air-cooled transformers, generators; as insulation for relays, rheostats, resistors, operating at elevated temperatures, and for electronic equipment.

Although it is slightly soluble in hot oil and petroleum solvents, the film is not affected during the conventional varnish impregnating cycle.

"VARTEX" SILICONE RESIN-COATED FIBERGLAS CLOTH

Two Standard Thicknesses

"Vartex" Silicone Resin Coated Fiberglas is available in two standard thicknesses—.004" and .007"—and is supplied in full width rolls (36") or cut into tape of any desired width down to ½".

You will be interested in our Bulletin No. B-6 which gives further details about this new sheet insulation and charts showing test data and solvent resistance. Write for it today. 3" x 5" Samples of .004" and .007" sheets will also be sent at your request.

INSULATION MANUFACTURERS CORPORATION

★ CHICAGO 6 • 565 Washington Blvd.
★ CLEVELAND 14 • 1005 Leader Building

Representatives in
MILWAUKEE 2: 312 East Wisconsin Avenue
DETROIT 2: 11341 Woodward Avenue
MINNEAPOLIS: 316 Fourth Ave., South
PEORIA: 101 Heinz Court

idea-people were paid a total of $94,-035. Production of war equipment during the first nine months of the year has been $612,099,591, or 22 percent above a year ago.

AMERICAN STANDARDS ASSOCIATION has moved into new and larger quarters at 70 East 45th Street, New York, N. Y.

PHILCO CORP., Philadelphia, Pa., has plans for experimental television relays between Philadelphia and Washington, D. C. Applications have been filed with the FCC.

WESTINGHOUSE ELECTRIC & MFG. Co., Pittsburgh, Pa., has started night classes for approximately 250 employees who wish to work for advanced degrees in electrical engineering. Operating since 1927 in conjunction with the University of Pittsburgh, the work-study plan has made it possible for 108 students to receive master of science degrees and seven to receive doctor of philosophy degrees.

STROMBERG-CARLSON CO., Rochester, N. Y. has made a deal with Armour Research Foundation for inclusion of wire recording devices in the company's postwar home radio receivers.

WESTERN ELECTRIC CO., New York, N. Y., has become a member of Television Broadcasters Association.

MUZAK CORP., New York, N. Y., has plans for a non-advertising public-subscription f-m radio service. Costs are reported to be $10 million. A three-channel service is to be offered at an individual cost of about 5¢ a day.

BENDIX RADIO DIV., Bendix Aviation Corp., Baltimore, Md., has established a new engineering and service organization to coordinate the company's expanding activities in the field of railroad radio communications.

TOWNSEND BROWN FOUNDATION, Columbus, Ohio, has planned the erection of a large research laboratory at Laguna Beach, Calif. Facilities, which are estimated at $120,000 for building and more for equipment, will be devoted to general research in the fields of radia-

ACES

In POPULARITY and PERFORMANCE

Cetron Type 306 handles primary currents of many small resistance welders, light control, arc welding control, etc. Also serves in motor control application; and for other industrial purposes.

Cetron Type CE-29 Particularly sensitive to blue and violet light. RMA spectral sensitivity designation S-4. 5-Pin base interchangeable with other similar tubes.

CETRON

RECTIFIERS . . . PHOTOTUBES . . . THYRATRONS . . . ELECTRONIC TUBES . . . SPECIAL TUBES TO FILL SPECIAL NEEDS . . .

Whatever the need . . . Continental is usually "a jump ahead" in creating and producing a fine tube to *fill that need.*

Through the years "CETRON" has become more than a well-established trade-mark . . . It has become a "buy word" for all who seek better-engineered tubes, of quality materials . . . insuring better performance.

The two tubes illustrated above were selected at random from the

COMPLETE LINE

which Cetron has to offer you. Write for catalog.

CONTINENTAL ELECTRIC COMPANY GENEVA, ILL.

★ CHICAGO OFFICE, 903 Merchandise Mart
NEW YORK OFFICE, 265 West 14th Street

"CAN IT BE IMPROVED...WITH PLASTICS?"

This question does not presuppose that plastics is the magic "cure-all." On the contrary it rules out the lady-luck influence as irrelevant to the problem.

***"Can it be improved with Plastics?"* is the number one question in any consideration of engineered plastics for a product or part.**

Our engineers are trained to consider plastics in relation to the requirements of a product and the improvement desired. They have an appreciation of the complementary values of plastics and metals and have developed some original techniques with these combinations which have solved a number of product problems.

Improvements in products and parts have been attained by us through close collaboration with the design and production staffs of aircraft manufacturers. Along similar lines, we may be able to suggest applications of molded plastics to your products . . . present or planned.

For the right application of plastics to your product, call on Plastic Manufacturers during the design stage. The design of your product may determine how close tolerances can be held. Selection of the right plastic material and molding method should be left to our experienced judgment. Send for free copy of Folder File E12, describing our facilities.

TRADE MARK
THE SYMBOL OF ENGINEERING EXPERIENCE AND MOLDING SKILL

REPRESENTATIVES

DETROIT 2
805-06 NEW CENTER BLDG.

LOS ANGELES 35
1440 SO. ROBERTSON BLVD.

CANADA
A. & M. ACCESSORIES LTD.
19 MELINDA ST., TORONTO
1405 BISHOP ST., MONTREAL
920 SECOND AVE.
SEATTLE

PLASTIC MANUFACTURERS

INCORPORATED

STAMFORD, CONNECTICUT

ENGINEERED PLASTICS FOR INDUSTRIAL APPLICATIONS

MOLD MAKING • INJECTION & TRANSFER MOLDING • COMPLETE ASSEMBLY tion, cosmic rays, and high and ultra-high frequencies. It will be known as the Temple Hills Radiation Laboratory.

LAFAYETTE RADIO CORP., Chicago, Ill., and Atlanta, Ga., has changed its name to Concord Radio Corp. Policies and personnel remain unchanged.

WESTINGHOUSE ELECTRIC & MFG. Co. has located its prospective production on postwar home radio receivers at its Sunbury, Pa., plant. The company has recently acquired a manufacturing license from Hazeltine.

BROWN INSTRUMENT CO. Div. of Minneapolis-Honeywell Regulator Co., Philadelphia, Pa., has a plan to offer free technical and practical instruction in precision industrial instrumentation for students from Latin-American companies.

PHILIPS LAMPS & RADIO WORKS, Eindhoven, Netherlands, was stripped of 36 carloads of machinery and technical equipment by retreating Nazi forces.

TEMPLETONE RADIO CO., Mystic, Conn., has acquired a new plant involving 90,000 sq ft. of space in New London, Conn. The Mystic plant will be maintained for the manufacture of radio cabinets.

WESTINGHOUSE ELECTRIC & MFG. Co. has announced that electronic tube production in its lamp division has expanded to 30 times the dollar values of tube production in 1939. Ninety-eight percent of the tubes are for war use.

PERSONNEL

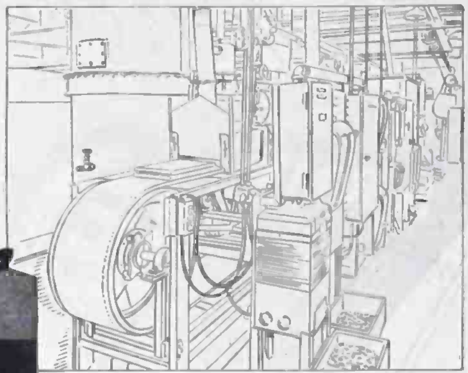
HERMANN D. MYSING has been made manager of engineering service for the auto radio department of Radio Corp. of America at Detroit, Mich. He was formerly in charge of an RCA group working with the Signal Corps.

DORMAN D. ISRAEL will preside as chairman of the panel meeting committee for the first annual conference of the Television Broadcasters Association. He is vice president in charge of engineering and produc-

We've Done Away With Silver Soldering

P.R. MALLORY & CO. Inc.
MALLORY

Silver-Faced
STEEL-BACKED



This giant electrical furnace, carefully regulated, permanently bonds the silver contact face directly to the base metal backing.

STANDARDIZED CONTACTS


TYPE SUF


TYPE SUR


TYPE SVF


TYPE SVR

You're assured of quick delivery, high efficiency and long life when you specify Mallory standardized, silver-faced, steel-backed contacts. Brazing is eliminated by a patented Mallory process and by the ingenious equipment pictured above. The silver face is bonded directly to the steel back, insuring completely even wear and at least 20% longer service than when the faces are attached with silver solder.

By eliminating the silver solder, high currents can be carried without overheating the contact. Safe operating temperatures are constant, and contact drop and heat development are greatly reduced.

Mallory's specialized fabricating process produces silver-faced contacts of a hardness equivalent to cold headed rivets. To prevent any danger of corrosion, steel backs are *nickel-plated*. Standard sizes of Mallory silver-faced contacts can be furnished attached to arms, studs, brackets, or ready for your own assembly operations. Literature giving detailed dimensions and specifications is available upon request.

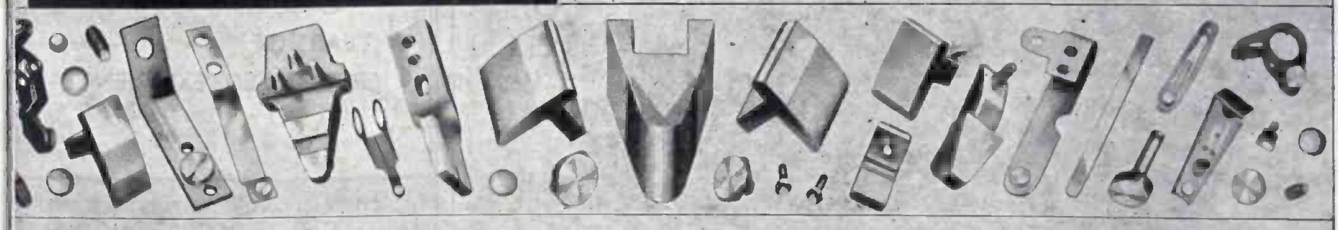
There's a Job for All to Do: Buy War Bonds!

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

**Elkonite is a registered trademark of P. R. Mallory & Co., Inc., for electric contacting elements.*

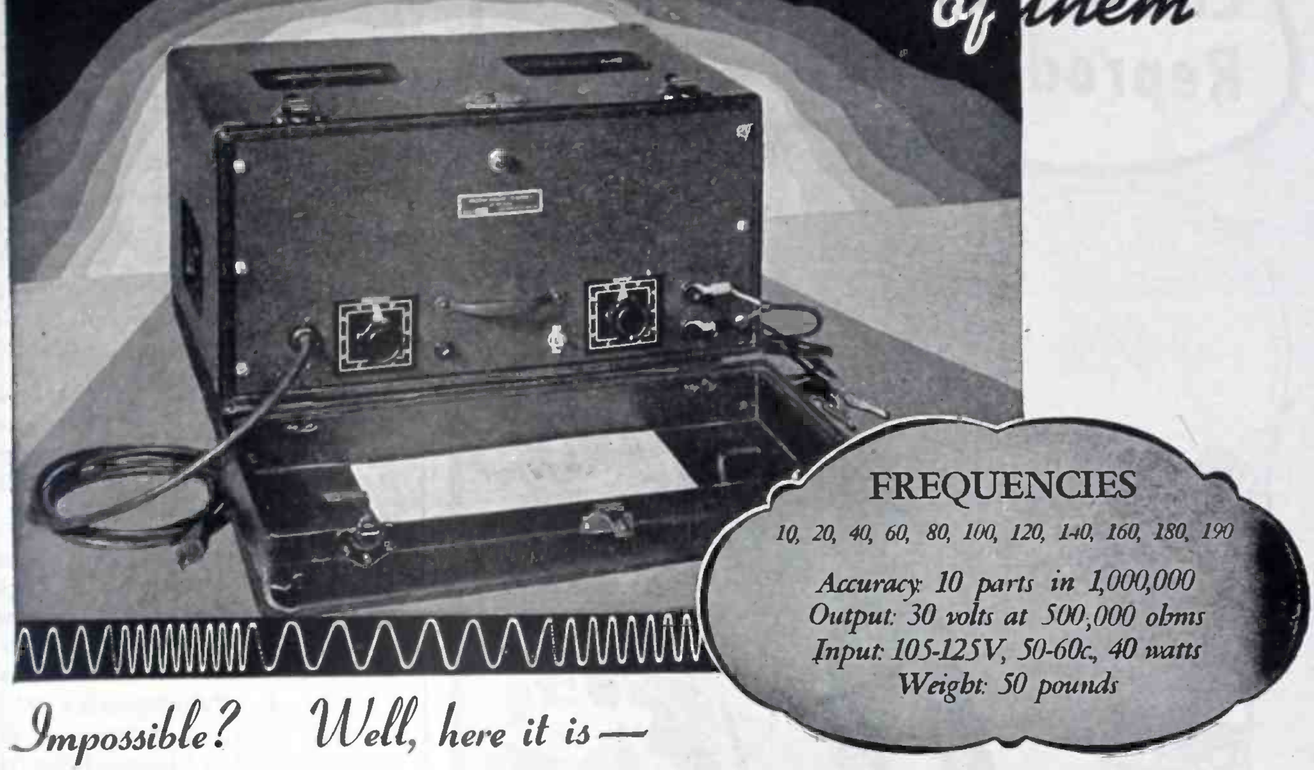
P.R. MALLORY & CO. Inc.
MALLORY

MANUFACTURES CONTACTS OF TUNGSTEN, MOLYBDENUM, SILVER, PLATINUM, ELKONITE* AND SPECIAL ALLOYS FOR INDIVIDUAL REQUIREMENTS. SPECIAL DESIGNS TO SUIT YOUR APPLICATIONS



ELECTRICAL CONTACTS AND CONTACT ASSEMBLIES
NON FERROUS ALLOYS AND POWDERED METAL PARTS

STANDARD FREQUENCIES—*Octaves of them*



Impossible? Well, here it is—

This Multi-frequency generator furnishes the frequencies shown above at the turn of a switch. All frequencies are obtained from a temperature-compensated tuning fork and voltage-stabilized circuit.

With this unit it is possible to calibrate oscillators at many selected points without encountering complex oscilloscope patterns. One of the uncertainties involved in development work on tuned circuits, filters, reeds—and in time measurement can be minimized with the aid of this instrument.

Developed primarily to check frequency meters for precision war work, this Multi-frequency generator possesses a rugged durability and dependability in service that will prove an extra value to many laboratories.

Additional information available on request.

Manufacturer of the

Watch Master

and distributor of Western Electric Watch-rate Recorders

American Time Products, INC.

580 Fifth Avenue — New York 19, N. Y.

tion for the Emerson Radio & Phonograph Corp., New York, N. Y.

David Sussin has been made chief of research at Kelley-Koett Manufacturing Co., Covington, Ky. He was formerly chief engineer.

Manfred K. Toeppen has resigned from FCC to enter communications consulting engineering practice in New York, N. Y. He was assistant chief engineer in charge of the Common Carrier Division of FCC.

Dr. A. M. Skellett, formerly of Bell Telephone Laboratories, has been made chief engineer in charge of research at National Union Radio Corp., Newark, N. J.

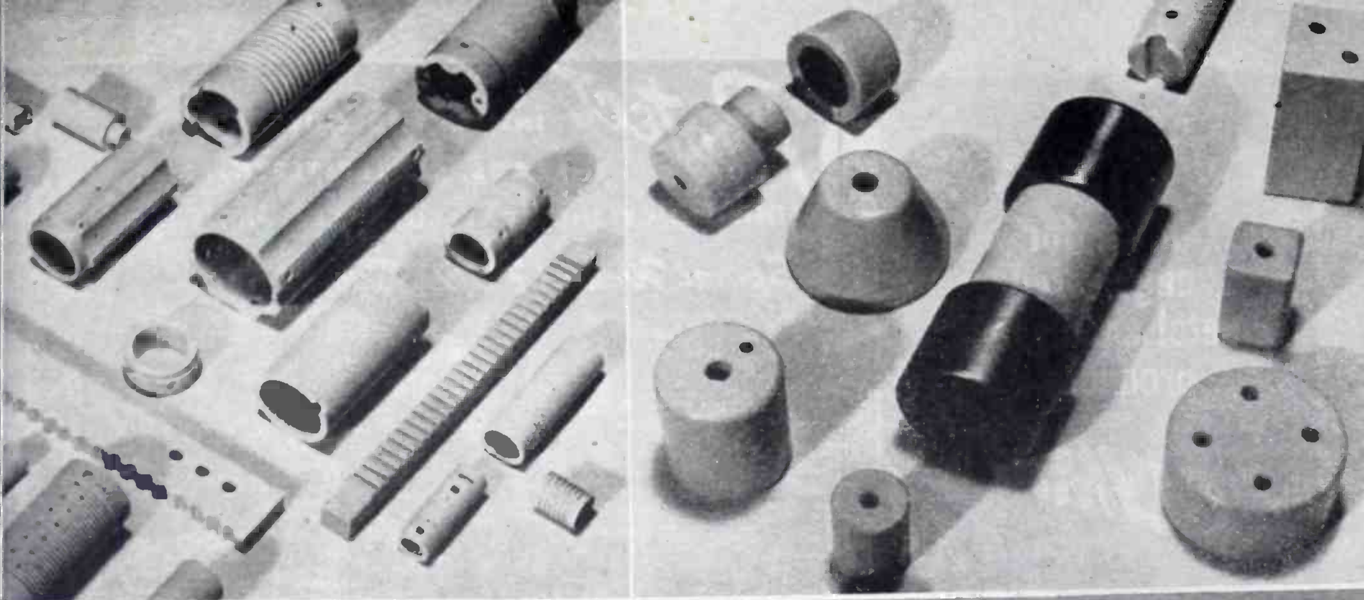
A. C. Streamer has been elected president of the National Electrical Manufacturers Association to succeed Leonard Kebler. Mr. Streamer is vice-president of Westinghouse Electric & Manufacturing Co.; Leonard Kebler is chairman of the board of the Ward Leonard Electric Co., Mt. Vernon, N. Y.

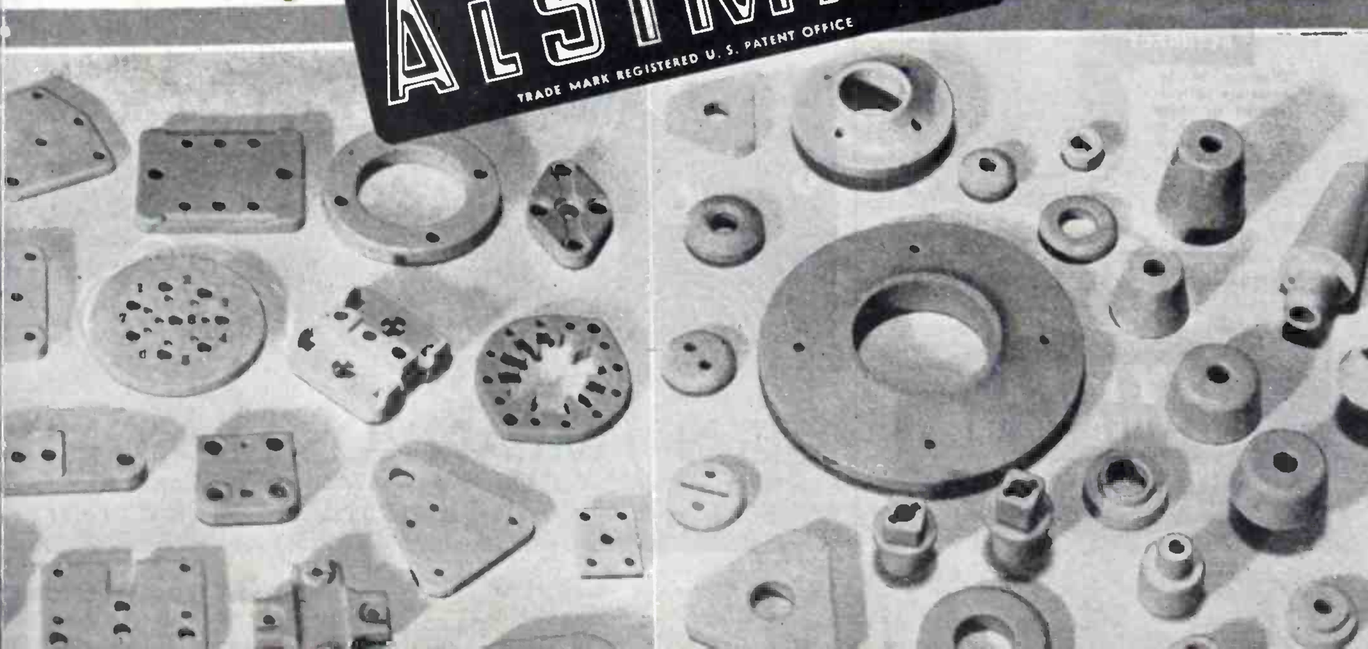
Morris H. Cook has been made director of specialty products development at Bell Telephone Laboratories, New York, N. Y. He was for-

merly superintendent of manufacturing engineering at the Hawthorne Works of Western Electric Co.

