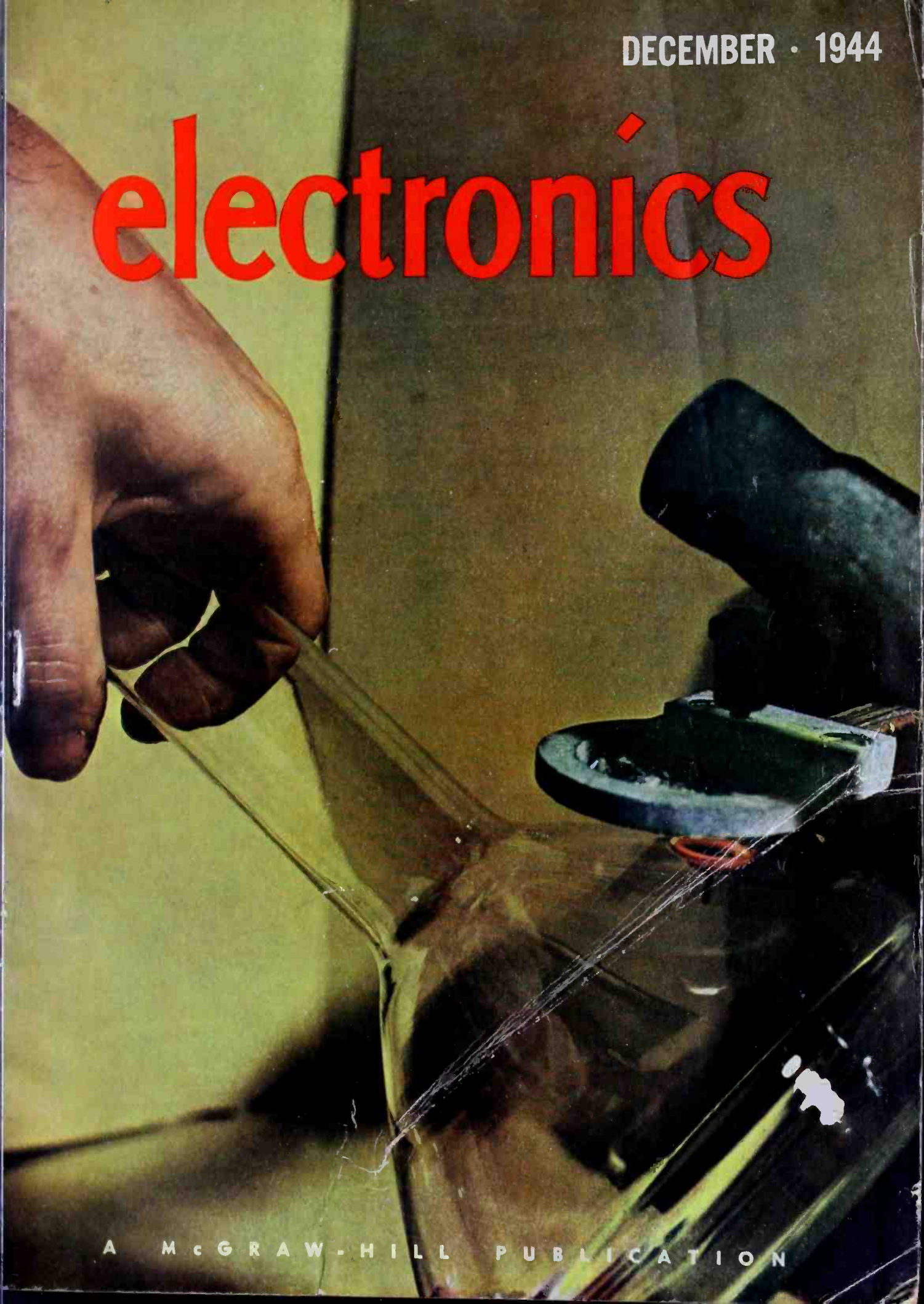
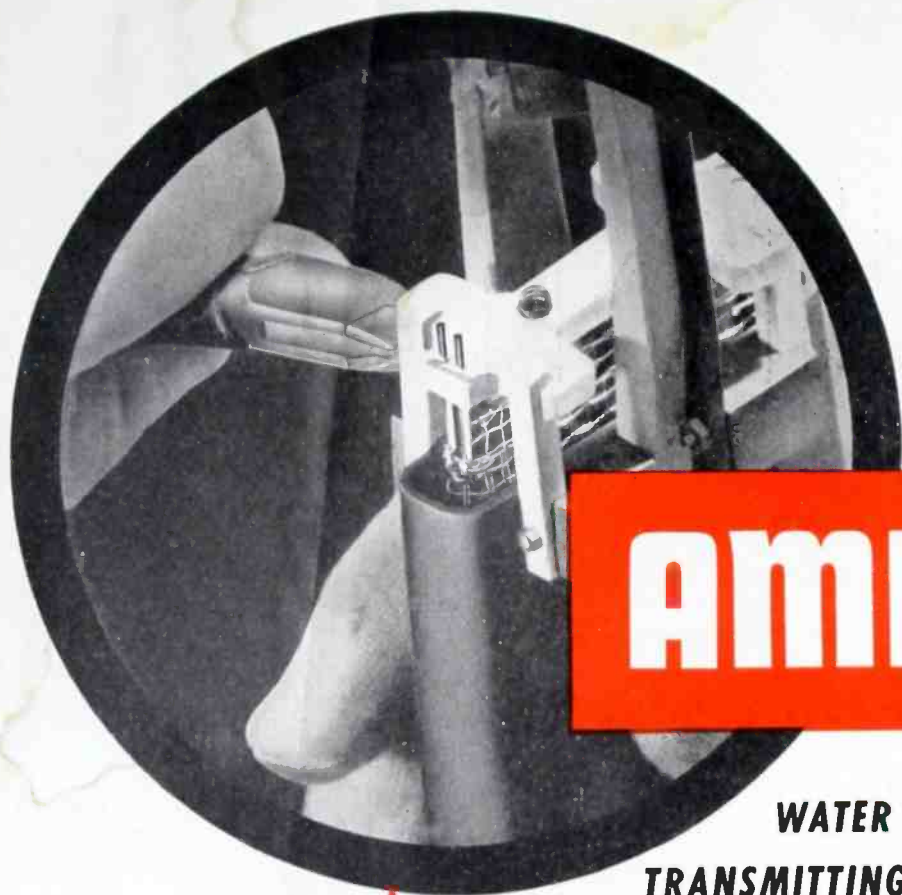


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electronics



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TRANSMITTING and RECTIFYING TUBES**

AMPEREX

*... the high
performance
tube*



Amperex engineers have made many important contributions to the refinement of electron tubes. One "Amperextra" 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.

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electronics

DECEMBER • 1944

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To

Signed

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ELECTRONICS — December 1944



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It is small and compact even though air cooled, and designed to deliver full plate output at frequencies up to and including the present FM band.

Designers of electronic devices will find in

the small size and large output of this tube the answers to many of their problems. In addition, it has the same rugged dependability that characterizes all Westinghouse Electronic Tubes.

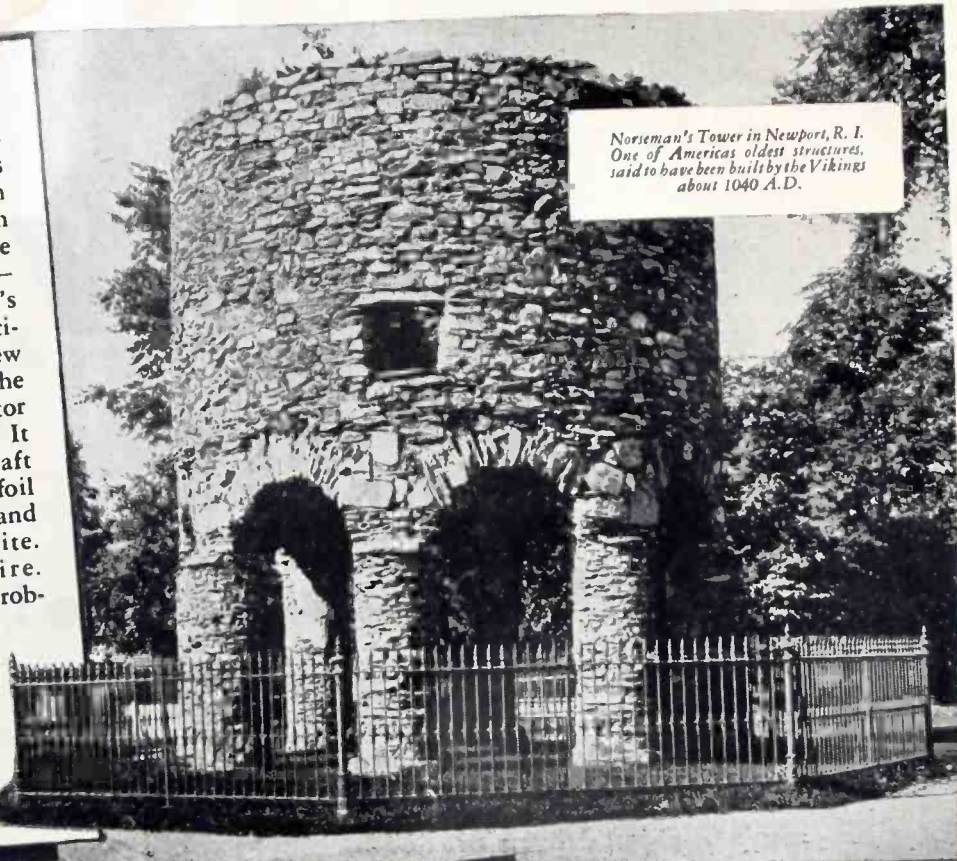
The outstanding features of the WL-473—which are exclusively Westinghouse—will appeal to you. Ask your nearest Westinghouse Electronic Tube Distributor or write to the Westinghouse Electric and Manufacturing Co., Lamp Division, Bloomfield, N. J. for complete information.

Quality Controlled Electronic Tubes



Stalwart *against* Time

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LONG LIFE ASSURED



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 POWER FACTORAt 1000 cycles .004 to .006
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		"A" Characteristic	"B"
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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



A SMALL PART IN VICTORY TODAY

A BIG PART IN INDUSTRY TOMORROW

An Important Statement

BY MYCALEX CORPORATION OF AMERICA

Issued in an Effort to Clear up and to Avoid Continued Confusion in the Trade

IT has come to our attention that in some quarters electronic engineers and purchasing executives are under the erroneous impression that the MYCALEX CORPORATION OF AMERICA is connected or affiliated with others manufacturing glass-bonded mica insulation, and that genuine "MYCALEX" and products bearing similar names are all "the same thing" . . . are "put out by the same people" . . . and "come from the same plant."

THESE ARE THE FACTS:

- 1 The MYCALEX CORPORATION OF AMERICA is not connected or affiliated with any other firm or corporation manufacturing glass-bonded mica insulating materials.
- 2 The word "MYCALEX" is a registered trade-mark owned by MYCALEX CORPORATION OF AMERICA, and identifies glass-bonded mica insulating materials manufactured by MYCALEX CORPORATION OF AMERICA.
- 3 The General Electric Company, by virtue of a non-exclusive license it had under a MYCALEX patent through the MYCALEX (PARENT) COMPANY LTD., was permitted to use the trade-mark "MYCALEX" on its glass-bonded mica insulating materials.
- 4 The MYCALEX CORPORATION OF AMERICA has behind it over 20 years of research leadership, dating back to work done by the original MYCALEX (PARENT) COMPANY, LTD. of Great Britain, from which it obtained its American patents. MYCALEX CORPORATION OF AMERICA owns U. S. patents and patent applications on improved glass-bonded mica insulation marketed under the trade-mark "MYCALEX".
- 5 The products of MYCALEX CORPORATION OF AMERICA are: (a) "MYCALEX 400"—the most highly perfected form of MYCALEX insulation, approved by the Army and Navy as Grade L-4 insulation. MYCALEX 400 is sold in sheets, rods and fabricated form. (b) "MYCALEX K"—an advanced capacitor dielectric with a dielectric constant of 10 to 15, which can be fabricated to specifications. (c) MOLDED MYCALEX available to specifications in irregular shapes and into which metal inserts may be incorporated.
- 6 "MYCALEX" in the forms described above is made by exclusive formulae and exclusive patented processes. It is utterly impossible for any one other than the MYCALEX CORPORATION OF AMERICA to offer any product, similar in appearance, as "the very same thing".

MYCALEX CORPORATION of AMERICA

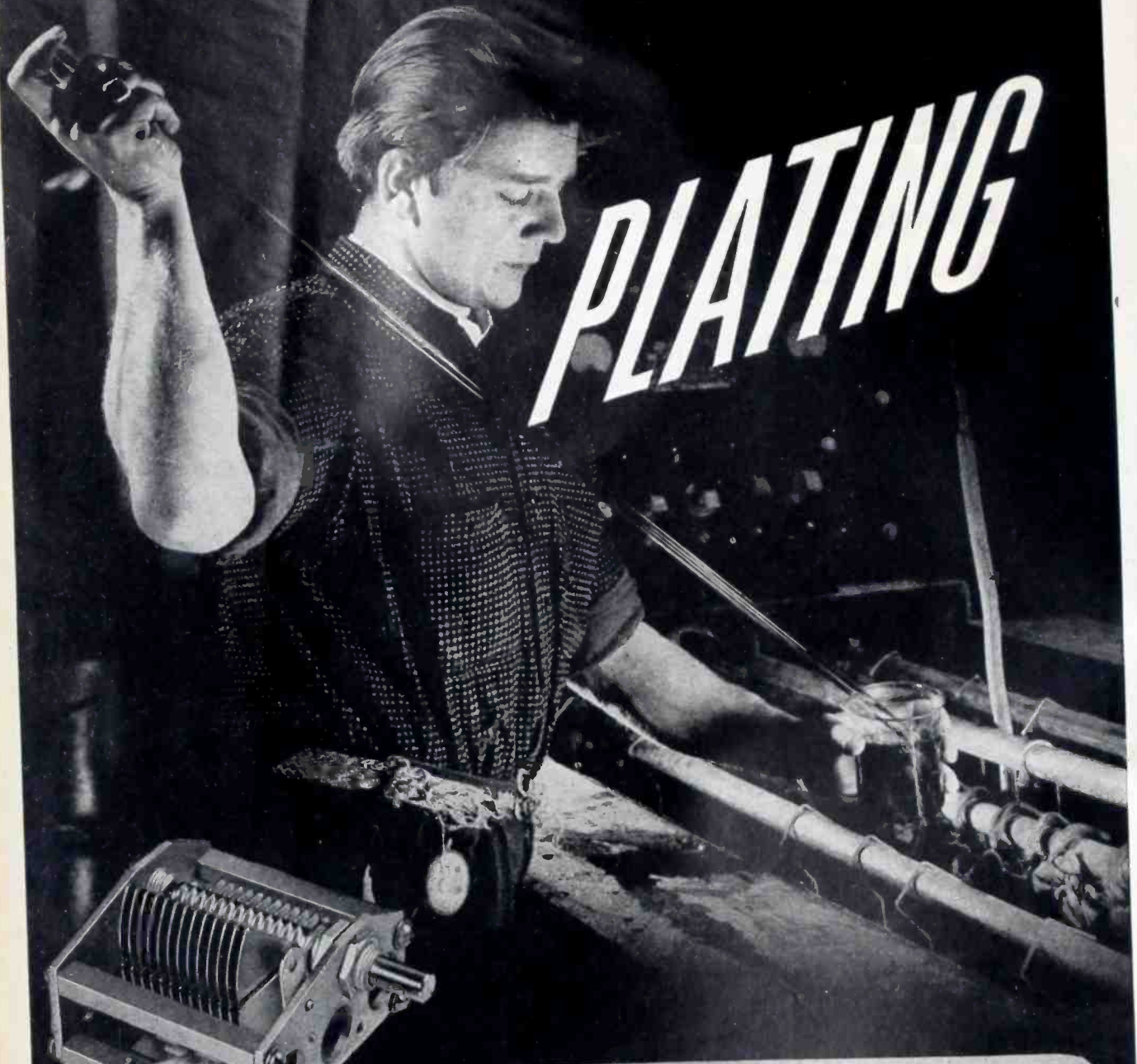
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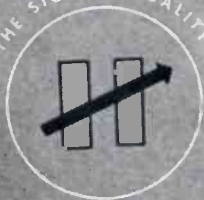


Constant checking of plating solutions and rigid quality control gives Hammarlund variable capacitors a finish that will last a lifetime under practically every operating condition.

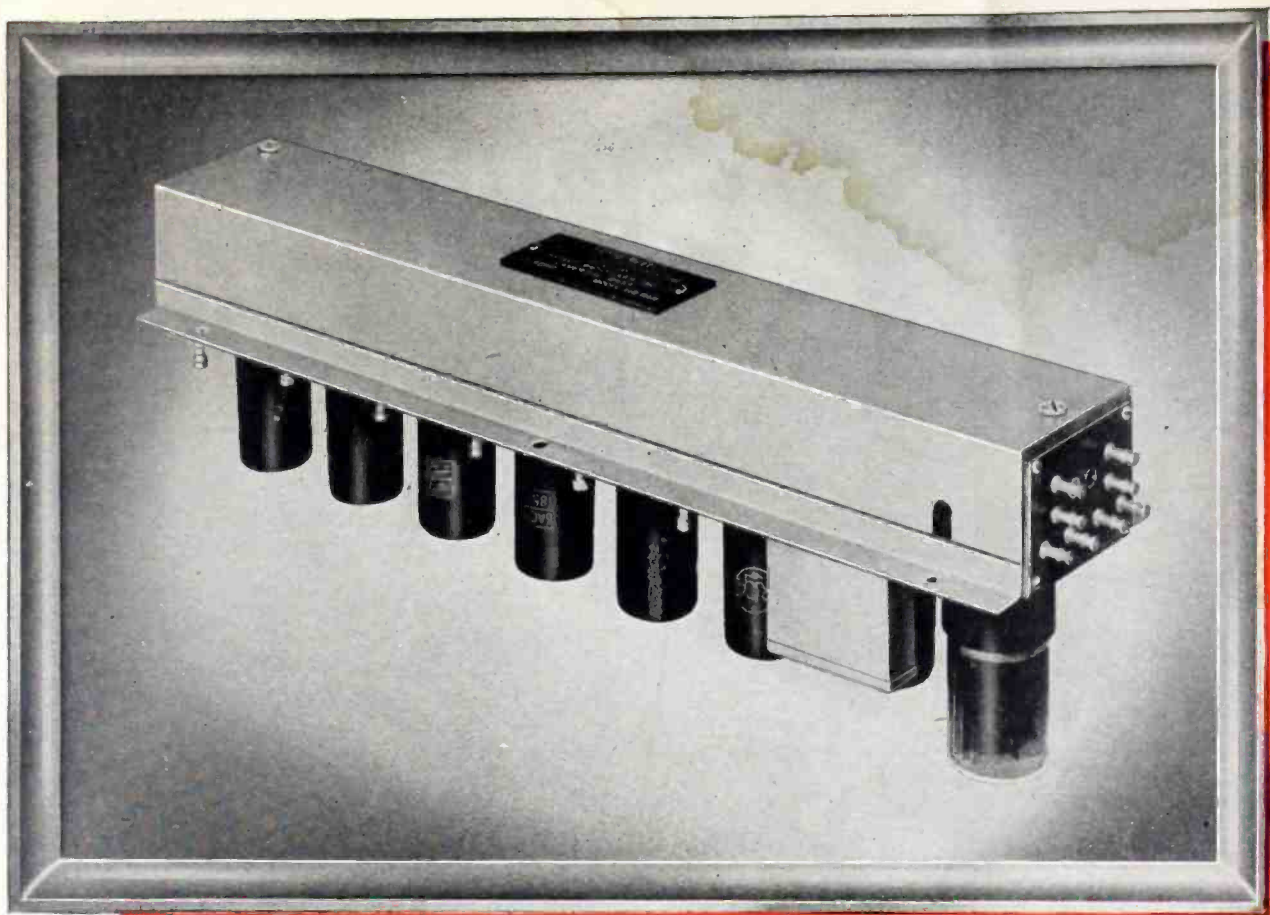
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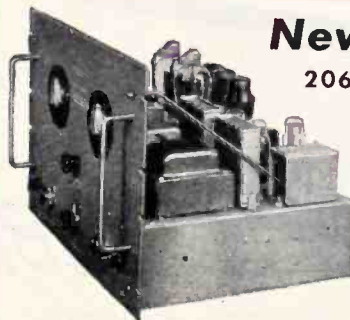
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Available for operation between 1.5 M.C. and 30 M.C.



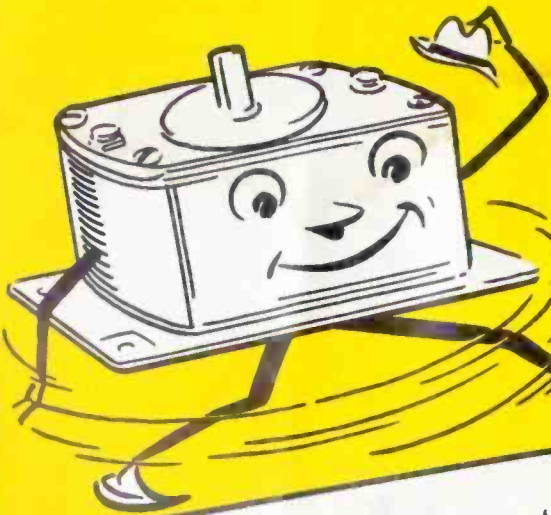
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for Laboratory
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**RANGE 500
to 1000 VOLTS**

500 to 700 at 1/4 ampere
700 to 1000 at .2 ampere

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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.

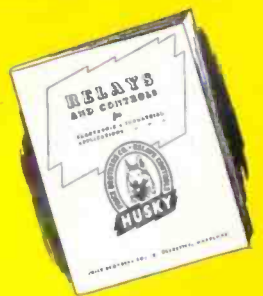
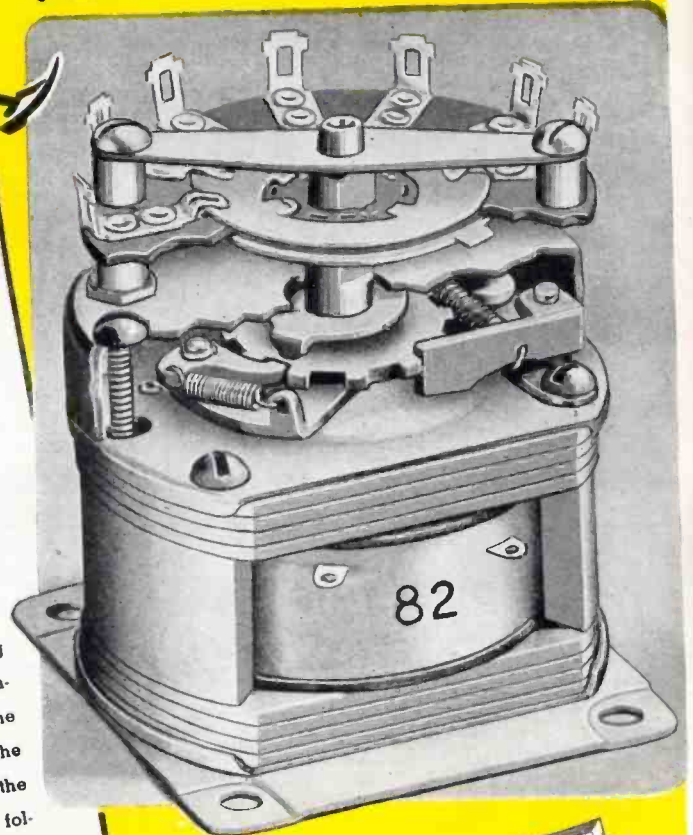
The Type 82 Rotary stepping unit is a compact twelve position driving mechanism which operates a shaft extension through 360° in twelve progressive steps.

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.



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for resistance welding

FG-238B
—The G-E ignitron
for converting a-c to d-c



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.

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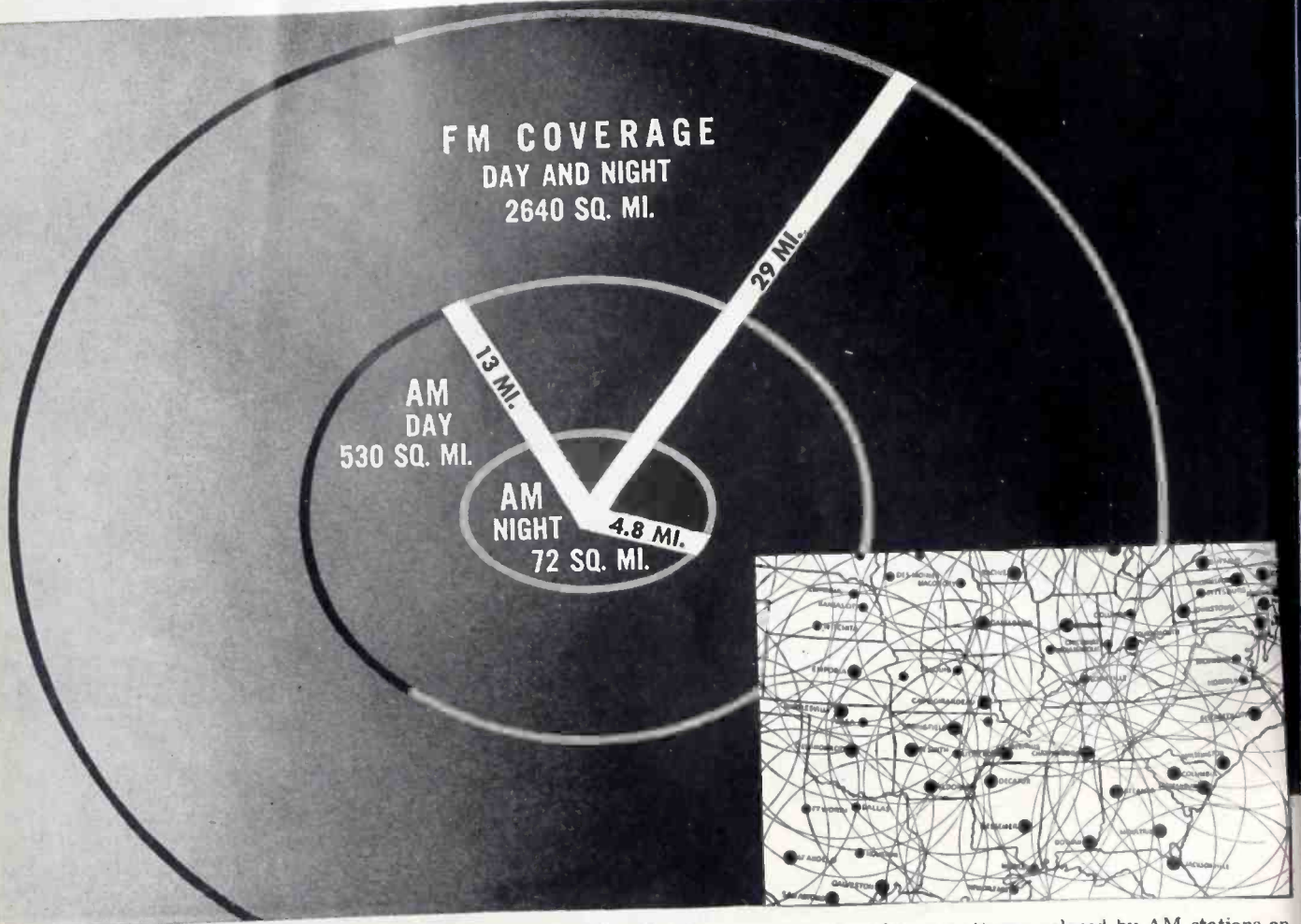
OTHER G-E TUBES ARE FIRST IN INDUSTRY, TOO! For example, General Electric developed the thyatron tube, which usually teams up with the ignitron where precision control is needed—as in “timing the shots” in high-speed spot welding. The G-E thyatron is also used to maintain constant speed in power tools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

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

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FM does it...



Effective signal-coverage comparison of an FM station and a 1400-kc AM station. Most AM stations could enjoy better coverage by switching to FM. Moreover, their FM signals would neither cause interference with other stations nor be affected by interference from other stations.

Station interference pattern produced by AM stations on the 1400-kc channel. Dots indicate location of stations. Large circles indicate possible 400-mile interference range. At night, areas in which the circles overlap usually are subject to serious heterodyne interference. This pattern is typical of many crowded regional and local channels.

PLAN YOUR FM STATION NOW—50 FM BROADCAST STATIONS ARE ON THE AIR AND OVER 300 APPLICATIONS ARE PENDING. Write for the General Electric booklets covering FM station planning, equipment description, and general station operation. These publications describe G-E transmitters, antennas, associated equipment, and contain operating data from FM station records.

STUDIO AND STATION EQUIPMENT • TRANSMITTERS

GENERAL  **ELECTRIC**

160-C11-6914

December 1944 — ELECTRONICS

day and night

**5 times the
coverage by day**

**35 times the
coverage by night**



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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.

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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.

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FM • TELEVISION • AM

See G.E. for all three!

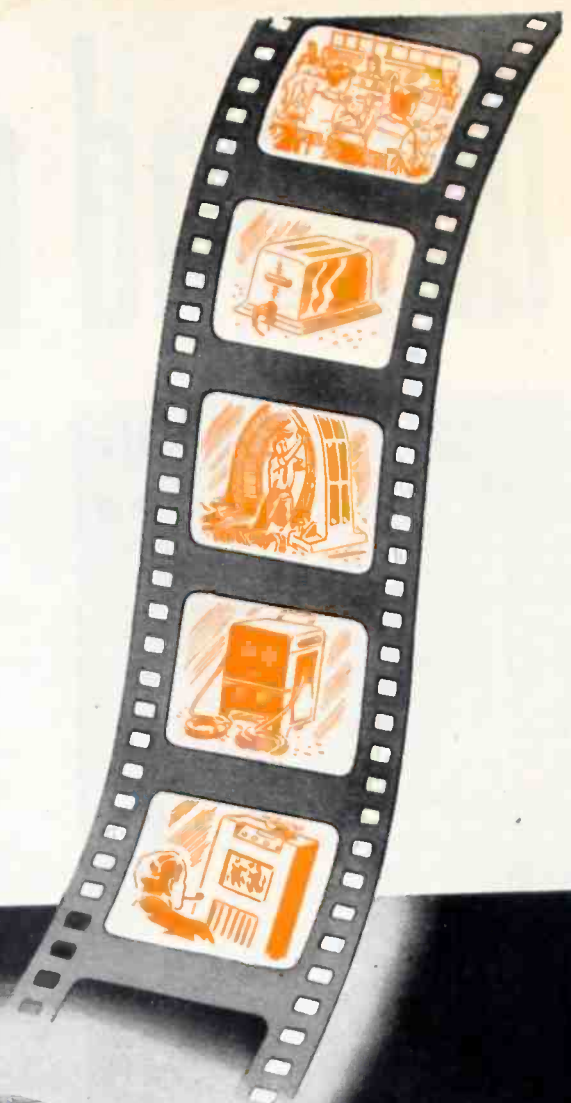
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National Union Radio Corporation Newark 2, New Jersey

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TUBES BY UNITED



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.

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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.

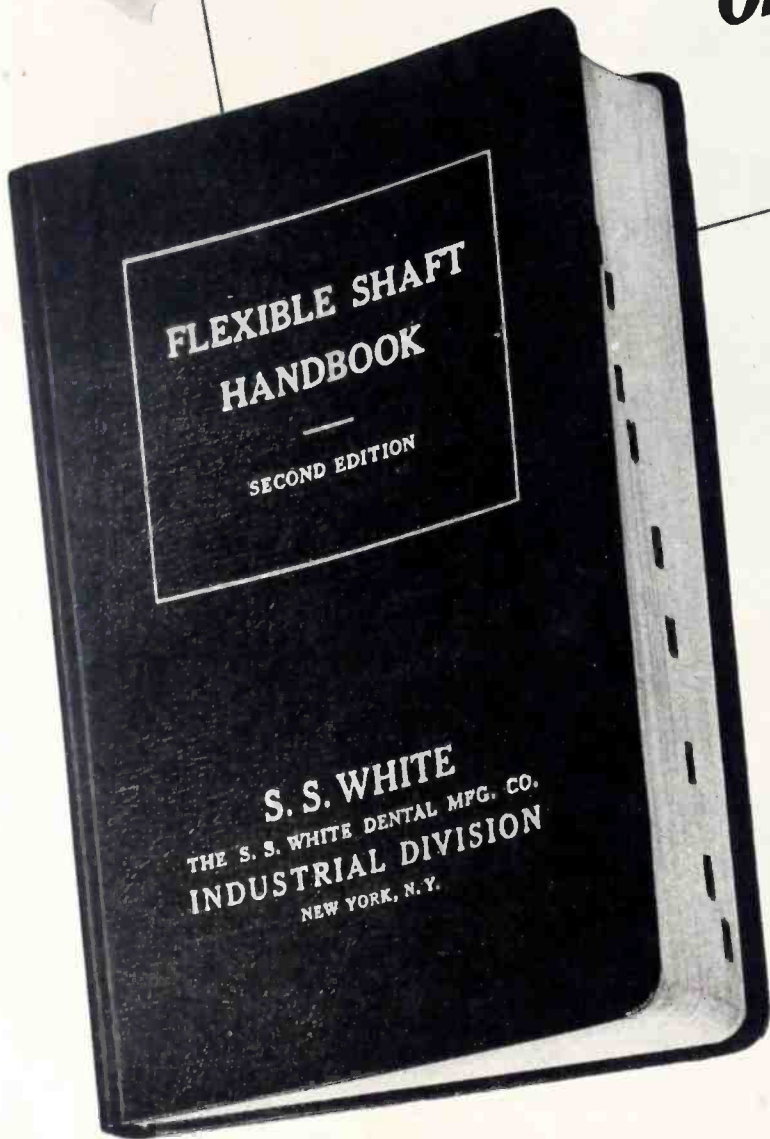
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FREE - TO ENGINEERS

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- It explains in detail the procedure of making a flexible shaft application—including how to select the right shaft for a specific set of conditions and how to work out all application details.

▶ HOW TO GET YOUR COPY ◀

We will be glad to send a copy of this Handbook *free*, to any engineer who has an immediate, or possible future, interest in flexible shafts. We make only this understandable provision—that you write for your copy on your business letterhead and indicate your position or title.

S.S. WHITE
THE S. S. WHITE DENTAL MFG. CO. **INDUSTRIAL** DIVISION

DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS

AIRCRAFT ACCESSORIES

MOLDED PLASTICS

MOLDED RESISTORS

FLEXIBLE SHAFT TOOLS



THE PICTURES MUST GET THROUGH!



Awarded to our Hicksville 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
- MODULATED UNITS "TRADEMARK"
- CHANNELING DEVICES
- RADIO PHOTO TERMINALS
- FACSIMILE MACHINES
- AND OTHER TYPES OF RADIO AND COMMUNICATIONS EQUIPMENT

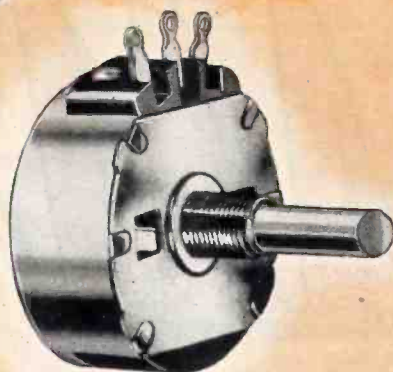
PRESS WIRELESS, INC.

Executive and Sales Office
1475 BROADWAY, NEW YORK 18

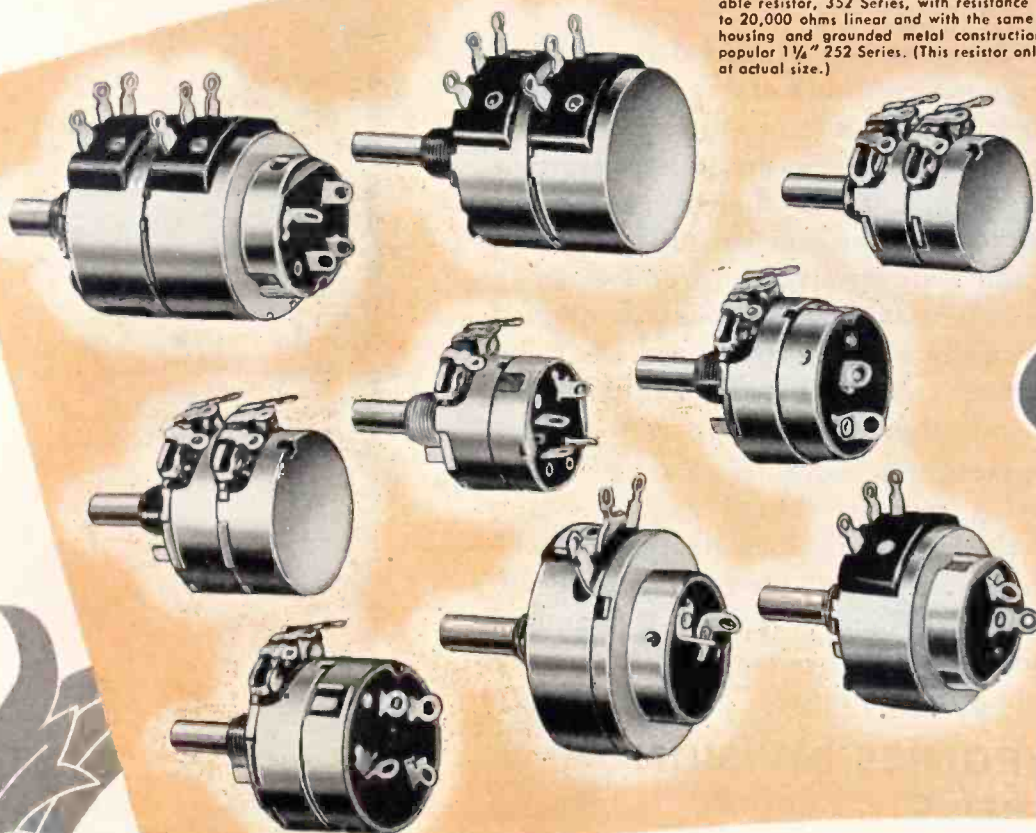
RIO DE JANEIRO • MONTEVIDEO • BERNE • SANTIAGO DE CHILE • NEW YORK • CHICAGO • LOS ANGELES • LONDON • HAVANA

Craftsmanship

KNOWN THE WORLD OVER



This is the new 1 1/4" diameter, wire wound variable resistor, 352 Series, with resistance value up to 20,000 ohms linear and with the same bakelite housing and grounded metal construction as the popular 1 1/4" 252 Series. (This resistor only, shown at actual size.)



Chicago Telephone Supply Company is an internationally known manufacturer of the finest variable resistors for all applications. Behind these products are a modern scientific mass production organization and many years of intensive research.

When wartime demand slackens, Chicago Telephone Supply Company's tremendous production facilities and unexcelled craftsmanship will be turned once again to civilian production of wire wound and carbon types resistors.

Manufacturers of Quality Electro Mechanical Components Since 1896



CHICAGO TELEPHONE SUPPLY
Company

ELKHART • INDIANA

**VARIABLE RESISTORS, PLUGS AND JACKS
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AAC

CRYSTALS

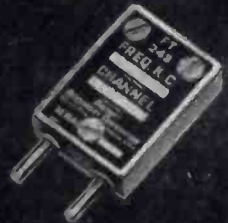
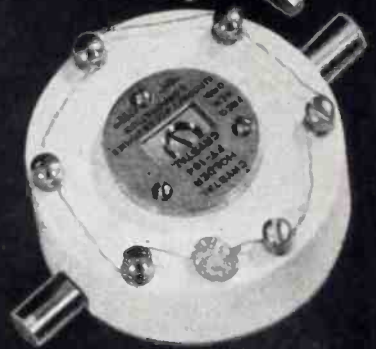
The recognized quality and dependability of AAC quartz crystals is the result of AAC's wide experience as one of America's largest producers of transmitters and other precision radio equipment. AAC quartz crystals and crystal units have proved so outstanding in meeting intricate specifications and exacting requirements that they are today demanded by many of the world's greatest airlines, radio manufacturers, various branches of the armed services and other government agencies.

This practical achievement background—plus AAC's staff of skilled engineers and modern-to-the-minute manufacturing facilities is ready to meet your crystal needs advantageously. Rapid delivery of standard types—also special types, ground and mounted to your specifications.

ELECTRONICS DIVISION
Kansas City, Kansas



WRITE now for your free copy of the new AAC crystal catalog giving detailed facts about AAC quartz crystals and crystal units.



Products



AIRCRAFT
RADIO and
Kansas City, Kans.



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

ACCESSORIES **C**ORPORATION
ELECTRONICS • ENGINEERED POWER CONTROLS
New York, N. Y. Burbank, Calif. Cable Address: AACPRO

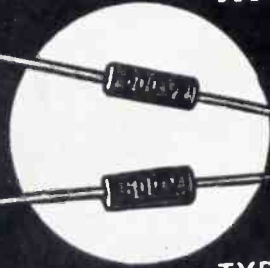
The TINYMITE

SMALLEST PAPER
CAPACITOR . . .

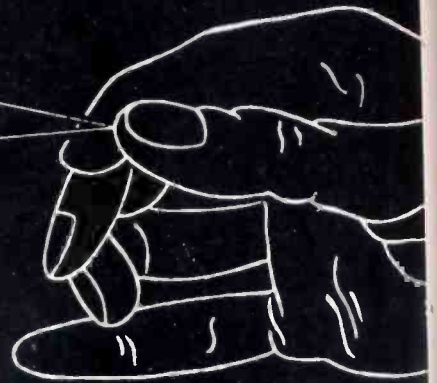
yet 100%

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 . . .

Pat.
Pend.

. . . 'TIL THE WAR IS OVER.

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

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.

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.



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.

THE

DOBECKMUN

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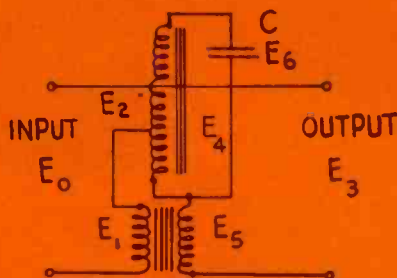
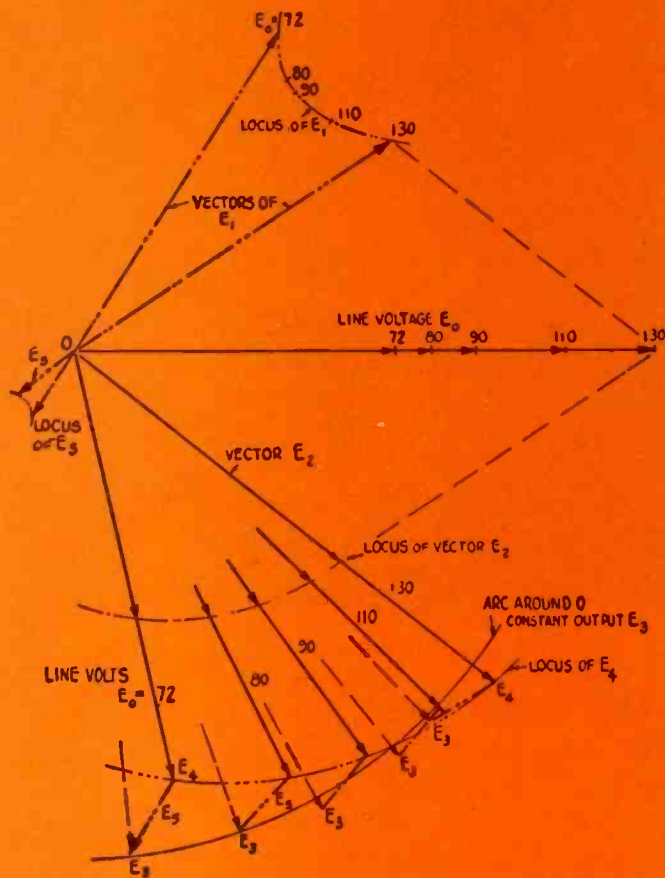
INDUSTRIAL PRODUCTS DIVISION • CLEVELAND 13, OHIO
WESTERN SALES HEADQUARTERS • SAN FRANCISCO 4, CALIF.

Raytheon Voltage Stabilizers

CONTROL Output Voltage to $\pm 1/2\%$



Endbell Model



VECTOR RELATIONS FOR FULL LOAD AND VARIABLE LINE VOLTAGE

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 $1/2\%$. 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.

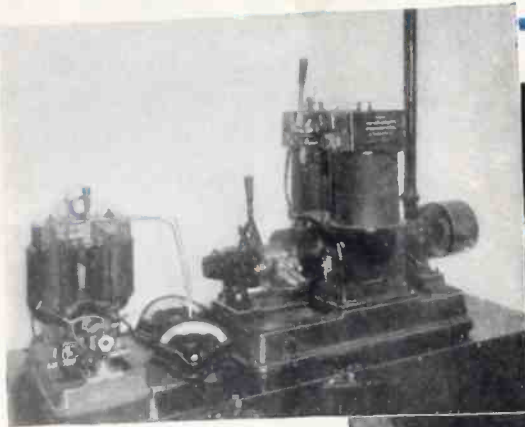


RAYTHEON
MANUFACTURING COMPANY
 190 WILLOW STREET, WALTHAM, MASS.

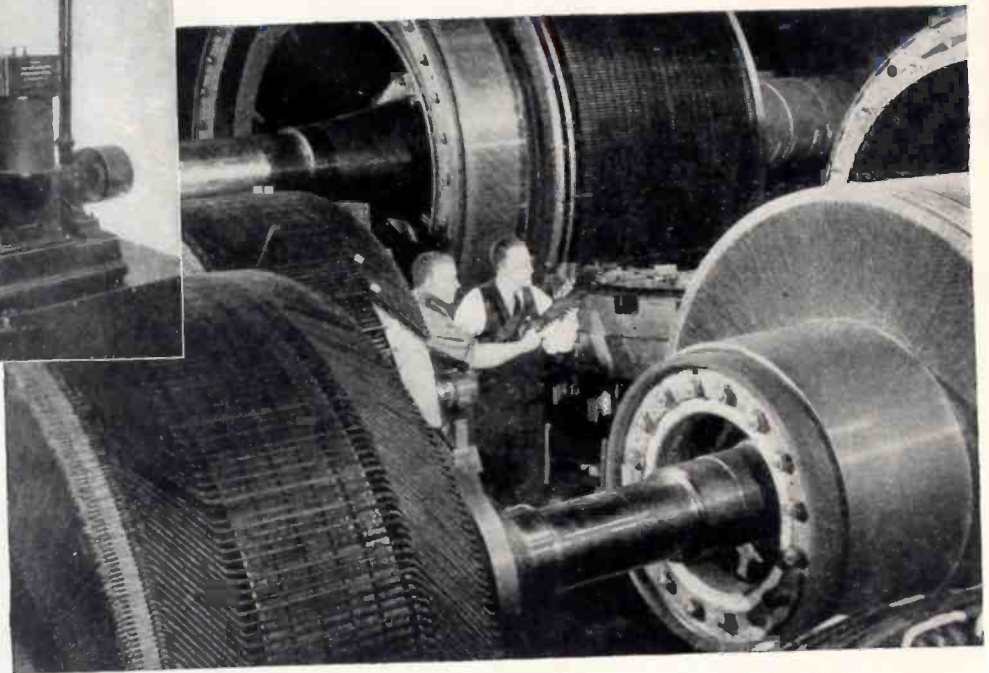
MANUFACTURERS OF VOLTAGE STABILIZERS, RECEIVING AND TRANSMITTING TUBES AND COMPLETE ELECTRONIC EQUIPMENT

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.

In Electrical Insulation...the first



Above: One of the earliest Edison bi-polar generators—now on display at the Mica Insulator Company plant in Schenectady. It is still in operating condition.



Electrically powered equipment and the Mica Insulator Company have grown up together... and it's a far cry from our first manufactured insulation to the multiple materials we're producing today. During the fifty years of our business existence, virtually the entire span of electrical history is encompassed... from the early Edison bi-polar generators (for which we made sheet mica insulation) to the gigantic turbo-driven jobs of today and tomorrow. Since 1894, our birth date, electricity has stretched its slender tentacles to the farthest corners of the country. It has powered the growth of our industrial stature and nurtured the evolution of the electronic wonder world. No longer earth-bound, it soars the skies and sails the seas... it flings Man's voice, Man's philosophies, his music and now his image, full around the world. And every step of the path, faltering or fleeting,

has depended on the *certain* sheathing of the insulation which harnesses and guides the flow of electrical energy.

Our job—small but important—has been to keep pace with the constant flux and growth of the electrical world, and to provide dependable insulation—designed and made for each progressive stage in electrical development. And, while it's pleasant to realize that we've done that job, mere age or past privileges are not tempting Mica Insulator Company to sit back and regard its laurels. We're too impressed with the need of keeping ready our every resource for the job ahead. Electrical manufacturing, electronics, communications, public utilities—even repair and maintenance fields will need new insulations—fabricated with the care and craftsmanship that comes only with experience. Mica Insulator Company's job therefore, lies ahead!

MICA INSULATOR

half hundred years were the hardest

A SINGLE SUPPLY SOURCE FOR DIVERSIFIED INSULATION MATERIALS

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.

Manufacturers and designers now planning postwar products are invited to investigate, through our nearest sales office, the advantages to be obtained by utilizing the fifty years of insulation experience which is ours . . . and yours for the asking.

FABRICATORS

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S. BOSTON 27, Mass., Insulating Fabricators of New England, Inc., 22 Elkins St.
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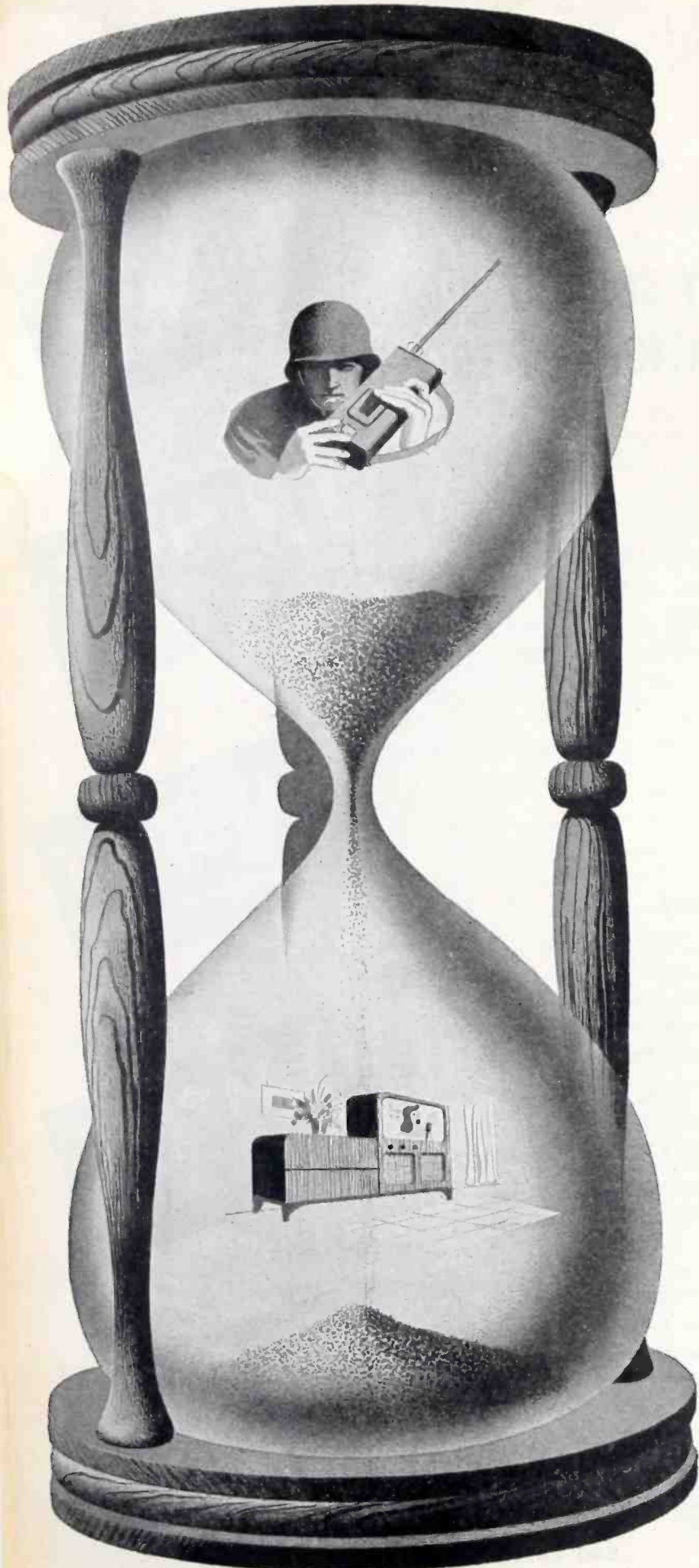
THE TRIANGLE PACIFIC COMPANY

SAN FRANCISCO: 1045 Bryant Street • SEATTLE: 95 Connecticut Street
LOS ANGELES: 340 Azusa Street

COMPANY



200 VARICK STREET, NEW YORK 14, N. Y.



WILCO facilities Expanded to Meet Wartime Needs!

But Postwar Industry will be
the ultimate gainer from the
many new WILCO products
and developments

As the Hourglass indicates . . . at the coming of peace, the skill and experience gained in the development and application of new WILCO products and techniques will mean much to automotive, electrical appliance and many other types of manufacturing customers.

Though now chiefly applied to the war effort, these new WILCO developments are destined to play as vital a role in the postwar industrial "comeback" as they are now playing in scores of wartime applications.

Thermostatic Bimetals, Electrical Contacts, and Precious Metal Bimetallic Products are such important factors in the precision performance of ships, planes, tanks, guns, and various instruments of the Army and Navy that the H. A. Wilson Company has found it necessary to enlarge its facilities and develop these important new products and techniques.

In the postwar period no company will be better equipped to meet individual requirements for Thermostatic Bimetals and Electrical Contacts on any desired scale than the H. A. Wilson Company, pioneers in this field.

WILCO PRODUCTS ARE: *Contacts*—Silver, Platinum, Tungsten, Alloys, Sintered Powder Metal. *Thermostatic Bimetal*—High and Low Temperature with new high temperature deflection rates. *Precious Metal Collector Rings* for rotating controls. *Silver Clad Steel*. *Jacketed Wire*—Silver on Steel, Copper, Invar, or other combinations requested. *Rolled Gold Plate*. *Special Materials*.

THE H. A. WILSON COMPANY
105 Chestnut Street, Newark 5, New Jersey



Thermometals—Electrical Contacts
Precious Metal Bimetallic Products

December 1944 — ELECTRONICS

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.

C-D PAPER TUBULAR CAPACITOR TYPE DT
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.

To the human element in making C-D Capacitors are added the finest facilities—the careful selection of flawless materials. These, together with the expert workmanship of trained minds and skilled hands, have given Cornell-Dubilier a reputation for quality, for minute attention to every detail, and dependability since 1910. Cornell - Dubilier Electric Corporation, South Plainfield, New Jersey.

ALSO AT NEW BEDFORD,
BROOKLINE, WORCESTER,
MASS., PROVIDENCE, R. I.

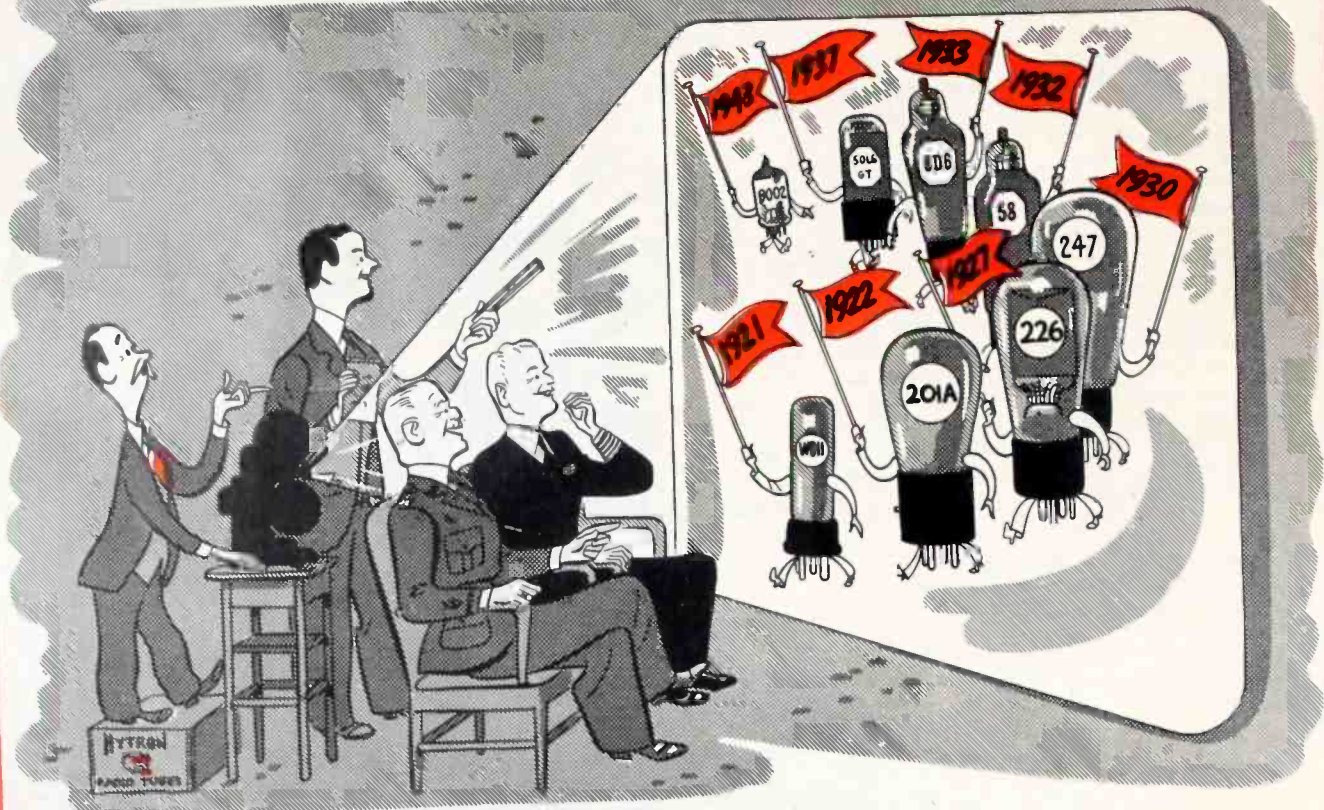
CORNELL - DUBILIER CAPACITORS



MICA • DYKANOL • PAPER •
WET AND DRY ELECTROLYTICS



HYTRON has made them all!



The march of Hytron receiving tube progress down through the years is fascinating. One looks back on tubes, tubes, and more tubes: battery, AC, AC/DC, diodes, triodes, pentodes, beam tetrodes, multiple purpose types, G's, MG's, BANTAM GT's — and now the miniatures. Price and size have been drastically cut; quality and performance, amazingly improved.

Hytron has made them all. Its long and varied experience is priceless in a complex industry where probably never will all the answers be known. In making radio tubes, painfully acquired practical

experience must supplement the formulae of science.

With an eye to present and future, Hytron is concentrating its production of receiving tubes on preferred BANTAM GT types needed for war — for today's civilian replacements — and ultimately for post-war. Its wartime activities are teaching Hytron new techniques of miniature production. Many potentially popular Hytron miniatures are in development. Typical American dissatisfaction with anything but perfection continues; the parade of Hytron receiving tubes marches on.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON
CORPORATION
ELECTRONIC AND
RADIO TUBES
SALEM AND NEWBURYPORT, MASS.



BUY ANOTHER WAR BOND

Variable Tuning Condensers, Push Button Tuning

Mechanisms and Actuators, Phonograph Record Changers



**A NEW DIVISION
UNDER THE DIRECTION OF
LEE GOLDNER**

identified for more than 20 years with
the manufacture of radio speakers.

Millions of radio components on the far flung battle areas of the world bear the G. I. insignia. What they have accomplished is already in the archives.

Behind General Instrument's record of achievement in the quantity production of electronic equipment for military use, stands nearly a quarter century of highly specialized production and experience in the field of radio components for home receiving sets.

GENERAL ELECTRONIC APPARATUS CORP.

A SUBSIDIARY OF

GENERAL INSTRUMENT CORP.

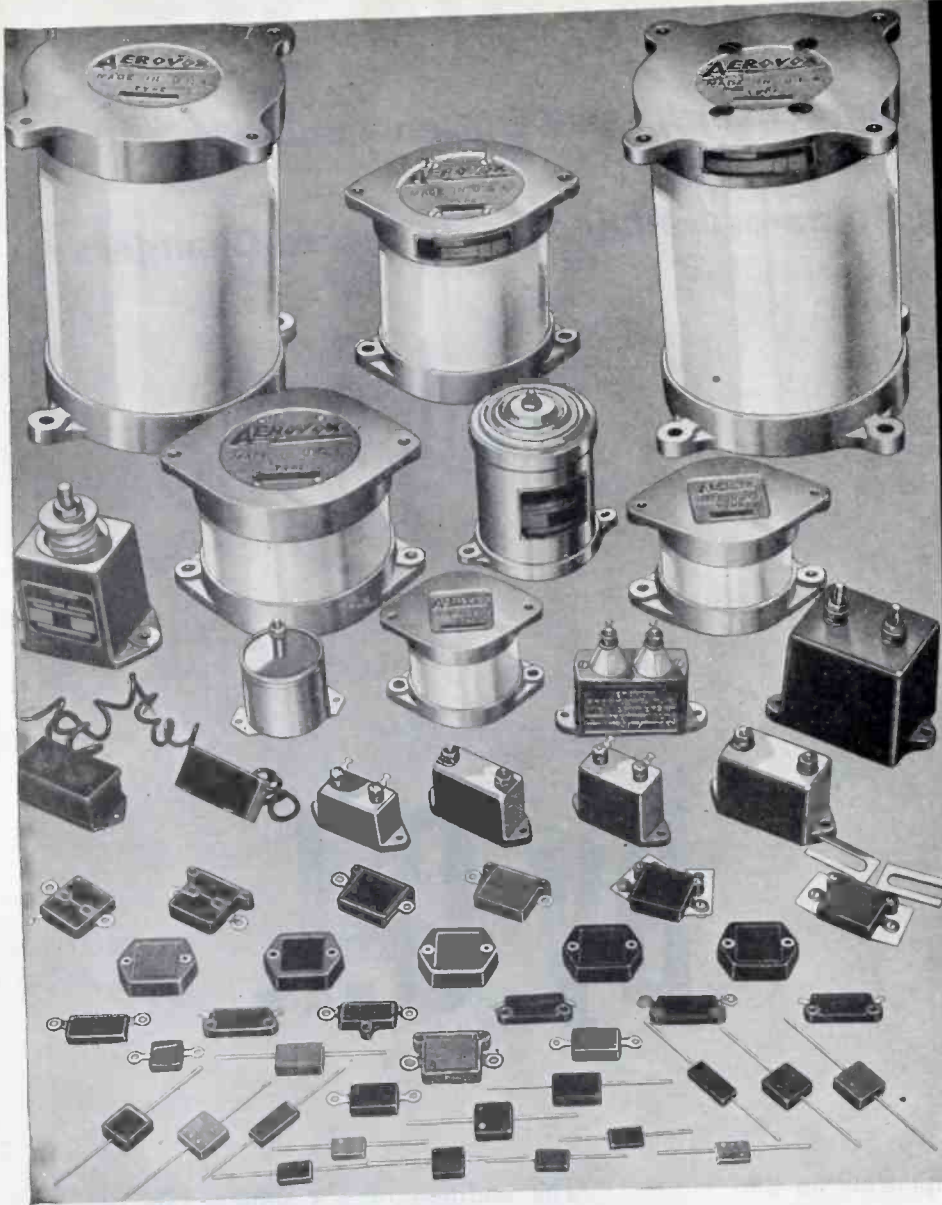
829 NEWARK AVE., ELIZABETH 3, N. J.

... and now
speakers
by G.I.

The addition of a complete line of speakers is, therefore, not a venture into a new field, but the logical outgrowth of our expanded facilities, developed by wartime activities and increased resources in the radio equipment industry.

The resourcefulness and ingenuity—the expanded and perfected facilities that made this mammoth production possible will be put, without stint, behind our new speakers. Set manufacturers will know what this will mean.





**THERE'S A
TYPE FITTED
PRECISELY TO
YOUR NEEDS...**

**AEROVOX
MICA**

Capacitors

SPECIFY AEROVOX

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 condi-

tions such as high humidity, altitude, extreme temperatures, etc. **Mechanical:** (g) Basic type; (h) Terminals; (i) Case; (j) Mounting holes; (k) Name-plate 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.



Capacitors

INDIVIDUALLY TESTED

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

SALES OFFICES IN ALL PRINCIPAL CITIES

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December 1944 — ELECTRONICS

FOOD PRODUCTS

THERMOSETTING PLASTICS

DRUGS AND CHEMICALS

THERMOPLASTICS

TEXTILES

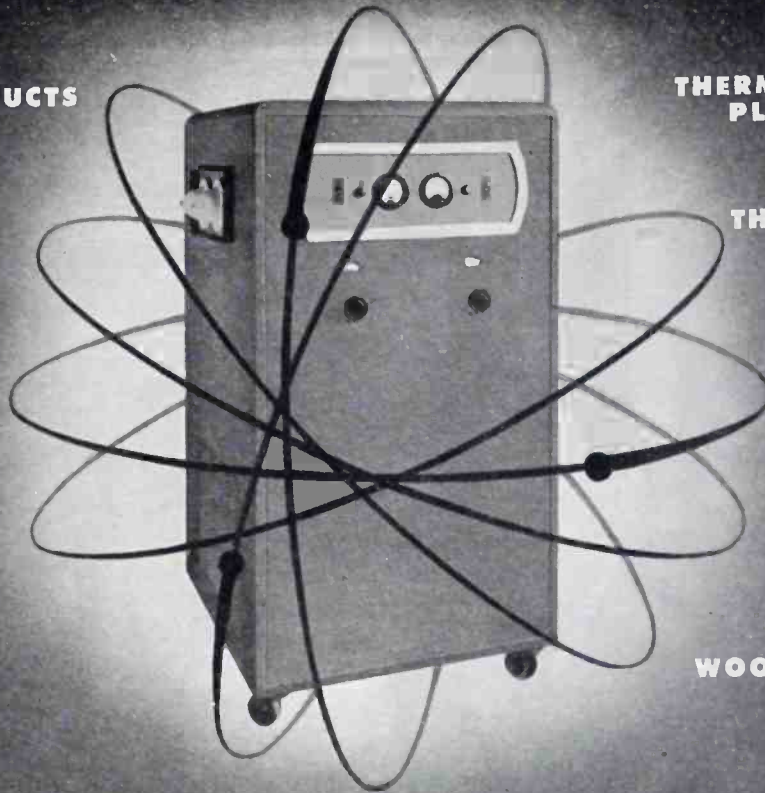
RUBBER

DEHYDRATION

PLYWOOD

STERILIZATION

WOOD PRODUCTS



YOUR PRODUCT?

YOUR COMPETITOR'S PRODUCT?

Thermatron

ELECTRONIC HIGH FREQUENCY HEATERS

... in these general fields and specific applications, as well as in countless others, make possible better, quicker and, in most cases, cheaper processing than by any other known method.

The **Thermatron** method of accurately controlled internal heat generation in non-metallic materials may revolutionize your industry and your business.

A wealth of practical knowledge on electronic high frequency heating applications is yours for the asking. Describe your problem to us *today*—*let's plan for tomorrow.*

Standard sizes from 500 watts to 30 kilowatts output.
Units of special sizes and frequencies built to order.

Thermatron Division

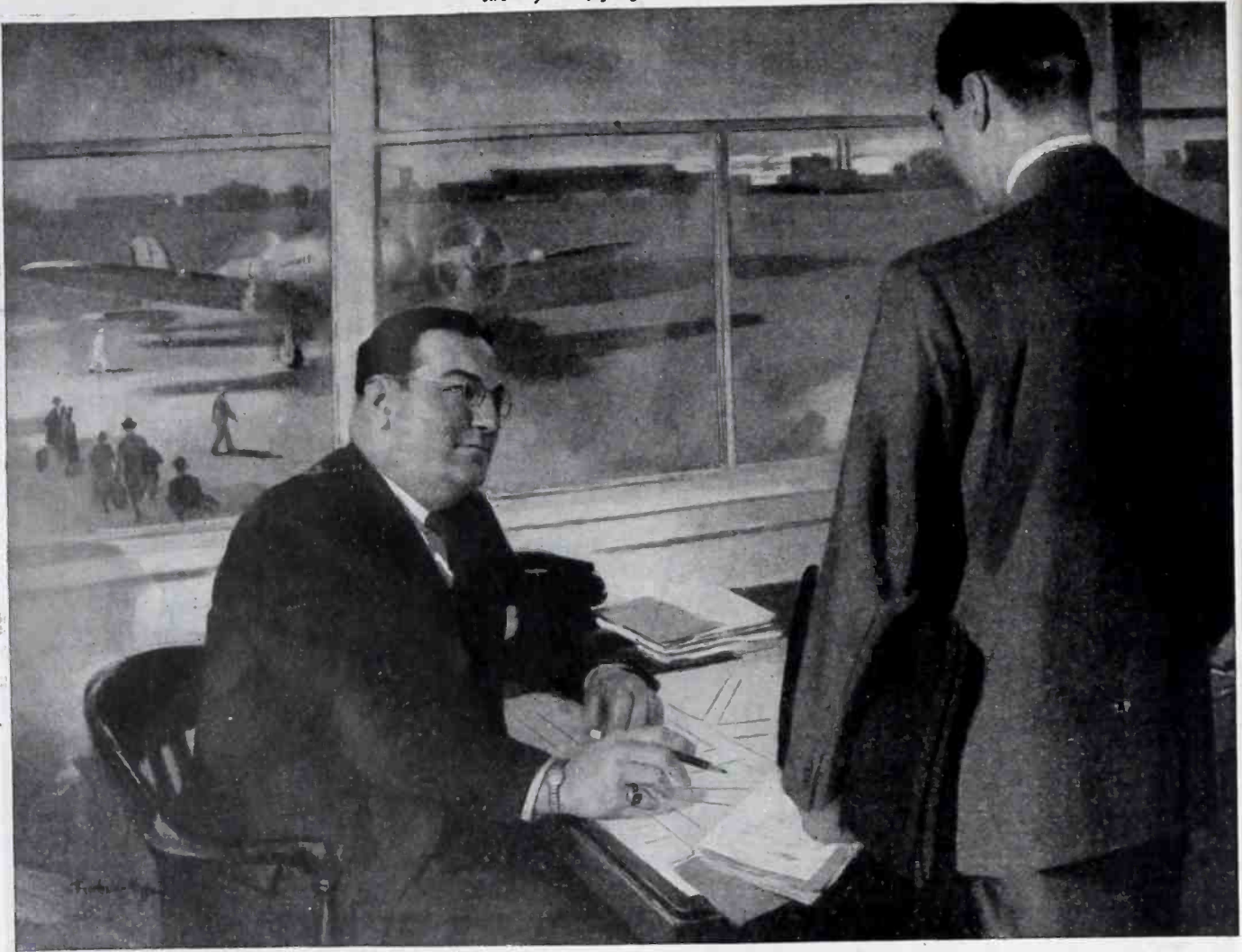


RADIO RECEPTOR COMPANY, INC.
251 WEST 19th STREET
NEW YORK 11, N. Y.

SINCE 1922 IN RADIO AND ELECTRONICS

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.

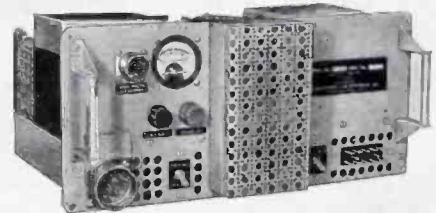
The life of E-L Vibrator Power Supplies is far beyond the customary overhaul requirement. With these units maintenance time is cut to a minimum—only a small fraction of the time previously required.

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 12 $\frac{3}{8}$ " x 7 $\frac{1}{4}$ ".



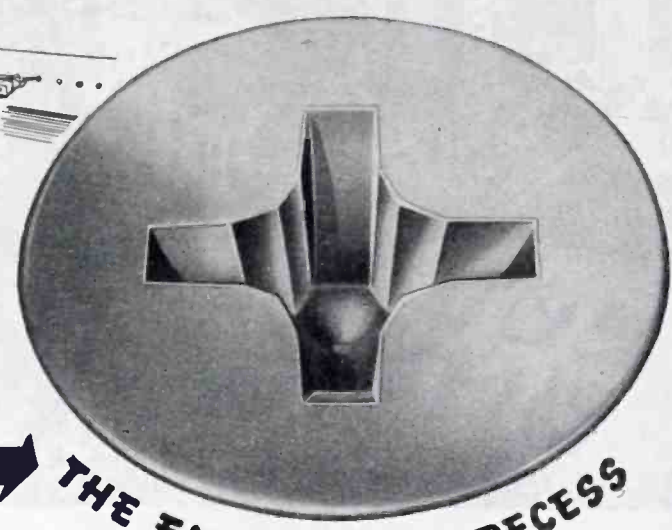
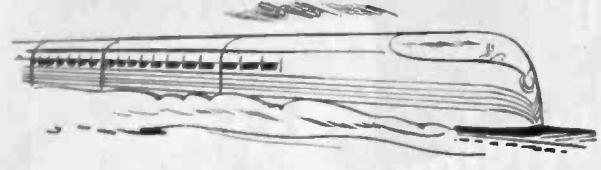
Electronic

LABORATORIES INC.

INDIANAPOLIS

VIBRATOR POWER SUPPLIES FOR LIGHTING, COMMUNICATIONS, AND ELECTRIC MOTOR OPERATION • ELECTRIC, ELECTRONIC AND OTHER EQUIPMENT

NO "DOCTORED-UP" VERSION OF AN OLD IDEA—IT'S A 20TH CENTURY DESIGN THAT TOOK YEARS OF RESEARCH AND TESTING TO DEVELOP! IT'S PHILLIPS THE ENGINEERED RECESS



In ease and speed of driving, there is nothing quite like the Phillips Recessed Head Screw.

That's because the Phillips Recess was developed from scratch—not just adapted from some older, less satisfactory type of recess. It's an *engineered* recess . . . with years of costly testing and research behind each design feature.

As a result, every angle, every flat plane, every dimension of the Phillips Recess makes a definite contribution to easier, faster, more efficient screw driving.

The recess walls are angled just right to eliminate fumbling starts, to let workers utilize their *full* turning power. The 16 flat planes are provided to hold even worn drivers snugly. And the depth of the recess is exactly figured to give unusual strength to Phillips Screw Heads, and make it easy to keep Phillips Bits and Drivers lined up with the axis of the screw.

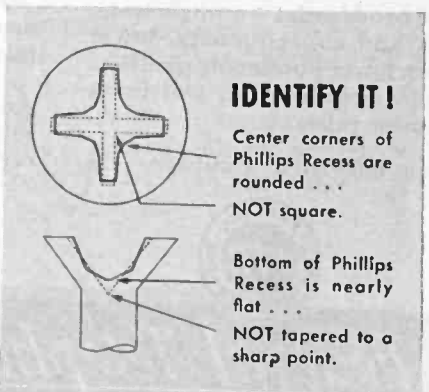
To Make Wartime Quotas and Peacetime Profits . . . get the faster starting—faster driving—stronger, better-looking fasten-

ings that only screws with Phillips Recessed Heads can give you! All over the country, manufacturers are switching to Phillips Recessed Head Screws to speed up assembly and cut costs. Give your assembly department "a shot in the arm" — change to Phillips Screws, too. Available in all head styles, types, and sizes!



PHILLIPS *Recessed Head* SCREWS

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



24 SOURCES

- American Screw Co., Providence, R. I.
- Atlantic Screw Works, Hartford, Conn.
- The Bristol Co., Waterbury, Conn.
- Central Screw Co., Chicago, Ill.
- Chandler Products Corp., Cleveland, Ohio
- Continental Screw Co., New Bedford, Mass.
- The Corbin Screw Corp., New Britain, Conn.
- General Screw Mfg. Co., Chicago, Ill.

- The H. M. Harper Co., Chicago, Ill.
- International Screw Co., Detroit, Mich.
- The Lamson & Sessions Co., Cleveland, Ohio
- Manufacturers Screw Products, Chicago, Ill.
- Millford River and Machine Co., Millford, Conn.
- The National Screw & Mfg. Co., Cleveland, Ohio
- New England Screw Co., Keene, N. H.
- Parker-Kalon Corp., New York, N. Y.

- Pawtucket Screw Co., Pawtucket, R. I.
- Pheoff Manufacturing Co., Chicago, Ill.
- Reading Screw Co., Norristown, Pa.
- Russell Burdall & Ward Bolt & Nut Co., Port Chester, N. Y.
- Seovill Manufacturing Co., Waterville, Conn.
- Shakeproof Inc., Chicago, Ill.
- The Southington Hardware Mfg. Co., Southington, Conn.
- Wolverine Bolt Co., Detroit, Mich.



FINEST PICTURE QUALITY IN BLACK AND WHITE AND IN FULL COLOR!

Sharper, more brilliant pictures than ever before possible are now a reality with Federal's new broad-band television technique . . .

In a revolutionary contribution to the television art, Federal's system permits combining *sight and sound* on one carrier frequency . . .

For the broadcaster—a single transmitter, and consequently, lower first cost, lower power consumption, less space requirement, and fewer high power tubes . . .

For the television audience — a

simpler, less expensive receiver, more compact and efficient, and requiring fewer tubes.

This great forward stride is the logical outcome of Federal's long list of achievements in the field and the contribution of Federal's engineers to the development of the "Micro-ray" more than a decade ago . . . the forerunner of modern television technique.

And as a result . . . Federal has been selected by the Columbia Broadcasting System for the construction

of its new television transmitter atop the Chrysler Tower in New York.

Federal's modern television technique will also be reflected in an equally advanced Federal television receiver for the home . . . producing the finest picture quality.

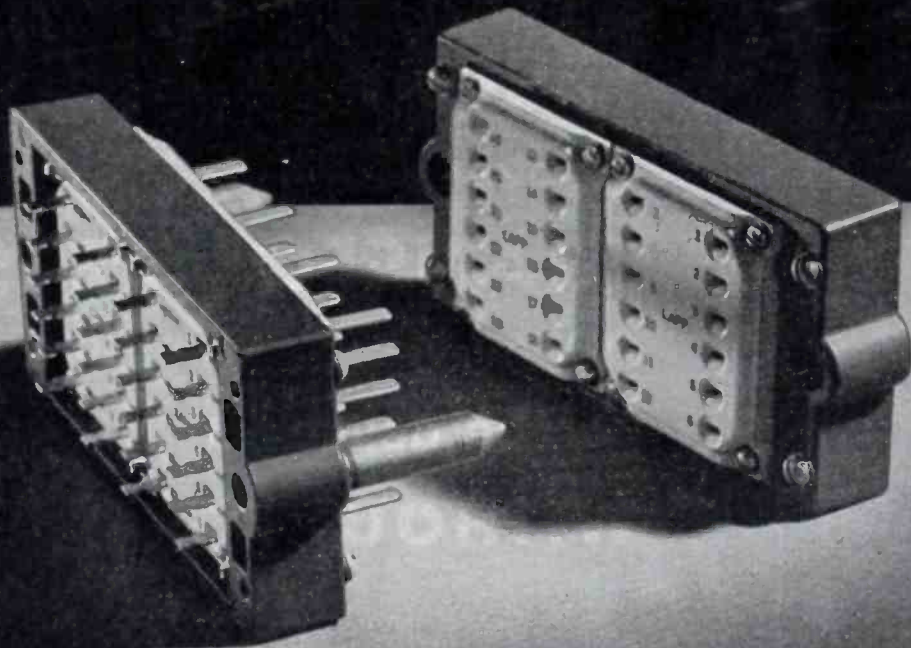
Federal has the experience, the facilities, the technique, needed to build television equipment for any broadcasting requirement. For the best in television — see Federal first.



Federal Telephone and Radio Corporation



Newark 1, N. J.



An Electronic Part ... ENGINEERED TO A SPECIFIC NEED

This is a special-purpose electronic part. It is a plug-receptacle assembly for use with rack-panel type of mounting. Twenty-four silver-plated phosphor-bronze contacts are provided, each male and female contact full floating between steatite plates. Heavy guide pins and matching holes in the frame assure perfect alignment.

We don't know that your product has any need for such a part as this. We do know, however, that this part is most exactly suited to its special requirement just as are hundreds upon hundreds of other parts which have been created through Lapp engineering and Lapp production facilities directed to the solution of specific problems.

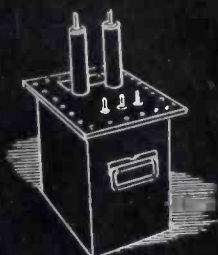
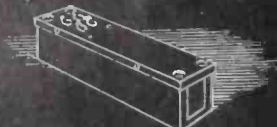
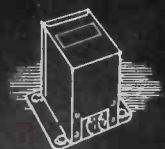
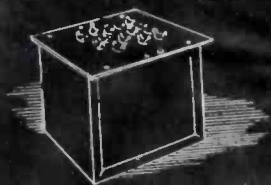
With a broad basic knowledge of ceramics—their capabilities and their limitations—Lapp has been able to simplify and to improve many types of elec-

tronic equipment through engineering and production of sub-assemblies that make most efficient use of porcelain or steatite and associated metal parts.

There may be a way you can improve performance, cut costs and cut production time through use of Lapp-designed and Lapp-built sub-assemblies. We'd like to discuss your specific requirements with you. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp





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Production Facilities
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ORDER ONE AND SEE FOR YOURSELF

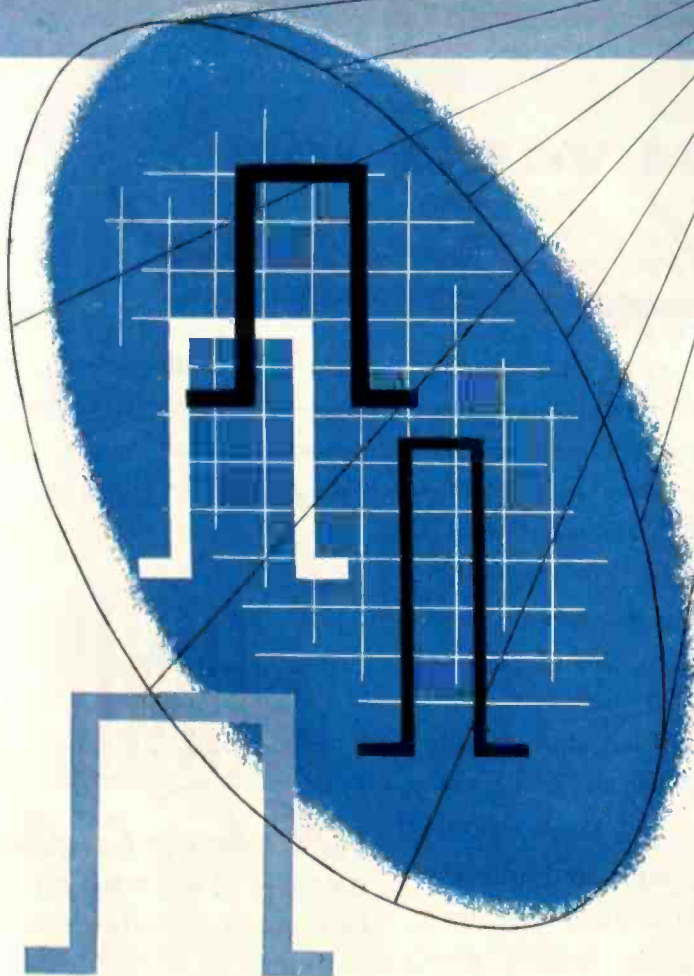
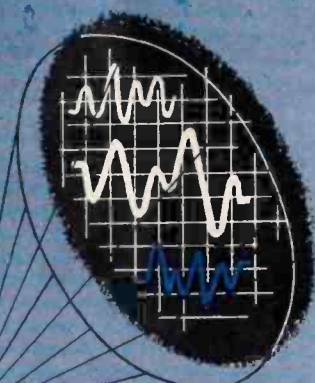
THE REINER 530

square wave generator . . . has a very special feature

It is individually hand calibrated to $\pm 5\%$ over the entire range.

Also worth talking about — and worth having, are the other wanted features of the 530—it can be synchronized with any external frequency source, decade Multiplier (4 steps), positive synchronization with any standard generator, output voltage in steps or continuously variable.

If you're interested in saving time and greater accuracy, order the Model 530 today. It is designed to operate at 110-125 volts, 60 cycles AC — and costs only \$95.00.



FEATURES OF THE REINER 530

- ★ **DECADE MULTIPLIER** (4 steps) increases useful range. The accuracy of the frequency calibration is $\pm 5\%$ over extended periods.
- ★ **OUTPUT VOLTAGE**—may be varied in fixed steps or continuously varied by means of variable voltage potentiometer . . . with the latter, output impedance is from 0 to 2,000 ohms. Approximately 20 volts maximum voltage output.
- ★ **OUTPUT IMPEDANCE** — 100-200-500-600-1,000-2,000 ohms.
- ★ **LEADING EDGE TRANSIENT TIME** — 3 microseconds. Positive to Negative half cycle ratio to 1 within 10%.
- ★ **POWER SUPPLY** designed to operate on 110-120 volts, 60 cycle, A.C. is available for other voltage or line frequency at slight additional cost.
- ★ **POWER CONSUMPTION**: 30 watts.
- ★ **FUSE PROTECTION**: 1 ampere.



FOR MORE INFORMATION ON THIS AND OTHER REINER EQUIPMENT SUCH AS OSCILLOSCOPES AND SIGNAL GENERATORS, WRITE REINER ELECTRONICS CO., INC., 152 WEST 25TH ST., NEW YORK 1, N. Y.



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Half Finished

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FOR THIS
BOOKLET



It contains details of FCC Tool Steels Cast To Shape and of other important Forging and Casting Division specialties that may offer you money-saving production ideas. Get your copy—write for it today.

Address Dept. E-26

WHEN it's dies you're making—small or large—or various other forming tools or gages or certain fast-wearing parts of machines, FCC Tool Steel Cast To Shape can really save you money.

Very intricate shapes can now be cast in one piece within an eighth-inch of finished size. This means that you pay for less steel to begin with, and reduce machining time substantially.

Air Hardening, Oil Hardening and special Hot Work Tool Steels of various grades—each a thor-

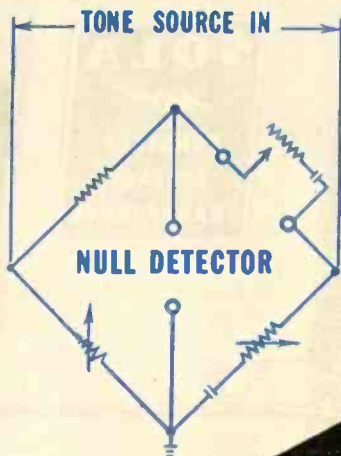
oughly dependable performer in its class—are available in this modern, economical form.

Prompt delivery under CMP.



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STEEL CORPORATION
Forging and Casting Division
DETROIT 20, MICHIGAN

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.

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.

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.

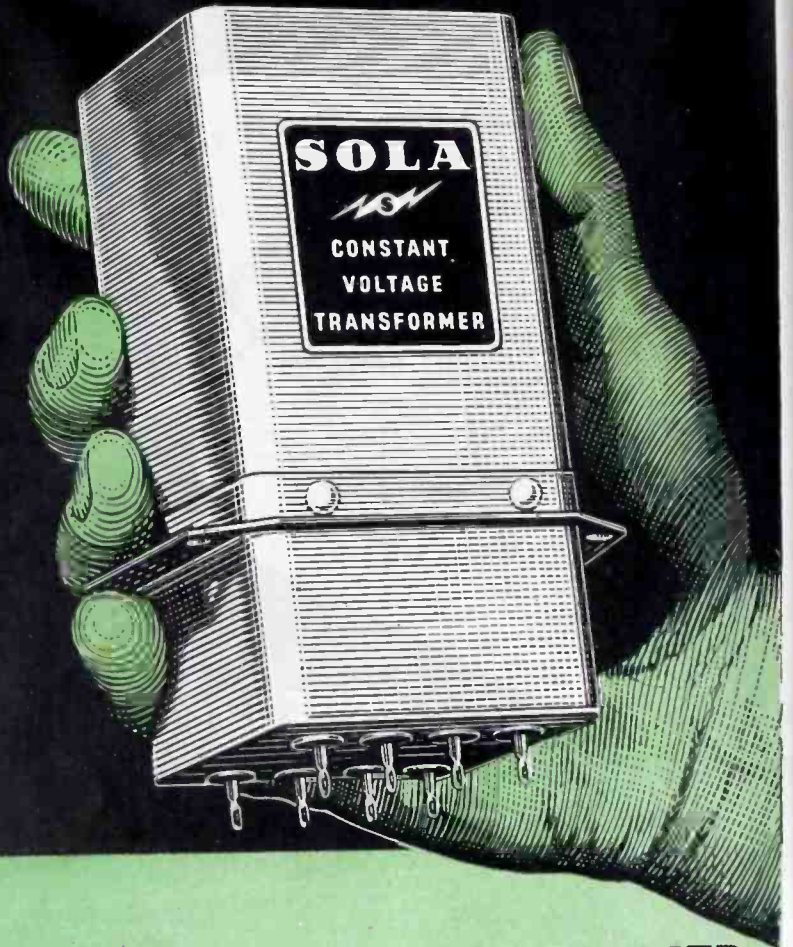
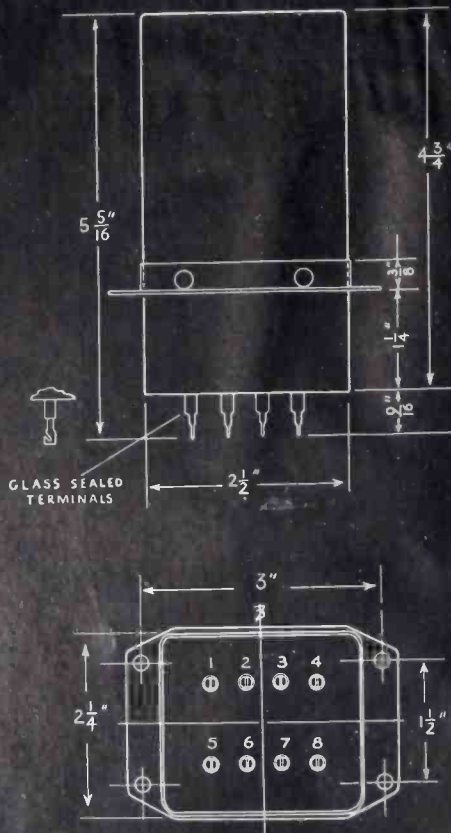
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Electronics*

SHERRON ELECTRONICS COMPANY

Division of Sherron Metallic Corporation

1201 Flushing Ave., Brooklyn 6, N. Y.

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



Another SOLA CONSTANT VOLTAGE TRANSFORMER that has an important future in *YOUR* postwar plans

There may be one vulnerable spot in the design of *your* equipment that this SOLA Constant Voltage Transformer will correct.

Your customers do not have the stable line voltage called for on your label. They will blame *your* equipment for inefficient operation, *not* the fluctuating voltages that really cause it.

Build this SOLA Constant Voltage Transformer into your product and you can be certain that the operating voltages will always be within $\pm 1\%$ of rated require-

ments regardless of line fluctuations as great as 30%.

This SOLA Constant Voltage Transformer is built to fit your equipment. (Note the small, compact dimensions.) Its low cost will fit your production budget. Its automatic operation will eliminate the need for other costly components, and relieve your customers of the responsibility of making manual voltage adjustments.

There's a powerful sales story behind a product equipped with a SOLA Constant Voltage Transformer.

SOLA

Constant Voltage Transformers

To Manufacturers:

Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.

Ask for Bulletin DCV-103

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs • Oil Burner Ignition • Radio • Power Controls • Signal Systems • Door Bells and Chimes • etc. SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.

GAMMATRON TUBES



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.

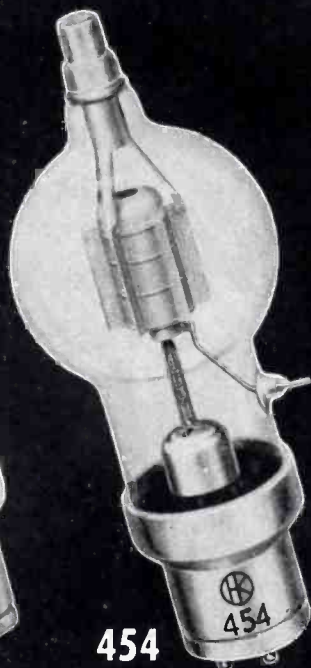
24G

PLATE DISS.
25 W.



257B

PLATE DISS.
75 W.



454

PLATE DISS.
250 W.

HEINTZ  KAUFMAN
SOUTH SAN FRANCISCO, CALIF. 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.v.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.v.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.v.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 1/16	7	5 1/16	7 3/4	7 3/4	9	9	10	10	10 1/4	12 3/4	12 3/4	16 3/4	18	21 1/4	30 3/4
Diameter, Inches	1 3/8	1 3/8	2	2 3/8	2 3/8	3 1/2	3 1/2	3 3/8	3 3/8	3 3/8	3 3/8	3 3/4	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 rebounding 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:

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 rebound, 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 rebound 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 rebound 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 rebounds before establishing definite contact. Total duration of series of rebounds is $1/250$ th 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 rebound 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.

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DUMONT

Precision Electronics & Television

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MYKROY #51

**Glass-Bonded
Mica Plastic
High Frequency
Insulation for
INJECTION
MOLDING**



MYKROY
PERFECTED MICA CERAMIC INSULATION

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 (19 1/4" x 29 3/4") of perfected mica ceramic insulation now available.

MYKROY IS SUPPLIED IN SHEETS AND RODS . . . MACHINED OR MOLDED TO SPECIFICATIONS

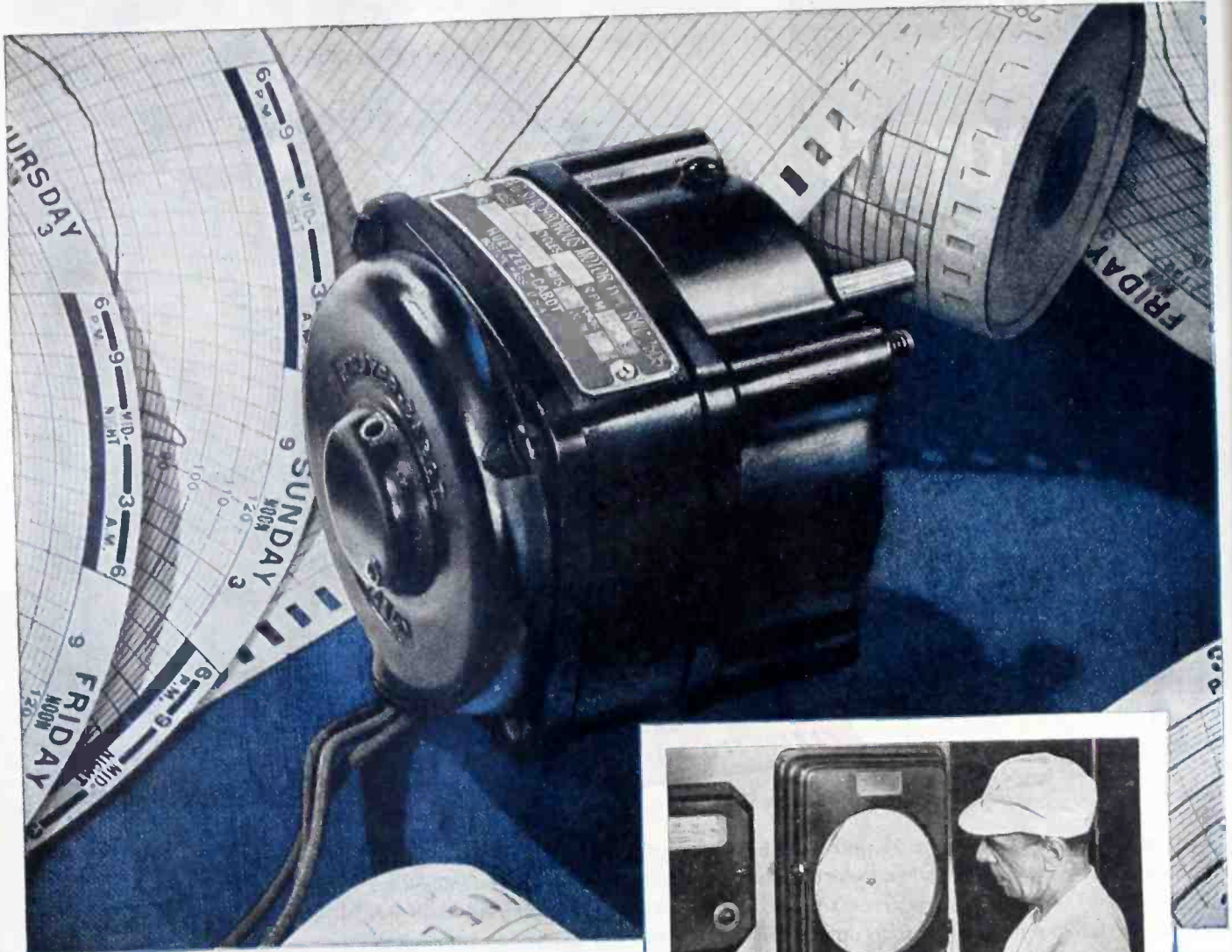
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Chicago 47 • 1917 NO. SPRINGFIELD AVENUE . . TEL. Albany 4310

Export Office: 89 Broad Street, New York 4, N. Y.

Increased Power and Constant Speed

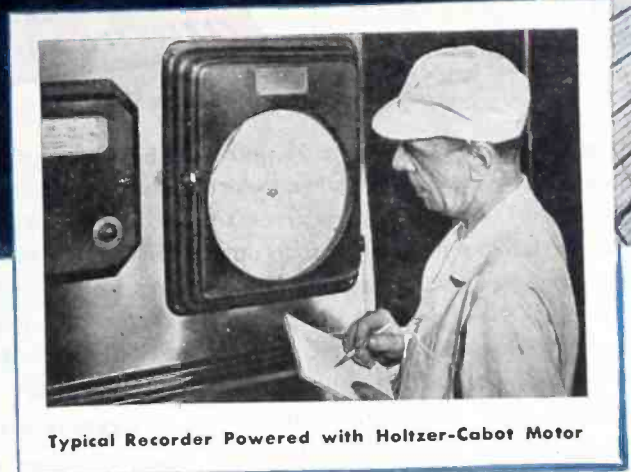
...YET FITS MOTOR SPACE AVAILABLE



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.



Typical Recorder Powered with Holtzer-Cabot Motor

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.

Special Motors Designed to Fit the Application

HOLTZER-CABOT

Division of First Industrial Corporation

Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

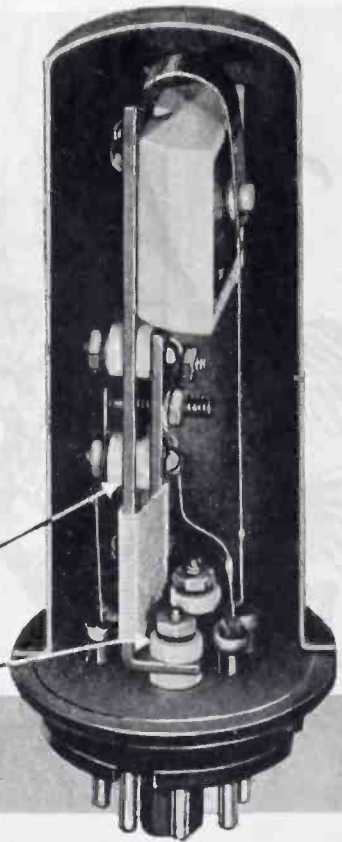
125 AMORY STREET, BOSTON 19, MASSACHUSETTS • CHICAGO, ILLINOIS • NEW YORK, NEW YORK • PHILADELPHIA, PENNSYLVANIA

December 1944 — ELECTRONICS



MYCALEX

SOLVES ANOTHER TOUGH INSULATION PROBLEM



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.

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. On Sunday evening listen to the G-E "All Girl Orchestra" at 10 E.W.T. over NBO.

GENERAL ELECTRIC

177-M-C11-0010

Over 21 Years of Mycalex Experience
—Your Assurance of Quality!

FREE—G-E MYCALEX BULLETIN

Electronics Department
GENERAL ELECTRIC CO.
Schenectady, N. Y.

Please send me a free sample and my copy of the booklet describing G-E Compression-Molded mycalex.

Name

Company

Address





IF YOUR PRODUCT
IS DESTINED FOR
SOUTH PACIFIC FRONTS

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Tropicalized

Q-MAX A-27 H. F. LACQUER

If your communication or electrical equipment is destined for the tropics, then you will send delicate, precision-built apparatus into steaming, humid atmospheres where fungus, mold and harmful moisture, are waiting to impair its performance and its consequent usefulness to our fighting forces.

The problem is vitally important and calls for a safe, dependable remedy to be applied right in your factory, when the product is being assembled. And it's a problem that has now been solved, thanks to our chemists who long searched for an ideal fungicide that would com-

bine well with Q-Max A-27 H.F. Lacquer, without interference with its good electrical characteristics or its fine corrosion resistance.

Tropicalized Q-Max A-27 H.F. Lacquer, a factory-mixed fungicide-and-high dielectric coating lacquer combination so efficient that it not only provides a surface of coated protection, but provides a zone of inhibition *around* the coated area besides. For insurance against fungicidal damage for your product, specify Tropicalized Q-Max A-27 H.F. Lacquer... and be sure to look for the word Tropicalized on the Q-Max label.

Communication

PRODUCTS COMPANY, INC.

346 BERGEN AVENUE, JERSEY CITY, N. J.

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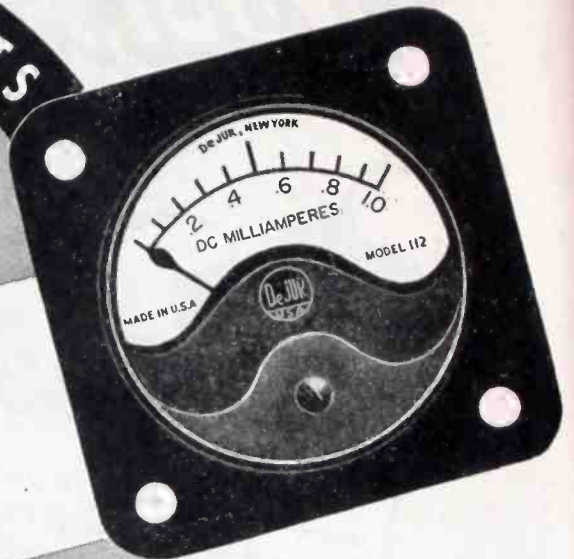
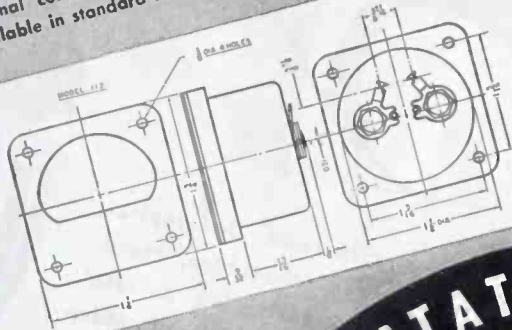


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DeJUR ELECTRICAL INSTRUMENTS

1 1/2 INCH METER • SQUARE TYPE • MODEL 112

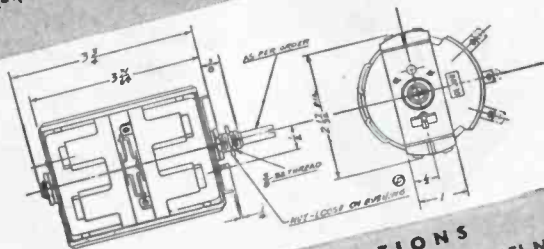
This miniature instrument may be successfully used in a variety of applications, and it is particularly useful where space is an important factor. The DeJur 112 measures only 1 3/4" square and 25/32" deep, and uses basically the same carefully designed components as our larger instruments. In order to conserve space, soldering lugs are used for the terminal connections instead of the conventional studs. Available in standard ranges.



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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



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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

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



A New Vacuum Switch KEYING RELAY

*... for Aircraft and
Other Applications*

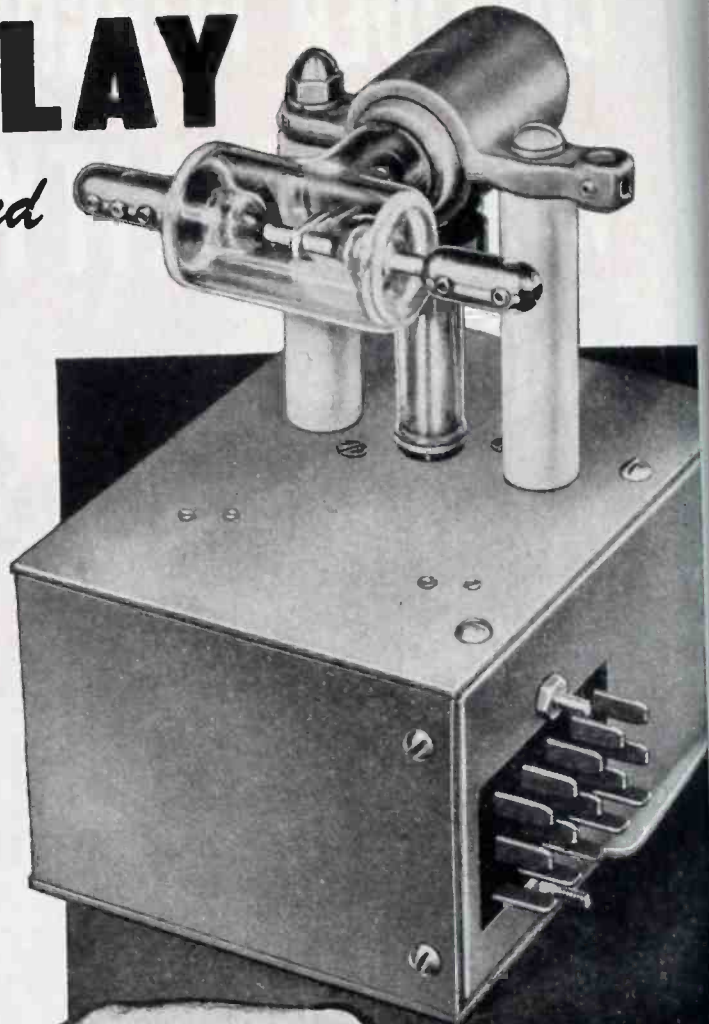
Here is convincing proof that a keying relay does not have to be complicated to be efficient. In fact, just the reverse! Actually, the extreme reliability with which Struthers-Dunn Type 78CCA100 Relay holds its adjustments is the direct result of its new simplified and rigid design which utilizes an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

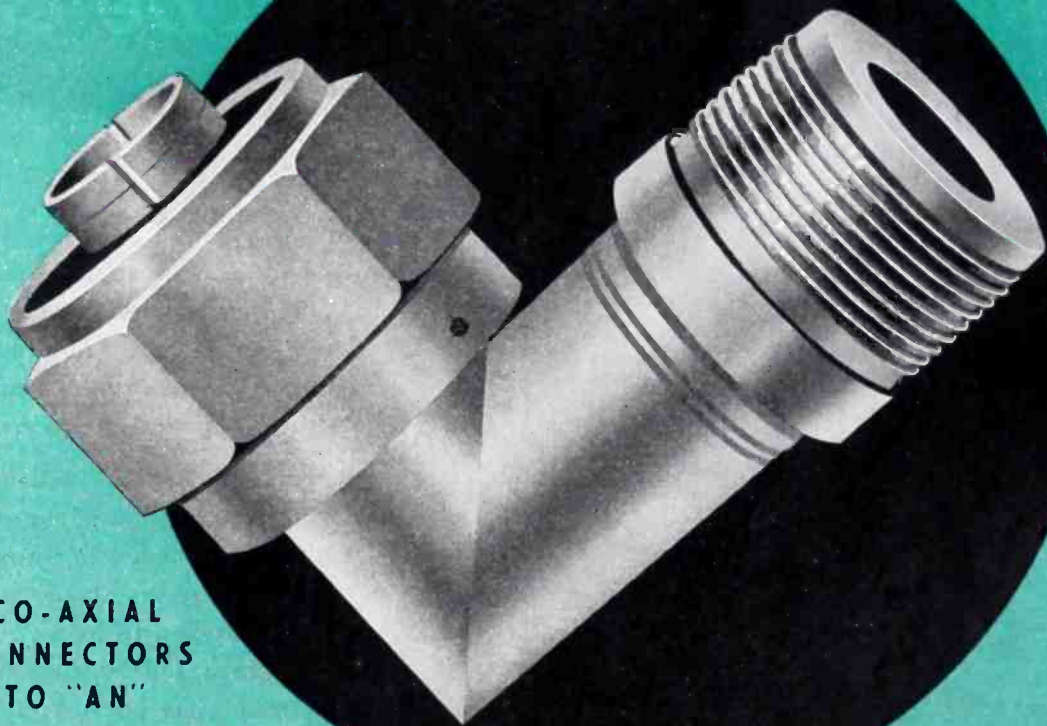


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5,312 RELAY TYPES

DISTRICT ENGINEERING OFFICES: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND
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CO-AXIAL
CONNECTORS
TO "AN"
SPECIFICATIONS

In the specialized high-frequency applications that demand uncompromising quality, DICO co-axial connectors have demonstrated their ability to satisfy every operating requirement.

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2530 SUPERIOR AVENUE • CLEVELAND 14, OHIO



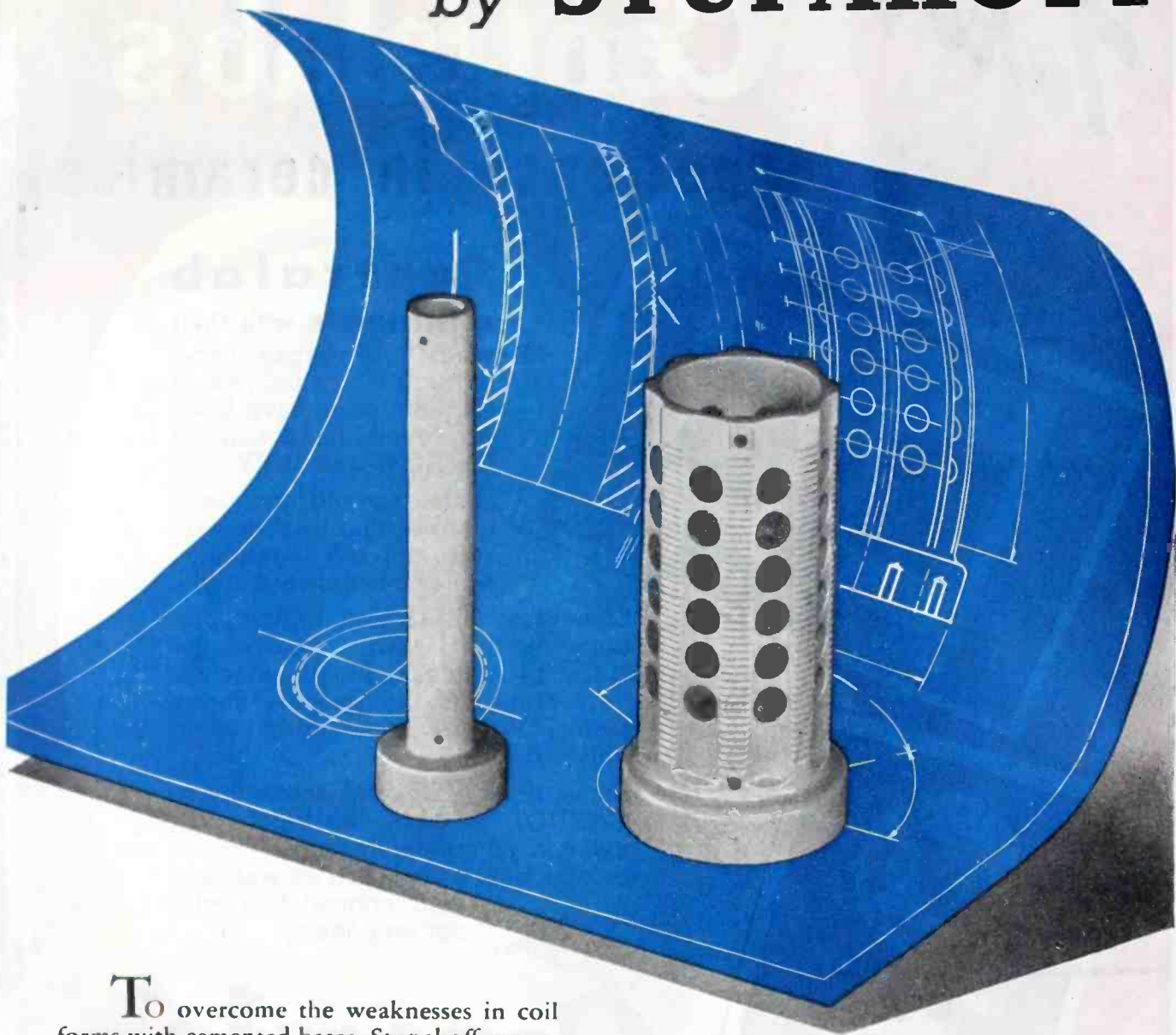
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December 1944 — ELECTRONICS

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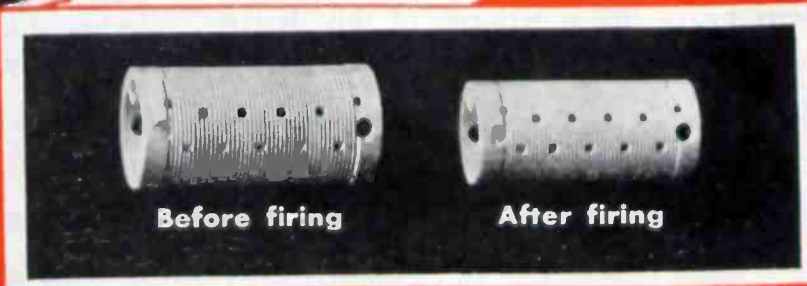


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Hallicrafters
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win Army-Navy
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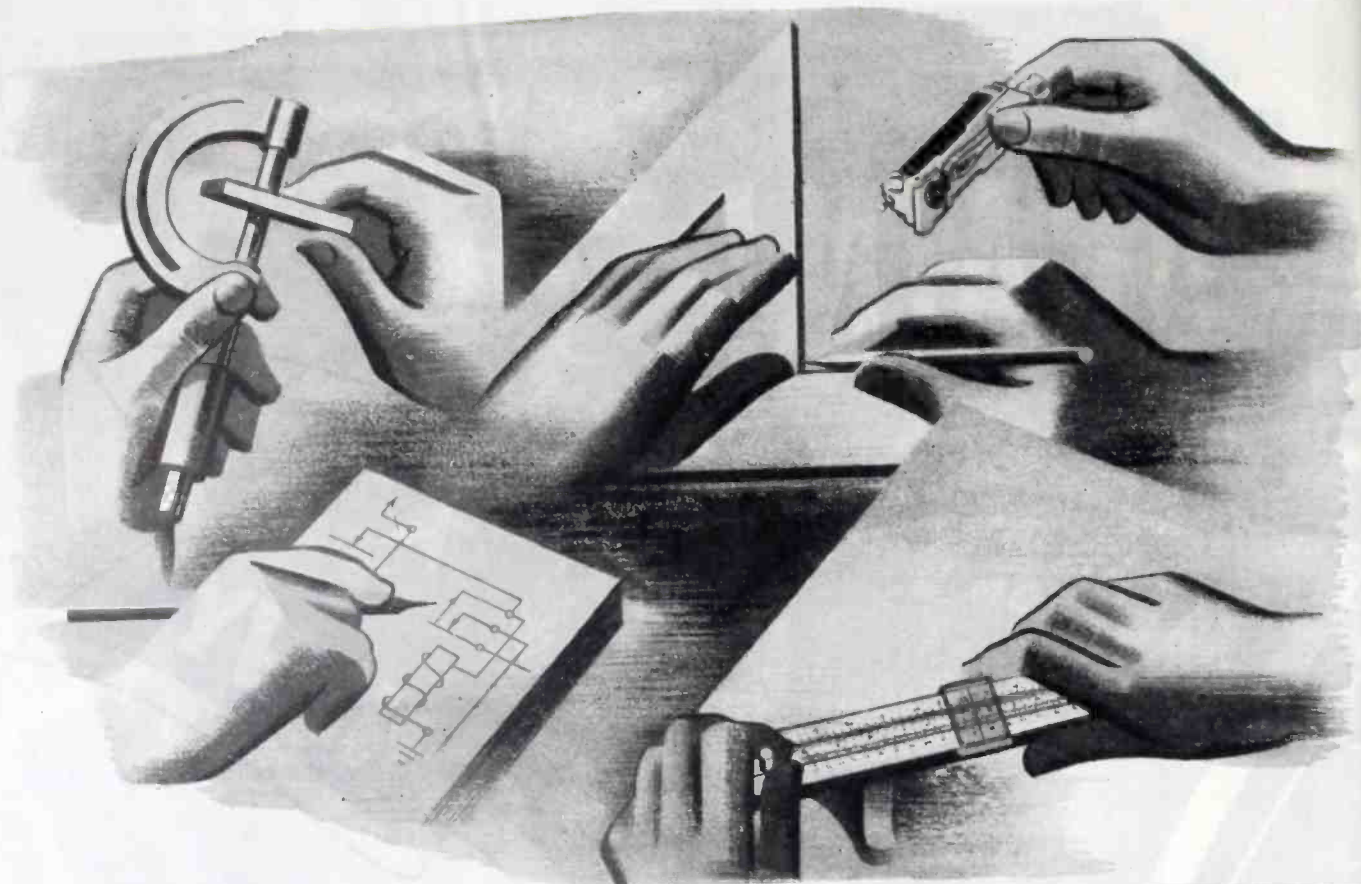
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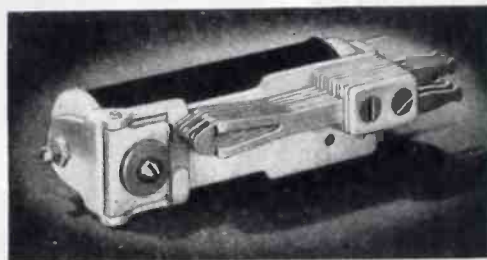
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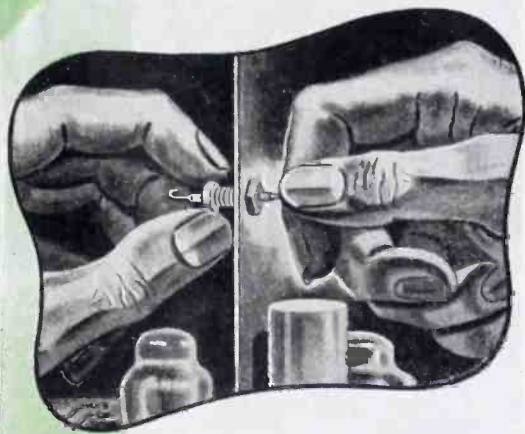
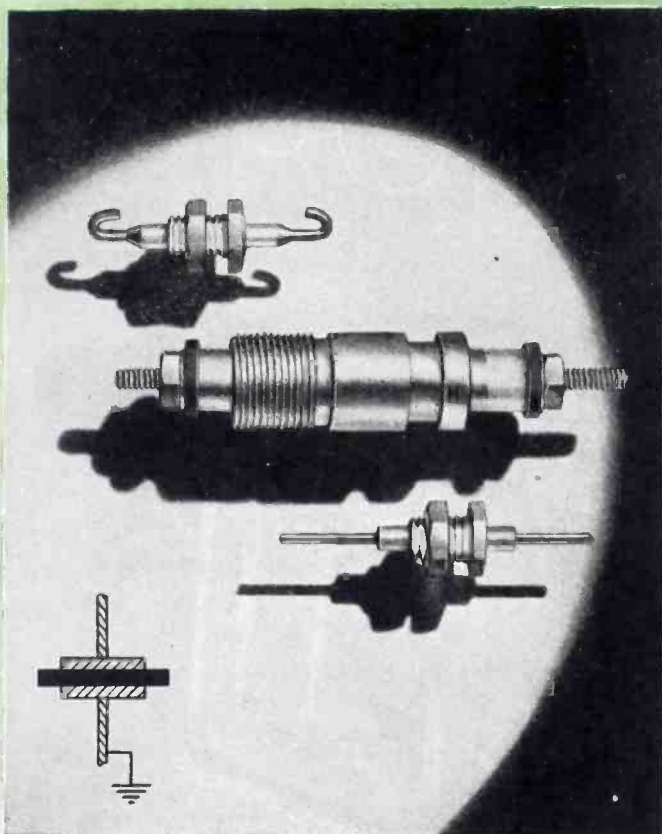
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ERIE Feed-Thru CERAMICONS

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.		OVERALL LENGTH
			SEA LEVEL	50,000 FT.	
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"



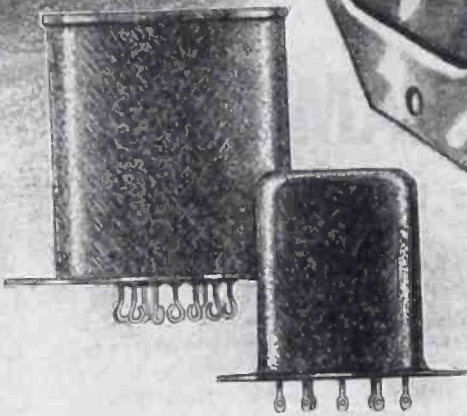
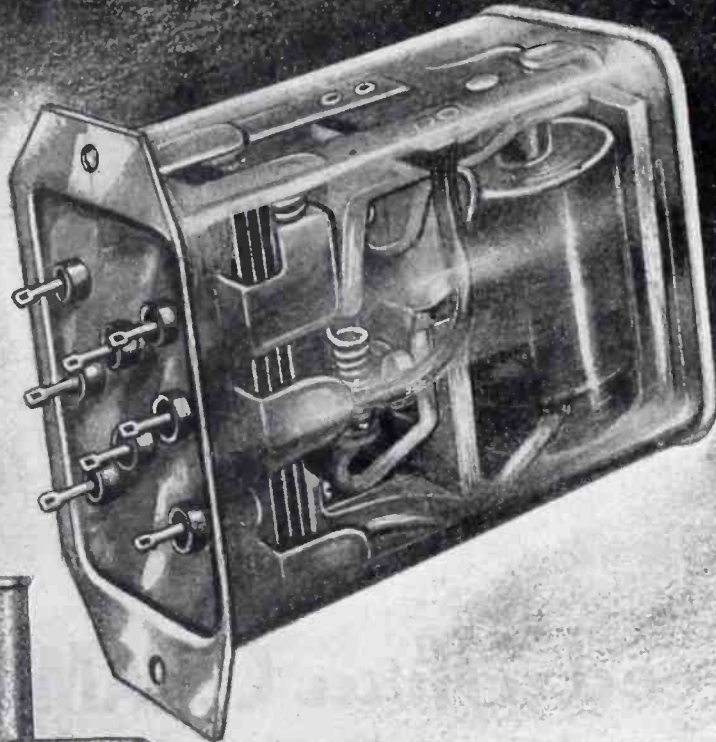
Electronics Division

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- **AIRCRAFT USE...** designed to overcome altitude effects to 70,000 feet.
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- **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.**



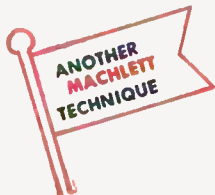
ALLIED CONTROL COMPANY, INC.
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PRECISION AT

2,000,000

VOLTS



WE ARE not going to tell you here why this tube was made, what it does, or what it is for. The important thing about it to you as a user of radio oscillator, amplifier and

rectifier tubes for communications or induction heating is that it represents the toughest assignment ever handed the electronic tube industry, and that of all tube makers only Machlett perfected the techniques that made the tube possible.

The tube is sealed-off, vacuum-tight, and operates at 2,000,000 volts, direct current. These and other difficult conditions were essential to assure high and constant power, reduction of heat, and precise focusing of the electron beam.

Electrical and mechanical problems presented by the tube were so severe that some scientists doubted they could be solved, but Machlett, drawing upon its long experience, met every requirement in a little over two years.

This is significant to you because every electronic tube, whether it produces X-rays, or radio waves, or is a rectifier, depends for its success in your service upon correct design, proper vacuum, adequate insulation, and precision-made parts, to assure precise control of the electrons that make any such tube function.

The perfection of this 2,000,000-volt direct-current tube is the best proof we can offer of the value of the Machlett skills that go into the design and manufacture of every tube bearing our name . . . Machlett Laboratories, Inc., Springdale, Connecticut.



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Wire or telephone if we can be of assistance

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70 Types PLUGS & CONNECTORS SIGNAL CORPS • NAVY SPECIFICATIONS

Types :		PL			
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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			

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Throughout the trying periods encompassed by 3 wars . . . and in all the intervening years of peace since 1895 . . . Thordarson leadership has been accentuated by its association with the most outstanding concerns in America.

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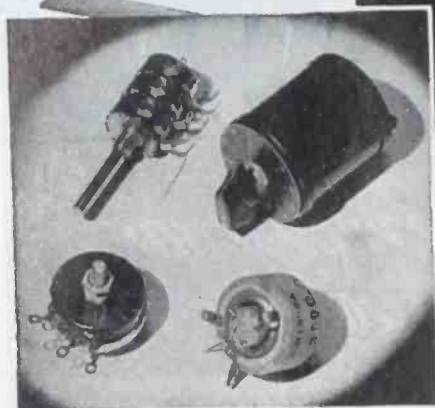
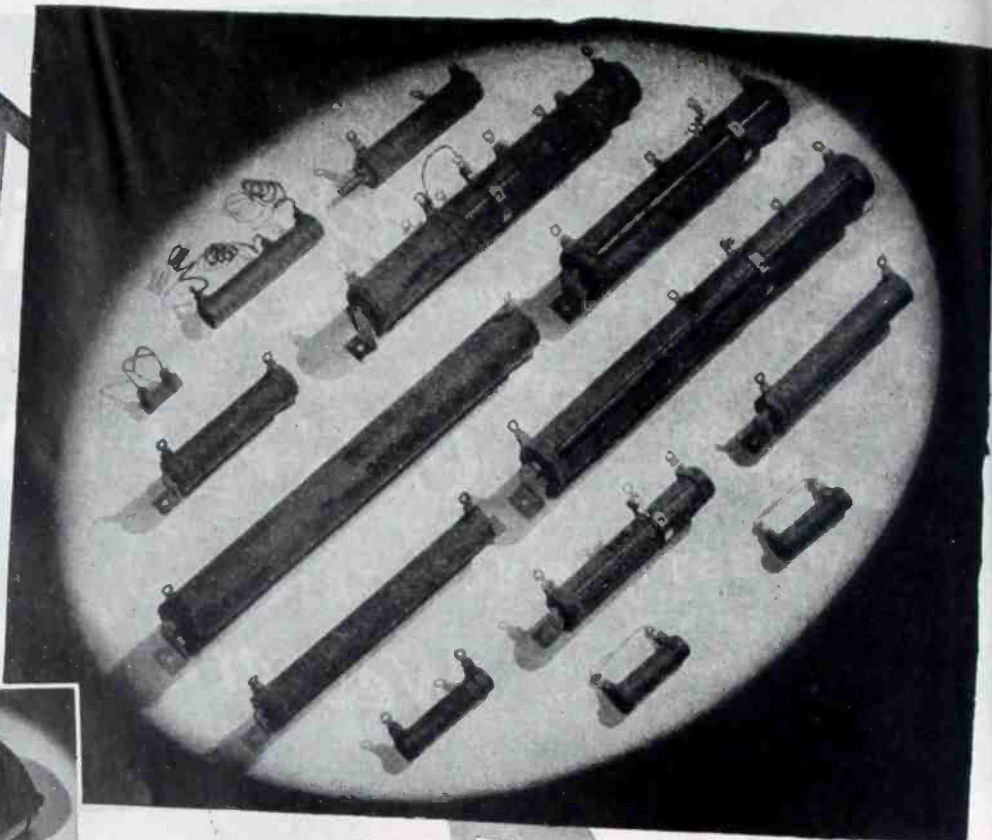
Thordarson Transformers and Amplifiers are "good right hands" to a host of America's leading organizations who are concentrating on winning the war as quickly as possible. Thordarson products are helping to do everything from making communications easier and more accurate to conducting fatigue tests which insure more dependable airplane propellers. All of these services and experiences, now devoted to war, will enable us to serve you better when peacetime needs are again paramount.



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Transformer Specialists Since 1895
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Products of "THE HOUSE OF RESISTORS"

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

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

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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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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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New in Principle!
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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.

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COMMUNICATION MEASUREMENTS LABORATORY

Rotobridge · Electronic Generators · Power Supply Units

120 GREENWICH STREET

NEW YORK 6, N. Y.



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.

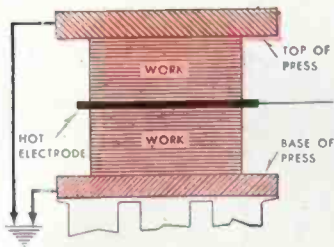
The "long life" air-cooled tubes eliminate all the complications of water cooling. Air cooling also provides an extra margin of safety—against failure and, at the same time, effects worthwhile savings in both space and *initial* cost.

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

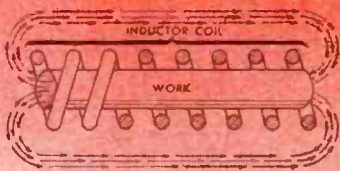


Westinghouse RADIO FREQUENCY HEATING
PLANTS IN 23 CITIES . . . OFFICES EVERYWHERE



APPLICATIONS AND BENEFITS OF WESTINGHOUSE RADIO FREQUENCY HEATING *Dielectric Heating* (for nonconducting materials)

INDUSTRY	APPLICATIONS	GENERAL BENEFITS
WOOD	Plywood • Compreg • Setting glue • Pressure bonding • Drying	Boosts Production by creating the proper heat instantly throughout the material. No waiting for heat to "soak in" from the surface.
PLASTICS	Heating preforms • Curing • Setting • Processing of sheets	Uniform Heating throughout the material prevents damaging internal stresses caused by uneven heating.
TEXTILE	Heating forms • Twist setting • Drying • Bonding thermoplastic fabrics	Rejects Reduced because there is no surface charring—checking or drying out.
FOOD	Drying • Thawing • Dehydrating • Sterilization	Cuts Equipment Costs — Westinghouse Radio Frequency Generators can be used with most existing hot or cold plate presses. Fewer jigs, dies and presses needed.
RUBBER	Heating • Thawing • Curing • Vulcanizing • Devulcanizing	Quickly Installed on most existing presses, using either hot or cold plates.

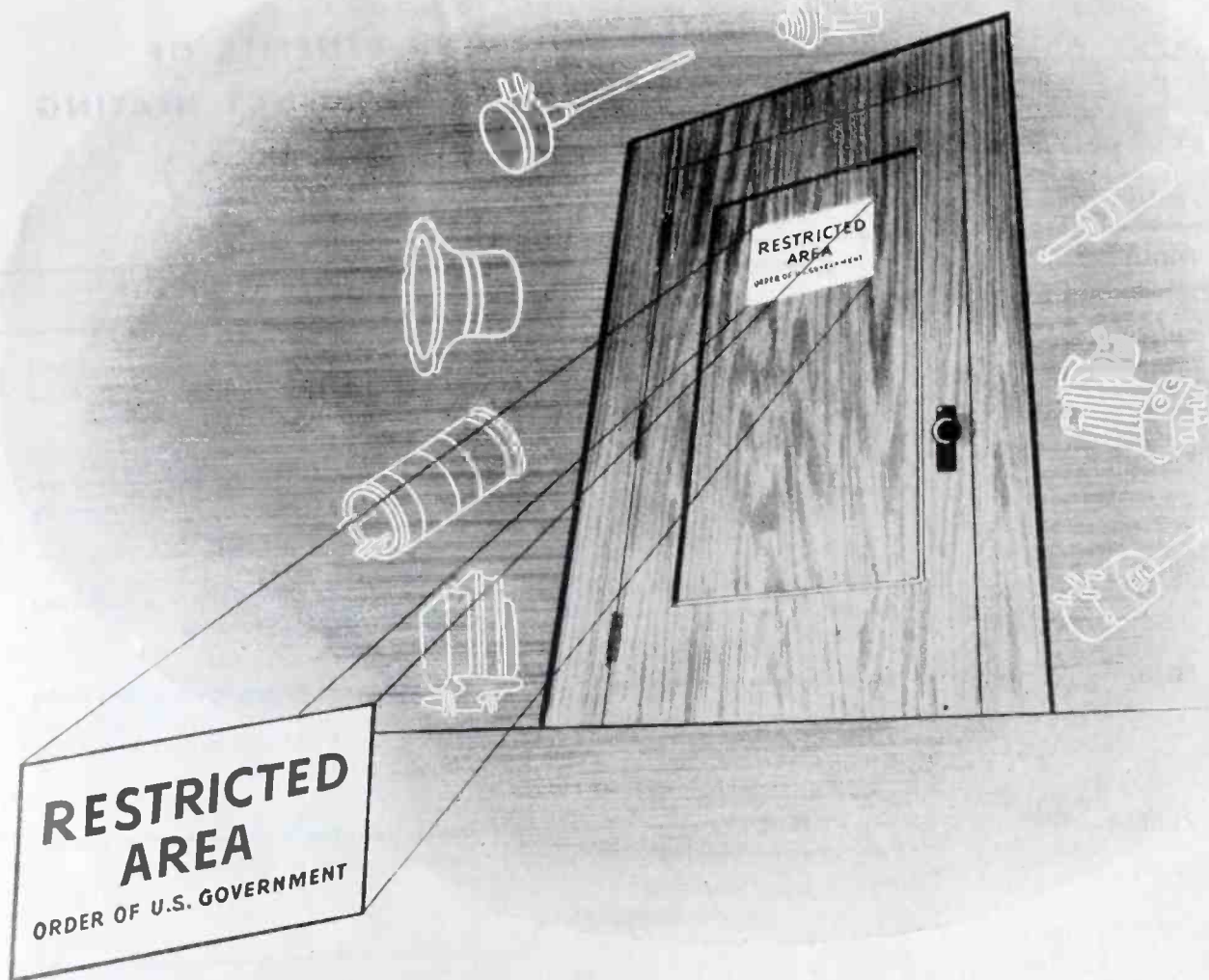


Induction Heating (for ferrous and nonferrous metals)

INDUSTRY	APPLICATIONS	BENEFITS
METAL WORKING	<p>ANNEALING contact plugs • welded sections • tire rims.</p> <p>BRAZING spark plugs • aviation gas line fittings • spiral tubing • tool tips • piston assemblies.</p> <p>HARDENING spindles • cams • punches • ball bearing races • gears • sprockets • drill chuck bodies • camshafts • mandrels and many others.</p> <p>SINTERING—SOLDERING</p>	<p>Saves Production Time through instantaneous, accurately controlled heat.</p> <p>Simpler—Low-Cost Designs are made possible by multiple soldering and brazing operations.</p> <p>Precise Control of depth of hardening leaves strength and machinability of interior unaffected.</p> <p>Automatic Operation permits use of unskilled operators.</p> <p>Heating Can Be Localized externally or internally for specific applications.</p>

Electronics at Work





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 for military needs. Inevitably, the wartime secrets of this forbidden room will
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Utah



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SUSTAIN EXTENDED OVERLOADS



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Silicone Insulation

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They provide the bonding and filling medium for inorganic, or Class B, spacing materials such as Fiberglas, asbestos and mica, which are natural components of this type of insulation.

Dow Corning Varnishes open the avenue to the designing of more compact, lighter weight electrical equipment.

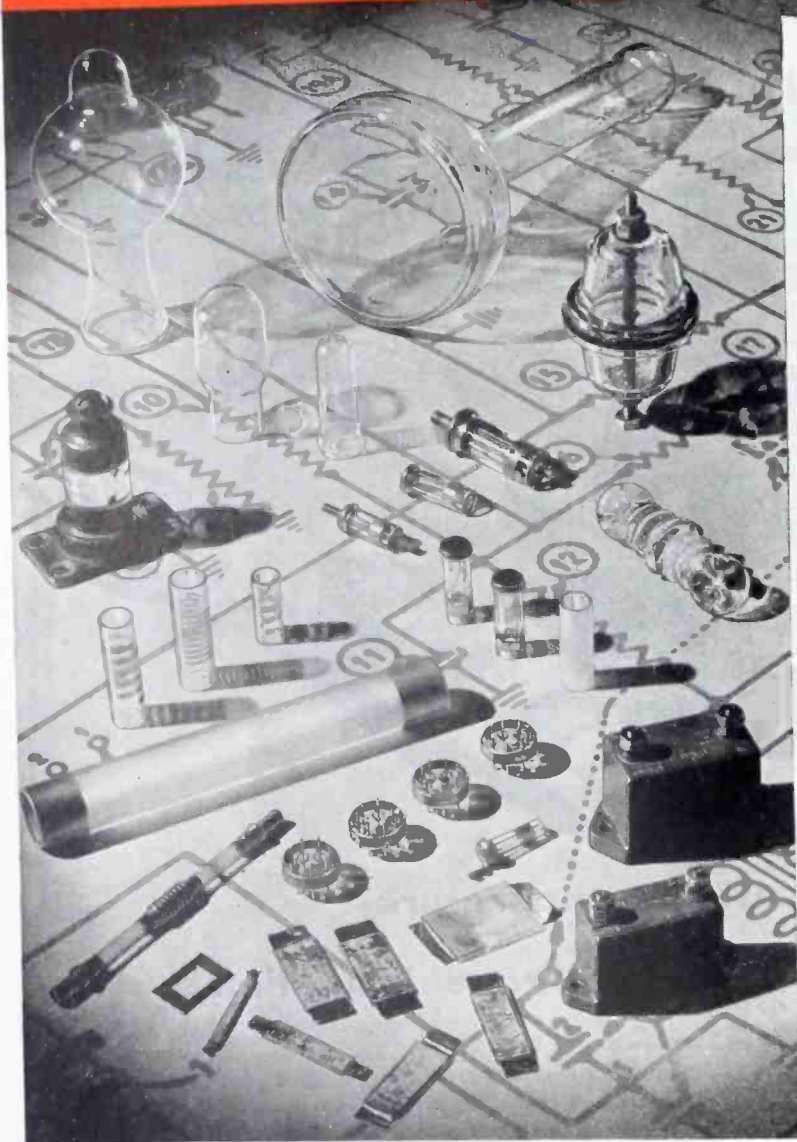
DOW CORNING CORPORATION
BOX 592, MIDLAND, MICHIGAN

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.

Dow Corning

WHAT WILL YOU NEED TO PRODUCE BETTER POST-WAR PRODUCTS ?

**CORNING
GLASS
GIVES YOU**



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Hermetic Sealing

Mechanical Strength

Corrosion Resistance

Precision

Permanence

Metallizing

Dimensional Stability

High dielectric strength — high resistivity — low power factor — wide range of dielectric constants — low losses at all frequencies.

Permanent hermetic seals against gas, oil and water readily made between glass and metal or glass and glass.

Commercial fabrication to the fine tolerances of precision metal working.

Corning's metallizing process produces metal areas of fixed and exact specification, permanently bonded to glass.

AS YOU plan post-war electronic products, give a thought to versatile glass. We really mean glasses, for Corning has, at its fingertips, 25,000 different glass formulae from which to select those especially suited to your electronic applications. Let us show what glass can do for you. We may already have a solution — or Corning Research can find the answer for you. Address Electronic Sales Dept., E-12, Bulb and Tubing Division. Corning Glass Works, Corning, New York.

CORNING
— means —
Research in Glass

Electronic Glassware



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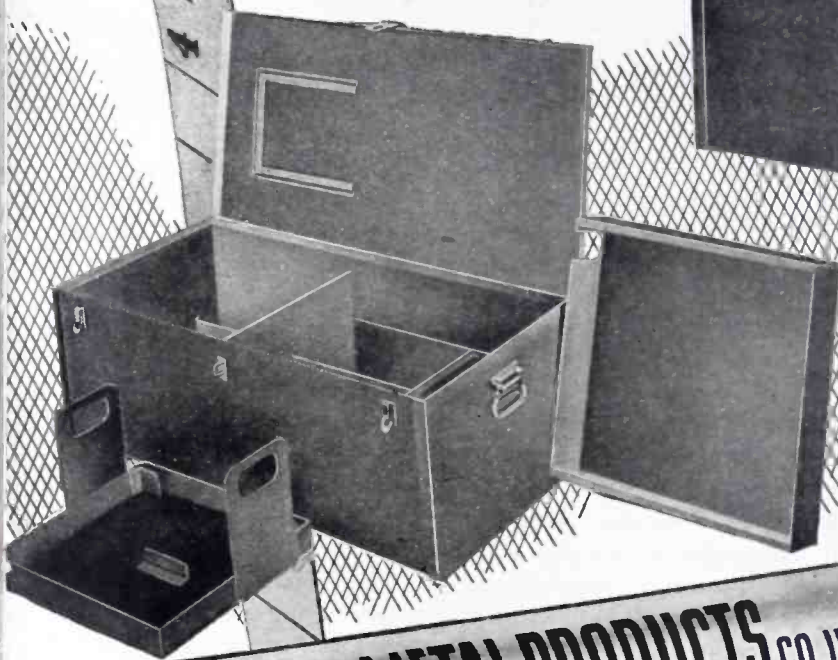
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Made-to-order at no extra cost

For the many years that sheet steel has been designated for spare parts boxes, Karp has been a major national supplier. Vast experiences, coupled with unusual production facilities, permit us to lay out and design boxes to *individual order* . . . at no extra cost. Each is built in accordance with U. S. Navy specifications. Tightly welded seams are vermin-proof. Special corrosion resisting paint is applied. Partitions, fittings, supports and trays are added as the case demands. Sizes range from 12" x 6" x 6" (and smaller where special existing conditions require) to boxes of sufficient length to house long motor shafts. *Rapid deliveries, too.*

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.



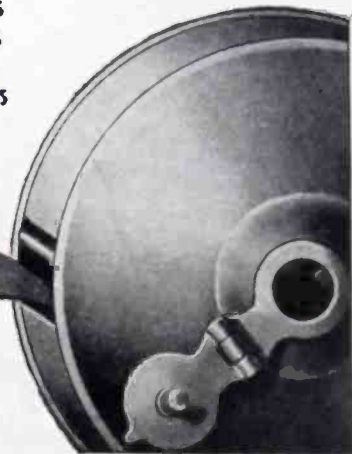
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IN
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KARP METAL PRODUCTS CO., INC.

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HELP SHORTEN THE WAR . . . BUY MORE WAR BONDS

CABINETS
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RACKS
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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 crys-

tals 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.

But research has continued and experience has grown mightily to meet the challenge of war requirements. With the return to peace, and relaxation of wartime restrictions there will be better Bliley crystals for every application as well as new Bliley crystals for the new services that loom on the horizon. That's a promise.

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



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CRYSTALS

Do more than before . . .

buy extra War Bonds

BLILEY ELECTRIC COMPANY
UNION STATION BUILDING • ERIE, PENN.

December 1944 — ELECTRONICS

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.



RAYTHEON

Raytheon Manufacturing Company
ELECTRICAL EQUIPMENT DIVISION
Waltham and Newton, Massachusetts



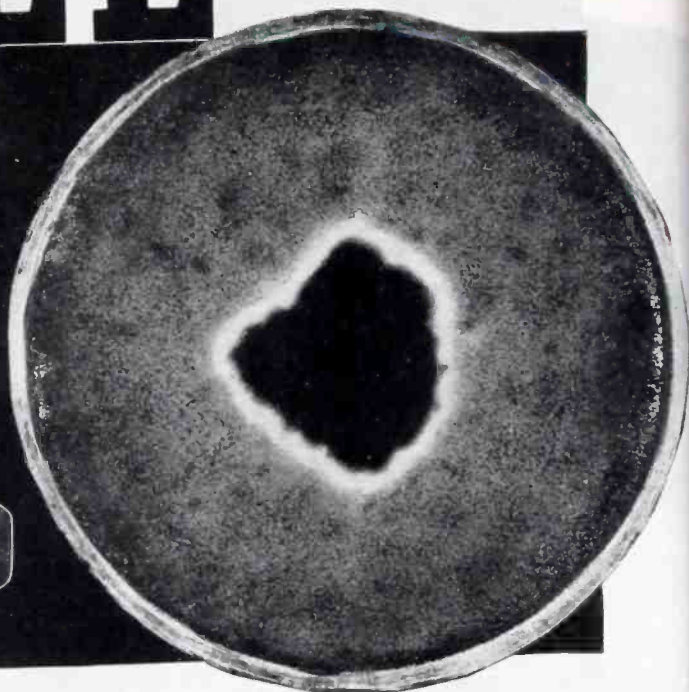
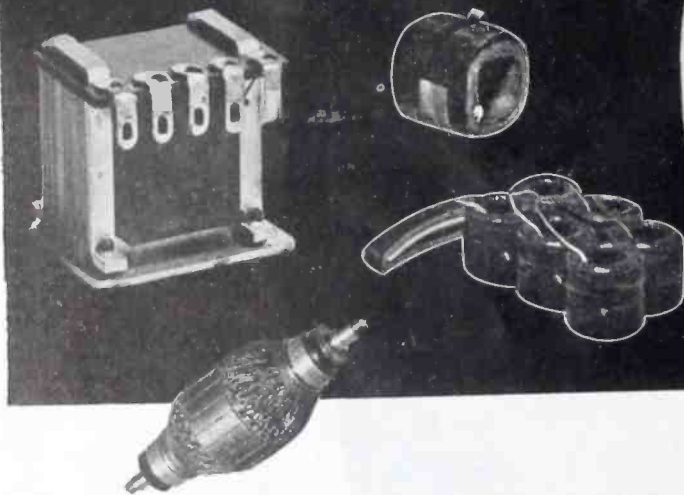
ARMY-NAVY "E" WITH STARS
Awarded All Four Divisions of Raytheon for Continued Excellence in Production

DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS

HARVEL

612-C

DOES **NOT** SUPPORT
FUNGUS GROWTH*



Photograph illustrates the fungus resistance of Harvel 612-C Clear Baking Varnish. Note that the fungus culture of chaetomium globosum has not attacked the sample film of Harvel 612-C.

Fungus Resisting Properties protect electrical equipment

Electrical equipment operating in humid atmospheres, must be protected against the constant danger of the attack of fungus growth. This growth has been known to cause failure of electrical units within a few hours under severe tropic conditions.

Guard against fungus growth! Use Harvel 612-C Baking Varnish on component parts of radios, instru-

ments, generators, motors, etc., and increase the life and usefulness of your equipment many-fold.

Where an air-drying fungus resistant varnish is desired, use Harvel 902-F. This type, like Harvel 612-C, does not support fungus growth.

Complete information and a free sample of either Harvel 612-C or Harvel 902-F varnish will be sent on request.

*Tested by the U. S. Testing Laboratories in accordance with A. S. T. M. Specification D684-42T.

IRVINGTON VARNISH & INSULATOR COMPANY

IRVINGTON 11, NEW JERSEY, U. S. A.

Plants at Irvington, N. J. & Hamilton, Ontario, Canada

Representatives in 20 principal cities

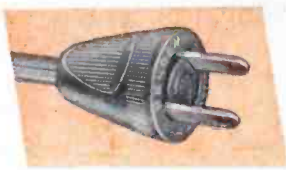


EXTRUDED PLASTIC TUBING • FIBRON PLASTIC TAPE • CARDOLITE RESINS
HARVEL & IRVINGTON INSULATING VARNISHES • VARNISHED INSULATIONS

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**A Good Motor
PLUS
A Good Cord...**



Unbreakable Plugs



Unbreakable Connectors



Unbreakable Strain Relief

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

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.

BELDEN MANUFACTURING COMPANY
4625 W. Van Buren Street, Chicago 44, Illinois

Belden
Corditis-free **CORDS**



BH NON-FRAYING FIBERGLAS SLEEVING



BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

2 WAYS BETTER

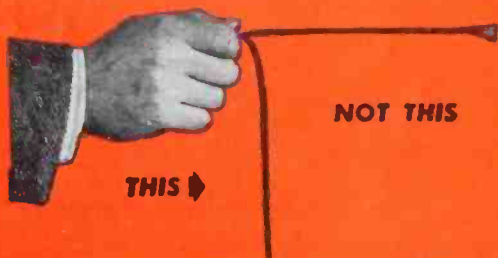


THIS



NOT THIS

NON-FRAYING



THIS

NOT THIS

NON-STIFFENING

ASSEMBLERS and electricians don't have to be contortionists when working with non-fraying BH *Extra Flexible* Fiberglass 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 Fiberglass—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* Fiberglass Sleeving is available in all standard colors. Sizes from No. 20 to $\frac{5}{8}$ ", inclusive. Write for your samples today and compare!

BH SPECIAL TREATED FIBERGLAS SLEEVING FLEXIBLE AS STRING!

Here's another high quality BH Fiberglass 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!



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

BENTLEY, HARRIS MANUFACTURING CO.

Dept. E Conshohocken, Penna.



FOUR Jensen Technical Monographs

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

MONOGRAPH No. 1: "Loud Speaker Frequency-Response Measurements." Deals with one of the most interesting and controversial subjects in the field of acoustics. Discusses, among other topics, frequency response of the human ear, the influence of environment on frequency response, the practical aspects of frequency-response measurements. Amply illustrated with charts and graphs.

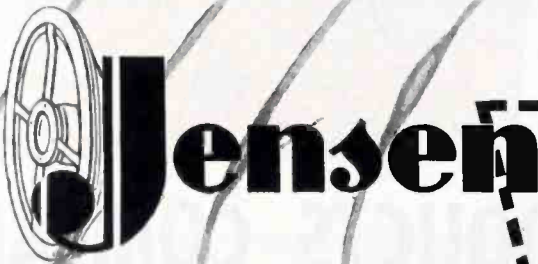
MONOGRAPH No. 2: "Impedance Matching and Power Distribution." Discusses such subjects as multiple speaker connection, volume control, design of efficient transmission lines, and conversion of volume levels to power and voltage. The text is supported by

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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Get any or all of these Monographs today from your Jensen jobber or dealer. Fill in the coupon and send with it 25c for each copy desired, or clip a dollar bill to the coupon and get all four.



FREE to men in the Armed Services, and to Colleges, Technical Schools and Libraries.

RADIO MANUFACTURING COMPANY

6607 South Laramie Avenue, Chicago 38, Illinois

Send me:

- Loud Speaker Frequency-Response Measurements
 - Impedance Matching and Power Distribution
 - Frequency Range in Music Reproduction
 - The Effective Reproduction of Speech
- (Check one or more. Send 25c for each book ordered.)

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Plastic

MOLDING SERVICE

Through years of experience, the Standard Products Co. has acquired a wealth of knowledge in the art of molding plastics. Standard offers complete molding service.

Standard's molding equipment is capable of producing items of phenolic, cellulose-acetate, butyrate, polystyrene, ethocel and other plastic and thermo-plastic materials. These facilities assure perfection in the molding job.

The Standard Products Co., with its great resources, can do your job quickly and effectively at moderate cost. Let us have the necessary data and our engineers will submit designs and proposal.



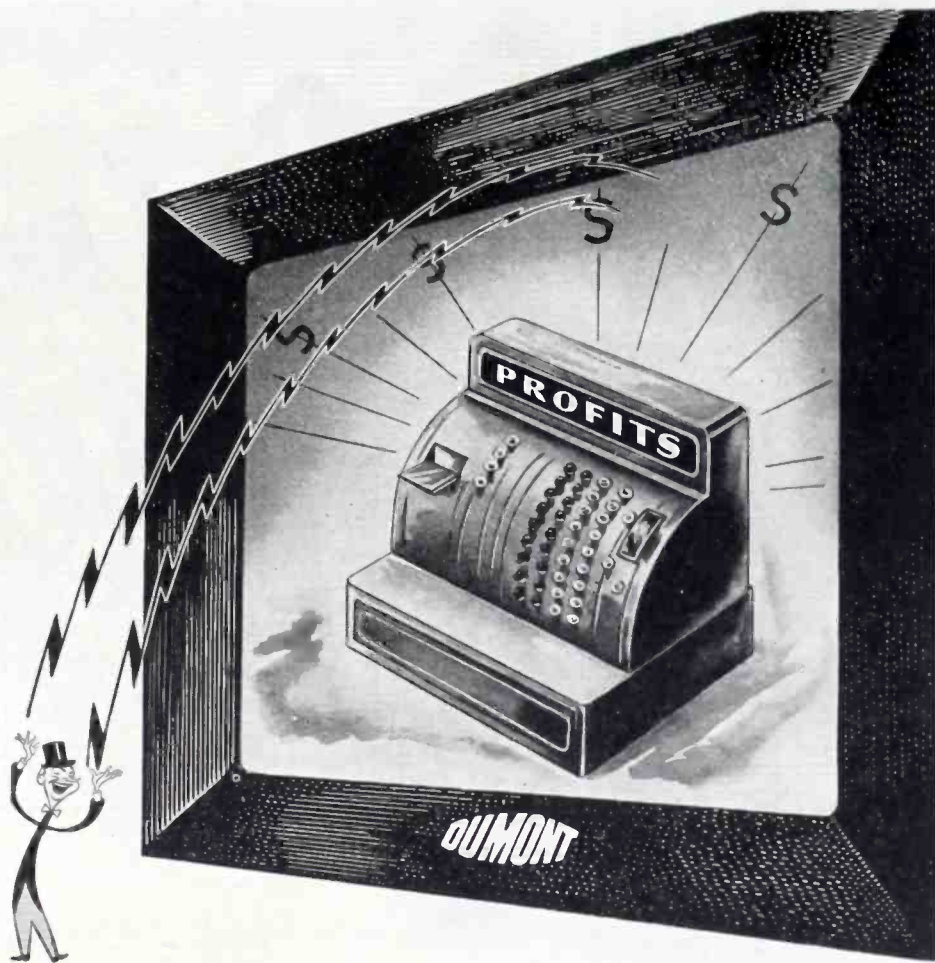
THE STANDARD PRODUCTS COMPANY

General Offices and Research Laboratory

505 Boulevard Bldg.

Woodward Ave. at E. Grand Blvd.

Detroit 2, Mich.



PROFITS Lie Where the Public's Heart Is

War, Love and Television share top honors in the talk of today. And you have the assurance of DuMont—acknowledged leader in Television—that public expectations will not be disappointed. A vast improvement over present-day video telecasting and reception waits only on the release of materials. DuMont's own contributions to this advancement are fascinating and impressive!

War halted Television expansion but not DuMont research. Just as DuMont's refinement and mass production of the cathode-ray tube (the heart of a Television set) made Television commercially possible... so has the groundwork for early postwar profits in this great new industry been laid by DuMont pioneering in low-cost station design, construction, operation and programming.

DuMont designed and custom-built 3 of the 9 Television stations providing service today. At Station WABD, New York, DuMont has kept "live talent" shows on the air steadily since 1940. DuMont collaboration with national advertisers has developed interesting and unusual commercial techniques. A complete pattern has been set for profitable station design and management... a pattern that is available to prospective station owners. NOW... is the "ground floor" era of this great new mass sales medium!

A copy of "Planning Your Television Station" is yours for the asking. This booklet outlines equipment requirements for a complete, low-cost telecast operation... and suggests plans for expediting postwar delivery of equipment and training of personnel.

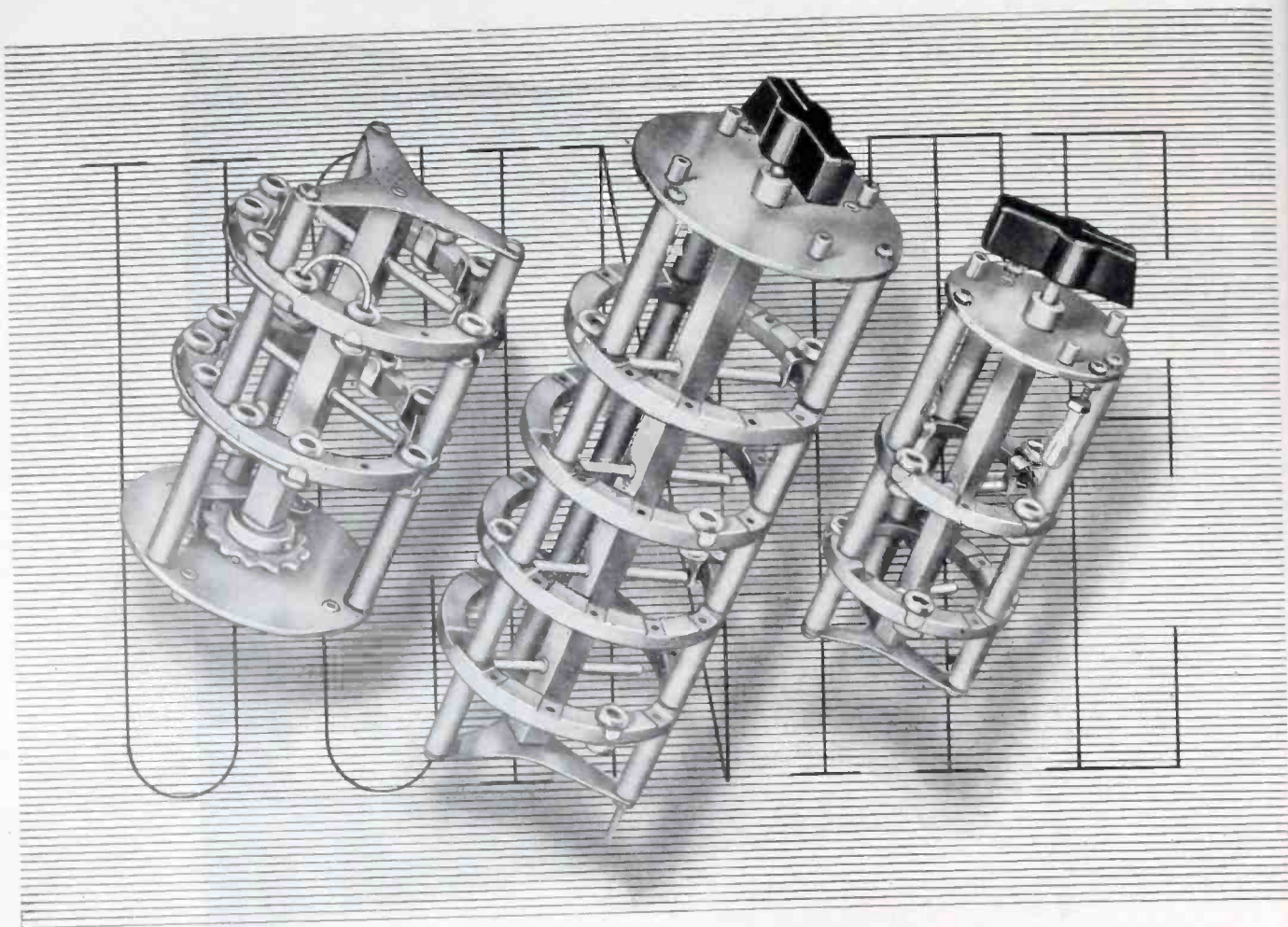
Copyright 1944, Allen B. DuMont Laboratories, Inc.

DUMONT



Precision Electronics and Television

ALLEN B. DUMONT LABORATORIES, INC., GENERAL OFFICES AND PLANT, 2 MAIN AVENUE, PASSAIC, N. J.
TELEVISION STUDIOS AND STATION WABD, 515 MADISON AVENUE, NEW YORK 22, NEW YORK



Here's Only Half of It

One of the things that made these very special switches a hard job was their size. Actually they are more than twice as big as this photograph shows them. And that meant an unusually tricky production problem in taking care of the warping and the variation in tolerances in such a large ceramic-and-metal assembly.

We specialize in combining metal parts with any and all kinds of insulating material. This order called for ceramic insulation throughout — and you know how brittle that can be. So we show them here with some pride in the skill that it took to produce them.

The UCINITE CO.

Newtonville 60, Mass.

Division of United-Carr Fastener Corp.

Specialists in RADIO & ELECTRONICS

LAMINATED BAKELITE ASSEMBLIES

CERAMIC SOCKETS • BANANA PINS &

JACKS • PLUGS • CONNECTORS • ETC.

POLICE RADIO EQUIPMENT

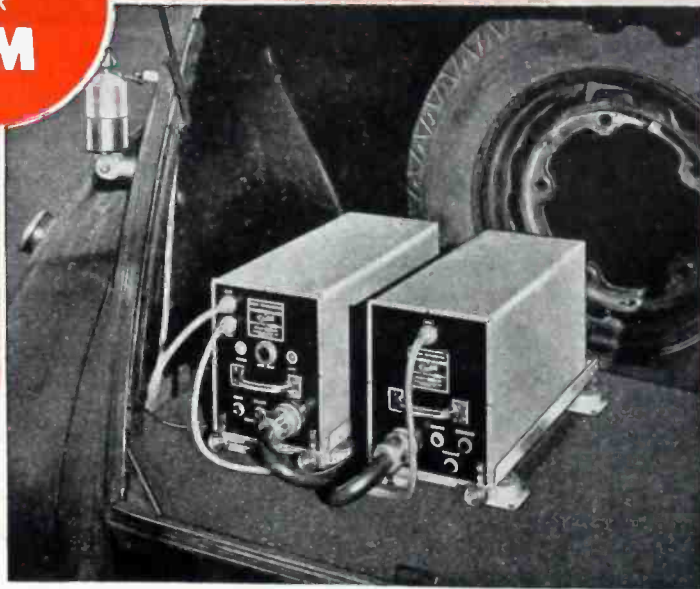
AVAILABLE NOW!

WPB has permitted us to return to our pre-war products to a limited extent. Police Radio Communication Equipment can be supplied on priority ratings.

Our Sales Department is ready to assist you in getting priority ratings. Write for Police Radio Equipment Catalog and further particulars.

by
Doolittle

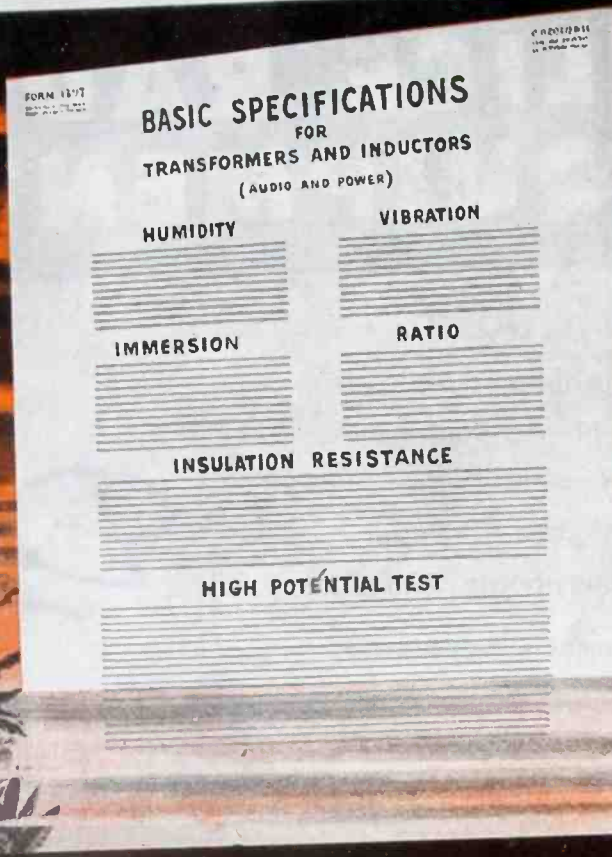
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Doolittle RADIO, INC.

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BUILDERS OF PRECISION RADIO COMMUNICATIONS EQUIPMENT



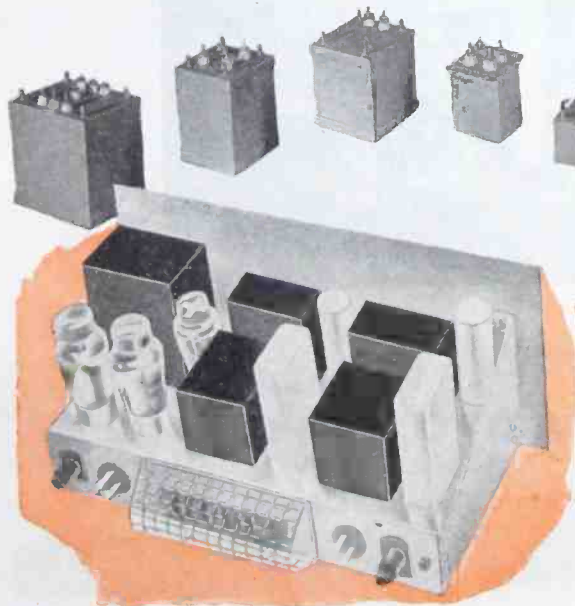
CONFORMANCE TO SPECIFICATIONS— TO THE LETTER *And the Spirit*

At AmerTran, conformance to every detail—and implication—of the most rigid Army or Navy specifications is taken literally. Routine precautions include: vacuum impregnation and slow-baking of coils; infra-red heating to insure complete filling with insulating compound; torque gauging

and resilient gaskets to protect ceramic terminals; induction heating for soldering operations to insure perfect hermetic sealing. Quality control is maintained by frequent inspections during the manufacturing process.

After the war, similar extraordinary care will be needed. Video-f.m.-a.m. and other combinations will complicate sets and circuits—emphasizing the need for perfectly coordinated components. That means rigid adherence to the letter AND THE SPIRIT of specifications—what AmerTran has been furnishing for forty-three years. Write or phone us, today.

AMERICAN TRANSFORMER CO., 178 Emmet St., Newark 5, N.J.

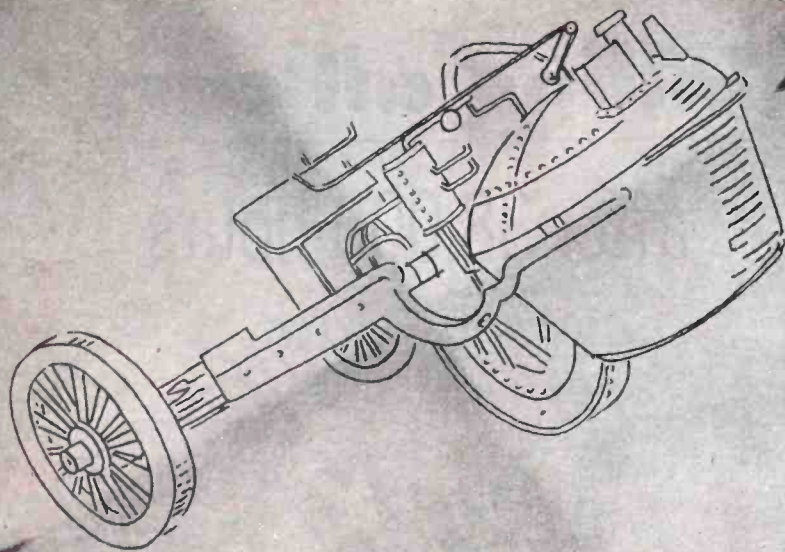


AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission





Experience Counts

That machine above was built by Nicholas Cugnot in 1769. It is the great, great, great grandfather of the modern automobile. Cugnot's machine was the original Stanley Steamer. It had a boiler in front and when it ran it might go as fast as 2½ m.p.h. That machine was a far cry from our modern car, but it was a fine idea. The reason it was not more successful was that Cugnot simply did not have enough experience.

In the manufacture of all products, Experience Counts.

The WARD PRODUCTS CORPORATION has long been a leader in the design and manufacture of antennas for automobiles and home radios. Many important design

changes, pioneered by WARD, have become accepted standards in industry. WARD products are quality products, reflecting the workmanship of craftsmen using modern equipment. . . . For the finest antennas for all automobile and home applications, look to WARD!

THE WARD PRODUCTS CORPORATION
1523 E. 45TH STREET, CLEVELAND 3, OHIO



BUY
WAR BONDS



WARD

Antennas

"Calling all cars"

after 38,000 hours



... with Callite
thoriated tungsten
filaments

Station WRAQ of the Barnstable, Mass., Police Radio System, has a pair of Heintz & Kaufman HK-54 Gammatrons still in service in the final amplifier of this station after continuous 24-hour-a-day use, for 57 months.

Callite thoriated tungsten filaments contributed to the extraordinary life of these Gammatrons by having the right proportions of thorium to give the required electronic emission, plus the rugged strength to endure long, hard service.

Makers of heavy duty tubes appreciate Callite's careful processing of tube components, the result of C-T's long expe-

rience in tungsten metallurgy. Outstanding performance is *usual*, not exceptional with Callite products. So if you are thinking in terms of electronic components, it will pay you to consult with us. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, New Jersey, Branch Offices: Chicago and Cleveland.



Callite
Tube components



"MADE BY NATIONAL SCREW"

means

Quality Control



Bench inspection.



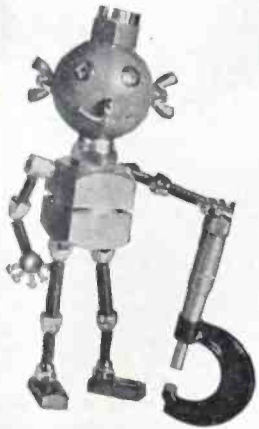
Inspection under magnifying glass.

1944 outlining procedures to be followed in establishing Quality Control Rating for the National Screw & Mfg. Company. The Air Technical Service Command is pleased to advise that Quality Control procedures at your facility are such as to warrant approval. Therefore, the National Screw & Mfg. Company has been listed on the Army Air Forces records as a Quality Control "APPROVED" facility.

As a principal source of supply for aircraft fasteners, we have developed facilities for achieving tolerances formerly unheard of in bolts, nuts and screws.

There is only one way to insure rigid adherence to the quality required by the Air Forces, with a production of millions of parts daily. That is by a system of inspection that is complete and foolproof.

The excerpt reproduced above from a recent letter of formal approval from the Air Technical Service Command indicates how well National Screw has achieved this goal.



National

HEADED AND THREADED
PRODUCTS



Checking pitch diameters with roller snap gauges.



Magnetic inspection by Magnaflux machine.

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

Thanks

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.

Come back, Mr. G. I., just as soon as your trouble-shooting is done. Radio will need you—your skill—your sureness. Radio will not forget your part in victory. Solar Manufacturing Corp., 285 Madison Ave., New York 17, N. Y.



5133

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.

★ ★ ★

The Orient—stretching in a vast semi-circle 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 count-

less 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.

★ ★ ★

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 ex-

porting 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.

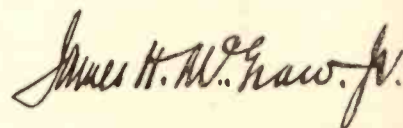
Despite changes in our technologies which will probably reduce our future takings of such important items as rubber and silk, the achievement of a high level of economic activity in this country after the war will provide a basis for increasing our Eastern imports, but only if it is an accepted part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

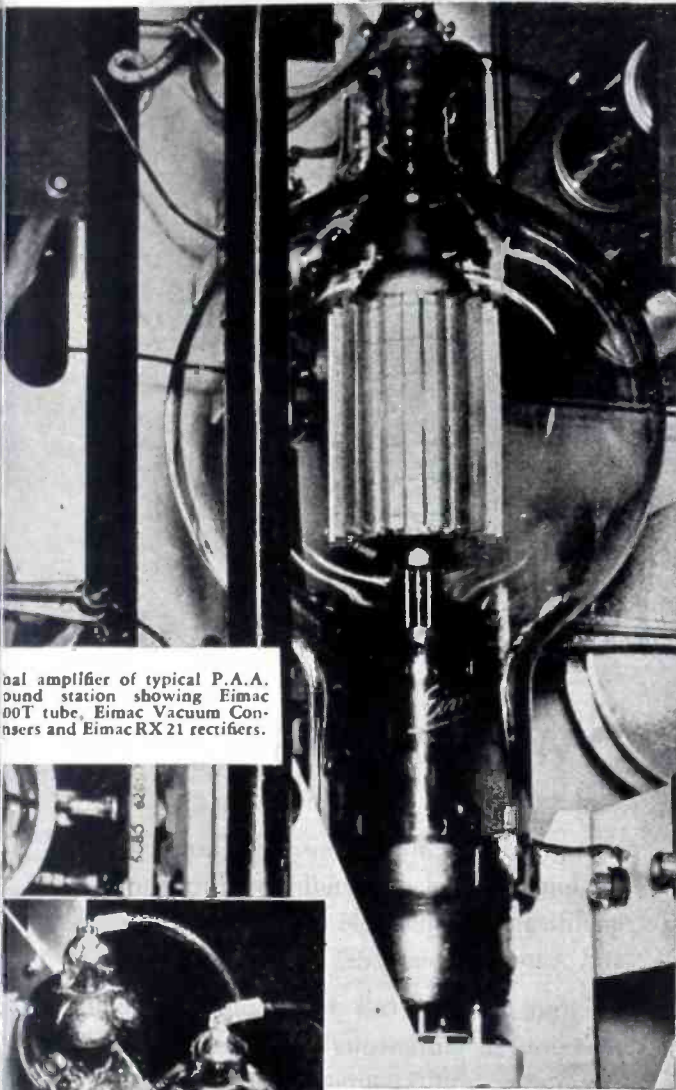


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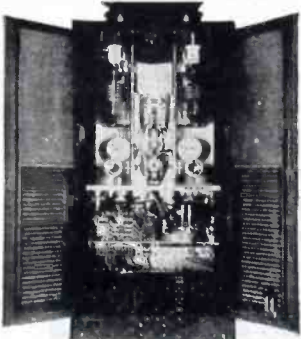
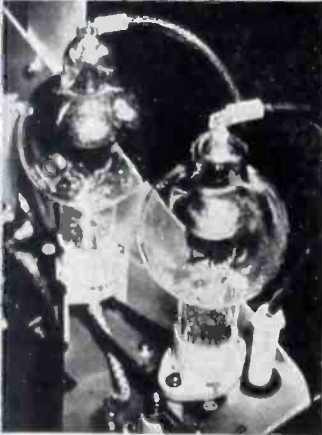
PAN AMERICAN USES EIMAC TUBES



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.