Leslie J. Woods, formerly vice-president and general manager of National Union Radio Corp., has been made manager of the industrial radio division of Philco Corp., Detroit, Mich.

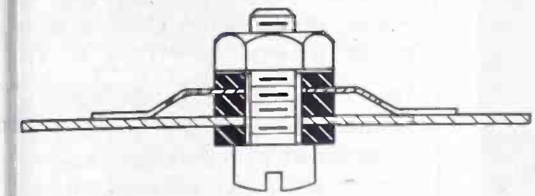
A. R. Buckles has been made chief inspector at Emerson Radio & Phonograph Corp., New York, N. Y. He was formerly a field engineer





C. A. **DATA SHEET 22-L**

APPLICATIONS of Dual Sealed-In Electrode Selenium Rectifiers



Standard Electrode

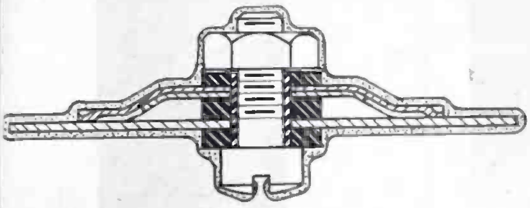


Figure 1

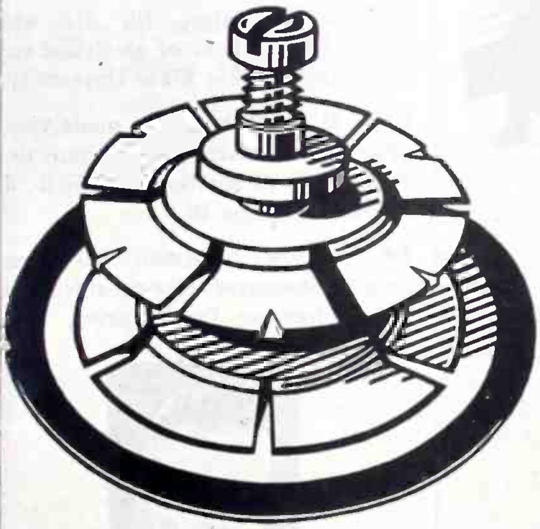


Figure 2

Dual sealed-in electrodes are a recent Selenium Corporation of America development to meet demands of exceptionally severe service applications without sacrifice of the desirable characteristics of spring electrode contacts.

Figures 1 and 2 show how the dual sealed-in unit employs a spring contact of conventional construction hooded by a spring member shaped to conform to the surface of the spring contact . . . completely sealing the interior. The entire unit is then hermetically sealed with a coating best suited to the particular service requirements.

The sealing member is of spring material, which gives it an additional function in helping to maintain the contact spring against the face of the electrode, assuring positive contact under conditions of extreme vibration, shock or impact.

Net result . . . a rectifier that gives rugged, dependable service under all atmospheric conditions.

The table below lists the conditions likely to be encountered in installing rectifiers, a check mark indicating the correct rectifier.

	REGULAR	DUAL SEALED-IN
Normal indoor use, non-tropical climates	X	
Portable equipment not subject to excessive shocks or vibration	X	
Outdoor use in enclosed cases	X	
Tropical, high humidity or jungle climates		X
Automotive and aviation equipment		X
Corrosive atmospheres, as chemical, plating or battery charging establishments		X
Maritime and naval installations		X
Military equipment		X
Heavily dust-laden atmospheres, non-corrosive, or desert conditions	X	X
As part of machinery operating with considerable shock or vibration		X

SELENIUM CORPORATION of AMERICA

1719 WEST PICO BOULEVARD • LOS ANGELES 15, CALIFORNIA

FOREIGN DIVISION: FRAZAR & HANSEN • 301 CLAY STREET • SAN FRANCISCO 11, CALIFORNIA responsible for design and development of radar equipment for the War Department.

RUSSELL H. LASCHE, formerly in charge of the company's sound equipment division, has been made director of engineering and research at Fairchild Camera & Instrument Corp., New York, N. Y.

DR. W. L. EVERITT has been appointed professor and head of the department of electrical engineering at the University of Illinois,

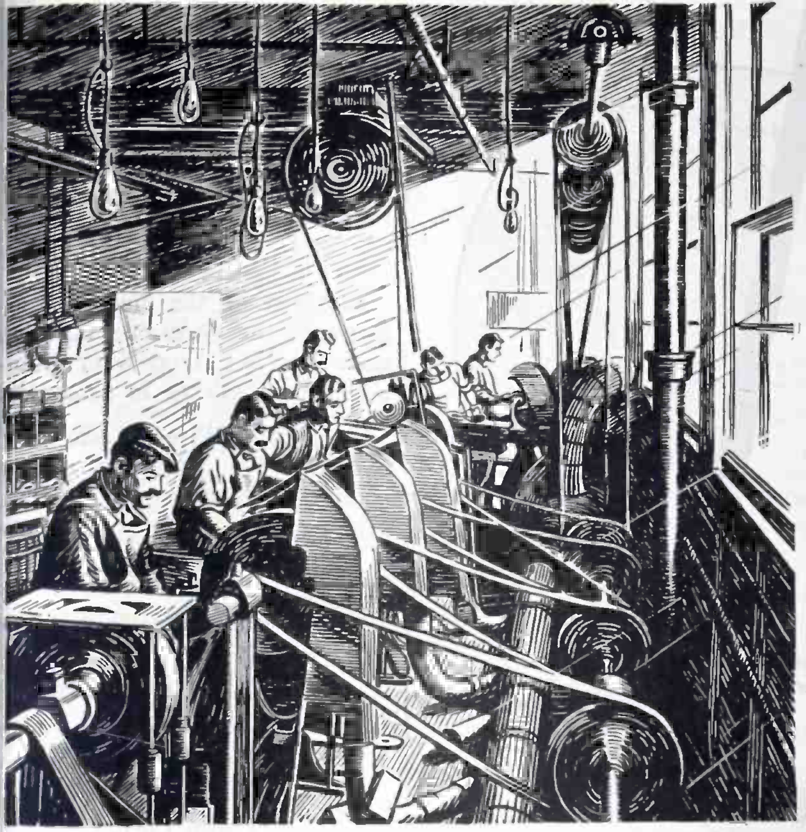
Urbana-Champaign, Ill. He was formerly professor of electrical engineering at Ohio State University.

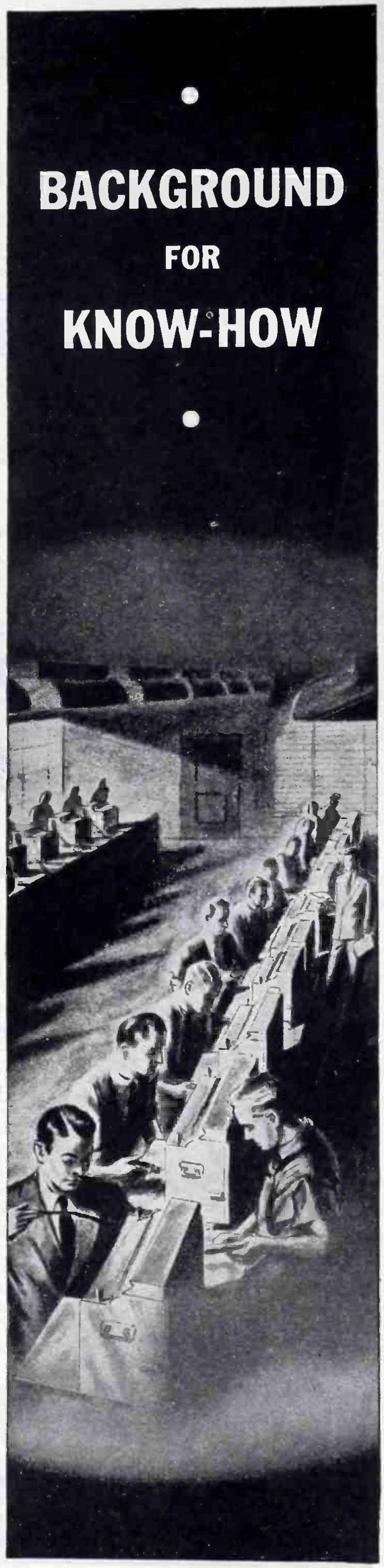
L. A. MCNABB has been made vice-president in charge of electronic design and production at Bell & Howell, Chicago, Ill.

DR. MERVIN J. KELLY has been elected executive vice-president of Bell Telephone Laboratories, New

York, N. Y. He was formerly director of research in charge of development of radar and other fields.

JOHN S. MILLS has been made production planning manager at Emerson Radio & Phonograph Corp., New





The telephone was still a novel device when *Connecticut Telephone & Electric* opened the doors of its first modest factory. Ever since, its people seem to have formed the habit of contributing to each revolutionary step ahead in communications.

For example, they helped to take the electronic tube out of the laboratory, and put it to work for everybody, by producing one of the first such tubes to be manufactured on a commercial scale.

For the past four years, every ounce of our engineering and production experience has been at work for Uncle Sam. Postwar American industry will naturally seek to draw on the *know-how* developed during the war. Ours applies not only to communications, but to the general field of electronics and precision electricol engineering and manufacturing. If you have o problem involving communications, product improvement, product control, ignition, or the monufocture of precision electrical devices, our porticular *know-how* is at your disposal.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

ARMY E NAVY

GREAT AMERICAN INDUSTRIES, INC.

MERIDEN, CONNECTICUT

GAI

TELEPHONIC SYSTEMS • SIGNALLING EQUIPMENT • ELECTRONIC DEVICES • ELECTRICAL EQUIPMENT • HOSPITAL AND SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS • IGNITION SYSTEMS

York, N. Y. Formerly chief project manager, he had been a production engineer with the War Department.

DR. AUGUSTIN FRIGON, former acting manager, has been made general manager of Canadian Broadcasting Corp.

AWARDS

Workers of the following concerns in the electronic field have been awarded Army-Navy E burgees for excellence in production:

Anaconda Wire & Cable Co.
South Mill and North Mill
Sycamore, Ill.

Electronic Corp. of America
New York, N. Y.

Essex Electronics
Newark, N. J.

Minneapolis-Honeywell
Regulator Co.
Aero Division
Chicago, Ill.

Philco Corp.
Simplex Radio Div.
Sandusky, Ohio

Sentinel Radio Corp.
Evanston, Ill.

Sylvania Electric Products, Inc.
Brookville, Pa.

A Distinguished Service Award by the Army Ordnance Department recognizes outstanding and meritorious services by:

American Standards Association
New York, N. Y.

For meritorious conduct and outstanding ability in serving the Signal Corps, the War Department has bestowed on the following individuals the Legion of Merit:

Colonel David Sarnoff
Radio Corp. of America
New York, N. Y.

Colonel Thompson H. Mitchell
RCA Communications
New York, N. Y.

For notable accomplishment in the electronic field, the Navy Department honors with its Certificate of Achievement:

Radar-Radio Industries
Chicago, Ill.

RCA Laboratories
Princeton, N. J.

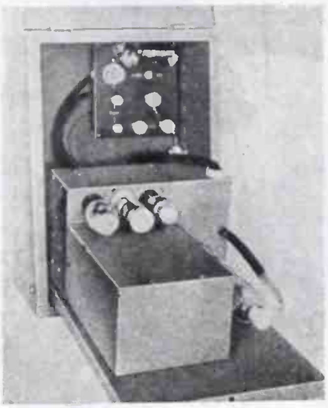
"I'LL BE BACK. I FORGOT TO TELL THE BOSS THAT ALBION CAN SHIP ALL THE COILS HE NEEDS"

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Resistance-Welding Control

THIS ELECTRONIC TIMING unit controls a-c resistance welding operations. It is easy to operate and can easily be applied to either existing or new installations. A single knob

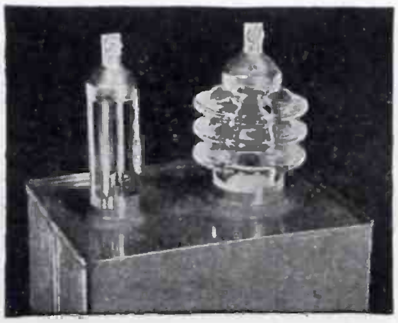


gives instant time control from 1 to 28 cycles in steps of 1 cycle. The unit handles welding powers from ½ to 5 kva.

Electrical Industries, Inc., 42 Summer Ave., Newark 4, N. J.

Glass-to-Metal Seals

CAPACITORS AND resistors are now available with glass-to-metal seals to guard against leakage and moisture. The new type seals make the glass and metal in these components

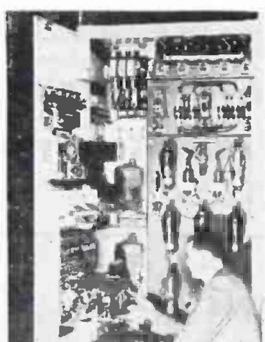


one integral unit which is leak-proof, shock-proof, humidity-proof and fungus resistant. Seal sizes range from very small to 3 in. in diameter. Capacitors and Koolohm resistors utilizing glass-to-metal seals are available in 8,000 different electrical characteristic combinations.

Sprague Electric Co., North Adams, Mass.

Electronic Forge-Pressure Timer

A NEW, PRECISE, electronic forge-pressure timer has been incorporated in the G-E line of capacity discharge controls for use with stored-energy type resistance welding machines. The new timer, designed for dual pressure spot welding machines of the capacitor discharge type, functions to supply accurately timed forge-pressure, so that the required welding energy, cracks, indentations and sheet sepa-



ration are reduced. The timer is calibrated in milliseconds.

Industrial Control Div., General Electric Co., Schenectady, N. Y.

Fungus-Resistant Coating

DESIGNED FOR application on phenolic insulators, terminal blocks, junction blocks, and the fixed windings of motors, generators and dynamotors is a new coating which has been designated as Durad Fungus-Resistant Coating No. 524. The manufacturer states it has been tested for dielectric strength, hardness, flexibility, and resistance to salt spray and thermal shock.

Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Industrial Sound Equipment

AVAILABLE ON AA-5 priorities to war plants, hospitals and schools is Model M-50-C, 50-watt amplifier supplied complete with radio tuner (which covers the full broadcast

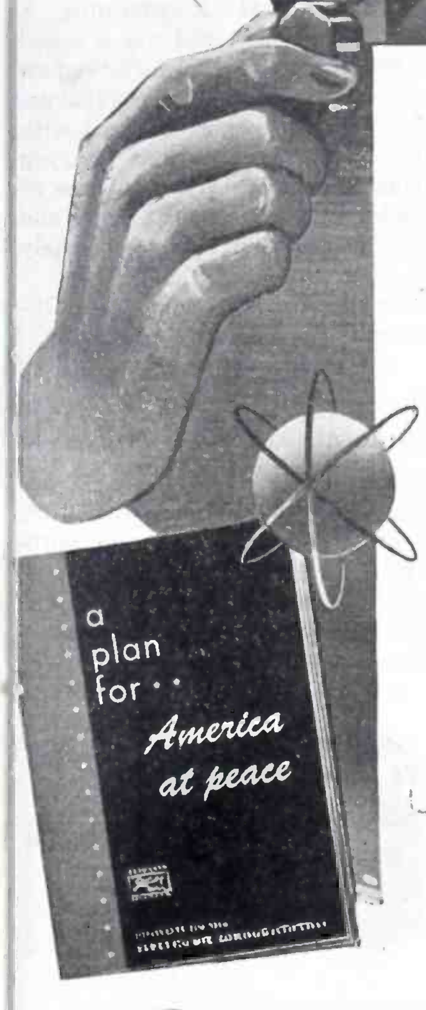
band), record changer and space for record storage. A smaller 25-watt model, complete with record player, will be available shortly.

John Meck Industries, Plymouth, Ind.

Floating Cage-Type Speednut

NO RIVETING, welding or spinning operations, nor any special tools, are necessary to install this new self-locking Speednut in screw-receiving position for blind attachments. Although originally designed for front mounting of aircraft instruments (approved by Army Air Forces), this new cage nut may be used for any type of blind attachment. It is available in two styles: A6939, made of brass and phosphor bronze, for use with standard 6-32 machine screws; and A5939, made

EXACTING
STANDARDS FOR AMERICA . . . . .



The elections are over. The essential greatness of the American nation, the profound democratic spirit that has made Uncle Sam a symbol of human liberation in the darkest corners of the earth, has closed the ranks of our people and united them behind their chosen Commander-in-Chief.

Only a few short weeks ago, the passions of political partisanship caused human emotions to run high and deep fissures seemed to appear in our national life. Fears and suspicions were aroused, hatred, bigotry, racial prejudice and other subversive doctrines were spread broadcast by campaign orators lacking real issues. Our Axis enemies gloated and saw visions of a soft peace in the success of their "divide and conquer" technique.

But America was too robust and intelligent to be undermined by its greatest asset. American democracy has withstood the acid test of an election in the midst of a war. And its people emerge from a partisan struggle, united and determined to work together for a speedy victory and an enduring peace.

Nothing must be permitted to obstruct or frustrate these historic objectives. Disruptive groups seeking to undermine our harmony, confuse our minds, promote class discord and racial hatred, must be weeded out, isolated, quarantined from American life.

This is a time for national greatness. We are winning this war, winning it because we remain united, because we never lost sight of the crusade and the riches in its victory.

To all of us, there is the common problem of making our country stable, prosperous, contented; of making the world secure, peaceful, democratic. If we jointly accept this problem, the eras ahead for our children are literally golden ones.

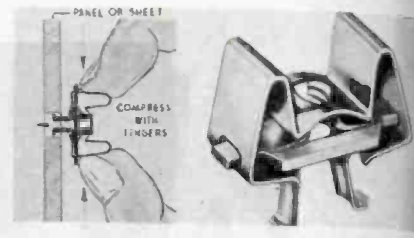
To these aims, we of the Electronic Corporation of America dedicate ourselves, our thoughts, our energies and our resources.

Our thoughts on this, and other matters of vital importance to every American, are more fully expressed in "A Plan for America at Peace", the 44-page book prepared by a group of distinguished economists and writers. This plan, designed, as is all ECA equipment, to exacting laboratory standards, will be particularly interesting to the men and women of our industry. We will be glad to mail you a copy, without cost or obligation. Write for it today.

eca

ELECTRONIC CORP. OF AMERICA

45 WEST 18th STREET · NEW YORK 11, N. Y. WATKINS 9-1870



entirely of spring steel, for use with standard 6Z sheet-metal screws. Both styles are available to fit panel thicknesses from 0.062 in. up, and require only one clearance hole of 0.171 in. diameter. These Speednuts have a wide range of applications and can be made for larger screw sizes to meet individual requirements.

Tinnerman Products, Inc., 2106 Fulton Rd., Cleveland 13, Ohio.

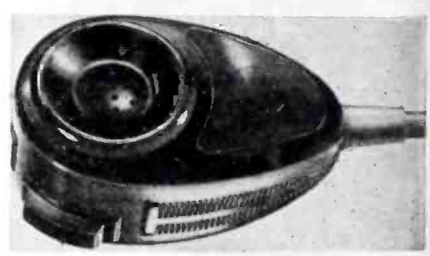
Soldering-Iron Tips

IN JULY 1944 ELECTRONICS, a soldering iron shaped like a pencil is described. Its manufacturer now has available five new interchangeable tips which may be used with the iron in applications ranging from delicate operations to some of the larger, heavier tasks. Irons and tips may be purchased separately or as a unit.

Harry A. Ungar, Inc., 615 Ducommun St., Los Angeles 12, Cal.

Communications Microphone

MODEL 600-D MICROPHONE is designed for police, airport, utility, mobile communications and portable PA systems. It has a press-to-talk switch, weighs 9 oz, and will withstand temperature changes from 640 to −185 deg F. The frequency response ranges from 50 to 8,000 cps, with an output of −57 db. The curve is substantially flat for high articulation.



Electro-Voice Corp., South Bend, Ind.

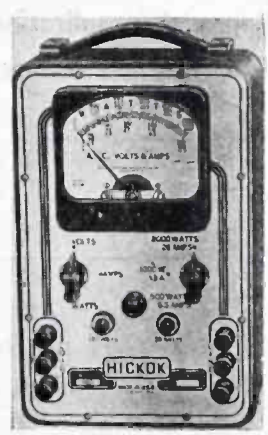
Voltage-Breakdown Testers

TWO TYPES OF testers are available for simple, positive means of testing voltage breakdown of materials or components. The first of these is Type P-3, which has an operating range of from zero to 10,000 v d.c., or from 0 to 8,000 v a.c. The second type is Type P-1, which has a sloping panel and a range of from zero to 4,000 v d.c., or from zero to 3,000 v a.c. The voltage of these instruments is continuously variable over the entire range. They operate directly from 110-130 v, 50-60 cps, a.c. A panel light indicates when the instruments are on. Breakdown is indicated by a red signal light, and a built-in meter indicates the direct-reading voltage. Current-limiting (to approximately 50 milliamps) resistors safeguard the equipment in the event of a dead short.