Ground amplifier of typical P.A.A. ground station showing Eimac 60T tube, Eimac Vacuum Condensers and Eimac RX 21 rectifiers.



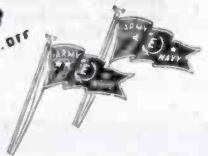
Pan American Airways and all its associated and affiliated companies, which comprise the P. A. A. World System, have been using Eimac tubes in the key sockets of all ground stations for a number of years.

Because of the extensive operations of Pan American World Airways, these tubes have been subjected to about every test possible — altitudes; ground level; extremely cold climates and high temperatures found at the equator; conditions of high and low humidity; and in some instances, when new bases are being built, perhaps somewhat trying power conditions. The high regard which P. A. A. engineers have for Eimac tubes is clearly evidenced by their continued and more extensive use, as the years roll by.

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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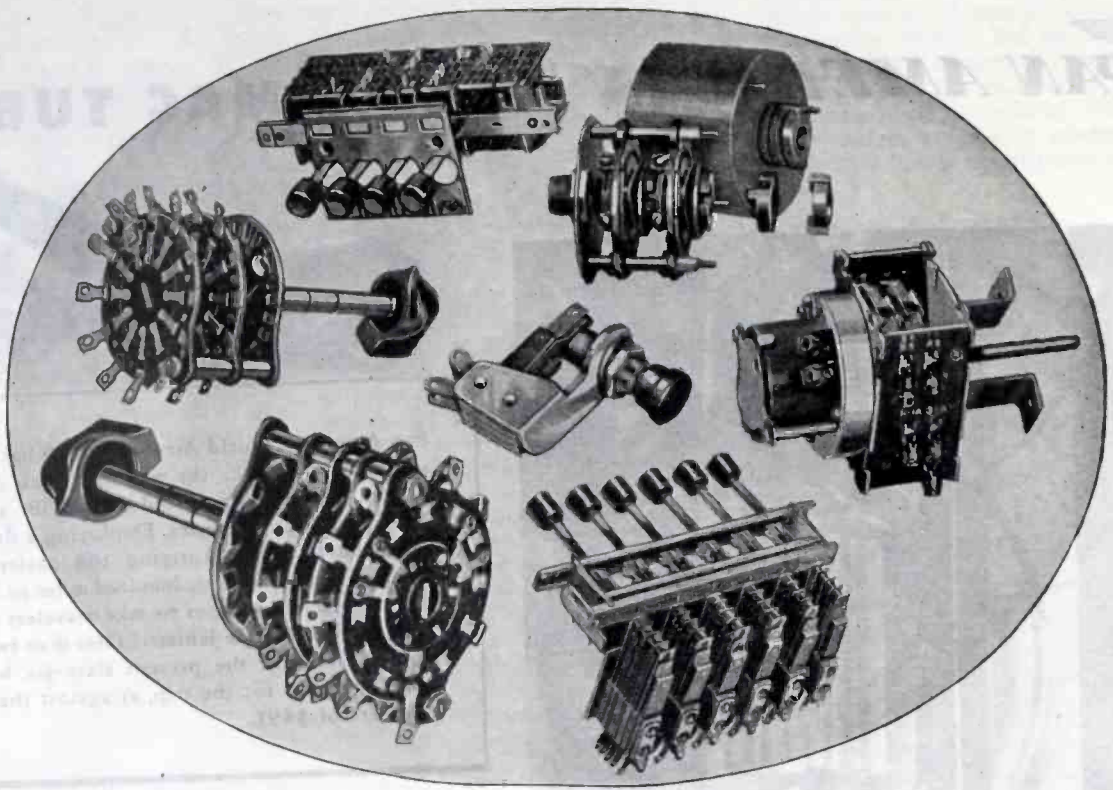


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CROSS TALK

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

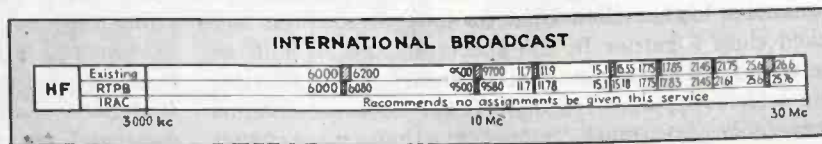


FIG. 2—International broadcasting would be continued on approximately the pre-war basis by the RTPB. The IRAC would drop it entirely insofar as direct reception by the radio audience is concerned, substituting spot-frequency relaying and re-broadcasting by standard broadcast stations

ALLOCATION HEARING

ur national security regulations.

Dr. Baker further stated that an important aspect of the RTPB's work was to obtain agreement on frequencies and standards for such services as would provide maximum employment after the war. He said that Panels reporting on two of the most important post-war services, frequency modulation and television, had agreed upon standards and had resolved all conflicts on frequency allocations. Finally, he pointed out that many new services, not originally included in allocation discussions, now had to be considered. Among these were industrial and scientific oscillators not used for communication purposes, relay systems, and new types of mobile radio communication equipment for buses, railroads, taxicabs and even the private citizen.

Then followed reports from the chairmen of two RTPB Panels having a broad outlook on the whole spectrum, Panel 1 on Spectrum Utilization, and Panel 2 on Frequency Allocation. The major exhibit of these two panels was a chart of the spectrum showing the present allocations under FCC rules, and the RTPB proposals in each class of service. The "chart" is so voluminous that it takes 30 sheets, each 10 by 30 inches, to cover the range. The illustrations accompanying this report represent a summary of the more important services, and include also the allocations proposed by the IRAC and ARRL.

Following this presentation, testimony was taken by the FCC on all phases of the art. The first week was devoted to general communications services, including amateur and international broadcast. The second week was given over to broadcasting in its various forms; standard, FM, television, facsimile, and educational. Portable and mobile units used by

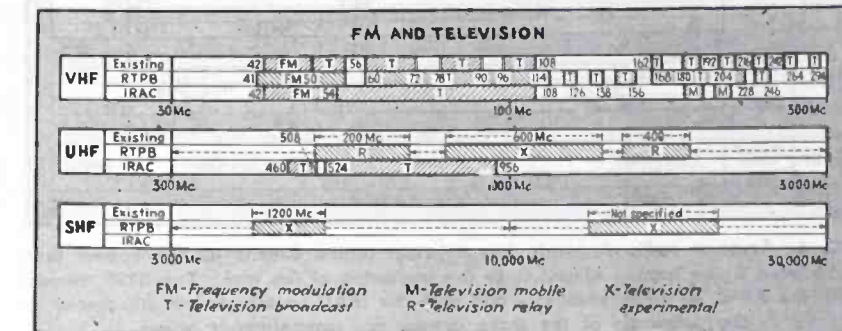


FIG. 3—FM and television frequency assignment clashes between RTPB Panels were compromised and solved before the FCC Hearings took place. Some differences, however, remained between RTPB and IRAC proposals

police and other similar services, as well as by public utilities, were discussed in the third week. The fourth week covered industrial, medical and scientific sources of interference and services intended to relay public and private communications.

Finally, the chairman of RTPB Panel 2 again appeared and made recommendations based on all the evidence presented. Similar recommendations from all other interested parties were invited, and the Commission then rested from its labors and retired to peruse the record in the quiet of its chambers. From such contemplation will come, and it is believed in the not-too-distant future, a binding allocation of the spectrum to govern the industry 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 importance 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 equipment 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 frequency 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 channel) but it is argued that modern equipment provides plenty of selectivity 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 already in use in Canada. Some evidence was brought forth purporting to show that interference was occasionally experienced from auto-alarm SOS devices on this frequency.)

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 broadcasting station. Thus some 10,000,000 of our people can enjoy radio only at night, and then often only under adverse conditions. The RTPB proposes to ease this situation by set-

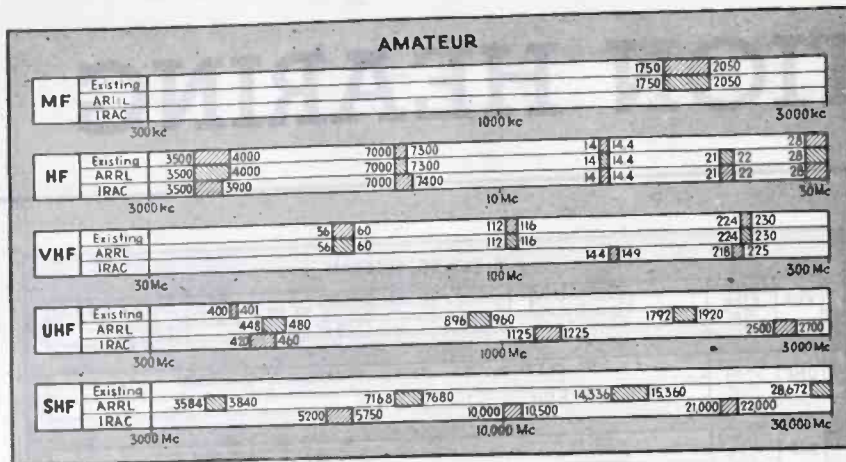


FIG. 4—Amateur radio obviously has a bright future, despite all the rumors that have been flying around almost since the beginning of the war. The RTPB agrees with the ARRL on some proposals and with the IRAC on others, but differences in the proposals of the three groups are comparatively minor

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 Janu-

ary 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

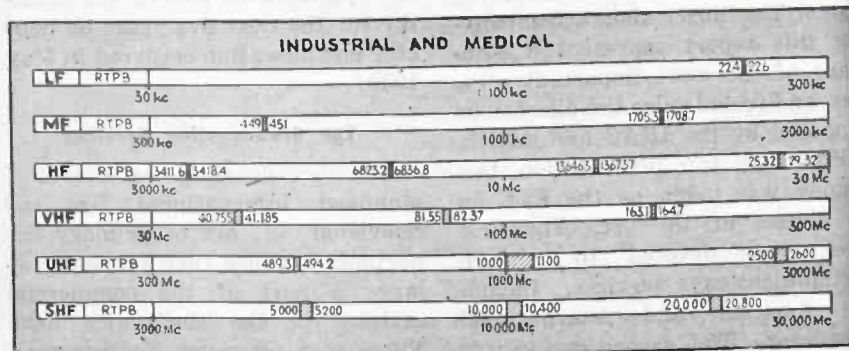


FIG. 5—Industrial and medical equipment radiating radio interference should, thinks the RTPB, be assigned specific frequencies. There is some question as to whether the Communications Act covers such gear, and obviously many clashes exist between the allocations suggested in this chart and other services

permitted in the width of channels allocated, since such reduction would impair the quality of the service and would also remove the possibility of multiplexing facsimile in the same channel. He also argued against limiting the power of f-m outlets.

Paul Kesten, vice president of CBS, urged that practically unlimited competition be permitted on the f-m bands, with each outlet covering a single market area. This, he said, would mean larger networks, more extensive rural coverage, and general benefit to all radio listeners. The plan would mean limiting the power of stations. Mr. Kesten believes that a total of 4000 to 5000 f-m stations could be supported in 10 national networks. He said CBS engineers were not certain as to the best region of the spectrum for f-m but said they hoped the present region was the best habitat of the service.

Questions asked by the Commissioners and the FCC engineering staff indicated that there was much doubt in official quarters that the present f-m band was the best for the service. These doubts have apparently arisen from measurements made by the FCC on long-distance interference effects in the region from 40 to 100 Mc. Dr. L. P. Wheeler of the Commission's engineering staff presented a report on these measurements which indicates the extent of tropospheric and "burst" interference, sporadic E, and F₂ layer reflections from February 1943 to the present date over distances of from 100 to 1400 miles. Sporadic E-layer propagation was prevalent in the summer months, producing field strengths in excess of 25 microvolts-per-meter at 2 percent of the time in July 1944, at 900 miles on 44.3 Mc. In the winter, on the other hand, such fields occurred less than one percent of the time. Such interference would not, of course, be troublesome in the vicinity of the desired station, but would cut into the outer limits of the coverage area, where field strengths are low. The burst-type of interference was, incidentally, definitely correlated with meteorite tracks by direct visual observation, during these tests.

Dr. K. A. Norton, formerly with the FCC and now serving as a civilian consultant to the Army, appeared for the FCC to reveal similar 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 reflections, present at the longer distances, can cause interference for several percent of the total time during sun-spot maxima, at frequencies lower than 60 Mc, and for

fact that the most serious interference 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 effects 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 transmitters. 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-

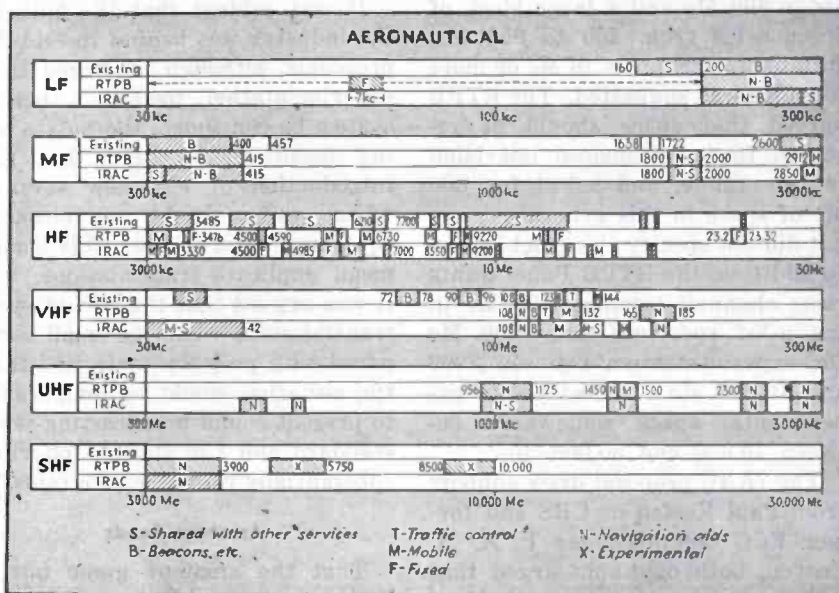


FIG. 6—Aeronautical progress in the post-war years will undoubtedly be rapid. So, spectrum-wise, proposed allocations are just about as broad as they come, with the basis for compromise evident when RTPB and IRAC proposals are compared

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 potentialities. This evidence has some bearing on television assignments as well, although television assignments are higher in frequency, because the picture transmission uses amplitude modulation which is more susceptible to interference than f-m transmissions.

Major Armstrong questioned Dr. Norton concerning these measurements, particularly in view of the

port has been discussed at length in these pages (ELECTRONICS, August, p. 92), recommended that the present television standards be changed only in one major respect, a reduction of the maximum frequency deviation of the associated f-m sound signal. Again the discussion hinged on the extent of the television band and its position in the spectrum (Fig. 3).

Panel 6 requested nine commercial 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-

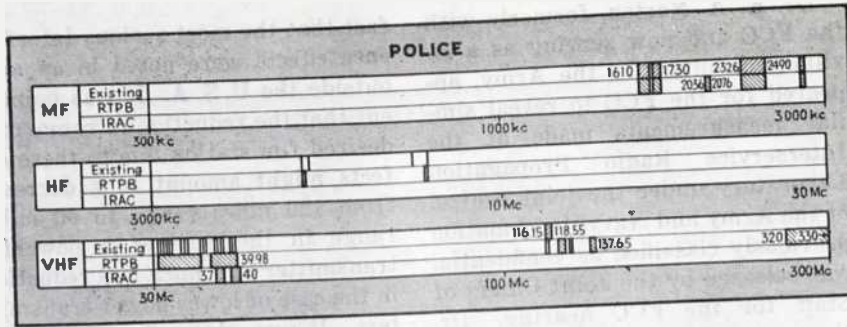


FIG. 7—Police channel assignments represent a bone of contention between IRAC and RTPB. The former would confine all such service to a narrow v-h-f band, the latter would continue existing m-f and h-f bands and open up the v-h-f too

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 qual-

ity 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-

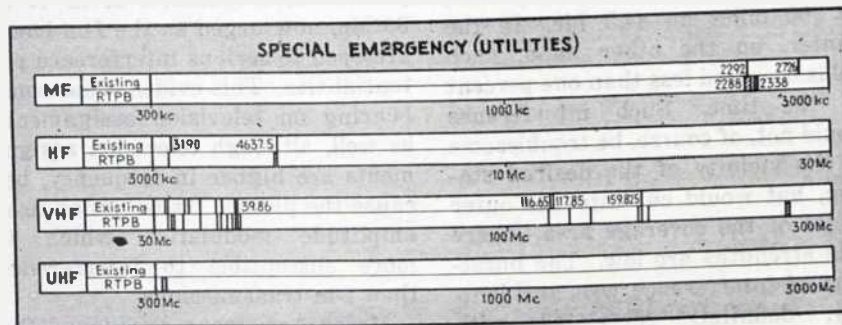


FIG. 8—Special emergency services such as those used by public utilities will gain a few frequencies, but nothing radical in this direction

Unfortunately, interference created by such devices covers the whole spectrum, and certain specific frequencies are needed for efficient equipment operation. For example, a wide band from 25 to 30 Mc is required for self-excited oscillators of the diathermy type.

Since none of the services included in this category is a radio service per se, there remains a legal question as to whether the Communications Act covers them. That the idea of considering allocation is a good one cannot be doubted, but the conflict of the proposed allocation with other services is only too evident.

Aeronautical Channels

In aviation, the radio business meets a partner whose post-war prospects are very similar to its own, that is, much down from war-time levels but much up from pre-war levels.

To meet the needs of the expanding air services, Panel 11 of the RTPB proposed the scheme shown in Fig. 6. Spectrum-wise, this allocation is just about as broad as they can get, extending from below 200 kc to 10,000 Mc. It would permit an airplane to be entirely filled with radio equipment to the exclusion of passengers.

Specifically, RTPB and IRAC agree that the radio-range beacon band from 200 to 400 kc be continued and extended to 415 kc. They both agree that the band from 1800 to 2000 kc, lately the province of the amateurs, should be reserved for a new navigation device. The region from 3000 kc to 30 Mc, now thoroughly populated with air-to-ground and fixed point-to-point air service, is continued, with more space reserved exclusively for aviation.

IRAC asks for space from 30 to 102 Mc, but RTPB has other plans for this (police and similar services). IRAC and RTPB Panel 11 agree that the region from 108 to 32 Mc now widely used for airport control should be continued. Here, however, a conflict exists with the RTPB television plan.

Between 956 and 3900 Mc the IRAC and RTPB have got together,

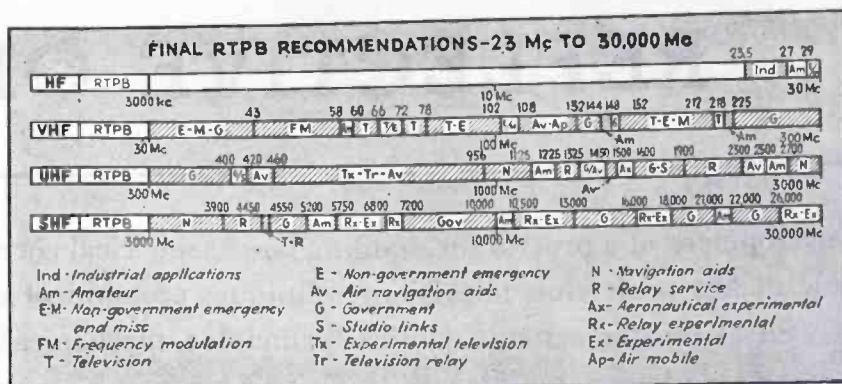


FIG. 9—Final RTPB recommendations relative to assignment of frequencies between 23 and 30,000 Mc, representing a compromise on certain conflicting proposals presented earlier, concluded the FCC Hearing

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 plastic now makes projection television techniques economical and practical for home receivers as well as theater systems. Optical principles, mechanical mounting problems, design of correcting lenses, molding methods and a receiver console arrangement are presented

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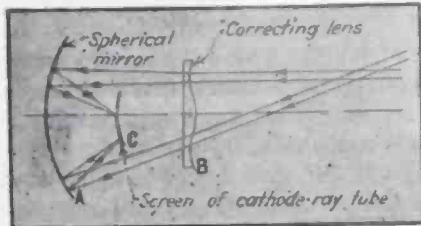
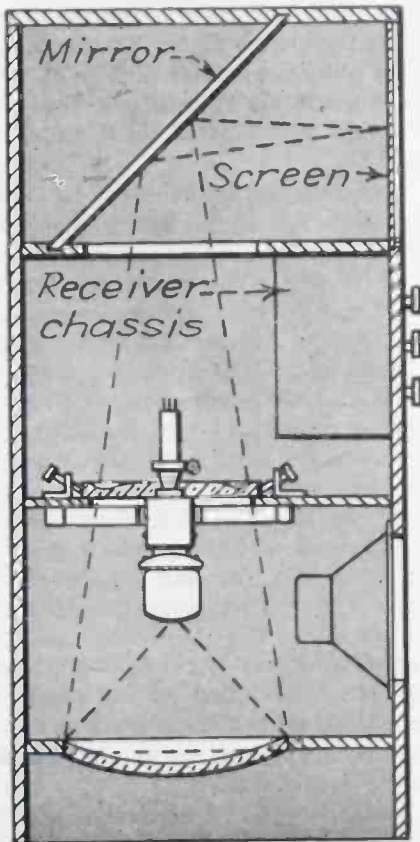


FIG. 1—Optical system of the so-called Schmidt astronomical camera, adapted by RCA for use in projection television systems



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 making aspherical molds and by development of a process for molding aspherical lenses from plastics. RCA reflective optical systems are designed for a fixed image distance and require cathode-ray tubes having face-curvatures fixed in relation 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 small price to pay for the manifold gain in light. The design, manufacturing, installation and servicing of the RCA reflective optical systems have been improved and simplified to such a point that these systems can be considered as proven tools in television and oscillography techniques. Reflective systems designed for infinite throw have been already applied successfully to television outdoor pickup cameras with the same manifold gain in light.

Analysis of the Problem

The problem of projecting images originating on the screens of cathode-ray tubes has received a great deal of attention from investigators here and abroad over a period of years. It has been shown that the space distribution of light emitted by the screen of a cathode-ray tube follows very closely the cosine or Lambert law of perfectly diffusing surfaces. When a lens

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

PROJECTION TELEVISION

uch as the conventional motion-picture projection lens is used to project a cathode-ray tube image onto a viewing screen, the overall efficiency of such a system is extremely low.

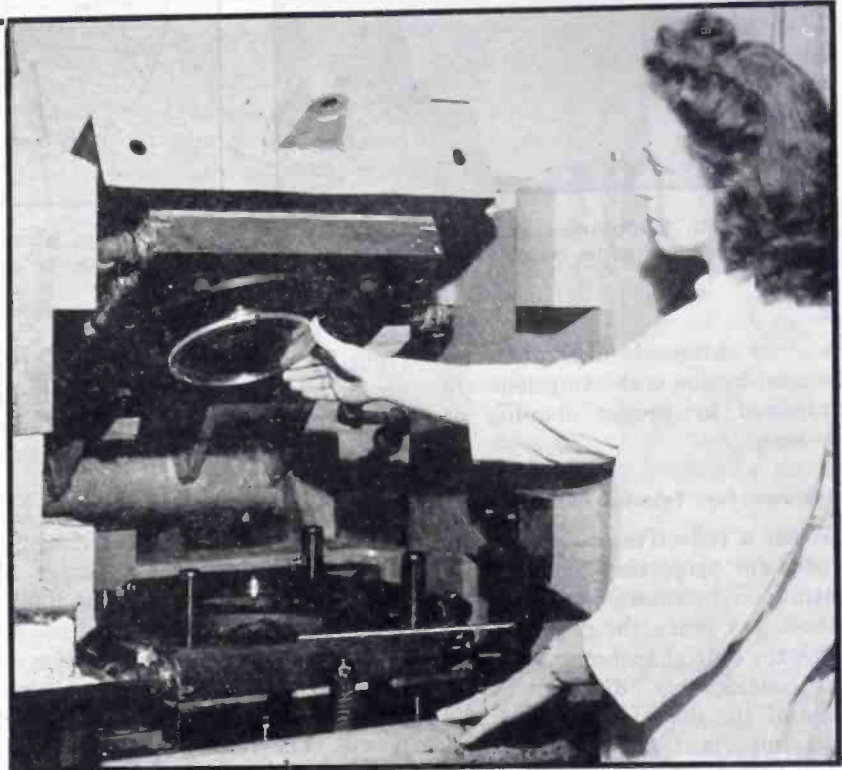
In motion-picture projection most of the light striking the film is delivered to the viewing screen, except of course for the light absorbed by the darkened portions of the film, thus creating the picture itself. However, when projecting light from a perfectly diffusing surface onto a viewing screen by means of the same lens, much of the light is lost. For large magnifications the following relation holds:

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

where K is the transmission coefficient of the lens and f is the f /number of the lens. Good, commercially available, treated projection lenses having a relative aperture of $\sqrt{2}$ and a transmission coefficient of nearly 100 percent, collect from the tube and deliver at large magnification to the viewing screen only 6.25 percent of the light generated.⁶

The image on the face of the cathode-ray tube is obtained at a relatively high cost in equipment, effort and power. Any increase in the brightness of this image may be obtained only at great cost from the standpoint of design and operation. For this reason, the problem of providing a more efficient optical projection system has received a great deal of attention. Improvement 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 principle known to astronomers and adapting it to the problem on hand.

For quite a long time, "astronomers



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

ers 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. Schmidt⁶ 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 aberration, 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-

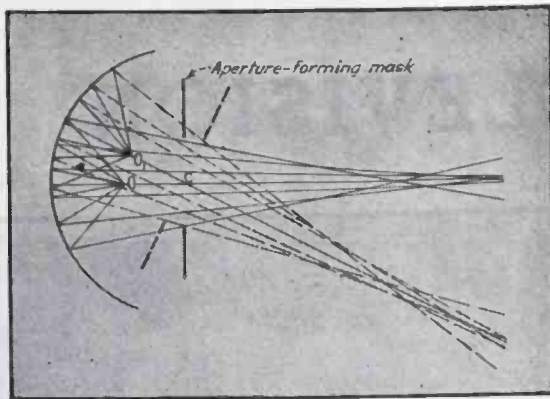


FIG. 2—Spherical mirror with an aperture at its center of curvature

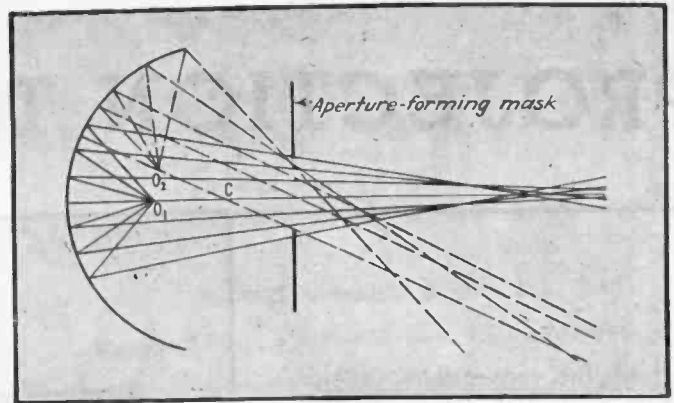


FIG. 3—Spherical mirror with an aperture that is not at the center of curvature

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 mak-

ing 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 foci

length of the correcting lens is infinite and the shape of the curve is concave. Alternatively, if a zonal focal length of the mirror is chosen as that of the system there will be a zonal focal length of the correcting lens which is infinite and the shape of the curve is convex at the center and concave past this zone. If a peripheral focal length is chosen, the required correcting lens is convex. The maximum slope is least for a convex-flat-concave curve.

The shape and size of the correcting lens depend upon the throw or magnification for which the system is to be used. For a given focal length and relative aperture, the correcting lens aperture decreases as the magnification decreases. That this must be so, may be surmised from the fact that for unity magnification the plate aperture is zero, since object and image coincide at the center of curvature.

Figure 4 shows the variation of correcting lens aperture and mirror aperture with magnification. Thus, for different correcting lens is required for each throw or magnification. If a high relative aperture astronomical Schmidt camera is used for projection at a throw only a few times the focal length, the resulting image is of poor quality. The reason is that a high relative aperture optical system can be well-corrected for only one position of object and image. The throw or magnification tolerance for a given correcting lens decreases with increased relative aperture for a given resolution.

To obtain a flat image field, i.e., focus on a flat viewing screen, it is necessary that the object field or tube face be curved. Calculations show that in general the shape of tube face depends on the throw—a sphere for infinite throw and an ellipsoid for finite throw. The eccentricity of the ellipsoid is sufficiently small, however, so that even for finite throw the tube face may be made spherical with a radius of curvature equal to that of the focal length of the system.

Design of Correcting Lens

The shape of the correcting lens must be such that all rays emanating from an object point O , and reflected 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 of 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

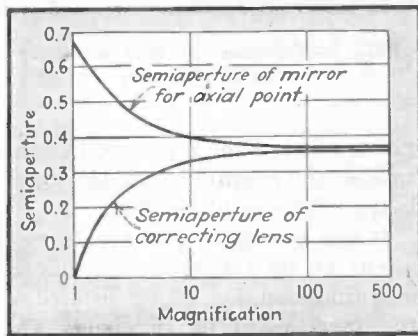


FIG. 4—Manner in which the semiapertures of the mirror and correcting lens vary with magnification

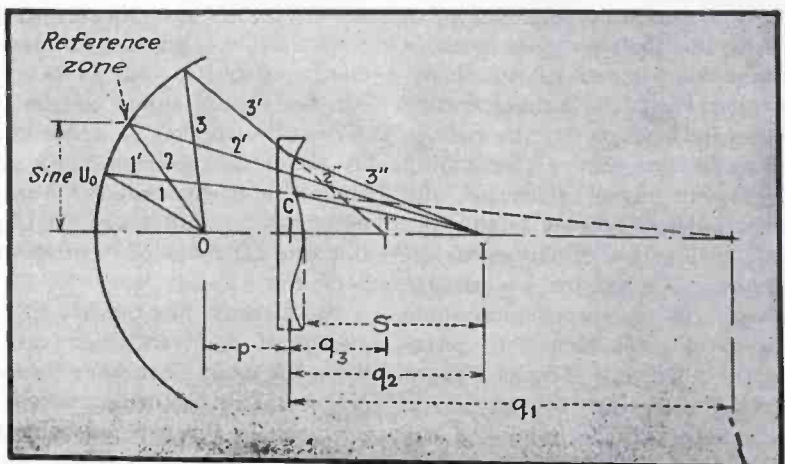


FIG. 5—Diagram illustrating how a suitably designed correcting lens makes the required corrections for spherical aberration

calculated to about the same accuracy as that obtained with the equation given by Hendrix and Christie⁷ for infinite throw, from the formula

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

or from its equivalent

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

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

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

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

$$S = f(m-1) \quad (5)$$

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

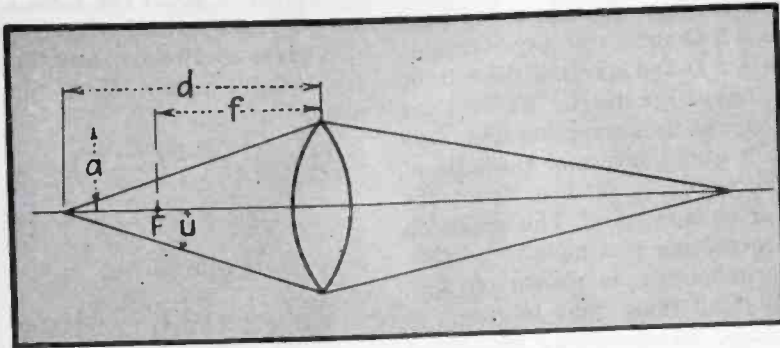


FIG. 6—Efficiency of a simple lens decreases as the lens is moved away from its source to decrease the magnification

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 diffusing 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

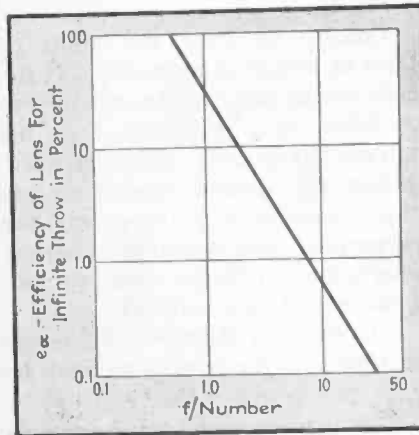


FIG. 7—Variation of lens efficiency with its f /number

given lens is from a source, i.e., the smaller the magnification, the lower is the efficiency of the lens.

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_0 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

$$e = (e_0 - e_1) 100\%$$

Here e_0 and e_1 (fractions, not percent) may be calculated approximately from the equations

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

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

where h_c is the semiaperture of the correcting lens and h is half the diameter of the tube face. For high-efficiency systems e_0 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

correcting 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 $0.01 R$, 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 receiver⁶ 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 degrees 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.⁷ 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

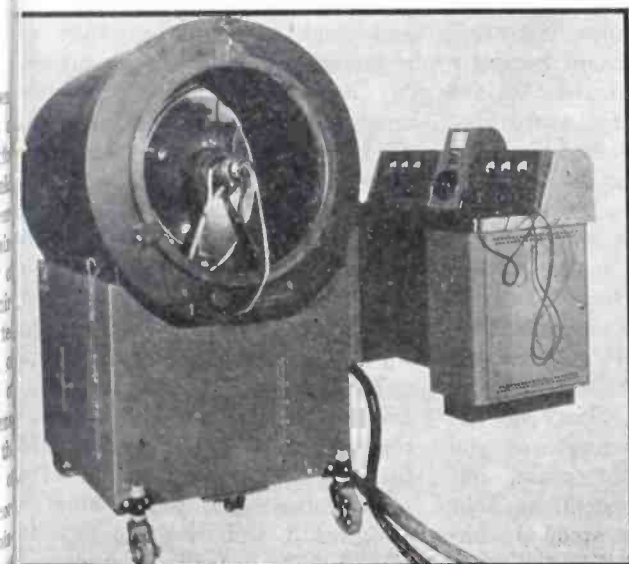


FIG. 8—RCA theater television projector, with control console in background

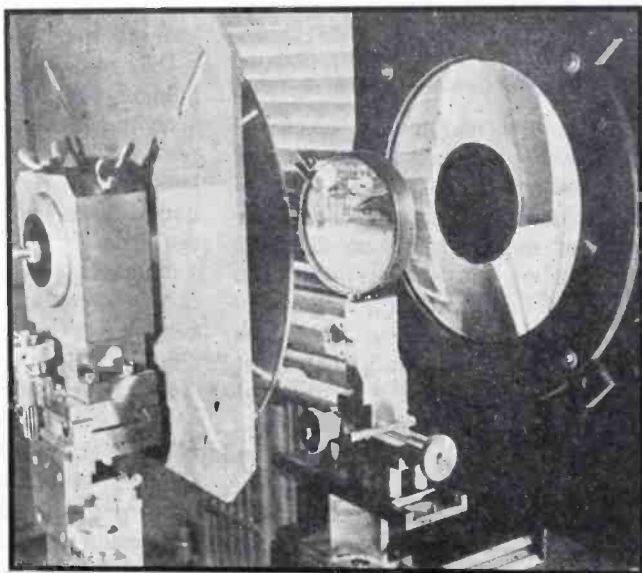


FIG. 9—Image of Philadelphia skyline as formed on the face of a dummy tube by a reflective optical system

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 curvimeter, and final adjustments of the curve are done by fine grinding and pol-

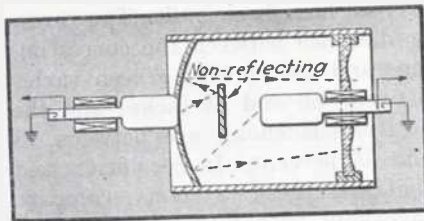


FIG. 10—Bi-reflective optical system, employing two projection television cathode-ray tubes

ishing 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 perseverance.

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, involv-

ing 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 Micalax 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.

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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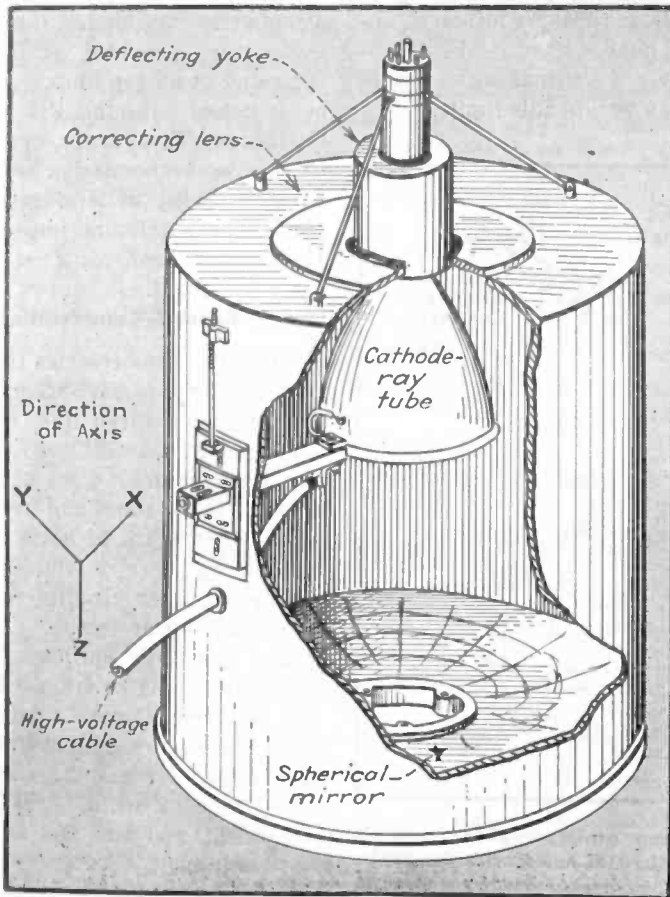


FIG. 11—Method of mounting optical components of a projection television system to give rigidity while permitting adjustments when required

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.

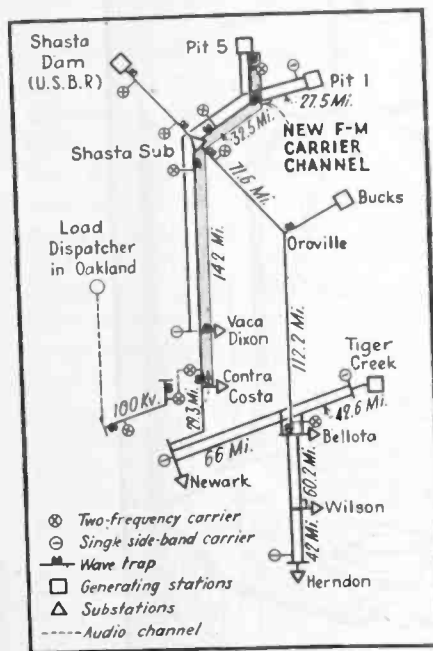
When it became necessary to provide additional communication facilities from the dispatching office to Pit 5 and the government's Shasta Dam plant which now feeds into the PG&E system, consideration was given to the three types of carrier thus far developed, namely the single side-band and double side-band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

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.



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

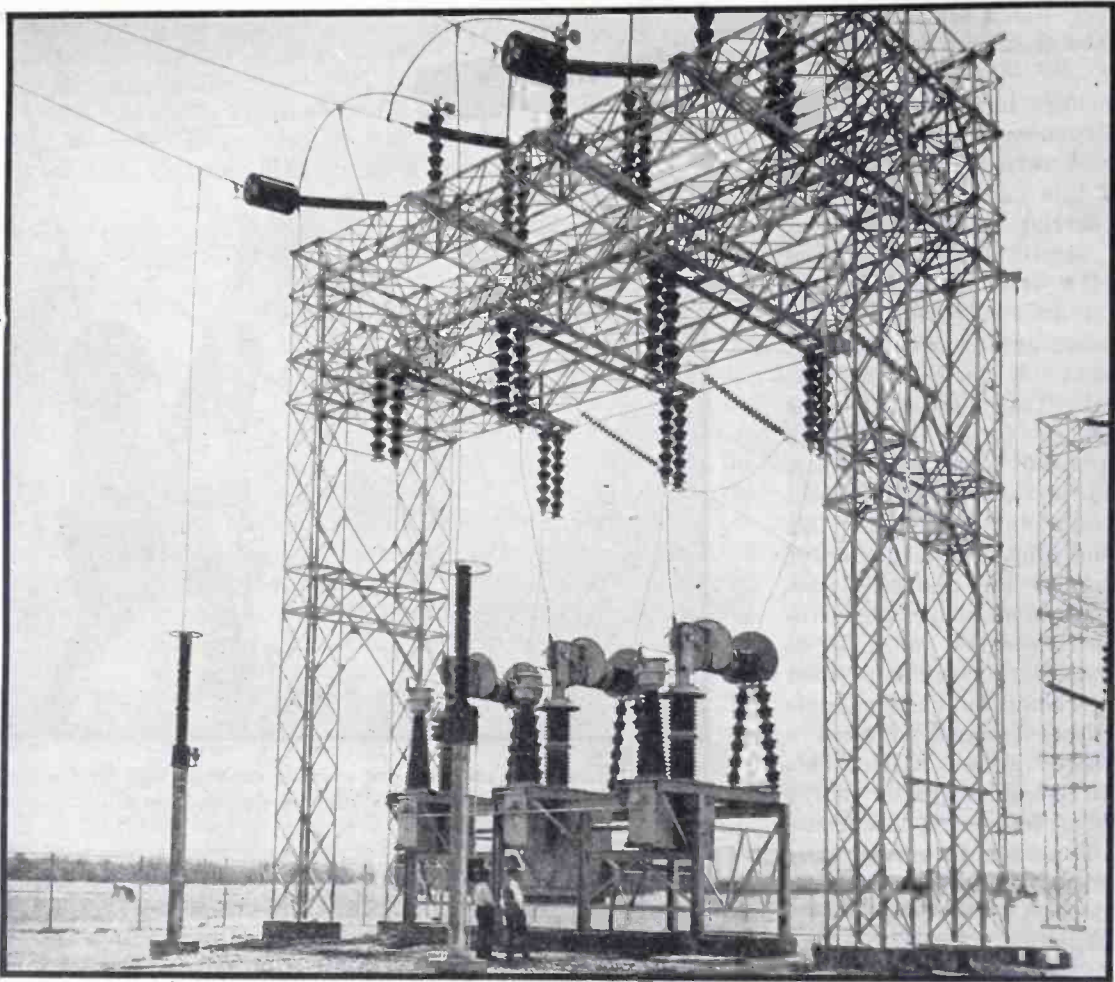
Channel Considerations

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 modulation



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

on met both the bandwidth and the trap requirements. With the low carrier frequency, however, this deviation gives a frequency shift that is a larger percentage of the carrier frequency than is used in present f-m broadcast practice. Thus, a 3000-cycle shift is 6 percent of a 50-kc power line carrier, whereas the standard 75-kc shift of a broadcast transmitter at 10 Mc is only 0.2 percent. The 6 percent shift gives readily attainable bandwidth requirements for the receiver and coupling apparatus, along with a high degree of modulation.

A picture of what a one-to-one deviation ratio produces in the way of side bands can be obtained by conventional mathematical analysis. For a modulating frequency of 1000 cycles, this shows that most of the side bands are confined to a bandwidth of ± 3000 cycles. Of course, 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 modula-

tion 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 pri-

mary function of a service is to get intelligence from one point to another.

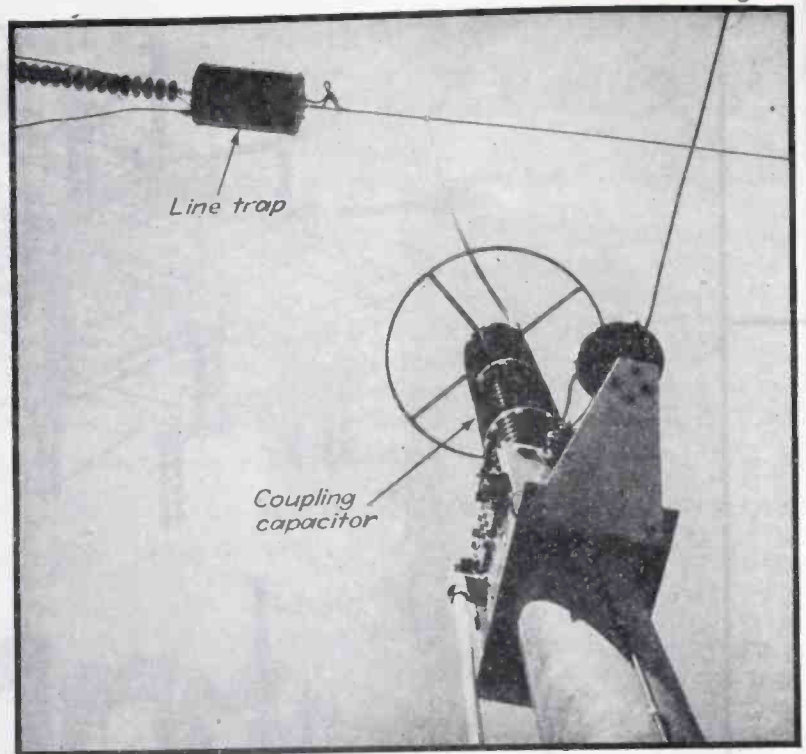
Power lines have a fairly high level of random noise, caused by corona and various types of arcs. Noise of this nature added to the desired carrier causes a complex type of amplitude variation and phase shift. It is possible for the limiter in an f-m receiver to remove the amplitude modulation, but it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

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 de-



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

crease 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 a-m receiver is analogous to a fast and flat type of automatic volume control. The AVC system used in a-m receivers is comparatively lower and is not so flat. A flat AVC action is advantageous in two-frequency duplex, where one frequency is used to transmit in one direction and the other frequency is for the other direction. The transmitter and receiver audio circuits must then connect to a hybrid circuit and can be set closer to a critical point if the audio output of the receiver is quite constant. Since the limiter in an f-m receiver can hold the output extremely constant, a two-frequency voice 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.

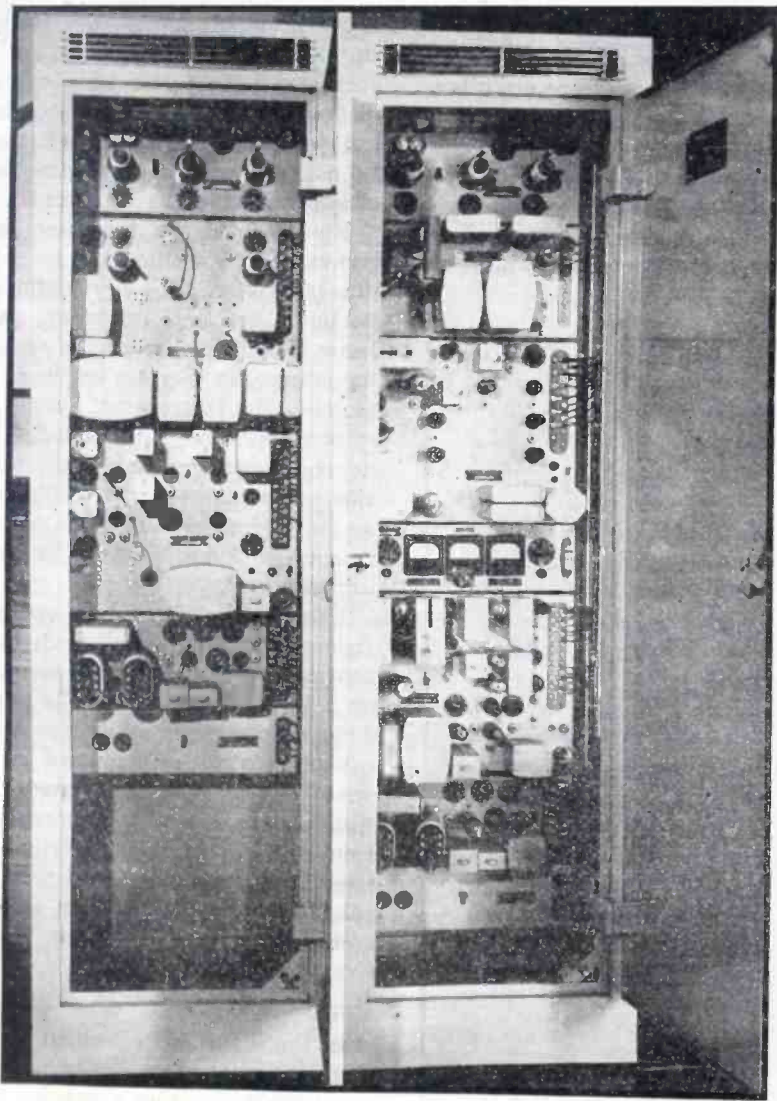
Two broadcast f-m stations operating on the same carrier frequency have considerably more interference-free operating area than two a-m broadcast stations on the same frequency. This holds true for f-m power line carrier systems also, though to a lesser degree since the deviation ratio is one-to-one 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.

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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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.

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 $10 \mu\mu\text{f}$. A $0.01 \mu\text{f}$, 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

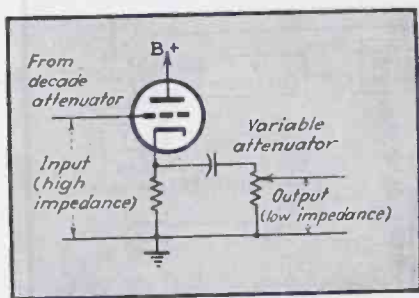


FIG. 2—Cathode-follower circuit acts as an impedance transformer between the high-impedance decade attenuator and the low-impedance continuously variable attenuator

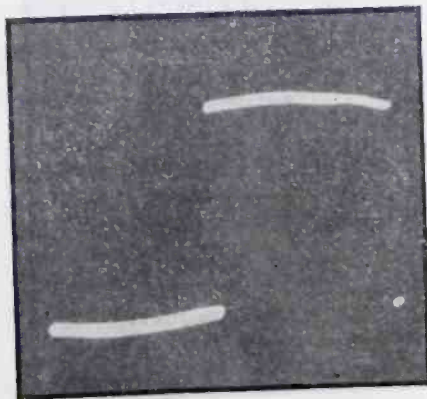


FIG. 3—A 30-cps square wave, as reproduced by the vertical axis amplifier

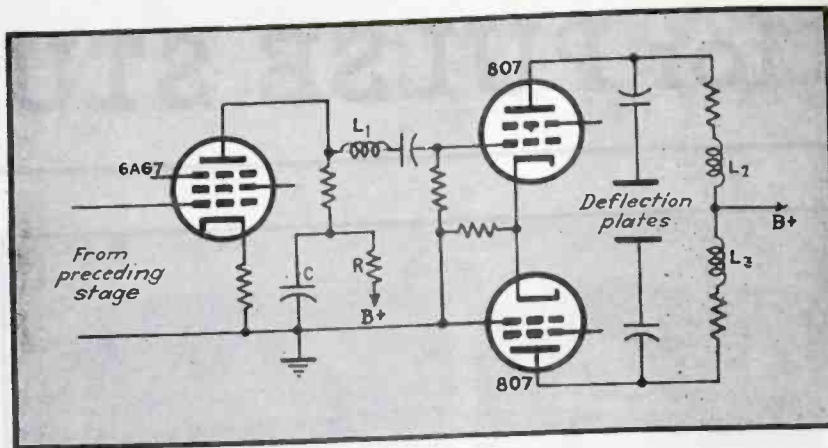


FIG. 4—Y-Axis amplifier is low-frequency compensated by the RC network, and high-frequency compensated by the series inductor L_1 and the shunt inductors L_2 and L_3 . The X-axis amplifier is similar

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.

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-

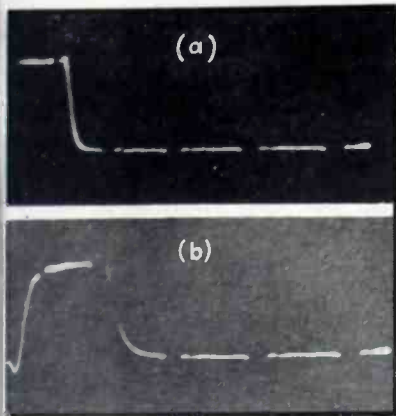


FIG. 5—Pulse reproduced with (a) and without (b) time delay for the signal. Marking spaces are 1 μ sec apart

scope get under way in a small fraction of a microsecond, part of the wavefront is obliterated as shown in Fig. 5(a) unless there is a short time-interval before the signal appears at the vertical deflection plates.

A delay of about one-half microsecond can be obtained by switching in a delay network ahead of the variable attenuator. This network of the low-pass filter type has a characteristic impedance of 200 ohms to match the output of the thode-follower, and a cutoff frequency of twelve megacycles in order that it will be essentially distortionless up to approximately six megacycles. With the signal delayed by this network, the trace is shown in Fig. 5(b).

Time Bases

Two linear time-bases are provided. One, providing the usual continuous sweep, is shown in Fig. 6 and is a modified form of the high-vacuum circuit first described by Puckle. It has a range of 15 cps to 150 kc when running free and is exceptional in its ability to synchronize steadily at high signal-to-sweep frequency-ratios. Stable operation with more than 100 cycles of the signal on the screen can be obtained at medium frequencies.

FIG. 6—Simplified wiring diagram of the vacuum-tube sweep circuit indicates the principle of operation. The triode of the multivibrator periodically charges one of the frequency-range capacitors. The constant-current pentode, which includes the frequency-vernier control, linearly discharges the frequency-range capacitor

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

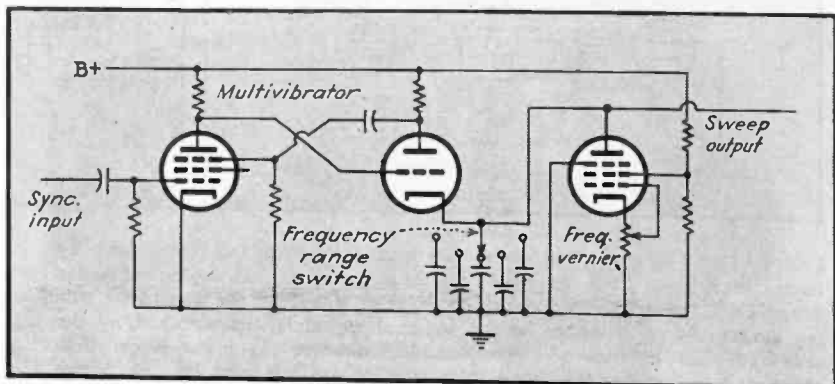
beam by either a positive or negative signal. This amplifier, together with the time-bases, acts as a beam control circuit serving to blank the return trace of continuous sweeps, and to drive the beam from cut-off during stand-by to full intensity during sweep when the driven time base is in use.

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



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.

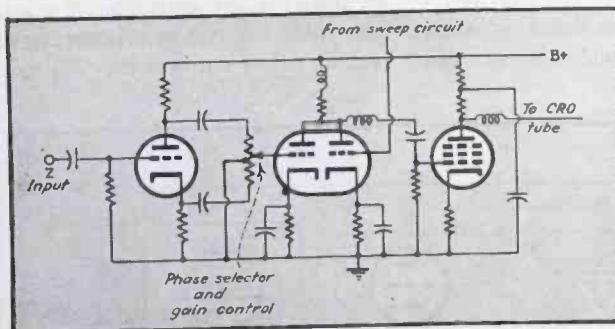


FIG. 7—The Z-axis or beam modulation amplifier blanks the return trace by means of a pulse from the sweep circuit (see Fig. 1). This blanking pulse is superimposed upon any external modulation signal by the dual-triode mixing stage. Phase selection of the external signal is accomplished by the balanced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

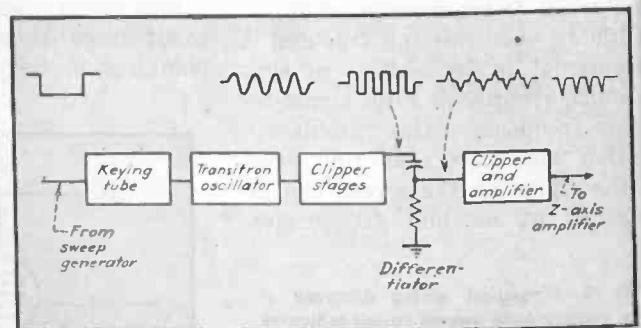


FIG. 8—The oscillator of the time-interval marker circuit is keyed on for the duration of each driven sweep. Wave shapes show the manner by which the oscillations are converted to marker pulses

Automatic Tuning System for PREHEATING PLASTICS

A small, reversible electric motor moves the top electrode away from the plastic preform during the heating cycle in response to an electronic control circuit, to keep the output circuit of the h-f generator in tune despite changes in power factor and swelling

THE utilization of dielectric electronic heating in pre-heating plastic molding materials, particularly the thermosetting materials, has proved to be a definite asset in plastic molding processes.^{1,2} Production of sufficient high-frequency power at a suitable frequency is a relatively simple engineering problem, but the average molding shop is generally too crowded for location of the necessarily bulky generating equipment adjacent to the molding presses. Also, the generally high ambient temperatures, excessive dust, occasional steam and water leaks, and the heavy work involved in mold-handling all constitute an unfavorable environment for electronic equipment.

These conditions led to an assumption that the generating equipment should be located in a remote and more satisfactory location, and the r-f power fed through standard transmission lines to relatively small and simple heating heads located at the presses. Furthermore, such an installation system offers flexibility in the relocation of presses and heating units, and simplifies maintenance by confining mechanical damage to a readily replaceable unit. Ultimately, all of the high-frequency shop heating power could be distributed from a central air-conditioned generating room through permanently installed rigid high-frequency transmission lines, with removable droplines to the individual heating heads.

Application of such a system is straightforward except for the

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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 briquetted 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-

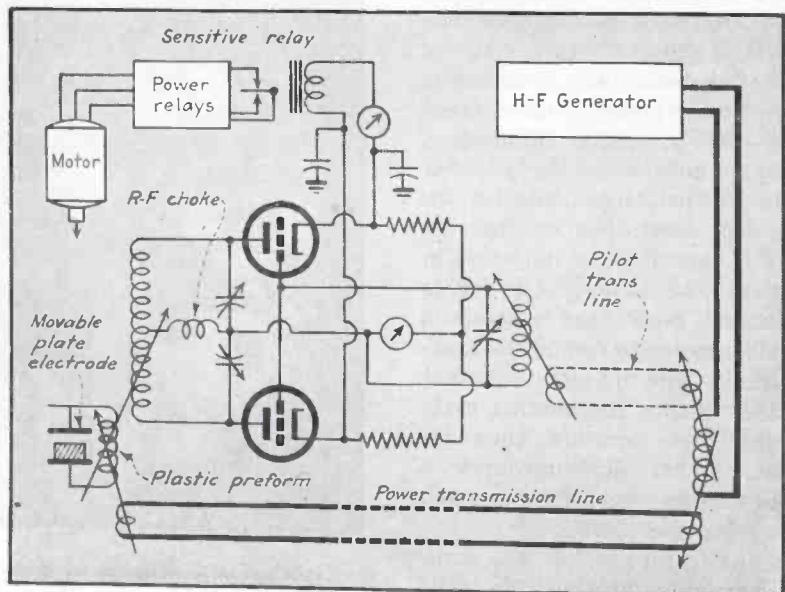


FIG. 1—Automatic tuning circuit used with h-f generator to keep the output tank circuit in tune during the heating cycle

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, dif-

ferences 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.

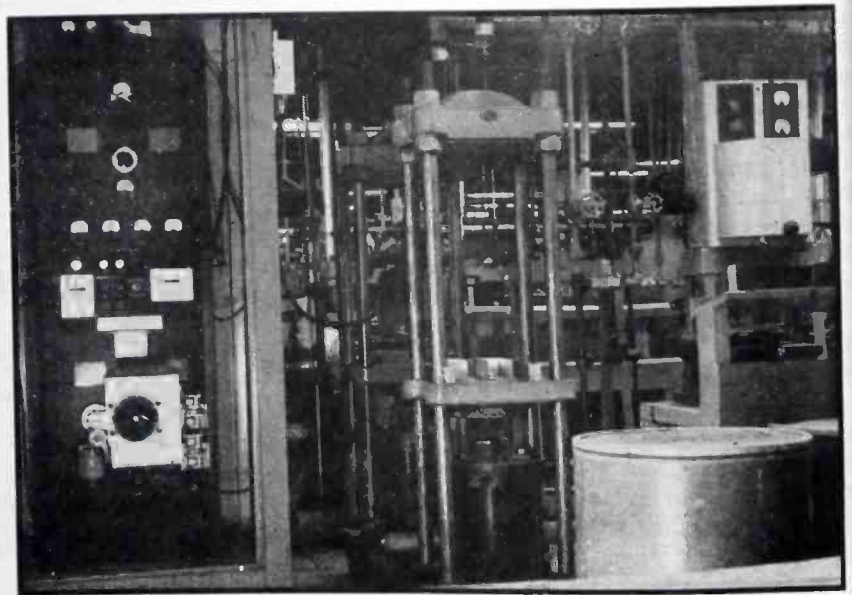
Meters and Limit Switches

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 ar-

ranged 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.

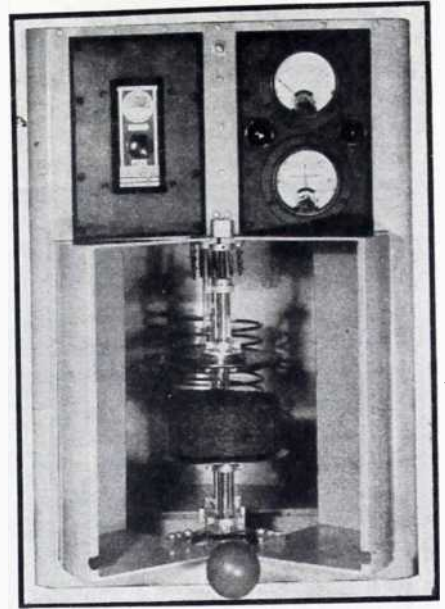
Operation of any one of the heads energizes a magnetic contactor in the generator plate supply, turning on the high-frequency power. In addition, operation of any head controls a motor-driven variable plate-input transformer to deliver a preselected generator output individually adjustable for each head. 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



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

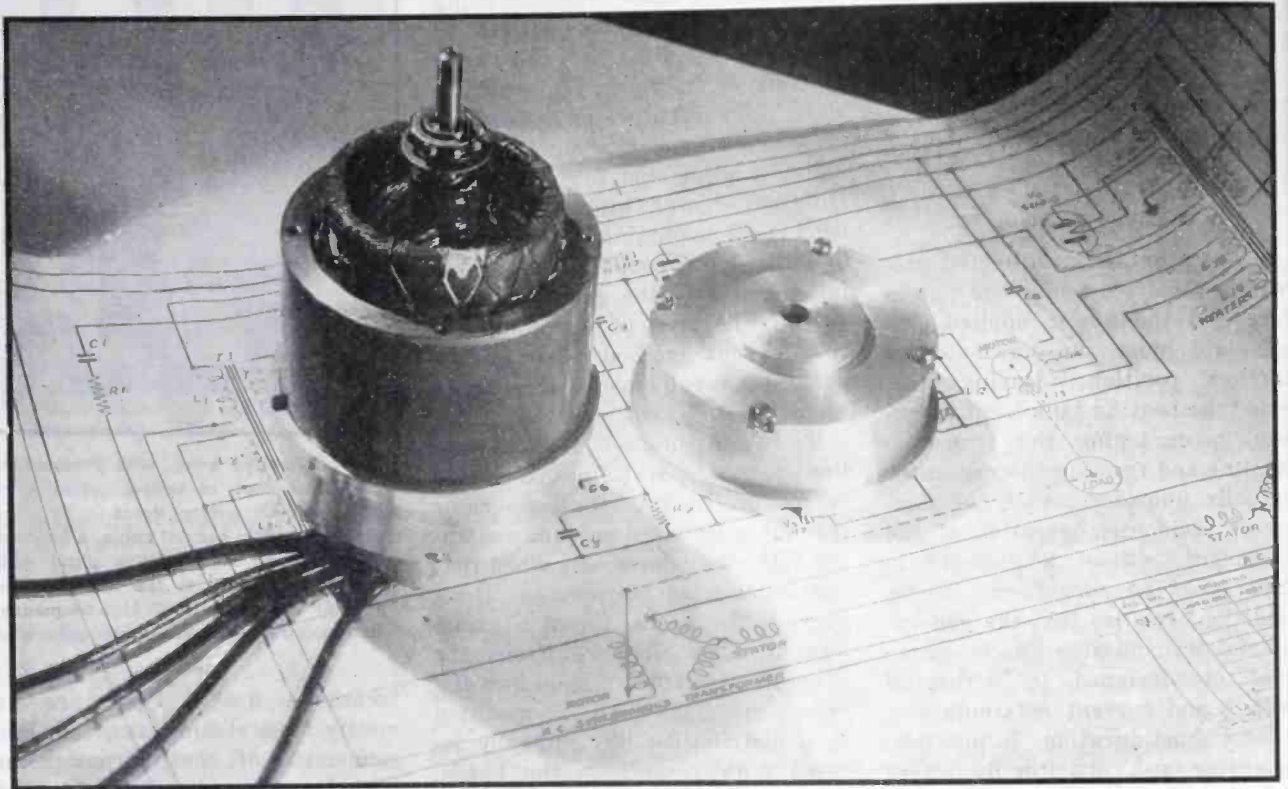
treatment, dust, temperature, humidity from steam leaks, etc. Plug connection of control, power and high-frequency lines to facilitate routine replacement for cleaning and adjustment is therefore advisable. The heating plates rather rapidly become coated with hardened resin from the molding material,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

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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- (2) Taylor, J. P., *R-F Heating Speeds Plastic Molding*, *ELECTRONICS*, p. 102, Sept. 1943.

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

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

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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

equations to automatic control of aircraft.

The system which will be discussed here is of the electronic continuous-control type, which may be defined as a type in which a restoring force is approximately proportional to the deviation of the output with respect to the input and acts continuously on the output in both direction and magnitude until the deviation has been corrected. This type of servo would be ideal if input and output indications were equal every instant. Since it is impracticable, if not impossible, to realize the ideal, a certain amount of error must be accepted in such servo applications. This type of servo mechanism is often referred to as a follow-up system in which tolerable limits of error depend on the amount the load can lag or lead its indicated position at the control point without seriously interfering with efficient operation.

Fundamentally, the block diagram 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

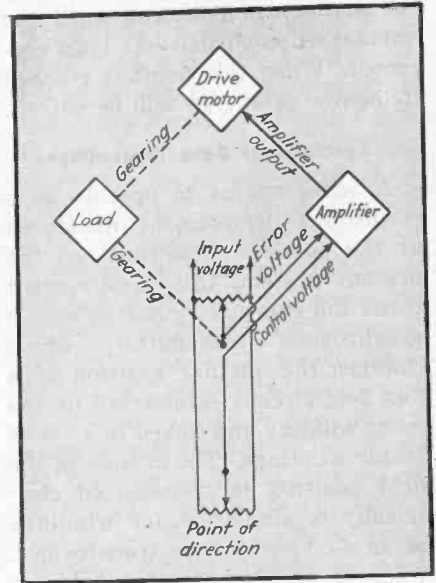
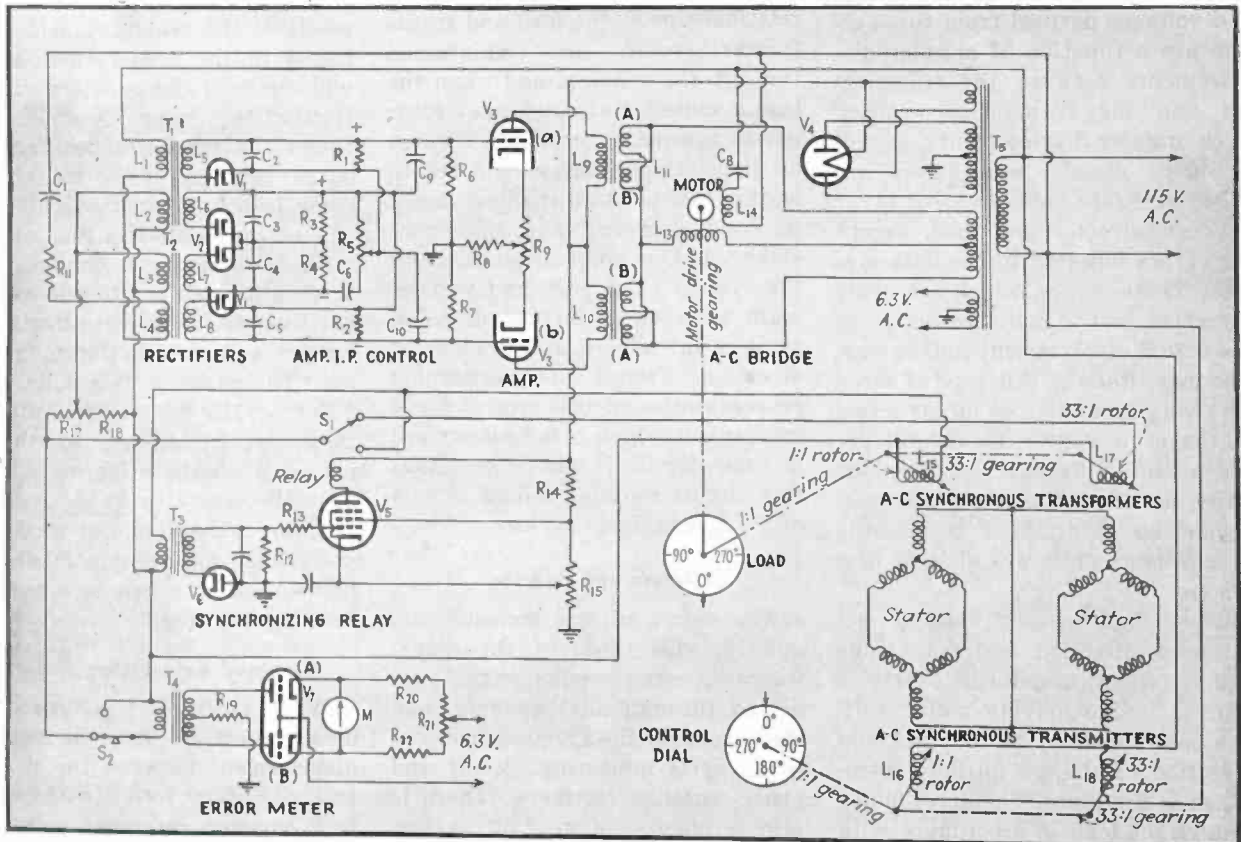


FIG. 1—A Wheatstone bridge, two arms of which are mechanical and two arms of which are electrical, constitutes the basic servo system

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

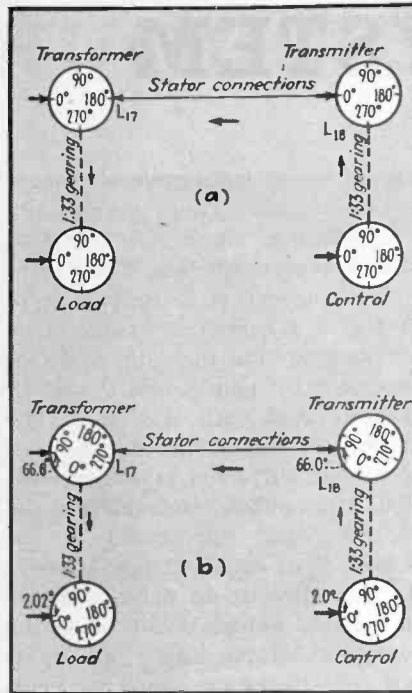


FIG. 3—At (a) is shown by means of dials the condition for all parts of the servo system in perfect alignment, while (b) illustrates how the gearing reduces errors which may appear in the transmitter network. There is only a slight misalignment between control and load

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.

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 main-

shaft 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_{18} 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_{18} 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_{11} . 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

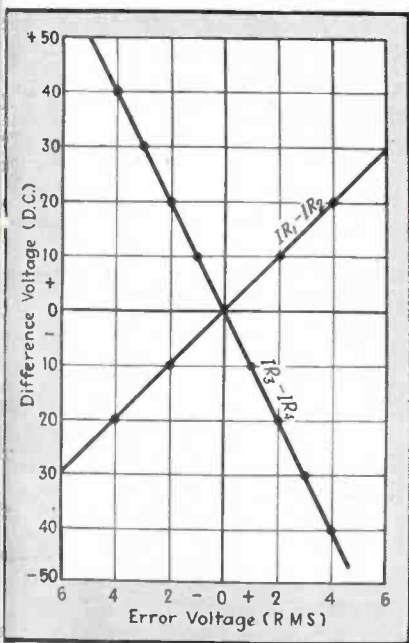


FIG. 4—The stabilizing and grid-control voltages developed by the phase-sensitive rectifier are in opposition

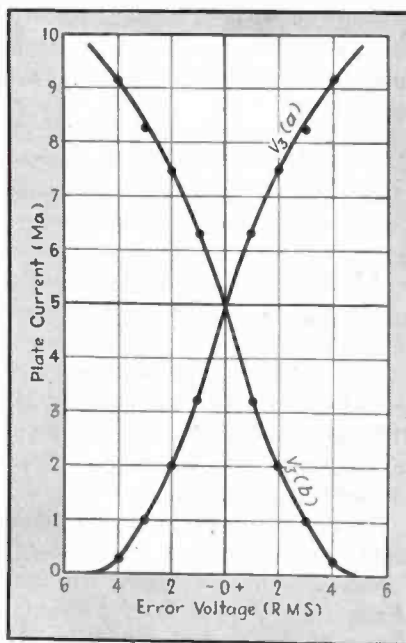


FIG. 5—When there is an error voltage, the balance in the motor control triodes is upset as indicated here

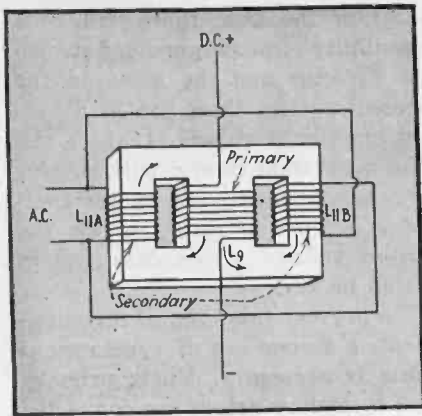


FIG. 6—As indicated by this drawing of one of the saturable reactors, the alternating component of flux is kept out of the primary leg, but the direct component of flux flows in both secondary legs

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_6 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_2 are connected in series with dropping resistor R_{11} and phasing capacitor C_1 across the 115-volt alternating source. Primaries L_3 and L_4 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_5 and R_7 , nor through R_6 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_5 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_5 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_6 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_5 and R_7 in a direction opposite to that desired. The resulting grid difference volt-

age 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_6 and C_{10} in combination with R_1 and R_2 function as a bridge across whose output are resistors R_5 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

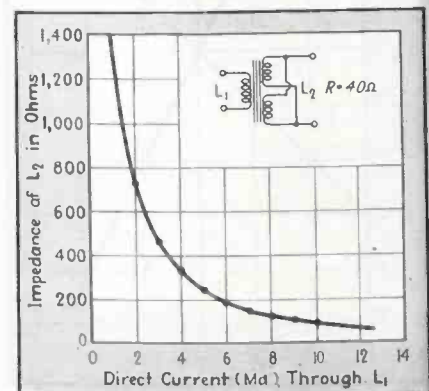


FIG. 7—The impedance of the saturable reactor secondary is controlled by the direct current in the primary

5.0 volts. During this step function, capacitor C_s has the effect of a short-circuit, causing an IR drop of 3 volts across R_s .

Currents from each source will tend to flow through R_s and R_i in opposite directions. By adjustment of R_s , the current flow can be made zero for an instant, allowing the input voltage to the amplifier to change with time. Neglecting the amplifier and transformer winding resistance, which are negligible, the time constant of the circuit is $\tau = [R_s + (R_s + R_i)/2]C_s$. The time at which the amplifier input voltage begins to rise from zero is actually delayed by the adjustment of R_s to a point where the opposing voltage is greater than the input voltage, between 2.5 and 3.3 volts in this illustration.

The charging time of C_s , in combination with the adjustment of R_s , produces a servo response that is proportional to an integral of the displacement voltage. After a time interval, the motor assumes a velocity that is proportional to the displacement. Thus violent action is prevented and at the same time rapid follow-up is permitted when restoring forces make corrections to displacements.

When the displacement is given a constant velocity, the motor will also attain a constant velocity, below a limit fixed by the rpm rating of the motor. Unless the motor runs at a speed that maintains exact synchronism between the transmitter and the transmitter rotor of the data system, there will be times when it will run alternately too slow and too fast. Such changes in motor speeds will cause changes in displacement voltage. A change in displacement voltage is at all times opposed by potentials across R_s , and therefore the motor will be under constant control.

A similar stabilizing action results when a constant velocity displacement is suddenly reduced to zero. Under such conditions, the capacitor C_s will discharge through R_s in a reverse direction, setting up a voltage which causes the motor to continue its rotation in the same direction. Due to the inertia in the system, which is also aided by the voltage across R_s , the displacement voltage goes through zero and reverses 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_s , 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_s , 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 $L = 1.26N^2A\mu/10^9l$, 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

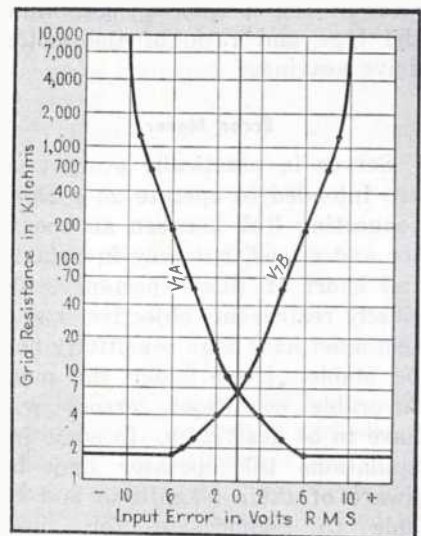


FIG. 8—The action of the error-meter tube depends on the change in grid-circuit resistance which is controlled by the plate voltage

R_s 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

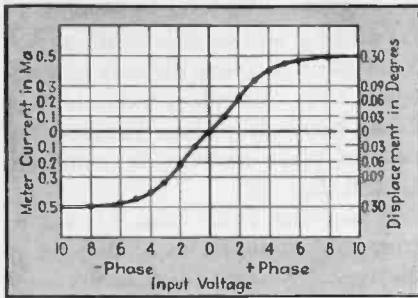


FIG. 9—To prevent damage to the meter the error tube saturates. This limits the amount of error that can be indicated, but in applications where close tolerances must be held this is no disadvantage. The meter can be calibrated in degrees displacement of the load as shown on the right

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 incidentally 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-

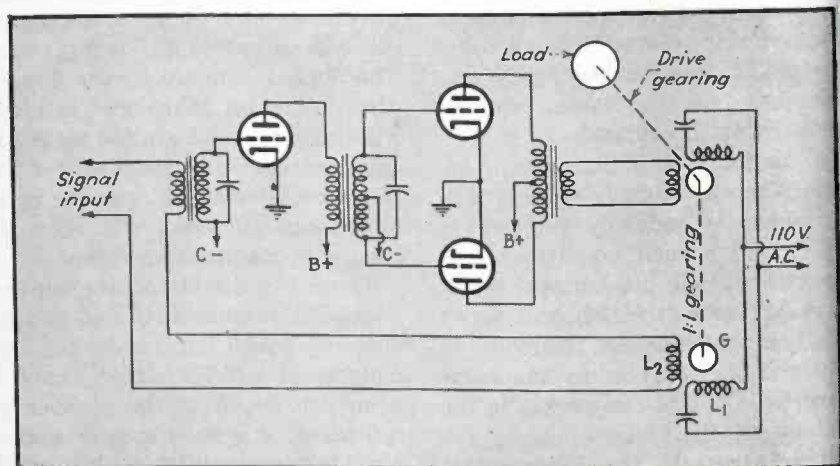


FIG. 10—Conventional servo amplifier, illustrating direct motor-control and feedback to prevent hunting

it protects the meter from possible overloads. Resistor R_{10} limits the current in the plate circuit to a few microamperes. An spdt switch is used to short-circuit the input when balancing the meter after a tube change.

Other Amplifier Circuits

With reference to the servo system being discussed, the amplifier and control circuits described formerly one of the various combinations generally used. The type chosen depends largely on the size and kind of motor required to operate the load and the circumstances surrounding the servo application. Saturable reactors are commonly used as power amplifiers in a large variety of servo systems, but more in particular for the control of fractional horsepower motors.

Figure 10 is a schematic of the more conventional vacuum-tube amplifier preferred for some servo applications. The 60-cycle output of the data system is amplified and used to drive the motor. A separately generated 60-cycle source is coupled back to the amplifier input as an anti-hunt measure.

A generator G is driven by the motor through a one-to-one drive. The generator is similar in construction to a split-phase, low-inertia motor having two field windings angularly spaced 90 degrees. The rotor is of soft iron construction covered with a copper shield. The field, L_1 , which is supplied from the 60-cycle source, serves as a primary winding. When the motor is not rotating there is no transfer of voltage from this field to the other. During rotation, the 60-cycle flux established by the primary is distorted by the eddy currents in the copper shield. By this action a voltage is induced in secondary winding L_2 that is proportional to the speed of the rotor. The phase of the induced voltage changes with the direction of rotation. This voltage is opposite in phase to the signal input to the amplifier.

During operation, a type of dynamic braking is produced. The signal normally overrides the feedback voltage beyond a small angular displacement. This excess voltage is effective in stabilizing the system after a constant velocity error has

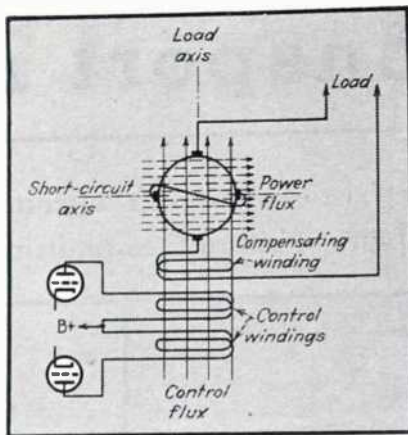


FIG. 11—Dynamo-electric amplifier-motor combines in one unit the saturable-reactor flux amplifier and the motor for servo applications

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, pro-

ducing 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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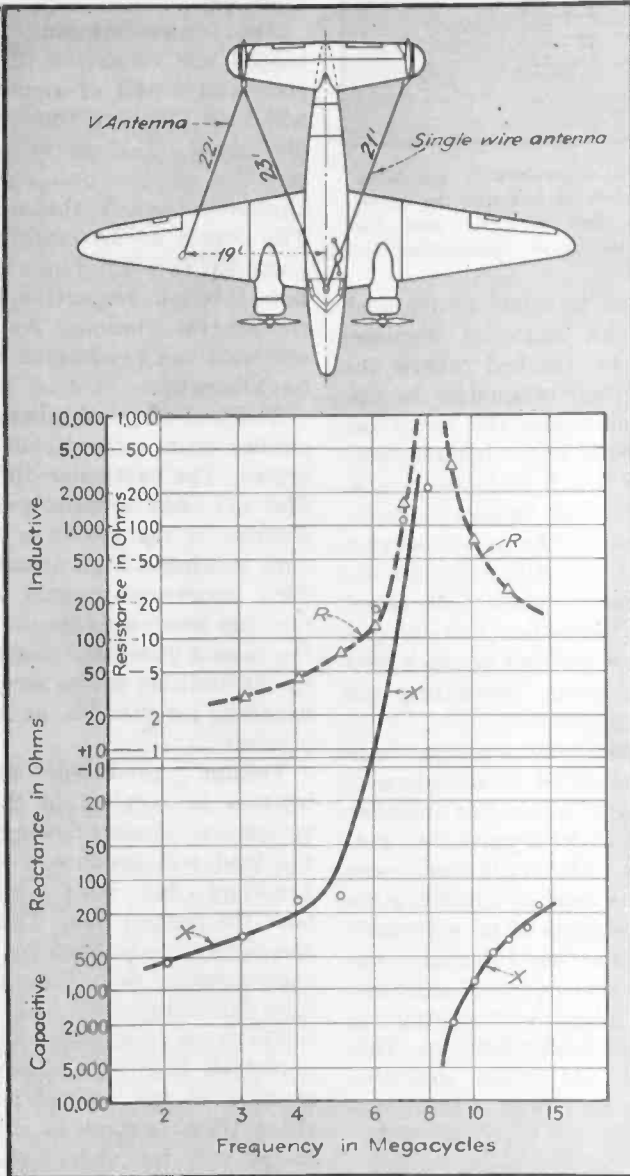
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Transport Aircraft

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

stants. 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

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

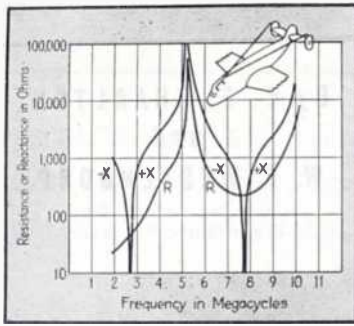
Two methods may be used for obtaining antenna data. One involves an r-f bridge upon which values of resistance and reactance can be

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 con-

Antenna Characteristics



Impedance characteristic of the Douglas DC-4 V antenna

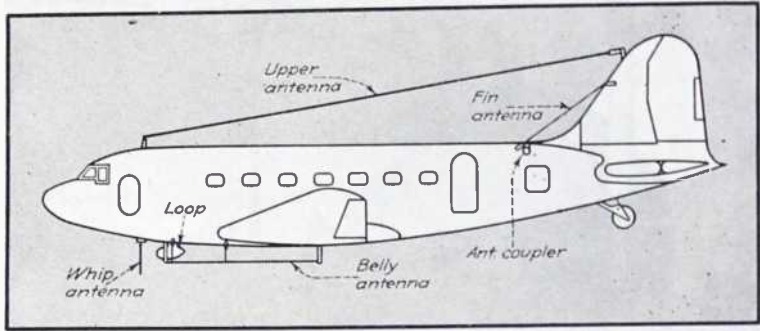


FIG. 1—Profile of Douglas DC-3, showing the various types of antennas used for communication and navigation purposes

reason it is undesirable to use an ac power line on the Q meter. A rotary converter supplied from the plane battery or a battery cart is required.

A number of coils are needed depending upon the frequency spectrum over which measurements are to be made. Several low-loss fixed capacitors may be needed to supplement the variable capacitor in the Q meter and to place in series with the antenna when the Q readings fall below those conveniently made on the Q meter. In these cases it is necessary to make additional calculations to obtain the antenna reactance. It is necessary to exercise care in adjusting the Q meter when the antenna is in the vicinity of half-wave resonance, because the reactance and resistance values change rapidly in this region.

Table I gives data concerning the top antenna on a Douglas DC-3, shown in Fig. 1. The data in the first seven columns was taken in the field; that in the last five was computed.

The readings C_1 and Q_1 are taken with the antenna disconnected from the Q meter; C_2 and Q_2 with the antenna connected. In the columns labelled C added, P indicates a parallel connection, and S a series connection. It should be noted that when using a series capacitor, if the value of $C_1 - C_2$ becomes larger than the series added capacitance, the antenna has become inductive. This also holds true when C_2 becomes larger than C_1 . The formulas used in conjunction with the data are as follows:

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

$$X_A = 1.59 \times 10^8 / f C_A$$

$$R_A = X_A / Q_A$$

$$C_A = C_1 - C_2$$

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

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 $\mu\mu\text{f}$
 C_S = series capacitance in $\mu\mu\text{f}$
 C_1 and C_2 = reading of variable capacitor in Q meter, in $\mu\mu\text{f}$

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.

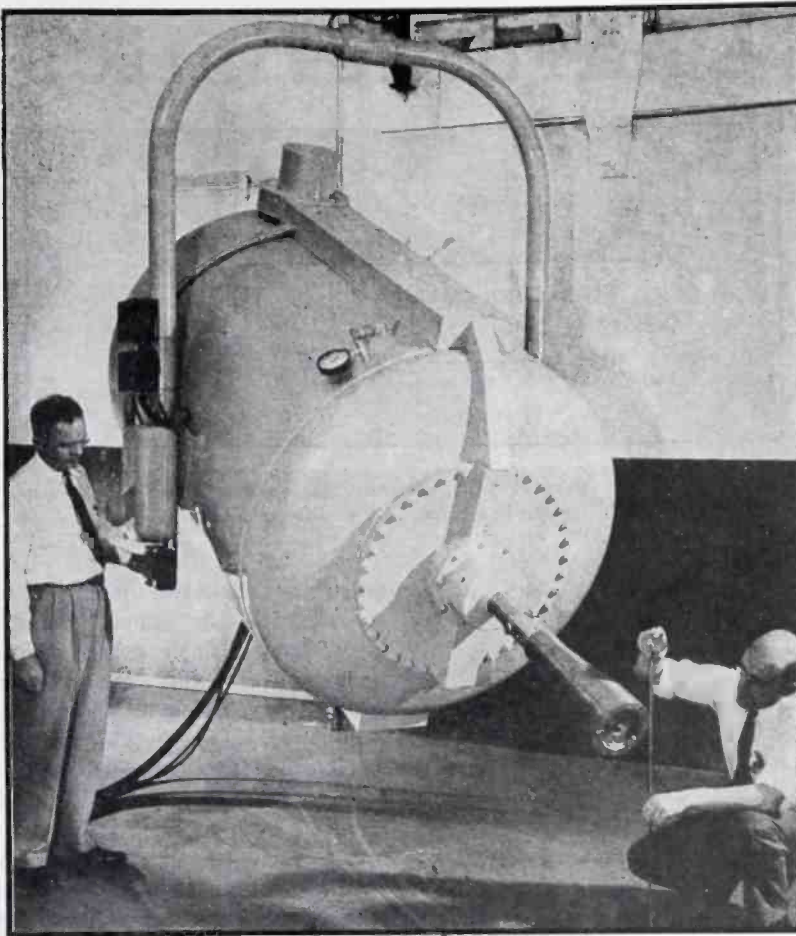
TABLE I. DATA ON DC-3 TOP ANTENNA

Freq. in kc	C added		C added		Q_1	Q_2	$C_1 - C_2$	$Q_1 - Q_2$	Q_A	X_A	R_A
	C_1	C_2	C_1	C_2							
2500	443	P141	290	P141	315	120	153	195	50.8	-j416	8.08
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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and
W. F. WESTENDORP

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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 be radiographed

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.

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

Industrial X-Ray Unit

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

The natural frequency of oscillation of the high-voltage winding is 60 cps. The 180-cycle power is derived from the 60-cycle supply through a synchronous motor-generator set which also eliminates the effect of line voltage fluctuations.

The coil is held under compression by spring-loaded drawn glass disks free of air lines and blow holes and with their surfaces sandblasted to increase their resistance to surface creepage discharges. This type of support makes it possible for the unit to be operated in any position. Since the tube is mounted in the center of the resonance transformer, it is located in a uniform electric field and a weak magnetic field parallel to the tube axis. The magnetic flux does not interfere with electron focusing.

To avoid overheating of the surrounding steel tank by eddy currents there is an inner lining of narrow overlapping silicon steel strips spotwelded to the tank wall. These steel strips guide the magnetic flux of the transformer from the top to the bottom. The bottom is provided with a ring of similar radially spotwelded strips.

Continuous operation at 120 degrees F ambient temperature is made possible by the coolers mounted diametrically opposite each other near the top of the tank. A small fan circulates cooling gas through ducts, through the transformer and over finned water-cooled copper tubing mounted in each cooler. For ambient temperatures below 50 degrees F an electric heater raises the water temperature to maintain the gas pressure. The tank of quarter-inch thick sheet steel is designed for an operating pressure of 60 pounds per square 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 sec-

tions. 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

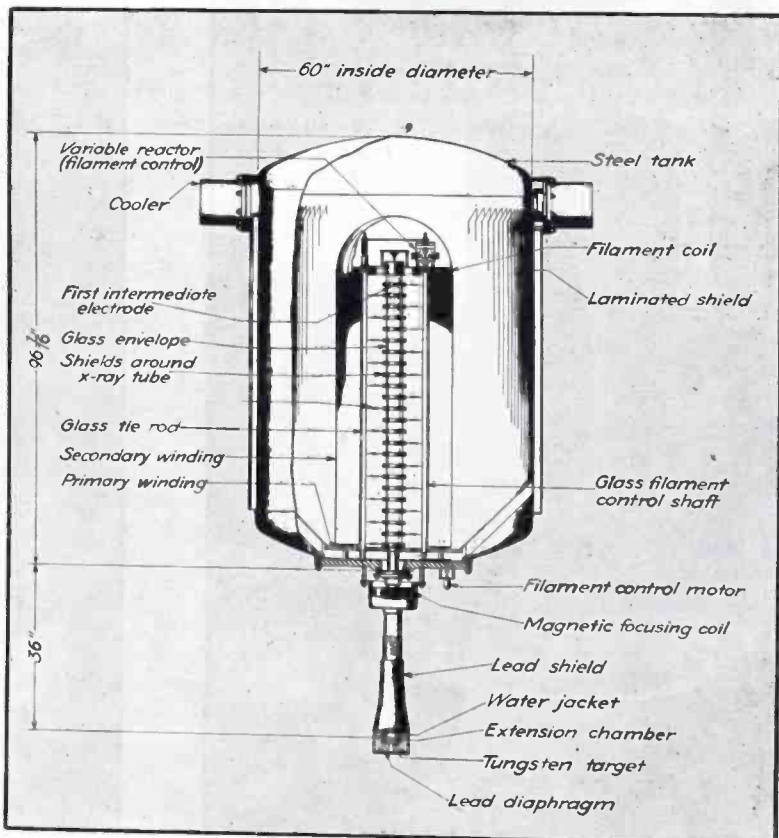


FIG. 1—This cutaway drawing shows the construction of the two million volt x-ray unit

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-di-

fluoro 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 spark-over 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

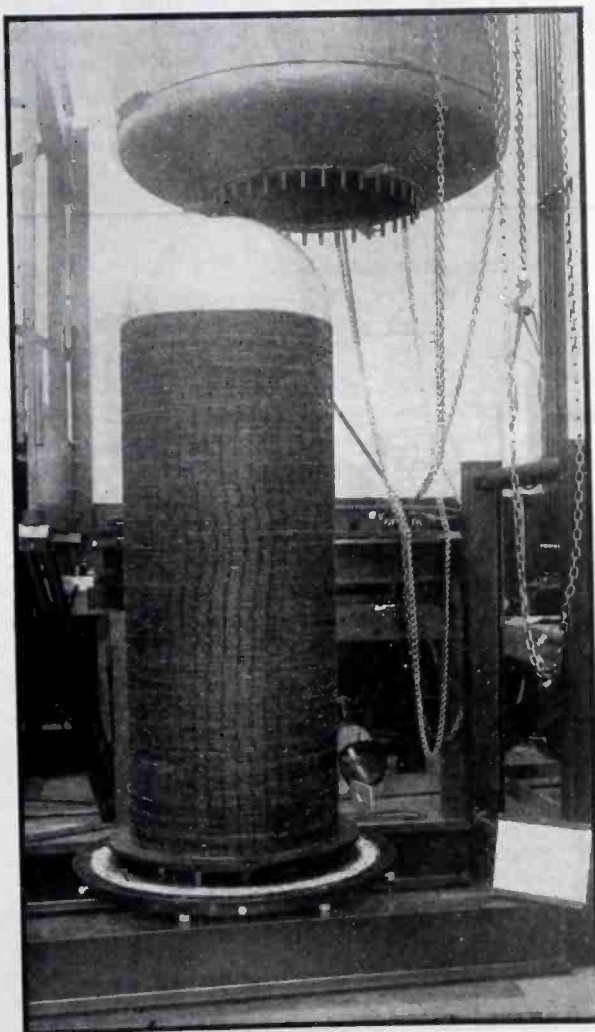
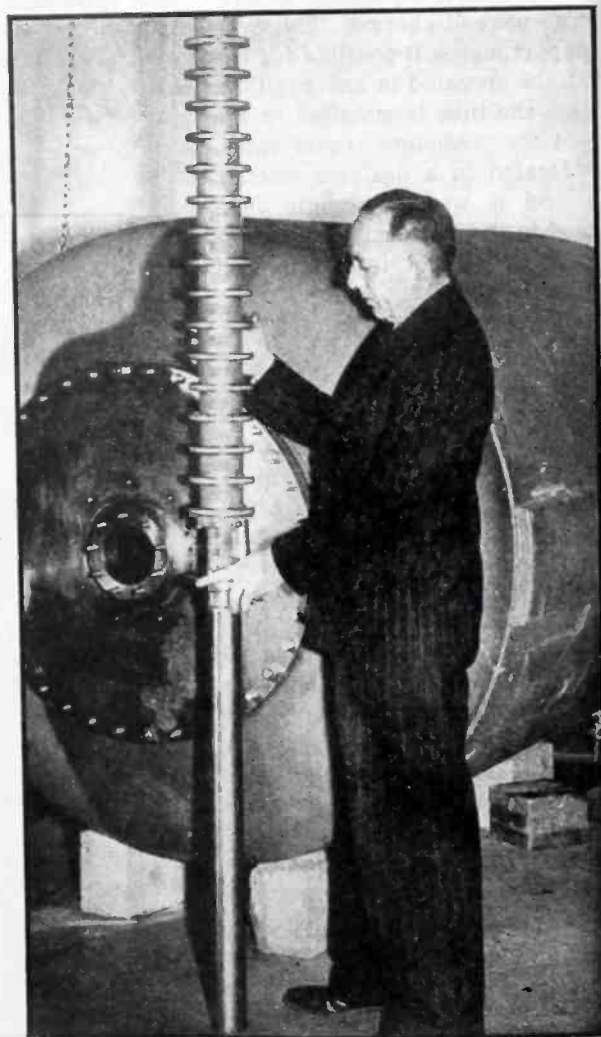


FIG. 2—The steel tank has been removed to show the transformer and the slotted brass shield at its upper end



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

primary voltage and variable frequency, the transformer produces a voltage maximum at 180 cps.

The series reactor and shunt capacitor so modify the constant-voltage operation of the generator that the resonance transformer again has a maximum of voltage at 180 cycles. Small frequency variations of the order of one-tenth cycle can therefore occur at the flat top of the resonance curve and will not show any effect on the output voltage.

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

Metering Circuit

The metering circuit, connected between the lower end of the high-voltage winding and the grounded tank, consists of a d-c milliammeter with a reactor in series, and an a-c milliammeter with a capacitor in series. The unidirectional x-ray electron current registers on the d-c milliammeter; the secondary charging current (131 ma rms at the 2,000,000-volt peak) passes through the capacitor and thus registers on the a-c milliammeter which is calibrated in megavolts peak.

Auxiliary Circuits

The field of the generator is connected through a push-button operated relay to a motor-driven potentiometer which in turn is connected across the exciter of the generator. The motor is operated from the control panel by a megavolt control lever. Interlocking contacts are provided so that the unit cannot be started unless this potentiometer is in its lowest position, corresponding to approximately one million volts. Another control lever on the panel operates the filament-control motor.

A selector switch on the control panel chooses one of four scales on the tube current meter. The same switch simultaneously adjusts the deflect current through the magnetic focusing coil, thus setting the spot size on the target for each of the current ranges. This switch also switches various shunts on a tube-current operated relay which protects the x-ray unit and meters

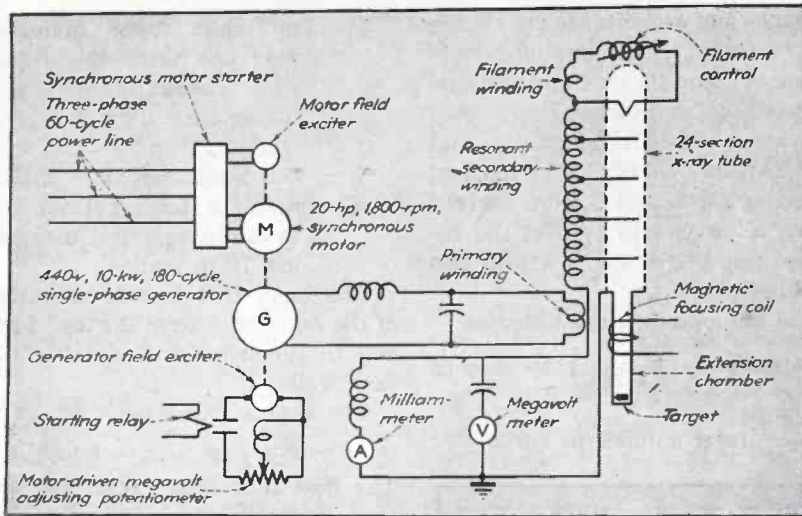


FIG. 3—Simplified schematic circuit diagram of 2,000,000-volt x-ray unit

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 in-

ductance 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

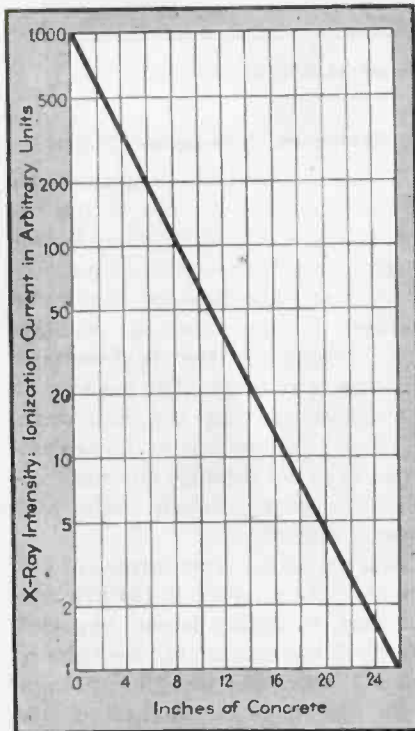


FIG. 4—This plot of the transmission of two million volt x-rays through concrete indicates the thickness necessary to provide safe shielding of the radiograph room

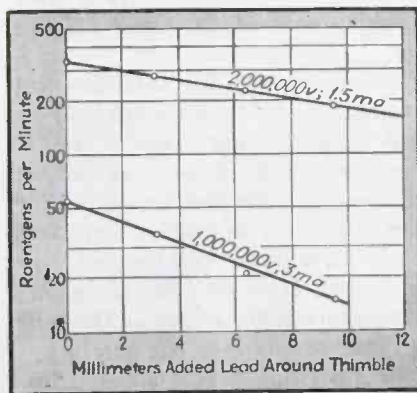


FIG. 5—Comparison of one and two million volt x-rays shows that the higher-voltage rays have relatively higher penetration for thick objects than do the lower-voltage rays

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 $C = 67.1 \mu\mu\text{f}$, $L = 11,700$ henrys.

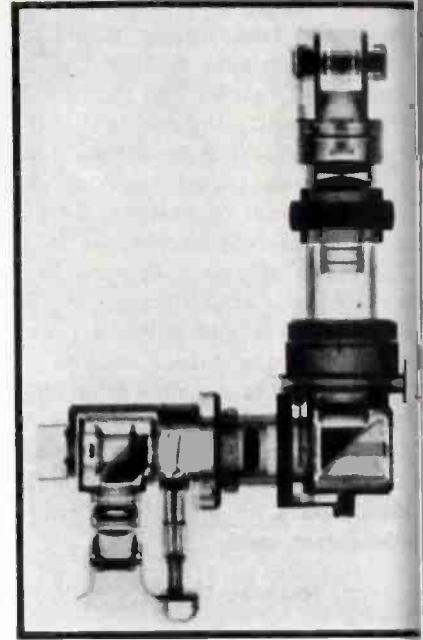
Three times as much inductance would be required for resonance at 60 cps and the wire diameter for such a design would be impractically small. Higher frequencies than 180 cps could be used but are not desirable since the iron losses in the return magnetic shell would increase almost proportionally to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

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

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_5 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 $1/3$. Be-



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

cause the dielectric displacement current per unit height of the coil is proportional to the height, the term of C_5 will appear with the coefficient $1/2$ in the expression for C_5 , thus

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

The calculated value of C_5 is $83 \mu\mu\text{f}$ with a reactance of 10.66 megohms drawing a charging current of 131 ma rms at 2 megavolts through the ground connection of the high-voltage coil. This calculated current is close to the 131 ma rms determined by measurement.

Megavoltmeter Calibration

Calibration was done in air at atmospheric pressure with an external 12.5-cm sphere gap corrected and adjusted for 100 kilovolts peak. The hemispherical brass terminal cap of the transformer was connected through one of the cooling holes by a metal tube and a high voltage insulating bushing to the external sphere gap. The added capacitance threw the transformer out of tune and the charging current read on the meter in the ground lead of the high-voltage winding was meaningless. However across the other hole in the tank diametrically opposite the bushing was temporarily mounted against the inside wall of the tank a large

smooth, insulated pick-up plate. A lead shield from this plate passed through a hole to a vacuum-tube rectifier and a d-c microammeter.

By operating the transformer at 60 cycles and raising the voltage until the spheres sparked, a reading was obtained on the pick-up plate microammeter corresponding to 100 kilovolts peak. After removal of the brushes and the sphere gap the transformer was again in tune and the 100 kilovolts peak obtained by reading the pickup plate microammeter was used as the basis of the calibration of the megavoltmeter on the control panel.

The insulating shaft for adjusting the filament current is also of brass similar to the transformer tie rods. This control shaft, mounted beside the transformer stack and driven by a reversible motor, provides remote control for the variable inductance in the filament circuit. By controlling the filament current the x-ray tube electron beam current is made adjustable.

Electron Beam Control

Toroidal shields surrounding and connected to the various electrodes electrostatically shield the electron beam. The size of the beam is largely determined by cathode geometry and by the ratio of the voltage used in the first section to that of the remaining sections. Without magnetic focusing the spot on the target is about $\frac{1}{8}$ in. in diameter. It can be changed to any desired size by the magnetic focusing coil. For industrial radiography the size of the focal spot is reduced as far as possible without overloading the tungsten target and thereby shortening the life of the tube.

X-ray Protection

The x-ray protection for this unit must be supplied largely by building the enclosure in which it is to be used with thick walls of concrete or lead. This becomes necessary because diversified radiographic techniques with metal structures of different shapes demand that the extension chamber not be covered with a large and heavy protective shield.

A lead shield with two-inch thick walls and weighing 140 lb is placed around the extension chamber. This provides 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.

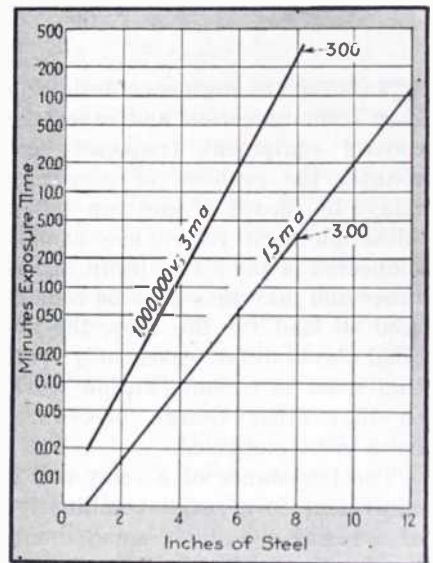


FIG. 6—The data for this graph was obtained with a three-foot target-to-film distance using 0.010-in. lead screens, type A x-ray film, density 1.5 and development at 68 degrees F for six minutes. With two million volt rays (1.5 ma curve), only one-hundredth the time required by million-volt rays is needed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

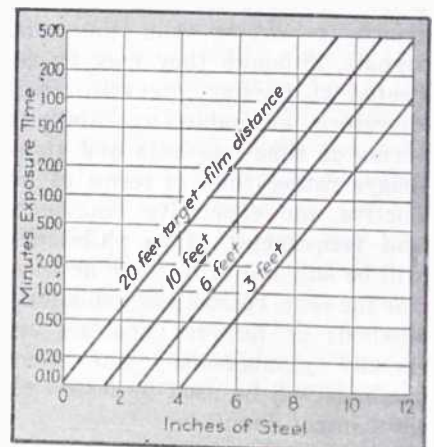


FIG. 7—Exposure times for various thicknesses of steel and for different target-to-film distances for 2,000,000-volt needed for radiographing 8 in. of steel

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 thyatron, multiplier phototube and other special industrial tube circuits

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

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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

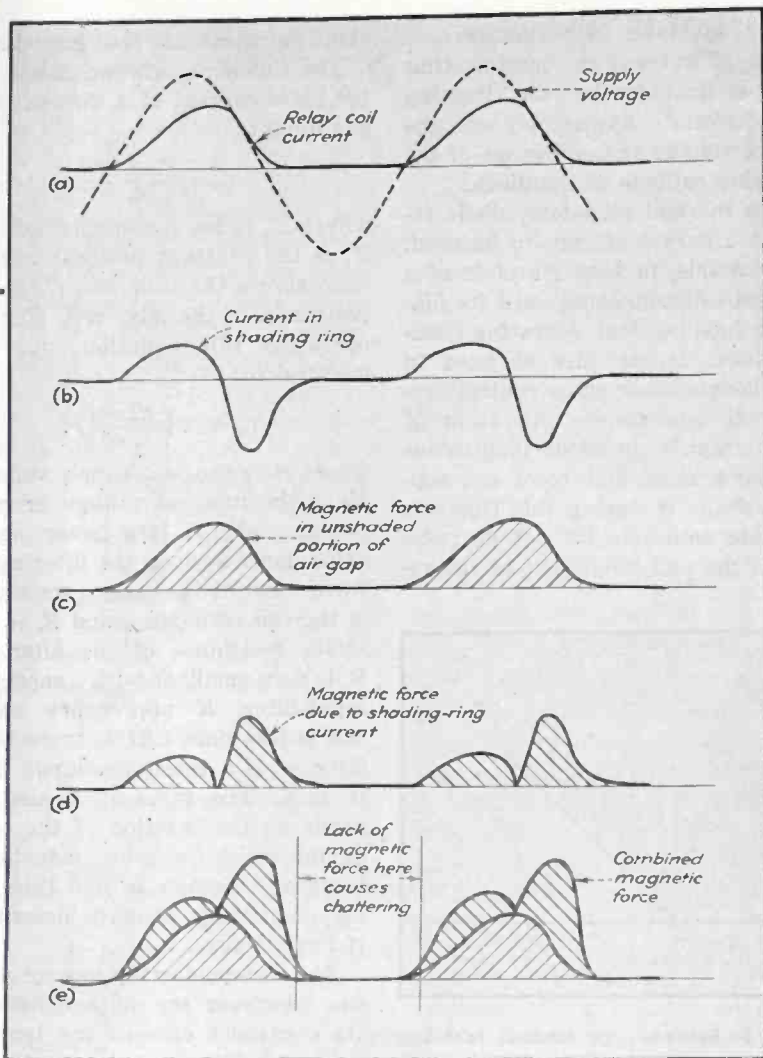


FIG. 1—The shading ring of an a-c relay operated in series with a half-wave rectifier will not prevent chattering

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

higher 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 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 tube 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

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 pub-

lished 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 re-

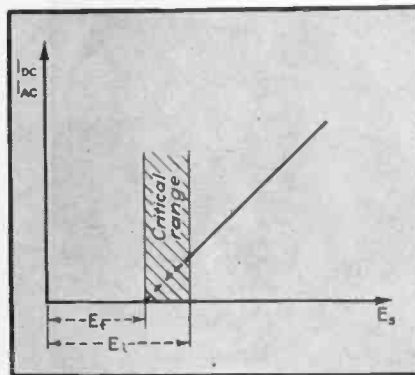


FIG. 2—Between the internal tube-drop voltage and the ignition potential of gas tubes there is an unstable operating region

lay. A false alarm is thus avoided.

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 igni-

tion potential of the gas diode.

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

$$I_{dc} = \frac{E_s - E_i}{R_s} \quad (1)$$

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

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

where E_s is the peak supply voltage, E_i 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_s is the coil resistance, and R_f is the series resistance of the filter. If R_f 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 radical representation of Eq. (1) and (2).

To avoid damage to the gas diode, a series resistor is needed. This resistor can be either the relay coil resistance or an additional series resistor. The tube fires when a ignition potential is reached. If the voltage across the tube remains at this high value, the cathode will be damaged. However, if there is resistance in series with the gas diode, the current will become such that the IR drop across this resistor will be the difference between E , and the applied control voltage, and the tube will be protected. The series resistance should be such that the current that flows will be at least the pull-in current for the relay, but not greater than the maximum allowable tube current.

Sensitive Control With Vacuum Tubes

More important than diodes for relay operation are triodes and pentodes. (Ordinary and beam diodes have essentially the same behavior as pentodes and shall be included in this group.) These tubes make operation of relays possible with practically no power consumption in the controlling or pilot circuit.

The simplest case is on-off control of the relay. The tube may be normally biased beyond cut-off; when the relay is to be energized

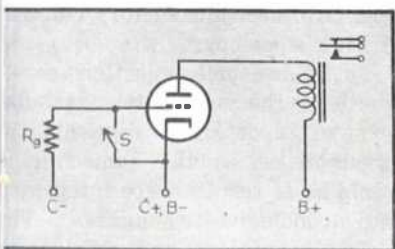


FIG. 3—This circuit illustrates the basic arrangement for vacuum-tube relay control. Closing the switch actuates the relay

the grid is connected to the cathode so that the full plate-current flows through the relay in the plate-circuit, as shown in Fig. 3. If the bias is supplied through a very high resistance R_g , the magnitude of which is only limited by the grid-current characteristic, the current through switch S can be made extremely small, 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-

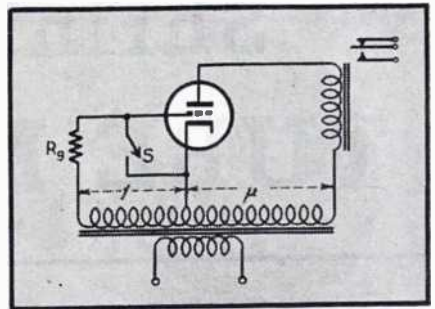


FIG. 4—For a-c operation, the power transformer is tapped approximately in the ratio of 1 to μ

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 wave-shape 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

By **EUGENE GODDESS**

*Special Projects Engineer
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Dobbs Ferry, N. Y.*

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.

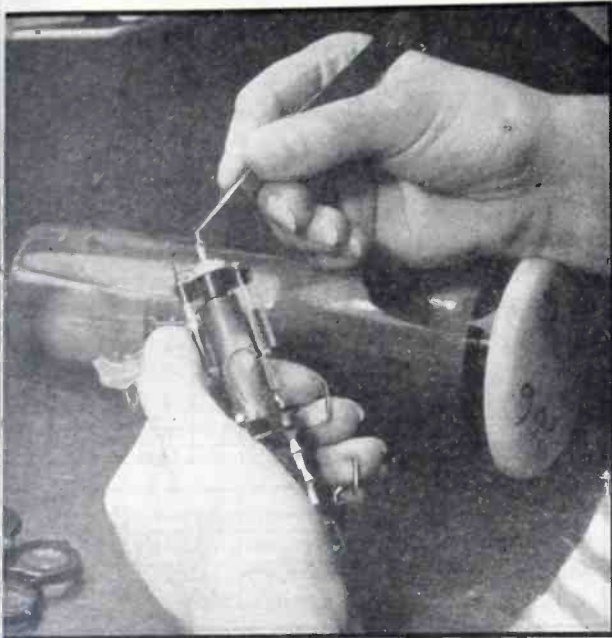
It is desirable that shrinkage analysis work be performed by a single specially trained group rather than by individuals from different departments. The Shrinkage Analysis Department is not concerned so much with reduction of shrinkage as it is with presenting accurate facts concerning the condition. 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



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



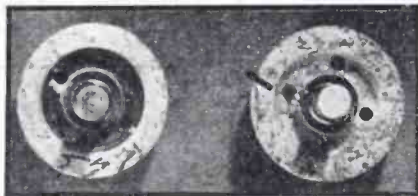
Shrinkage analyst uses a hot-wire glass cutter to open a defective cathode-ray tube for investigation

factors: 1. Factual content; 2. Thorough study of the findings. The first factor depends on the efficiency of the analyst; the second factor depends on the engineering personnel of the sections involved.

Relation to Other Departments

Failure of production and engineering personnel to utilize the potentialities of the Shrinkage Analysis Department may be ascribed to the natural reticence of anyone to ascribe his errors, and to misunderstanding concerning the function of the Shrinkage Analysis Department in the general scheme of factory operation. Since reticence can be overcome only when misunderstanding is clarified, it is imperative to discuss the main problem: "What relationship does the Shrinkage Analysis Department have to general factory activity?"

Development engineers set up specifications for making tubes, and factory engineers watch manufacturing procedure to be sure specifications are followed. Naturally, all specifications cannot be followed exactly—the slight changes that are necessary are termed variables. The Quality Engineering Department gives a dynamic picture of production by observing deviation of the variables; 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

Analysis of Tube Type 24G
Subject - grid lead assemblies

Distribution General
Requested by Mr. Thomas
Analysis by Mr. Daniels
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. Thomas, Mr. Daniels, Mr. Jerome, Mr. Thomas and Mr. Daniels. Mr. Jerome reported that the bulges in the wires and the angle of lead to grid were not serious enough for rejection. Final reports from 200 grid lead assemblies were for 8 loose wires.
Mr. Thomas and Mr. Jerome brought up the question of the I.D. of collar and grid. The remaining 192 grid lead assemblies were re-inspected by using a .0015" gage # T3010.3. Faults were found to be too small to be in collar and on grid.
Making of the grids and the assembly of grids and leads was planned 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 the chemically cleaned. The results are shown in Table II.

Table II.

ANALYSIS	No.	%
Good	183	91.5
I.D. too small	12	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 reports were 3 assemblies which look wired.
One hundred ninety-seven good grid lead assemblies were put into production. Mr. Jerome 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 inspections 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-seven units passed into production time have been completed.
Mr. Daniels reported that the grid lead assemblies are submerged in clean water and dried in oven. 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 made. Inspection as now administered seems inadequate.

Submitted by:
P. Shaughenacy

Shrinkage Analysis of:

Tube Type: A, B, C
Subject: Electron shorts

Distribution: General
Requested by: Mr. Thomas
Analysis by: Mr. Daniels
Number of Tubes Analyzed: 42
Shrinkage received from: Test Dept
Shrinkage received on: July 31, 1944

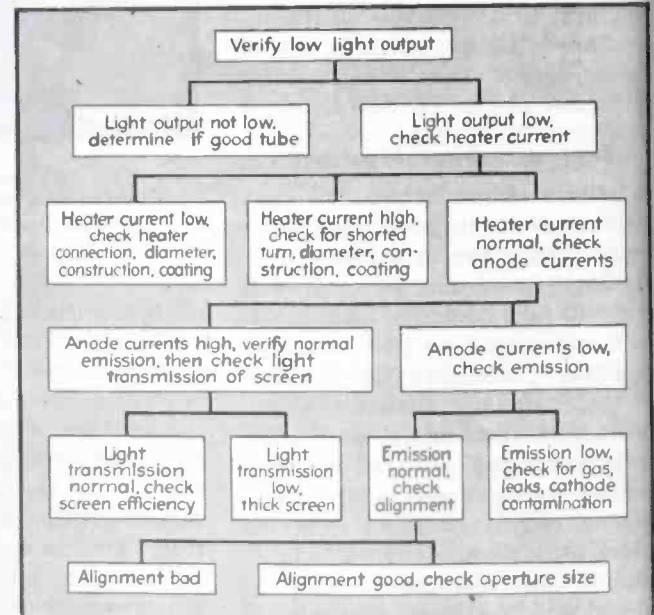
	Type A	Type B	Type C	Total	%
At neck & passed against anodes	2	8	1	11	26.2
At wire & touching the anode	2	9	1	12	28.6
Good tubes	5	6	1	11	26.2
Faults were at 1st position		2		2	4.7
At wire touching anode	1		1	2	4.7
Good tubes		2		2	4.7
Long wires were against at wire & d			1	1	2.4
At wire & burned out at weld to lead wire		1		1	2.4
Total	10	28	4	42	100.0

Breakdown of Shrinkages	No.	%
Loose wires at position	28	66.7
Good tubes	11	26.2
Good tubes	2	4.7
At 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, over-carburization 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.

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 fis-

sure. 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.

Shrinkage Analysis of Cathode-Ray Tubes

As a second example, consider a cathode-ray tube which has been rejected for low light output. Here again, the rejection should be verified. One convenient method uses several test sets for checking the reject against a standard tube. A standardized test set is preferred in which heater current and anode voltages can be observed. The heater current can act as an index of cathode temperature. By reading second or third anode currents, if required, intensity of the beam hitting the screen can be checked. If anode currents are low, it is correct to assume that cathode emission is reduced. This value must be checked separately with a low positive voltage on the grid. Once it has been definitely established that cathode emission is inadequate, various beads and wires could be examined for cracks or filaments that permit entrance of gases which destroys the emitting surface.

When the tube is opened, the cathode should be examined for ion spots. If none are present, it could be examined for other types of contamination such as chloride oil, which also reduce emission. Suppose, however, that emission is adequate but second anode current is low. In that case, the geometry of the electron gun should be examined for alignment and con-

centricity 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) Kullin, 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: Van Taylor
 Analyzed by: Van Taylor
 Number of tubes analyzed: 123
 Test made at: Special Commission, exhaust, aging, test.
 Test made on: July 27, 1944.

Shrinkage due to:																					
Operation	# of tubes submitted	Out of Align.	Broken cathode filaments	Cracked cathode (fluoresc.)	Cracked tip (agg)	Cracked bulb	Inter-element short	Mis-align 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 Exam	135	30																		30	22.2
Sealing	105		32																	32	24.2
Exhaust	72			5	1	1	1													8	5.9
Aging	64							2	4	1	5	1	1							14	10.2
Test	50								1		1		2							4	2.9
Test	46						1							16	1	1	1	1	3	24	17.8
Total shrinkage		30	32	5	1	1	2	2	5	1	6	1	3	16	1	1	1	1	3	113	83.3*
% of Tot. shrinkage		26.5	27.2	4.5	.8	.8	1.8	1.8	4.5	.8	5.2	.8	2.7	14.2	.8	.8	.8	.8	2.7	99.6	

* 22 on 14.3 % tubes were good.

Copies sent to:
 Dykes
 White
 Perry

Note:
 Upon removing "out of alignment" mounts there were no spots off center. Projects to be found among the remaining 46 mounts which essentially came to the test set. It is recommended that a "page" 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

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 equilib-

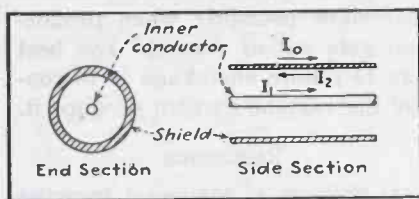


FIG. 1—Section of coaxial line, showing the currents which can flow

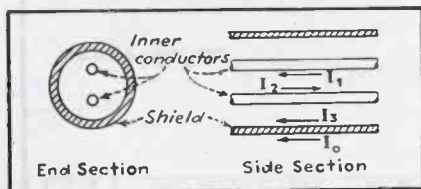


FIG. 2—Section of a balanced two-wire transmission line, showing the line and shield currents which can flow

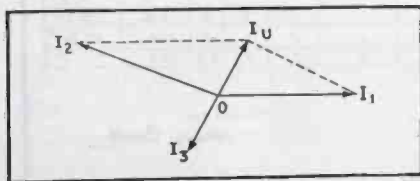


FIG. 3—If the currents of a two-wire line are not equal, an unbalance current I_3 flows. In this case the inequality of the line currents is in the nature of a small phase shift. The two line currents should be 180 degrees apart for balance

rium 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.

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 im-

portant 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_3 . I_3 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

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TRANSFORMERS

straneous current induced on the outside of the shield.

The first problem encountered in maintaining the normal equilibrium conditions in a balanced transmission line is to keep I_1 equal and opposite to I_2 so that I_0 will be zero; the second problem is to prevent the shield from coupling into the transmission line at any point.

The problem is to convert from a balanced transmission line to a coaxial transmission line by introducing some type of transformer. First, in order to prevent I_0 from coupling into the lines the outside shields of both lines should be kept continuous so that there can be no way in which I_0 can get into the line. If this method is not possible, some other means must be used to prevent I_0 from coupling into the line. Secondly, in order to maintain I_1 equal to I_2 in the balanced transmission line, the impedances from each conductor to the shield must be maintained equal. Any difference in impedance will cause I_1 to differ from I_2 . Third, the continuity of large impedance, or impedance matching, should be maintained as close as possible, to obtain maximum power transfer.

Single-Frequency Transformation

In Fig. 4 is shown one type of transformer that can be used for single-frequency transformation. A

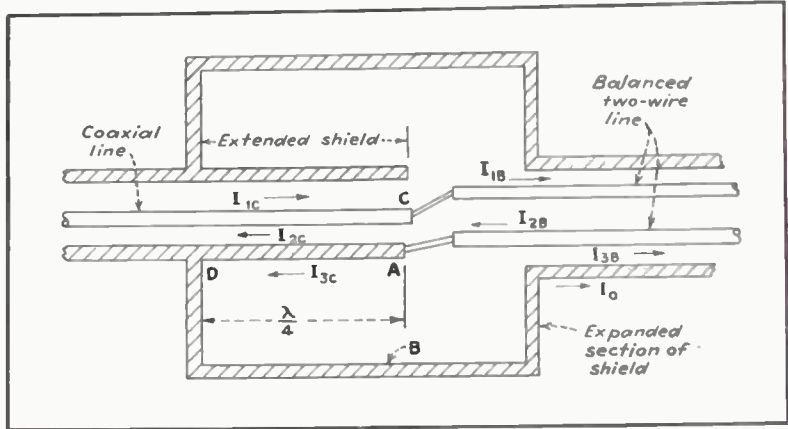


FIG. 4—Cross-section of a single-frequency conversion section, showing how the coaxial shield can be extended to reduce I_0 to zero at resonance

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.

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 bal-

anced 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

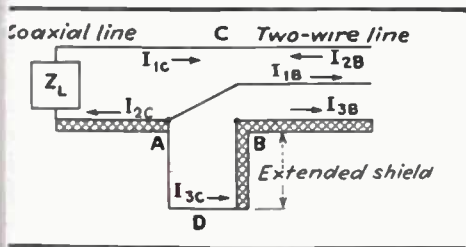
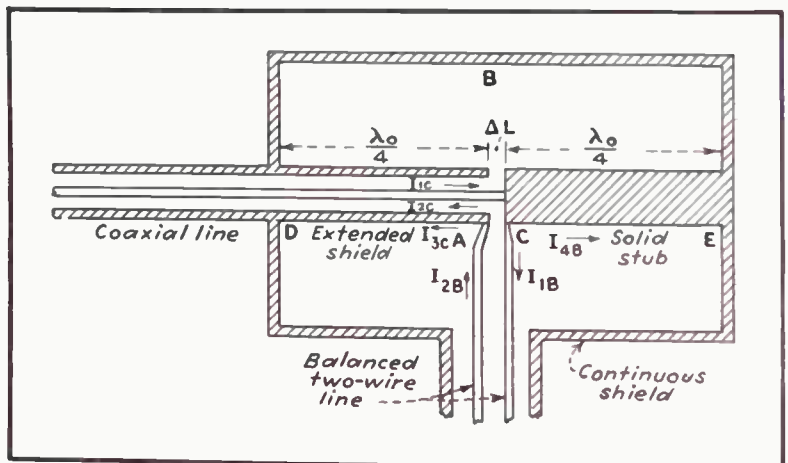


FIG. 5—In this equivalent circuit of the conversion section shown in Fig. 4 the shield is represented by cross-hatching

FIG. 6—The addition of a solid stub inside the conversion section improves the off-resonant action of the transformer



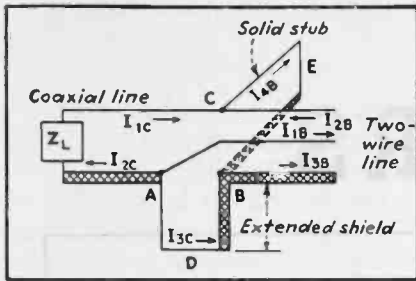


FIG. 7—The loop formed by the solid stub of Fig. 6 is shown on a plane extending into the page in this equivalent circuit

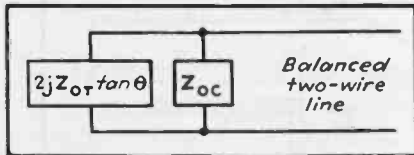


FIG. 8—The lumped constant equivalent of Fig. 6 shows a reactive impedance in parallel with the coaxial impedance. It is this reactive impedance which limits the frequency band over which the conversion section will operate

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 conver-

sion 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_{1b} and I_{3c} will flow. However, because of the quarter-wave extended shield and solid stub construction, I_{1b} will equal I_{3c} in magnitude and they will cancel at B . This will result in I_{2b} being zero and I_{3b} 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

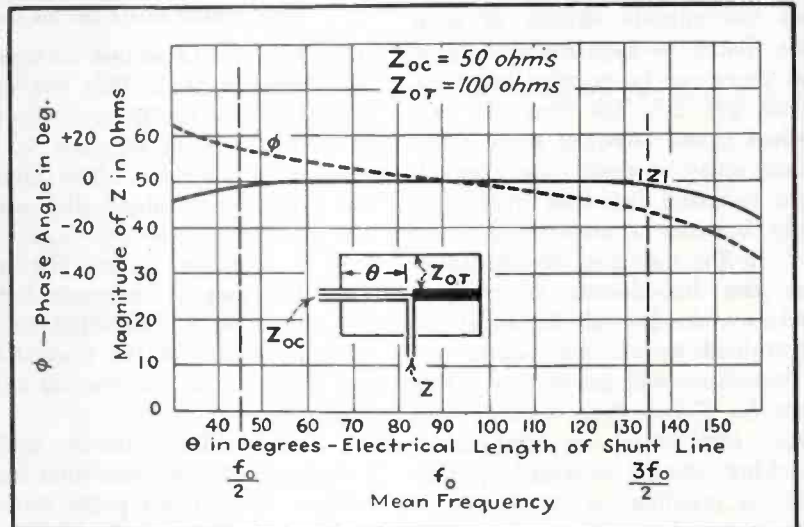


FIG. 9—Theoretical plot showing the variation in magnitude and angle of the impedance presented to the balanced two-wire line by the coaxial line and conversion transformer of Fig. 6 for conditions given in the text

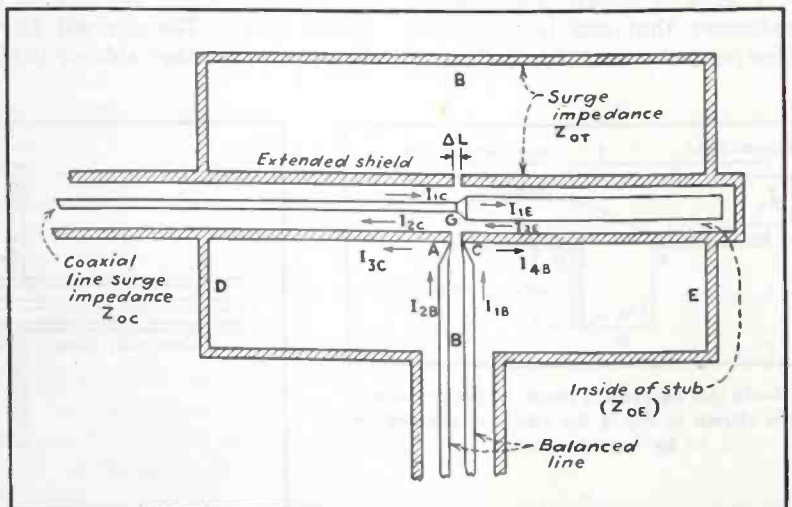


FIG. 10—To decrease the angular variation in impedance as seen by one of the lines being joined, the coaxial line is extended into the stub of Fig. 6.

where Z_{oc} is the surge impedance of the coaxial line. If the surge impedance of the transmission line, composed of the inside of the conversion box and the outside of the extended inner conductor, is Z_{oe} then the impedance across the balanced line is

$$Z = \frac{(Z_{oc})(2jZ_{or} \tan \theta)}{Z_{oc} + 2jZ_{or} \tan \theta} \quad (1)$$

where θ is the electrical length AD which is equal to CE . The lumped constant equivalent circuit is shown in Fig. 8. θ of course will vary with frequency. In Fig. 9 is shown the impedance characteristic presented at the end of the balanced two-wire line in this type of transformer with an impedance Z_{oc} of 50 ohms and an impedance Z_{or} of 100 ohms. Here θ is picked to be 90 deg at the mean frequency f_0 . The balance remains very good over the whole range. For a three-to-one range in frequency the impedance will vary between the points noted as $f_0/2$ to $3f_0/2$. The value of the phase angle ϕ at these points will be about 15 deg. This calculated curve neglects the capacitance between the edges of the extended shield and stub. This capacitance will increase the impedance variation slightly.

Phase-Shift Correction

It is now desirable to make the conversion transformer wideband without the shift in phase. This can be done by constructing the transformer as shown in Fig. 10. The only difference between this transformer and the transformer shown in Fig. 6 is that the coaxial line is extended into the solid stub. This extended line has a surge impedance of Z_{oe} which is equal to

$$Z_{oe} = \frac{(Z_{oc})^2}{2Z_{or}} \quad (2)$$

where Z_{oc} is the coaxial line surge impedance and Z_{or} is the surge impedance of the coaxial shield and box inside the transformer box. Thus the inner conductor of the extended line must be made large since Z_{or} is always larger than Z_{oc} . The length of the extended shield is resonant as a shorted quarter wavelength at the mean frequency f_0 . If the capacitance across ΔL were neglected, the length from the box to the break would be 90 deg. The extended line is left open at the

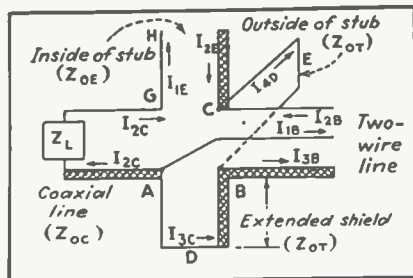


FIG. 11—As this three-dimensional equivalent circuit shows, the extension of the coaxial line into the stub is equivalent to adding an open quarter-wave line in series with the inner conductor of the coaxial line

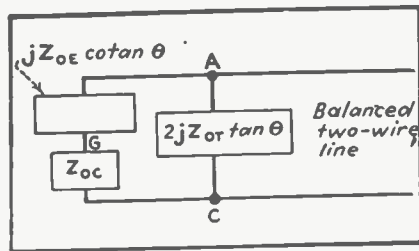


FIG. 12—The lumped-constant equivalent circuit of the conversion section shown in Fig. 10 shows how the addition of an open line in series with the coaxial line will correct the angular variation of impedance of the conversion section

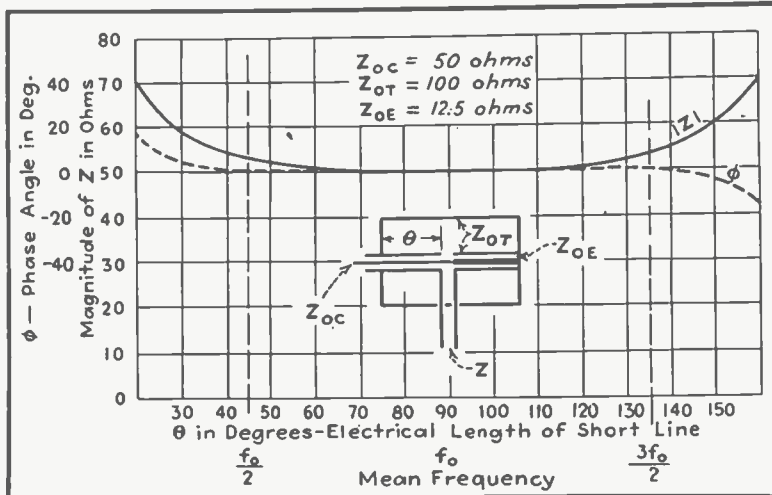


FIG. 13—The theoretical variation of impedance seen by the balanced two-wire line, when converted to a coaxial line by the transformer of Fig. 10, shows but slight change in magnitude and negligible change in angle over a one-to-three change in frequency

end and is made resonant as a quarter-wavelength open stub.

Calling the currents in the extended line I_{1B} and I_{2B} , 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_{1B} . 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

$$Z = \frac{(Z_{oc} - jZ_{oe} \cotan \theta)(2jZ_{or} \tan \theta)}{Z_{oc} - jZ_{oe} \cotan \theta + 2jZ_{or} \tan \theta} \quad (3)$$

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),

$$Z = Z_{oc} \frac{1 - j(Z_{oc}/Z_{or}) \cotan \theta}{1 - (Z_{oc}/2Z_{or}) \cotan^2 \theta - j(Z_{oc}/2Z_{or}) \cotan \theta} \quad (4)$$

Substituting the value of Z_{oe} given in Eq. (2), Z becomes

$$Z = Z_{oc} \frac{1 - j(Z_{oc}/2Z_{or}) \cotan \theta}{1 - [(Z_{oc}/2Z_{or}) \cotan \theta]^2 - j(Z_{oc}/2Z_{or}) \cotan \theta} \quad (5)$$

As long as Z_{or} is kept large this circuit is an excellent transformer.

The calculated impedance of a transformer where $Z_{oc} = 50$ ohms, $Z_{or} = 100$ ohms and $Z_{oe} = 12.5$ 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 thyatron 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 semicircle² 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

Theorem³, 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_o . If the Z_o branch is closed by the insertion of a voltage equal and opposite to E_o , 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 superposition⁴ 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 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

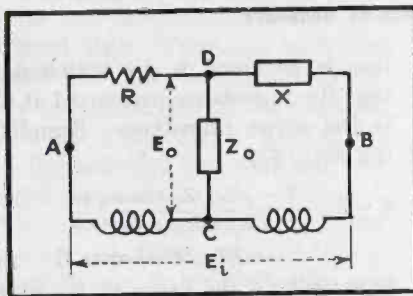


FIG. 1—Typical phase-shifting network in which the voltage applied is E_i and the shifted voltage is E_o . R and X constitute the shifting network. Z_o is the load across the shifted voltage.

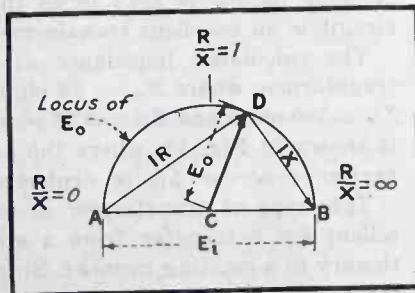


FIG. 2—When the load Z_o in Fig. 1 draws no current, E_o can be made to rotate on a semicircle by varying the ratio of R to X . If this ratio varies from zero to infinity, E_o rotates through 180 degrees

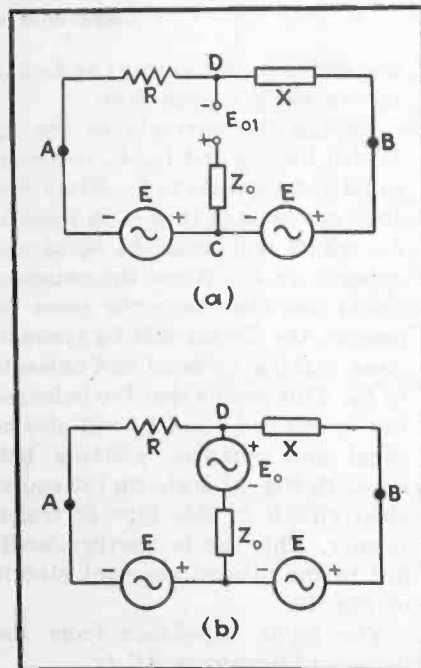


FIG. 3—As a preliminary to developing equivalent circuits, E_i of Fig. 1 is broken into two equal voltages E . If the center branch of Fig. 1 drew no current, it would be equivalent to an open circuit across which E_o appeared as shown at (a), or to a circuit in which there operated an equal but opposite voltage as at (b)

Networks

By P. T. CHIN

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and easily by means of Ohm's Law. Referring to Fig. 4, the correction voltage V_R is

$$V_R = \frac{-E_{o1} \left(\frac{\pm jRX}{R \pm jX} \right)}{Z_o \pm j \frac{RX}{R \pm jX}} \quad (1)$$

Simplifying,

$$V_R = \frac{-E_{o1}}{\frac{Z_o}{R} + \left(1 + \frac{Z_o}{\pm jX} \right)} \quad (2)$$

From Eq. (2) it can be seen that the correction voltage V_R depends on Z_o , $\pm jX$ and on whether R or 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 the method.

When Z_o is purely resistive, $Z_o = R_o$ and Eq. (2) becomes, for this particular case,

$$V_R = \frac{-E_{o1}}{\frac{R_o}{R} + 1 + j \frac{R_o}{X}} \quad (3)$$

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

$$V_R = \frac{-E_{o1}}{\frac{jX_L}{R} + \left(1 - \frac{X_L}{X} \right)} \quad (4)$$

The locus depends upon whether X_L is greater than, equal to, or smaller than X . If $X_L > X$,

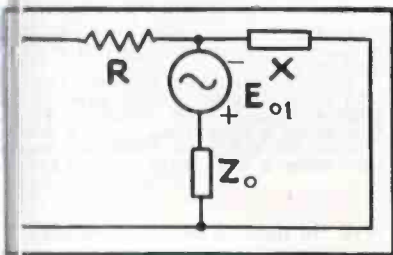


FIG. 4—To account for the current drawn by Z_o , the voltage developed across Z_o by the equivalent voltage E_{o1} must be added vectorially to the voltage whose locus is shown in Fig. 2

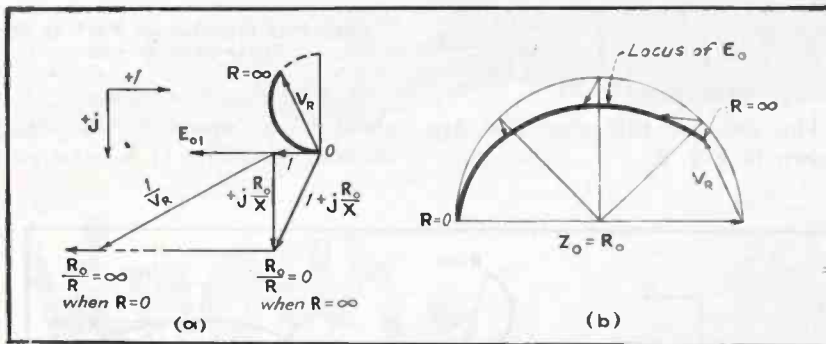


FIG. 5—(a) Vector operations give vector V_R which is the voltage correction to be applied to E_o because of current drawn by Z_o . In this case Z_o is a resistance. (b) V_R from (a) is added to semicircle of Fig. 2 to give locus of E_o .

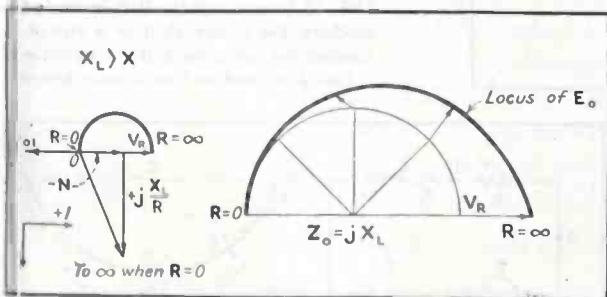


FIG. 6—Similar vector diagram to Fig. 5, but for the condition that Z_o is an inductance larger than X

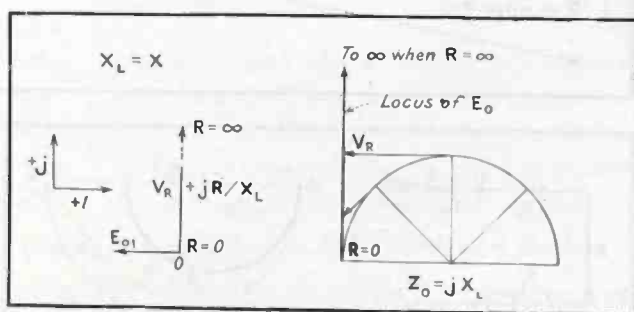


FIG. 7—This figure, Fig. 6 and 8 comprise a series showing effect of varying an inductive Z_o relative to a capacitive X

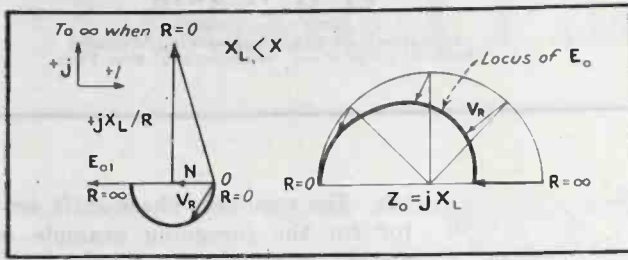


FIG. 8—In all the cases illustrated, X of Fig. 1 is a capacitance. The internal impedance of the driving voltage E_i is neglected

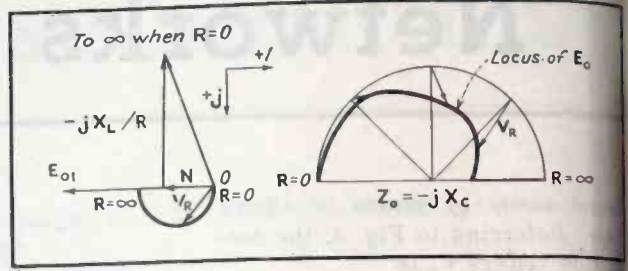


FIG. 9—If Z_o is a capacitance, complete 180-degree phase shift is possible, but there is amplitude variation

$$V_R = \frac{-E_{o1}}{\frac{jX_L}{R} + \left(1 - \frac{X_L}{X}\right)} = \frac{-E_{o1}}{N + \frac{jX_L}{R}} \quad (5)$$

where

$$N = 1 - X_L/X$$

The locus of V_R and the resultant locus of E_o are shown in Fig. 6.

If $X_L = X$

$$V_R = \frac{-E_{o1}}{\frac{jX_L}{R} + \left(1 - \frac{X_L}{X}\right)} = \frac{-E_{o1}}{\frac{jX_L}{R} + jR\frac{E_{o1}}{X_L}} \quad (6)$$

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 $X_L < X$

$$V_R = \frac{-E_{o1}}{\frac{jX_L}{R} + \left(1 - \frac{X_L}{X}\right)} = \frac{-E_{o1}}{N + \frac{jX_L}{R}} \quad (7)$$

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

$$V_R = \frac{-E_{o1}}{-\frac{jX_c}{R} + \left(1 + \frac{X_c}{X}\right)} = \frac{-E_{o1}}{N - \frac{jX_c}{R}} \quad (8)$$

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

$$V_R = \frac{-E_{o1}}{\frac{R_o + jX_L}{R} + \left(1 + \frac{R_o + jX_L}{-jX}\right)} = \frac{-E_{o1}}{N + jM + \frac{R_o + jX_L}{R}} \quad (9)$$

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 semi-

circle (due to coil resistance) when there is no load between points C and D of Fig. 1. If the internal resistance R_o is separated from the reactance $+jX$ and combined with R , the locus of point E in Fig. 1 will fall on the original semicircle. If R and R_o are constant, and the phase shifting is obtained by varying inductance, the voltage across AD and DE will be in the ratio of $R : (R + R_o)$. It can be seen that the diameter of D is $V_R \cdot R / (R + R_o)$ and its center is $V_R \cdot R_o / 2(R + R_o)$ 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 $R_o : R$ 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, 469-471.
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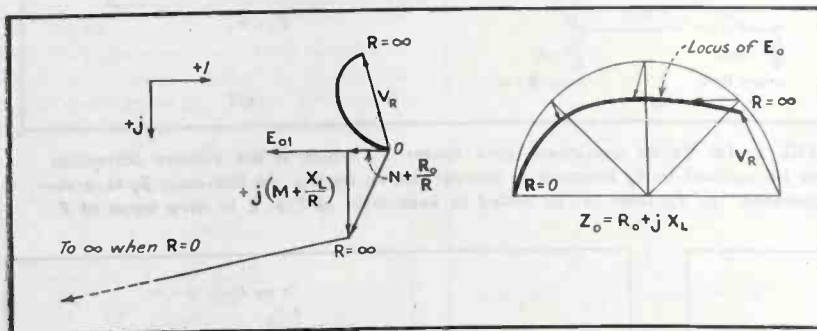
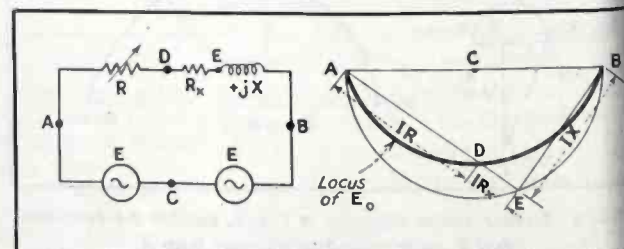
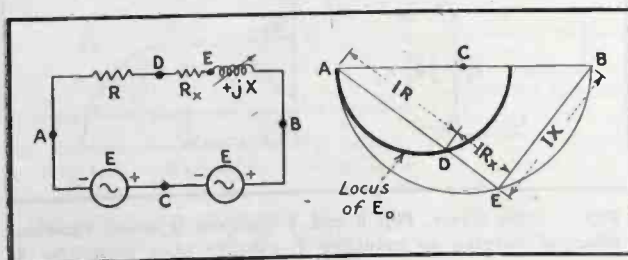


FIG. 10 (left)—Analysis of an inductor having internal resistance

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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INDUSTRIAL CONTROL

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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.

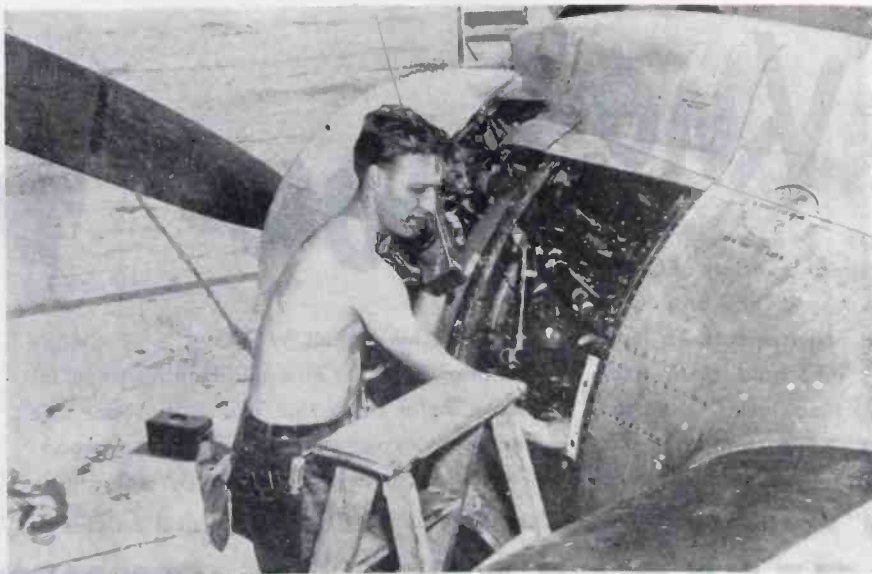
Outside telephone communications were provided by the Douglas f-m two-way Motorola police radio-telephone system. Messages were transmitted by radio over the police system to a Douglas patrol car, parked in front of the Park Ridge telephone exchange three miles away, then relayed over the regular telephone wires.

The original handie-talkie was developed by Donald Henry



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

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



At a Douglas hangar, N. Berkshire reports the condition of a plane motor with a Motorola handie-talkie borrowed from the Signal Corps

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.

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.

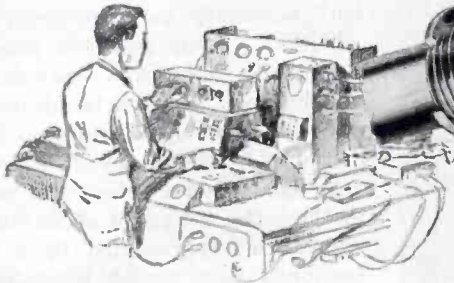
Industrial X-Ray of Ammunition in Ordnance Plant

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.

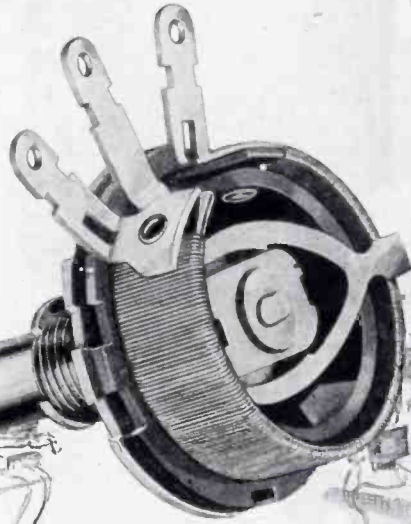
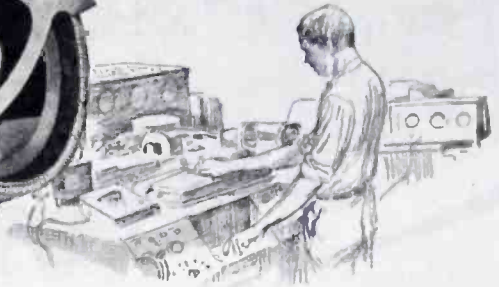
When it became apparent that x-ray could do an unprecedented inspection job more economically than previous methods, three million-volt industrial x-ray units were purchased by the Ordnance Depart-

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**NEW MALLORY TYPE "CA"
VARIABLE RESISTOR**

Insulated contact arm. Dissipates 2 watts. Total rotation, 280°. Effective electrical rotation, 270°. Diameter, 1½ inches.



**MALLORY TYPE "E"
VARIABLE RESISTOR**

Grounded contact arm. Dissipates 9 watts. Total rotation, 310°. Effective electrical rotation, 299°. Diameter, 2¾ inches.

In the host of electrical and electronic devices for communications, industries and laboratories, Mallory Rheostats and Potentiometers are setting impressive records for accuracy and dependability. This Mallory Type "CA" Variable Resistor is a new member of that group.

Available in single or dual units, with or without switch, and in resistance values up to 20,000 ohms, it is designed for use either as a series variable element (rheostat) or as a potential divider (potentiometer). Allowable power dissipation is approximately 2 watts with the control set at its maximum resistance value. For intermediate points of rotation, the dissipation in watts decreases—the amount depending upon the taper of the resistor element and the rotational setting of the control.

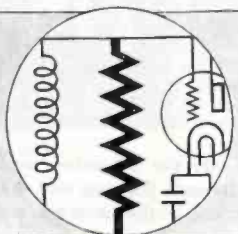
In light dimming applications, the characteristic of the incandescent lamp filaments must also be taken into consideration. Where this is a factor, complete details should be submitted for recommendation. In fact, wherever a special resistor problem arises, Mallory engineers are ready to give you prompt assistance and service.

For standard units consult your nearest Mallory Distributor.

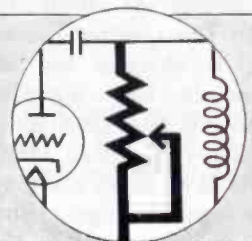


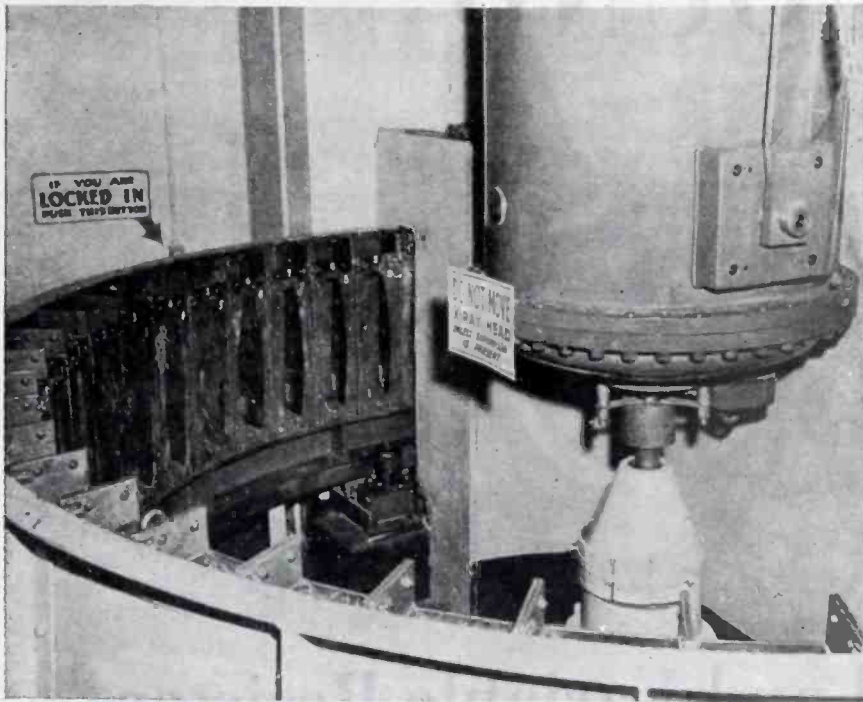
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MALLORY
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RESISTORS





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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Here is an inside picture of a piece of equipment housed in—and completely supported by Lindsay Structure.

Note that the housing supports coils, switches, motors—all the heavy equipment that goes into the unit. No additional supporting structure of any kind is required. There are two important advantages:

It saves weight. Ls is the improved method of light sheet steel construction that utilizes the great strength of light sheet metal. The resulting unit is light, and yet has amazing strength and rigidity—there are no flimsy rattling parts.

It saves space—the second important feature of Lindsay Structure. No space lost for superstructure. Lindsay Structure cabinets are available in any desired dimension.

Furthermore, you can tool up quickly for Ls production. No special machinery, no delay, no welding, no riveting, no waste. Only ordinary tools are needed. Investigate Ls today. Lindsay and Lindsay, 222-D W. Adams Street, Chicago 6, Illinois; or 60 East 42nd Street, New York 17, New York; Lindsay Structure (Canada) Ltd., Dominion Square Bldg., Montreal.

NOTE:
Entire mechanism is supported by the thin sheet metal panels of Lindsay Structure. Makes for compact efficient arrangement.

NOTE:
A 36-inch sheet of 24 gauge steel under uniform tension possesses greater strength than a 1-inch steel rod. Ls easily supports heavy loads.

NOTE:
Smooth, trim finish of Ls cabinet.

Easy to assemble

strong and rigid is Ls that an Ls originally intended for support. It sags below this Ls housing though it bore the added weight of men.

Ls
REG. U. S. PAT. OFF.

LINDSAY STRUCTURE

Patents 2017629, 2263510, 2263511
and 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.

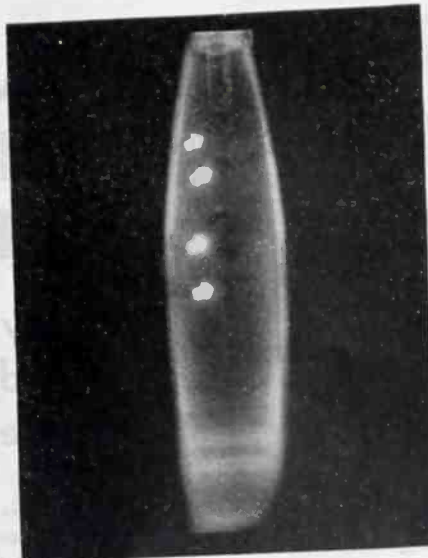
The shell and loaded cassette enter the exposure room on the motorized ring by passing through an aperture in the concrete wall. Within the room, the x-ray radiation produces a radiographic image of the shell and its contents on the film. With one-half of the ring extending outside the exposure room, 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-

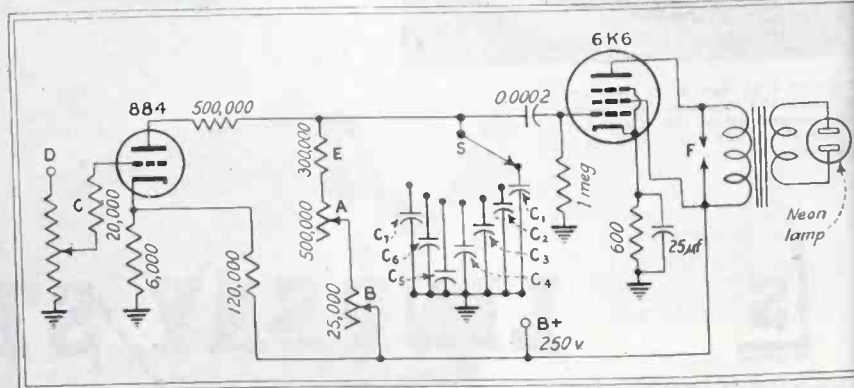


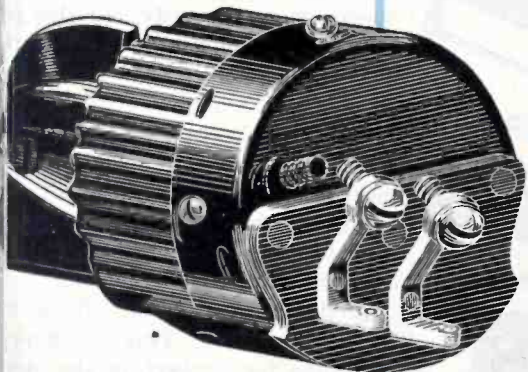
FIG. 1—Circuit diagram of a simple stroboscope using a neon lamp for the flashing element

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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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THE 'DP' CONNECTORS
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AND MANY NEW
DESIGNS ARE COMING

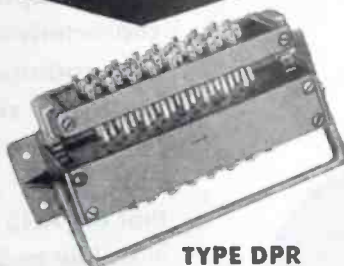
NEW applications of the exclusive Cannon Electric "DP" series of connectors have recently been extended from rack equipment in radio assembly to such uses as special centralized aircraft control on through to signal relay equipment.

Several new "DP" connectors of strikingly new design will be released in 1945—testimony to the progressive engineering Cannon Electric incorporates into its products. Since Cannon Electric pioneered the aircraft electrical connector in 1932, this development process has gone steadily onward. Cannon is prepared to meet the demands of postwar electrical equipment.

Cannon Type DP Connectors cover a variety of rack, panel and bail-type fittings, carrying from eight to 135 circuits with amperage range from 10, 15, 30 and 40 in many varied arrangements, including coaxial contacts.

All these and many other high quality electrical connectors are Cannon designed and manufactured.

For detailed engineering data on Type DP Connectors refer to the Cannon DP Bulletin. Write to Department A-120, Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, California.



TYPE DPR



TYPE DP-30



TYPE DP-D



TYPE DP-P10

CANNON ELECTRIC

Cannon Electric Development Co., Los Angeles 31, Calif.

Canadian Factory and Engineering Office:
Cannon Electric Company, Limited, Toronto



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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 shown 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

Rauland VISITRON Phototubes

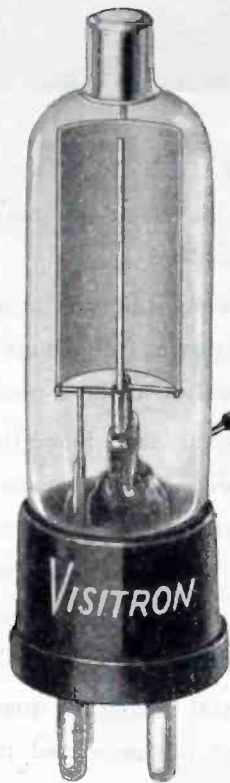
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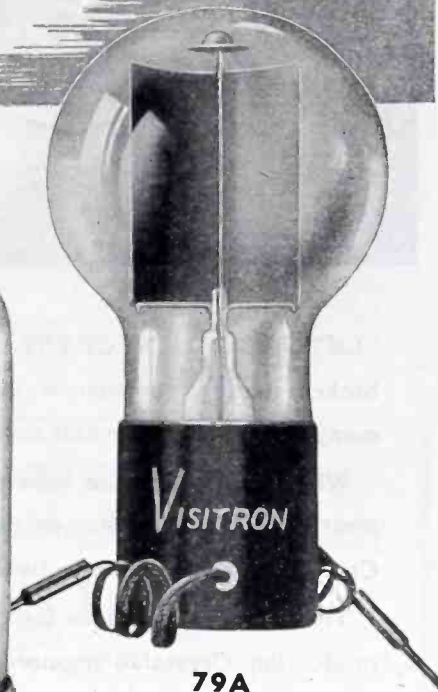
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59TA



79A

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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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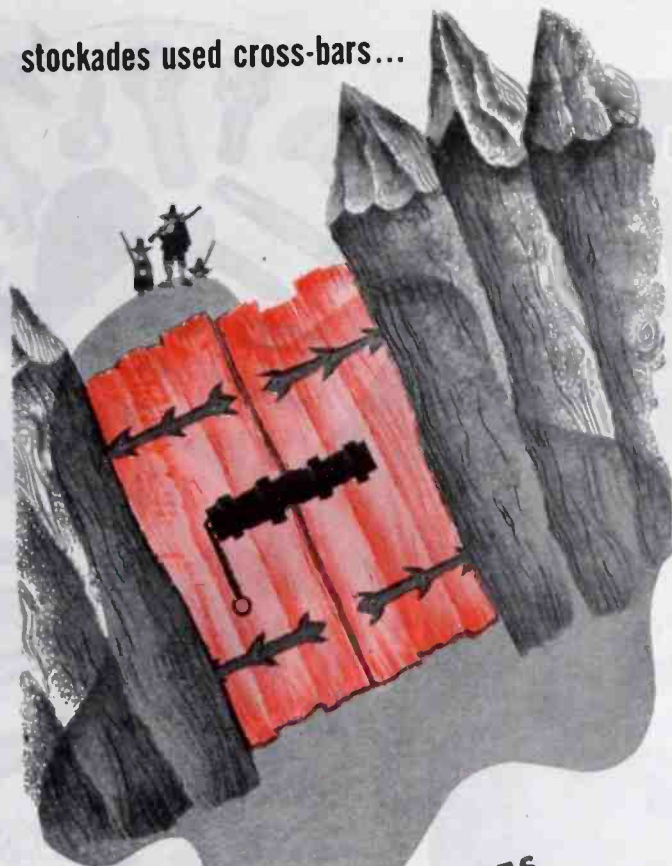
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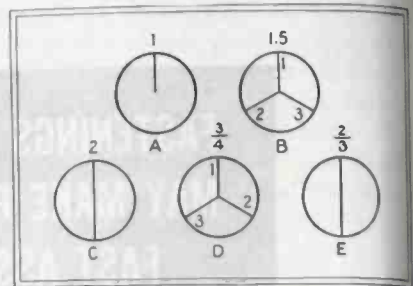


FIG. 2—Appearance of patterns of a single spoke painted on a rotating disk when illuminated by a stroboscope lamp at the indicated frequency ratios

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 — $(\frac{4}{3}) = 0.25$, 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 illuminated

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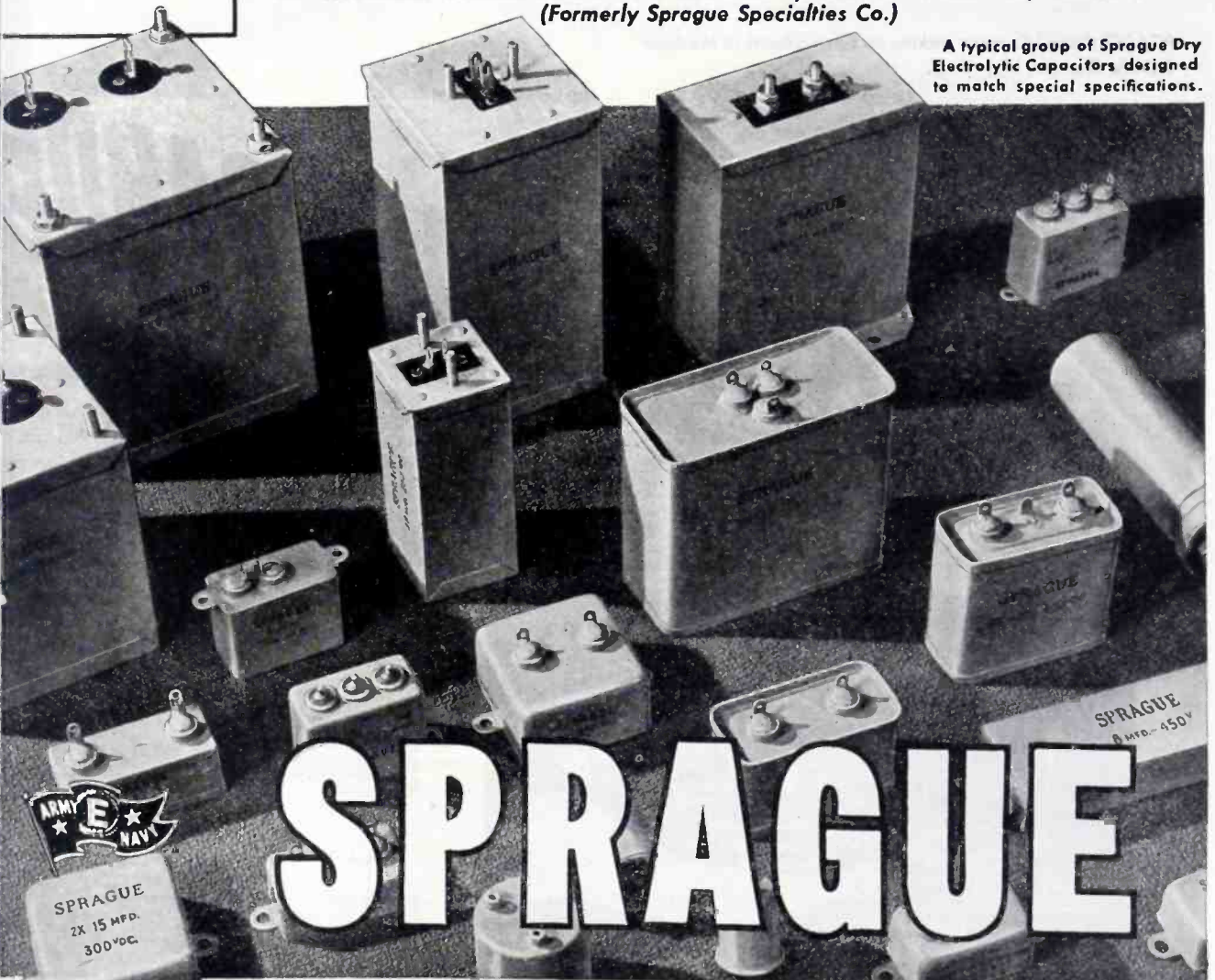
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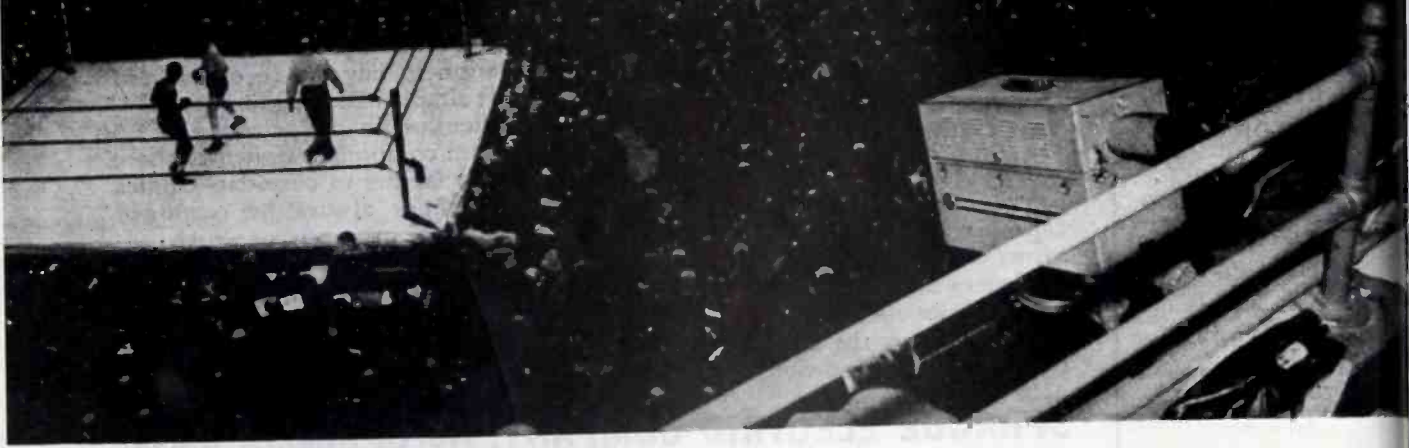
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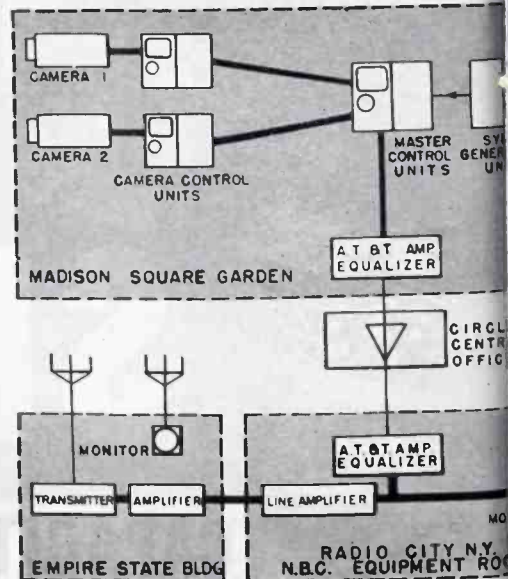
RCA "Orthicon" Camera picking up boxing bouts at Madison Square Garden, New York.