Industrial Instruments, Inc., 17 Pollock Ave., Jersey City, N. J.

Electrical Appliance Tester

AN IMPROVED ELECTRICAL appliance tester, having 0-20 watts and 200-watt scales, tests appliances operating on the 220-v, three-wire Edison system. The tester is an electronic instrument (designated as Model 900). It measures actual load values of volts, amperes, and watts, and quickly locates trouble



in a-c appliances while in actual operation. The tester is protected from accidental overload by means of a fuse. Overall dimensions of the unit are 9½ in. high, 6¾ in. high and 3 in. deep. It weighs 8½ lb. The meter of the unit is 4 in. sq.

Hickok Electrical Instrument Co., 10527 Dupont Ave., Cleveland 8, Ohio.

108 SERIES *Amplifiers*

WITH MOUNTING ACCESSORIES

TYPE 108-B two-stage Amplifier provides transformer input impedances for either 30 or 250 ohms with nominal output impedance 500 or 8 ohms. Variable gain 65/105 db. with electronic volume control. Frequency response better than ±1 db. 30/16,000 c.p.s. Power output +43 V.U. (20 watts) with less than 5% RMS harmonic content. Noise level full gain 56 db. below full output.

THE 108 SERIES consist of four different amplifiers available simply by changing one or two small input panels on the master chassis. Except for these input panels all amplifiers have the same transmission characteristics. Input impedance, gain and noise level depending on types listed below.

These units are designed for the highest type audio service having gain-frequency characteristics better than ±1 db. 30/16,000 c.p.s. Power output +43 V.U. (20 watts) with less than 5% RMS harmonic content.

TYPE 108-A two-stage Amplifier provides transformer input for either 600 ohm or bridging. 600 ohm input fixed gain 61 db. Bridging input variable gain 6/46 db. Noise level 68 db. below full output.

TYPE 108-B as illustrated and described above.

TYPE 108-C combines the input channels of the 108-A and 108-B Amplifiers. Channel 1—600 ohm input variable gain 20/60 db. Bridging input variable gain 2/42 db. Channel 2—high gain 30/250 ohm input variable gain 62/102 db. with electronic volume control. Noise level 56 db. below full output.

TYPE 108-D two-channel each 30/250 ohm input. Either channel variable gain 62/102 db. with electronic volume control. Noise level 56 db. below full output.

MOUNTING ACCESSORIES

TYPE 202-A Wall Mounting Cabinet permits universal installation of 108 Series Amplifiers to any flat surface. Well ventilated and designed for maximum accessibility, servicing and convenience of installation. Standard aluminum gray finish.

TYPE 9-A Modification Group permits 108 Series Amplifiers to mount on standard 19" telephone relay racks. Occupies 7" rack space. Allows servicing from front of rack. Standard aluminum gray finish.

The Langevin Company
INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
37 W. 65 St., 23	1050 Howard St., 3	1000 N. Seward St., 38

Improved Soldering Stand

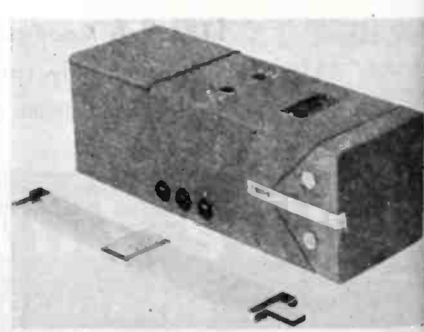
THE NEW MODEL SS-10 soldering stand embodies changes in the design and construction for greater protection against injurious fumes, hand fatigue, and eye strain. The stand is available with a cast bracket for mounting on assembly

tables, or it can be supplied mounted on a wood base. The fume stack measures 3 x 9¼ x 32 in. The shield is fitted with a plate glass window, or a magnifying glass.

Dept. SS, Ess Specialty Corp., Bergenfield, N. J.

Miniature Six-Element Oscillograph

TYPE PM-17-A1 IS a new self-contained, compact, permanent-magnet oscillograph. The unit consists of three principle systems—the optical system, the six parallel galvanometer channels and the photosensitive-material transporting mechanism with internal motor and removable film holder, which are all enclosed within a light-tight metal case measuring 4½x4½x14 in. The weight of the complete instrument is approximately 10 lb. Designed to directly record small values of potential or current, such as the output of amplifying equipment, this new unit makes it possible to obtain performance records on many types of equipment where

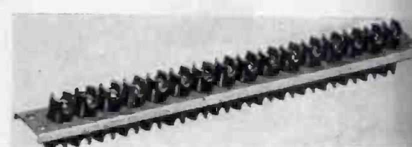


larger general-purpose oscillographs cannot be used because of space and weight limitations. A wide range of potentials or currents can be recorded by the use of appropriate external resistors, instrument transformers, or shunts.

Bulletin No. GEA-4331 describing this instrument is available from General Electric Co., Schenectady, N. Y.

Terminal Blocks

IN JUNE 1943 ELECTRONICS, the editors described in detail these terminal-blocks for sub-panel mounting. The blocks consist of individual feed-through terminals and were originally available in any number of units between 1 and 10. Now the manufacturer has available, on factory production, blocks



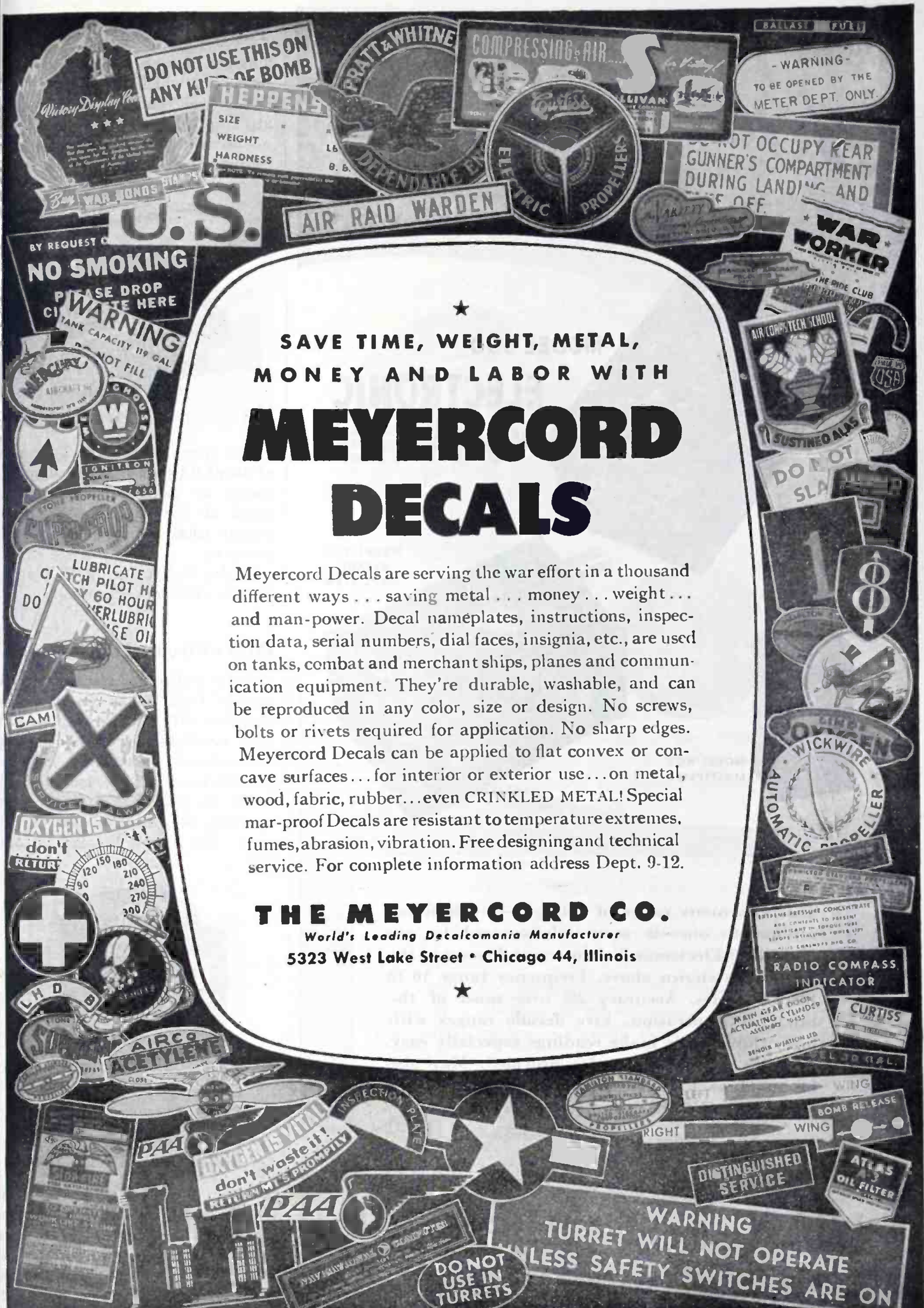
which will accommodate any number of units between 1 and 16, and because of their design the blocks can be furnished, on specification, with any number of terminals desired.

Curtis Development & Mfg Co., 1 Crawford Ave., Chicago, Ill.

Thermosetting Plastic

THERMOLAX IS a thermosetting plastic, with dielectric characteristics, especially designed for insulating electrical components to make them salt, moisture and acid resistant as well as impervious to fungus growth and climatic changes. The plastic has low density and is designed primarily for very deep penetration on coils, capacitors, wires, and vacuum impregnation. The six different types available include 100-PC for thick applications; 430-GC which is high in penetrating qualities; 210-GC for extremely thin coatings; 850-26 whose penetrating powers are limited by a filler; 850-26 which withstands high temperatures; and 200-C which is a thinning agent and acts to speed up the drying process.

Thermolex Liquid Plastics Co., 901 Nepperhan Ave., Yonkers, N. Y.



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MEYERCORD DECALS

Meyercord Decals are serving the war effort in a thousand different ways . . . saving metal . . . money . . . weight . . . and man-power. Decal nameplates, instructions, inspection data, serial numbers, dial faces, insignia, etc., are used on tanks, combat and merchant ships, planes and communication equipment. They're durable, washable, and can be reproduced in any color, size or design. No screws, bolts or rivets required for application. No sharp edges. Meyercord Decals can be applied to flat convex or concave surfaces . . . for interior or exterior use . . . on metal, wood, fabric, rubber . . . even CRINKLED METAL! Special mar-proof Decals are resistant to temperature extremes, fumes, abrasion, vibration. Free designing and technical service. For complete information address Dept. 9-12.

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Tubes in Aircraft Testing

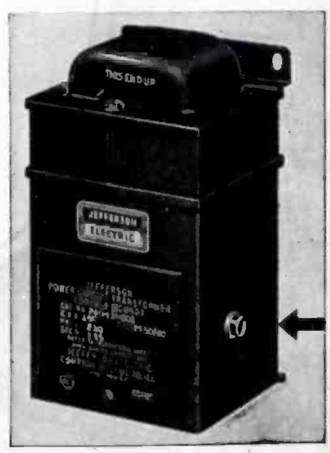
THE USE OF tube type 866A in dynamometers which are used to test horsepower and performance of airplane engines has been announced. The tube and associated equipment is used to hold the speed

of the aircraft engine to tolerances of about 0.1 percent. The dynamometer, by using tubes, holds the speed of the engine constant no matter what the output in horsepower is.

Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill.

Power Circuit Transformers

POWER CIRCUIT transformers in capacities from 100 to 750 watts are available with simple, effective circuit breakers for overload and short-circuit protection. These transformers can be mounted directly on machines to step down the 550, 440, or 220 volts to 110 volts. The circuit breaker is tam-



per-proof and is housed in the transformer case with an extending reset button. Glass-enclosed fuses are provided in place of circuit breakers for 25- to 75-watt transformers.

Jefferson Electric Co., Bellwood, Ill.

OF POSTWAR IMPORTANCE TO ELECTRONIC ENGINEERS

For tomorrow's world—the world of electronics—sensitive instruments and finely integrated mechanisms will require the protection of scientific insulation against vibration. Tolerances hitherto acceptable, will have to be sharply narrowed.

Rubber, undoubtedly, will continue to prove itself the most effective material for such service. Rubber mountings, properly engineered, will help reduce vibration to the vanishing point.

This is not a new concept. For United States Rubber Company technicians have been furnishing mountings and other rubber-bonded-to-metal vital parts for specific industrial uses over a long period of years . . . and with steadily advancing success.

The war is affording even more exacting opportunities for test . . . providing invaluable technical data. In tanks, P-T boats, aboard planes and ships . . . in the shock of combat, U.S. Rubber mountings have provided the requisite protection for electronic and electrical equipment against impact and vibration.

The exact knowledge of the chemical and physical properties of rubber—both natural and synthetic—as well as the techniques for engineering it—gained by "U.S." specialists, is of timely significance for electronic engineers.

Manufacturers in this and allied fields are sure to benefit quickly and continuously through their cooperation, at war's end.

Serving Through Science
with Engineered Rubber Mountings

UNITED STATES RUBBER COMPANY

1230 SIXTH AVENUE, ROCKEFELLER CENTER, NEW YORK 20, N. Y. • *In Canada*: DOMINION RUBBER CO., LTD.

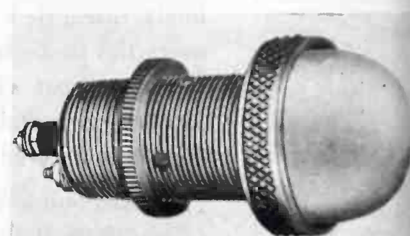
Lacing Cord

A LACING CORD, designated Band-Tite Lacing Cord, Grade R80, is a plastic material which may be used in place of waxed twine to lace or tie together electric wires or cables in electronic or switchboard applications. The cord is unaffected by adverse weather conditions or by tropical insects. It is somewhat elastic and retains its elasticity indefinitely. The material is easy to handle because any knots tied with the cord will not slip due to the elasticity. The cord hugs the wires to which it is bound and remains that way permanently, according to the manufacturer.

The Art Chrome Co. of America, 141 Malden St., Boston, Mass.

Glass-Lens Indicating Light

AVAILABLE FOR heavy-duty service (120 volts) is an indicating light which has been designated as Type 590 D/E and which features a small-diameter mounting hole and a new type of lens-cap. The lens-cap is a threaded type of cap and contains a heavy-walled glass lens,



cupped in shape. Servicing is easily accomplished without the use of tools or springs. The lens design provides 180 deg visibility. Lenses are available in red, green blue, amber and white with sand-blasted interior surfaces, or in clear glass.

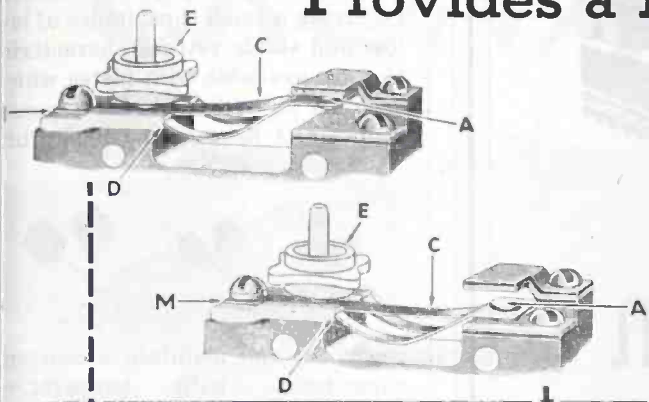
The H. R. Kirkland Company, Morristown, N. J.

Coaxial Connectors

COAXIAL CONNECTORS, designated as Dico, are for use with high frequency instruments and one of their features is the precision silver-plating of their accurately machined brass bodies and berryllium-copper contacts. The contacts maintain close contacts and are corrosion resistant. These units comply with Army and Navy specifications.

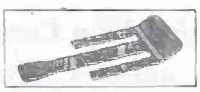
Diamond Instrument Co., Wakefield, Mass.

Why MICRO SWITCH
Provides a Long Snap-Action Life



Micro Switch Operating Principle

The operating principle of the Micro Switch as illustrated here is simple and fundamentally correct. The long member of the one-piece spring "C" is supported as a cantilever at "M". The two shorter compression members of the spring rest in specially shaped (patented) V's. When the plunger "E" deforms the long tension member, the cantilever force overcomes the vertical force supplied by the compression members and the free end of the spring "A" snaps the contact from one stop to the other with lightning-fast speed. Snap action in the reverse direction occurs when the deformation of the tension members of the spring by plunger "E" is removed.



This one-piece beryllium copper spring is heat treated to provide the high fatigue resistance necessary to insure a minimum of 5,000,000 trouble-free mechanical operations, at full overtravel.

The rivet type contact is of superfine silver 99.95% pure.

The operating plunger is a highly polished, hard, stainless steel pin molded into an accurate Bakelite head. This head is so shaped that it cannot rotate, hence bears on the switch spring at the same point through millions of operations.

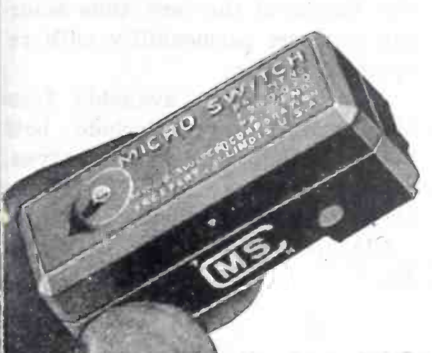
Micro Switch provides lightning-fast, snap-action control of electric circuits with reliable and positive operation accurately repeated over millions of cycles.

This performance is made possible by use of the unique, field tested, and proven operating principles of the Micro Switch. The snap motion of the Micro Switch contact is in the same direction as that of the operating plunger. There are no reverse bends in the Micro Switch spring, and there is no life-limiting "oil can" action.

The experience of design engineers with millions of Micro Switches in a great variety of applications has shown performance ability and operating characteristics never before found in snap-action switches.

Its small size, its high electrical rating, its ability to operate satisfactorily for millions of operations on minute movement and force differentials, its availability in various types of housings and a wide range of actuators . . . have made Micro Switch the choice of design engineers for precise operation of many types of plant equipment.

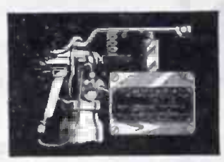
Micro Switch Handbook-Catalog No. 60 will give you complete details as to electrical characteristics, construction, applications and dimensions. If you happen to be specializing in aircraft equipment, also send for Handbook-Catalog No. 70.



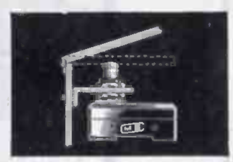
The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate repeat performance is experienced over millions of operations. Wide variety of basic switches and actuators meets requirements varying from high vibration resistance to sensitivity of operating force and motion as low as 2/1000 ounce-inches. Many types of metal housings are available.

© 1944

HUNDREDS OF SPOTS FOR MICRO SWITCHES

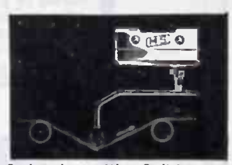


An explosion-proof Micro Switch is used with a spray gun to cut off the ventilating system of the spray booth automatically when the gun is hung up.



Micro Switches are used as safety switches on high tension cabinet doors. A normally open switch breaks circuit as door is opened.

Two Micro Switches with spring type plungers are used to insure correct position of material in jigs and fixtures.



Spring plunger Micro Switches serve as break indicators in textile and paper mills.

MICRO SWITCH TRADE MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILL., U.S.A., Sales Offices in New York, Chicago, Cleveland, Los Angeles, Boston, Dallas, Portland, (Ore.)

. . . . USES

UNLIMITED

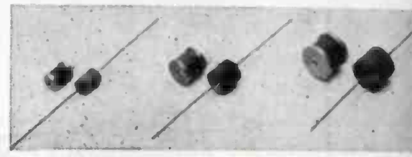
"Uses Unlimited"—a dramatic talking motion picture of Micro Switches, in color, is available to industrial groups, training classes, schools and colleges, through Y.M.C.A. Motion Picture Bureau, New York, Chicago, San Francisco. Size: 16 mm. Length: 40 minutes. Write us for details.

A star has been added to our "E" flag as further recognition to the men and women of Micro Switch for maintaining our war production standards.

Let's All Back the Attack—Buy Extra War Bonds

High Voltage Ceramic Capacitors

New types of capacitors for use in high frequency power circuits requiring a small capacitance of low loss and stable retrack characteristics are available with plates which are pure silver fixed to the ceramic. NPO units have zero temperature



coefficient and maintain a constant capacitance with temperature change. The dielectric constant of this ceramic body is approximately 40. N750 units have a uniform retraceable change with temperature coefficient of -0.00075 $\mu\mu f/\mu\mu f/$ deg C.

Centralab, 900 East Keefe Ave., Milwaukee 1, Wis.

Side-Molded Iron Cores

Molded by means of pressure applied from the sides rather than from the ends, improved iron cores are produced for permeability-tuning applications at broadcast band frequencies. Similar side-molded cores are now available for short-wave frequencies including television and frequency modulation. Density resulting from molding pressure extends evenly over the entire length of the core, thus assuring uniform permeability with respect to length.

Iron-core types available from this manufacturer include both standard and high-frequency types; insulated types; iron cores for choke coils; and others.

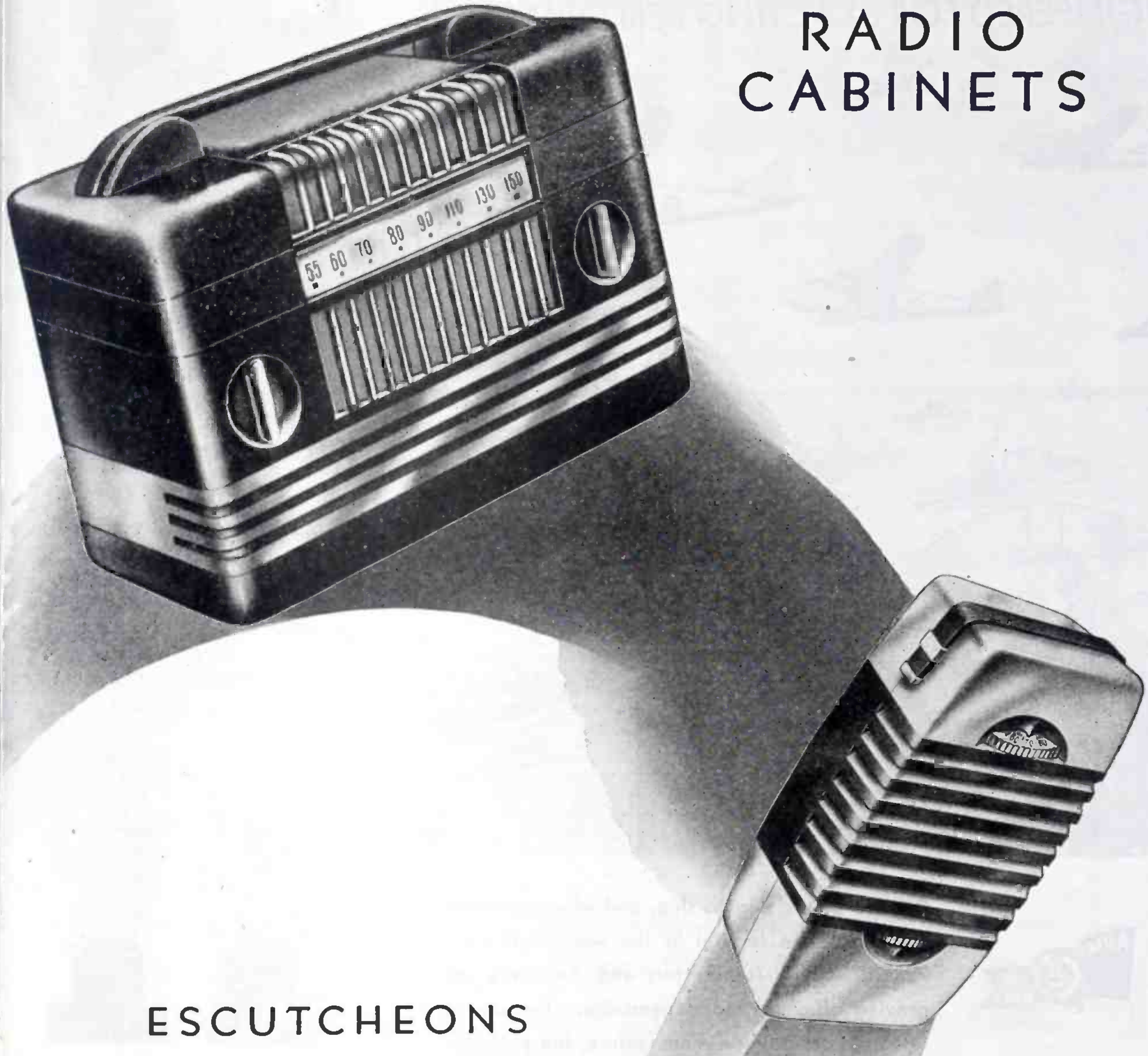
Stackpole Carbon Co., St. Marys, Pa.

Dielectric Test Set

For flash and breakdown testing of capacitors, TAC Model No. 1031-R dielectric test set is provided with a built-in high voltage cutoff relay which operates in conjunction with a remote control switch to apply test potential only while the remote switch is closed. An additional feature of this instrument is the provision for automatically discharging capacitive

CRONAME

METAL
RADIO
CABINETS



ESCUTCHEONS
DIALS
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OPERATING MECHANISMS

CROWE NAME PLATE & MANUFACTURING CO.

3701 RAVENSWOOD AVENUE — CHICAGO 13, ILLINOIS

OVER 40 YEARS EXPERIENCE IN FINE METALCRAFT

test specimens through a bleeder resistor when the remote switch is released.

The test set delivers up to 4000-v dc, continuously adjustable by means of a primary Variac. An output meter is used to indicate the voltage being applied to the specimen.

Bulletin 1044-F contains detailed information. Technical Apparatus Company, 1171 Tremont Street, Boston, Massachusetts.

Fence-Controller Tubes

TYPE 208 is a glow discharge tube which is rated 875 to 950 v dc at 8 milliamp. Type 207 (illustrated at the left) is a rectifier tube. It is rated 2.5 filament v, ac; filament current 2.5 amp; maximum rms a-c

volts 1250; maximum dc current 125 milliamp. Both tube types have glass envelopes and standard 4-pin bases. All connections are brought out to the pins in the base.

Taylor Tubes Inc., 2312 Wabansia Ave., Chicago, Ill.

Cut-Off Wheel

DESIGNATED AS Bevil Diamond-Impregnated Cut-Off Wheel, this wheel cuts all non-metallic materials of dense, brittle structure such as quartz, vitreous and ceramic wares,

NEW AUDIO OUTPUT TRANSFORMER

by FOSTER

Only 1-inch in diameter by 1⅝ inches long, this small, compact transformer* is Foster-designed for a longer life of steady, dependable service. Terminals are loop-shaped for easy hook-up and hermetically sealed against widely varying temperature and moisture conditions by VITROSEAL, the sensational new Foster development in hermetic sealing.

* Also available in same case size and style are new microphone input transformer, and modulation transformer.

And this is only *one* of *more than a thousand* types of transformers designed and custom-built by Foster during the past year.

Wherever transformers of a specialized function or design are involved, it may well be worth your while to consult Foster Engineers or a Foster Representative, who are ready now to consult with you on either present work or post-war planning.

REPRESENTATIVES

BOB REID	810 EAST 57TH STREET,	INDIANAPOLIS 5, IND.	TELEPHONE: BROADWAY 2725
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SPECIALISTS IN BUILDING TRANSFORMERS SINCE 1938

A. P. FOSTER COMPANY

TRANSFORMER ENGINEERS & MANUFACTURERS

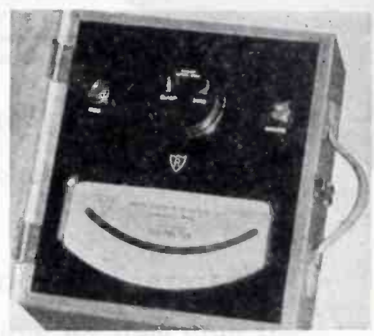
719 WYOMING AVENUE, LOCKLAND 15, OHIO *(SUBURB OF CINCINNATI)*

porcelain, glass, and tile—easily, quickly and without chipping or cracking. The Bevil process involves the use of a fusion bond which prevents the rim on the wheel from pulling loose, or the diamonds from wearing faster or dropping out entirely. Wheels are made in sizes of 3, 4, 6, 8, 10, 12 and 14 inches. Diamond impregation is $\frac{1}{8}$-in.

Bulletin No. 15, describing these wheels in detail, is available from Cryco, Inc., 1516 Mission St., S. Pasadena, Cal.

Electrostatic Voltmeter

IN TYPE 518 electrostatic voltmeters, the insulation resistance is guaranteed to be higher than one million megohms, making it possible (without disturbing the circuit) to measure high-voltage sources which are designed for a load current of only a few microamps. It is possible to use these meters for the measurement of electrostatic voltages such as are generated in the process of manufacturing paper, cloth, celluloid, and other dielectric materials. For a-c measurements, the input impedance is

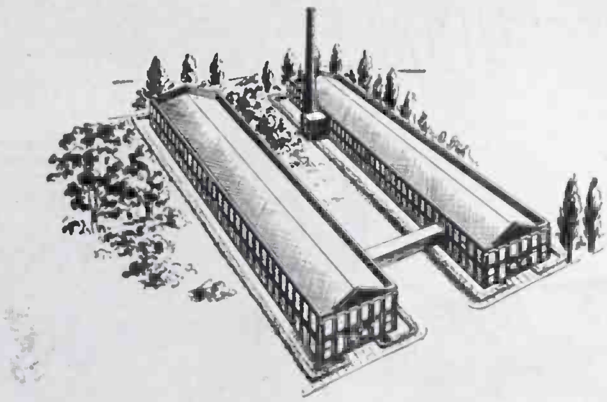


that of a small capacitance in parallel with a very high leakage resistance. As an example, the 5000-v meter has a capacitance around 8 micromicrofarads, and a resistance of several million megohms.

At present these meters are available in ranges of 1, 2, 3, 5, 10 and 20 kilovolts, full scale. Other ranges are available on special order. The accuracy is guaranteed to be 1 percent or better, with a scale length of approximately $5\frac{1}{2}$ in. The meters are completely portable.

Rawson Electrical Instrument Co., 111 Potter St., Cambridge 42, Mass.


SEEBURG
THE AMERICAN PUBLIC IS CONFIDENTLY LOOKING
AHEAD TO IMPROVED "RECORD CHANGER PERFORMANCE"
THIS CONFIDENCE WILL BE JUSTIFIED BY
THE NEW
SEEBURG RECORD CHANGERS
YOU SAVE LIVES
WHEN YOU SUPPORT
ALL WAR LOAN DRIVES!
ARMY
NAVY
Awarded to the J. P. Seeburg Corporation for outstanding production of war materials in each of its four plants
Seeburg
FINE MUSICAL INSTRUMENTS SINCE 1902
J. P. SEEBURG CORPORATION · CHICAGO



Literature

Industrial Brush Catalog. Slip ring, commutator, motor and generator brushes, as well as metal graphite and carbon products are listed in a 24-page catalog designated as Price List No. K-15. Keystone Carbon Co., Inc., Saint Marys, Pa.

Data Book. This 124-page "Esna Data Book and Catalog" includes complete information on three types (Hex, Anchor, Clinch-Nut) of elastic stop nuts, out of some 2500 different kinds manufactured by Elastic Stop Nut Corp., 1060 Broad St., Newark 2, N. J.

Precision Crystal Units. "Quartz Crystal Blanks and Units" is the title of a 32-page well-bound catalog which illustrates and describes crystal units available for use in broadcasting, amateur, aircraft, police, and marine activities. Types include: filter, test, multiple, and blanks. Specifications for these units are also given. Crystal Products Co., 1519 McGee St., Kansas City 8, Mo.

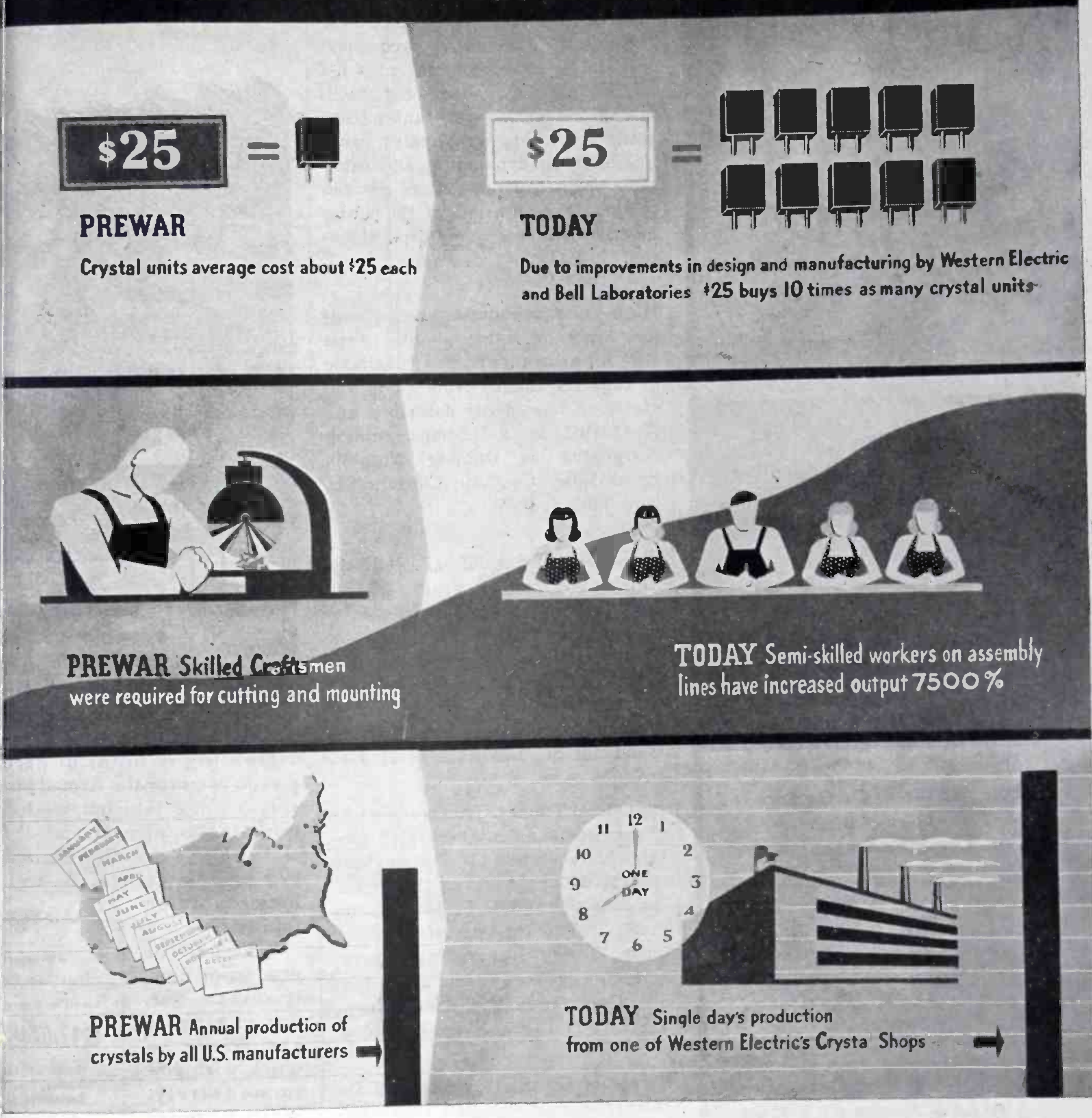
Polethylene Resins. Forms, properties, fabrication procedures, and uses of polethylene resins are contained in a 12-page catalog. Plastics Div., Carbide & Carbon Chemicals Corp., 30 East 42nd St., New York 17, N. Y.

Sylvania News-Letters. A 2-page index to past issues of "Engineering News Letters" is available from Sylvania Electric Products Inc., Emporium, Pa.

Masts, Towers. Easy-to-erect masts and towers for radio communication are graphically described in an 18-page catalog. Harco Steel Construction Co., Inc., 1180 East Broad St., Elizabeth, N. J.

Quartz Etching. "Frequency Etch" is the name of a pamphlet which describes a specially compounded product for etching quartz oscillator plates to frequency. Hudson American Corp., 25 West 43rd St., New York 18, N. Y.

LOOK WHAT'S HAPPENED TO CRYSTAL OUTPUT



Astonishing? Perhaps, but it is just one of the many things Western Electric has done to make better products in larger quantities and at lower costs. Increased manufacturing facilities, new production methods and intensive research by Bell Labs — all have played their parts in this war production miracle.

When Western Electric radio equipment is again available for peacetime use, you can count on getting the benefits of this wartime experience.

Buy all the War Bonds you can—and keep all you buy!

75TH ANNIVERSARY

Western Electric

ARSENAL OF COMMUNICATIONS EQUIPMENT

General Catalog. Catalog C is a 32-page catalog which gives the background data of this company, and contains descriptive matter, as well as illustrations of such equipment as Q meter; QX checker; beat-frequency generator, frequency-modulated signal generator; v-h-f circuit checker; supersonic oscillator; inductors; constant-voltage transformer; power supply; coupling, output, dynamotor, and oscillator units. Two pages are devoted to an index and prices of the equipment. Boonton Radio Corp., Boonton, N. J.

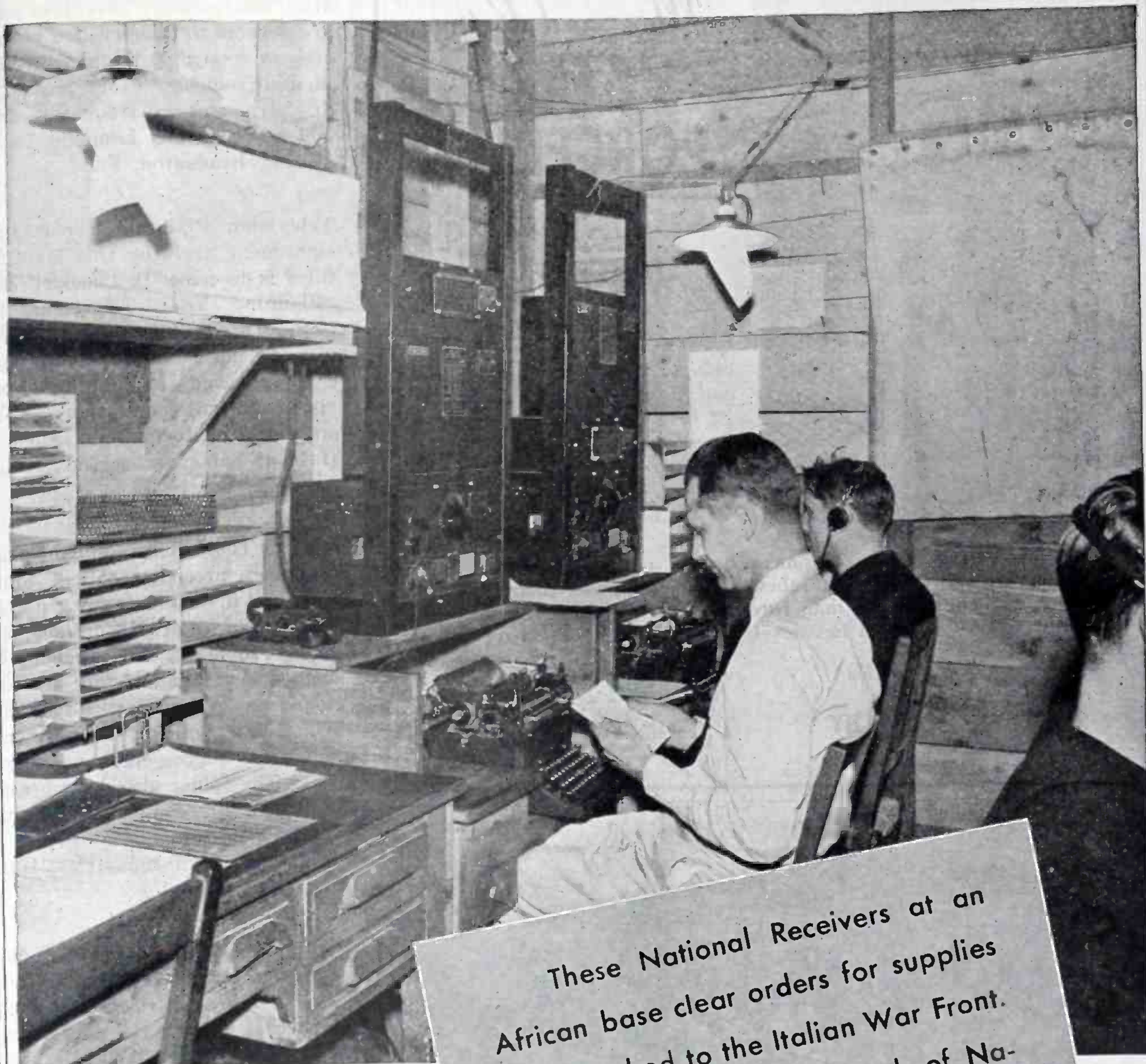
High Vacuum Pumps. Seven standard sizes of rotary-piston (Type RP) high vacuum pumps (available in capacity ranges from 15 to 750 cfm) are thoroughly described and illustrated in a 12-page catalog designated as Catalog No. 80. Beach-Russ Co., 50 Church St., New York 7, N. Y.