MADISON SQUARE GARDEN

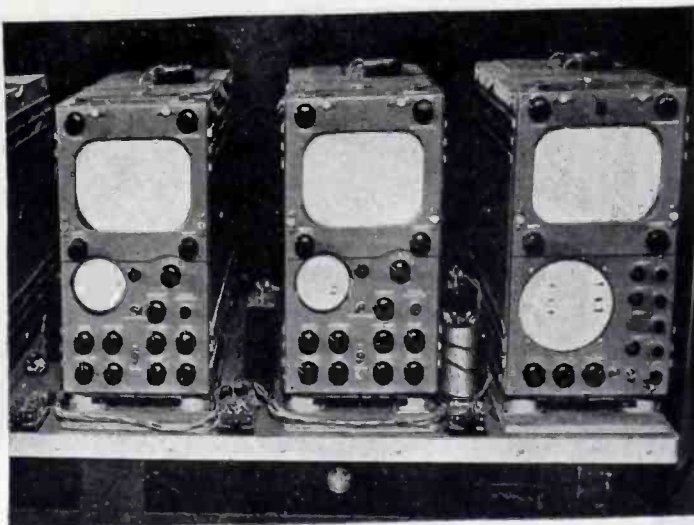
Using RCA Television Field Pickup Equipment is relatively easy. Units are arranged as shown in diagram. Video and audio output are fed over an ordinary telephone line (especially equalized) to Radio City, a mile away.



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.

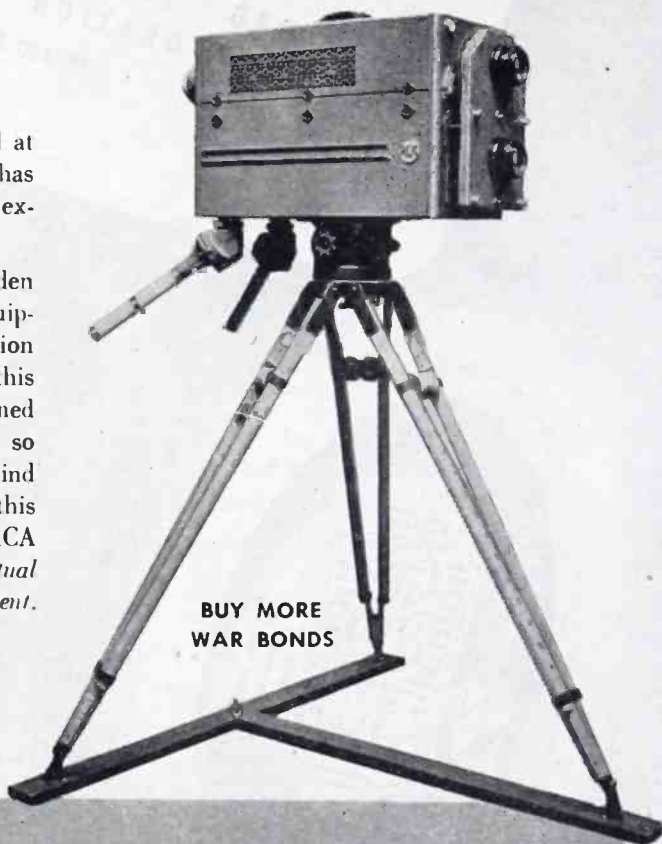


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These broadcasts are picked up at Madison Square Garden by NBC, using RCA's standard Television Field Pickup Equipment, and are put on the air through NBC's Television Station WNBT. Some idea of the advanced design of this equipment and the ease with 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.

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.



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S/R	L	Relative Brightness (= 1/L)					
		1	0.5	0.33	0.25	0.2	0.167
1/8	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
5/8	0.83						5
1/1	1	1					
7/8	1.17						
6/5	1.2						6
5/4	1.25				5		
4/3	1.33			4			
7/6	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			
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

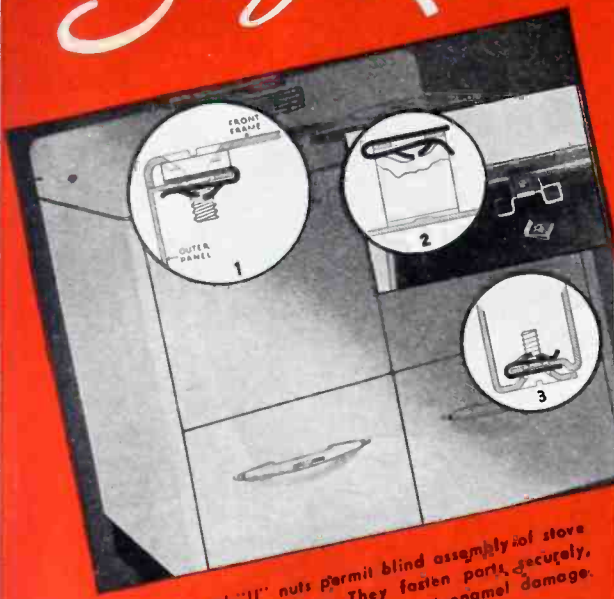
once for each revolution of the disk for a brightness of 0.167, $R = 6$ and each position of the spoke is illuminated only once in six revolutions. Corresponding to each degree of brightness in the table is the number of spokes seen in the patterns at that brightness and on the same horizontal line is 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

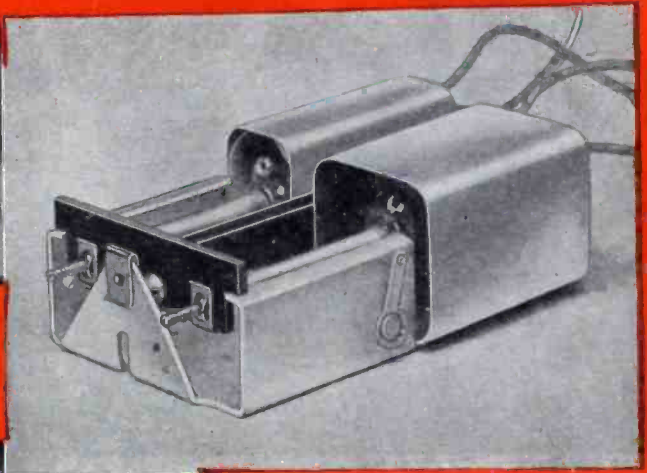
This table can be used in determining the speed of revolution of a machine when it is not even known approximately. For example, when only one spoke is seen, the frequency per second at which the lamp

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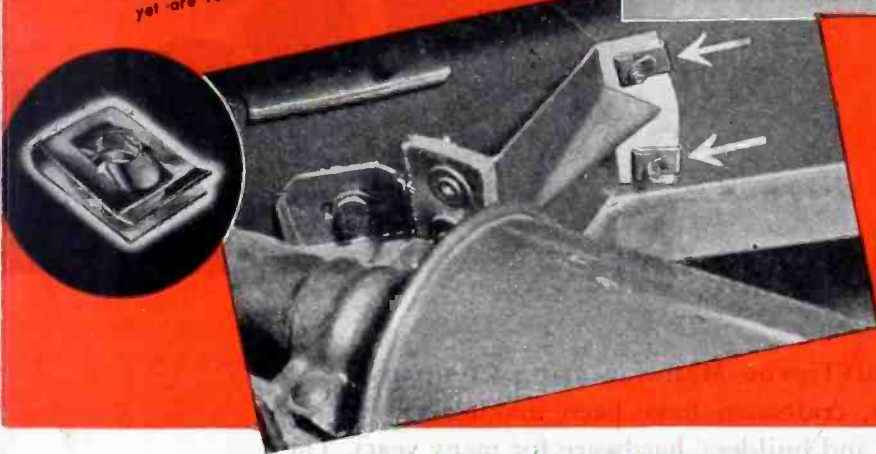
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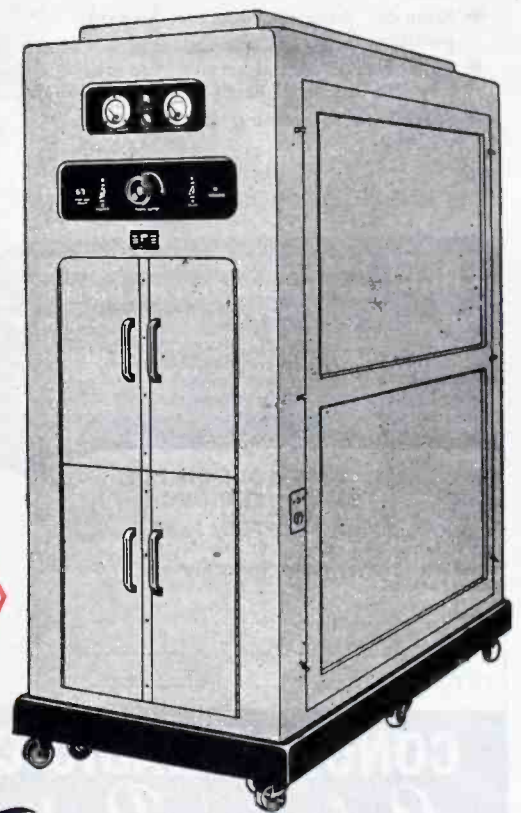
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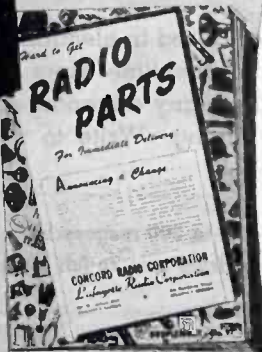
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is flashing may be equal to the revolutions per second or it may be only 0.5, 0.33, or 0.25 of this value (or even less, although such patterns will be quite dim). If the lamp frequency is equal to the revolutions, the pattern will be quite bright 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.

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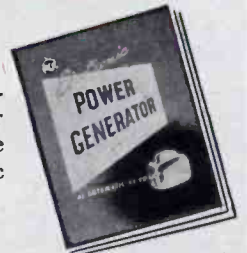
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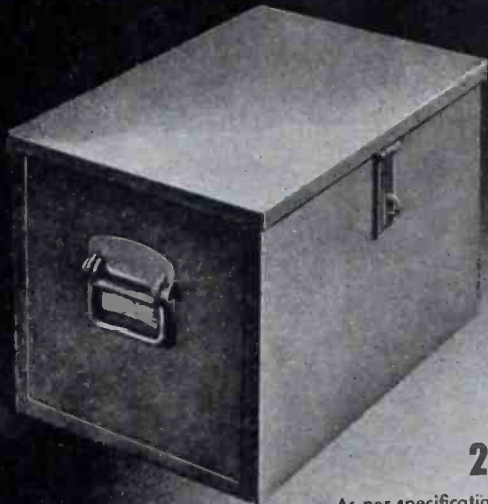
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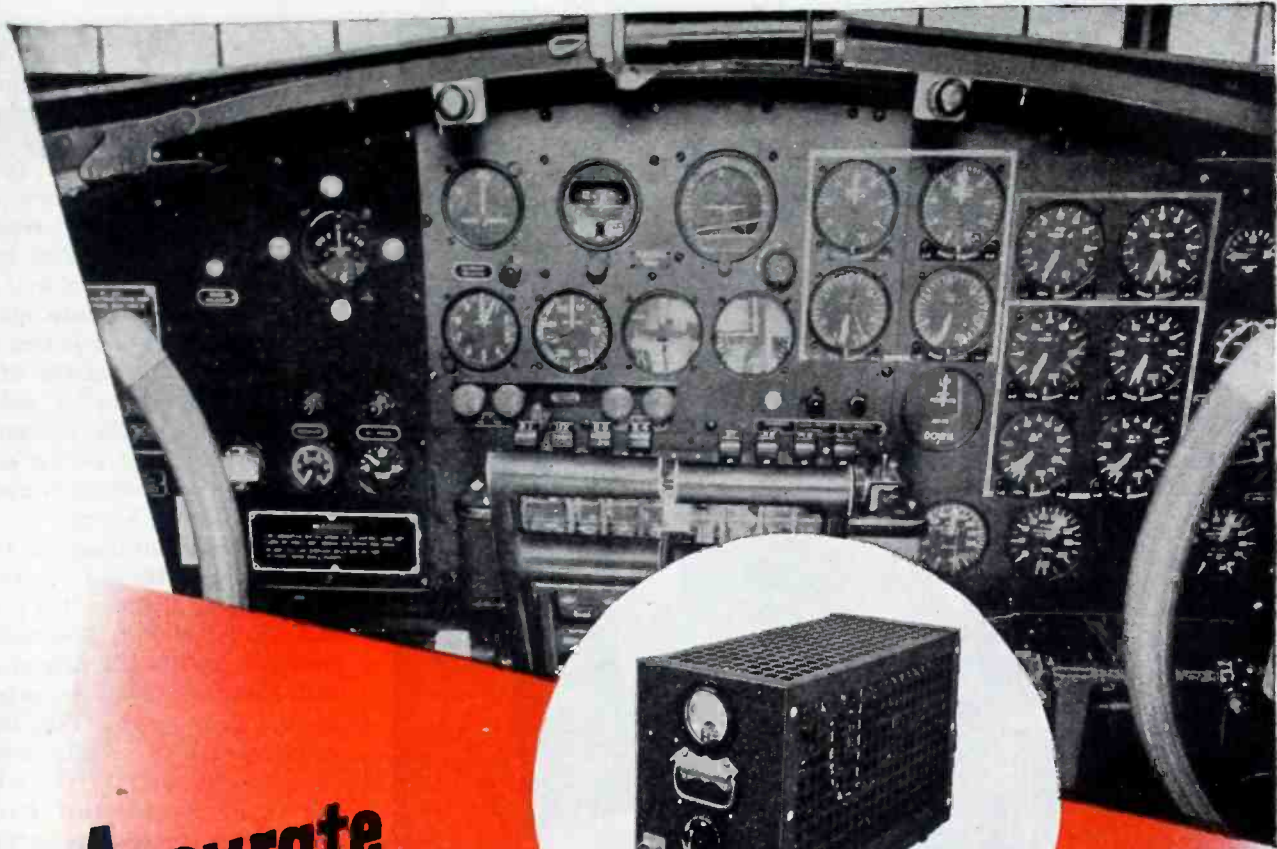


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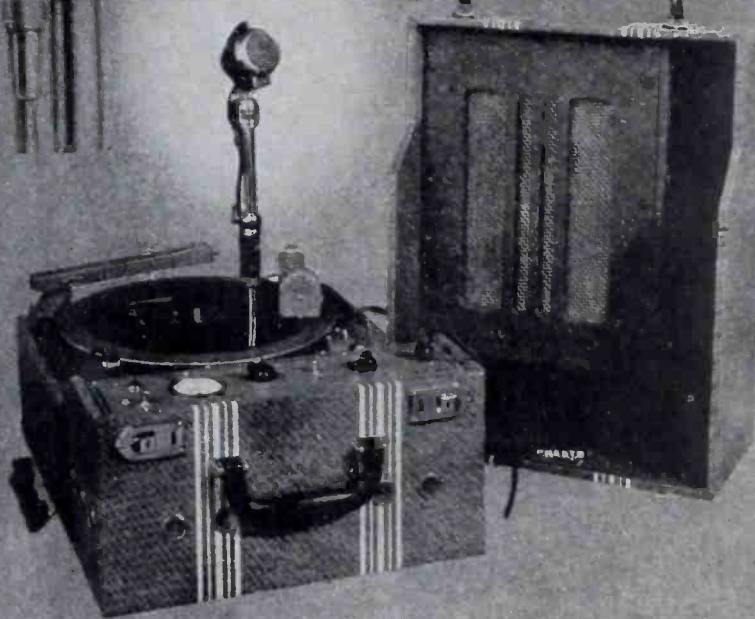
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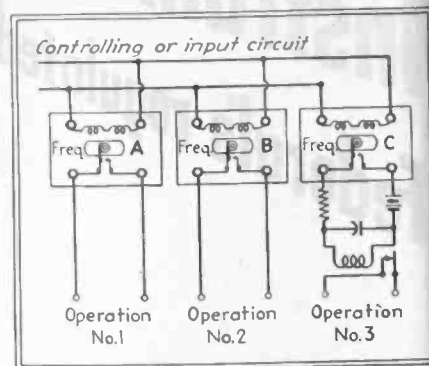
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current pulses of constant amplitude and frequency are impressed upon the system, only that relay will respond which is adjusted to the corresponding frequency. In practice, the constant frequency at the control point is obtained from contactors which 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.

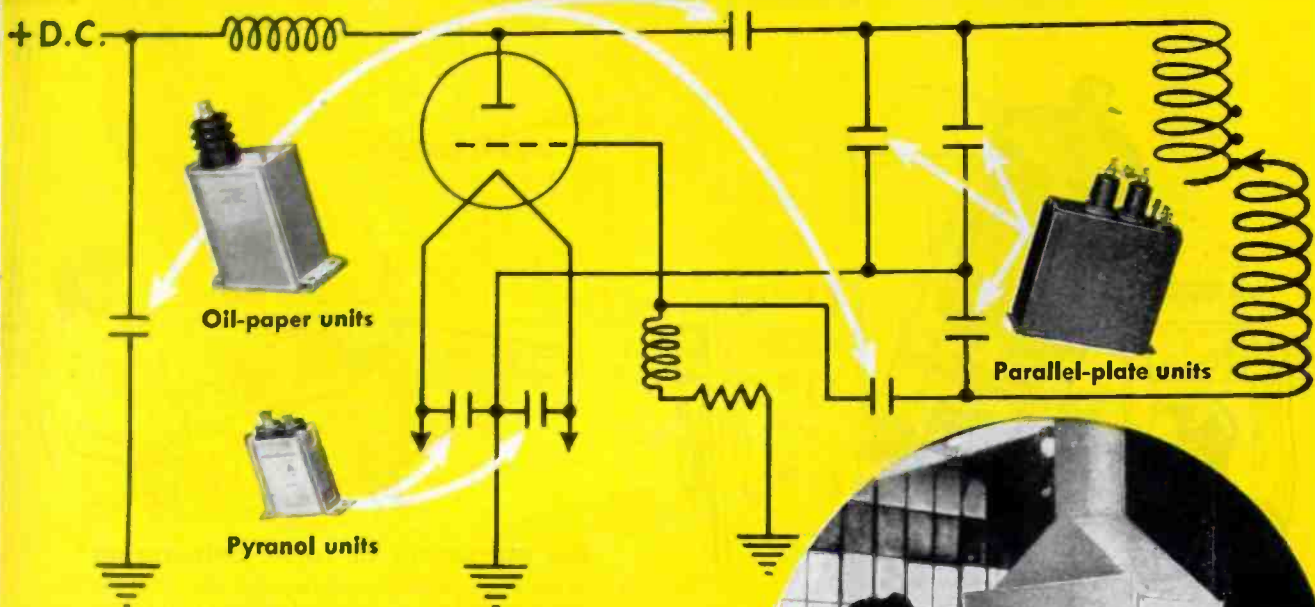
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plitude of the oscillation equals or exceeds 90 deg and is approximately equiangular 45 deg from the static position. As contact is periodic at the resonant frequency of the relay instead of continuous, it is necessary to use an auxiliary d-c relay 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

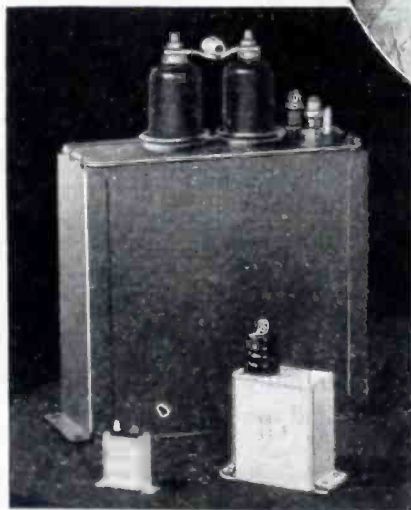
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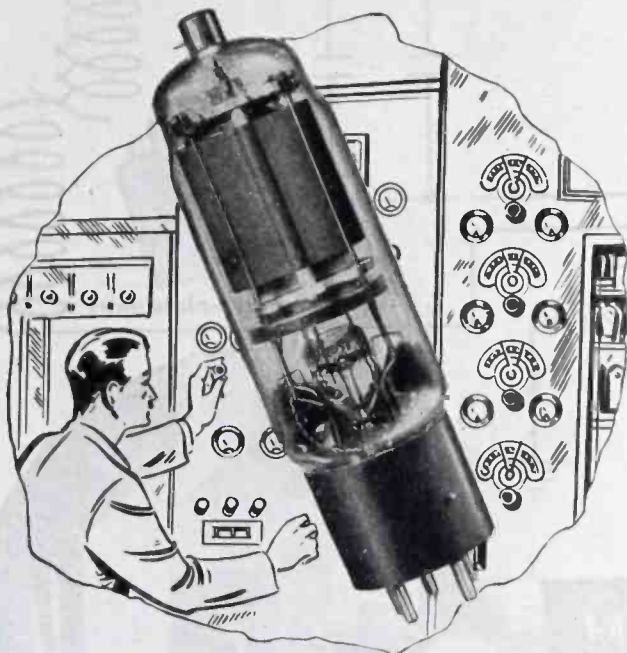
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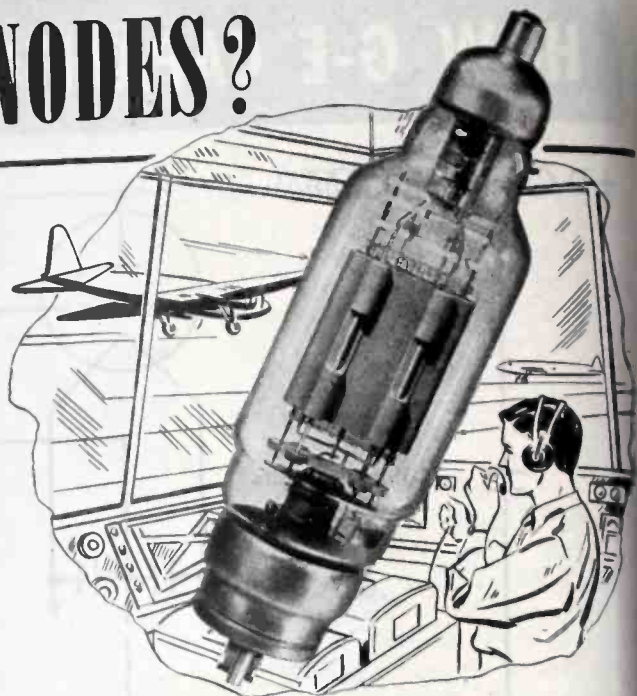
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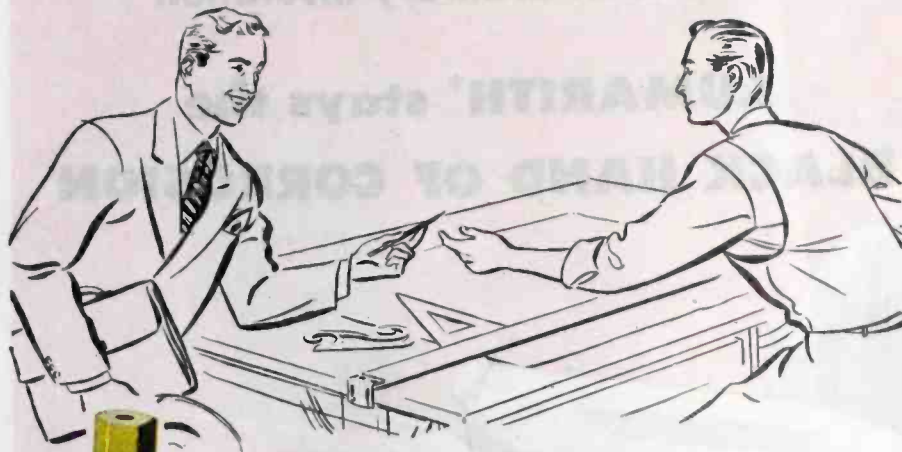
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Check up *now*, while your plans are still in process. Choose fastenings as carefully as you settle any other factor of design. Make sure you are using the *short cut fastening method* - Parker-Kalon Self-tapping Screws - wherever possible.

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.

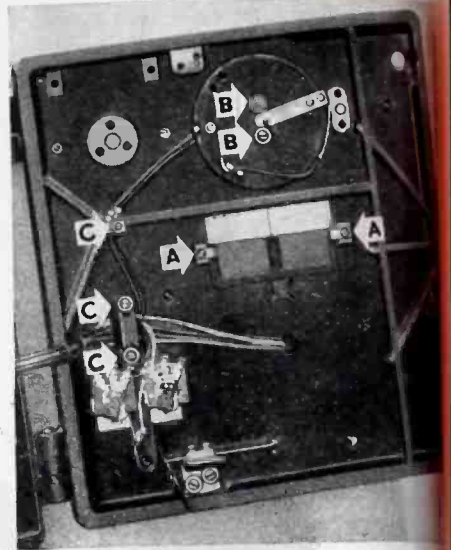
USER'S GUIDE - FREE! P-K "Users' Guide" describes all types of Parker-Kalon Self-tapping Screws and tells where to use them. Designers and assembly planners need this important information. Write for a copy.

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.



For Every Metal and Plastic Assembly



Will "Blind Fastenings" boost your parts breakage?

Heres' how Tagliabue licked this "bug" and speeded production

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P-K Type "Z" Screws are used (A) to attach steel clips fastening window to plastic door; (B) to fasten plastic rheostat disc to door; (C) to attach steel clamps holding wire to door. The screws form their own strong threads as they are turned into plain holes. One easy operation makes a fastening.

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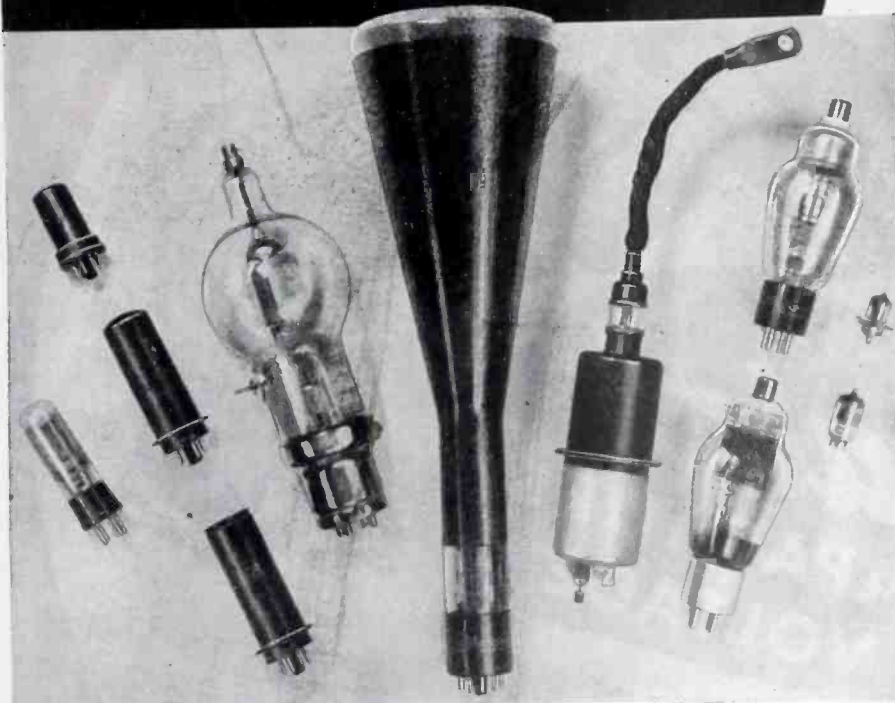
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cathode resistance. Due to the small magnitude of the current expected in the usual applications, it is absolutely necessary that none of the minute quantities of current be absorbed in surface leakage. Therefore, every precaution has been taken to 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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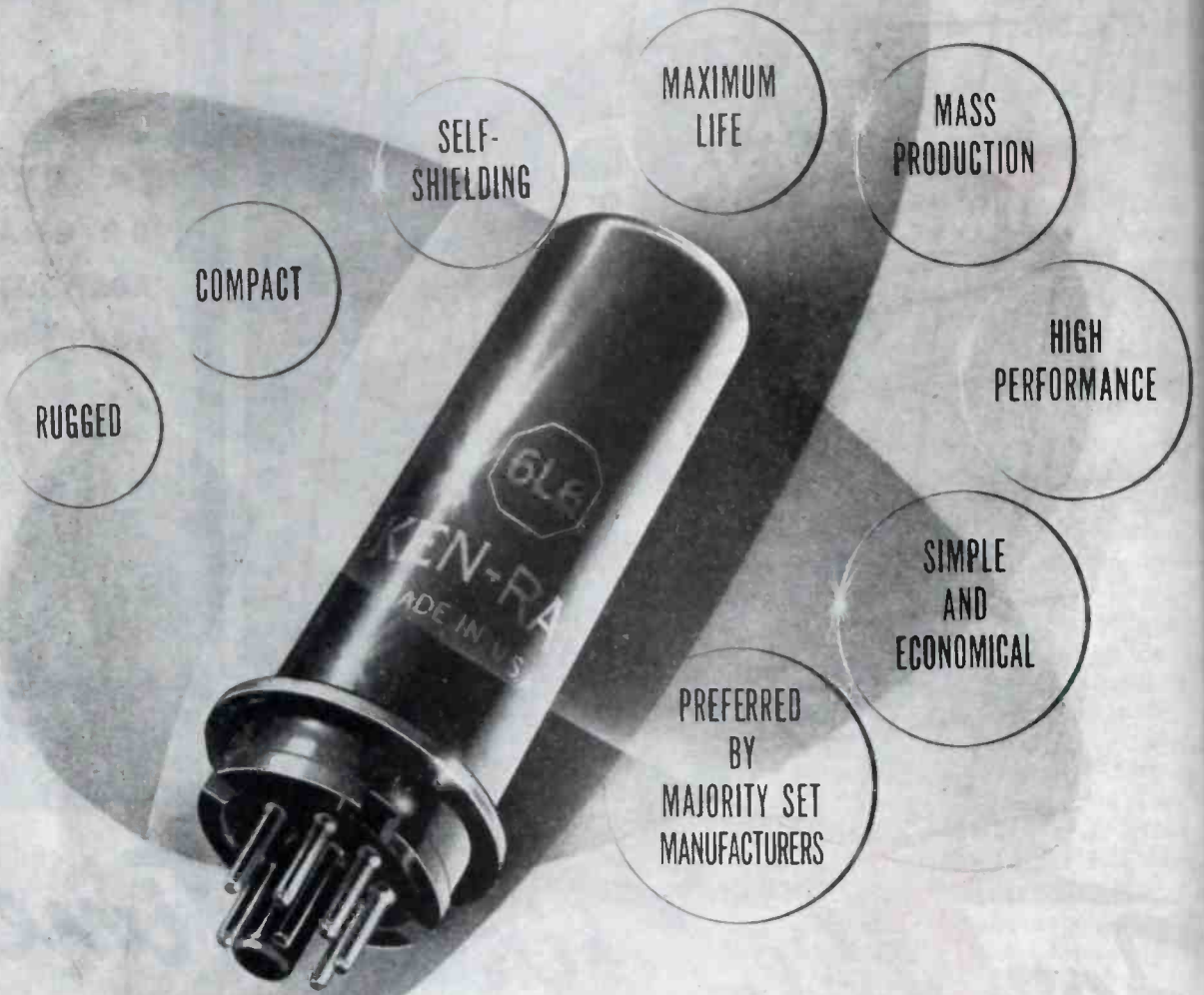
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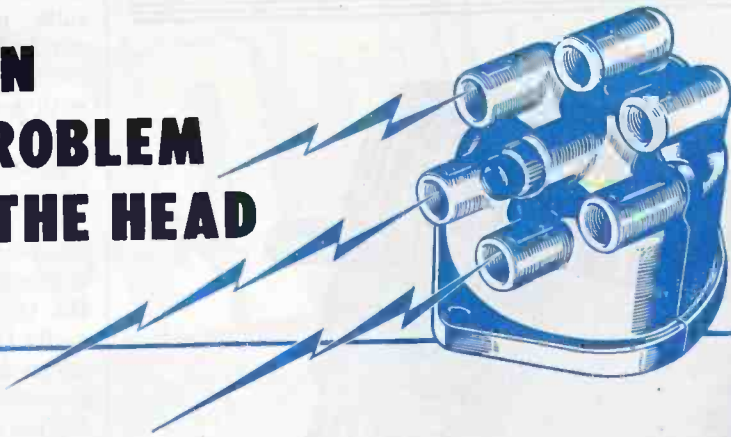
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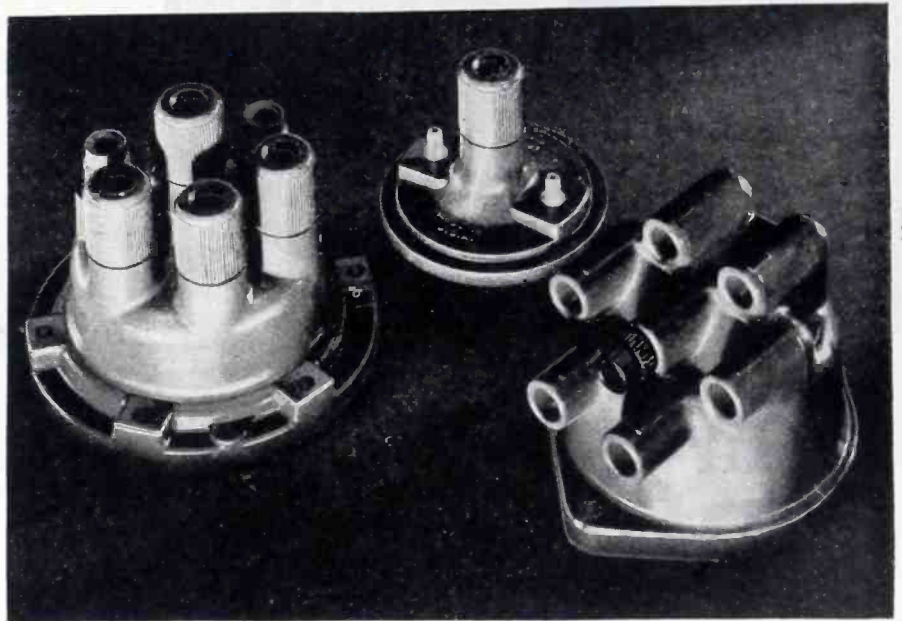
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A major problem confronting today's designer of electrical products is the proper selection of material for use where wide temperature variations occur frequently as in automotive ignition distributor parts. The unusually rigid requirements for dielectric strength and heat resistance in these items call for a plastic compound of extraordinary capability.

For the ignition parts illustrated at left, 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 coefficient of expansion, good moisture resistance and low shrinkage which reduces stress around inserts and renders the finished parts less susceptible to cracking. *This particular compound is mineral-filled and possesses far better arc-resisting qualities than the usual wood-flour-filled material.*

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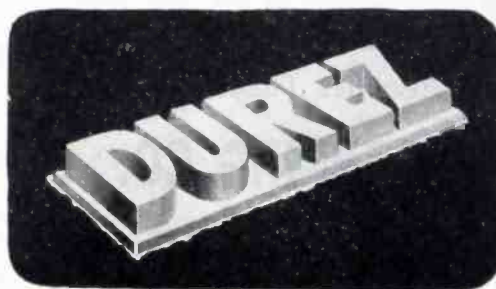


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tric field also makes consistent results practically impossible. To eliminate this condition, a small piece of spring wire is mounted with a slight pressure against the inner wall of the glass bulb. The connection is then brought out to a base pin 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-

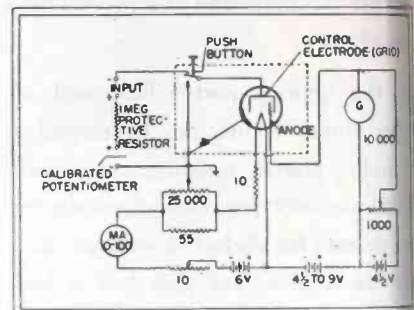


FIG. 1—Circuit of an electrometer using the inverted triode for high sensitivity

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

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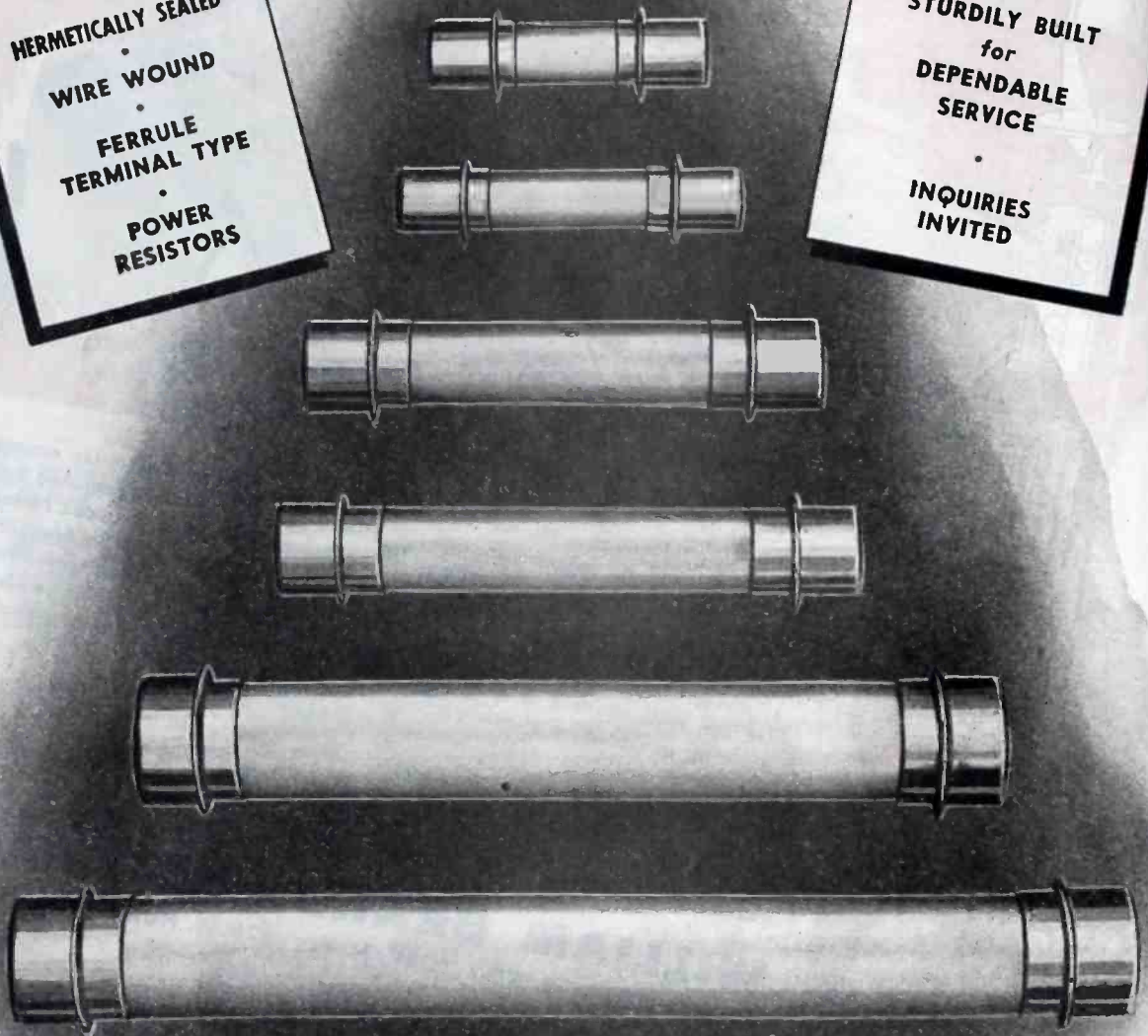
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Bristo: Key exerts inward pressure; no danger of rounding out or breaking socket wall.

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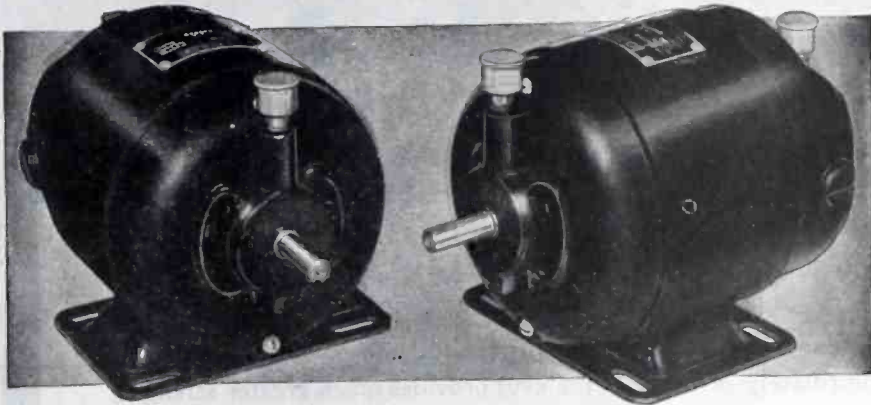
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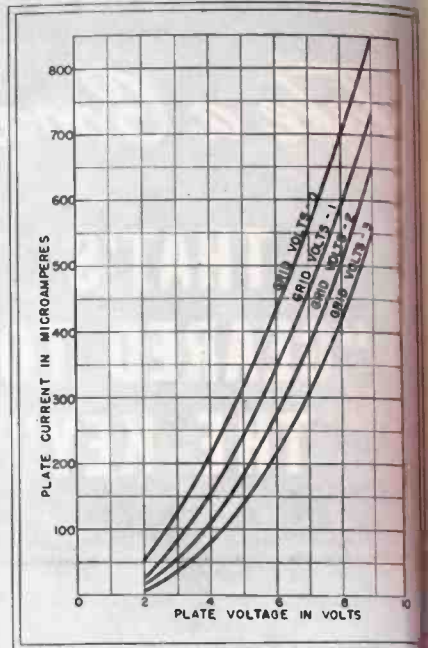


FIG. 2—Average characteristic plate current curves for the inverted triode.

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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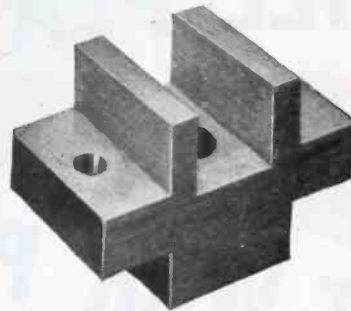
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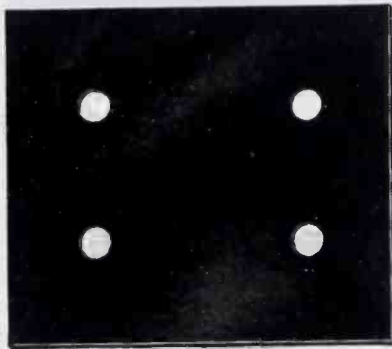
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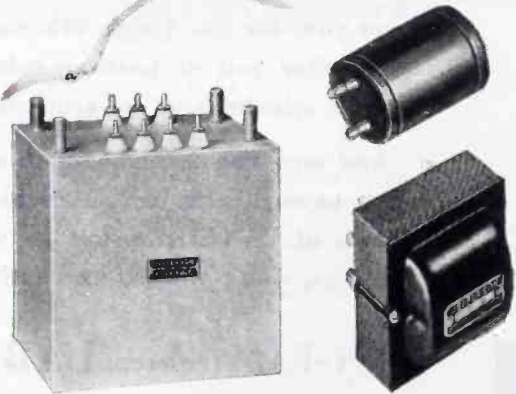


When the guns are racked . . .

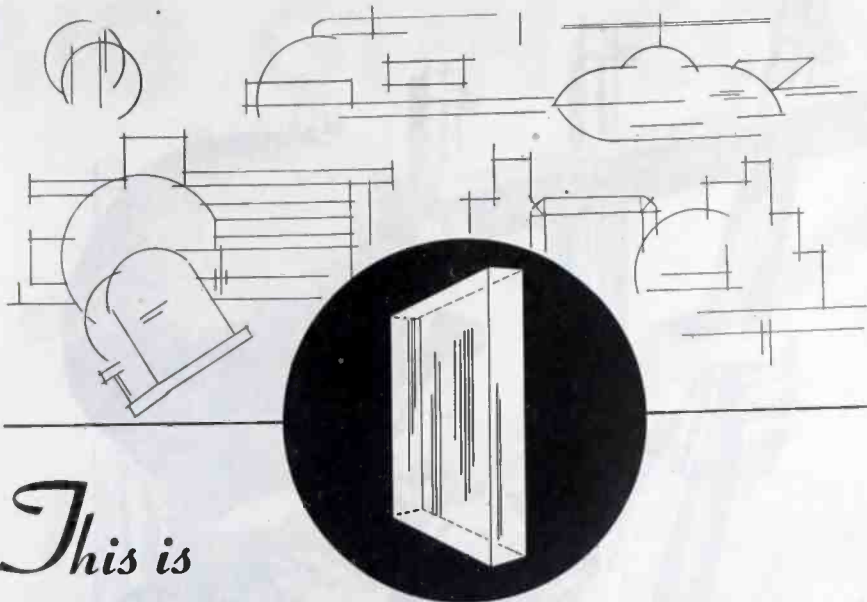
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shown in Fig. 2 represent average values, although individual tubes should not vary greatly from the average.

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

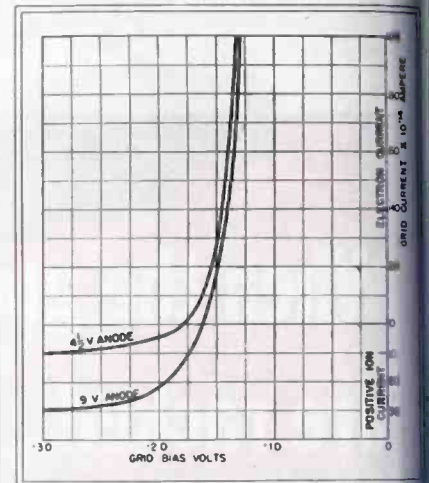


FIG. 3—Average characteristic grid current curves for the new tube show the possibility of selecting a value of grid bias that permits zero grid current

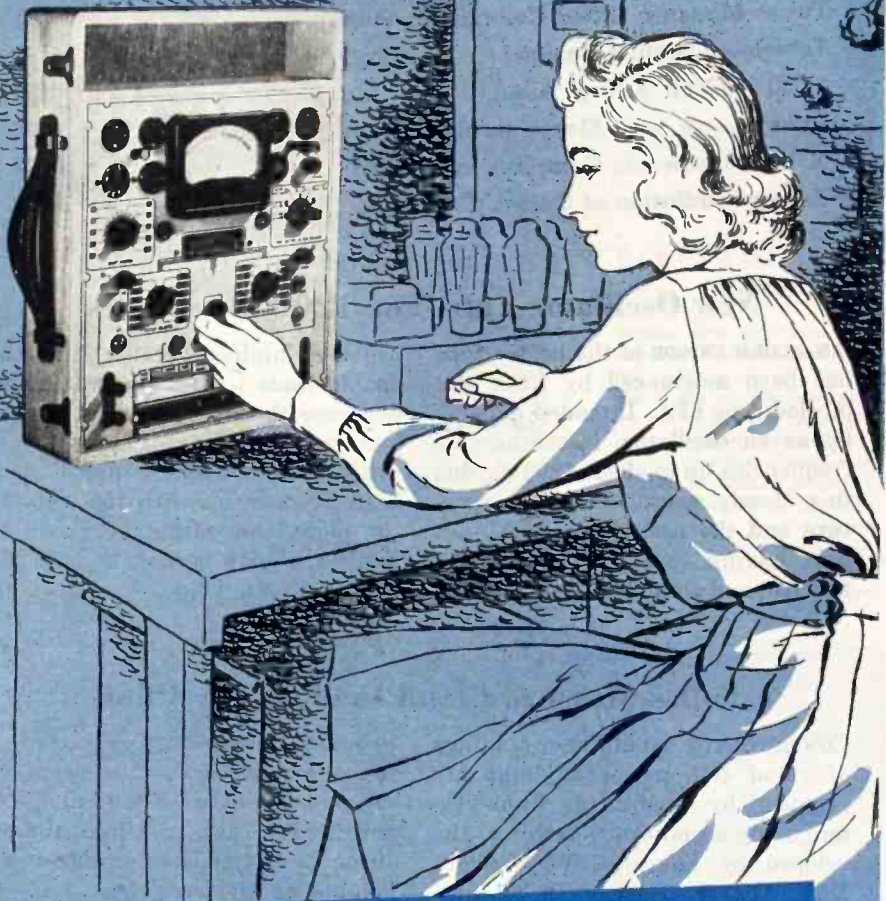
zero; hence, extremely minute currents can be measured accurately. By adjusting the grid bias so that the grid current is zero it has been found practical to measure grid currents as low as 10^{-14} ampere to obtain indications of grid currents as low as 10^{-16} ampere. By providing a bias adjustment 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

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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 permeance 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



Electronic equipment of the Novalux ceilometer. The scanning drum may be operated by a hand crank at the side

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.

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 standard equipment will be required.

Austin engineers also exhibited their design for a two-studio 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 clear view of both studios. Active

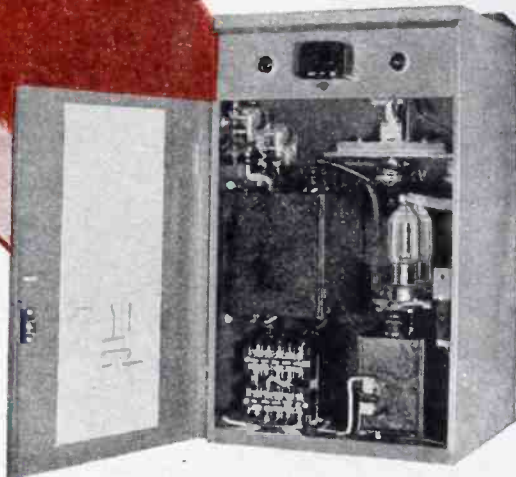
wherever a tube is used...

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



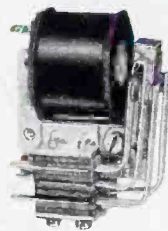
THERE'S A JOB FOR *Relays* BY **GUARDIAN**

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 $12\frac{1}{2}$ 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

1625-P W. WALNUT STREET

CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

Differences of Opinion

... provide the many functional advantages of E-E Electronic Tubes.

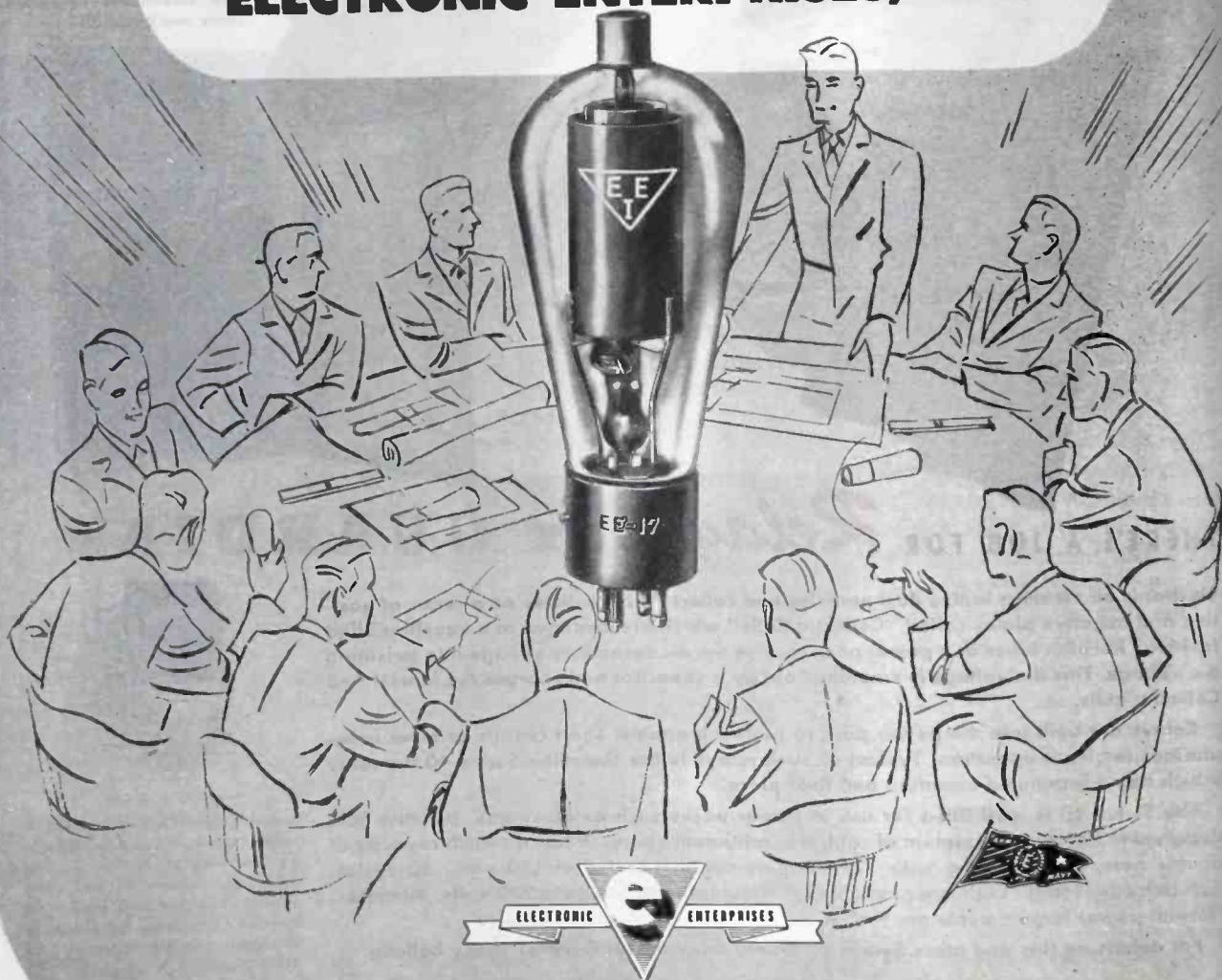
Quite another thing is to endeavor consistently to make a good product better. E-E engineers and research technicians—since the inception of the organization—have adopted a policy of round table discussions. Executive and employee alike have their say at these open forums.

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.

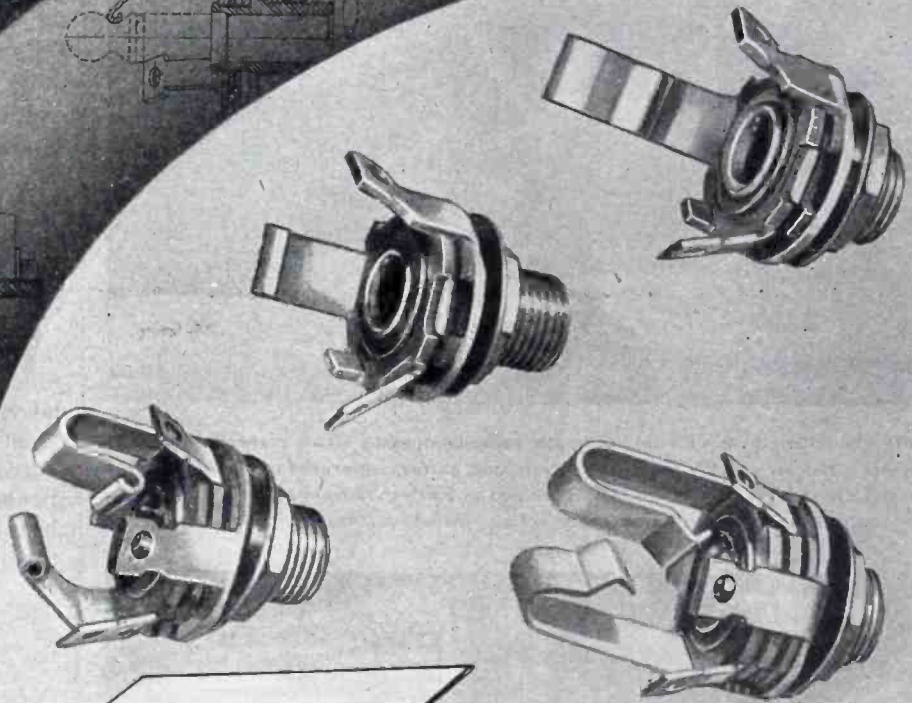
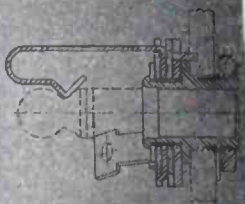
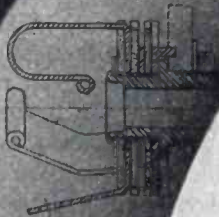
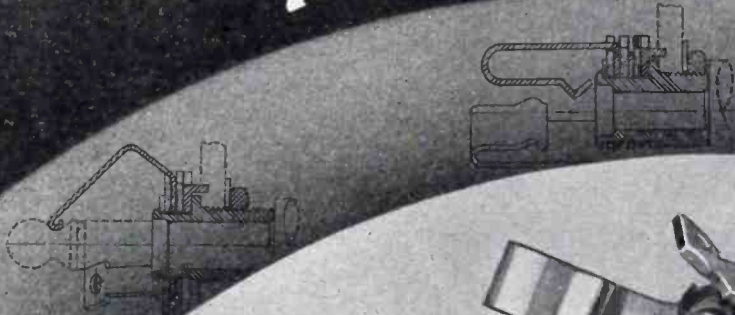
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Specifications

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.

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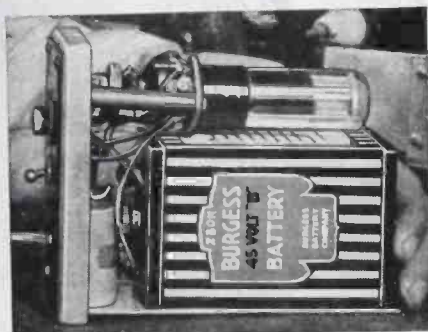
Manufacturers of **SOCKETS, TERMINAL ASSEMBLIES, JACKS AND CONNECTORS** for use in every field of electronics.

PORTABLE POWER PROBLEMS

THIS MONTH—EASTERN AIR LINES' RADIO COMPASS TEST UNIT



ACCURATE PRE-FLIGHT tests of vital automatic radio compasses on all planes operated by Eastern Air Lines are quickly made with a portable, battery-operated oscillator unit. The time-saving, dependable instrument was developed by Eastern radio engineers, who selected Burgess Batteries to provide the necessary voltage for test readings.



THE OSCILLATOR UNIT is not influenced by external conditions, permitting service technicians to check for dangerous radio compass defects while aircraft are inside hangers or close to metal objects, long before plane departure time. Burgess Industrial Batteries are designed to meet the requirements of exacting special applications. Let Burgess engineers help you solve your portable power problems. Write us today about your specific needs, or send coupon for free Engineering Manual. Burgess Battery Company, Freeport, Illinois.

FREE . . . 80-PAGE ENGINEERING MANUAL!

31 descriptive pages, 25 charts and 36 data tables on dry battery characteristics for electronic applications. Tabbed for ready reference. Write Dept. 9 for your free copy. Burgess Battery Company, Freeport, Ill.

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BURGESS BATTERIES

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

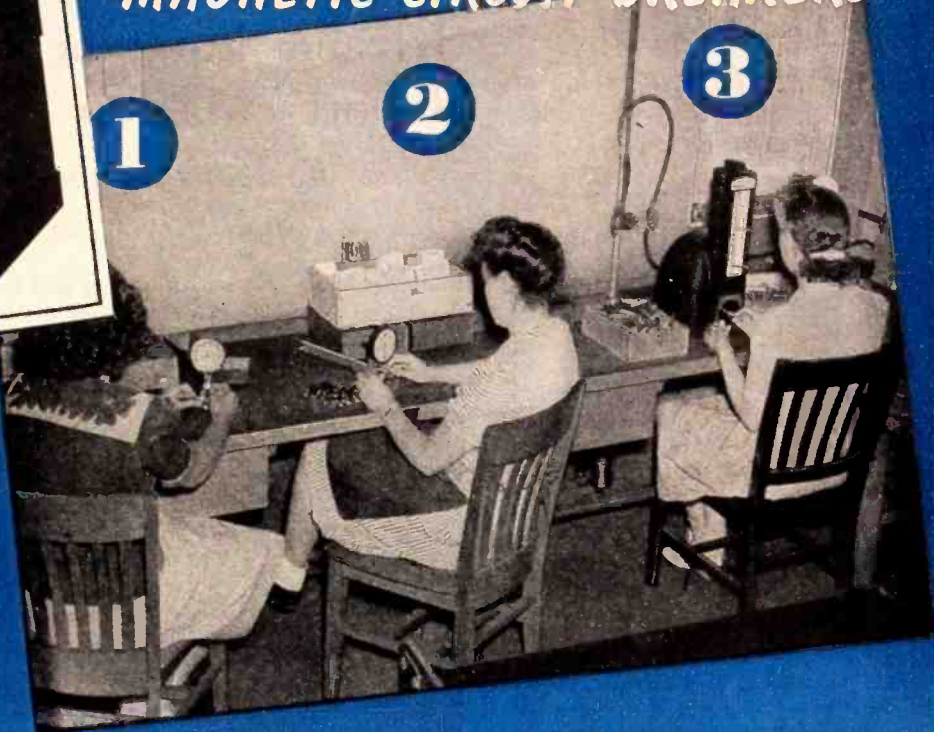
IF ALL THE RADIOGRAPHIC equipment previously in existence, plus all the radium mined to date, could be concentrated on the taking of a single radiograph through 12 in. of steel, it would require a longer exposure time for the job than would a two-million-volt x-ray tube recently introduced by Machlett 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

Constant and Rigid
INSPECTION of
HEINEMANN
MAGNETIC CIRCUIT BREAKERS



Just One Corner of Our
PARTS INSPECTION DEPT.

SHE is inspecting part of the tripping mechanism for accuracy of radius.

SHE is inspecting contact bars for amount of deflection under a given load.

SHE is using an air gauge to inspect time-delay tubes for correct inside diameter.

Means Positive, Unvarying
PROTECTION
FOR YOUR EQUIPMENT

HEINEMANN CIRCUIT BREAKERS employ an over-
 load trip unit that is FULLY
 ELECTRO-MAGNETIC. Short circuits and danger-
 ous overloads open the
 breaker instantly, while
 it is delayed on momen-
 tary harmless overloads.
 They are vibration- and
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You may have complete confidence in the positive operation
 of your HEINEMANN Circuit Breaker. Our Quality Control
 Department is responsible for production of parts and assem-
 blies according to rigid specifications set up by our customers
 as well as our own Engineering Department.

Process Inspection on sub-assemblies and final assemblies
 consists of raw material, parts, finish and workmanship inspec-
 tion. The completed Circuit Breaker then passes a final test
 insuring a finished product worthy of the HEINEMANN label.

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary of Heinemann Electric Co., Established 1888

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SYLVANIA NEWS

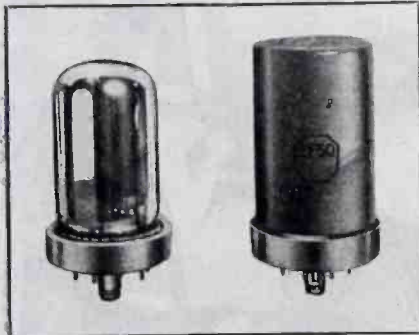
ELECTRONIC EQUIPMENT EDITION

DECEMBER

Published in the Interests of Better Sight and Sound

1944

Type EF-50 Pentode Found Useful at High Frequencies

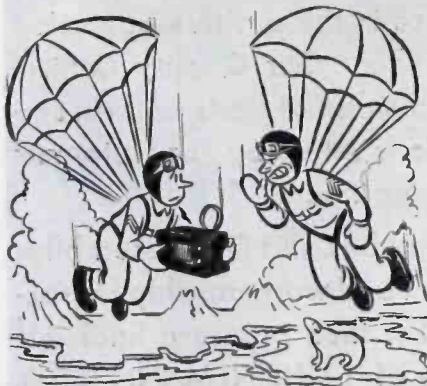


Sylvania's Type EF-50 Amplifier Pentode, originally produced primarily for military purposes, has a number of unusual features that suggest many applications in postwar design.

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.

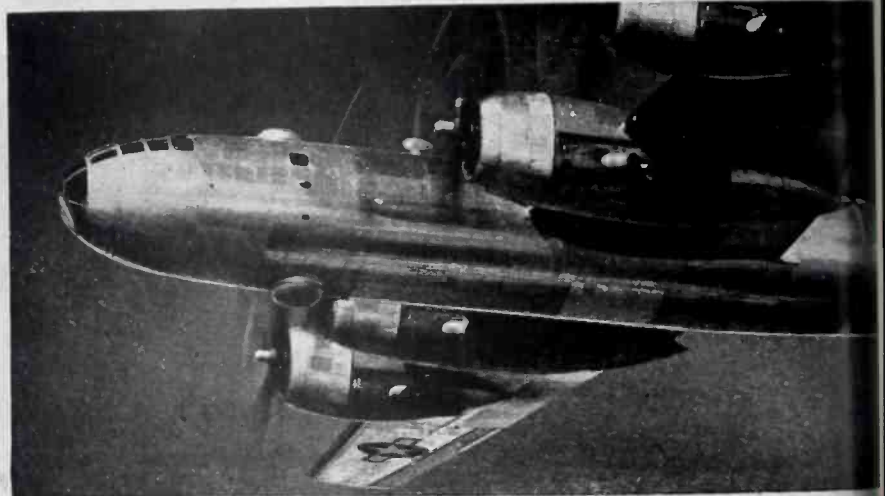


"Next time you go bailing out, for heaven's sake grab a set with Sylvania Tubes!"

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 been developed to a new pitch of perfection aboard the giant Boeing Superfortresses 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)

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?

bases. The long operating range of the Superfortresses necessitates a complex electronic nerve system to assure close control in flight, accuracy in reaching target, and safe return to base. Radio and electronic equipment—estimated to total approximately one ton for each Superfortress—includes the most modern navigational devices, in addition, of course, to the transmitters, receivers and other apparatus necessary for communication between crew members, between aircraft in flight, and between planes and their distant bases.

Sylvania has made important contributions to the electronic equipment that helps make possible—and ultimately transmits—the terse, stirring message, "Mission Accomplished." Not only are many Sylvania tubes utilized in the various radio sets and control devices carried by the Superfortresses, but Sylvania is among the manufacturers supplying electronic equipment for the B-29s

SYLVANIA ELECTRIC

PRODUCTS INC.

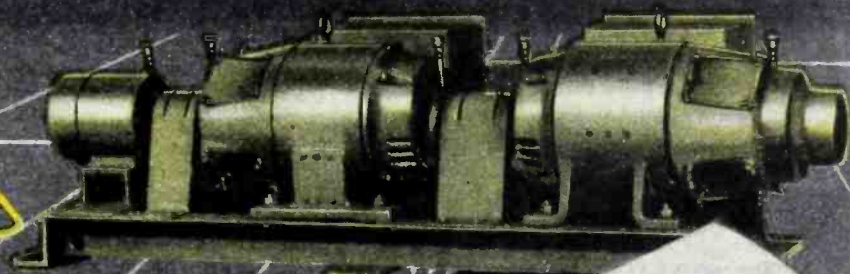
Radio Division · Emporium, Pa.

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.



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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.

No. 845

Popular Three Decade Type
Input constant: 1,000 ohms.
Voltage increments: 0.001 to 1.0 in
steps of 0.001



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INSTRUMENT CATALOG!

Shallcross DECADE POTENTIOMETERS (Accurate Voltage Dividers)

Shallcross Decade Potentiometers or Voltage Dividers are designed to provide accurate increments of input voltages. Actually, the instruments consist of two accurately calibrated resistance boxes operated simultaneously by a single set of controls. As the dials are rotated, the resistance in one circuit increases while the resistance in the other circuit decreases by the same amount. Thus the total resistance remains constant across the input terminals.

These accurate Voltage Dividers are available in a wide range of total resistances and voltage increments. Two of the popular standard types are listed here. For complete details, or for special units for specialized applications write, giving full particulars of your application.

(Where required, all Shallcross Instruments can be supplied with overall **FUNGICIDAL MOISTURE-RESISTANT** protection)



SPECIALISTS IN ACCURATE RESISTORS

The reliability of all Shallcross Test and Electrical Measuring equipment is doubly assured by use of Shallcross Akra-ohm wire-wound resistors throughout. Made in the widest variety of shapes, types, and ranges, Akra-ohms are available to tolerances as exact as 0.05 of 1%. Write for Catalog No. 825.

No. 835

Four Decade Voltage
Divider

Input constant: 10,000
ohms.

Voltage Increments:
0.0001 to 1.0 in steps
of 0.0001

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Portable Galvanometers, etc., etc.

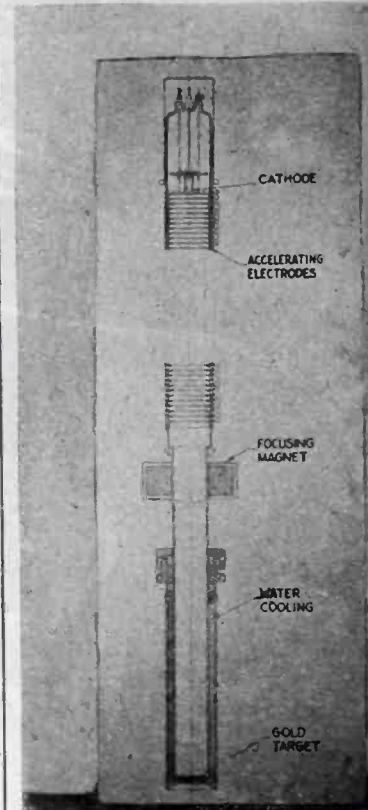
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DEPT. E-124, COLLINGDALE, PA.

ENGINEERING • DESIGNING • MANUFACTURING

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-

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For "AN" Series
Electrical Connectors



You may have this helpful chart. You can in an instant find the correct insert that fits your particular combination of conductors, voltage and current requirements.

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Also included are two ringbook charts. One shows all connector shell types and styles including the special purpose shells—pressure-tight, moisture-seal, explosion-proof, light-proof. The other clearly explains the numbering system for connectors.

eye the most complete line of AN inserts made by any one company—arranged and divided according to number of contacts—readable from top to bottom and left to right. Each insert is illustrated full size on this 38" x 50" chart. A table gives the mechanical spacing of contacts and other valuable information.

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and **Cost Less to Use**

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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.

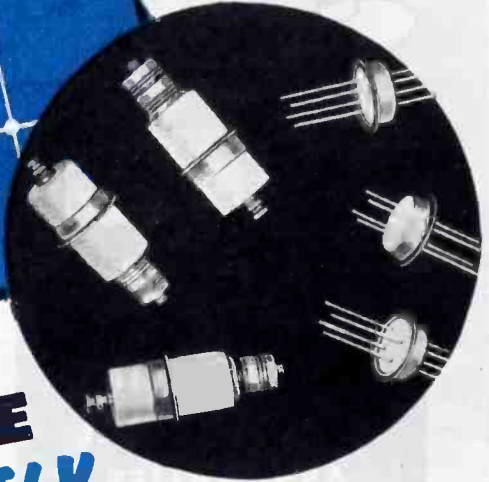
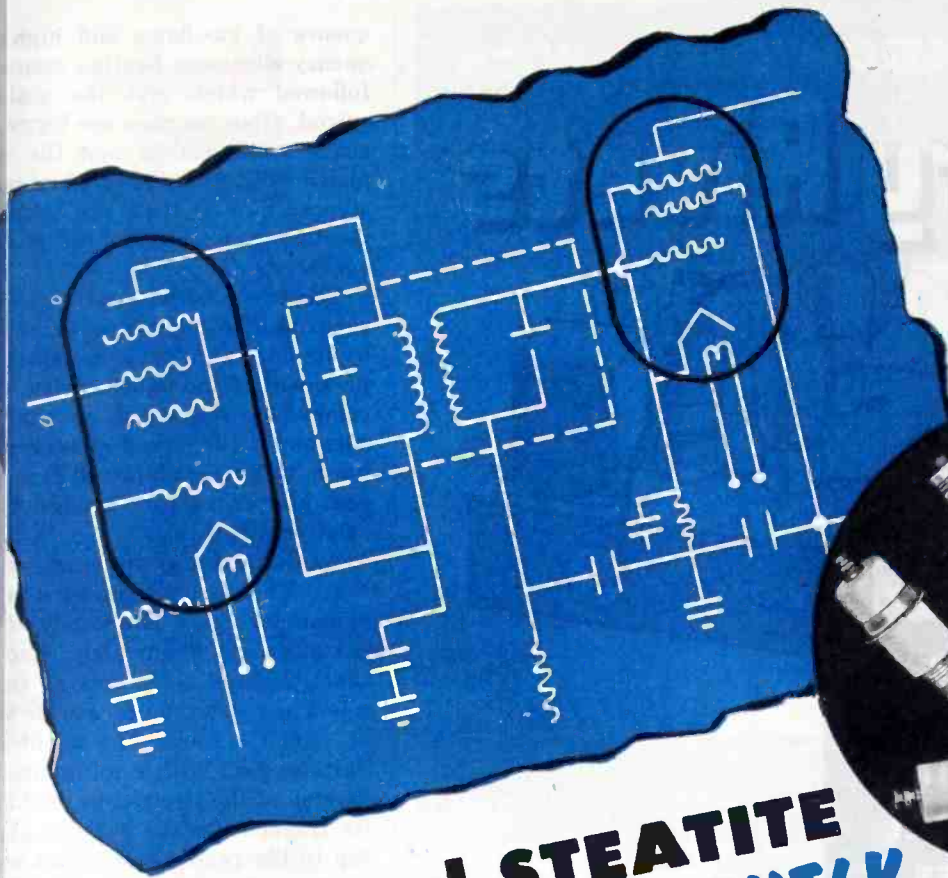
What's more, American Screw Company inspects every American Phillips Screw . . . for physical fitness of head, thread, and point . . . then checks shipments by automatic weigh-count to assure full value. Try American Phillips Screws on your own assemblies. You'll find they cost less because they help you produce much more.

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TWIST OUT OF ENGINEERED
TAPERED RECESS IN AMERI-
CAN PHILLIPS SCREW HEAD

AMERICAN PHILLIPS *Screws*

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STEEL and STEATITE bonded **PERMANENTLY**

The high mechanical strength of steel and the excellent, permanent insulation qualities of STEATITE have been combined by General Ceramics through its development of a new method of hermetically sealing and permanently bonding together STEATITE and metals in various combinations.

These SEALEX combinations successfully withstand the most severe temperature changes, and show no vibration fatigue. The metal parts are tinned to facilitate soldering where desired.

The General Ceramics method of fusing steatite and steel solves the problems of hermetically sealing and permanently protecting equipment against moisture.

For long-life, dependable, efficient service specify "Steatite" and "Sealex" Combinations.



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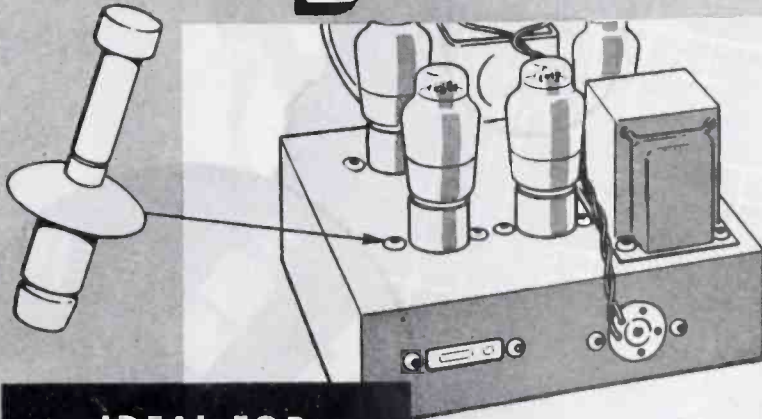
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CUT PRODUCTION COSTS WITH

Cherry Rivets



**IDEAL FOR
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Don't think of Cherry Rivets only as "blind" rivets. Just remember they are upset with a *pull* instead of a *pound*—that they need no bucking bar—no backing up—that they turn a *two man* job into a *one-hand* operation.

Then you will use them in all hard-to-get-at spots (in corners—wherever space is limited). You will use them in all types of metal structures; you will use them in plastics, plywoods, enameled surfaces (the pull action doesn't crack or shatter brittle surfaces)—They will work in soft materials (rubber, leather, fabric) without bending, buckling or tilting the rivet.

With Cherry Rivets, short runs become production jobs without tooling or special set-up. Remember, too, that Cherry Rivets have wide tolerance in hole size and grip length—are fast to use and most economical.

See for yourself how Cherry Rivets can cut production costs in your plant. Write for Handbook A-43. Address Department A-120, Cherry Rivet Company, 231 Winston Street, Los Angeles 13, California.

CHERRY RIVETS. THEIR MANUFACTURE AND APPLICATION ARE COVERED BY U. S. PATENTS ISSUED AND PENDING



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.

Reduce weight 40%



HIPERSIL CORES

COMBINE THESE ADVANTAGES:

- 30% to 50% lighter weight
- 33 1/3% more flux-carrying capacity
- Very high, high-density permeability
- High, low-density permeability
- High incremental permeability
- Very low losses in direction of rolling
- Space factor as high as 95% . . . thin glass films insulate adjacent laminations.

This aircraft transformer is tangible proof of the weight and space savings made by Hipersil Cores.

With them, engineers cut the weight of the transformer to 8 ounces, approximately 40% less than the nearest competitive item of the same output. The unit has a low temperature rise of 30° which permits operation over all ambients from minus 65° to plus 70° C at all altitudes up to 50,000 feet.

Hipersil Cores release engineers from the limitations of ordinary silicon steel. Hipersil affords a wider range of linear response . . . approximately 1/3 greater straight-line response for winding and core section. Construction is simplified because there are no "tissue-thin" laminations to stack . . . only 2 or 4 pieces to handle. Learn the facts about Hipersil. Write for Booklet B-3223. Address: Westinghouse Electric & Manufacturing Co., P. O. Box 868, Pittsburgh 30, Pa. J-70433

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PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

HIPERSIL

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
- Instrument Transformers
- Sensitive Relays
- DC, AC, and Thermo Switchboard and Panel Instruments
- Specialized Test Equipment
- Light Measurement and Control Devices
- Exposure Meters
- Aircraft Instruments
- Electric Tachometers
- Dial Thermometers

Weston

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618 FRELINGHUYSEN AVENUE, NEWARK 5, NEW JERSEY**

FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING EQUIPMENT

**STRONG,
SMOOTH,
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That's Formica Pregwood!

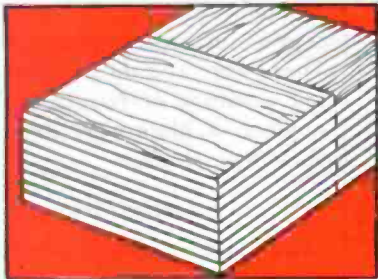
PREGWOOD is a relatively new material possessing many unusual qualities that have adapted it to many uses—such as switchgear in heavy duty switches, picker sticks on textile looms, ski bottoms on military skis.

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 alkalis.

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

4661 Spring Grove Avenue
CINCINNATI 32, OHIO



TENSILE STRENGTH

#/sq. in. 30,000

COMPRESSIVE

#/sq. in. 20,000

IZOD IMPACT

Ft. Lbs./In.

Notch Width

Flatwise
7.0

Edgewise
6.0

FLEXURAL

#/sq. in. 48,000

PREGWOOD 1100

Test samples are available on request—

FORMICA

B & W *Miniature* R-F INDUCTORS



**SAMPLE
FREE**

Write for
sample card
containing ac-
tual unit. Also
ask for Bulletin
78C describing
B & W Miniduc-
tors in detail.

B & W

New Standards of Efficiency for Many Types of Radio Equipment

THINK of all of the places where you can use exceptionally rugged, finely made, light-weight little coils like this! Many types of mountings, pitches from 4 to 44 t.p.i., and any diameter from 1/2" to 1 1/4" can be supplied. Q is amazingly high, due to the small amount of insulating material in the electrical field.

These B & W Miniductors can be

equipped with either fixed or variable, internal or external coupling links, and many other special features. They are adaptable to every need from complicated band-switching assemblies and "tailor-made" coupling link units, to sturdy, easy-to-mount coils for any tuned r-f circuit. Send us your specifications. We'll match them!



BARKER & WILLIAMSON

DEPT. E-124, 235 FAIRFIELD AVE., UPPER DARBY, PA.

Export: LINDETEVES, INC., 10 Rockefeller Plaza, New York, N. Y., U. S. A.

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 gramophone record with equidistant 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

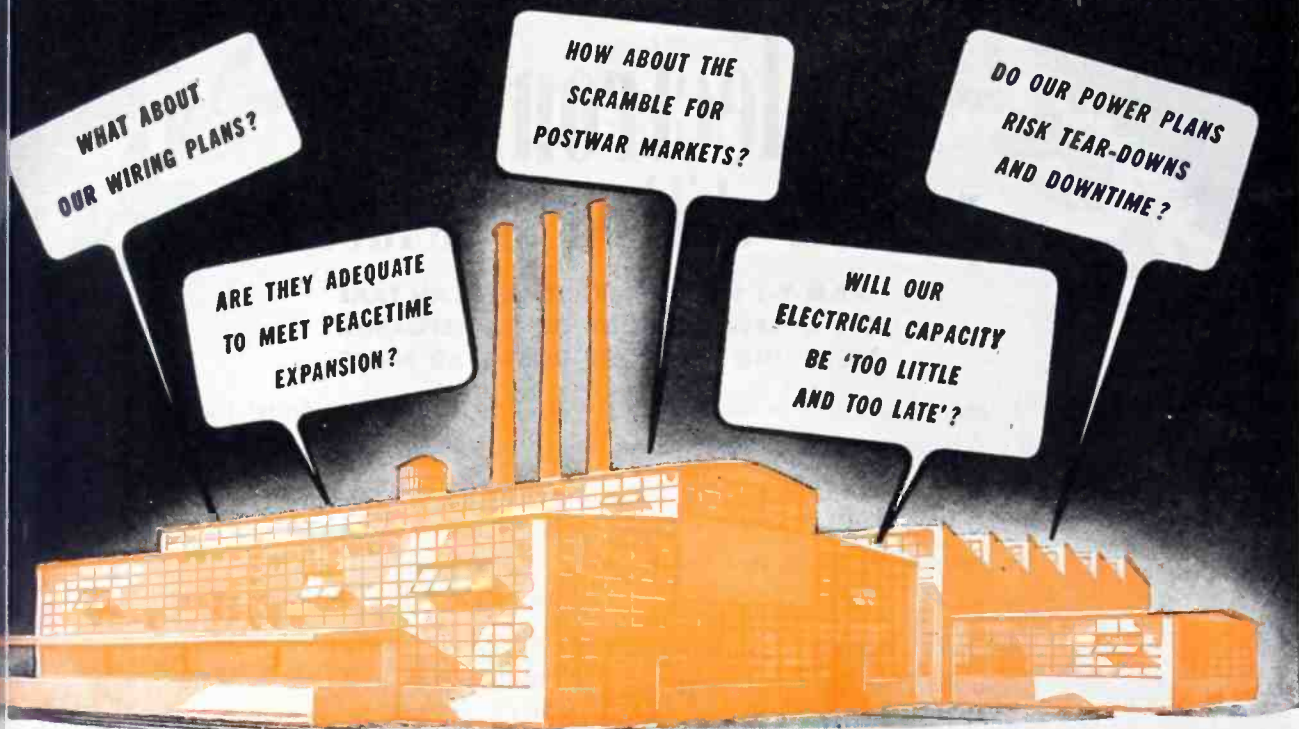
Vibratory systems were then examined and a start was made using stretched wires, where the vibrations produce variations of capacitance which are translated into oscillatory voltages across a high resistance. To generate sustained (organ) tones, the wires must be kept in continuous vibration. This was 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 magnets 1/3 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.

44251



ANACONDA WIRE & CABLE COMPANY

25 Broadway, New York 4... Sales Offices in Principal Cities

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'.