D-C Solenoids. A 32-page bulletin which contains photographs of this manufacturer's full line of d-c solenoids, together with tabular data, dimensional drawings, wiring diagrams, and response characteristic charts is available from Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Cal.

Industrial Timers. This is the name of a loose-bound catalog which contains data sheets on electric time control devices such as the manufacturer's P and M Series of automatic reset timers; time delay units; Series S signalling timers; running time meter; and a new tandem timer. Industrial Timer Corp., 117 Edison Place, Newark 5, N. J.

Selenium Rectifiers. Pertinent information covering the characteristics and applications of Type B-L metallic rectifiers in electronic and battery-charging equipment is contained in Bulletin R-41. The Benwood Linze Co., 1811 Locust St., St. Louis 3, Mo.

Micrometer Frequency Meters. Types 103 and 105 meters are described in a 36-page bound booklet entitled "Micrometer Frequency Meter Engineering Data Sheets" which contains specifications, cir-



These National Receivers at an African base clear orders for supplies being rushed to the Italian War Front. They are typical of thousands of National Receivers in key spots throughout the world, serving the Armed Forces with superb dependability and performance.

NATIONAL COMPANY

MALDEN MASS, U. S. A.

NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD cuit diagrams, parts lists, and operating instructions. Seventeen pages are devoted to tables which make it easy to determine the meter fundamental-frequency for measuring any transmitter frequency from 100 kc to 56 Mc. Lampkin Laboratories, Bradenton, Fla.

Television Planning. Telecasting equipment made by this manufacturer is described in a booklet called "Planning Your Television Station." This booklet also attempts to give an idea of the approximate costs involved in planning a television station, the station's set-up, and other information. Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.

Optical Tools. This company manufactures precision optical equipment and instruments for visual inspection of internal surfaces, and among some of the products described in a 6-page folder are such items as Borescopes, lenses and prisms, electronic glass components, industrial microscopes and magnifiers. The folder also describes the facilities this company has available for the manufacture of its products. Polan Industries, Huntington 19, West Va.

Miniature Ball Bearings. A complete and integrated line of miniature ball bearings for instrument, industrial, and special uses is contained in Bulletin No. 44. Miniature Precision Bearings, Keene, N. H.

Fastening Application Bulletin. Type 1 thread-cutting screws for metals and Type 25 thread-cutting screws for plastics are discussed in this bulletin. Shakeproof Inc., 2501 N. Keeler Ave., Chicago, Ill.

Bakelite Booklets. Two new booklets available from Bakelite Corporation (300 Madison Ave., New York 17, N. Y.) include "Catalog of Bakelite and Vinylite Plastics" which contains a complete listing of all the products marketed by this company. The second booklet is entitled "Bakelite Resin Baking Catalog" and it contains specific information on the properties and characteristics of phenolic resin baking coatings.

A PORTABLE TESTING INSTRUMENT WITH NO PROJECTING PARTS

ROLLER-SMITH TYPE NP . . .

Roller-Smith Type NP Portable Testing Instruments are designed for general service where a highly accurate and extremely rugged instrument is required. The case is made in two parts: an outer walnut case and an inner two-piece metal case. This construction furnishes full magnetic shielding, protects the mechanism from external strains, and the movement from dust and moisture. The lid of the instrument is designed to completely cover the dial and all binding posts, so that when closed there are no projecting terminals or other parts. The window is of maximum area for high dial visibility; scale length is 5¼″. Instruments are 8″ square by 5½″ in depth and weigh approximately 7 pounds. Ratings cover a broad range of testing requirements.

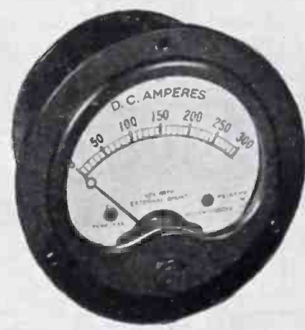
Roller-Smith Type NP Instruments are supplied in single or multiple ranges for the measurement of direct current in milliamperes, amperes and volts, and alternating current in amperes, volts, watts, power factor and frequency. D-c instrument mechanisms are permanent magnet moving coil (d'Arsonval) type; a-c ammeters utilize a repulsion iron-vane mechanism and all other a-c instruments, an electro-dynamometer mechanism.

Catalog 4340 contains complete description and full information with prices. Write for a copy.

OTHER R-S INSTRUMENTS

Panel, switchboard and portable instruments of practically every standard size, shape, capacity, type and style are included in the R-S line of electrical instruments. Let us quote prices and deliveries on your instrument requirements.

"Steel-Six" Portable Ammeter. Scale length 5³⁄₁₆″. Size 6″ x 6″ x 4″. Accuracy ½ of 1%.



Type T-3.5″ Miniature Panel Ammeter. American War Standard type conforming with AWS C39.2—1944.

ROLLER-SMITH BETHLEHEM, PENNA.

Canadian Plant: ROLLER-SMITH MARSLAND LTD., Kitchener, Ontario

Sales Representatives In all Principal Cities

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS • AIRCRAFT INSTRUMENTS • SWITCHGEAR
AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • RELAYS • PRECISION BALANCES

NEW BOOKS

Aircraft Instruments

By George Ellis Irvin, *late president, Irvin-Aircraft Instrument Schools. McGraw-Hill Book Co., New York, 2nd ed., 1944, 607 pages, price $5.00.*

In this second edition much new material has been added. The subject matter has been considerably amplified in the chapters dealing with electrical type thermometers and temperature gages and other electrical aircraft instruments and meters, the vapor-pressure manifold, the Weston a-c/d-c tachometer, synchronizer circuits and instruments, Kollsman hp indicator, Kollsman accelerometer, Pioneer Magnesyn compass, and fuel flowmeter.

The operating principles, contruction, procedure for testing, calibrating and repairing of numerous types of aircraft instruments are explained in detail. More than fifty tables of reference and working data are presented.

The scope of the volume covers engine instruments, navigation instruments, and flight instruments. There are also chapters on meteorology and meteorological instruments, instrument-panel design, antivibration mounting of airplane instruments, vacuum pumps, and fabrication and installation of aircraft tubing.

While primarily a textbook, the information presented should attract both technical and nontechnical readers, who have a desire to understand the purpose, fundamental principles of design and operation of the many instruments now in use in modern aircraft.—J.K.

• • •

Alternating Current Bridge Methods

By B. Hague, *Issaac Pitman & Sons, New York, 5th ed., 1943, 616 pages, price $8.50.*

Dr. Hague's standard work on a-c bridges is now in its fifth—and war—edition, which follows the scope and arrangement of the fourth edition (1938) with minor changes. Some new material has been added, as that on copper-oxide and cathode-ray detectors, and an appendix dealing with the sensitivity of bridge networks, bridged-

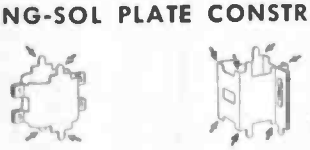
BUILT TO WITHSTAND WHIP AND VIBRATION

Electronic Tubes used in the communications equipment of planes and ships, industrial controls, car radios and even in home sets are all subjected to vibration in varying degrees. Long life and maintained efficiency is therefore very dependent on a firmly supported mount.

The demands of war have emphasized the importance of rugged construction. To impart a new sturdiness to the mounts of miniature tubes TUNG-SOL Engineers have designed a plate construction for the 6AK5 that greatly strengthens the mount . . . in fact, it makes it virtually impossible to tilt it after the plate has been placed in position. This feature assures straight, sturdy mounts and the maintenance of close tolerances.

The many dependability features that have been designed into TUNG-SOL tubes before and during the war will be invaluable to manufacturers and users of electronic devices afterward. When you are ready to plan your post-war electronic products, have a TUNG-SOL Engineer sit in with you. His knowledge of tubes and their application will greatly simplify your job.

NEW TUNG-SOL PLATE CONSTRUCTION



The former two-piece plate in the 6AK5 tube was supported only at four points in the center. In the new TUNG-SOL one-piece plate, there are four corner supports, top and bottom. This construction provides a firm support between micas, assuring straight, sturdy mounts.

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ELECTRONIC TUBES

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ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

T networks, a brief survey of developments since about 1937, and improved bridge methods and bridge apparatus. No attempt has been made to present these supplementary notes as a complete survey of recent advances.

Although there are only five chapters the chapter headings will give an adequate indication of the scope and content of the volume. These are: (1) Fundamental Principles, (2) Symbolic Theory of Alternating Currents and Application to Bridge Networks, (3) Apparatus, (4) Classification of Bridge Networks, and (5) Choice of a Bridge Method and the Precautions to be Observed When Using It.

The research worker or laboratory technician can find many useful hints and worthwhile ideas in the third chapter, which treats in considerable detail the desirable features of circuit elements and other bridge apparatus, giving examples of good design and, when possible, indicating limitations and ranges of the equipment.

Chapter IV presents a concise description and classification of bridge networks, together with a summary of the literature concerning them. In some respects, this chapter may be regarded as the heart of the entire volume.

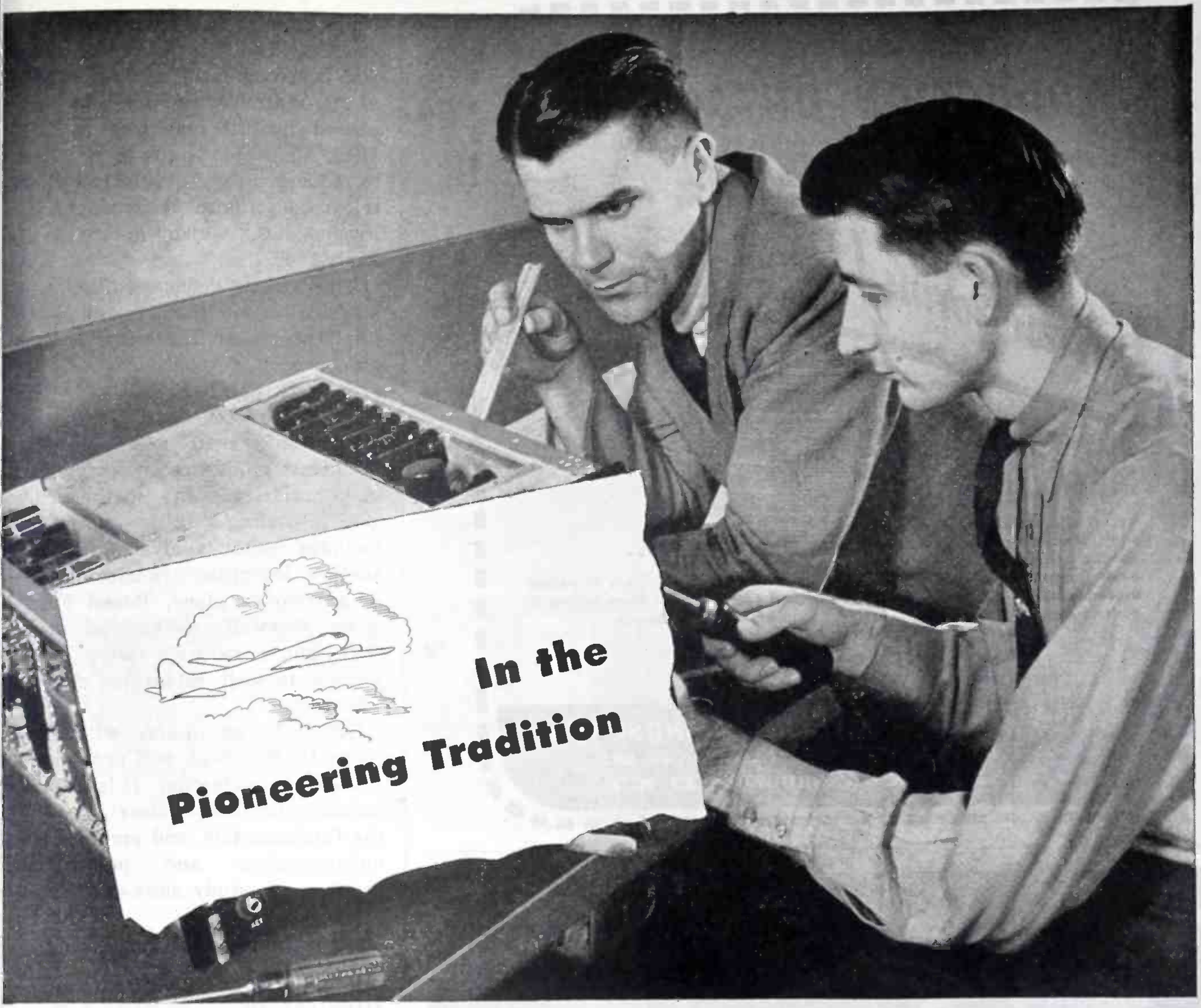
The final chapter contains much practical and theoretical information which will assist the laboratory worker to select that bridge arrangement which will provide the desired results and the required precision with the minimum amount of expenditure of time, energy, and equipment. A valuable portion of this chapter is the summary of bridge methods suitable for the measurement of electrical quantities in various ranges. Errors due to stray field and grounding and shielding practice are treated adequately.—B.D.

• • •

Fields and Waves in Modern Radio

By SIMON RAMO, *Electronics Laboratory of General Electric Co. and Union College, and* JOHN R. WHINNERY, *Electronics Laboratory of General Electric Co., John Wiley and Sons, Inc., 1944, 502 pages, $5.00.*

THE AUTHORS have coordinated much of the material previously published disjointedly in books and papers for those who have had the



THE COLLINS RADIO organization has always been driven by the urge to pioneer . . .

To introduce professional standards of design and performance in transmitters and receivers for radio hams in the early thirties.

To engineer a radio outfit that stood up to the rough-and-tumble of Admiral Richard E. Byrd's second expedition to Little America.

To take high quality broadcast equipment out of the laboratory and make it economically practicable for any broadcasting station.

To meet the individual requirements of some of our great airlines with specially engineered communication equipment, including the Collins Autotune.*

To be prepared on December 7, 1941, to go into production of airborne and ground based radio gear of highly advanced design for the Armed Forces—the result of research and development looking years ahead.

Very soon, we hope, this restless Collins urge to pioneer beyond present horizons will be exerting itself again for the airlines and other commercial and private users of radio communication equipment. *Collins Radio Company, Cedar Rapids, Iowa.*

*The Collins Autotune is a repositioning mechanism which quick-shifts all transmitter or receiver controls simultaneously and with extreme precision to any one of a number of pre-determined frequencies. U. S. Patents issued and pending.

COLLINS

usual engineering courses through calculus. The chapter on skin effect will be recognized as an extension of Mr. Whinnery's article which appeared in this magazine in Feb. 1942. Mr. Ramo is already familiar to readers through his paper, Electrical Concepts at Extremely High Frequencies, which appeared in Sept. 1942.

The book introduces concepts by means of static fields, examines the implications and limitations of such an approach, develops exact and approximate solutions at high frequencies for reflection, absorption and propagation, and concludes with wave guides, resonant cavities, and radiation. The mathematics used in dealing with these problems includes vector analysis, line and surface integrals, transformations in a complex plane, Bessel Functions, Maxwell's differential equations, and Poynting's vector. Each section is well integrated to the whole.

To those unfamiliar with field concepts, this book will provide an excellent introduction. It is not elementary, but it does clearly present the fundamentals, and provides the understanding and perspective necessary to study more specialized works.—F.R.

• • •

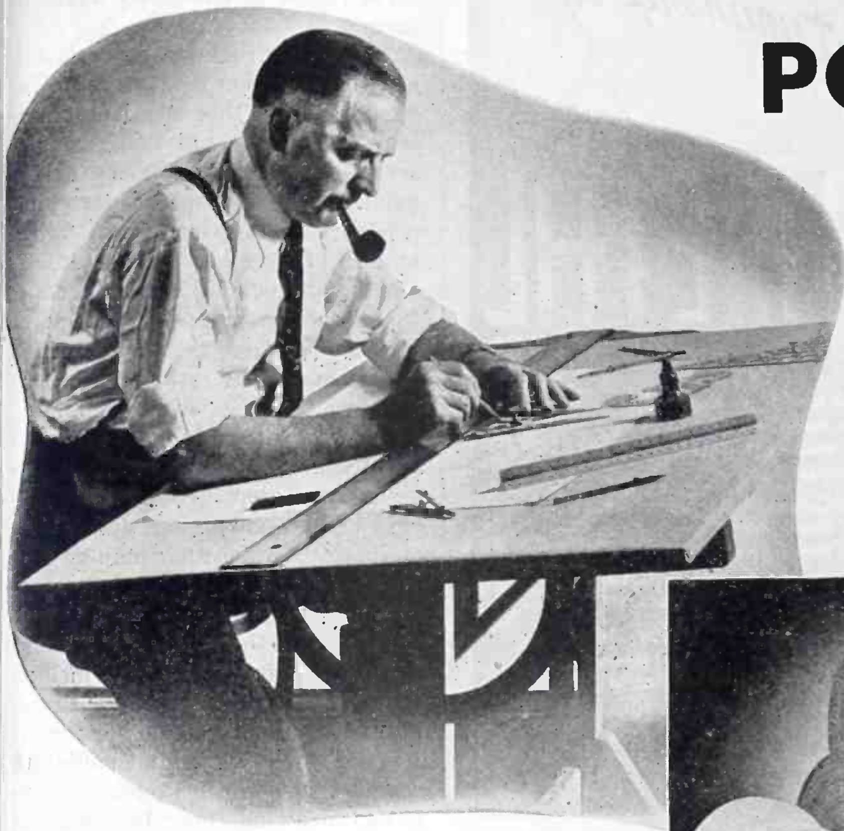
Aircraft Production Illustration

By George Tharratt, *McGraw-Hill Book Co., New York, 1944, 201 pages, price $2.75.*

The important functions of this book are the simplification of the principles of production illustration and a review of its value to industry. Various methods and types of production illustration are discussed with the ultimate purpose of clarifying the subject, in easily understandable and progressive steps to draughtsmen and artists with or without any engineering background or knowledge.

Production illustrations, as outlined by the author, are simple but accurately drawn to scale, three-dimensional picturizations of parts, subassemblies or any mechanical operation of assembling parts. They provide production line workers with picture instructions of proper mechanical procedure and also afford engineers a quick method of explaining operations to produc-

Redesigning your Instrument Transformers for POSTWAR?



Are you looking for:

- <u>smaller</u> current and potential transformers for savings in switchboard space?
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Don't overlook the low space factor of

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Design often begins with space needed for windings—including insulation on wire and tapes around coils. And always, a reduction in the bulk of insulation effects reductions in copper and iron.

Fiberglas Insulating Tapes have very high tensile strength. They permit an exceptionally tight wrap around coils—for a more compact winding. And, because they can be cut without seriously affecting their function as a tape, Fiberglas Tapes minimize "bunching" of insulation on inside corners of coils.

If space is at a premium—remember that a thinner Fiberglas Tape will do the job of a thicker organic tape. And Fiberglas Tape will occupy considerably less space than equivalent inorganic materials.

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WHAT IS FIBERGLAS?

Fiberglas is the trade name for glass manufactured in fiber or filament form by Owens-Corning Fiberglas Corporation. When made of a glass specially formulated for electrical uses, these fine filaments are twisted into yarns to be served on wires, woven into tapes and cloths, braided into sleevings or tubings or plied to form cords—to provide all standard types of plain or treated insulation required in electrical equipment.

ARMY E NAVY

FIBERGLAS

*T. M. Reg. U. S. Pat. Off.

ELECTRICAL INSULATIONS

YARNS • TAPES • CORD • SLEEVING • CLOTH AND OTHER FORMS

tion line supervisors. In this respect they do not displace blueprint or engineering-design drawing, but serve rather to effectively augment them.

The author reviews the basic values of production illustration to industry. From this standpoint several important angles are considered: eliminating needless delays during design stages; increasing production line technique; minimizing of possible changes in design and production after production routines have been decided. Methods are suggested by which this type of illustration can be put into practice in existing plants.

The student angle of the subject is intelligently approached in easily assimilated steps. Numerous problems are presented, and descriptive methods by which they may be successfully worked out are indicated.

Simple but effective explanations are given of the various types and methods of drawing. They include such problems as perspective drawing, angular perspective, determination of vanishing point, shades and shadows, technical sketching, exploded drawing, etc. Detailed information is presented on available drafting material and processes.

Repeated references to the applications of the principles of production illustrations in the aviation field fulfill the obligations of the title. However, it should not be overlooked that industry in general not only can take a page out of this book, but can literally take it from cover to cover, finding much that will aid in the production battle still ahead.—R.Q.

• • •

The Liquidation of War Production

By A. D. H. KAPLAN, *published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. 133 pages, price $1.50.*

WHEN THE SHOOTING is over and the economic life of the country can begin its return to normalcy some of the biggest problems will revolve around cancellation of war contracts and disposal of government-owned surpluses and plants. This book is a discussion of the ramifications of those problems and how they might be solved.

The author proves, with the help of statistics and past experience, that the problems are not insur-

mountable. He finds that if plans are laid now and business, government and labor will cooperate for the common good when the time comes, there should be a minimum of unemployment.