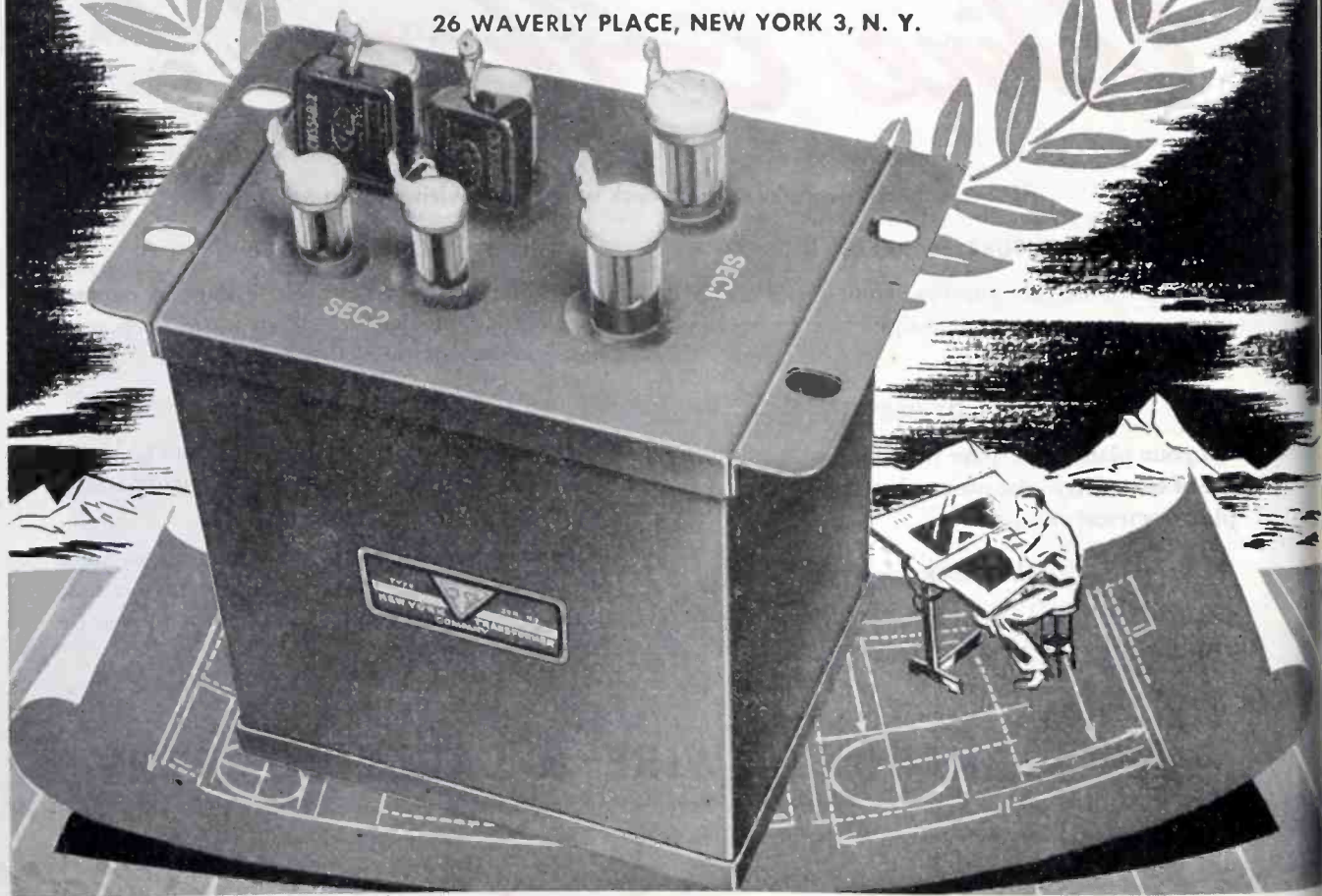
The N-Y-T Sample Department is helping to set the pace with research, engineering and development in the electronic field. Specially-built transformers, filters and

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.

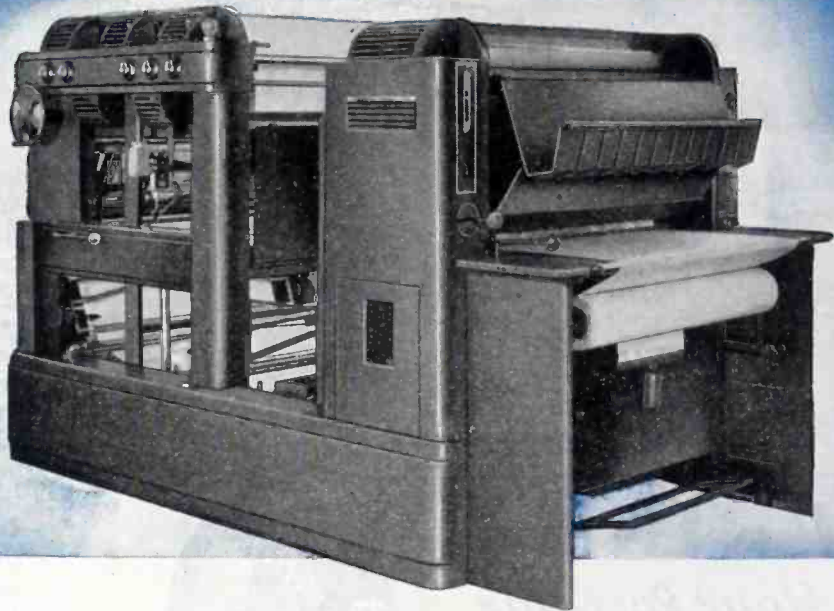
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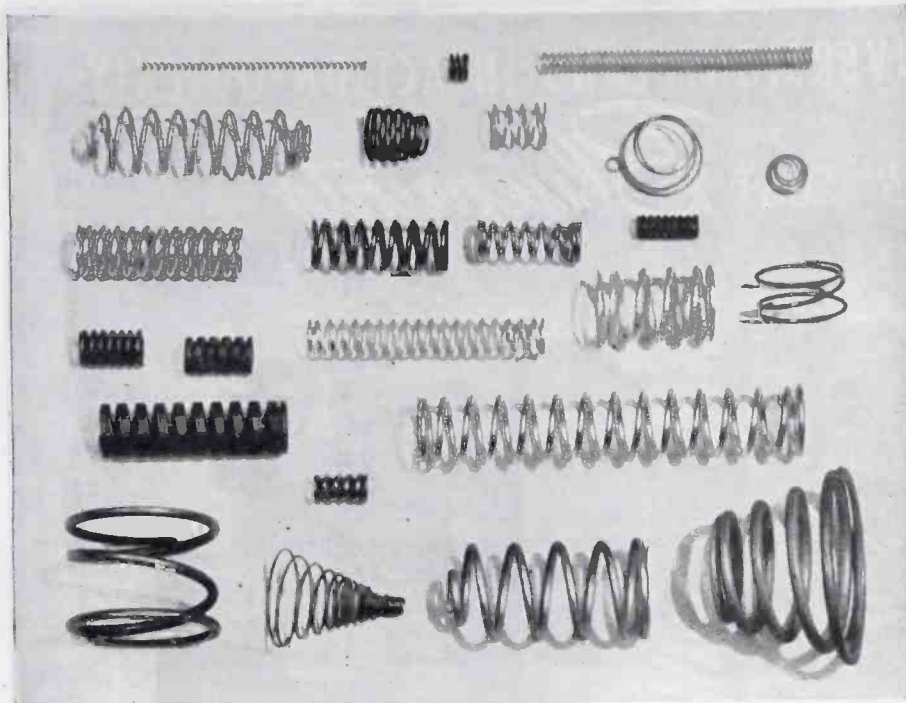
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The Importance of

SPRINGS in Your Post-War PRODUCT

Reliable

Every spring is a design problem in itself. Consider some of the factors involved: strength and tension, corrosion resistance, uniformity, fatigue, freedom from drift and "creep", temperature properties, electrical conductivity.

The question of failure, for instance, can in many cases be traced not only to fatigue but to corrosion, and is often overcome by a corrosion-proof material such as beryllium copper, nickel alloys, phosphor bronze or stainless steel, or by cadmium plating.

Or take the question of uniformity. The spring maker's ability to hold all springs uniform may often be found of greater value than the maintenance of absolute tolerances. Such uniformity is highly dependent on the manufacturer's technicians and equipment.

Reliable is thoroughly equipped and staffed to assure the combination of balanced properties best suited to the actual product use of the spring.

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WIRE SPRINGS

CLIPS

HOOKS

BENDS

LIGHT STAMPINGS

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 picking 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 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.

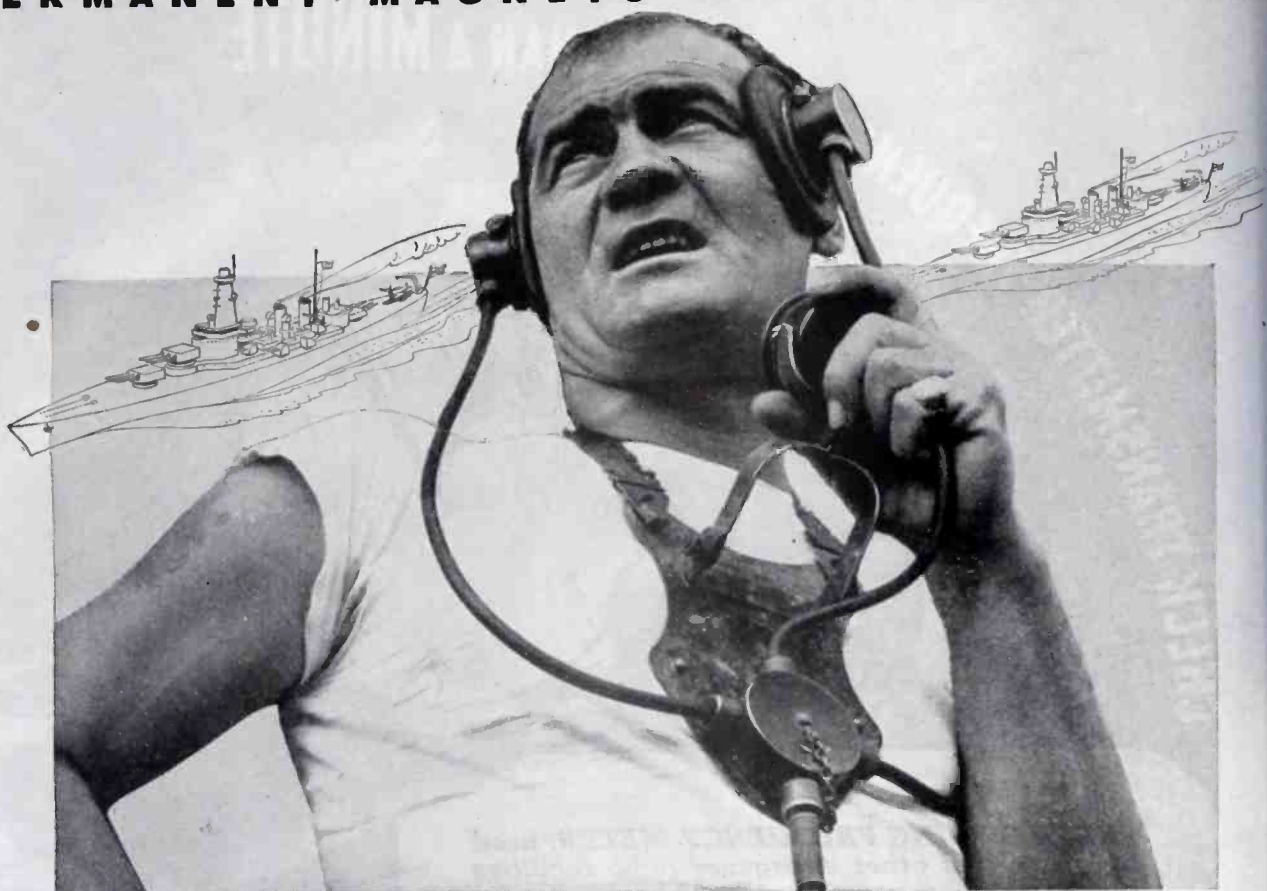


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**LABORATORIES, INCORPORATED
WINCHESTER, MASSACHUSETTS**



PERMANENT MAGNETS MAY DO IT BETTER



OFFICIAL U. S. NAVY PHOTOGRAPH

Battle Commands Reach All Hands!

ON a modern U. S. dreadnaught, about 2200 telephones and more than 300 loudspeakers link all battle stations. They flash orders and reports instantly—make possible the split-second timing that wins battles.

Vital parts of each telephone and speaker are permanent magnets. They are also employed in radio and sub-detection equipment, firing systems, compasses, instruments and numerous other devices, raising the total per battleship high into the thousands.

Because we manufacture permanent magnets for virtually every use known to science, our specialized knowledge of design and production is unusually complete. If you have a problem involving permanent magnets, our engineers will be pleased to consult with you. Write for a copy of our "Permanent Magnet Manual".



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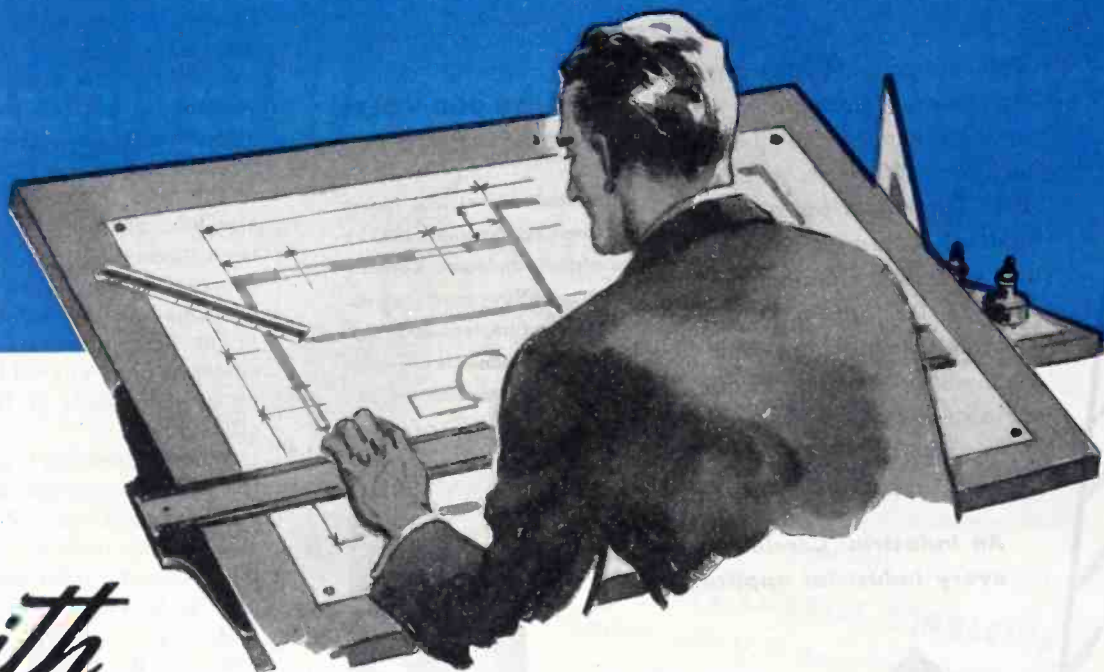
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in your Postwar Radio-Phono Combinations



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Dynamotors and
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TOMORROW

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WAR BONDS

are Top Value for
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We will be glad to discuss with manufacturers now the ways we may serve you today and tomorrow.

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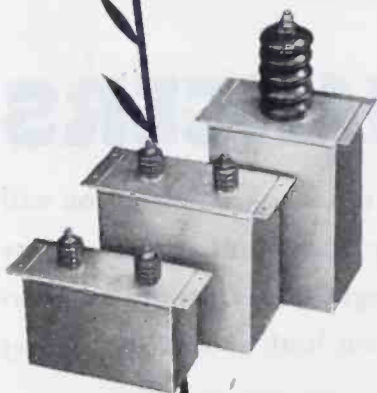
Unsurpassed QUALITY

• The Industrial Condenser Corporation manufactures a complete line of Oil-filled, Electrolytic, Wax and Special Mica Capacitors for all industrial, communications and signalling applications up to 250,000 volts working. Complete laboratory and engineering facilities available for solution and design of capacitor problems for special applications.

An Industrial Condenser for every industrial application.

.5 MFD. 50,000 VOLTS DC WORKING

(Illustrated above)...28 inches high, weight 175 pounds, built by Industrial Condenser Corporation to meet Navy specifications. Oil-filled, oil impregnated. Built for 24 hour continuous operation and total submersion in salt water.



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.

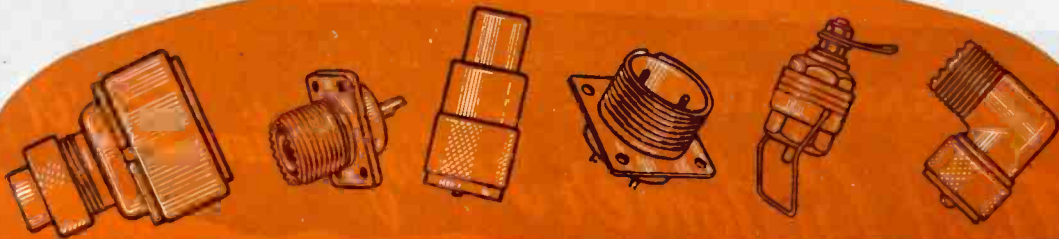
In actual practice, an alternating current of suitable frequency is passed through the exciting coil to produce an alternating magnetic field at right angles to the longitudinal axis of the armature. Then, when the armature is inductively magnetized by the earth's field, an alternating couple will be 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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Will coaxial cable connectors, cable plugs or special design parts in this general category, play roles in your postwar products? If so, we suggest you carefully consider both our offerings and exceptional facilities.

Connector Division, in addition to making a representative line of standard units, is uniquely staffed and equipped to serve your needs in this field on a mass production basis.

Our engineers will be happy to consult with you on specific problems or send you more detailed information.

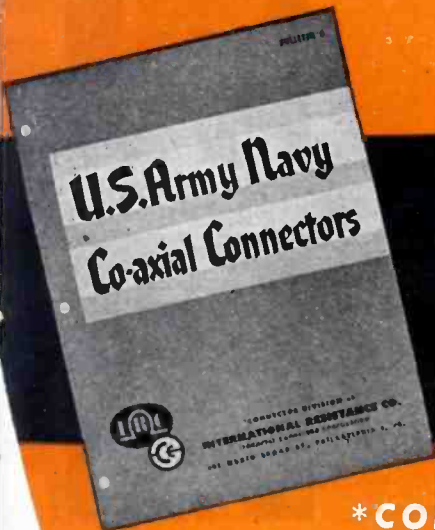
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(Actual Size)

U. S. ARMY-NAVY COAXIAL CONNECTORS

Built in accordance with U. S. Army-Navy designs and specifications, these precision units interlock firmly, when coupled, to assure positive, vibration-proof contact. The die cast, zinc housings and other metal parts are heavily silver plated. Contact parts (both pins and sockets) are made of specially tempered spring-brass. Cable plugs and receptacles alike are insulated with low-loss mica filled bakelite. Plugs may be had in either Signal Corps #PL-259, or Navy #C1-49195 models. Connector receptacle #50-392-1 is standard for each of these designs.



Write for Bulletin 4



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That Customer Satisfaction Built!



Like many another "depression-born" company beset by trying problems, we learned early and well the vital importance of giving *more* and *better* service than a customer ordinarily expected. Faithful adherence to this principle throughout the ensuing years has not only forged a stronger relationship with old customers but has laid the foundation for an organization, which today, is recognized as a leader in the field of precision fabrication of all types of plastic materials.

Send us the specifications for your next requirements and let us prove to you that we can produce these parts *better . . . faster . . . more economically!* We have a stock of standard materials on hand at all times—all of which meet Army, Navy and Air Corps specifications.



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Rubber Mountings and Bearings

- Control vibration, absorb shock
- Give trouble-free torque action
- Correct for misalignment



Silentbloc Rubber Mounting above is used to damp or isolate vibration and cushion shock loads in motors and other moving equipment.



Unassembled Parts

Assembled Silentbloc Torque Bearing

PATENTED CONSTRUCTION gives engineered performance. Silentbloc consists of outer metal sleeve into which inner shaft is forced under high pressure and inner shaft, "pushed" through rubber. Radial compressive force of elongated rubber forms indestructible rubber-to-metal union.



SILENTBLOC Mounting gives engineered control of vibration in motors and moving equipment, cushions shock loads, absorbs noise.

SILENTBLOC Bushing corrects for misalignment of hinges, shafts, bearings. Improves operation, cuts machining and fitting costs.

BEFORE you approve any blueprint, check the improvements you might make with General Silentbloc mountings, bearings and bushings.

If you have a problem of vibration, shock load or noise, a Silentbloc mounting can be engineered for your specific needs.

If your equipment has oscillating parts, a Silentbloc rubber torque bearing can simplify construction and give trouble-free operation without lubricants.

You can improve performance and cut production costs with Silentbloc rubber bushings that correct for misalignment of shaft supports or bearings.

General Silentbloc parts can be made any size, to carry loads of ounces to tons, using any kind of

metal and rubber. Skilled General engineers can design a Silentbloc to give the exact performance you specify.

Silentbloc has been proved in use on automotive, industrial, marine and home machinery, electrical equipment, aircraft and other products. *Silentbloc belongs in your new-product blueprints.*

It Will Pay You to Know More About Silentbloc

For factual booklet, write The General Tire & Rubber Company, Dept. 95, Wabash, Ind.



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Mechanical Goods Division, Wabash, Indiana

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GENERATORS . . . D C MOTORS
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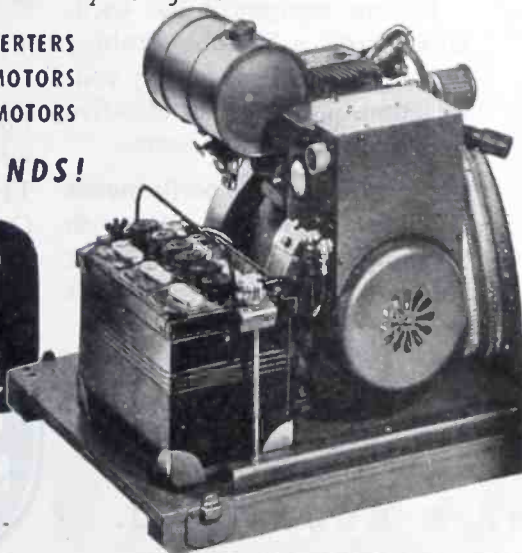
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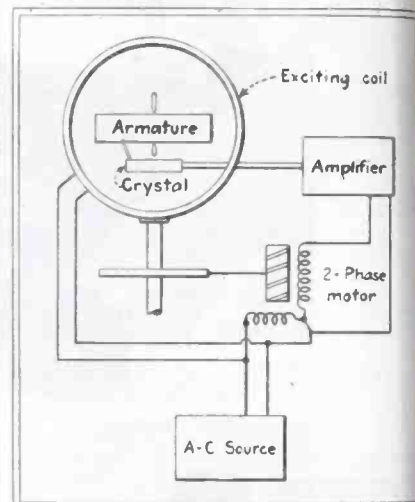


the armature, a mechanical vibration of the armature at the frequency of the alternating current in the exciting coil will result.

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

Design value

goes beyond

price

What does one designer build into his product that makes it sell at a profitable price, while a competing article loses money for its producer?

Little things, often hidden things. Little things that make a big difference, like Lord Shear Type Mountings of Bonded Rubber.

Where there is machinery in motion, there is vibration, and vibration means strain to machine and to man. Lord Shear Type Mountings and other bonded rubber products control and isolate vibration.

Factories that are quieter, pleasanter, more efficient; automobiles, trucks, buses, locomotives, airplanes that are smoother and safer in operation; delicate laboratory equipment that is made more accurate and trust-worthy; these are the results that Lord is helping designers and manufacturers to accomplish.

The science of vibration control and isolation has been developed by Lord for more than twenty years. This accumulated experience is available to you, without cost, whenever you are faced with a vibration problem.

Write for free literature which will bring you up to date in factual information on vibration control. Lord Vibration Engineers will work with you to bring your product to a new standard of perfection.

Buy More War Bonds

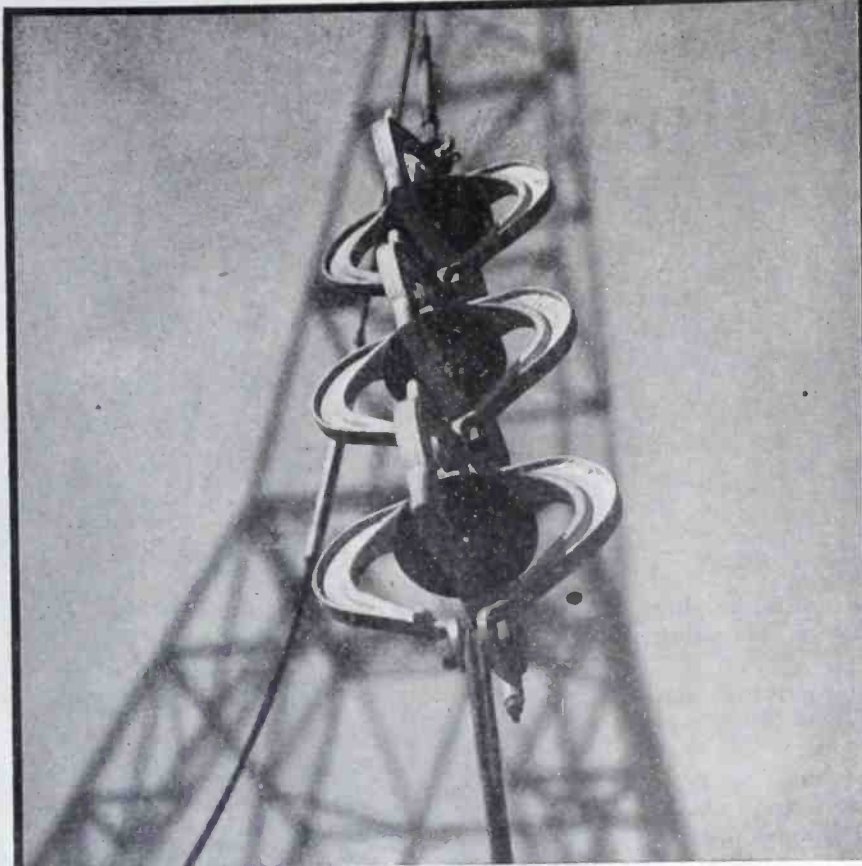
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Do you recognize these insulators?

They are the first radio tower insulators made in this country. They were designed and built by Locke for the original wireless telegraph stations.

That was a long time ago and every day since has added to our skill and experience. Research facilities available nowhere else in the industry have been in constant use finding better, simpler, lower cost methods of producing the finest in radio insulators.

Whether your requirements are standard or special, we think you will find them better filled by Locke.

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INSULATOR CORPORATION

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"Leaders in Clayramics"

A COMPLETE "CLAY"RAMIC SERVICE

For every electrical, chemical and mechanical application, Locke has unrivalled facilities for the production of fired clay pieces by every known method.

(1) Dry Process — Porcelain and Steatite

A process ideally suited to the production of certain pieces with reasonable tolerances and adequate mechanical and electrical strength.

(2) Vacutite Process—Porcelain and Steatite

A process developed by Locke for forming intricate pieces. Close tolerances. Mechanical and electrical strength almost equal to wet process.

(3) Wet Process — Porcelain and Steatite

The standard process for the production of high voltage insulators, and porcelain for mechanical and chemical applications. Exceptionally strong mechanically and electrically.

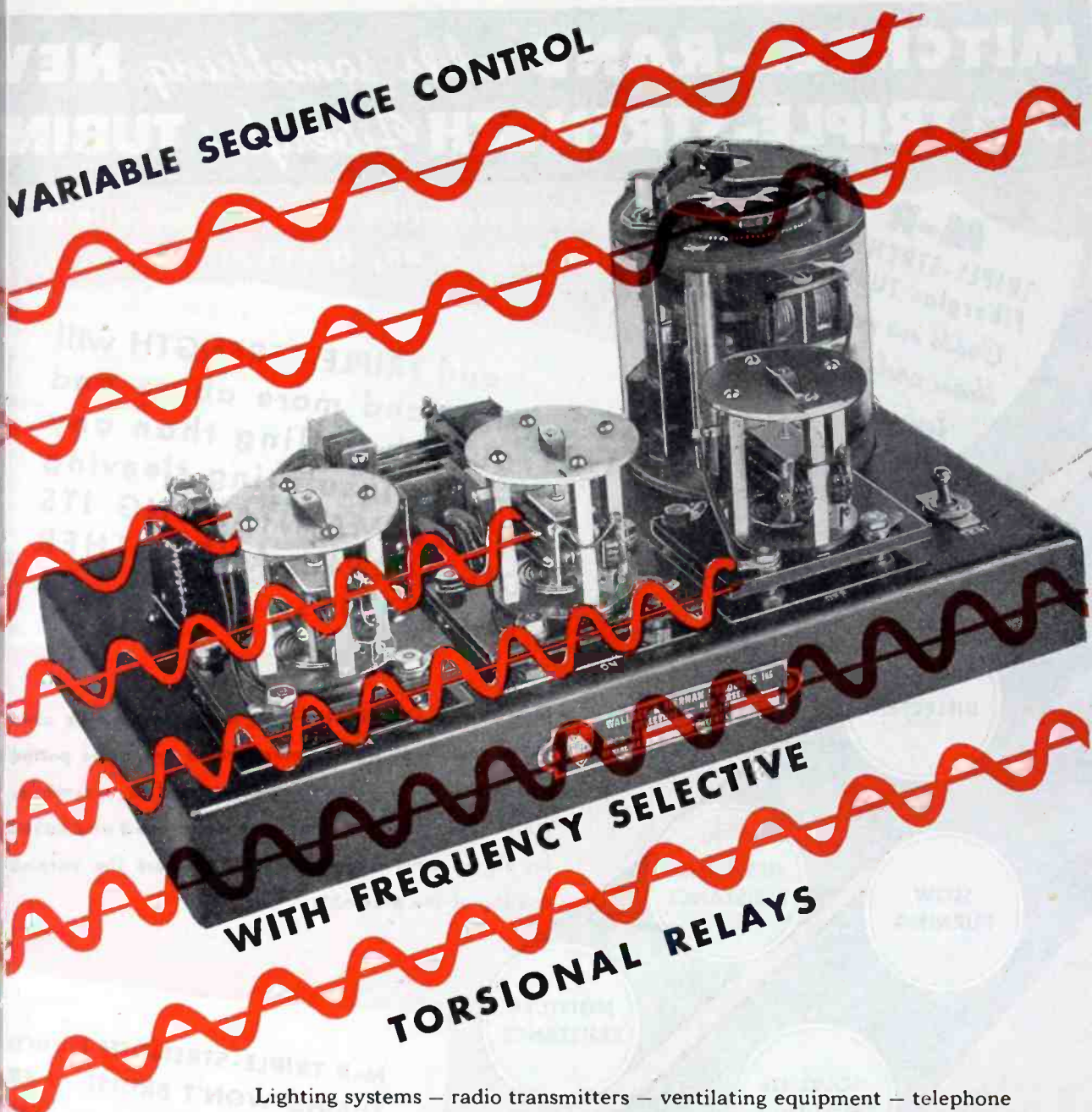
Locke Wet Process porcelain and Locketite is produced by the following methods, the selection of method depending upon the piece.

- | | |
|------------------|-------------------|
| (1) Pugging | (5) Jiggering |
| (2) RamExtrusion | (6) Plastic Press |
| (3) Wet and Dry | (7) Core Casting |
| Turning | (8) Drain Casting |
| (4) Plunging | (9) Throwing |

and certain other methods which at the present have only limited application.

Other clayramic products will be available in the future to meet special conditions. Whatever your problem, our experienced electrical, mechanical and ceramic engineers will be glad to help. Their services have resulted in material savings in money, time and critical materials to other manufacturers. Perhaps they can help you.

VARIABLE SEQUENCE CONTROL



**WITH FREQUENCY SELECTIVE
TORSIONAL RELAYS**

Lighting systems – radio transmitters – ventilating equipment – telephone circuits and a multitude of other operations must often be controlled from a remote point in varying sequence. Of itself remote control – even in varying sequence – is no insurmountable obstacle. Physical or economic factors, however, often dictate the use of only a single conductor of radio carrier wave circuit as the control medium. Such control is possible only if the operation-selective device possesses high sensitivity and critical response. The W&T Torsional Relay – stable over a wide range of ambient temperature and pressure – was developed to fulfill this specific requirement.

W&T Torsional Relays provide low cost, dependable variable sequence control which can be made completely automatic with the addition of W&T monitoring units.



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ELLEVILLE 9

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A-26

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*Costs no more
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Test Model

In our tests, this device was constructed with an armature ten cm in diameter surrounded by an exciting coil four inches in diameter. The output of the crystal pickup was amplified by a small amplifier having a gain 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 deflections 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.

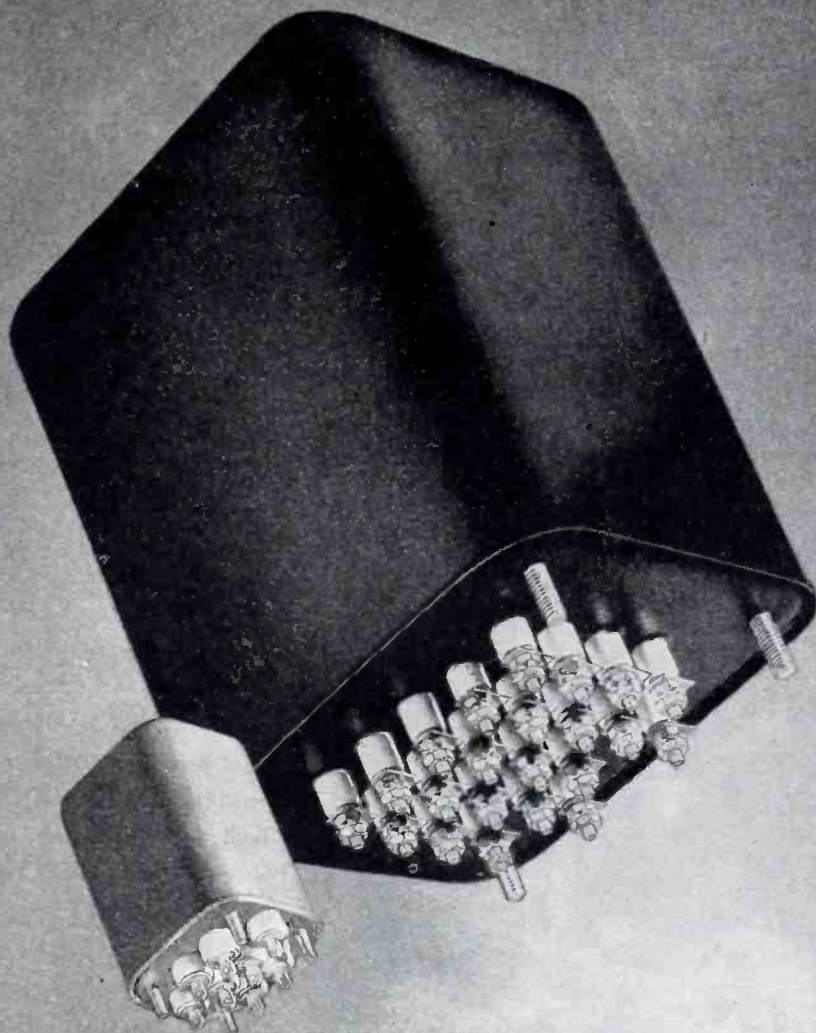
Additional information may be obtained by referring to United States Patent 2,331,617, or from the author at Fairchild Camera and Instrument Corp.

. . .

X-Ray Irradiation of Quartz Crystals

THE TECHNIQUE of permanently altering the frequency of quartz crystals by subjecting them to x-ray irradiation and so changing the atomic properties of the quartz itself is described by Clifford Fronde, director of research at Reeves and 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 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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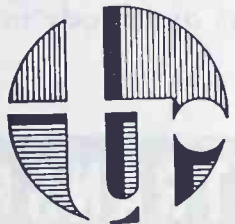
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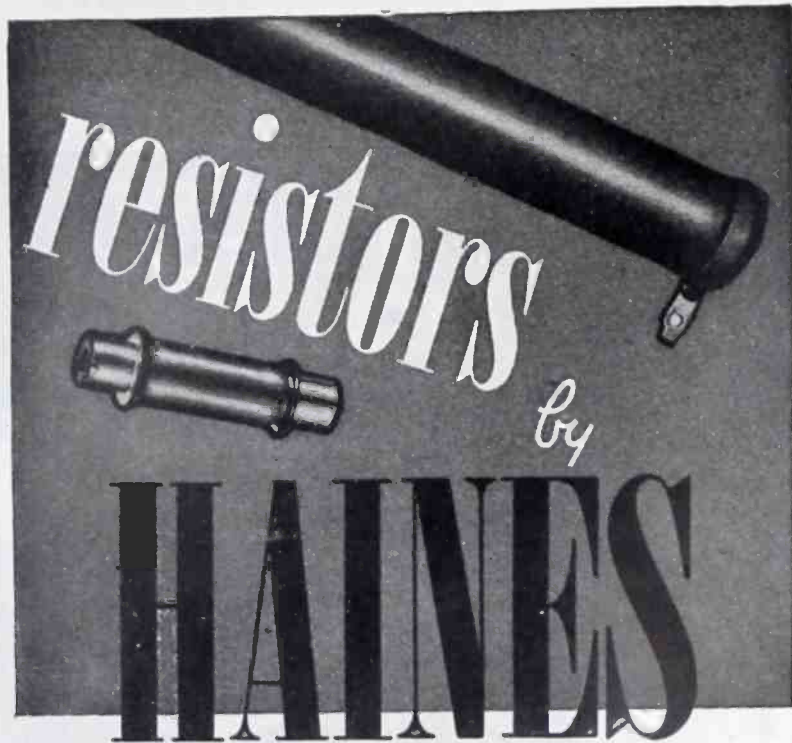
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other than the BT, and with substances other than quartz. The total frequency change that can be effected increases with increasing initial frequency of the plate, and can be roughly estimated for a given frequency on the basis of a decrease of approximately 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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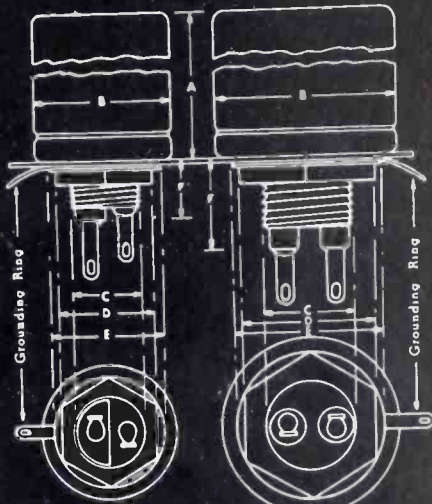
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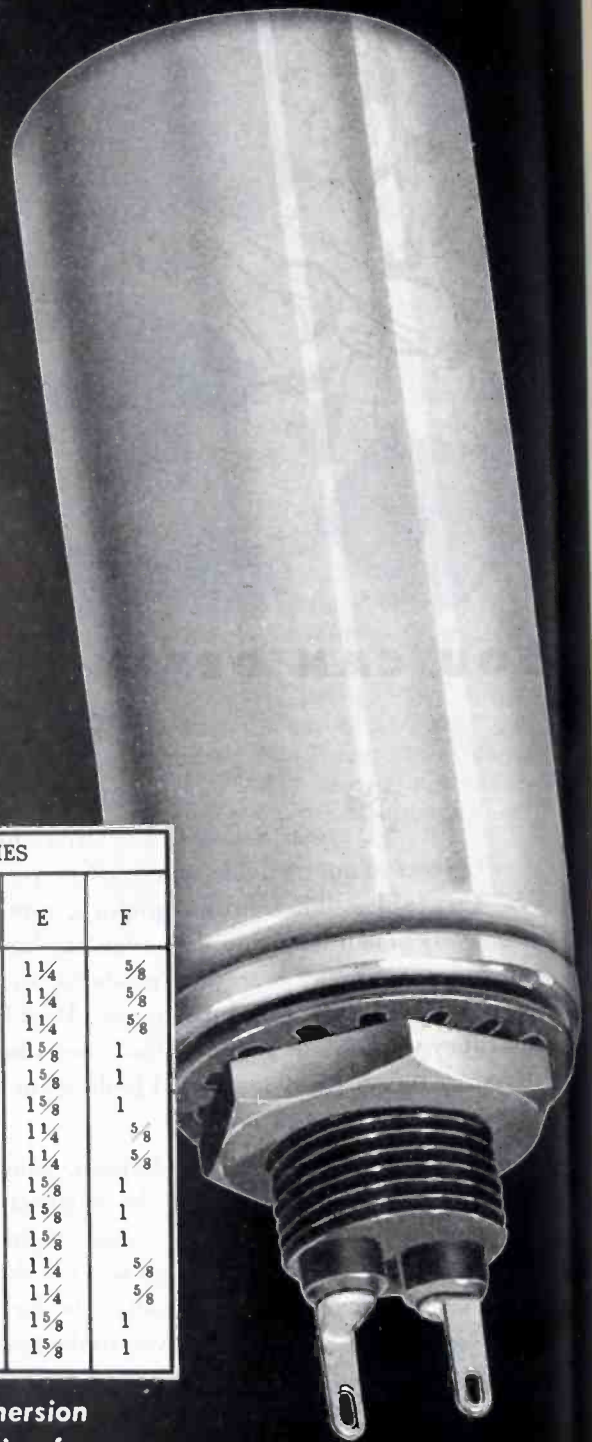
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6EC300	3.0	600	4 1/2	1 1/2	3/4 x 16thd	1	1 1/4	5/8
6EC400	4.0	600	4 1/2	1 1/2	3/4 x 16thd	1	1 1/4	5/8
6EC600	6.0	600	4	2	1 x 14thd	1 1/16	1 5/8	1
6EC800	8.0	600	4 1/2	2	1 x 14thd	1 1/16	1 5/8	1
6EC1000	10.0	600	4	2 1/2	1 x 14thd	1 1/16	1 5/8	1
10EC100	1.0	1000	2 3/4	1 1/2	3/4 x 16thd	1	1 1/4	5/8
10EC200	2.0	1000	4 1/2	1 1/2	3/4 x 16thd	1	1 1/4	5/8
10EC400	4.0	1000	4	2	1 x 14thd	1 1/16	1 5/8	1
10EC600	6.0	1000	4	2 1/2	1 x 14thd	1 1/16	1 5/8	1
10EC800	8.0	1000	5	2 1/2	1 x 14thd	1 1/16	1 5/8	1
15EC50	.5	1500	2 3/4	1 1/2	3/4 x 16thd	1	1 1/4	5/8
15EC100	1.0	1500	4 1/2	1 1/2	3/4 x 16thd	1	1 1/4	5/8
15EC200	2.0	1500	4	2	1 x 14thd	1 1/16	1 5/8	1
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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 have become very difficult to control while the radiation technique, on the other hand, is at its maximum power.

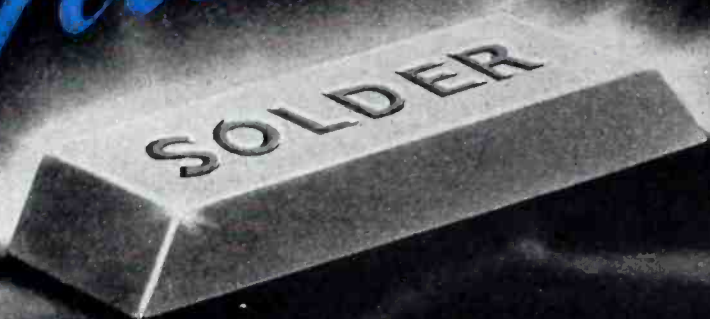
Magnitude of Change

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-ke, 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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"A-R"—Same as A-1, with leads reversed.

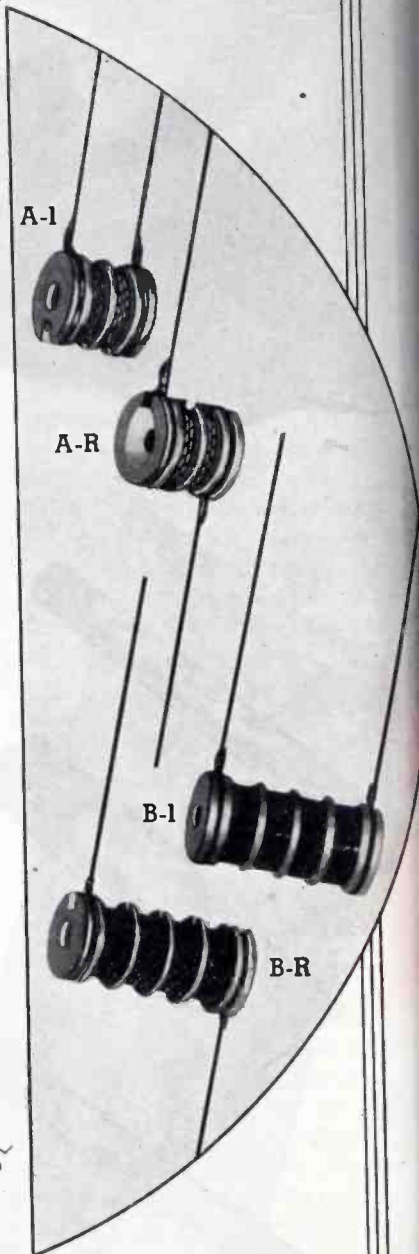
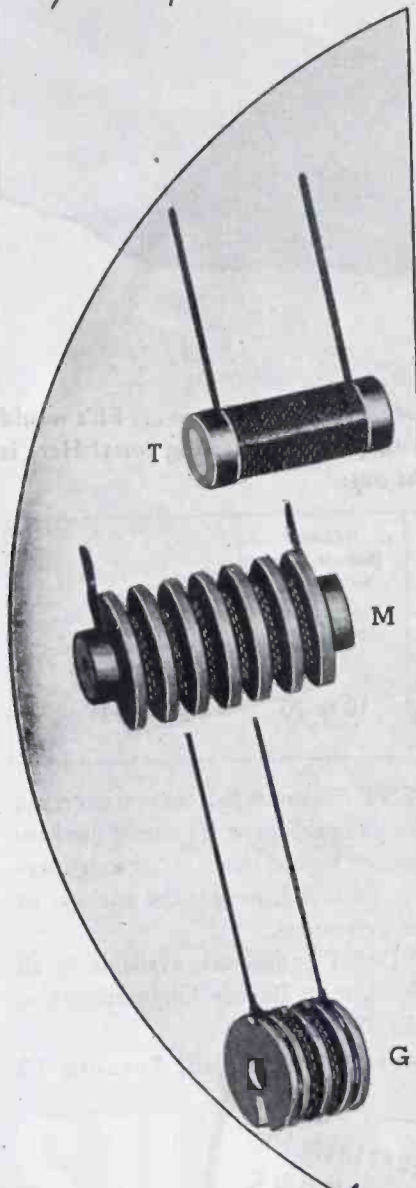
"B-1"—15/16 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—1/2% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

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"G"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. 1/2% 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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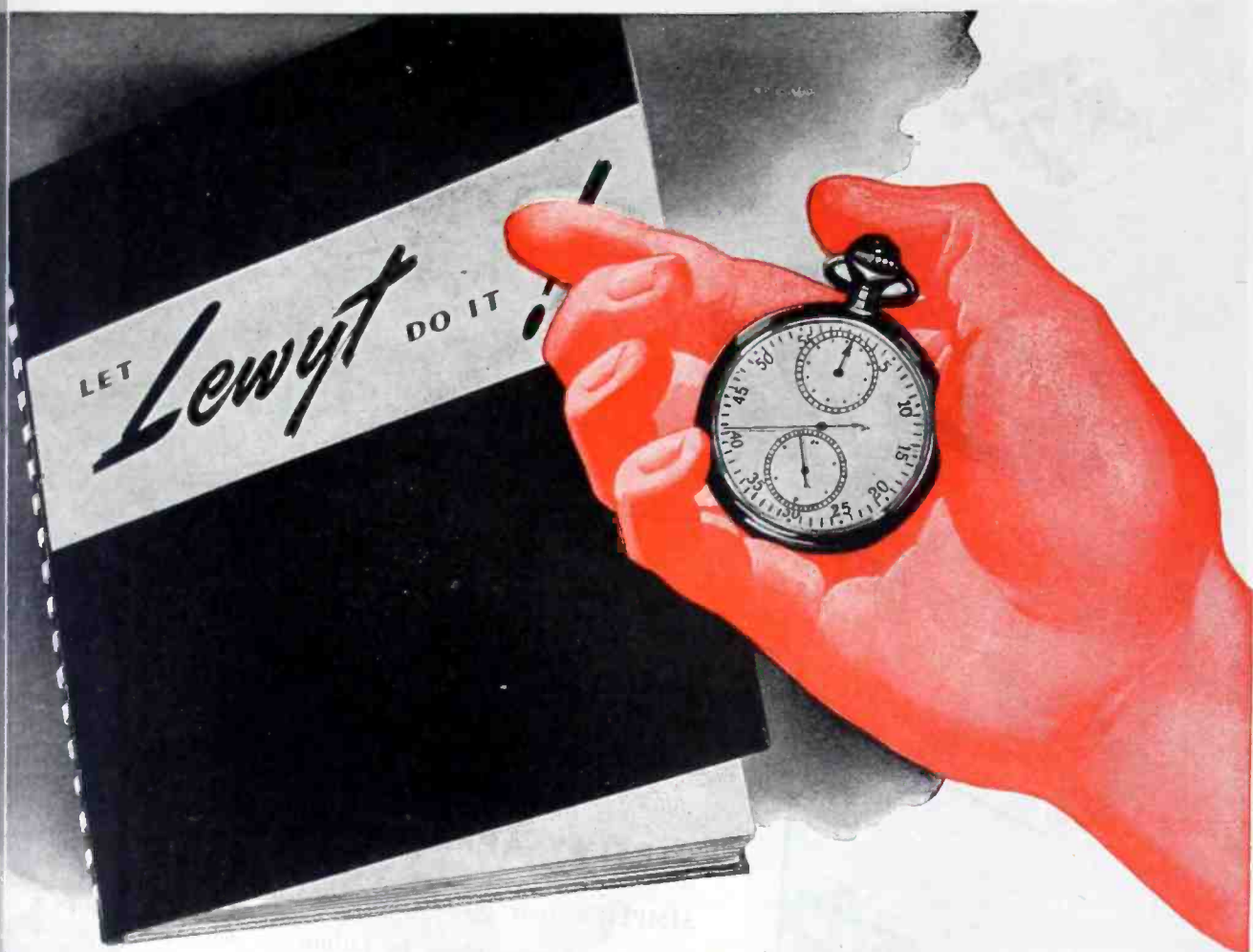
or thickness, of the plate and increases with increasing frequency. Preliminary measurements indicate that the average change in BT plates of a particular frequency can be calculated on the assumption that the frequency-thickness constant of irradiated quartz is less by some constant amount than in ordinary 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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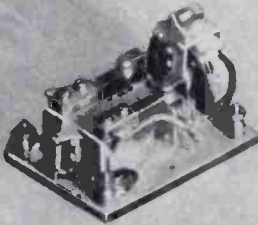
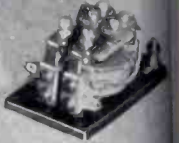
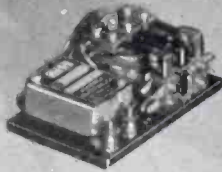
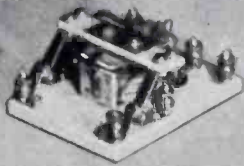
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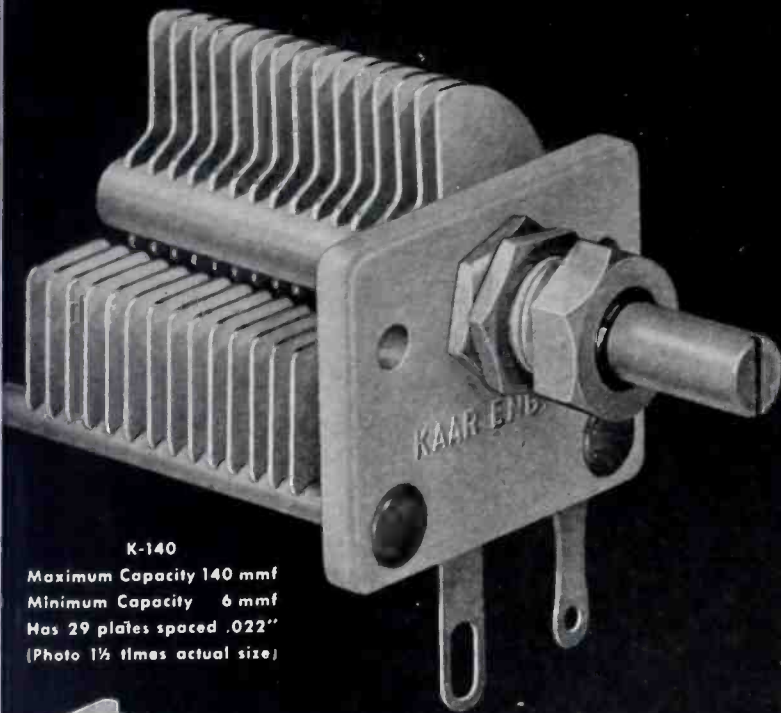
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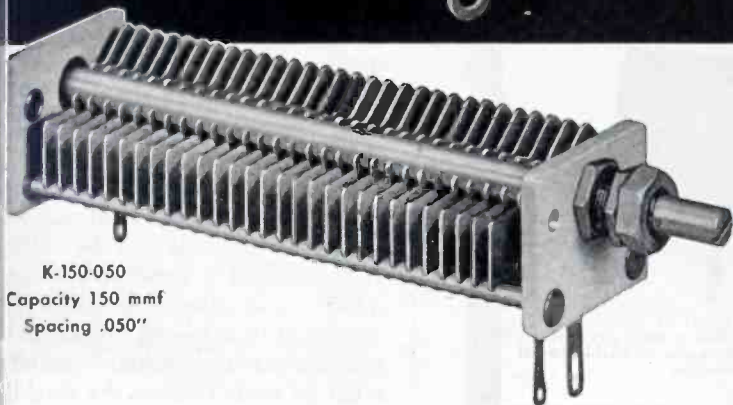




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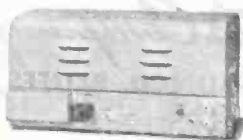
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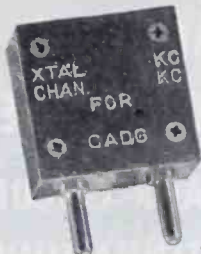
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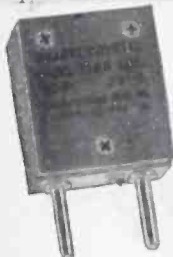
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possible, since the photo-electric response of the quartz appears to be directly proportional thereto.

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.

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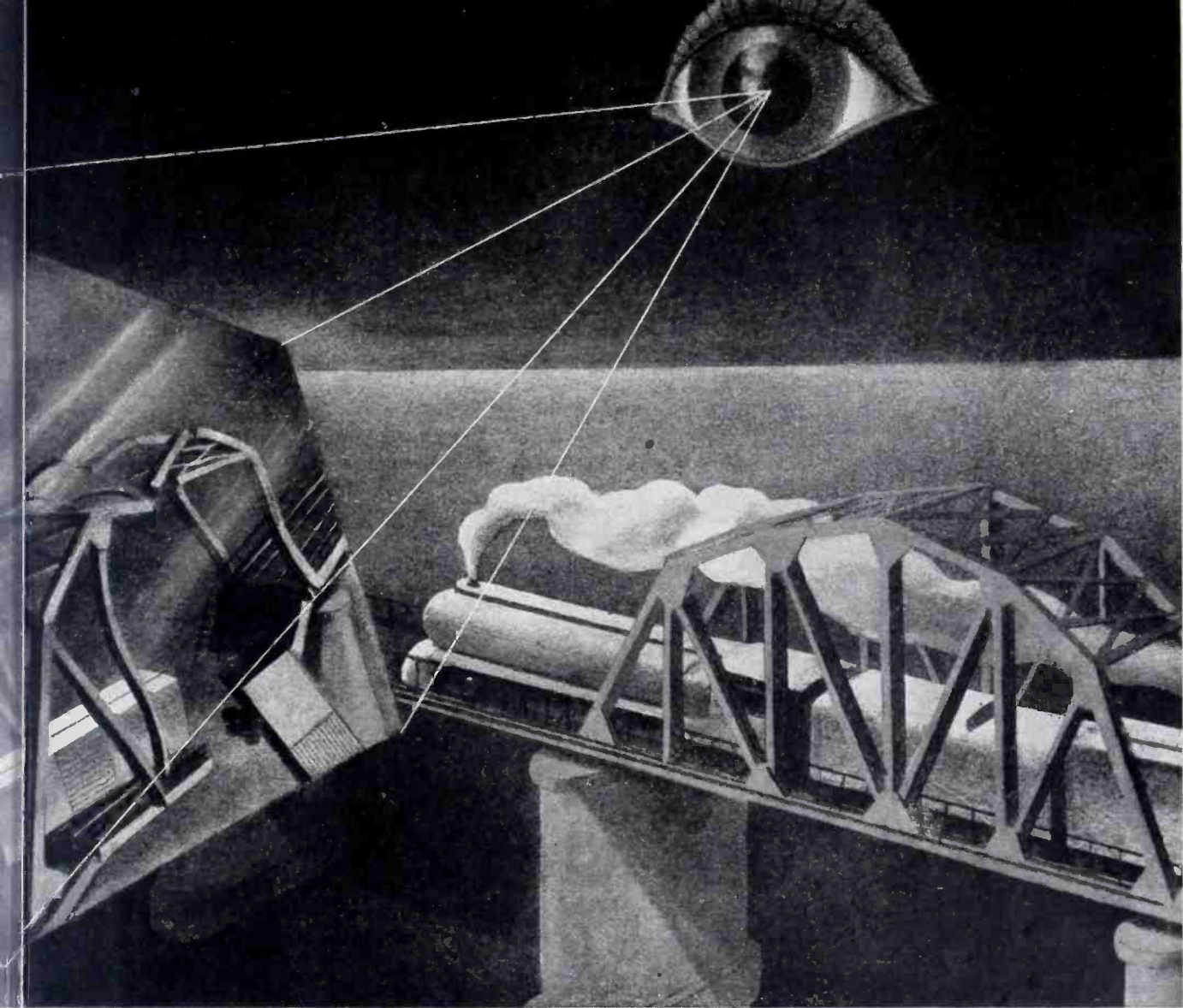
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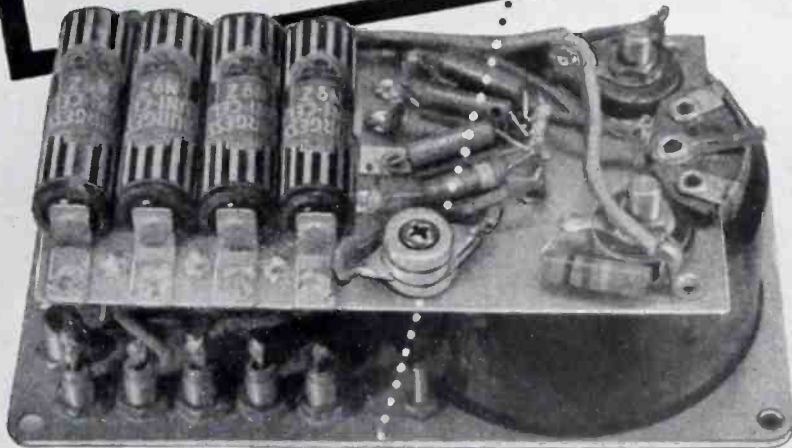


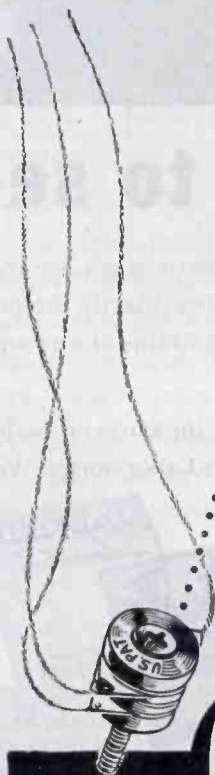
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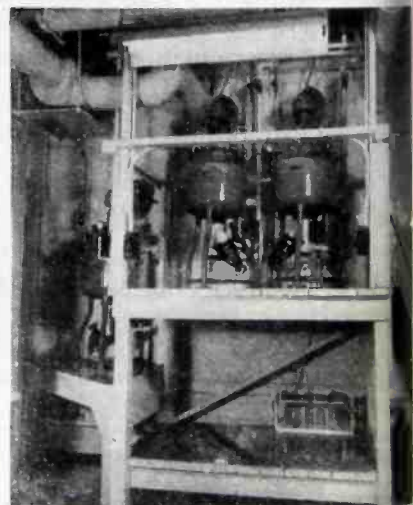
static electric charge during irradiation, especially if they are placed directly in contact with the window, and thereby may attract particles of dust to their surface. This dust can be blown off with compressed air—a much easier procedure than trying to remove the static charge. Under certain conditions 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.

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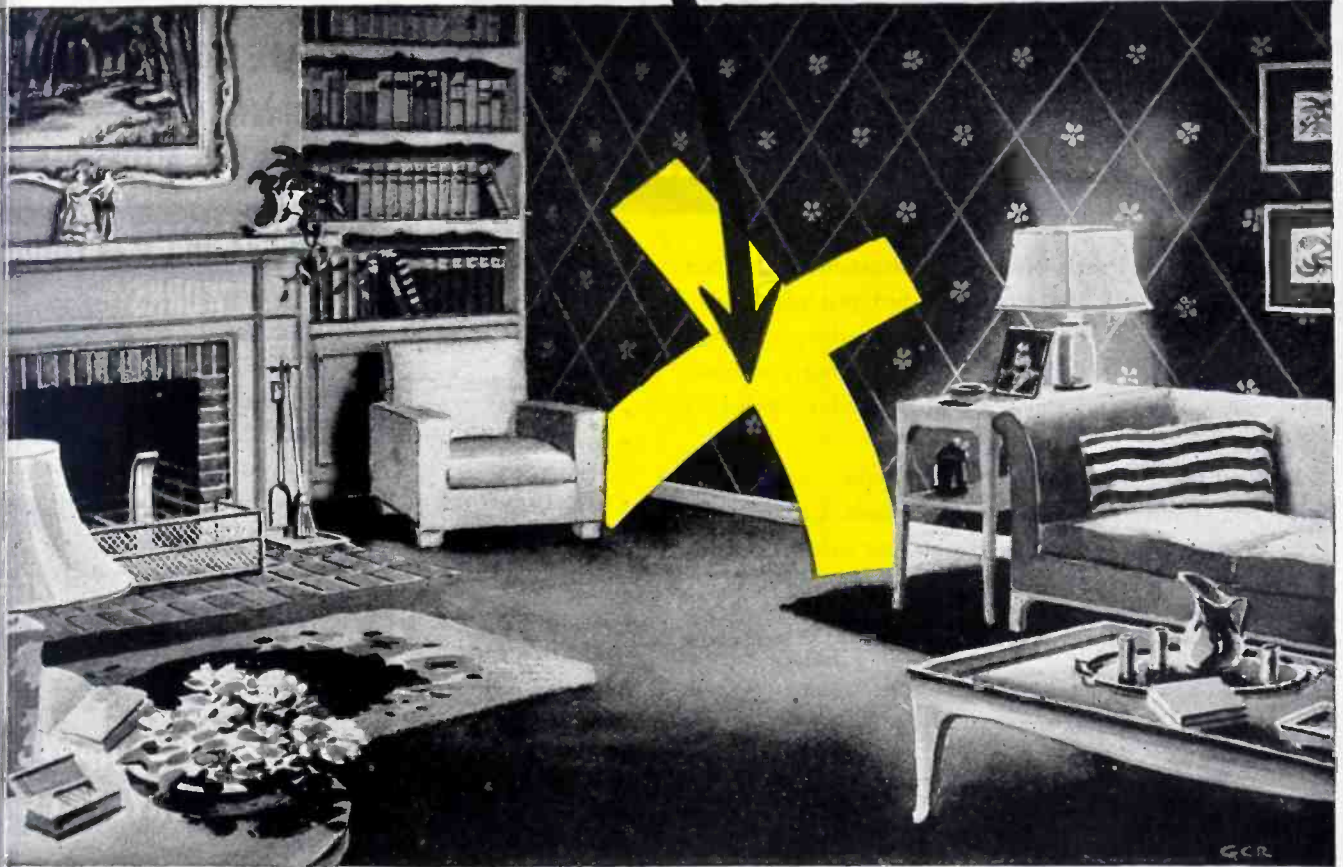
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That's the keynote of the postwar Stromberg-Carlson sales story.

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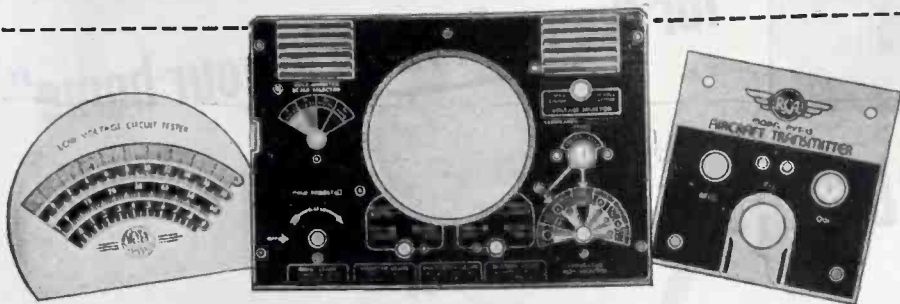
Stromberg-Carlson as:

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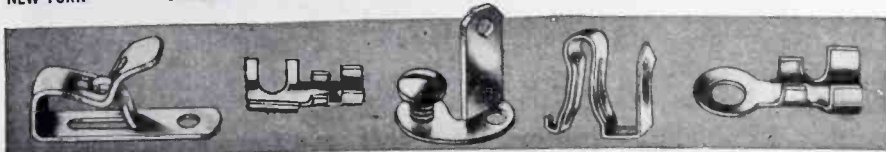
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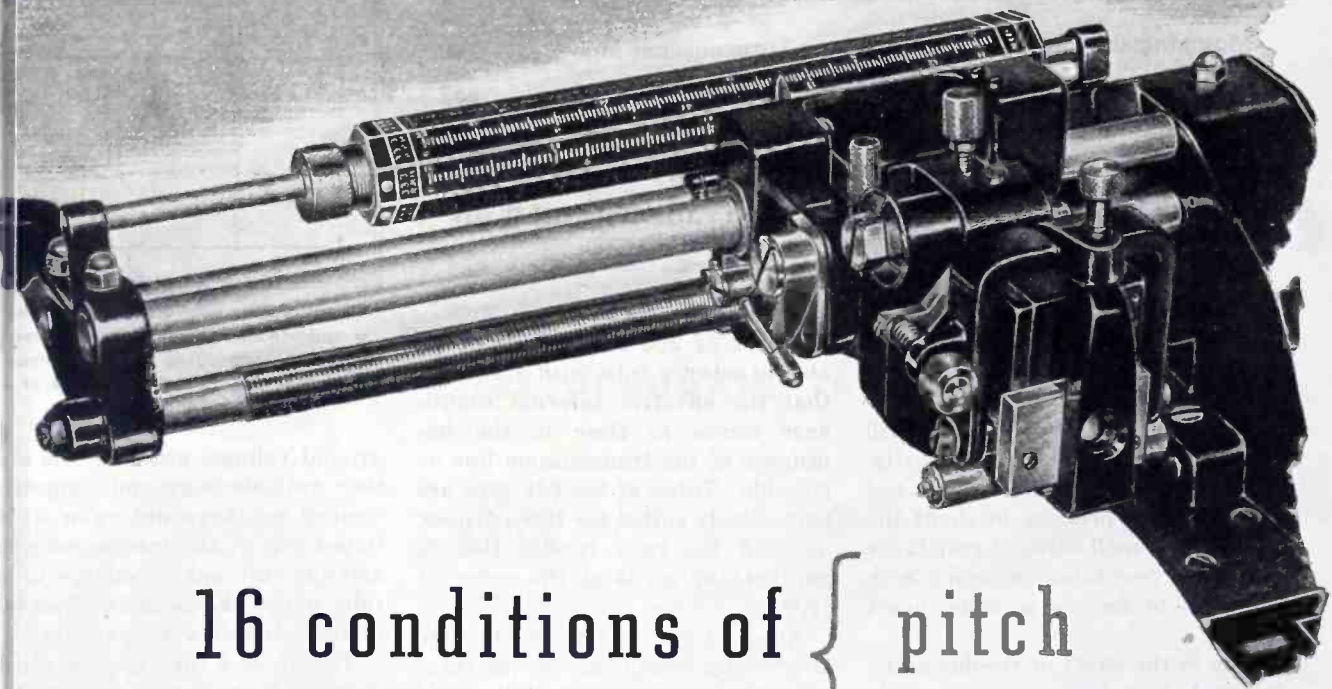
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...with one lead screw

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**SOUND
EQUIPMENT**



THE ELECTRON ART

Matching the Cathode Follower to a Transmission Line	250
Scaling Test of OFHC Copper for the Housekeeper Seal	252
A Neon-Counter for Medical Research	284

Matching Cathode Follower to Transmission Line

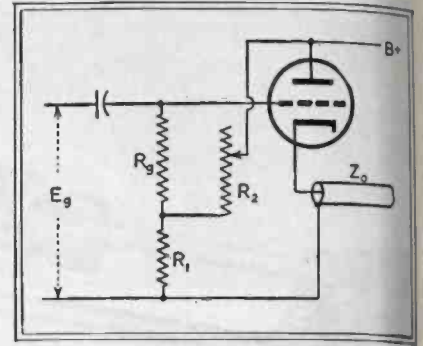
By L. R. MALLING
San Diego, Calif.

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



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

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 feedback or cathode-follower condition.

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 equivalent 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-

ELECTRONIC FLASH WELDING

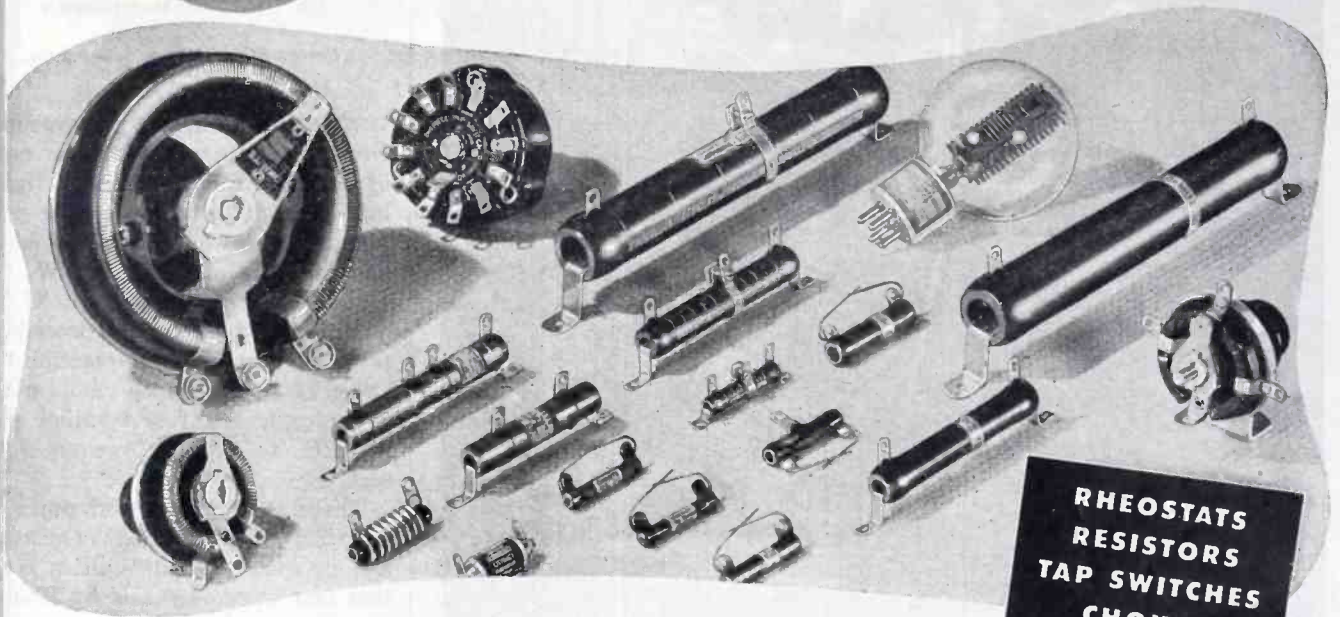


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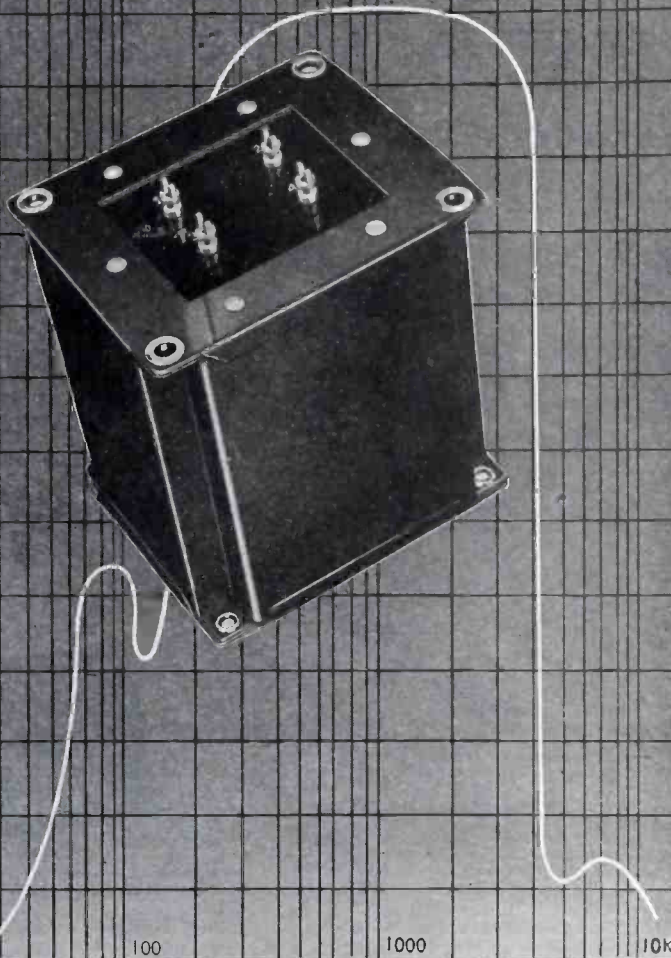
For helpful data and information, write on company letterhead for Industrial Catalog and Engineering Manual No. 40. Address Ohmite Manufacturing Co., 4818 Flournoy Street Chicago 44, Ill.

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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 practice.

This scaling test has assumed a formal status and it therefore seemed desirable to make an invest-

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 12 amps. 30 Volts D.C., 125 Volts A.C.



Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.



Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.



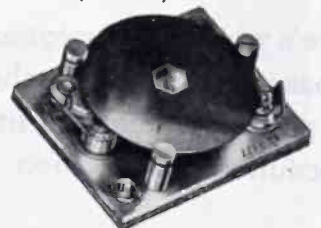
Type PM (NAF-1131) Circuit Breaker.



Type RT Thermostat.
 Adjustable Temperature Control.



Type ER Series. Ambient Compensated Time Delayed Relays.

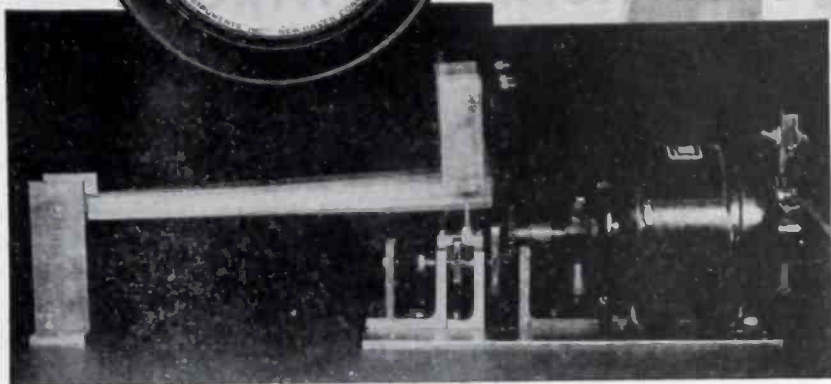
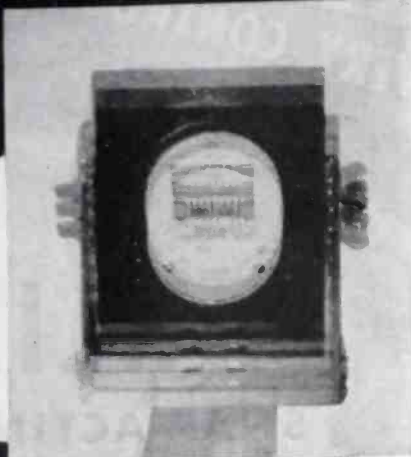


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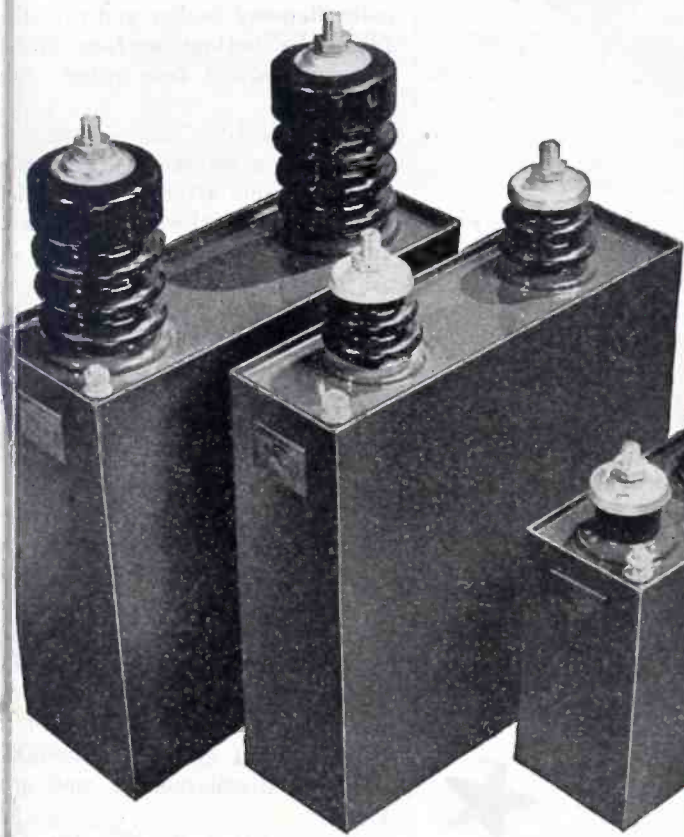
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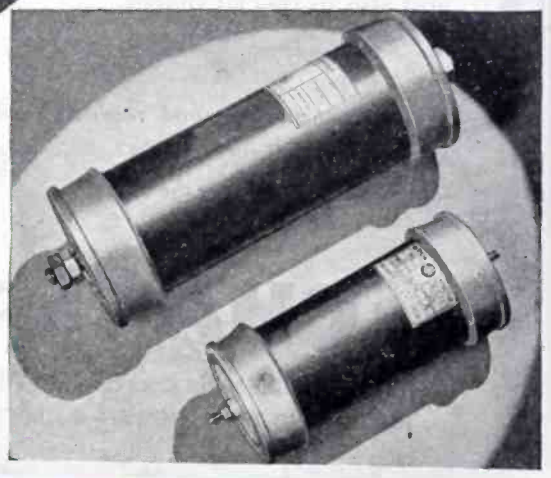
In the case of Westinghouse D-C Capacitors, materials . . . processing . . . assembly techniques . . . are combined to produce units that will give maximum life under the most severe operating conditions on land, sea and air.

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Designers of communications equipment find that the complete Westinghouse line meets all requirements. Capacitors are made in accordance with A.S.A. standards CP-70 and CP-71. Range is from 1,000 to 250,000 volts d-c; 400 to .001 mfd; for use in ambient temperatures ranging from -40° C. to 75° C. For complete application data, write for your copy of B-3300. Westinghouse Electric & Manufacturing Company, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-60560

NOTE THESE FEATURES of Type FPC (Porcelain-clad) Capacitors for higher ratings

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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 striations.

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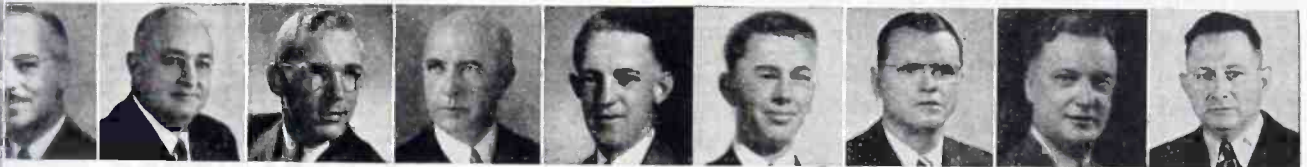
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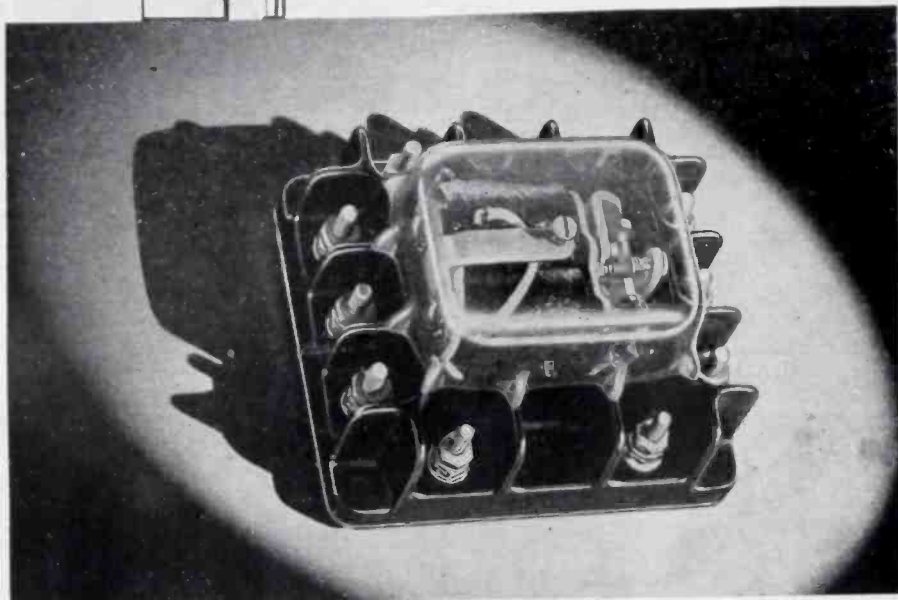
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The favorite yesterday, the favorite for tomorrow

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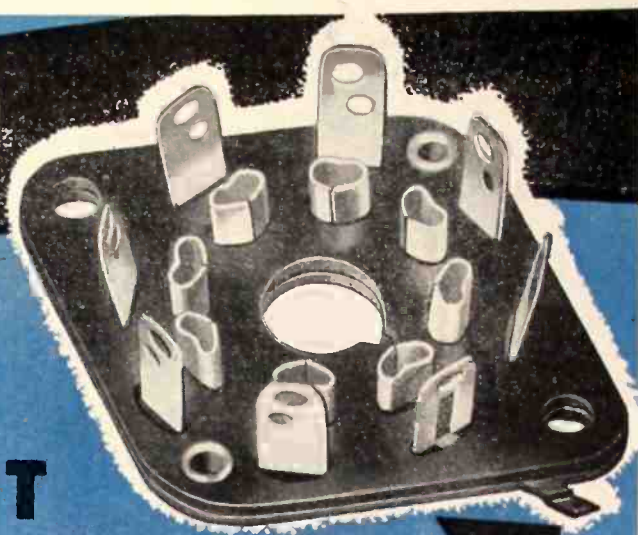
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The story of Franklin's series 39 Radio Socket, with patented "U" shaped bow spring action contacts, is most remarkable... developed and patented early in 1938 it received immediate acceptance and approval by practically all the radio set manufacturers and became standard equipment with most.

Series 39 sockets should be riveted to the chassis to become a permanent part of the set... no replacement will be necessary as the socket will outlive the set.

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This series 39 socket has a 39G Contact with a soldering tab which eliminates wiring to ground.

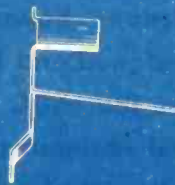
Illustrating the "U" shaped bow spring action contacts...39H and 39G...used in Franklin's series 39 Sockets.

Bow spring action maintains resiliency even after installation of oversize pins

Direction of metal grain prevents breaking of soldering tail and permits rough handling in production



"U" shaped contact provides separate soldering tail which prevents solder from flowing into contact body



The 39G contact has a soldering tab to eliminate wiring to ground... can be inserted in any position where grounding is desired.