The book is Dr. Kaplan's report of a year-long study of the over-all reconversion problem to the Research Committee of the Committee for Economic Development. Dr. Kaplan is dean of the School of Business Administration of the University of Denver, on leave.

The significance of this book for the electronics field lies in the fact that the major problem for many companies will be one of conversion rather than reconversion. Therefore, changing to peacetime production that will help to hold unemployment at a minimum is an even greater problem than it would be if the change was merely one of going back to established products. The recommendations and suggestions in this book should be even more significant for the electronics industry than they would for a well-established field.—K.S.P.

• • •

Modern Operational Mathematics In Engineering

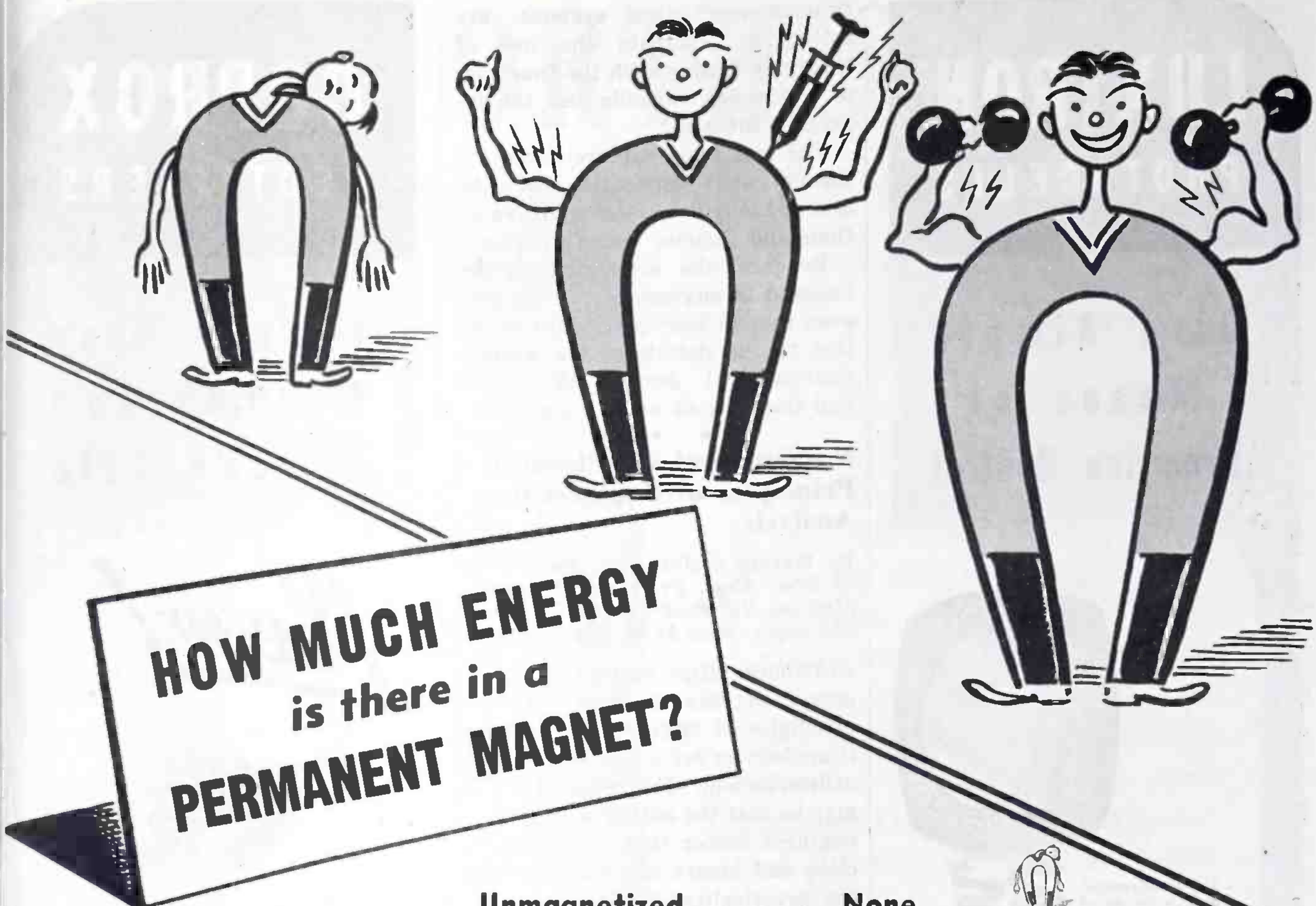
By Ruel C. Churchill, *Professor of Mathematics, University of Michigan. McGraw-Hill Book Co., New York, 306 pages, price $3.50.*

A companion volume to the author's earlier book entitled "Fourier Series and Boundary Value Problems."

This new textbook deals chiefly with the solutions of problems in engineering and physics that involve differential equations, by the applications of the Laplace transformation. Special emphasis is placed on the boundary value problems met with in partial differential equations.

Problems containing ordinary differential equations and partial equations are solved after a discussion of the Laplace transformation and derivations of its properties, with statements of operational theorems. These problems demonstrate the value of the operational method in the solution of differential equations in which some of the given functions or their derivatives are discontinuous.

Various problems relating to the conduction of heat in solids, also vibrations and resonance in con-



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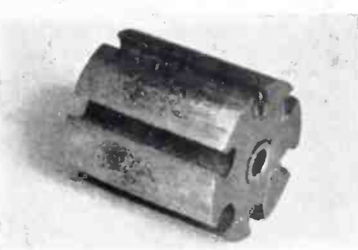

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tinuous mechanical systems, are solved to illustrate the use of theorems dealing with the functions of a complex variable and the inversion integral.

The last two chapters cover the theory and application of the Sturm-Liouville systems of equations and Fourier transformations.

Readers who are primarily interested in engineering or physics, even though they give scant attention to the details of the various mathematical derivations, should find the book of value.—J.K.

• • •

Mathematical and Physical Principles of Engineering Analysis

By WALTER C. JOHNSON, *Assoc. Prof. of Elec. Eng., Princeton University. McGraw-Hill Book Co., New York 18, 345 pages, price $3.00, 1944.*

ALTHOUGH THIS VOLUME is by no means the first to deal with the principles of engineering analysis, it appears to set a new standard of utilitarianism. The reason for this may be that the author writes as an engineer rather than a mathematician, and knows and can illustrate the practicality of the mathematical treatments he deals with. For this reason the engineer will find the volume a useful reference volume.

The author states, "The purpose of the book is to present the essential physical and mathematical principles and methods of approach that underlay the analysis of many practical engineering problems. The point of view is primarily utilitarian in an engineering sense but is aimed at a sound understanding of the basic principles and is designed to form a firm foundation for more advanced work. The book emphasizes basic physical principles and physical reasoning, and devotes considerable attention to the methods of attack, the use of assumptions, procedures in setting up equations, the use of mathematics as a tool in accurate and quantitative reasoning, and the physical interpretation of mathematical results. Graphical methods are used freely, and reasonable approximations are encouraged provided they lead to results within the required accuracy." This extract, from the preface, states very well the scope and aim of the volume. It only needs to be added that the volume

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fulfills its intended purposes in a highly satisfactory manner.

Chapter headings are: (1) Analysis of Engineering Problems, (2) Some Basic Physical Principles, (3) Transient and Steady-State Conditions, (4) Setting Up Equations, (5) Graphical and Numerical Solutions of Differential Equations, (6) Ordinary Differential Equations, (7) Vector Representation of Sinusoids, (8) Checking Equations, (9) Dimensional Analysis, (10) Fourier Series, and (11) Systems With Distributed Constants.

The emphasis which is placed on transient conditions in an early part of the volume is in keeping with recent developments in the electrical field and helps the student better to grasp the entire problem of analysis. Some thirty pages are devoted to setting up of equations, which is frequently a difficult matter for the student in spite of its importance.

Operational procedures are employed in treating ordinary differential equations. In most cases electric circuit theory is employed to illustrate the solution of the differential equations. An introduction to Bessel's equation and Bessel functions is included. The treatment of vector representations of sinusoids employs the rotating vector $e^{j\theta}$ instead of the more familiar trigonometric components, thereby achieving greater rigor with simpler mathematics. Mechanical and electrical problems are employed to illustrate mathematical principles. Checking physical dimensions on both sides of an equation, means of tracing errors, and evaluating limiting cases are treated in chapter VIII.—B.D.

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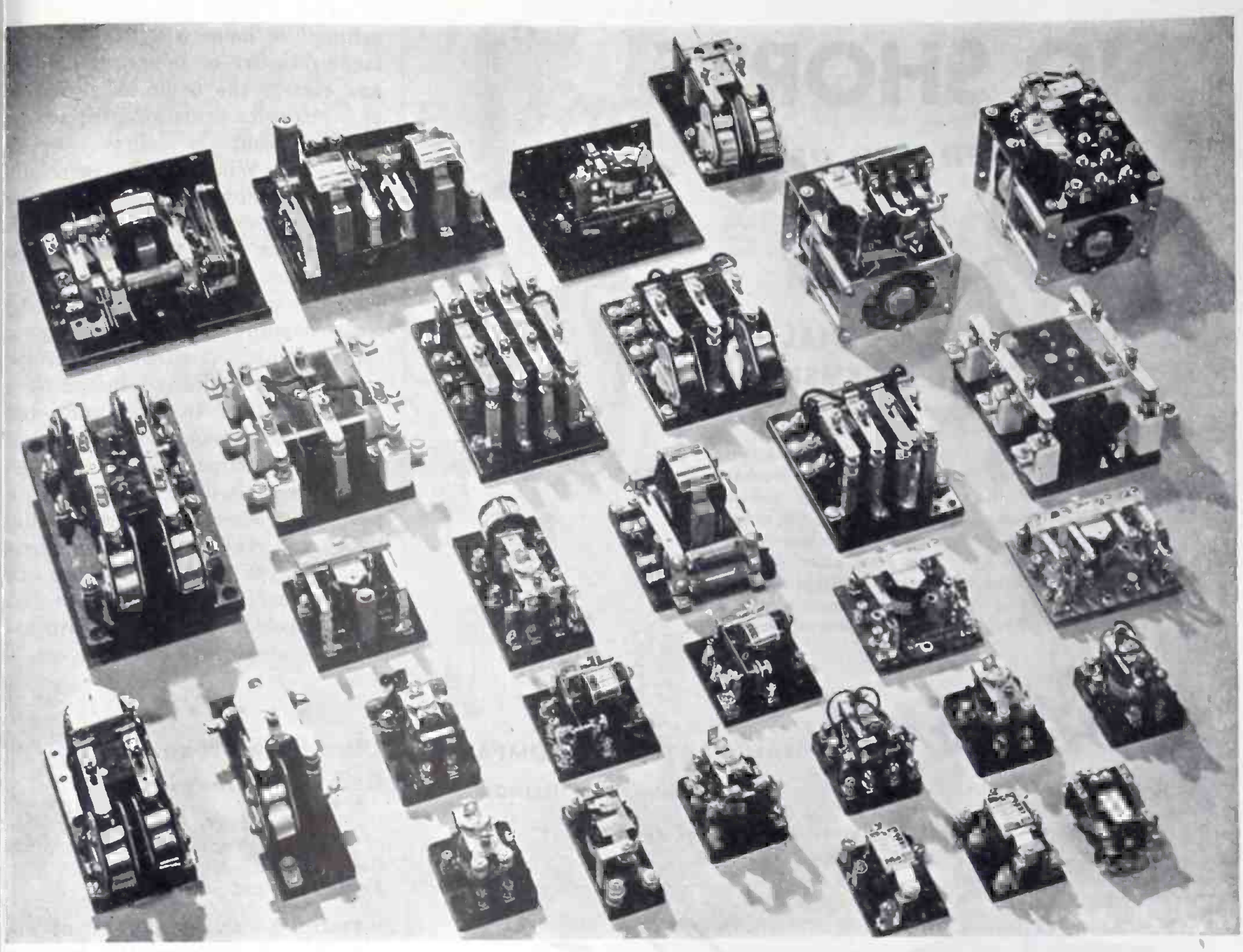
Speak Well—and Win

By WILLIAM P. SANFORD, *published by Whittlesey House, 330 W. 42nd St., New York 18, N. Y. 176 pages, 1944, price $2.*

ELECTRONICS AS AN INDUSTRY is on the spot because the general public has been led to believe that when the war is over this "new science" is going to revolutionize our living. People in the industry, especially the leaders, will have a hard time in some instances explaining why this revolution does not happen overnight but, instead, will take years.

How effectively this job of "un-



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When you can select the relay that exactly meets your requirements from a regular line, you have saved man power, time and money. WARD LEONARD RELAYS include types and sizes for every application. They all have crisp action, are dependable and durable yet consume but little current. Send for the data bulletins of interest to you.

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Bulletin 362

Motor Driven Time Delay Relays for operation on alternating current.

Bulletin 104

Midget Relay for tight places—Vibration resistant—Double Pole, Double Throw—Available for 6 to 115 volts A.C. or D.C.

Bulletin 131 and 132

Heavy Duty Relays single and multipole, single and double, contracts rated up to 25 amp. on 125-250V.

Bulletin 251

Sensitive Type Relays for direct and alternating current operating on .014 watts.

Bulletin 351

Thermal Time Delay Relays with thermostat built into relay assembly.

Bulletin 103

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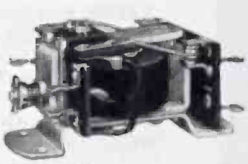

Midget Metal Base Relay measures 1¼ inches high for tight places in aircraft radio and control circuits where space is limited.

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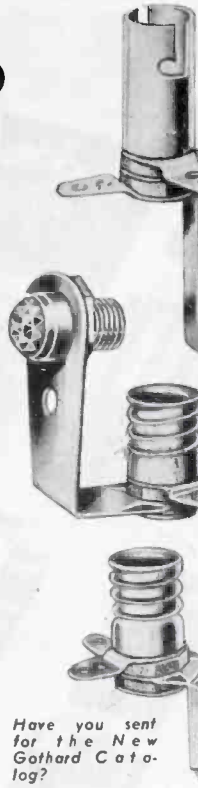

selling" is done will depend in a large measure on how convincingly and clearly the technical problems of electronics are presented to the public. That is where "Speak Well—and Win" can be especially useful to those who must do the explaining.

The meat of this book lies in the first section, which explains and illustrates what the author calls "the four constant aims of speaking"—communicate, illustrate, motivate and activate. This is followed by a second section that contains ten speeches by various prominent people to demonstrate these aims. The final section is a series of hints on preparing speeches, effective delivery and everyday speaking problems. The principles presented can be very useful to anyone who discusses problems and ideas with associates, employers or employees.—K.S.P.

• • •

Ultra-High-Frequency Radio Engineering

By W. L. Emery, *Former Instructor of Electrical Engineering, Iowa State College, The Macmillan Co., New York, 1944, 295 pages, $3.25.*

Written as an outgrowth of the 1941 MIT conference, this book is directed to college students and ESMWT radio classes. The subjects included are regulated power supplies, electronic switching, cathode-

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OPERATION IN RUINS

The regimental signaller of a British infantry unit reports to headquarters from the ruins of Aquino with the English version of the walkie-talkie

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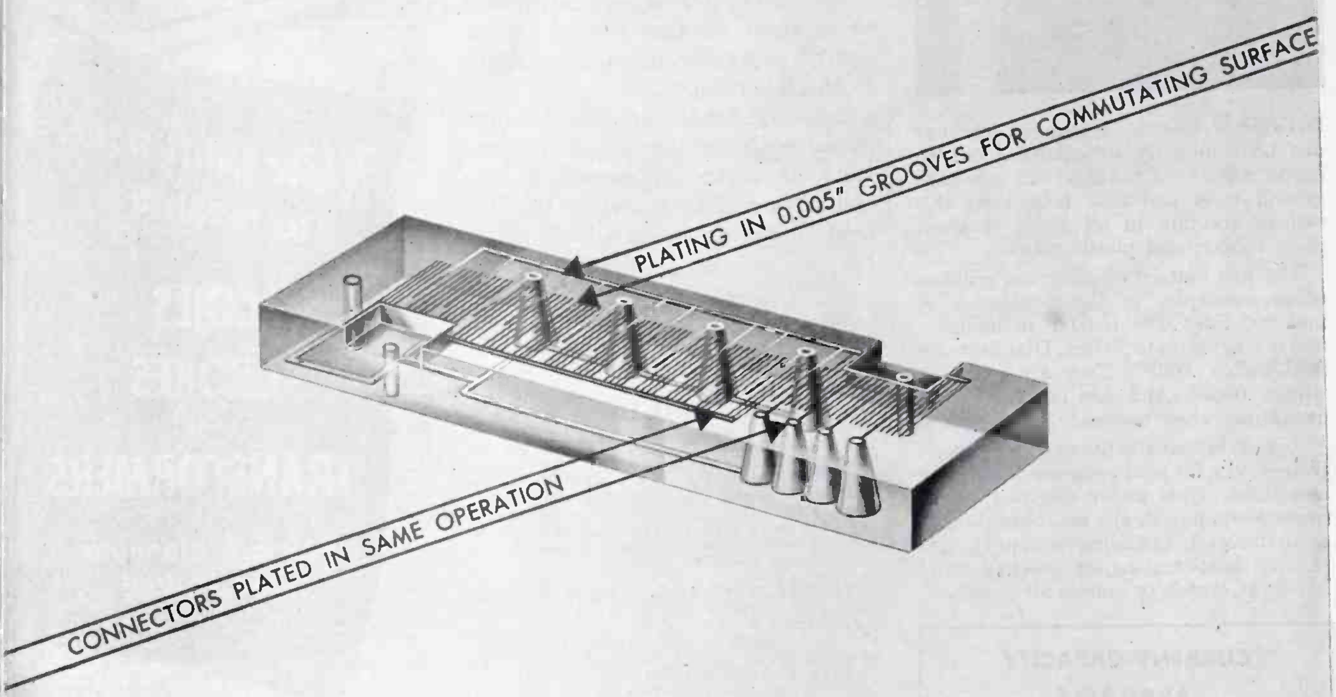

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As new as tomorrow, are the Metaplast developments . . . typified by the above one-piece commutator with Metaplated connectors and commutating surfaces.

When Metaplating is used there is no need for slow, expensive, alternate stacking of conductive and non-conductive pieces . . . always with the bug-a-boo of clamping pressure causing cold flow of certain segments over the commutating surface . . . not to mention the elimination of the multitude of soldered joints.

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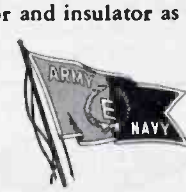
The molded parts vary only plus or minus .008" in length, thus eliminating separate calibration charts for each instrument in which the commutator is used. This new revolutionary manufacturing process also eliminates the troublesome gaps between conductor and insulator as well as the voltage breakdown problem between segments and mounting.



We invite you to confer with Metaplast Engineers to develop any ideas you have for bringing up to date the manufacture of commutators or similar electrical devices.

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METAL PLATING ON PLASTICS

ray tube sweep circuits, square-wave testing, transmission lines, uhf oscillators, wave guides and radiators, as well as the usual communication circuit elements and techniques.

The topics are presented briefly and directly. The mathematics includes calculus and vectors. To study this text intelligently the student should have had an introductory course in circuits.

An outstanding feature of this textbook is the experiments associated with each chapter. The experiments and problems are coordinated so that the student has an opportunity to verify problem-solutions in the laboratory.

Although this book serves only as an introduction to a wide variety of topics, references at the end of each chapter enable the student to extend basic knowledge.—F.R.

• • •

Books Received for Review

THEORY AND APPLICATIONS OF ELECTRON TUBES. By Herbert J. Reich. McGraw-Hill Book Co., Inc., New York 18, 1944, 716 pages, $5.00. Second edition, incorporating principal new developments of the past five years, rearranging and rewriting of much of the original material and inclusion of problem answers.