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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 great

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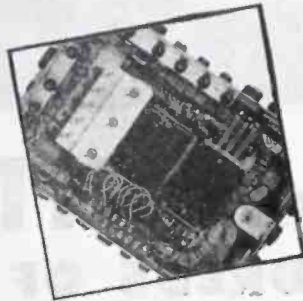
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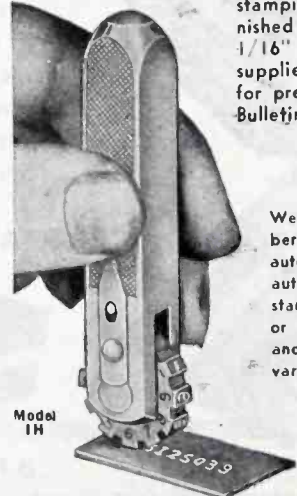
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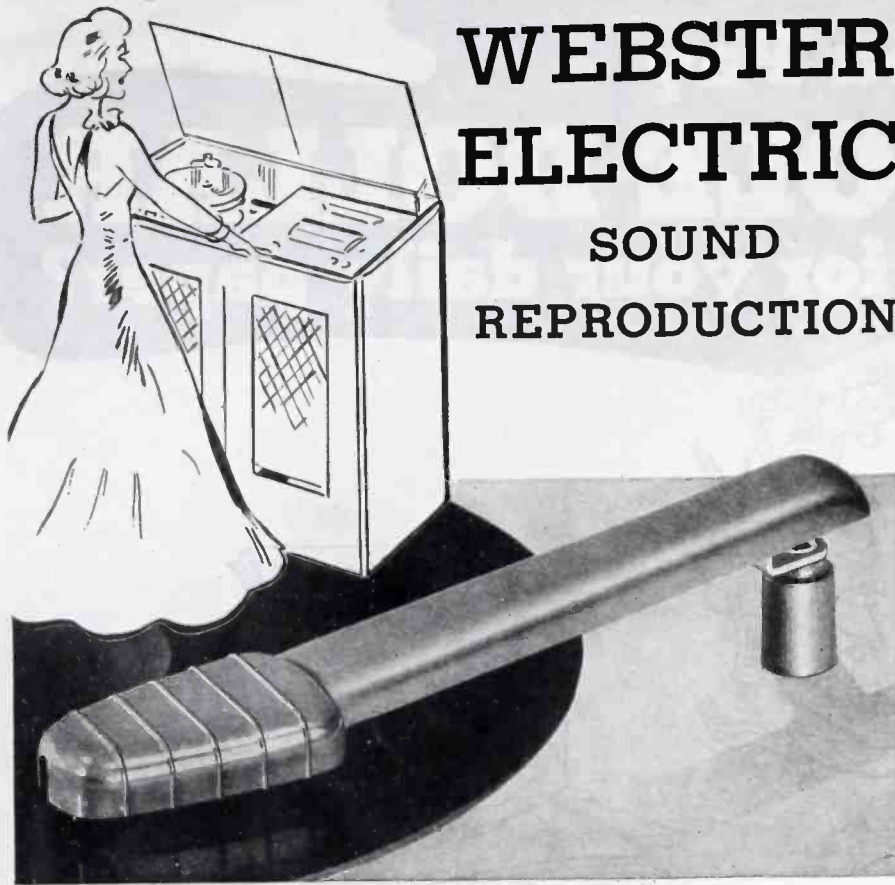
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Scale Loss

The percentage of scale loss is calculated according to the following method: Original weight = W_o
Weight after quenching = W_q
Weight after pickling = W_p
Then $W_o - W_p = \text{Total Loss of Cu}$. 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-

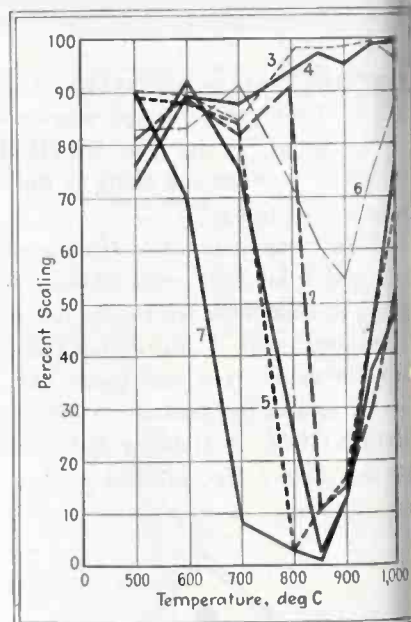
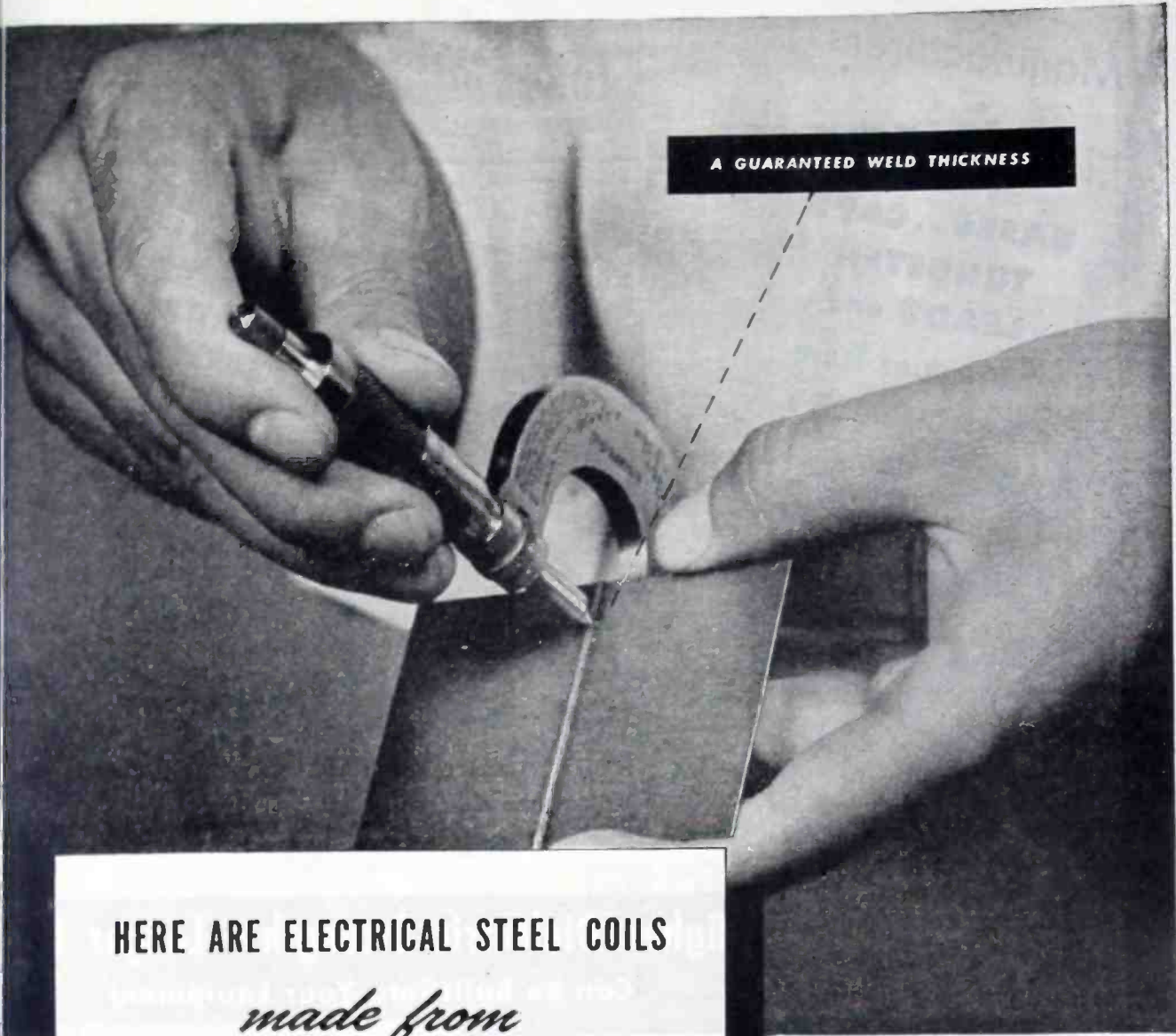


Fig. 1—Curves of percentage of scaling for several varieties of copper. Curve (1) is OFHC copper; (2) tough pitch; (3) tough-pitch deoxidized, 0.008 percent phosphorus; (4) tough-pitch deoxidized, 0.012 percent phosphorus; (5) cathode copper, plus 0.01 percent zinc; (6) cathode copper, plus 0.0015 percent phosphorus; (7) OFHC, plus 25-30 oz/ton silver



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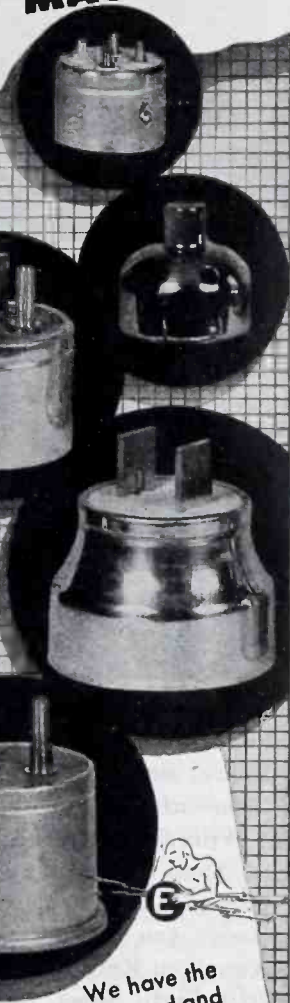
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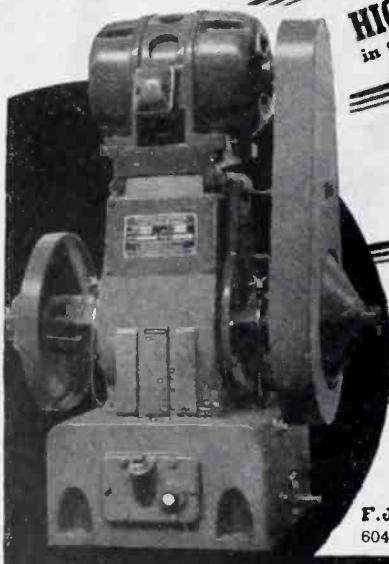


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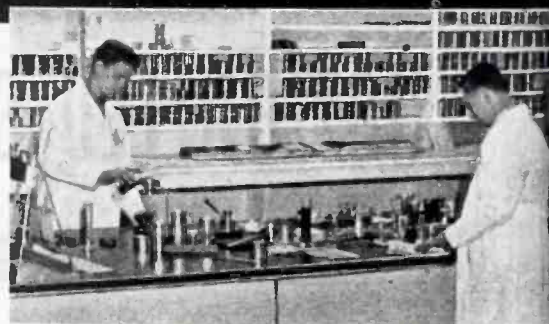
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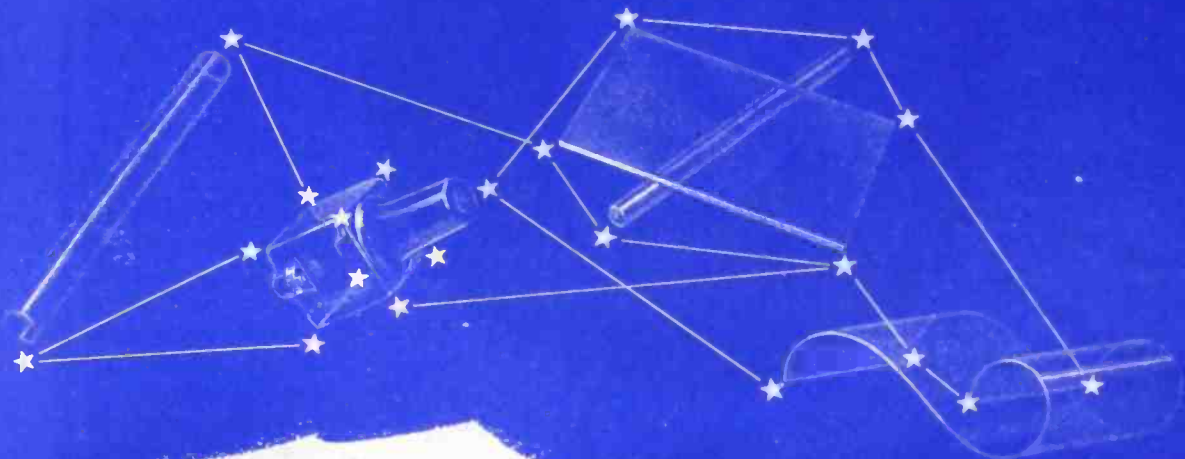
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This BAKELITE polystyrene group presents sweeping opportunities for superior and economical high-frequency equipment. In each of its varied forms, BAKELITE polystyrene offers the sterling qualities of

resistance to many chemicals, a high index of refraction, transparency and clarity, and excellent resistance to water absorption. It has low specific gravity, and is rigid or flexible, according to form. Its wide variety of transparent, translucent, and opaque colors can be used to enable ready identification of parts or to improve the appearance of countless products.

Our field engineers and development laboratories are always glad to team up with designers and fabricators in developing new uses for BAKELITE polystyrene in high-frequency equipment.



BAKELITE CORPORATION, 30 E. 42 St., New York 17

Unit of Union Carbide and Carbon Corporation



Polystyrene Plastics

ster, Christie and Pratt, who obtained negative values whenever W_q was greater than W_0 , this method expresses perfect scale adherence by "zero percent Scaling".

Molecular Weight of $Cu_2O = 127.14 + 16.00 = 143.14$.

$\frac{143.14}{127.14} \times \text{Total Loss of Cu} = \text{Total } Cu_2O \text{ formed.}$

$W_p + \text{Weight of Total } Cu_2O = \text{Weight of Specimen after heating but before quenching} = W_h$

$W_h - W_q = \text{Scale Loss.}$

$\frac{\text{Scale Loss}}{\text{Total } Cu_2O} \times 100 = \% \text{ Scaling.}$

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

ELECTRONICS GEARS
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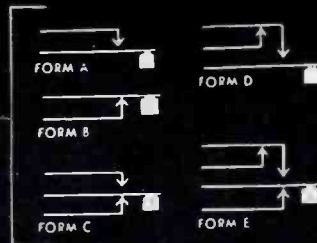
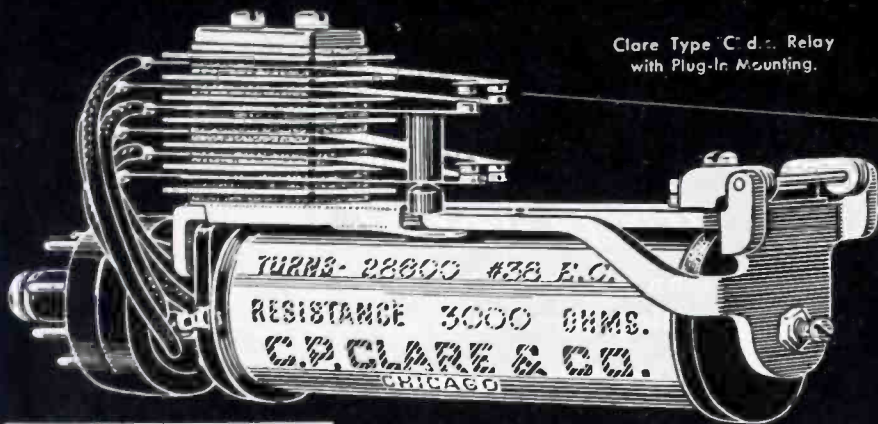
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DAYS OF LIGHTNING SPEEDS AND
WORLD WIDE COMMUNICATIONS,
ALL TUNED INTO OUR PRESENT
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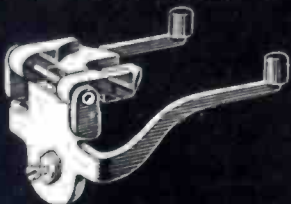
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Clare Type "C" d.c. Relay
with Plug-In Mounting.



Contact springs employing any of these basic forms can be furnished.



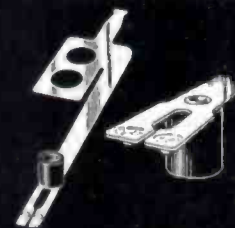
Double arm armature assembly of stainless steel shaft, operating in a marine brass yoke. Heelpiece, core and armature assembly are of magnetic metal.



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

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Can be depended on under most severe conditions of Temperature . . . Humidity . . . Atmospheric Pressure . . . Voltage . . . or Vibration

THE Clare Type "C" d.c. Relay, like all Clare "Custom-Built" Relays, has that unusual flexibility of design that permits the design engineer to have just the relay for the specific function required.

By "custom-building" the Clare Type "C" Relay in this way, Clare assures exceptional service in spots where hard usage, long life and absolute dependability are of prime consideration. Severe conditions of temperature, humidity, atmospheric pressure, voltage and vibration are met by including in the relay construction the particular Clare feature or features to meet them.

The Clare Type "C" Relay can be "custom-built" to work perfectly under conditions that call for definite times for operation and release of the relay, high speed keying without contact chatter, marginal operation which may include close pick-up and drop-out values, the transfer and switching of high frequency circuits . . . and many others.

Design engineers have found the innumerable contact arrangements possible with the Clare Type "C" to be valuable. Some of the important uses to which these relays have been put include:

- Sequence control of machine tools
- Radio, radar or other electronic controls
- Electric eye controls
- Counting equipment
- Alarm systems

Pictured and described here are some of the special Clare construction features that make it possible for Clare Relays to so effectively reduce overall relay cost, simplify installation and insure better and more dependable performance.

Clare engineers are ready at all times to assist in developing a relay "custom-built" to your exact requirements. Send for the Clare catalog and data book. C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago (30), Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

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MODEL 504-A TUBE AND SET TESTER

- ★ Design proven by over 5 years production of thousands of this model.
- ★ Operation as simple as ABC. Multi-section push-button switches do all work. Simply "follow the arrows" for tube checking. No roaming test leads for the multimeter.
- ★ Open face wide scale 4 1/4-inch rugged meter built especially for this tester—500 microampere sensitivity.
- ★ Each AC and DC range individually calibrated.
- ★ Professional appearance. Solid golden oak carrying case.
- ★ Guaranteed Rectifier.

SPECIFICATIONS

DC MICROAMPERES:
0-500

DC MILLIAMPERES:
0-2.5-10-50-250

DC AMPERES
0-1-10

DC VOLTS—1000 OHMS PER VOLT:
0-5-25-100-250-500-1000-2500

AC VOLTS
0-5-10-50-250-1000

OUTPUT VOLTS:
0-5-10-50-250-1000

OHMMETER:
0-200-2000-20,000 OHMS
0-2-20 MEGOHMS

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Check Dry Portable "A" and "B" Batteries Under Load

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A VHF Transmitter and Receiver especially designed for airport traffic control towers, aeronautical ground stations or relay service. Engineered for ease of installation and maintenance by men who have had actual "in the field" experience.



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Manufacturers of Radio and Electronic Equipment

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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

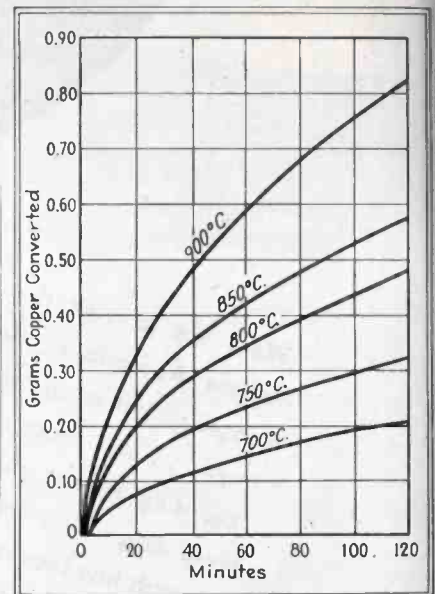


Fig. 2—These curves show the weight of copper converted to scale per sq in. of surface at various temperatures and heating times

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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DR8008, with Longer Pins, Wider Base

provides better filament contact and insures longer tube life. The longer pins and wider base of the DR8008 give positive filament contact and eliminate almost all pin resistance heretofore encountered with the 872A.

Other notable improvements such as dome type anode, glass boot, filament with large emission surface and bottom closed shield plate combine to give greater durability and performance, as well as longer tube life.

SPECIFICATION: 10,000 volt inverse peak. Extensively used for power supplies from 1,000 to 5,000 volt output. Current output: 2 tubes, 2½ amperes.

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IN THE FIRST SIX POST-WAR MONTHS



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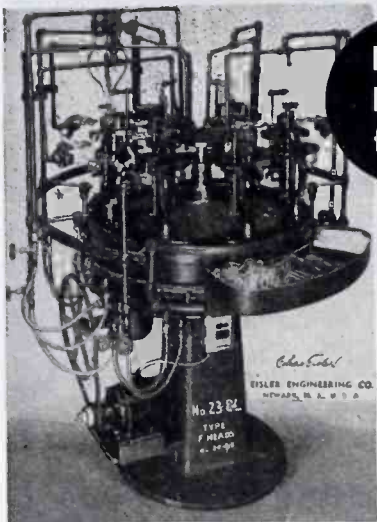
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(TOP) No. 23-BL Stem Machine, one of several in the EISLER line, speeds production and reduces breakage losses.

(RIGHT) No. 95-L Butt Welder, has simplified control, and assures perfect welds with minimum damage to metal grain structure.

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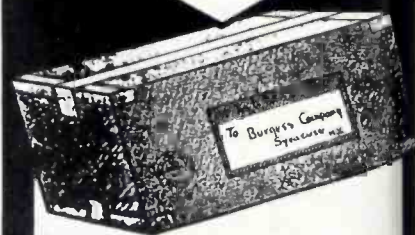


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Report on NATVAR #400

a New Extruded Plastic Tubing

Excerpts from the E.T.L. report covering tests made on Natvar No. 400 in accordance with A.S.T.M. Standards.

DIELECTRIC STRENGTH — A.S.T.M. D350-43
Average volts per mil: At 28°C — 1090
At 85°C — 700
Wall thickness: .0235"

DIELECTRIC CONSTANT AND POWER FACTOR
Dielectric constant at 29°C and relative humidity 60%
At 60 cycles: 8.15
At 1 megacycle: 4.35
Power Factor: At 60 cycles: .056
At 1 megacycle: .064

ARC RESISTANCE — A.S.T.M. D495-42
Average — 135 seconds

OIL RESISTANCE — A.S.T.M. D295-43T
"Turbol 10" at 105°C was used. After 15 minutes immersion there was no apparent change in the tubing. After 24 and 48 hours there was no sign of change in the tubing. Three separate tests were made.

HEAT ENDURANCE — A.S.T.M. D350-43
After 7 days at 125°C the tubing did not crack or otherwise fail when bent 180° around a $\frac{1}{8}$ " mandrel.

TENSILE STRENGTH AND ELONGATION
At 200% elongation: Average 1980 lbs. per sq. in.
At Maximum: Average 2870 lbs. per sq. in.
Total elongation: 350%

LOW TEMPERATURE FLEXIBILITY
After 3 hrs. at minus 30°F specimens were bent around a mandrel $\frac{1}{8}$ " in diameter. There was no sign of cracking or other failure.

FLAME RESISTANCE — D350-43
Burned about $\frac{1}{4}$ in. in 10 to 15 seconds and then went out. Three tests were made.

EFFECT OF CHEMICALS
Effect of 7 days immersion in solvents at room temperature; average of 3 tests in each solvent:

Solvent	Change in weight Per cent of weight of speci- men as received	Change in dimensions Per cent of dimensions of specimen as received		
		Length	Outside diameter	Thickness
5 per cent sulfuric acid	+ 0.41	none	none	none
1 percent potassium hydroxide	+ 0.83	none	none	none
Petroleum	+ 6.62	+2.6	none	none
Ethyl Alcohol	+ 1.66	none	none	none
Benzol	+21.9	+6.6	+10.9	-24.0

WATER ABSORPTION
Average of 5 tests

Water absorption, per cent by weight of dry specimen	0.63
Soluble matter, per cent by weight of dry specimen	0.01
Total water absorption, per cent by weight of dry specimen	0.64
Change in dimensions:	
in length	none
in outside diameter	none
in thickness	none

This new tubing is now commercially available for war uses. For further information, write, wire or phone us.

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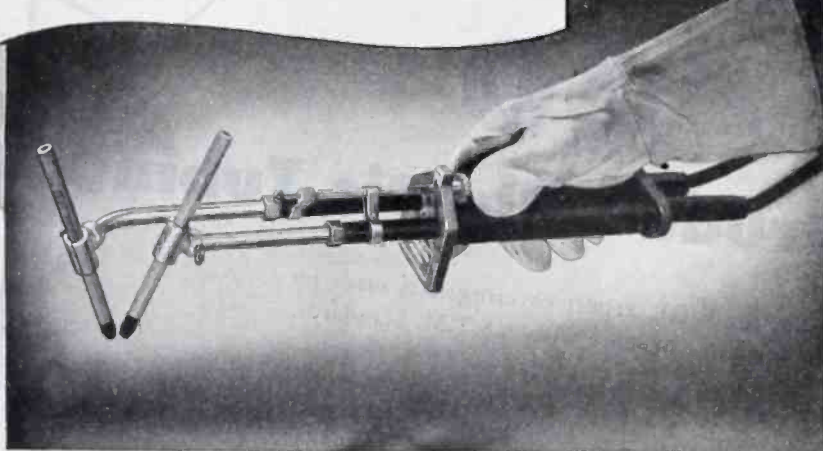
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Presented in the hope that they will prove interesting and useful to you.



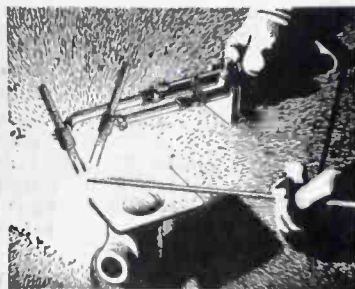
New 9000° Arc Torch can be used for Welding and Brazing all ferrous and non-ferrous metals and alloys

Now an arc torch that makes it possible to do most jobs *electrically* that previously were thought possible only with gas. This attachment for arc welders provides an independent source of heat by means of two carbons. It is capable of producing intense heat, approximately 9000° F., over 2000° hotter than an oxy-acetylene flame. Pure heat, no oxygen or gas to contaminate the weld. No pressure to force the molten metal away or blow holes in light sections.

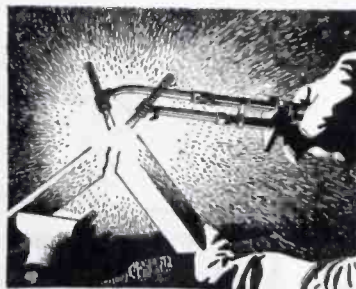
Developed to capitalize to the fullest on the time-saving advantages of electric welding, the new Mid-States 9000° arc torch can be used with any AC or DC electric welder. It opens up new horizons of service in this field, never before possible with an electrically operated instrument.

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For HEATING to Straighten or Bend, etc.

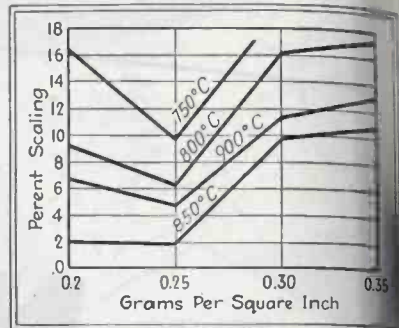


Fig. 3—Percent of scale versus weight of copper converted to scale for OFHC copper at four different temperatures

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-percent-age 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

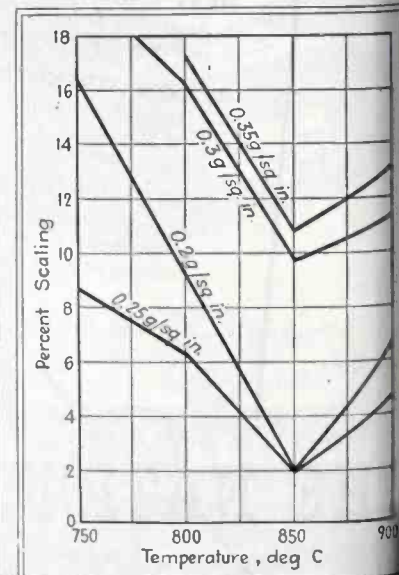
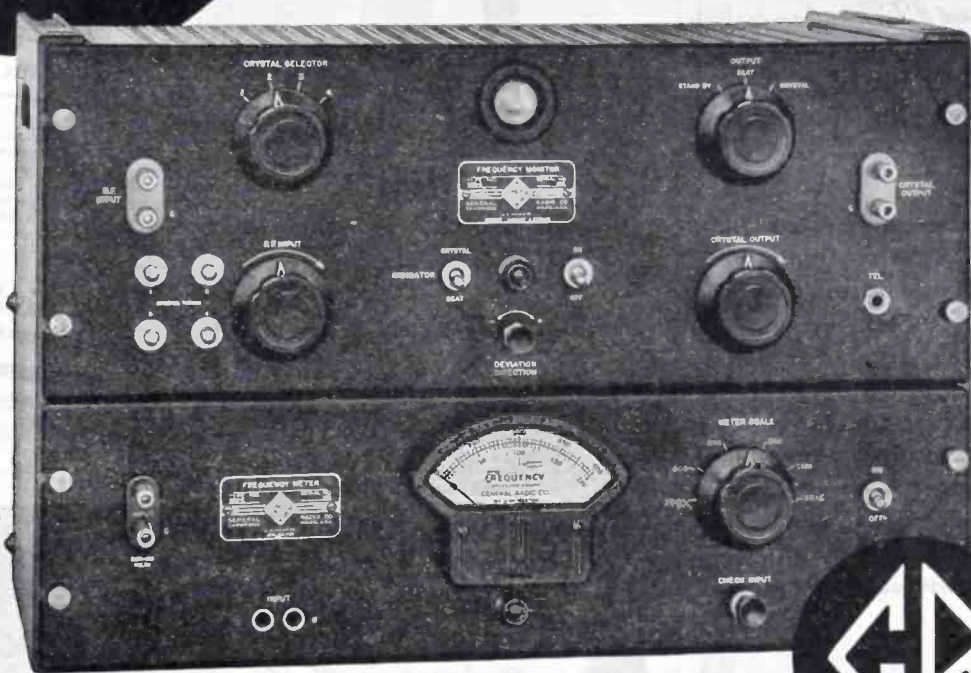


Fig. 4—Percent of scaling plotted against temperature for OFHC copper

NEW FREQUENCY METER and MONITOR

for HIGH FREQUENCY
SERVICES—1500 kc
to 200 Mc



For measuring and monitoring the carrier frequency of a-m transmitters, these two new G-R instruments offer many operating advantages over equipment formerly available.

With the Frequency Meter, readings are substantially independent of amplitude of modulation, input waveform and input voltage. Over very wide ranges, changes in any of these do not affect the meter indications. The instrument requires no direct connection to the transmitter... a foot or two of wire provides ample coupling. The indicating meter has six ranges with full-scale values of 200 cycles, 600 cycles, 1 kc, 6 kc, 20 kc and 60 kc.

One of the most useful features of the Frequency Monitor is its great sensitivity. It can be used to monitor mobile stations. The numerous operating conveniences include: a panel switch to select any one of four temperature-controlled quartz plates; a "stand-by" control to maintain operating temperature continuously with the tube circuits disconnected; positive indication of the direction of frequency deviation; panel terminals for the audio output and for the output of the crystal buffer stage for calibrating or adjusting transmitters or receivers.

You'll find that this combination of instruments is one of the best G-R has developed for high-frequency communications monitoring.

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ACCURACY: $\pm 2\%$ of full scale
INPUT VOLTAGE: Any between 0.25 and 150 volts
MOUNTING: Relay-rack panel; walnut end-frames (illustrated) for table mounting, extra

TYPE 1176-A FREQUENCY METER
\$185.00

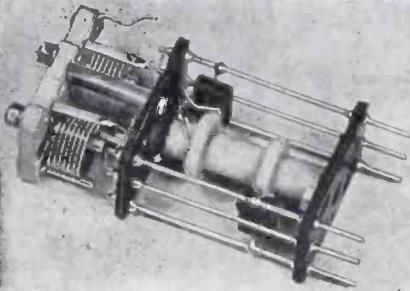
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CARRIER RANGE: 1500 kc to 200 Mc
ACCURACY: 0.003% with our quartz plates
QUARTZ PLATES: Up to four, not included in price; ground to channel frequency
MOUNTING: Same as Frequency Meter
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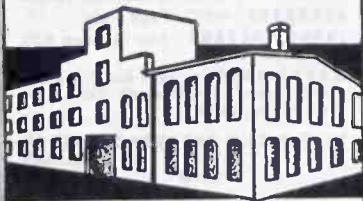
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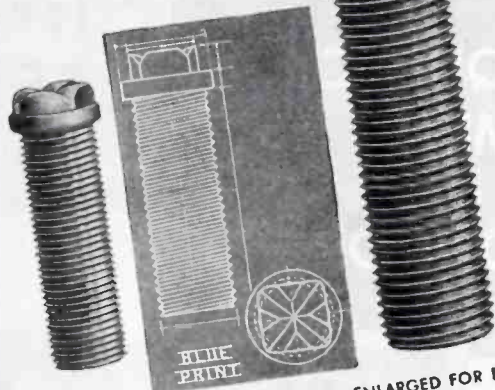


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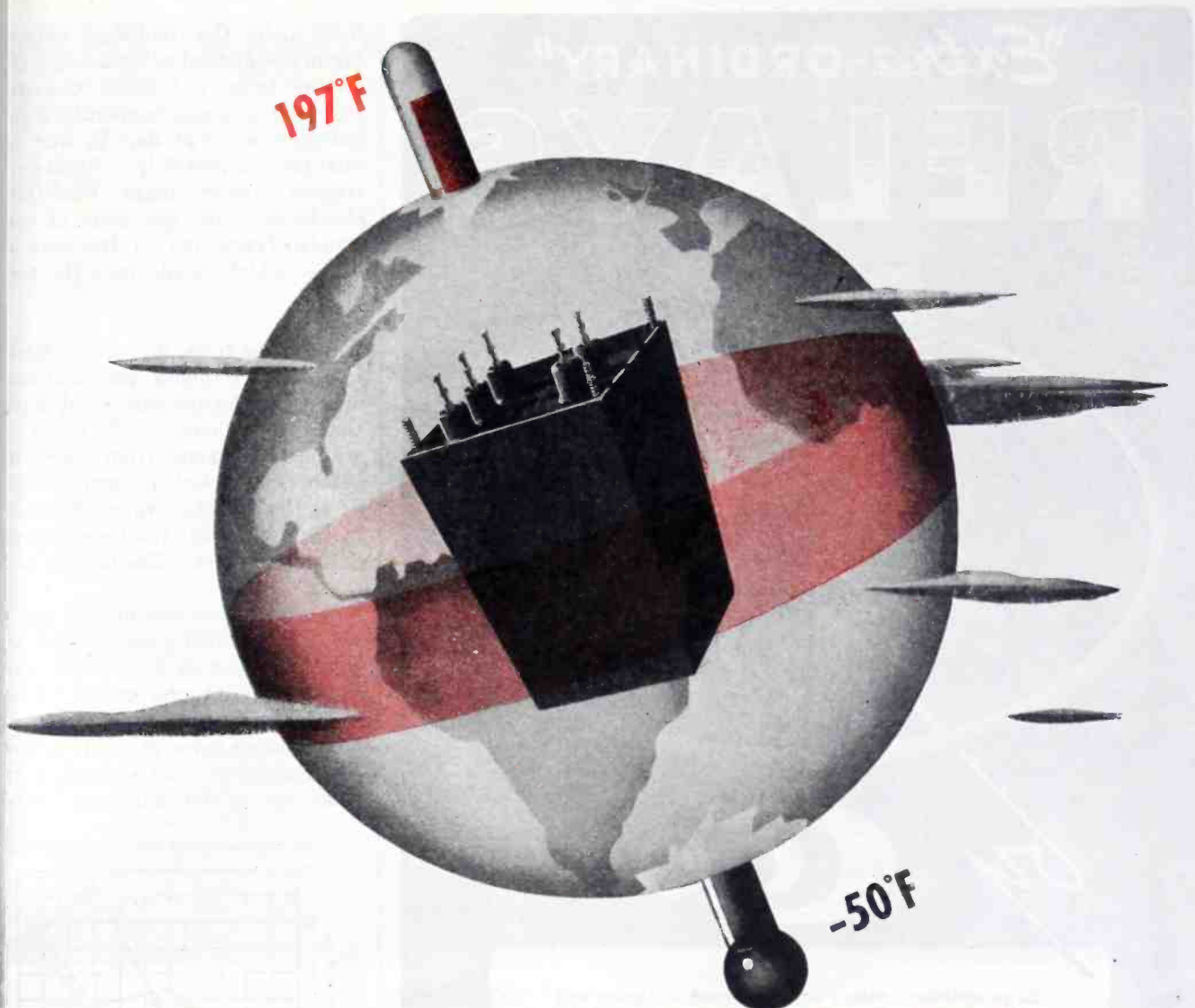
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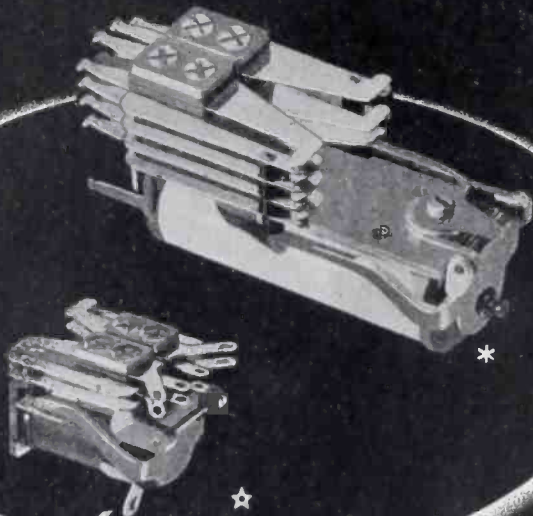


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*The large relay illustrated above is the Type 108, now in quantity production. Produced with the finest relay materials. High permeability, magnetic materials, annealed in controlled atmosphere. Various modifications adapt it to a wide range of applications. Adjustment to specific conditions provides extreme high speed sequence or marginal operation. Coils bakelite impregnated and heat cycled to meet severe humidity conditions. Available in a wide range of voltages from 6 to 220 Volts D.C. and 10 to 220 Volts A.C., 20 to 25 Cycle and 50 to 60 Cycle. Mounting holes provided in heel piece for direct mounting to panel. Can be equipped with octal speaker plug or other types to meet special requirements. Dust-proof housings and weather-proof covers are also available.

*The small relay illustrated above is the new Type 400. Its features include: Stainless steel bearing pins for long life and permanent adjustment. New coil terminal design to prevent coil losses due to breakage of lead wires. Wide spacing of staggered spring terminals and elongated holes to facilitate wiring. High permeability, magnetic materials, annealed in controlled atmosphere. Coils wrapped in serving and bakelite impregnated against moisture, to Air Corps specifications. Single or twin contacts and single or double spring pile-ups to six springs high. Saving in space and weight. Sturdy, durable construction. Nickel silver, beryllium copper or Inconel spring materials optional. Withstands high G and vibration tests due to light weight and balanced armature.



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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

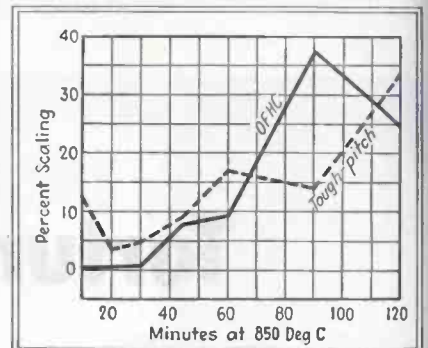


Fig. 5—Percent of scaling produced on OFHC and tough-pitch copper at 850 deg C for various heating times

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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Esmeralda Cope is one of many hundreds of women workers in the Detrola Radio Division who now are building land mine detectors, FM signal generators and other electronic war equipment. This job continues until Victory. But without detracting from this primary task, many of these workers are being acquainted also with their post-war assignments on the same production lines. Thus they will be ready to build hundreds of thousands of fine radio receivers, automatic record changers, television receivers and other products to enrich the life of a world at peace. Yes, Esmeralda Cope has two jobs. And International Detrola's creed of highest quality rules them both.

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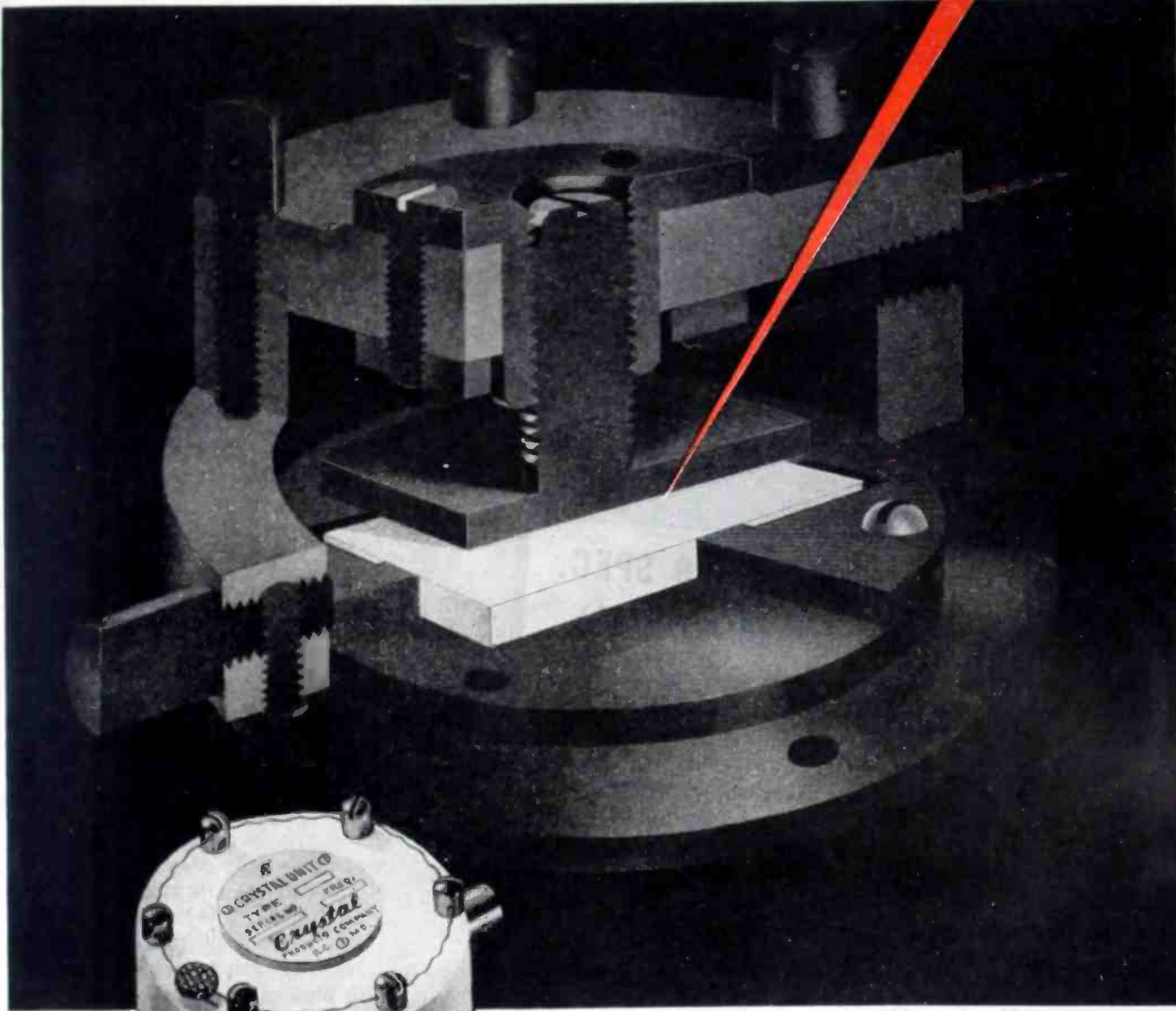


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was started and were therefore used. Our standard tests for certification of OFHC copper are made on hard-drawn wire.

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.

The technique for detecting this radiation is very difficult and time-consuming, so much so that Hollaender and other physicists decided that mitogenetic radiation does not exist at all. However, the fact that electronic engineering has produced some outstanding instruments

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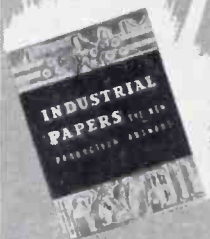
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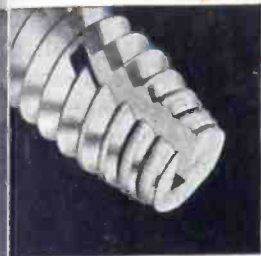
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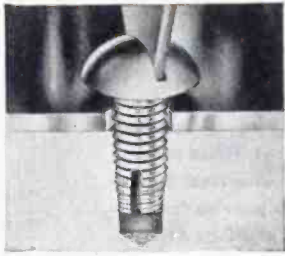
6 Important Reasons

WHY YOU SHOULD USE

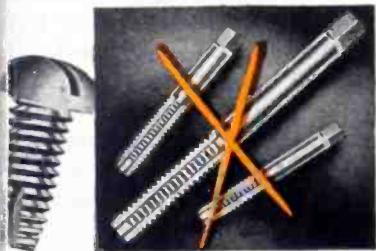
SHAKEPROOF TYPE 1 THREAD-CUTTING SCREWS



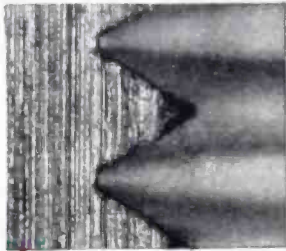
1 Exclusive Thread-Cutting slot provides sharp, serrated cutting edge.



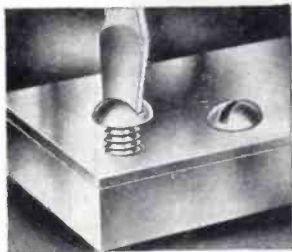
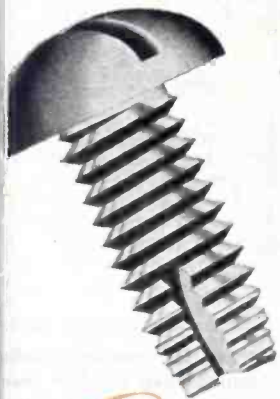
2 As each Type 1 is driven, it cuts its own perfect mating thread.



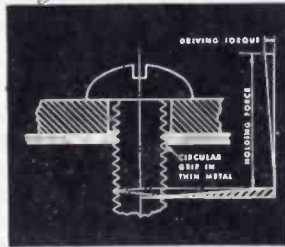
3 Eliminates tapping—no taps to buy or maintain.



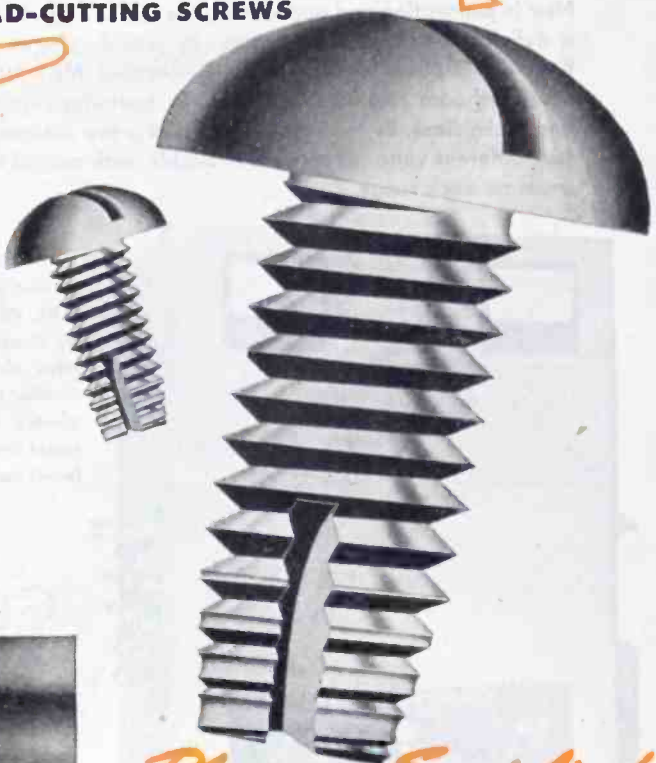
4 Snug, tight fit *always*, because each screw remains in the thread it has cut itself.



5 Drives easily in any thickness of metal.



6 Maximum thread contact assured because of standard machine screw thread.



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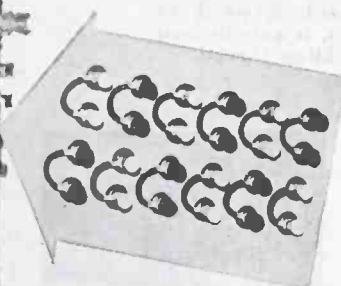
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. . . providing flexible DC power for laboratory work

New in conception and application, the Green Multi-Rectifier MRI fulfills a definite need in the laboratory. By providing in one compact unit a flexible DC power supply, the Multi-Rectifier MRI lifts the restrictions which orthodox rectifiers, generators or batteries impose upon engineers and technicians. By the simple shifting of a few external links a choice of four different voltage ranges is available, with control from zero to maximum on each range.



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- 0-24 volts, max. cap., 35 amps.
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For additional information about this new Green development, write for our explanatory brochure, or talk to a Green representative.

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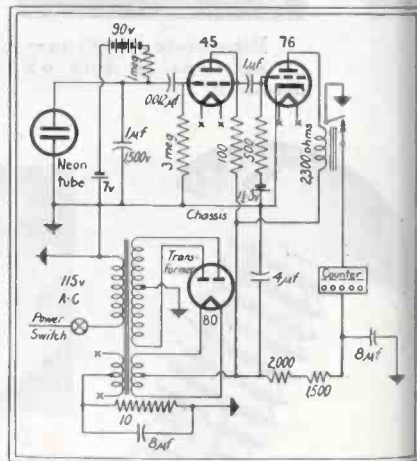
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available for laboratory medicine—such as the electrocardiograph, the electro-encephalograph, audio-frequency measuring instruments, not forgetting the electron microscope, suggests that something might be devised for detecting radiations of the kind 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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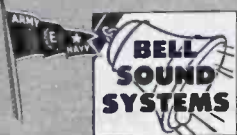


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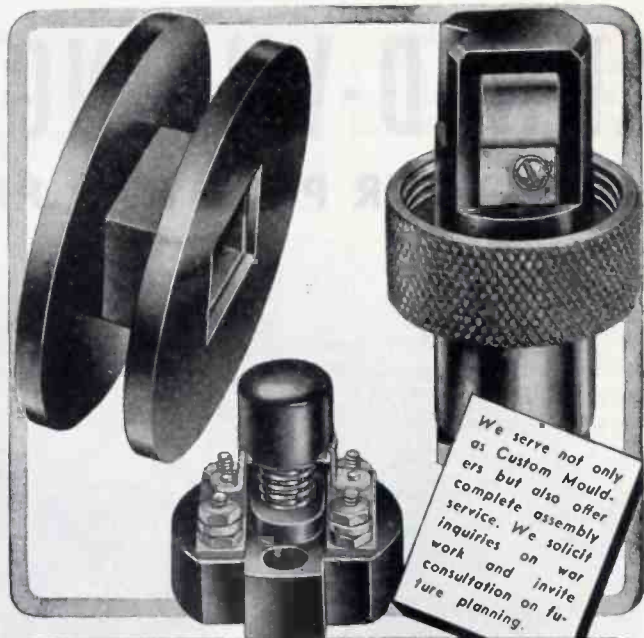
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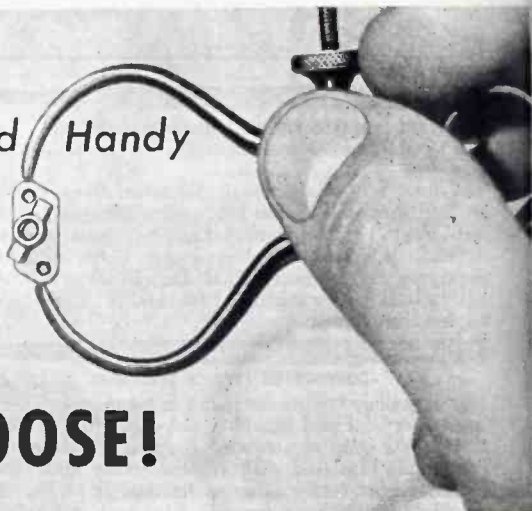
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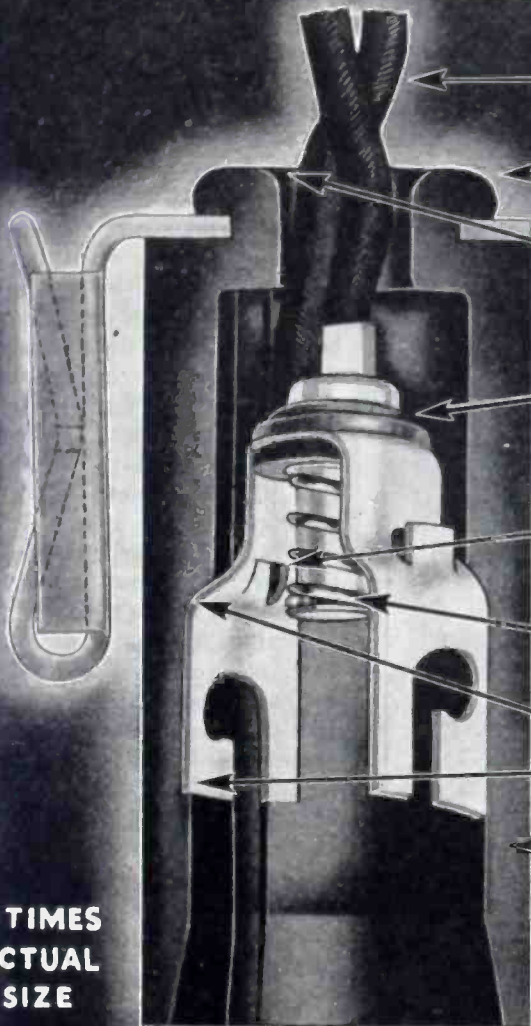
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was removed from an ordinary culture tube and placed on the slide.

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.



DOW ANNOUNCES
a further important

STYRON (**DOW POLYSTYRENE**)
PRICE REDUCTION

Dow announces a further reduction in the base price of Styron to 25c per pound, effective November 1, 1944.

Increased efficiency of production has made this further reduction possible. This is in keeping with the established Dow policy of manufacturing quality materials—in quantity—at low cost.

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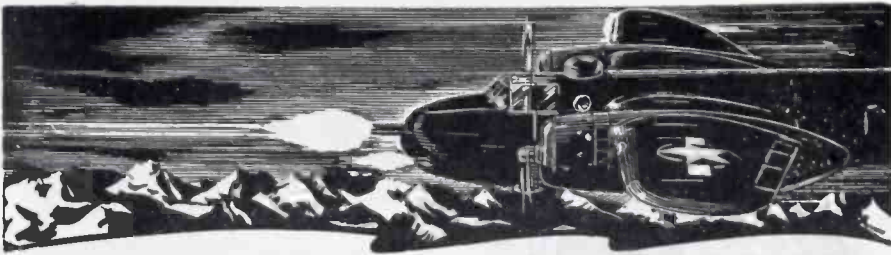
STYRON

(DOW POLYSTYRENE)

From the only privately owned synthetic styrene plant with sufficient facilities to care for molders' postwar requirements.



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CHEMICALS PLASTICS MAGNESIUM
INDISPENSABLE TO INDUSTRY AND VICTORY



For Positive Operation of Electrical Brushes and Contacts
USE SILVER GRAPHALLOY

Silver Graphalloy works in extremes of heat and cold. It is a molded graphite impregnated with pure silver, a highly-efficient conductor that is self-lubricating and extremely durable. Used in gun fire control, radar, slip-ring, instrument applications, and many others.

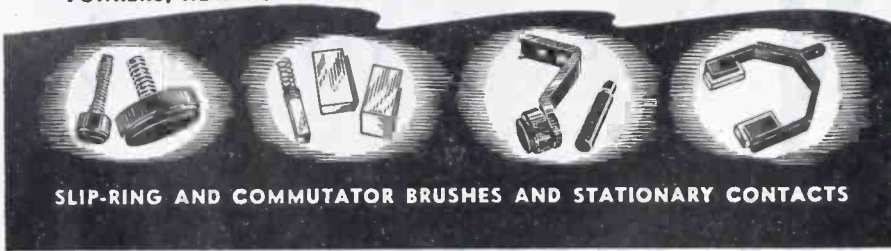


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Investigate the superior qualities of Silver Graphalloy. Make it a silver job.

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SLIP-RING AND COMMUTATOR BRUSHES AND STATIONARY CONTACTS



Vital bearings for a Mark XIV Gyro Compass being inspected with a Spencer Stereoscopic Microscope.

**A Ship—
 A Compass—
 A Microscope**

A bridge of American merchant ships is carrying tens of thousands of tons of fighting supplies to our allies and our own armed forces in every quarter of the globe.



Indispensable to navigation on many of these ships is the famous Sperry Mark XIV Gyro Compass. On hazardous voyages, blacked out and unable to use radio, ships are guided on their course by this precise instrument.

To inspect certain parts during manufacture, Sperry uses Spencer Stereoscopic microscopes. Their depth of focus, large object field and high resolution of fine detail enable inspectors to see greatly magnified images of parts with hair line sharpness and with stereoscopic, three-dimensional clarity.



Spencer LENS COMPANY
 BUFFALO, NEW YORK
 SCIENTIFIC INSTRUMENT DIVISION OF
 AMERICAN OPTICAL COMPANY

December 1944 — ELECTRONICS

STAMINA



The inherent stamina of Cinaudagraph Speakers is due to experience in design and manufacturing plus highest inspection standards. In all types of Cinaudagraph Speakers, from small watch-like Handie-Talkie units to large auditorium speakers, you'll find the same precision, the same painstaking workmanship and the same long-lived faithful reproduction.

Watch Cinaudagraph Speakers after Victory!

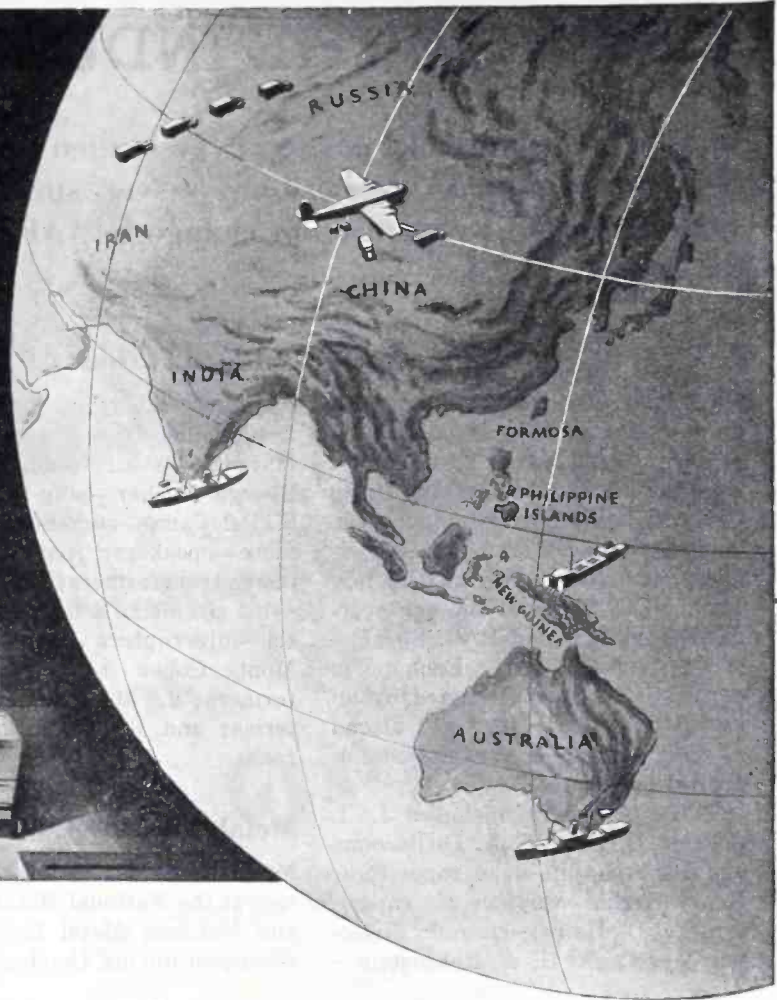


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OUT to the Far East, to ports on the seven seas identified only in code on the packing cases, goes war material so vital that it is needed on every beachhead and before the beachhead is created—poured out of *one* shipping room in just *one* factory in just *one* small Connecticut town!

Incredible? Not when Yankee ingenuity is taken into consideration—the same Yankee

ingenuity that stems from many lifetimes of meeting difficult situations.

That's the case here at Ansonia—typical of our approach to the problems which any form of electrical cables can solve. However difficult the requirements of peace may be, we feel that we can be of assistance in meeting them in new ways, as we have met the changing problems of war *and* peace before.

ANKOSEAL multi-conductor insulated cables are among the most promising of Ansonia war-proven developments. If you have, or expect to have, a use for electrical cables—

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Toward Parts Standardization

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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—

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Metal-Working Electronics

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**PRECISION Frequency Calibration up to
2000 Megacycles with the LAVOIE
HARMONIC FREQUENCY GENERATOR**

PROVIDES output voltages which are multiples of 10 megacycles or 40 megacycles with CRYSTAL-controlled accuracy.

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- The above methods can be used in the calibration of equipment requiring a voltage, such as receivers or wavemeters . . . or (by using the Beat Detector built into the Harmonic Frequency Generator) in the calibration of equipment producing a voltage, such as oscillators and signal generators.

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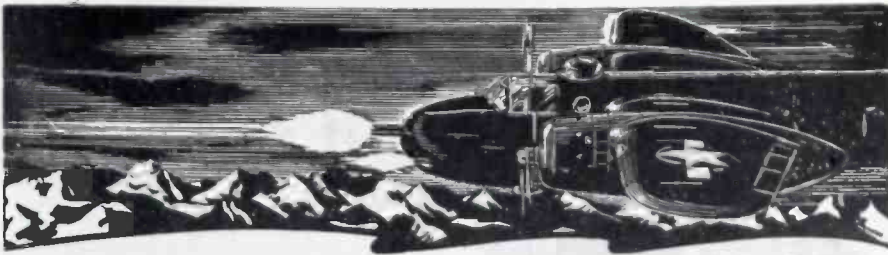


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Specialists in the Development of UHF Equipment



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USE SILVER GRAPHALLOY

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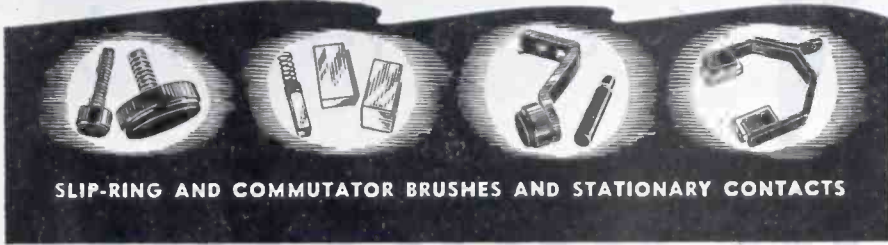


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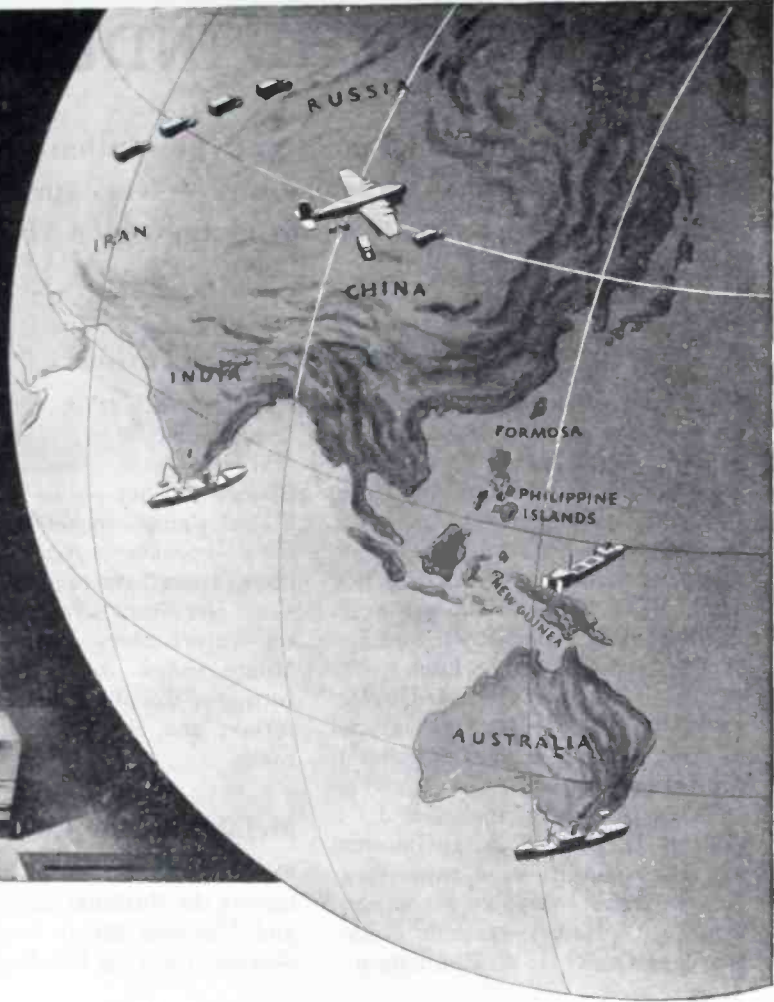


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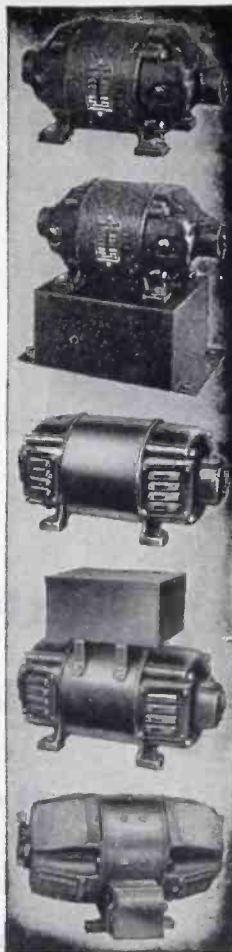


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FOR THE TASKS OF PEACE

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.

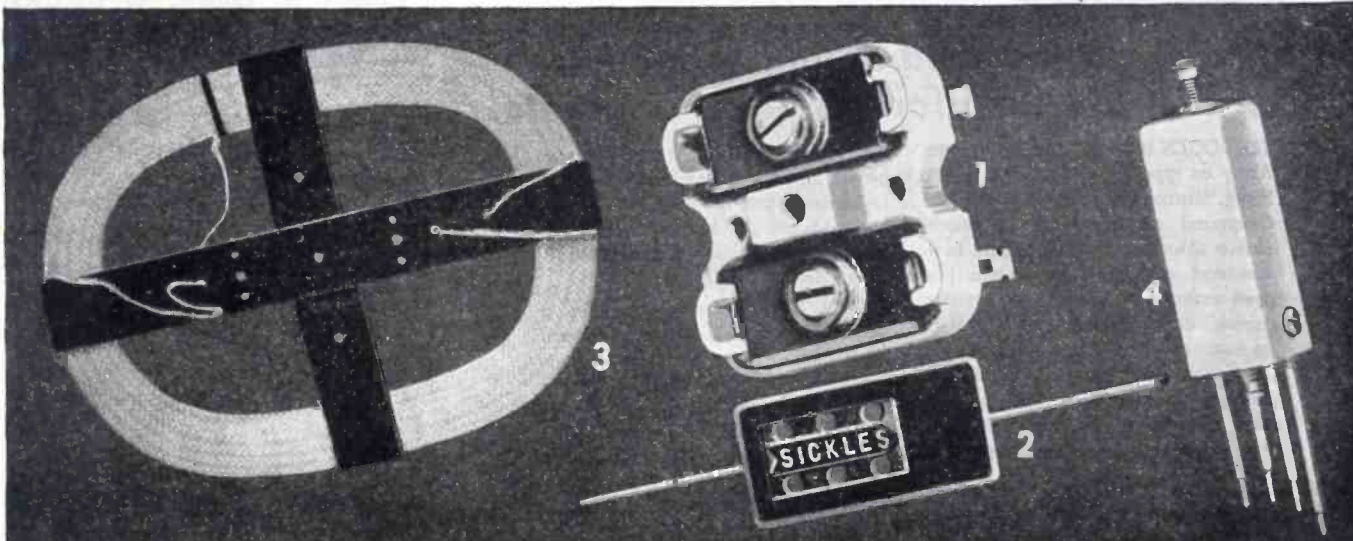
So our postwar plan is extremely simple. It is to continue to serve our customers in meeting their specialized needs for performance, quality, quantity and low cost. To us, that program seems sound. Can we help you now, to plan *your* postwar production "muscles"?

THE F. W. SICKLES COMPANY • CHICOPEE, MASSACHUSETTS

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1. 1933—Dual Mica Trimmers*
2. 1936—Silver Cap Condensers*
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4. 1941—Midget I.F. Assemblies
5. 194V—More Coming

* Patented



Radio and Electronic Specialties for Today and Tomorrow

SICKLES

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**SOUND
EQUIPMENT...**



**SERVING
ON ALL
FRONTS**

Ultra High-Powered Sound...another BOGEN first for post-war markets!

The BOGEN MC-225, identified by the Army as type AN UIQ-1, and by the Navy, Marine Corps and Amphibious Command as the Portable Beachmaster Announcing Equipment, is illustrated above. This system has seen extensive action in Normandy, as well as in the Battle of France in its entirety. Numerous other phases of its service include amphibious landings in the South Pacific, and more recently, a vital contribution to the success of the airborne invasion of Holland.

BOGEN sound engineers—by developing, designing and building ultra high-powered sound systems for

every branch of the Armed Forces—have gained the knowledge essential to leadership in the field. The experience gained "under fire" will lend impetus to both theory and actuality for tomorrow's applications.

BOGEN Sound Systems—setting a new standard for Industrial Program Equipment—for announcing, intercommunication and public address broadcasting—will be available for schools, hospitals, churches, industrial plants, airports, railway systems, recreation centers, etc.

BOGEN engineers are ready to assist you in the planning of sound equipment needs. Inquiries are invited.

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BOGEN SOUND SYSTEMS • AMPLIFIERS
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663 BROADWAY, NEW YORK, 12, N. Y.

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.

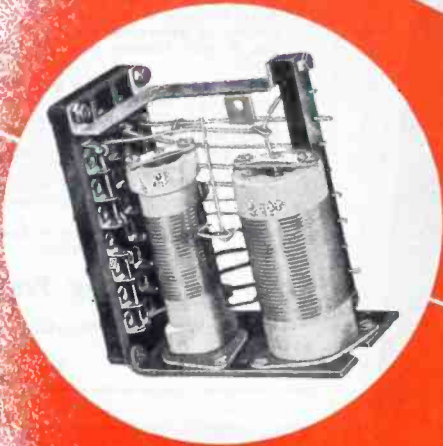
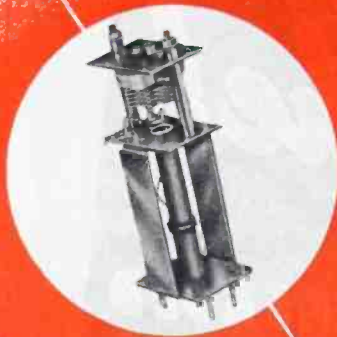
Fessenden's Papers Available

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-



*New Designs Simplify
Mass Production!*



**HIGH FREQUENCY COILS,
TRANSFORMERS AND SWITCHES
FOR ELECTRONIC APPLICATIONS**

Originality of design coupled with precision workmanship sets apart the SE units shown here. They are, however, but a small sampling of the extensive range of SE-engineered vital parts we are producing to our customers' own specifications. Our complete facilities, including laboratory, design, development and manufacturing, are available to interested makers of electronic equipment.

INQUIRIES ARE INVITED



SUPER ELECTRIC PRODUCTS CORP

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Also Makers of Transformers for: Power • Audio Frequency • Luminous Tube

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 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.



METAL-COATING PROCESS

- FAST AND ECONOMICAL
- FOR HEAVIER COATINGS

REQUIRES ONLY RAPID ELECTROLYTE—RAPID METAL CLEANER—RAPID APPLICATOR

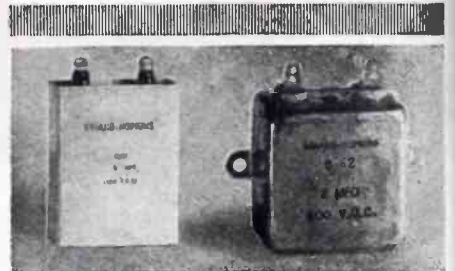
• Plating current is obtained from dry cells, storage battery, or any convenient source of direct current at 5 to 6 V., or use Rapid Plating Rectifier for heavy work.

• 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.



MODEL T-45
LIP MICROPHONE



UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA



FOREIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA · CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA

HOWARD CRYSTAL HOLDERS

*Built to Your
SPECIFICATIONS*

Tested, used, and proved by the armed forces of our country, Howard Crystal Holders are ready to serve you in peacetime. Dependability, accuracy, and assured performance are the results of precision work by HOWARD'S skilled personnel. Send your specifications to HOWARD.

★ BUY WAR BONDS ★

HOWARD MANUFACTURING CORP.

COUNCIL BLUFFS, IOWA



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.

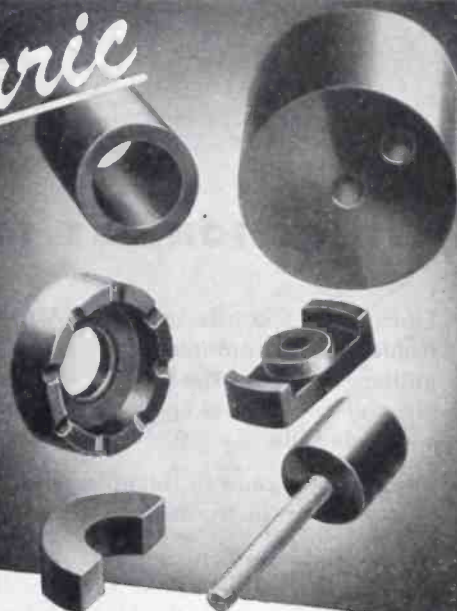
Electronics Training Course

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

PyroFerric

IRON CORES



Pyroferric powdered metal cores have kept apace the vital precision instrument development. They are manufactured to specification:

PERMEABILITY	} HIGH	as desired	FREQUENCY	} HIGH
"Q"					} LOW	} MEDIUM
RESISTANCE				LOW

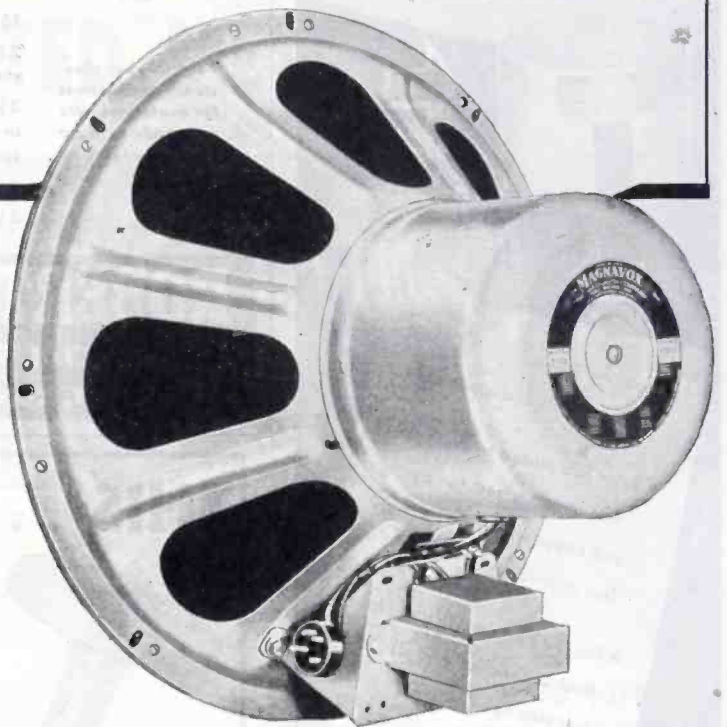
Consult Pyroferric on your Powder Metallurgy requirements

PYROFERRIC Co.

175 VARICK STREET NEW YORK, 14, N. Y.

LOUD SPEAKER HEADQUARTERS— MAGNAVOX

MAGNAVOX, the oldest name in radio, is at the very forefront in new design and advanced engineering. This company again will assume its former peacetime role—world's outstanding manufacturer of quality loud speakers—with skills and facilities stepped up to new high levels by its war work. Once more old friends and customers will be served in the traditional Magnavox manner, with the added advantages of all new developments and the superb equipment of its modern 6-acre plant. Magnavox radio components are made expressly for the manufacturing trade. When you're ready to talk about your postwar needs,



Model 15E 3015,
15 dynamic speaker. (118 additional models available)

get in touch with loud speaker headquarters. The Magnavox Company, Components Division, Fort Wayne 4, Ind.



Magnavox
has served the radio industry 33 years

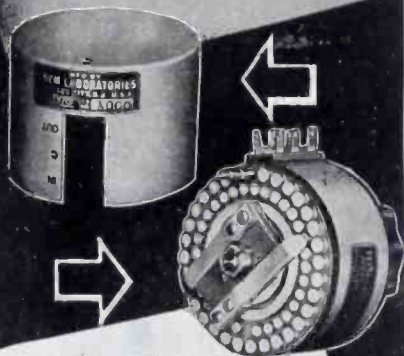


SPEAKERS • CAPACITORS • SOLENOIDS • ELECTRONIC EQUIPMENT

**NEW
IMPROVED**

**"T"
PAD**

**ATTENUATORS
BY TECH LAB**



- Stainless Silver Alloy contacts and wiper arms.
- Rotor hub pinned to shaft prevents unauthorized tampering and keeps wiper arms in perfect adjustment.
- Can be furnished in any practical impedance and db. loss per step upon request.
- Write for our Bulletin No. 431.

**TECH
LAB MICROHMMETER**



Direct and instantaneous resistance readings down to 5 microhms and up to 1,000,000 megohms. Write for Bulletin No. 432.

TECH
LABORATORIES

7 LINCOLN STREET
JERSEY CITY 7, N. J.



This New Jig Speeds Your Radio Assembly

Send us your chassis or specifications for quotations. We are ready to meet your delivery schedules.

- 1) Can be loaded and unloaded in two seconds.
- 2) Indexed 360° fixture to hold chassis in any position to step up soldering and all other assembly operations.
- 3) Adjustable to any size to base limits of the Jig. Comes in various sizes or we will make Jigs to your chassis or specifications.
- 4) Sturdy, rigid construction.
- 5) Holding adapters to fit your chassis.

ROBERT L. STEDMAN MACHINE WORKS
SPECIALISTS IN MASS PRODUCTION TOOLS
OYSTER BAY, LONG ISLAND NEW YORK

THIS . . .



. . . NOT THIS



GOOD DESIGN

Broad, flat head has more bearing surface, permits greater sealing compression. One-piece construction — no weak soldered connections — no "pin-holes", no complicated assembly.



Photo Courtesy Gudeman Co.

Leakproof TERMINAL SCREW

THE POSITIVE seal for all terminal openings where leakage of oil, water or air must be prevented. Can be drilled lengthwise. Useful in capacitors, transformers, etc. Available in 6-32 diameter with 1/2" head; 8-32 with 9/16" head; 10-32 and 12-24 with 5/8" heads. Write for samples, or phone Whitehall 4680.

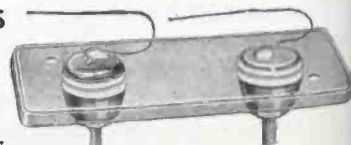
**MANUFACTURERS
SCREW
PRODUCTS**

223 West Hubbard St.
Chicago 10, Ill.



BAD DESIGN

Four operations — soldered connections subject to mechanical strain — slightest pinhole results in leakage of oil, water, air. Increases rejections — cuts production and profits.



Old way

Stronghold way

**Precious Metals
on
Base Metals**

**Base Metals
on
Base Metals**

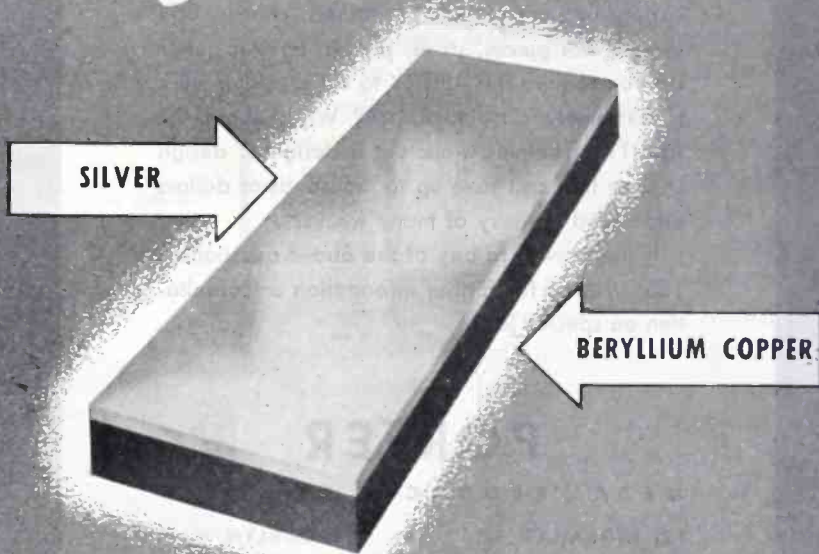
**Laminated
Electrical
Contacts**

AND NOW A NEW GENERAL PLATE LAMINATED METAL

Silver on Beryllium Copper

**For Extra
Conductivity**

**WHERE
SPRINGINESS
IS
REQUIRED**



Throughout the years, General Plate has pioneered in the development and manufacture of laminated metals for industry. Now it brings you, for the first time, a new laminated metal... Silver on Beryllium Copper.

This new metal combination gives you, for the first time, the extra good conductivity of silver... plus the springiness of beryllium copper.

No matter what the application, tiny switch blade or heavy strips, this new General Plate Laminated metal will give you better performance through its silver and beryllium metal combination.

It is available in combinations of silver on one or BOTH sides, or with silver between two layers of

beryllium (centrelay).

Investigate this new General Plate Laminated Metal today. Our field engineers will gladly consult with you on your problems and make unbiased recommendations. Ask for their services. Write:

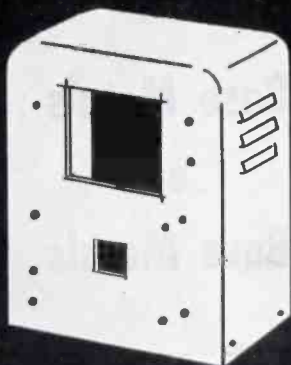
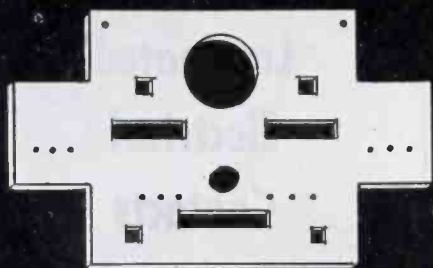
GENERAL PLATE DIVISION

OF METALS & CONTROLS CORPORATION

Metals and Controls Corporation Divisions manufacture the following products: Laminated & Solid Precious Metals, Electrical Contacts, Rolled Plated Precious Metals to Base Metals in all forms — Truflex Thermostat Metals.

ATTLEBORO, MASSACHUSETTS

50 Church St., New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 181 E. Main St., Canterbury, Ohio; 2635 Page Drive, Altadena, California



What are Your

PRECISION METAL WORKING REQUIREMENTS?

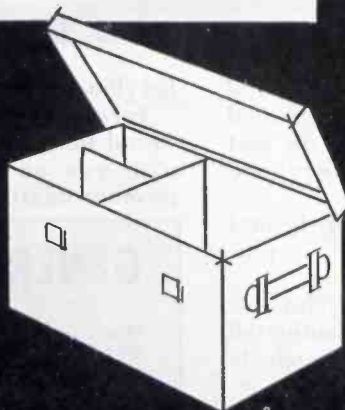
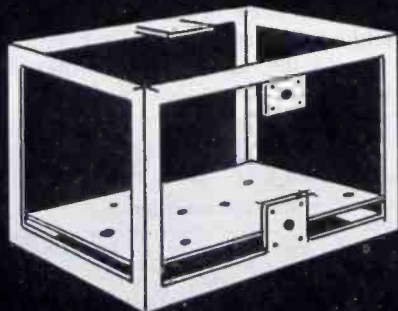
Do you require versatility—the ABILITY to do sheet metal work, stamping and fabricating—the ABILITY to build metal boxes and cases in a wide variety of sizes—to build cabinets, chassis, odd shaped flat pieces, strips, panels, housing, etc.? Do you require the ABILITY to do *precision* work to extremely close tolerance? What about the ABILITY of helping work out a design or design change that can save up to thousands of dollars and speed delivery of many weeks?

If the answer to any of the above questions is YES, write us for further information or consultation on specific jobs.

PORTER

METAL PRODUCTS COMPANY

121 INGRAHAM ST. • BROOKLYN, N. Y.



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

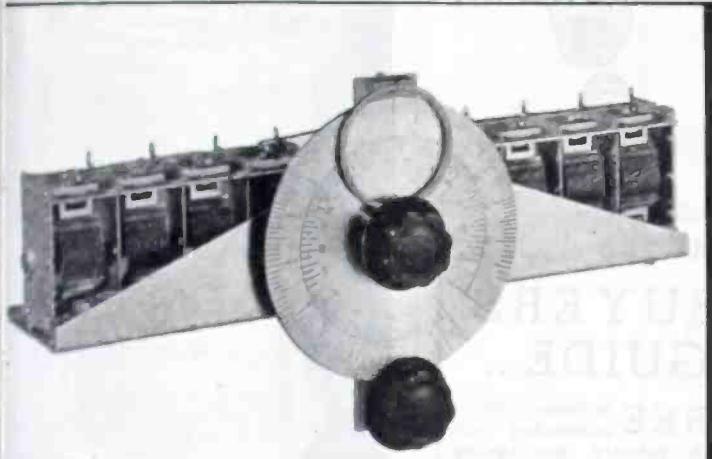
A NEW -hp- AUDIO OSCILLATOR

3 OUTSTANDING NEW FEATURES: 1. ACCURATE CONTROL DIAL

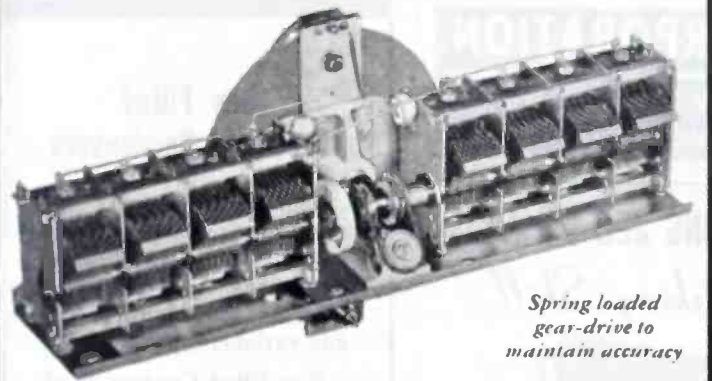
EASY TO READ • NO PARALLAX

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 200-1 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 200-1 -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

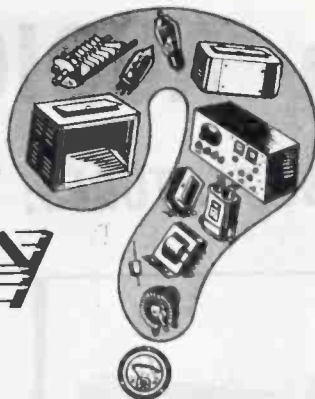
P. O. Box 930 A Station A, Palo Alto, California

WHAT ELECTRONIC PARTS DO YOU NEED

in a **HURRY**

HARRISON has it!

Most probably in Stock for immediate delivery

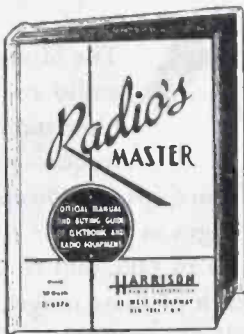


SINCE 1925

Still your best source of supply for the products of ALL leading Manufacturers.

Call WOrth 2-6276

FIRST!



Send for this
MASTER

BUYERS GUIDE...

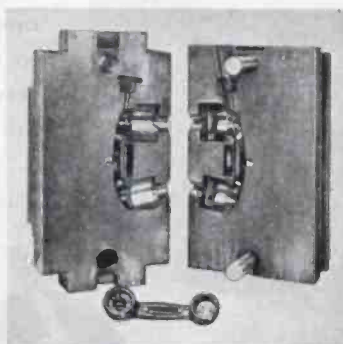
FREE to those directly connected with high priority purchasing. Kindly write on Company letterhead, giving your title.

HARRISON RADIO CORPORATION

12 WEST BROADWAY • NEW YORK CITY 7
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A GOOD MOLDING JOB DEMANDS Mold-making Skill



When choosing your molder, consider whether he makes his own molds. If he does, it usually means a better, faster job . . . often a more economical job. Then look at molds he has made. The skill and the care that are demonstrated in their construction are a sound measure of the worth of the final job.