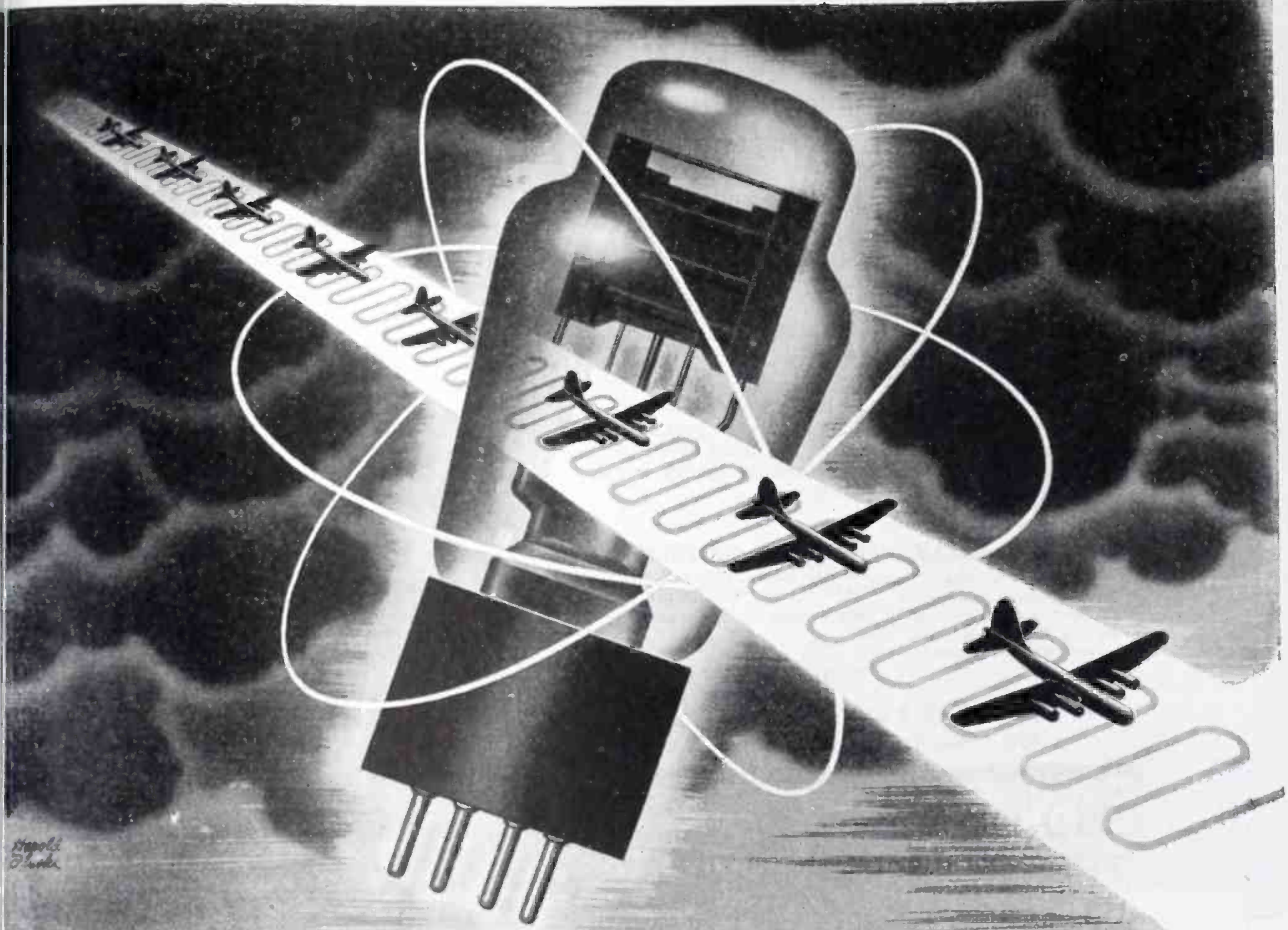
A TREATISE ON THE THEORY OF BESSEL FUNCTIONS. By G. N. Watson. The Macmillan Co., New York (also University Press, Cambridge), 804 pages, $15.00. Second edition of a book originally completed in 1922, embodying chiefly the correction of minor errors and misprints in the first edition. Over 120 pages are devoted to tables and extensive bibliographies. The book develops applications of the fundamental processes of the theory of functions of complex variables, and presents collected results in a manner most useful to mathematicians and physicists who encounter Bessel functions in the course of their researches.

PRODIGAL GENIUS: THE LIFE OF NIKOLA TESLA. By John J. O'Neill. Ives Washburn, Inc., 29 W. 57th St., New York. 326 pages, $3.75. Biography of an idea-producer who spurned both money and women during a lifetime devoted to science. Chapter headings outline the life of the man, as follows: I—Light and Power; II—Fortune and Fame; III—Internal Vibration; IV—Self-Made Superman; V—Afterglow.

ELECTRONICS FOR BOYS AND GIRLS. By Jeanne Bendick. Whittlesey House, McGraw-Hill Book Co., Inc., New York 18, 148 pages, $1.50. Elementary and interesting explanations and definitions, woven skillfully into a story of what electronics is doing now and what it may reasonably be expected to do in the future.

BEHIND THE MICROPHONE. By John J. Floherty. J. B. Lippincott Co., Philadelphia, Pa., 207 pages, $2.00. A nontechnical story of people—those who appear before the microphones in broadcasting studios and those who work behind the microphone to strengthen its feeble signals and send them to the farthest corners of the world. Many excellent photographic illustrations, each occupying a full page.

RADIO'S 100 MEN OF SCIENCE. By Orrin E. Dunlap, Jr. Harper & Brothers, New York, 294 pages, $3.50. A collection of biographical narratives, stressing contributions to radio, electronics, television and radar starting with Thales of Miletus in 640 B.C. and covering 45 men still living.



Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published.

Electron Microscope

REFERRING to the notice on Page 362, of the March 1944 Edition of ELECTRONICS, please note that the inventor of the electron miscroscope is Heinrich Siedentopf, Professor of Physics at the University of Goettingen, Germany, who, together with Professor Zsigmondi, the colloidal chemist, of the same University, received the Nobel Price for this invention. Compare E. Brueche: "Zur Entstehung des Elektron-Mikroskops", reprinted in the U. S. by the Enemy Alien Custodian, originally in the *Physikalische Zeitschrift,* April, 1943, which article contains much about the early and more recent history and development of the electron microscope in Germany. I shall be glad to see this contribution to the truth published in your paper.

L. A. AUSTRIAN
Chicago, Ill.

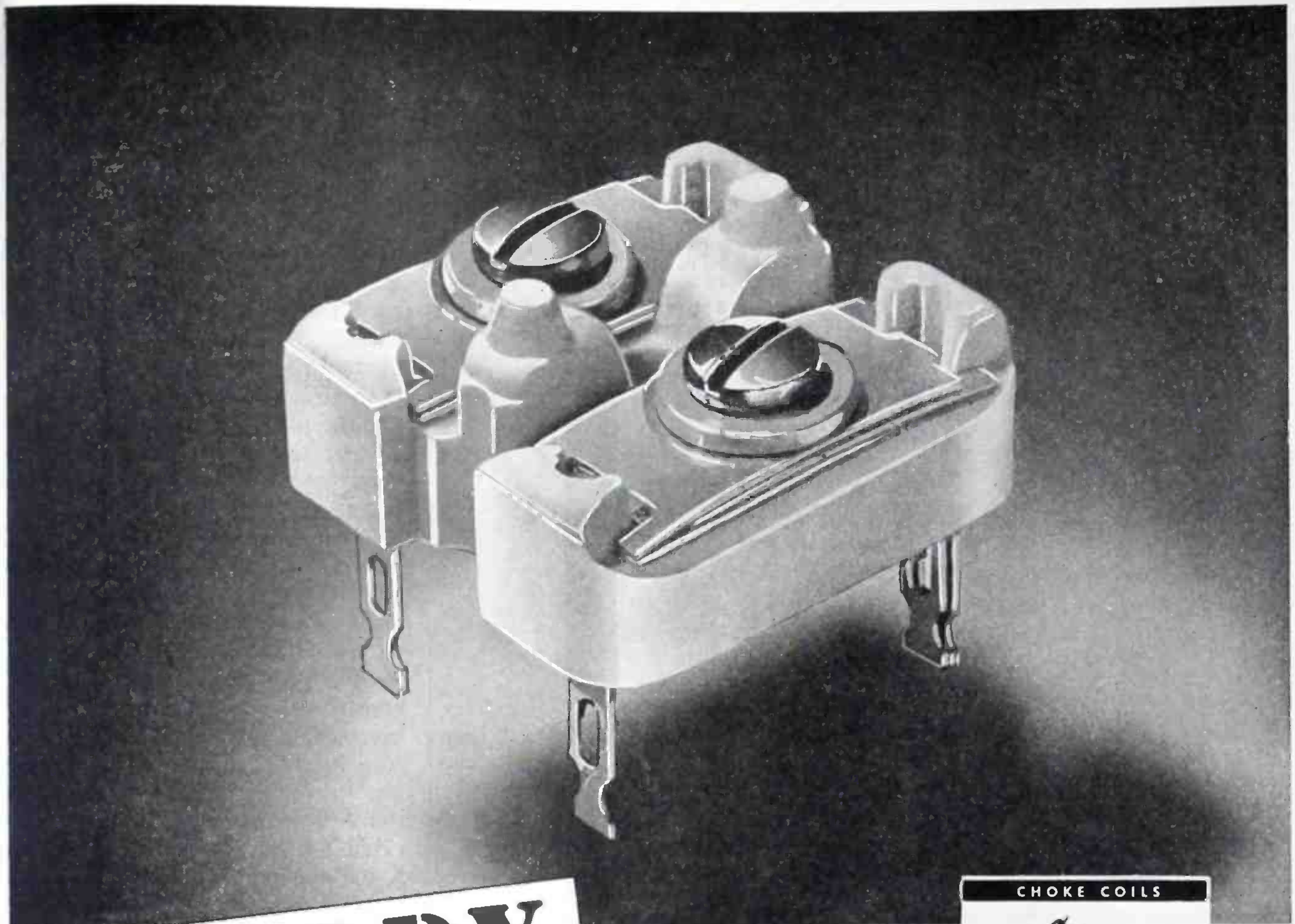
• • •

On Electronic Music

Gentlemen:

I HAVE READ with interest the article by Sidney T. Fisher in your May 1944 issue on an Argument for Electronic Music. However, the problem of adapting a keyboard instrument to the true, un-tempered scale is not quite so simple. The musical scale does not consist of a fixed series of frequencies but is flexible even within a given key, as recently pointed out by Lloyd. (Lloyd, L. S., *Music & Letters,* 24, 133, 1943; *Phil. Mag.,* 34, 472, 1943.)

For example, when Mr. Fischer's organ is tuned to the key of C the D-minor chord (which occurs frequently in C-major music) will produce a harsh dissonance because its frequencies (9/8:4/3:5/3) are not in the correct ratios for a justly



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SOON, we hope, the time will come to beat the sword into a ploughshare again. When that time comes, *AUTOMATIC* will be ready to resume the position of leader in the Mica Trimmer field. All of our pre-war tooling can be put into service without delay—and we still have the same skills and experience, waiting to give you once again the same excellent service.

A folder describing the standard trimmers is available at your request.

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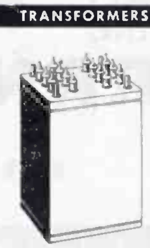

R. F. COILS

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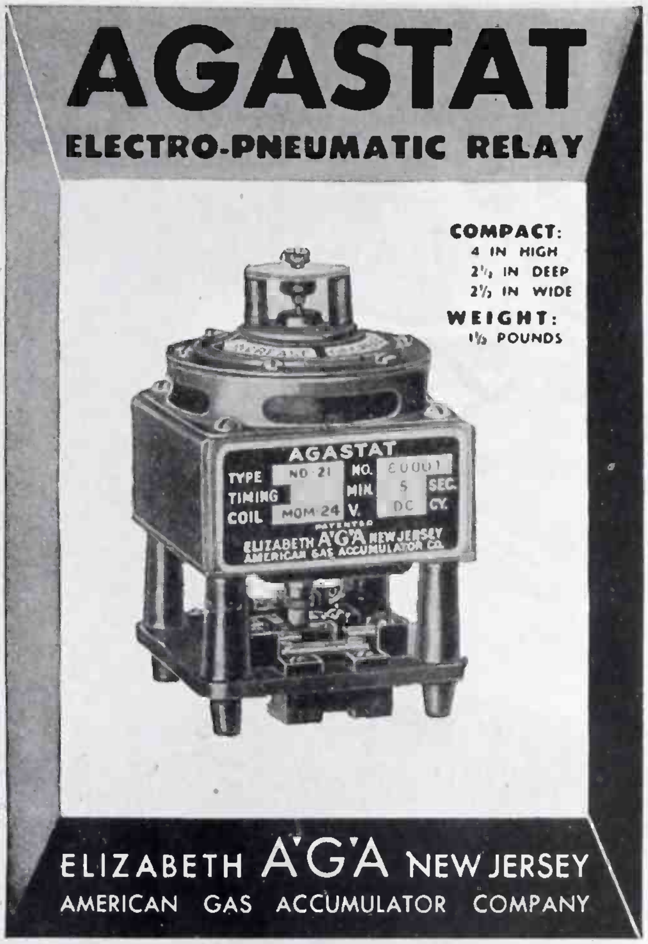

tuned minor triad (10:12:15). For use in this chord, the frequency of D must be 10/9 instead of 9/8, which could only be obtained by momentarily shifting the organ to the key of F whenever this chord occurs. The same difficulty of frequent shifts is found, to an enhanced degree, in modern polytonal music in which a given key may be used for less than a full measure before changing to another key. Certain passages from the works of Cesar Franck would require changing the tuning of the organ so frequently that the left foot would be kept too busy to play the pedal notes.

Those who have played much organ music will not be enthusiastic about making the organ a transposing instrument to be always played as though in the key of C. Aside from the greater ease in sight-reading, the key of C is about the most difficult in which to execute intricate music. Keys involving several sharps or flats are much easier because the raised and separated nature of the black keys is a distinct help in fast work on the manuals, as well as in feeling for pedal notes. From the standpoint of execution, a better key into which to transpose all music would be the key of E-flat.

The problem could perhaps be solved by re-designing the keyboard so that each note, instead of having three modifications (sharp, flat, and natural), would have five modifications (natural, sharp, flat, one in which the frequency is raised by 81/80, and one in which the frequency is lowered by (80/81). This would obviate the necessity of retuning the organ for each change of key, since all the required frequencies would be instantly available at the fingertips. Such a keyboard would, however, be much more complicated than the traditional one.

An electronic orchestra could easily play the true frequencies, since each player would have command of only one note at a time and would find no difficulty in using an instrument with continuously variable frequency. But in order to put all the harmonic and melodic components of a piece of music into the hands of a single performer, as with the piano and organ, it may well be necessary to sacrifice some

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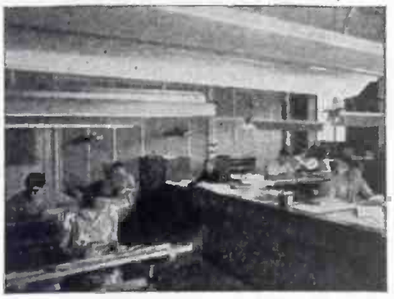

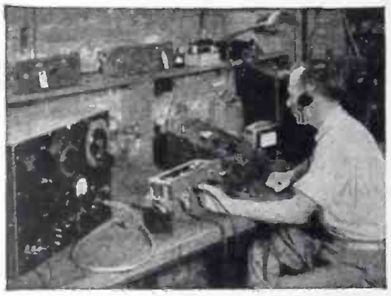

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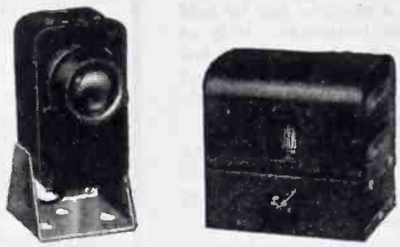

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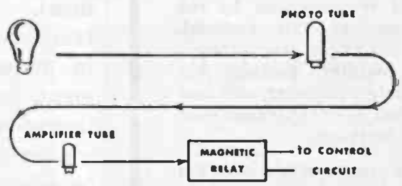

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of the fine structure and introduce simplifications such as the tempered scale.

C. ROLAND EDDY
Philadelphia, Pa.

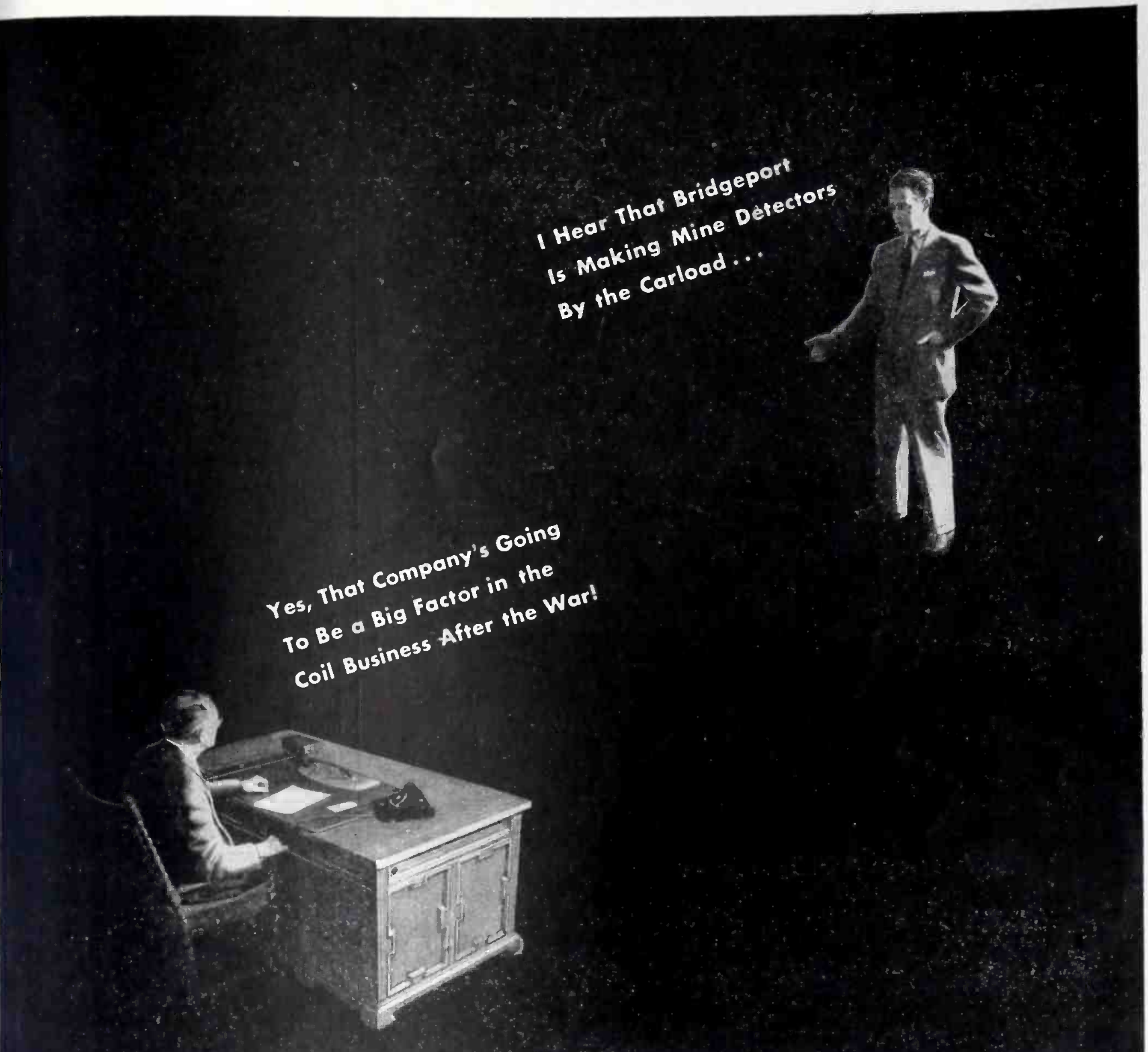
Dear Mr. Eddy:

IT IS TRUE that the implications of my suggestion, that the development of the electronic organ and piano should be extended to free keyboard musical instruments from the necessity of playing in the compromise tempered scale, are considerably more extensive than merely the electrical and mechanical design of the necessary instruments. It has been said, without exaggeration, I think, that the mechanism of the piano keyboard has been made the basis of the modern system of music.

This is an unworthy limitation on music and one from which the electronic engineer can now completely free it; but to do so he must have the fullest latitude to do away with whatever has not a sound basis in music or science. The real triumph of the engineer will come from freeing the musical art from the restrictions the imperfect mechanics of its instruments now impose on it, and not in extending hose restrictions, or retaining them because of habit or some other inadequate reason. These remarks apply not only to the details of the instrument and of the manipulation of it by the performer, but also to the way in which we regard the music to be played.

I have not primarily based my proposals on a transposing instrument. Whether the instrument is transposing or non-transposing is in no way essential to the argument, and it seems that even if the transposing instrument has greater convenience, its introduction should be delayed, first, to permit the transcription of the great body of existing musical literature, and second, to remove the assumption which might easily be made, that there is necessarily any correspondence between the two ideas of a just-scale instrument and a transposing instrument.

If a transposing instrument is designed, then care should be given to designing the keyboard so that without changing any of the essential dimensions the white notes could be more surely played in rapid passages. A careful study of this



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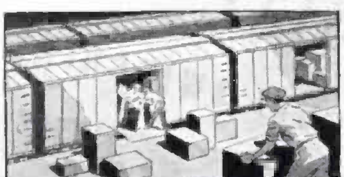

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problem would certainly lead to the desired result. The same comments apply equally to the pedal clavier of the organ.

I have perhaps not given proper consideration to the question of the key-changing switch. Rather than operate it with the left foot, it might be better to add an octave of switches in front of the manual keyboard, to be operated by one finger of the right hand. Other and possibly better schemes will occur to the ingenious.

Lloyd's approach to the question of the scale frequencies seems to me to be typical of the reasoning that is generally encountered in writing on musical theory, and so far as it goes, is of course correct. But it does not go nearly far enough at a time when we are searching out how science can best assist in re-establishing in music the basic—and ancient—tenets of harmony and tonality, after more than a century of neglect. Nor, I think, is a further complication of the keyboard a practical solution. There have been many proposals of this sort, since the time of Newton, but that advanced by you is less impractical than most. Nevertheless, such schemes are doomed because they increase the performer's task.

The answer lies rather in an analysis of the problem which you present. The problem itself, in a somewhat simplified form, may be stated thus: The theory of harmony, as taught in the schools, says that in any key, a triad or chord of three notes, can be set up on each of the notes of the scale. These triads are either major (ratio 4:5:6) or minor (ratio 10:12:15). This theorem, as we might call it, applies to both the major scale and the minor scale. The following tabulation shows the triads of one major key and one minor key:

Name of Chord	Notes	Desired Ratios	Actual Ratios	Key necessary for desired ratios
		Triads of C Major		
C	CEG	4: 5:6	4: 5:6	....
Min.	DFA	10:12:15	10 1/8:12:15	D Maj.
D Min.	EGB	10:12:15	10:12:15	....
E F	FAC	4: 5:6	4: 5:6	....
G	GBD	4: 5:6	4: 5:6	....
A Min.	ACE	10:12:15	10:12:15	....
G 7	(G)BDF	(4): 5: 6:7	(4): 5: 6:7 1/9	G Maj.
		Triads of A Minor		
A Min.	ACE	10:12:15	10:12:15	....
G 7	(G)BDF	(4): 5: 6:7	(4): 5: 6:7 1/9	E Min.
C Aug.	CEG#	16:20:25	16:20:25	....
D Min.	DFA	10:12:15	10 1/8:12:15	B Min.
E	EG#B	4: 5:6	4: 5:6	....
F	FAC	4: 5:6	4: 5:6	....
E 7	(E)G BD	(4): 5: 6:7	(4): 5: 6:7 1/5	C# Min.

The difficulty is now seen. In the

major scale, two of the chords ascribed to each key do not, in fact, belong to it, and are not properly used when writing in that key. They are, of course, replaced by two chords at present ascribed to two other keys. In the minor scale it is seen that three chords are erroneous, and must be replaced with three other chords. In the key shown, A Minor, for example, three of the chords ascribed to it in the classical theory of, harmony, G seventh, D minor and E seventh, properly belong, not in the key of A minor, but in the key of E minor, B minor, and C# minor respectively.

These errors are not as appalling as they seem; the compromise frequencies of the tempered scale obscure the differences between the correct and the incorrect chords. We have now a proper position; in any key the frequencies of the notes of the scale are fixed. That this is not at first evident is due to confusion in existing musical theory.

The just scale must not be considered an ideal scale; it is simply the best scale to fit our existing tradition of music played in the seven-note diatonic scale, with the conventions we have evolved regarding modulation and harmony. The just scale does not, and no scale ever did, fit the classical theory of music. Everything I have proposed is in some degree a compromise and the only way in which conclusive decisions can be obtained as to whether these compromises are the correct ones is by a statistical analysis of a representative amount of existing musical compositions.

From such an analysis we want to know what modulation sequences are used, and how commonly; what are the chords used, and in what keys should they sound, so that the texture, the continuity and the feeling for tonality, are best preserved. From these data, collected from the great mass of important and commonly-played compositions, properly evaluated, the best possible arrangement of the just scale, thoroughly in accord with our tradition of music, could be evolved.

It is not arithmeticians who make musical scales; scales are made by those who write and play music. Our new scale must make musical literature, as it now exists, possible and pleasing; and if our changes

are to be justified, must add new meaning now obscured by the tempered scale. This latter motive might be better phrased by saying that it must allow instrumental music to reproduce physically the plain intention of the written work, written by composers whose conception of musical intervals was subjective, and who were not influenced by the inexactnesses of the instruments on which, in fact, the music was performed.

That the great masters were not much influenced by the theory of music as taught in the schools, there seems no doubt. It appears to the writer, from a limited knowledge of present-day teaching of the theory of music, that such teaching is largely classifications of prejudice and habit, having no scientific basis, and what in fact is much the same thing, no basis in music as it is played and written.

I have examined at length the points raised because you and other correspondents have raised them as a serious bar to the argument I had advanced; that all keyboard instruments should now be generally discarded in favor of just scale electronic instruments. Such objections, arising out of the musician's regard for his art, must be adequately satisfied if electronic music is to seize its opportunities.

S. T. FISHER
Toronto, Ontario
Canada

• • •

Meteors and F-M Bursts

Dear Sirs:

THE STRANGE BEHAVIOR of f-m signals recorded in the July 1944 issue of ELECTRONICS on page 256 suggests immediately to an astronomer the possibility that these bursts are caused by the action of meteors. The following phenomena would suggest this:

(1) Duration of perhaps ½ to 1 second.
(2) Frequency of occurrence up to several hundred bursts per hour during maxima. (Maxima should be associated with meteor showers.)
(3) Daily variation of frequency with maximum near sunrise, and minimum near sunset. (Meteor frequencies show the same daily variation of frequency because near the time

of sunrise the linear speed of the earth in its orbit around the sun and the rotation of the earth on its axis combine to cause the sunrise portion of the earth to cut more meteor paths per unit of time.)

(4) The existence of bursts of all magnitudes.

All the above observed phenomena of the f-m bursts are consistent with the observed phenomena of meteors. The behavior of meteors in producing such a radio effect is not, I suppose, too difficult to visualize. It is conceivable that these meteors, in their sudden flare-up in the upper atmosphere, could produce sufficient ionization to form some sort of temporary reflection layer.

It seems that comparison of times of greatest frequency of bursts with the times of the known meteoric showers would provide a fairly conclusive test of whether these cosmic missiles are to blame. If they are found so to be, then considerable is known concerning their frequency, energy, velocity, height, and size, and these known facts could undoubtedly contribute to a study of the f-m effect.

The times of meteoric showers are well known. The most prominent showers occur on April 20, May 6, June 28, August 11, November 14 and November 24.

The frequency of meteors is likely to be abnormally high for several days either side of the listed dates, which are usually the maxima. The shower intensities vary from year to year, but almost always there is significantly increased meteor frequency on the shower dates.

WALTER ORR ROBERTS
Harvard College Observatory
Fremont Pass Station
Climax, Colo.

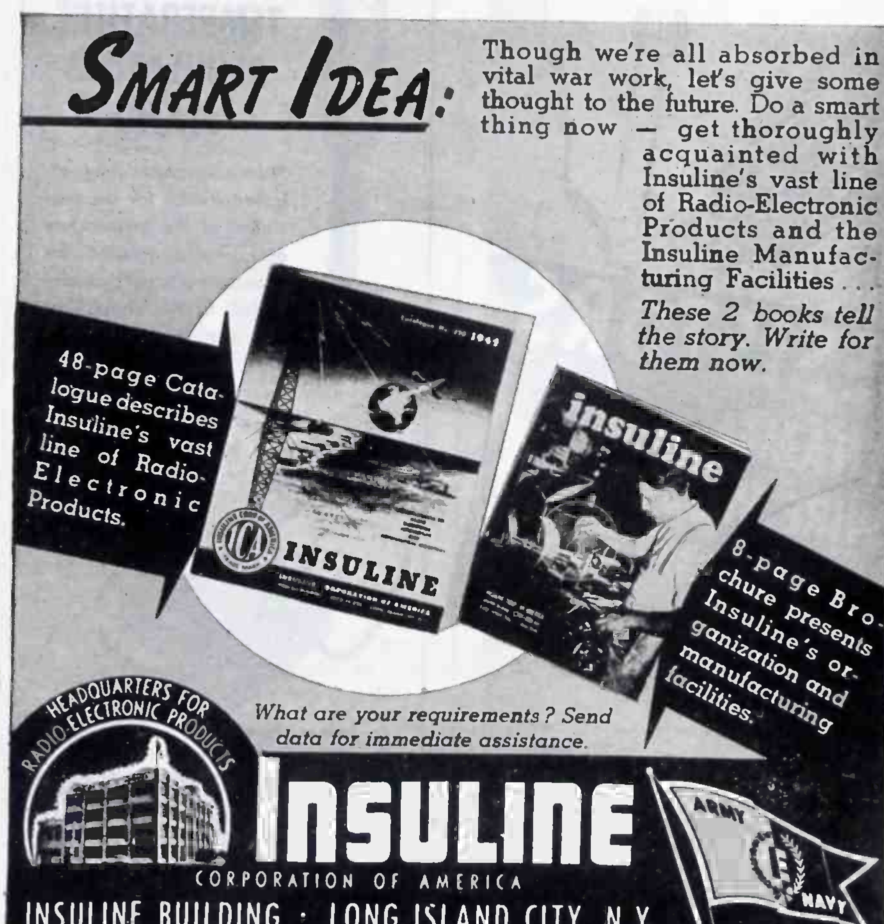
• • •

Surplus Solution

Dear Sirs:

I HAVE FOLLOWED with interest the editorials covering disposition of surplus electronic equipment and the postwar problems in connection with that subject . . . .

I believe it would be a big lift to those of us who will leave the service, to enjoy the advantage of purchasing at a reasonable cost such items as the War Dept. will have as surplus. That will enable the service men to become established in



their profession at a low initial investment. In addition, such items as receivers, etc., could be made available for those of us who would be interested, with a limit established on the number of units which any individual can secure.

For example, I am instructing and we use some test equipment which is adaptable to the type of work I do in my normal civilian occupation. The gear is expensive, and in normal conditions would be out of my reach, but should the Government make it available I would be glad to take advantage. Otherwise, I would never be a customer for its purchase, so the manufacturer is not affected. . . .

B. P. SCHROEDER, ART 1/C
Corpus Christi, Tex.

• • •

Colorful Electronics

Dear Sirs:

IT SEEMS LIKELY that electronics workers will be working with color to some extent since television in full color is a possibility and the various photometer gear available requires some knowledge of the subject.

ELECTRONICS has published several articles with physiological backgrounds giving rise to the suggestion that human nerves act somewhat like tuned circuits.

The color theories now used date from Maxwell and Helmholtz, since which time lots of new wave mechanics have been discovered. A review of current color theory is very disappointing.

Do you think that you could appoint somebody with an electronic background to work out a sensible color theory, bearing in mind that the eye sees with yellow and purple receptors (band-pass) and that purple is a color composed of the extremes of the visual color band, straddling yellow and that, therefore, the customary additive three-color theories are not physiologically acceptable? The wonders of color photography to the contrary, three-color systems do not reproduce faithfully. How about a tuned circuit color theory? What about side-bands? How about Fourier? How about color as a "beat" phenomenon?

This is a subject that will be of

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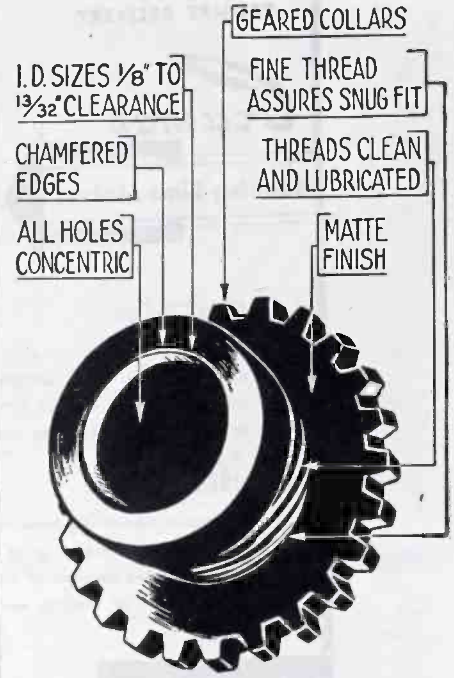

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interest, I believe, because, to get an economy going after the war, new designs to tempt customers will be good business. And a large part of design is color. In very few cases that I know about has the manufacturer been able actually to duplicate the colors his designer suggested—with the result that the finished product had less sales appeal than the design could have given it. The electronic engineer has here an opportunity.

EVERETT THEODORE SPRAGUE
R.T. 1/c U.S.N.R.
Fleet Service School
Virginia Beach, Va.

Any volunteers? (Ed.)

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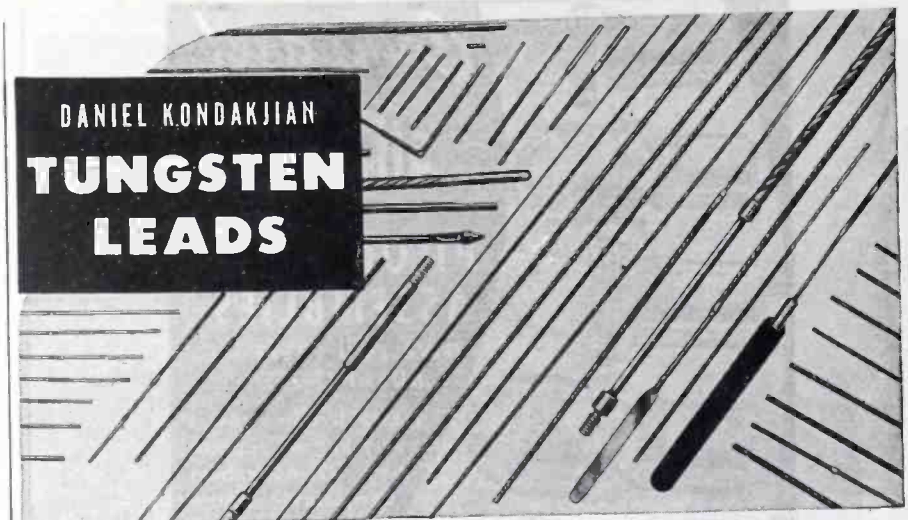

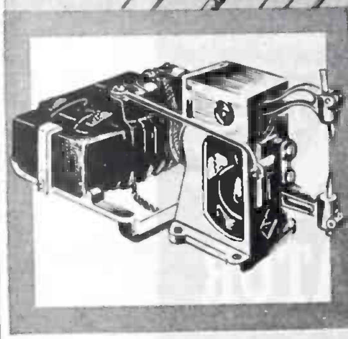

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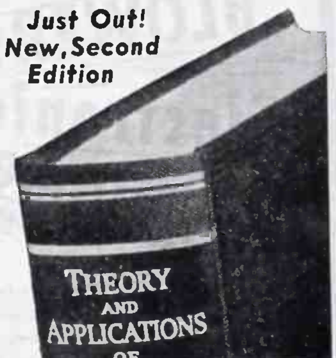

This book gives engineers and research workers a thorough, coordinated groundwork in tube and circuit theory with emphasis on fundamental principles and their use in many applications in industrial electronics, communications, power, and measurements. Meeting the need for a single volume to assemble and coordinate present knowledge of theory and application of electron tubes, the book covers its subject authoritatively and in detail, from the fundamental principles of atomic structure, excitation, ionization, radiation, and emission, to practical material on the design of voltage and power amplifiers, phototube circuits, power-control circuits, power supplies, and measuring instruments.

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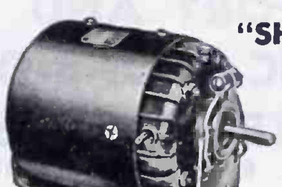

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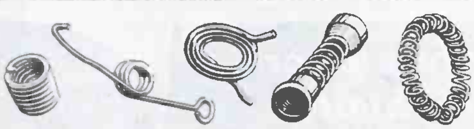

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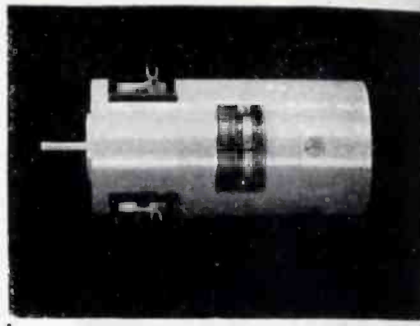

Type "C" D.C. Generator

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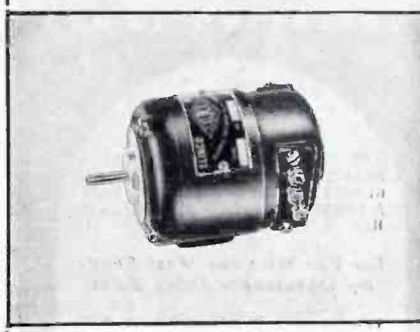

Type "B" A.C. Generator

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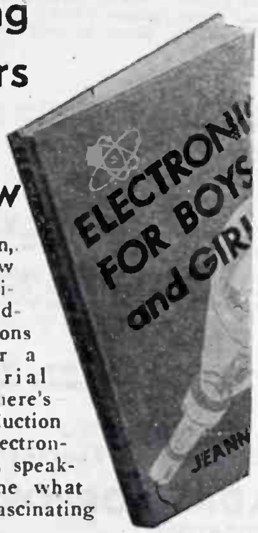

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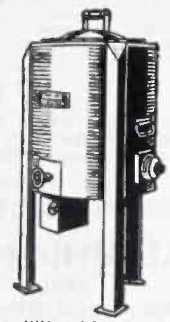
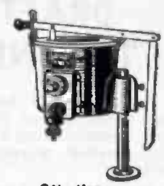
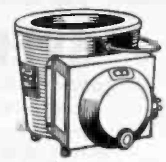


WV melting tank



CN dispenser



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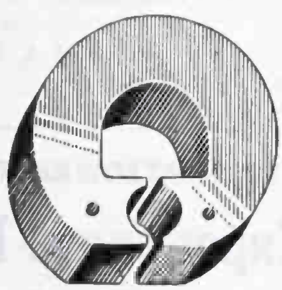

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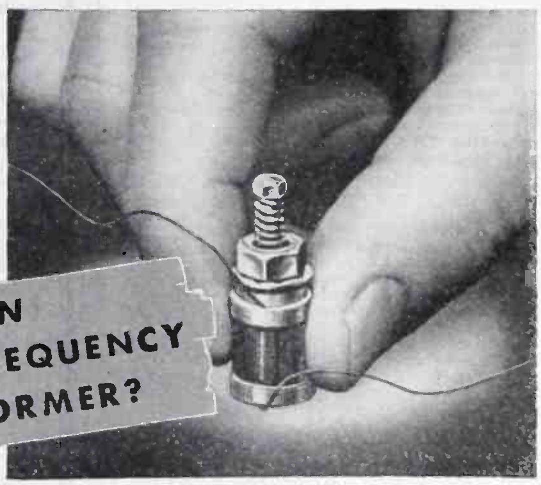

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Accuracy: ±5%.
Special Feature: Provision for use of headphone and/or meter.

ALSO

- to determine internal impedance or optimum load
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- to test band width, selectivity, fidelity, sensitivity

OP-182
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2.5 to 20,000 Ω
curacy: ±5%.

The DAVEN OP Series Power Output Meters offer a selection of four models for measuring the effect of power and load on audio amplifiers, filters, oscillators and similar equipment, as well as for standard radio receiver tests. Types OP-182 and OP-961 are widely accepted for their wide flexibility, accuracy and durability. Types OP-193-A and OP-193-B are especially adapted for noise pick-up level work in testing radio receivers, where the use of headphones is desired. A special three-position switch enables use of headphones circuit, meter circuit, or both simultaneously.

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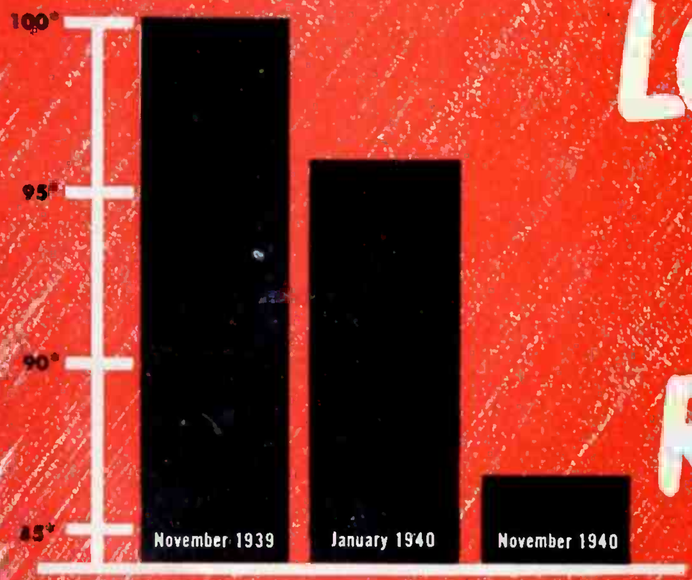

AVERAGE COST PER PREFERRED TYPE TUBE

*November 1939 average cost = 100; all costs based on [illegible] tube types

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