The molds of the telephone handset which are shown here were made by Auburn for Stromberg-Carlson. Because the wires used for connections to the transmitter and receiver must be molded accurately in place in the handle, with the terminals properly positioned, the transfer molding process was used. By this process the molding material, in a plastic state, is forced into the mold after it has been closed. Note the several parts of the mold necessary to form the threaded transmitter and receiver shells, the hole for the cord and the opening in the handle in which a switch will be assembled.

On your next molded plastic job, get in touch with Auburn. Learn how Auburn's complete service can help you.

For small parts molded automatically at low cost, write: Woodruff Company Division, Auburn Button Works, Auburn, New York.

AUBURN ENGINEERED PLASTIC PRODUCTS

Compression, Transfer, and Injection Molding

Extruded Vinyl or Acetate Tubes and Shapes

Cellulose Nitrate Rods, Sheets, Molded Parts

Mold Engineering and Complete Mold Shop

AUBURN BUTTON WORKS

INCORPORATED

FOUNDED IN 1876 AUBURN, N. Y.



Gas Filled Pressure Condensers

Johnson Engineers were among the first to design and build Gas Filled Pressure Condensers in fixed, variable, and combination fixed and variable types.

Gas Filled Condensers offer a decided advantage in size where large capacities or high voltage ratings are necessary. In some cases Gas Filled Condensers make possible an instrument that would be a mechanical impossibility in an air type.

Johnson Gas Filled Pressure Condensers are available in several sizes of housings depending on the rating specifications. Prices are low, efficiency is high, gas leakage is nil over long periods of time.

Write today for more information and prices.

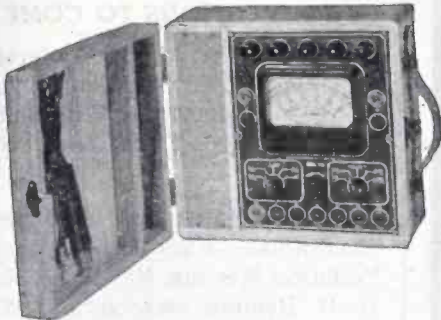
JOHNSON
a famous name in Radio

E. F. Johnson Co. Waseca, Minn.

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:

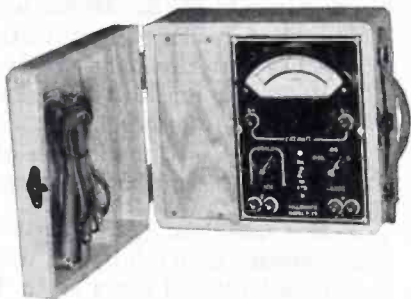
- 6 D.C. VOLTAGE RANGES: 0 to 15/60/150/300/600/1500 Volts
- 6 A.C. VOLTAGE RANGES: 0 to 15/60/150/300/600/1500 Volts
- 7 D.C. CURRENT RANGES: 0 to 3/15/50/150 Milliampers
0 to 3/15/30 Amperes
- A.C. CURRENT RANGE: 0 to 3 Amperes
- 5 RESISTANCE RANGES: 0 to 1,000/10,000/100,000 ohms
0 to 1 Megohm 0 to 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 parallax 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 1/2 of 1%.
- Circuit employed is exclusive adaptation of the potentiometric method of low resistance measurement.

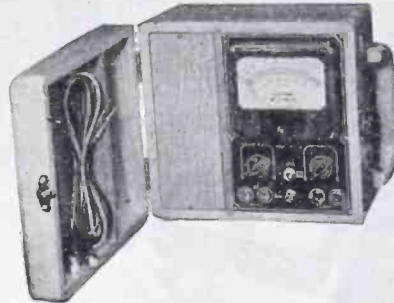
Model P-25 Milliohmmeter comes complete with battery, all test leads and instructions. Price

\$ 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 4 1/2". Price.....

\$ 49.50

SUPERIOR INSTRUMENTS CO.

Dept. E., 227 Fulton Street

New York 7, New York

ELEMATIC PYROMETER



*** Accurate Within $1\frac{1}{2}^{\circ}$... Direct Reading**
... Checking Radio Crystals in Sub-Zero Range

Designed especially for leading radio manufacturers, this Model 40 Elematic Pyrometer is unconditionally guaranteed for accuracy. It is a high resistance, precision made instrument—the result of exhaustive tests by manufacturers, as well as our own engineers.

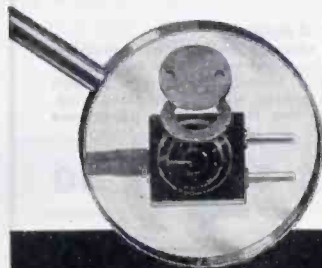
The Model 40 has many important features: a special compensator which automatically adjusts instrument for variations in room temperature... internal shunt that retards pointer swing... a mirrored scale to avoid parallax errors... $5\frac{3}{4}$ " scale with $\frac{1}{4}$ " numerals, 2° divisions... 6" knife edge pointer... sapphire jewels and hand-lapped pivots. Comes in walnut case with hinged removable cover and leather carrying handle. Write for further information.

*

Adaptable to All Types Crystal Holders
... and Available in Six Scale Ranges

Enlarged view on left shows thermocouple connected to a standard crystal holder. The Model 40 comes in following scale ranges:

0°— 150° C.	Minus 55°—Plus 90° C.
Minus 40°—Plus 50° C.	Minus 60°—Plus 100° C.
Minus 50°—Plus 100° C.	Minus 85°—Plus 85° C.



ELEMATIC EQUIPMENT CORP.

6046 WENTWORTH AVENUE, CHICAGO 21, ILLINOIS

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.

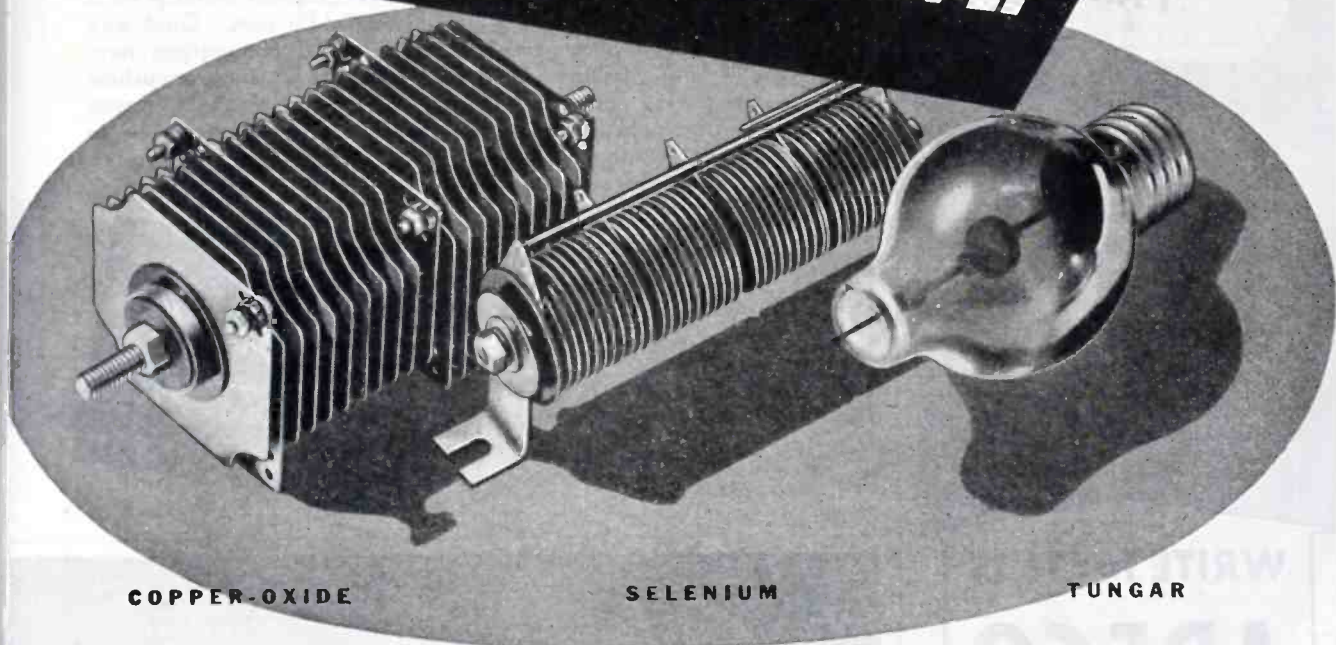
WASHINGTON NEWS

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.

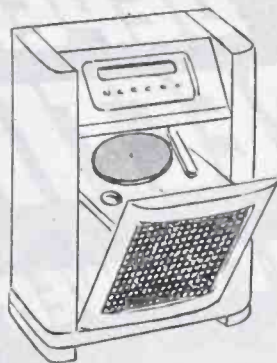
Send for this helpful book today.



AIRCRAFT & DIESEL EQUIPMENT CORP.

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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*



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- CRYSTALS
- CABLES
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- ELECTRONIC ASSEMBLIES
- CABINETS



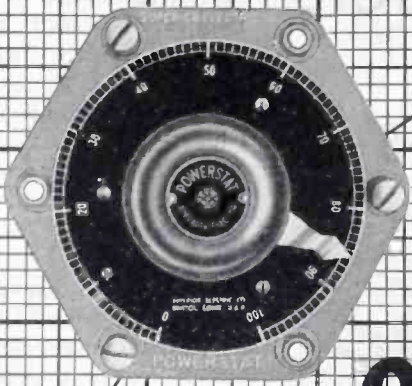
Telephone Peru, Indiana

151

Serving the Radio and Electronic Industries with precision engineered products.

Wm. T. WALLACE MFG. Co.

General Offices: PERU, INDIANA
Cable Assembly Division: ROCHESTER, INDIANA



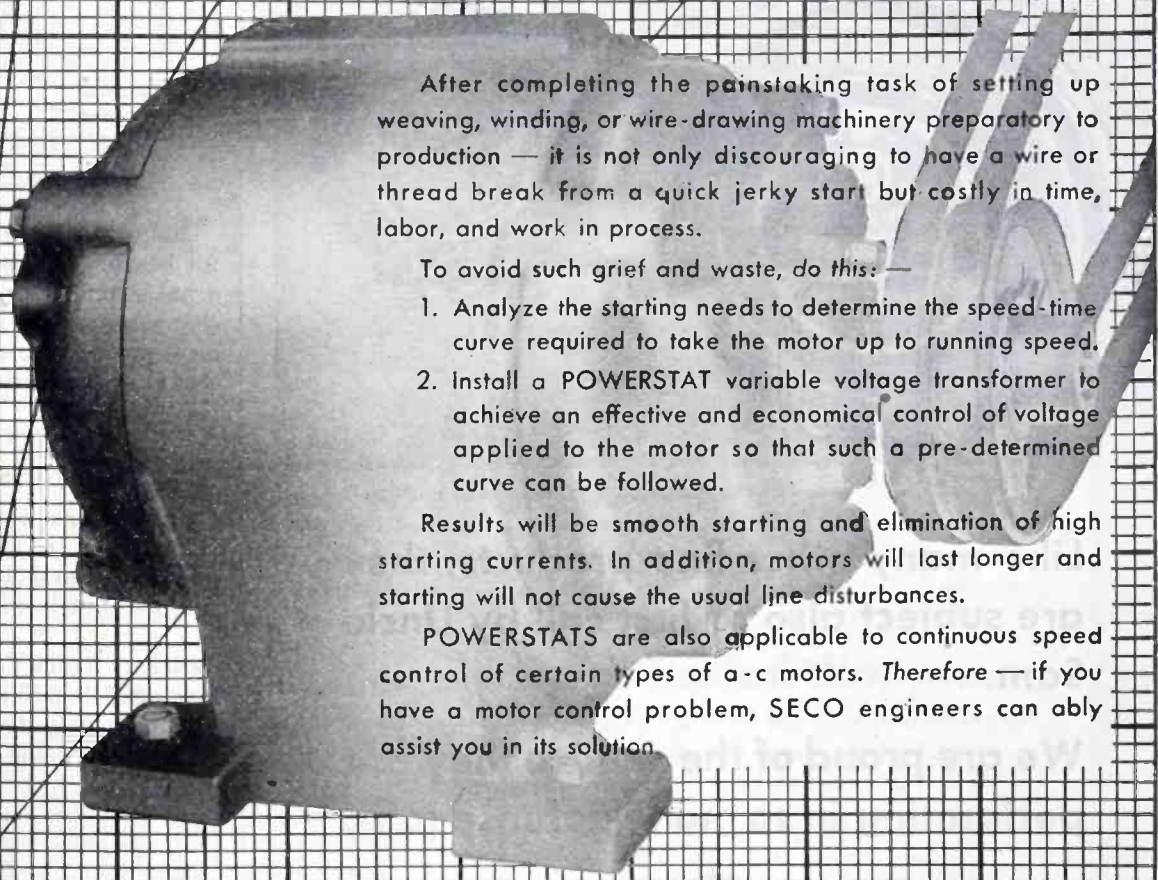
SMOOTH STARTING OF A.C. MOTORS IS ASSURED BY POWERSTAT CONTROL

SPEED (R.P.M.)

1600
1400
1200
1000
800
600
400
200

0 1 2 3 4 5 6

TIME (MINUTES)



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.

Send for Bulletins 149 LE and 163 LE

SUPERIOR ELECTRIC COMPANY

211 Laurel Street

Bristol, Connecticut

HARDWICK, HINDLE PRODUCTS ARE SUBJECT TO HIGH PRIORITY RATINGS



Like many other fine products, they are subject also to first call by Uncle Sam.

We are proud of the service they are performing in so many defense jobs.



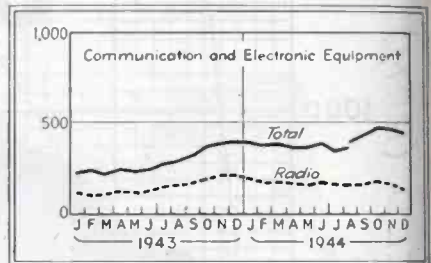
HARDWICK, HINDLE, INC.
RHEOSTATS and RESISTORS

DIVISION OF
THE NATIONAL LOCK WASHER COMPANY
ESTABLISHED 1886

Newark 5, N. J., U. S. A.

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



RESISTS HIGH
SUSTAINED HEAT

**"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.

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 1/2".

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.

**"VARTEX" SILICONE
RESIN-COATED
FIBERGLAS
CLOTH**

INSULATION MANUFACTURERS CORPORATION

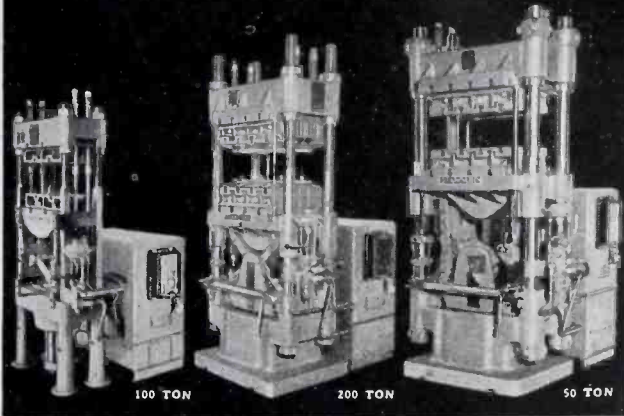
★ CHICAGO 6 • 565 Washington Blvd.

★ CLEVELAND 14 • 1005 Leader Building

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MINNEAPOLIS: 316 Fourth Ave., South
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STOKES STANDARD MOLDING PRESSES



**THEIR SAVINGS WILL MAKE
TOMORROW'S PROFITS**

USERS SAY:

- "... 240 more pieces per hour per 24-cavity mold on Stokes Standard Presses."
- "... Rejects less than 2% on precision pieces."
- "... 30% greater production due to automatic time cycle."
- "... Maintenance only \$5.00 per year total on all nine of our presses."
- "... Standard Presses protect molds, reduce mold maintenance."
- "... Controlled closing speed ideal for delicate pieces and precision work."
- "... One man attends battery of ten standard presses."

F. J. STOKES MACHINE CO.
6046 Tabor Road Philadelphia 20, Pa.

F.J. Stokes MOLDING EQUIPMENT



After The Others Failed..

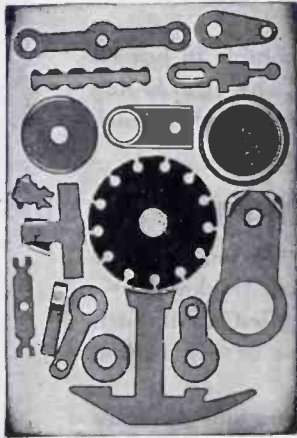
SpeedWay's "know how" was able to develop new gearmotor designs for the Armed Forces that did the required job. Today, expanded needs for these motors take SpeedWay's capacity, as well as the capacity of other large motor manufacturers, working to SpeedWay specifications.

If you need motors or gearmotors for a standard or special application bring your problem to SpeedWay. Motor outputs range from 1/3000 to 1/3 h.p. Unlimited gear ratios available from stock gears. Write for our recommendations on your war or postwar problem.

Write for SpeedWay's new Motor Bulletin showing standard A.C., D.C., and Universal Motors and generators.

SPEEDWAY MANUFACTURING CO.
1898 S. 52nd Ave., Cicero 50, Ill.

DO YOU NEED—



**Small Stampings
Special Terminals
Soldering Lugs
Precision Washers**

up to 5/8" O. D.

Manufactured to Your Specifications

Large Tool Room Facilities
plus 20 Years Experience insure

**HIGH GRADE STAMPINGS
QUICK DELIVERIES**

on Medium and Large Quantities

LET US QUOTE ON YOUR REQUIREMENTS

DIEBEL DIE & MFG. CO.

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Phone WELLington 4202

*We wish to
acquaint you with*



**STANWYCK
R. F. COILS**

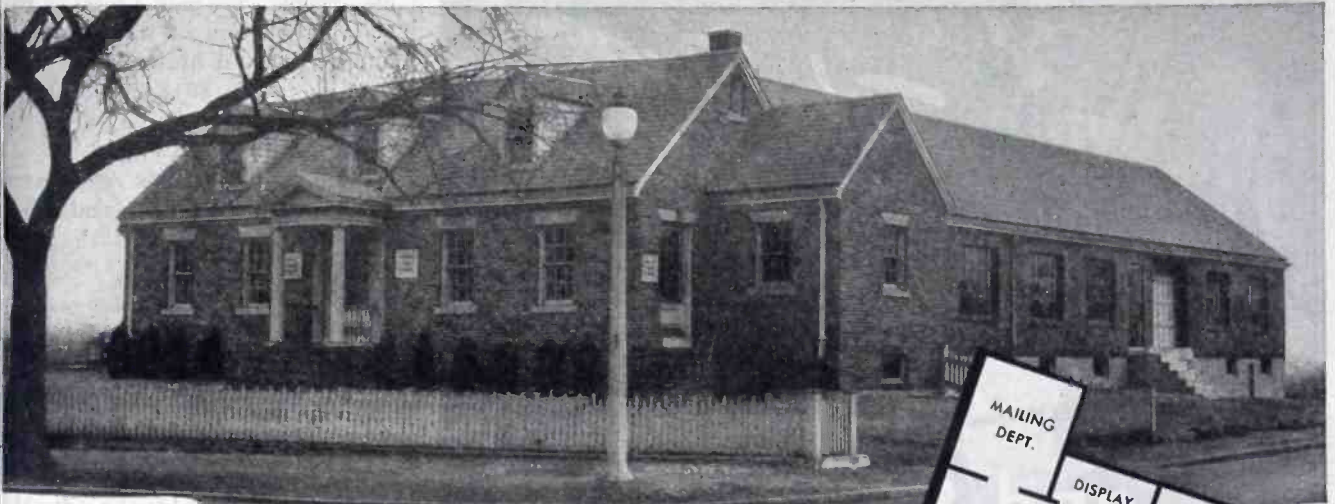
*and
Associated Assemblies*

There is a Stanwyck coil for every application in the Radio Frequency Spectrum — coils that have met the requirements of war and which will meet your requirements when the war is won. Send for folder describing our line and facilities.

**STANWYCK
Winding Company**

NEWBURGH

NEW YORK



BOSTON OFFICES

ARE YOU INTERESTED IN

Aggressive Representation

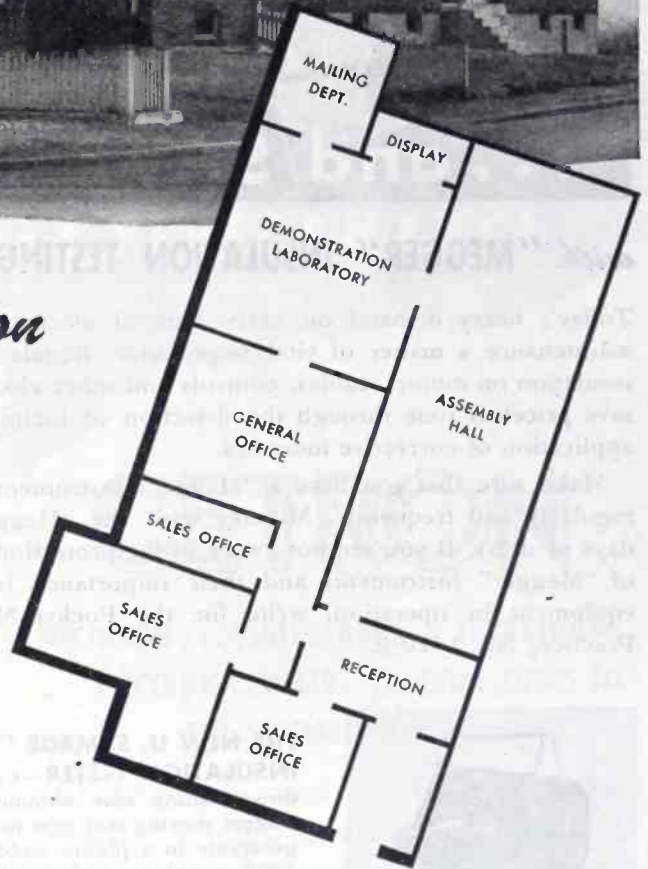
THROUGHOUT NEW ENGLAND?

The Electrical Apparatus Company is interested in representing manufacturers having products of advanced design and of an engineering nature for postwar applications.

We have unusually fine facilities, a specially trained personnel of many years experience, and are thoroughly capable of producing outstanding results.

In our opinion, the postwar era will require concerted and well organized sales effort. We are enthusiastic about obtaining the greatest amount of business possible for the manufacturers we represent.

An interesting brochure of a really unique sales organization will be sent gladly upon request.



W. J. Kelleigh

APPLICATION

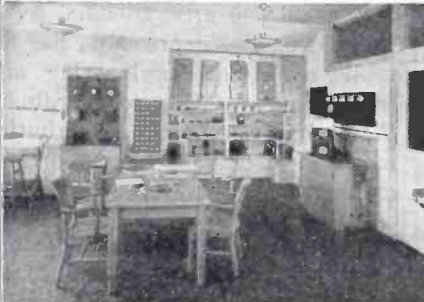


ENGINEERS

DEMONSTRATION LABORATORY

ASSEMBLY HALL

HARTFORD OFFICE



LAYS • RHEOSTATS • FOOT SWITCHES • CAM LEVER SWITCHES • LIMIT SWITCHES • SNAP ACTION SWITCHES • TRANSFER SWITCHES • RESET TIMERS
 MOTE CONTROL SWITCHES • PROCESS CONTROL TIMERS • SOLENOID VALVES • ELECTRONIC DEVICES • TEMPERATURE CONTROLS • PRESSURE CONTROLS
 ELECTRONIC CONTROLS • AUTOMATIC PRODUCTION GAUGES

ELECTRICAL APPARATUS COMPANY

1200 SOLDIERS FIELD ROAD, BOSTON 34, MASSACHUSETTS



with "MEGGER" INSULATION TESTING INSTRUMENTS

Today's heavy demand on every type of electrical equipment makes maintenance a matter of vital importance. Regular check tests of the insulation on motors, cables, controls and other electrical apparatus will save priceless time through the detection of incipient failures and the application of corrective measures.

Make sure that you have a "Megger" instrument and that it is used regularly and frequently. Minutes with the "Megger" tester can save days of delay. If you are not aware of the protection afforded by the use of "Megger" instruments and their importance in keeping electrical equipment in operation, write for the Pocket Manual of "Megger" Practice, No. 1420-E.



THE NEW U. S.-MADE "MEGGER" INSULATION TESTER—Consists essentially of a direct-reading true ohmmeter of the permanent magnet moving coil type mounted with a d-c hand generator in a plastic molded case. Ranges up to 1000 megohms, with hand generators up to 500 volts. Widely used in hard service. Variable-pressure ("Meg") and constant-pressure ("Super-Meg") types. Bulletin 1735-E.



THE "BRIDGE-MEG" RESISTANCE TESTER—This instrument is a combined "Megger" Insulation Tester and a four-dial, multi-ratio Wheatstone Bridge. Will measure any ohmic resistance from .01 ohm up to 100 or 200 megohms; hand generators rated up to 1000 volts. A complete and compact resistance measuring unit that is ideal for power companies and industrial plants. Catalog 1685-E.



THE MIDGET "MEGGER" TESTER—In many ways the most remarkable "Megger" instrument ever built. Weighs only 3 lbs.—will fit an overcoat pocket or tool kit. Reads up to 50 megohms. Generates 500 volts and is always ready to use anywhere because of the hand crank. Send for Catalog 1690-E.

JAMES G. BIDDLE CO. • 1211-13 ARCH STREET PHILADELPHIA 7, PA.

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. 6-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.



CONTINENTAL ELECTRIC COMPANY GENEVA, ILL.

The two tubes illustrated above were selected at random from the **COMPLETE LINE** which Cetron has to offer you. Write for catalog.

★ CHICAGO OFFICE, 903 Merchandise Mart
NEW YORK OFFICE, 265 West 14th Street

BROADCASTING STATIONS!

RECORDING STUDIOS!

SCHOOLS!

You Can Get Them
Without Delay!



GOULD-MOODY
"Black Seal"
GLASS BASE
INSTANTANEOUS
RECORDING BLANKS

The tributes paid to "Black Seal" discs by many leading engineers have been earned by distinguished service on the turntable. Your ears will recognize the difference in quality of reproduction, and the longer play-back life will prove the superiority of "Black Seal" construction. Choice of two weights — thin, flexible, interchangeable with aluminum, or medium weight — both with four holes.

An AA-2X rating is automatically available to broadcasting stations, recording studios and schools. Enclosure of your priority rating will facilitate delivery of **Old Aluminum Blanks Re-coated with "Black Seal" Formula on Short Notice**



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GOULD-MOODY
COMPANY

RECORDING BLANK DIVISION
395 BROADWAY • NEW YORK 13, N. Y.
EXPORT DEPT. ROYAL NATIONAL COMPANY, INC.
89 BROAD STREET, N. Y.



Specify **C.T.C. X-RAY ORIENTED CRYSTALS**

You'll find that X-RAY ORIENTATION — predetermination of the crystallographic axes of the Crystals to permit accurate cutting — insures constant frequency over a wide temperature range in every C.T.C. Crystal.

Multiple mechanical lapping operations; dimensioning by edge lapping; finishing to final frequency by etching, are among the other important operations that guarantee high activity and constant frequency throughout the long life of C.T.C. Crystals.

For prices, delivery dates etc., get in touch with

CAMBRIDGE Thermionic CORPORATION

439 CONCORD AVENUE

CAMBRIDGE 38, MASSACHUSETTS

CIRCULATE AIR AT 15 C.F.M.

Only 2 1/2" of space needed

WEIGHT: 2 oz. • CAPACITY: 15 C. F. M. at 8000 R. P. M. • CONSTRUCTION: Housing of high impact phenolic plastic • Wheel is turbo-type cadmium-plated steel
SIZE: 2 5/8" long x 1 1/4" wide x 2 1/2" high

The blower illustrated, No. 1 1/2, is one of many blower models manufactured by the L-R Manufacturing Company. These blowers were designed to outperform many larger and heavier types formerly in use. Where size and weight are factors these blowers with their minimum size and maximum output are the answer to cooling problems presented by electronic tubes or circuit components in such applications as air-borne communication units as well as in many industrial applications.

L-R MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT

"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.



THE SYMBOL OF
ENGINEERING EXPERIENCE
AND MOLDING SKILL

REPRESENTATIVES

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805-08 NEW CENTER BLDG.

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ENGINEERED PLASTICS FOR INDUSTRIAL APPLICATIONS
MOLD MAKING • INJECTION & TRANSFER MOLDING • COMPLETE ASSEMBLY



UP A TREE

because the tracing papers you use just won't stand up under frequent corrections or constant handling?

PUT A BEE

in your boss's bonnet to give tracing papers the old heave-ho, and to switch to tracing cloths . . . Arkwright Tracing Cloths!



YOU'LL SOON SEE

that frequent corrections and constant handling don't hurt Arkwright Tracing Cloths a bit. In the long run, you'll also see they cost no more than tracing papers. Arkwright Finishing Co., Providence, R. I.



Sold by leading drawing material dealers everywhere



Arkwright

TRACING CLOTHS

AMERICA'S STANDARD FOR OVER 20 YEARS

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.

TEMPLETON 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

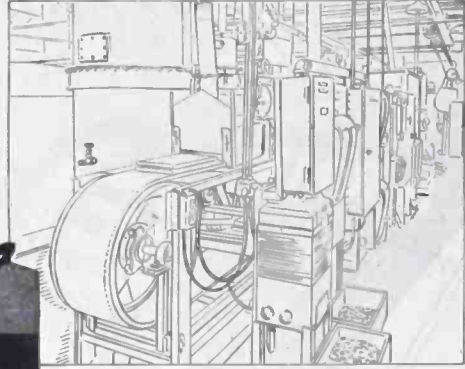
HERMANN D. MYSING has been made manager of engineering service for the auto radio department of Radio Corp. of America at Detroit, Mich. He was formerly in charge of an RCA group working with the Signal Corps.

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 con-

tact 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.



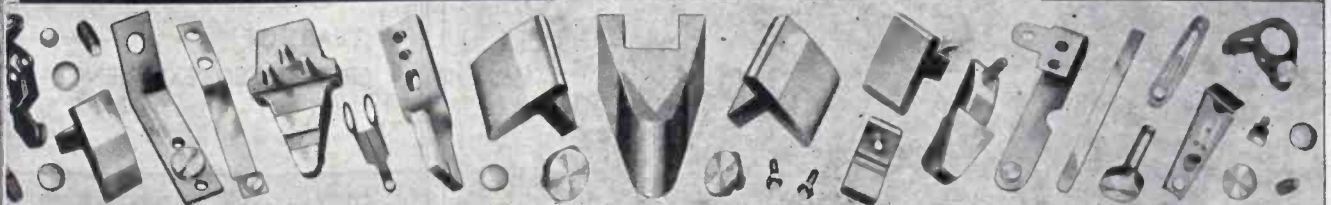
**There's a Job
 for All to Do:
 Buy War Bonds!**

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

*Elkonite is a registered trademark of P. R. Mallory & Co., Inc., for electric contacting elements.

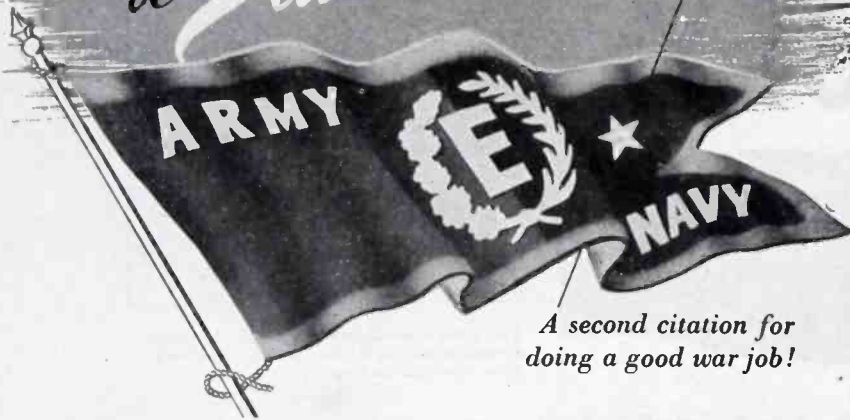
P. R. MALLORY & CO. Inc.
MALLORY

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

a Star is added



A second citation for doing a good war job!

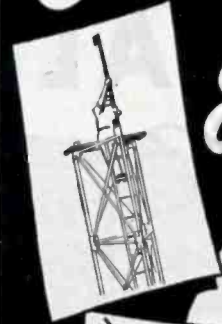
RADIO RECEIVERS • AUDIO OSCILLATORS • TELEVISION
ELECTRONIC TEST EQUIPMENT • SIGNAL GENERATORS
PHONOGRAPHS... Licensed by RCA • Hazeltine • Armstrong F. M.

ESPEY MANUFACTURING COMPANY, INC.

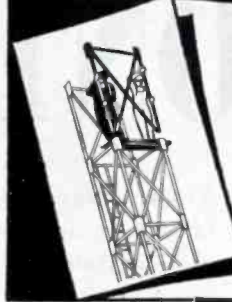
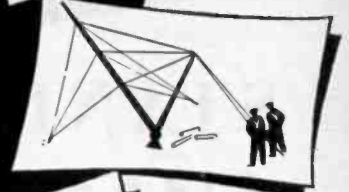
305 EAST 63rd STREET, NEW YORK 21, N. Y. BUTTERFIELD 8-7800

The only pre-war manufacturer of Home Radios in the New York Metropolitan area to earn both these awards.

Easy to Erect



MASTS AND TOWERS



Catalog will be sent to engineers and executives writing on their business letter-head.

Address Dept. AD
HARCO

STEEL CONSTRUCTION CO.
Elizabeth 4, N. J.

mica



Our specialized business is the production of mica fabricated parts for electronic and electrical use. This includes electronic tube and condenser parts, discs, bridges, supports, all varieties of stampings, condenser films, etc.

One of the most exacting phases of our business is the production of mica parts for radio tube and component manufacturers. Our 27 years of experience enable us to render a quick and understanding service on this and other phases. Hundreds of leading companies rely upon our complete facilities and wide experience to take care of both usual and unusual requirements.

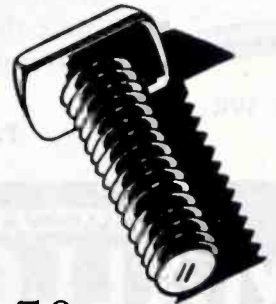
We shall be glad to quote costs or discuss any problems you may have.

FORD RADIO & MICA CORP.
Joseph J. Long, President
538 63rd St., Brooklyn 20, N. Y.
Telephone: Windsor 9-8300

Established 1917



New England Screw Co.
KEENE, NEW HAMPSHIRE

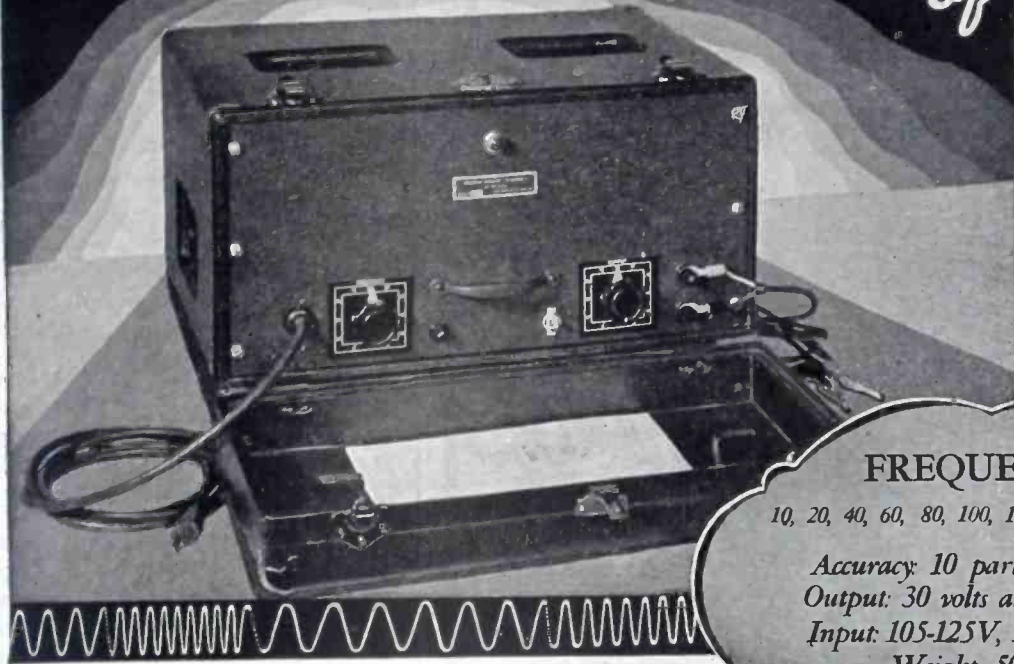


50
YEARS OF
SPECIALIZED EXPERIENCE

MACHINE SCREWS PLASTIC INSETS
SHEET METAL SCREWS HOLDING PINS
MACHINE SCREW NUTS SPECIAL RIVETS

ALL TYPES OF HEADS AND THREADS

STANDARD FREQUENCIES — Octaves of them



FREQUENCIES
 10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 190
 Accuracy: 10 parts in 1,000,000
 Output: 30 volts at 500,000 ohms
 Input: 105-125V, 50-60c, 40 watts
 Weight: 50 pounds

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

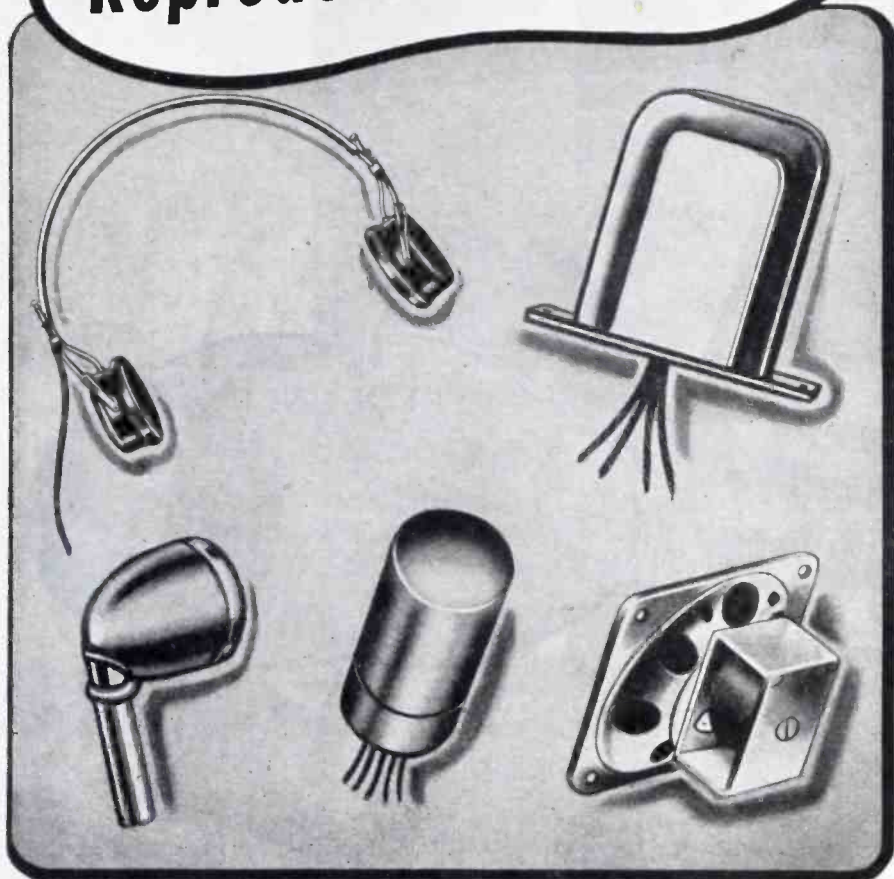
Watch Master



and distributor of
Western Electric
Watch-rate Recorders

American Time Products, INC.
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Does Your Postwar Design Problem Call for Better Acoustical Reproduction?



● Permoflux Acoustical Devices have brought vital improvement to numerous wartime communication projects. Many of these developments will soon be available for the betterment of designs now on your own planning boards. Our engineers will be pleased to confer with you at any time.

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 PERMOFLUX CORPORATION
 4916-22 W. Grand Ave., Chicago 39, Ill.

PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS

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.

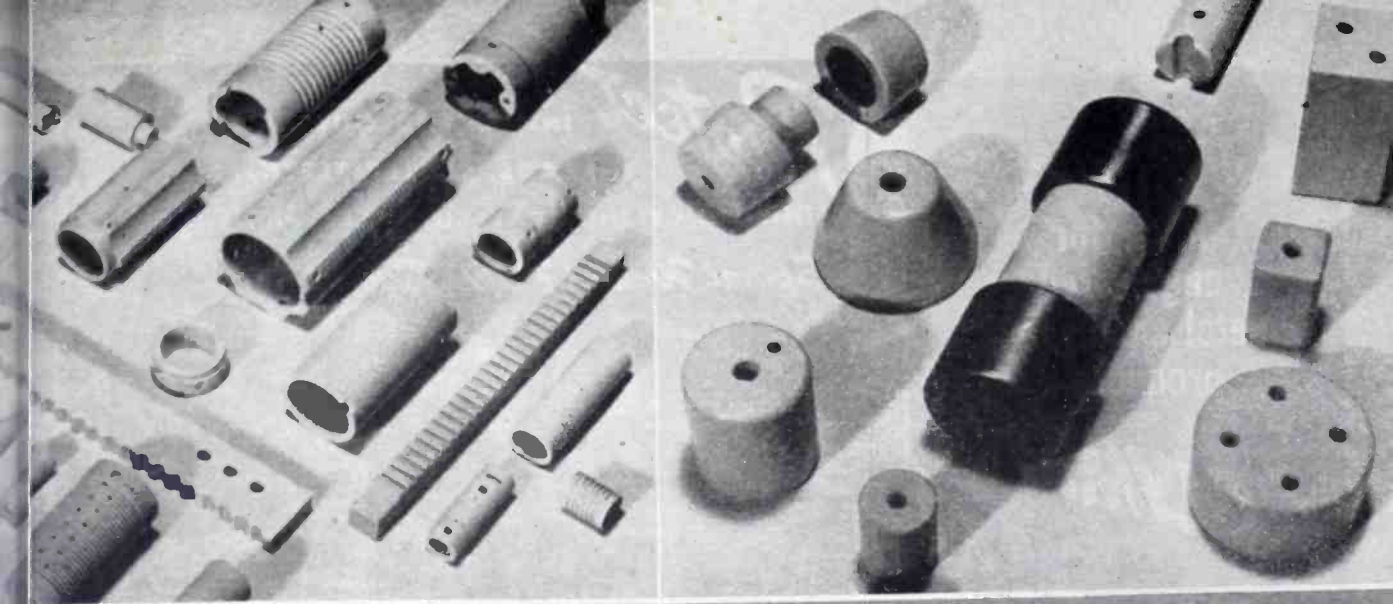
MORRIS H. COOK has been made director of specialty products development at Bell Telephone Laboratories, New York, N. Y. He was for-



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



GREATER EFFICIENCY FOR YOUR 1945 DESIGNS.

MASTER of power and heat, ALSIMAG is the ideal insulation for tomorrow's Electronic devices.

ACCURATE—manufactured to close tolerances.

ECONOMICAL—because of high speed production methods.

ALSiMAG Steatite Ceramic Insulators are permanent materials. They are strong, hard and rigid—do not distort by loading, nor do they shrink with time. Impervious to heat up to 1000° C. Non-corrodible. Do not absorb moisture.

No matter what insulation you have been using, investigate ALSiMAG. Send us a sample or design drawing. Let us prove that ALSiMAG will meet your requirements for improved efficiency and performance.

Write for Property Chart containing complete data on physical characteristics.

AMERICAN LAVA CORPORATION
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27 YEAR OF CERAMIC LEADERSHIP

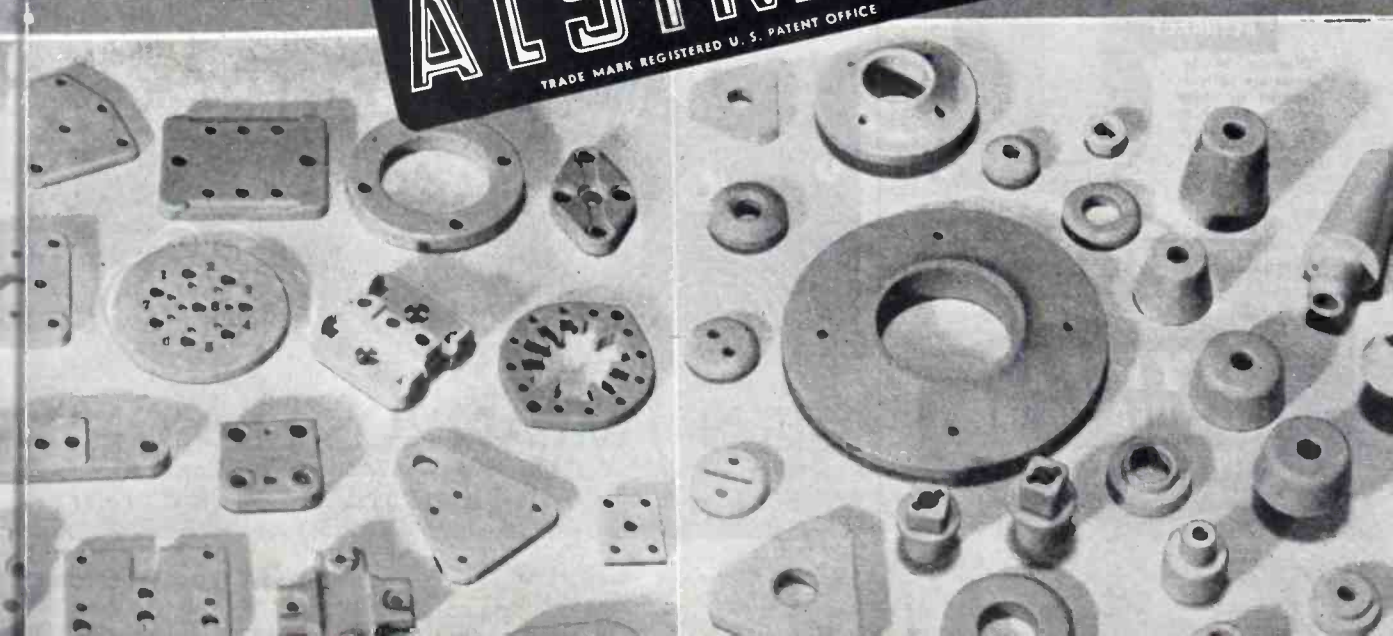
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CHARACTERISTICS OF ALSIMAG INSULATORS

- High Mechanical Strength
- Permanent Rigidity
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ALCO has been awarded for the fourth time the Army-Navy "E" Award for "continued excellence in quantity and quality of essential war production."



The name for
engineered
metal component
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OLYMPIC



Modern engineering, production facilities and equipment offer straight-forward solutions to all problems pertaining to production tooling, stamping, forming, drawing, grinding, welding, brazing, soldering and finishing.

With the conclusion of vital military contracts, OLYMPIC will be available for peacetime work, including complete design collaboration from blueprint to final production.



ACCURACY

"Diversity in facilities are aptly illustrated by these metal parts, which require particular attention to close tolerances."



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IN METAL PARTS

OLYMPIC
TOOL & MFG. CO., INC.
39 CHAMBERS ST.
NEW YORK 7, N. Y.

Protect INSIDE AND OUTSIDE
THREADS, CUTTER TEETH,
FINISHED CYLINDRICAL SURFACES with
Spiral Wound Paper Tubes!



Guard against damage in intra-plant handling or during shipment; save time and work in packing operations. Tubes made to your requirements in diameters from $\frac{3}{8}$ " to 6"—any length—from kraft, chipboard, special compositions; available waxed or plain. Write for complete information; get details, too, on our other lines of paper tubes and cans, gaskets, die-cut paper products.



PIERCE PAPER PRODUCTS CO.
2726-D AUBURN ST., ROCKFORD, ILLINOIS

MANROSS
hairsprings

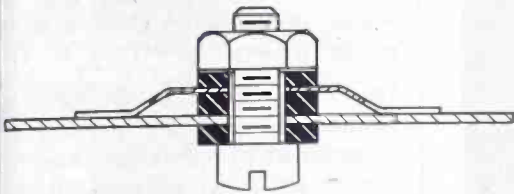
Whether yours is a problem in research, experimental design or large volume production, Manross craftsmen are well-equipped in experience and facilities to supply your hairsprings. *Performance counts*—Manross hairsprings set the standard for excellence and endurance.



HAIR
SPRINGS

F. N. MANROSS & SONS
DIVISION OF ASSOCIATED SPRING CORPORATION
BRISTOL, CONNECTICUT

APPLICATIONS of Dual Sealed-In Electrode Selenium Rectifiers



Standard Electrode

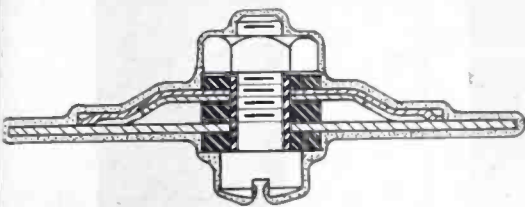


Figure 1

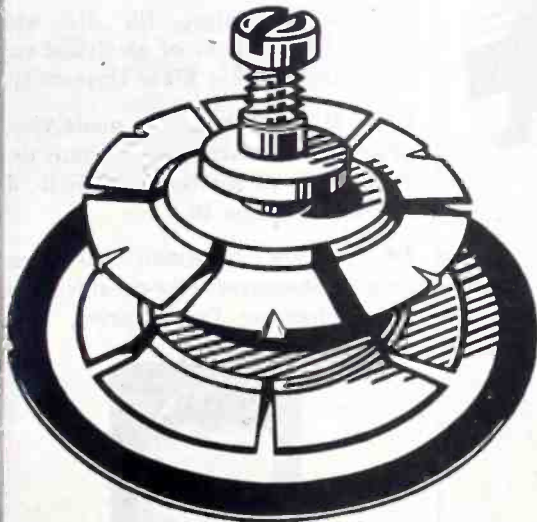


Figure 2

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.

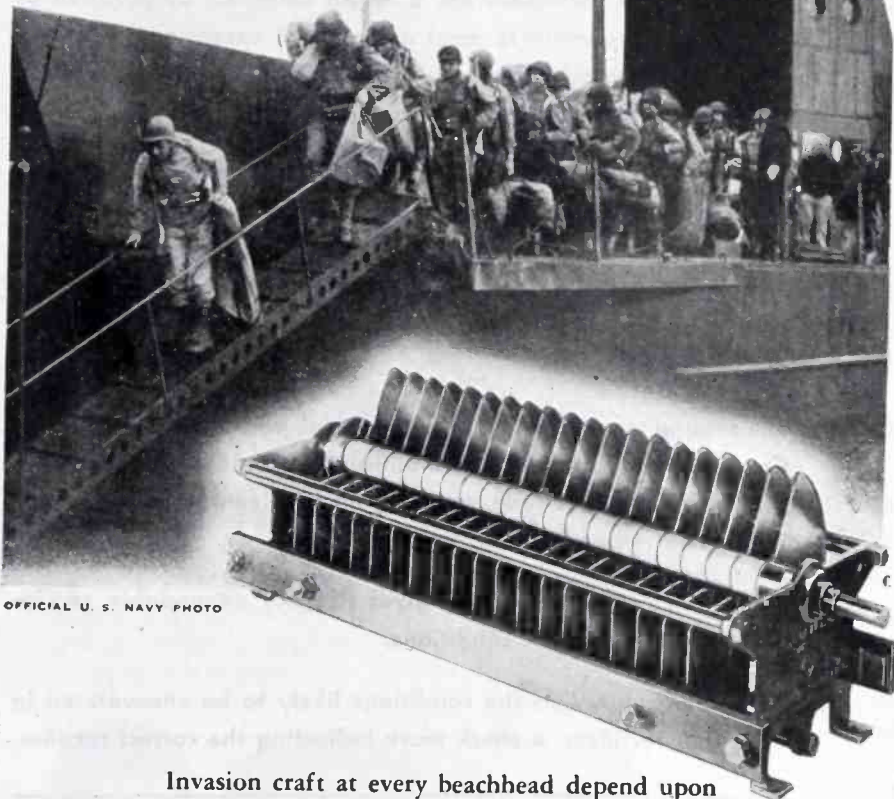
	REGULAR	DUAL SEALED-IN
Normal indoor use, non-tropical climates	X	
Portable equipment not subject to excessive shocks or vibration	X	
Outdoor use in enclosed cases	X	
Tropical, high humidity or jungle climates		X
Automotive and aviation equipment		X
Corrosive atmospheres, as chemical, plating or battery 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

Built like battle craft



OFFICIAL U. S. NAVY PHOTO

Invasion craft at every beachhead depend upon vital communications to guide them safely through their missions. Vital communications equipment, in turn, depend upon sturdy components for continued operations. Typical of these components is the Cardwell Model TK-300-US Variable Air Transmitting Condenser (illustrated).

Among transmitter manufacturers, Cardwell Condensers have the reputation for being thoroughly acceptable and reliable. Cardwell pioneered the metal frame, grounded rotor variable condenser as it is now used in electronic equipment, and Cardwell products continue to be the *Standard of Comparison*. May they go forward with the Navy to Victory.

CARDWELL CONDENSERS

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION
81 PROSPECT STREET
BROOKLYN 1, N. Y.

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.

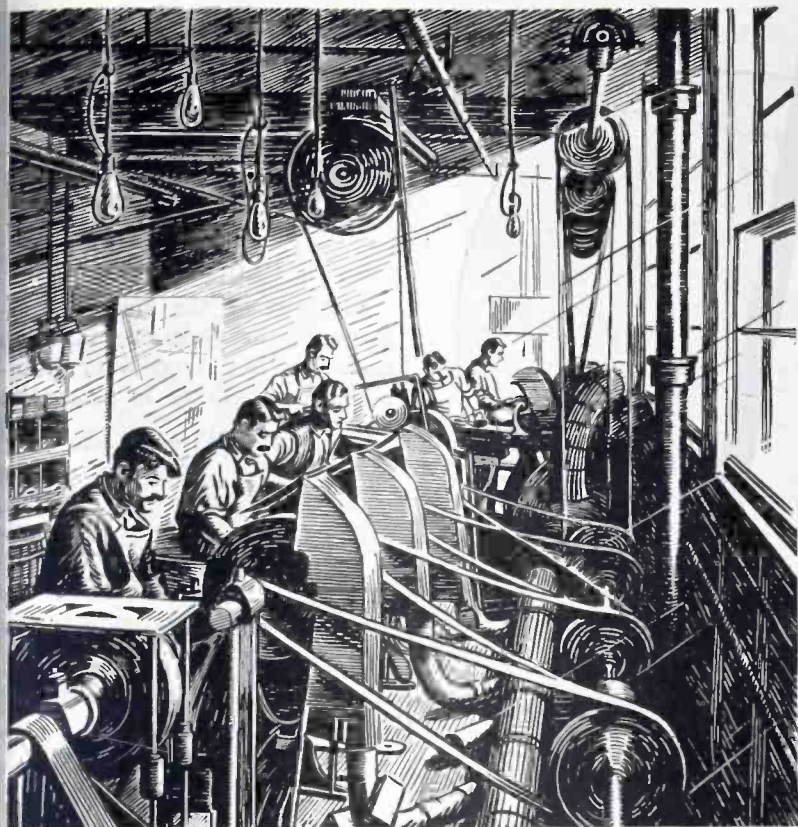
L. A. MCNABB has been made vice-president in charge of electronic design and production at Bell & Howell, Chicago, Ill.

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.

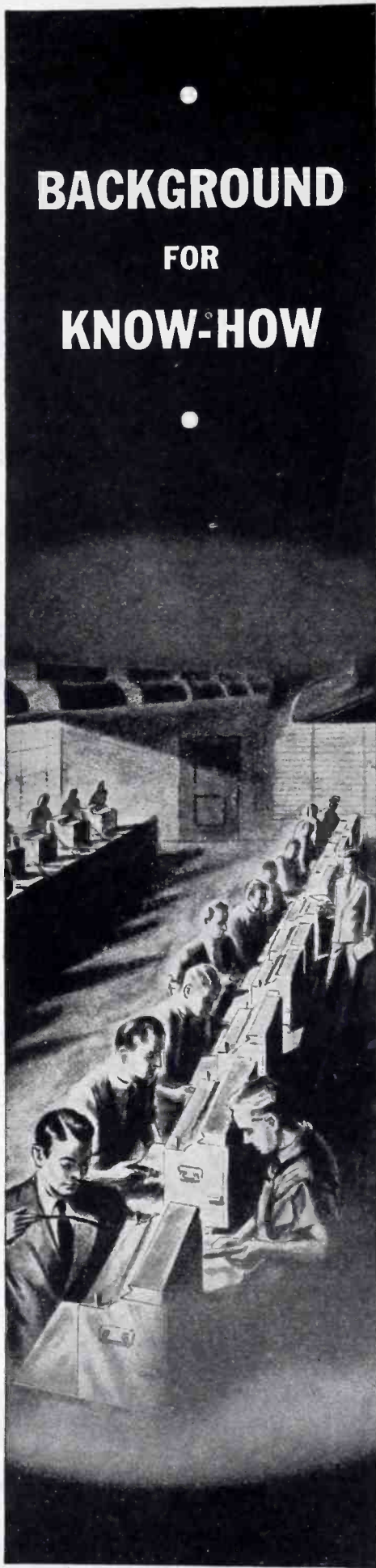
For the past four years, every ounce of our engineering and production experience has been at work for Uncle Sam. Postwar American industry will naturally seek to draw on the know-how developed during the war. Ours applies not only to communications, but to the general field of electronics and precision electrical engineering and manufacturing. If you have a problem involving communications, product improvement, product control, ignition, or the manufacture of precision electrical devices, our particular know-how is at your disposal.

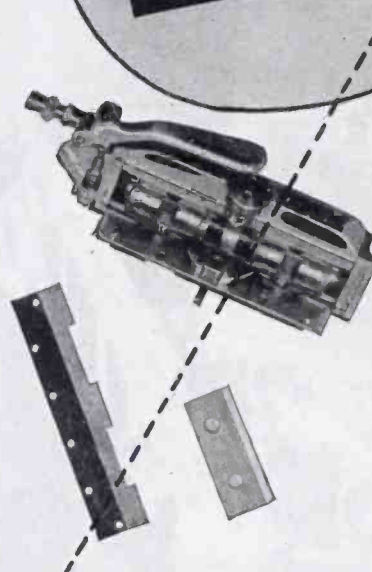
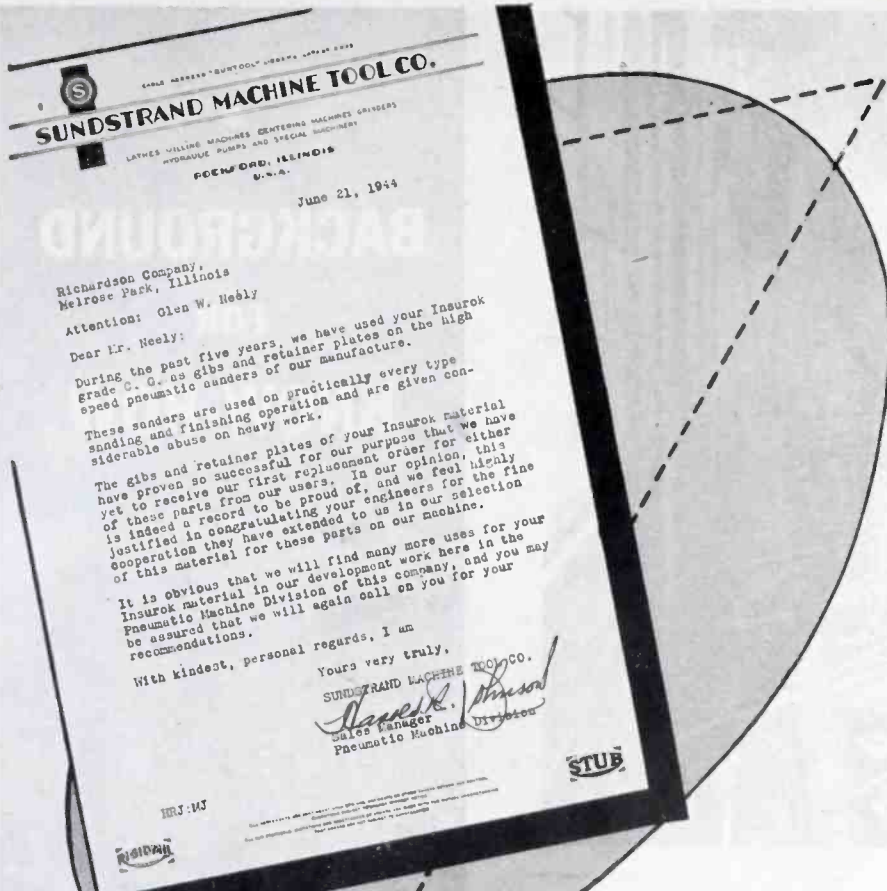
CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES, INC.
MERIDEN, CONNECTICUT

TELEPHONIC SYSTEMS • SIGNALLING EQUIPMENT • ELECTRONIC DEVICES • ELECTRICAL EQUIPMENT • HOSPITAL AND SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS • IGNITION SYSTEMS

•
BACKGROUND
FOR
KNOW-HOW
•





Go Ahead!

WE DON'T MIND IF YOU READ OUR MAIL

For it points out facts that we already know . . . and want you to know.

Five years ago, Sundstrand installed gibs and retainer plates made of Laminated INSUROK in their pneumatic sanders. And in those five years, not one replacement was needed for these two vital parts. Some of these sanders worked in water . . . some in solvents . . . others finishing dry woods and metals.

Yet this is not a strange story with Laminated INSUROK. For parts made of INSUROK are ready, willing, and able to take the abuse of hard work.

There are many grades and types of Laminated and Molded INSUROK. And Richardson Plastics combine years of experience with the working knowledge of designers and manufacturers . . . a combination which allows INSUROK to meet practically every industrial requirement. Richardson will be glad to work with you in redesigning an old line of products, or in designing the needs of a new line. Write for complete information.

INSUROK *Precision Plastics*

The RICHARDSON COMPANY
 MELROSE PARK, ILL. NEW BRUNSWICK, N. J. FOUNDED 1888 INDIANAPOLIS 1, IND. LOCKLAND, CINCINNATI 15, OHIO
 DETROIT OFFICE 6-252 G. M. BUILDING, DETROIT 2, MICHIGAN NEW YORK OFFICE 75 WEST STREET, NEW YORK 6, N. Y.
 CLEVELAND OFFICE 326-7 PLYMOUTH BLDG. CLEVELAND 15, OHIO

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 burges 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"**

UPER-QUALITY COILS AT REASONABLE PRICES

ore and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

**ALBION
COIL COMPANY**

ALBION, ILLINOIS

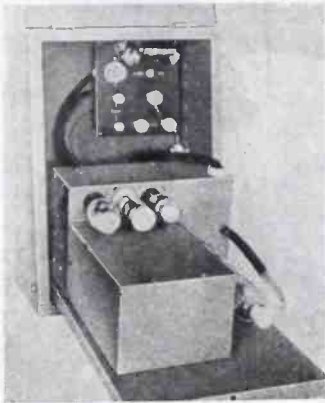
**R. F. AND TRANSMITTING COILS AND CHOKES;
I. F. TRANSFORMERS**

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

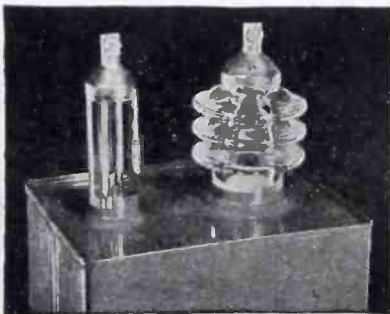


gives instant time control from 1 to 28 cycles in steps of 1 cycle. The unit handles welding powers from $\frac{1}{2}$ to 5 kva.

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 separa-



tion 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



CEXACTING 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.

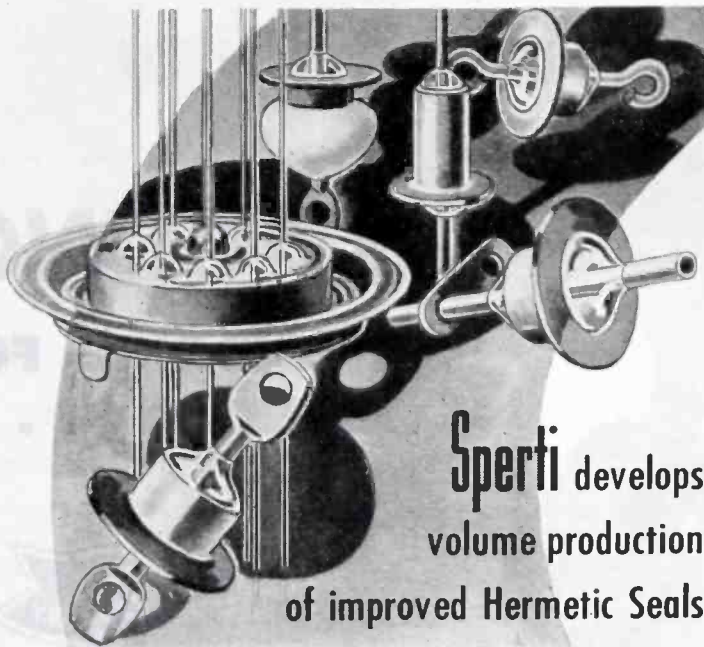
Our thoughts on this, and other matters of vital importance to every American, are more fully expressed in "A Plan for America at Peace", the 44-page book prepared by a group of distinguished economists and writers. This plan, designed, as is all ECA equipment, to exacting laboratory standards, will 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



Sperti develops volume production of improved Hermetic Seals

Conforming to Army-Navy requirements
for critical field conditions

Transformers, condensers, relays, vibrators and various component parts can now be protected against heat and tropical humidity, salt spray, sand infiltration, fumes, fungus attack and other varied conditions that cause sensitive equipment to fail under critical conditions.

In the laboratories beyond Sperti, Inc., techniques have been discovered which permit volume production of improved Hermetic Seals at low cost, safeguarded by unique inspection methods.

Principal features of the improved Sperti Hermetic Seal are:

1. Small, occupies little space, one piece, no other hardware needed, simple and easy to attach. (Soldering temperature not critical.)
2. Vacuum tight hermetic bond, hydrogen pressure tested for leaks.
3. Resistant to corrosion.
4. High flash-over voltage. Does not carbonize.
5. Insulation resistance, 30,000 megohms, minimum, after Navy immersion test.
6. Thermal operating range—70° C. to 200° C. Will withstand sudden temperature changes as great as 140° C.

Wire or phone for information, today. Give as complete details as possible so that samples and recommendations may be sent promptly.

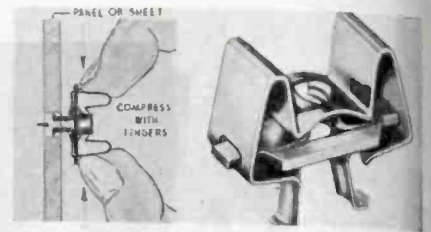


Sperti

INCORPORATED



RESEARCH, DEVELOPMENT, MANUFACTURING, CINCINNATI, OHIO



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.

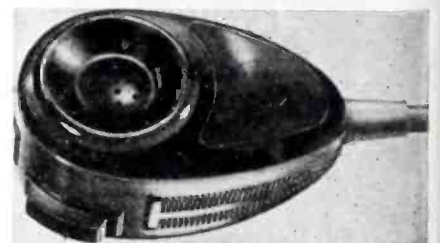
Soldering-Iron Tips

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 fre-



quency 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.

This Governor-Controlled Oster Motor

Gives You the New Design and Operating Advantages of CONSTANT SPEED

Here is a new Oster development in a constant speed, governor-controlled motor that backs up your good judgment when you specify it for applications where constant speed is a necessity. This motor is now in production and deliveries can be made in the very near future. Here are the features that assure you of satisfaction:

Housing: Die cast aluminum end brackets. Mild steel field housing. Totally enclosed.

Finish: Black anodized end brackets. Cadmium plated field housing.

Weight: 15 Oz.

Bearings: Single shielded ball bearings, lubricated with a grease suitable for any specific application. Bearing housings fitted with steel inserts.

Windings & Insulation: Field coils and armature wound with a select grade of insulated copper wire and impregnated with a high quality heat and moisture resisting insulating varnish.

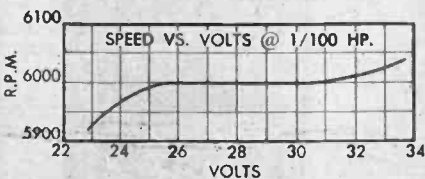
Brushes: Equipped with high grade metal graphite brushes. Beryllium copper brush springs.

Governor: Furnished with a centrifugal governor to maintain constant speed over a voltage range of 25 to 30 volts.

Temperature Rise: Maximum frame temperature rise at rated output will not exceed 55° C.

Modifications: Motors can be furnished with special shaft extensions, mounting arrangements, finishes, leads, etc. All modified units are considered special.

When designing your post-war product, consider this new Oster development in applications where constant speed is a necessity...



Rating of Motor Type BSTG-1A-2

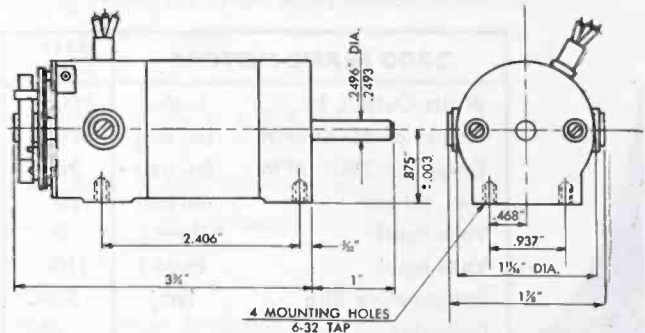
Horsepower—1/100 continuous duty

Speed—6000 R.P.M. \pm 1%

Voltage—25-30 volts D.C.

Amps. input—.95

Starting Torque—300% of full load torque

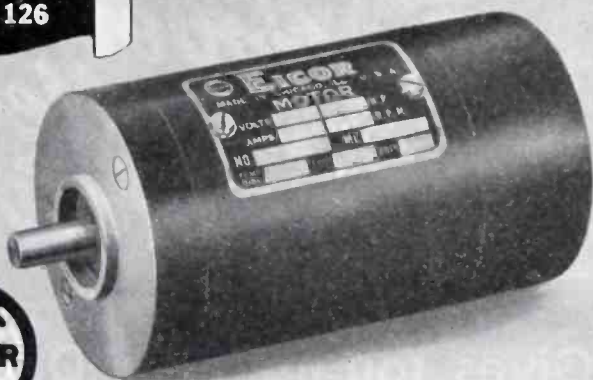


Let us help you fit this and other Oster Motors to your requirements.

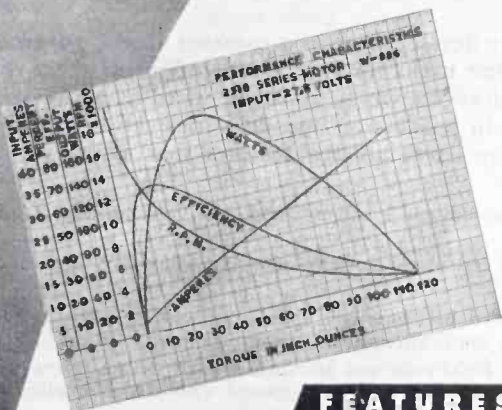
M-22

John Oster Manufacturing Co.
DEPARTMENT L-22 • RACINE, WISCONSIN

MOTOR DATA
No. 126



2300 FRAME MOTOR
1/5 HP at 3800 RPM



The basic design of the 2300 Frame Motor has been used in scores of individual modifications. Many of these designs are complete and available—others for new equipment can readily be developed.

FEATURES

ELECTRICAL

- Series or shunt wound
- High starting torque
- Low starting current
- High efficiency
- Low RF interference
- Unidirectional or reversible
- Armature and field windings varnish impregnated and baked

MECHANICAL

- Low weight factor
- Unusual compactness
- Completely enclosed
- Base or flange mounting
- Laminated field poles
- Precision ball bearings
- Segment-built commutator
- Permanent end play adjustment

2300 FRAME MOTORS		2318 Series	2310 Shunt
Watts Output, Int.	(max.)	160	50
Torque at 6000 RPM	(in. oz.)	40	10
Torque at 3800 RPM	(in. oz.)	57	—
Lock Torque	(in. oz.)	120	14
Volts Input	(min.)	5	5
Volts Input	(max.)	110	28
Temperature Rise	(int.)	50°C	50°C
Diameter		2 ⁵ / ₁₆ "	2 ⁵ / ₁₆ "
Length less shaft		4 ⁵ / ₃₂ "	2 ³ / ₄ "
Shaft Dia.	(max.)	.312"	.312"
Weight	(lbs.)	2.4	1.5

EICOR INC. 1501 W. Congress St., Chicago, U. S. A.
DYNAMOTORS • D. C. MOTORS • POWER PLANTS • CONVERTERS
Export: Ad Auriema, 89 Broad St., New York, U. S. A. Cable: Auriema, New York

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 9¹/₂ in. high, 6¹/₂ in. high and 3 in. deep. It weighs 8¹/₂ 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.

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-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.

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
37 W. 65 St., 23

SAN FRANCISCO
1050 Howard St., 3

LOS ANGELES
1000 N. Seward St., 38

At Home in Water



Danger Lurks Here

The fish and the seaweed are incidental. They're strictly at home in water and they thrive in it. But our armed forces, on sea or land, find water and moisture deadly enemies of electrical and electronic equipment.

If electrical coil windings that are dependably waterproofed and exempt from moisture damage are required in your products, Coto-Coil's 27 years of experience can help you with proper coil design and construction.

COIL SPECIALISTS SINCE 1917

COTO-COIL CO., INC.

65 Pavilion Ave.

Providence 5, R. I.

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

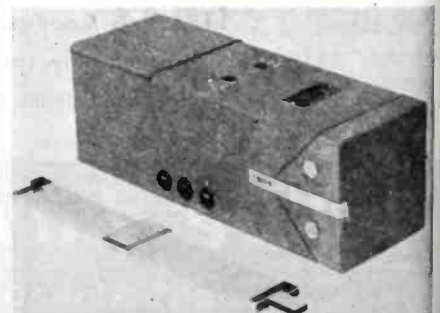


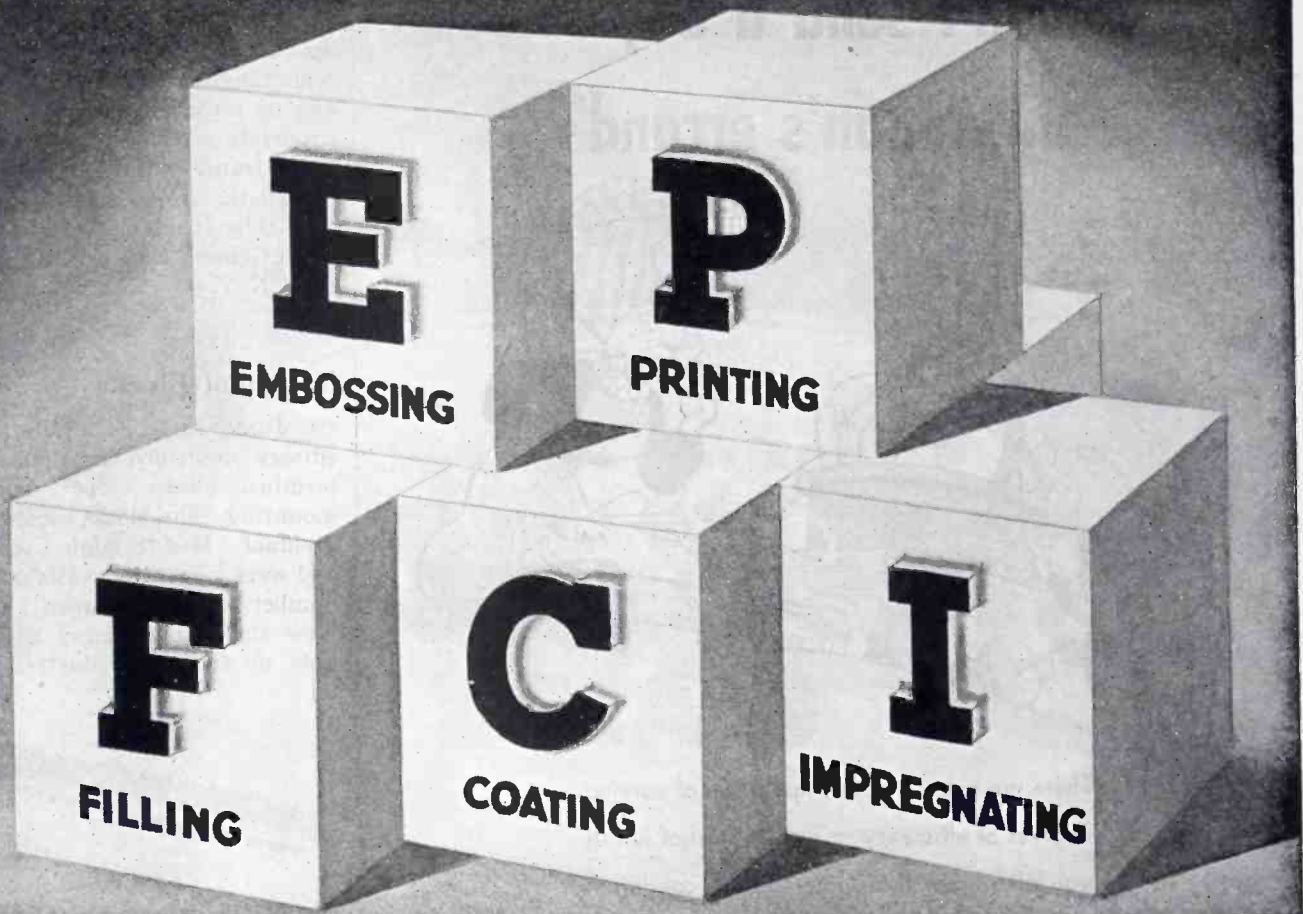
tables, or it can be supplied mounted on a wood base. The fume stack measures 3 x 9½ x 32 in. The shield is fitted with a plate glass window, or a magnifying glass.

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





To the basic F-C-I we now add *Printing* to broaden the use field of special finished cloth...

Printing means adding to the finished cloth surface a color, design or pattern purely decorative or in which may be combined a trade mark, firm name, pictorial sketch, etc. Cloth may be surfaced for any printing or lithographing process but as we use the term "printing" we mean running from cloth rolls on a production basis. Some very novel and beautiful printed effects have been produced on cloth for

bookbinding. Multiple colors may be used and reasonably accurate register of colors maintained. As cloth finds new fields of industrial use the possibilities of printing become greater. Printing may be definitely regarded as one of the major steps in preparing cloth for specialized uses.

PRINTING

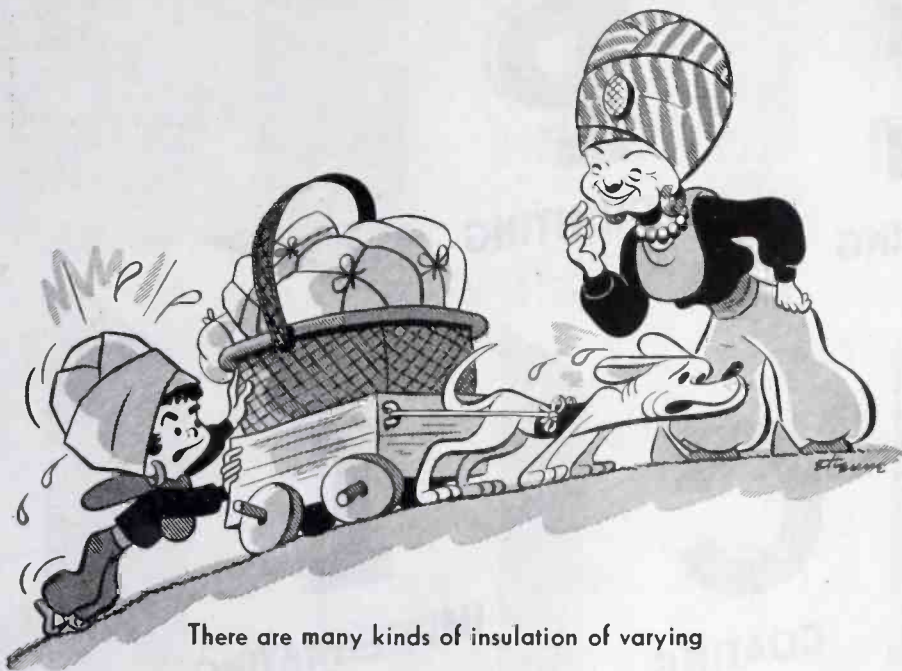
as a cloth finishing process involves the running of the cloth from roll to re-roll at production speeds. Penetrating colors are generally used and the cloth texture is not affected. Printing is one of the steps in specialized cloth processing offering many applications and variations to fit special needs.

CURRENT HOLLISTON PRODUCTION includes COATED AND IMPREGNATED FABRICS INSULATING CLOTH BASE SEPARATOR CLOTHS rubber, starch-filled, glazed. TRACING AND BLUE PRINT CLOTHS white and blue, ink or pencil. MAP CLOTH, PHOTO CLOTH, self-adhesive. REINFORCING FABRICS. SIGN, LABEL AND TAG CLOTHS, waterproof to take any ink, meet any inking problem. BOOK-BINDING CLOTHS. SHADE CLOTH, impregnated waterproof, opaque, translucent or light proof.

We urge you to consider CLOTH, and invite you to consult with us concerning possibilities and developments for your specific requirements.

The Holliston Mills, Inc.
PROCESSORS OF CLOTHS FOR SPECIAL PURPOSES
 NORWOOD, MASSACHUSETTS
 Sales Agents in Principal Cities

don't send a boy on a man's errand



There are many kinds of insulation of varying degrees of efficiency — you know that just as you also know that under certain conditions many types of insulation cannot measure up to the responsibility — they may not break down all of a sudden, but they don't last long. Where mica ought to be used that's where nothing else will serve — no compromise.



When you think of MICA think of MACALLEN

the Macallen Company

15 MACALLEN STREET - BOSTON 27

CHICAGO: 585 W. Washington Blvd.

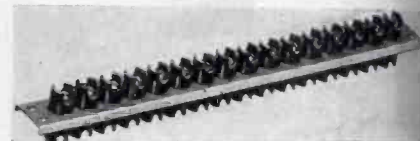
CLEVELAND: 1966 Leader Bldg.

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



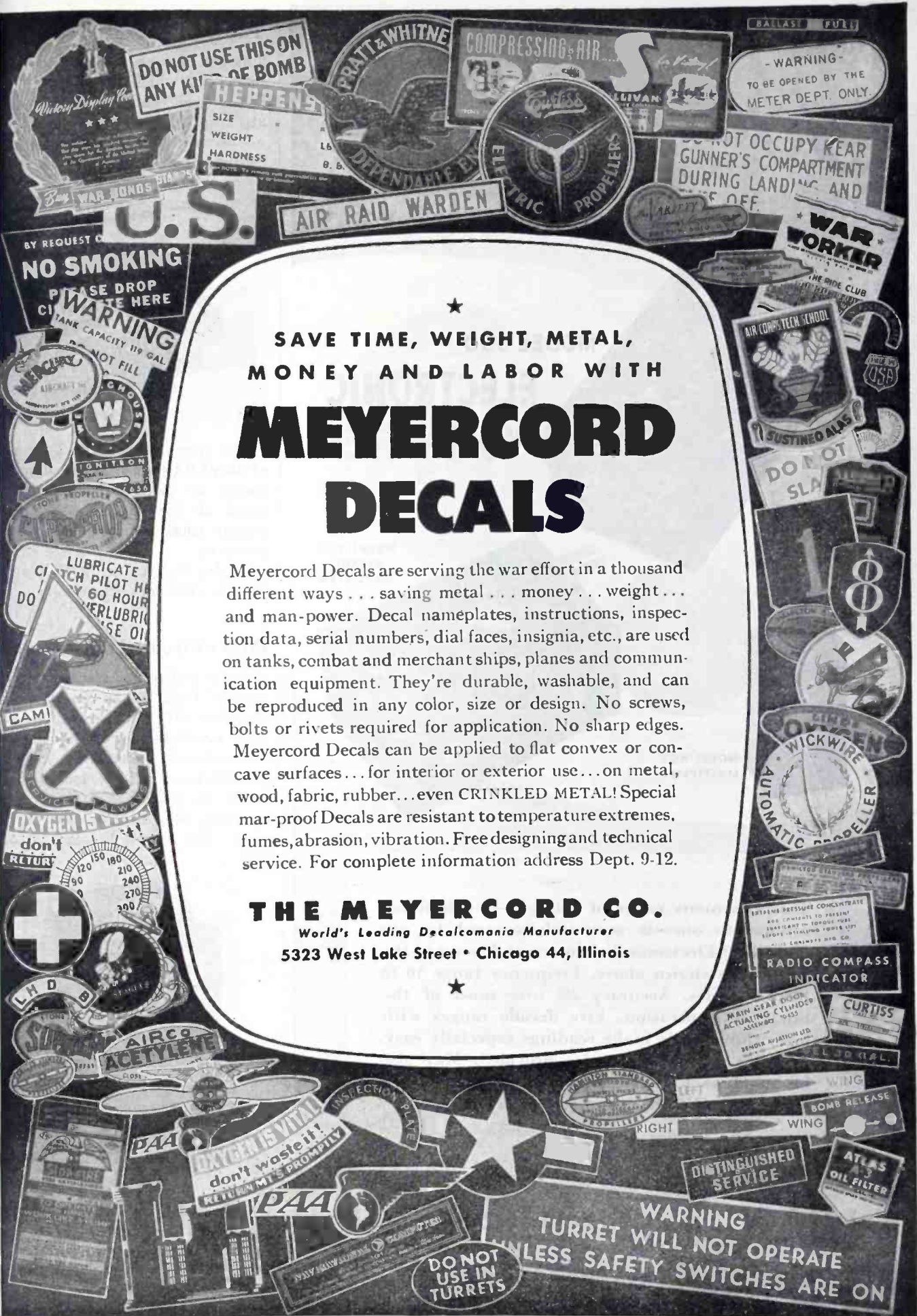
which will accommodate any number of units between 1 and 16, and because of their design the blocks can be furnished, on specification, with any number of terminals desired.

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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**SAVE TIME, WEIGHT, METAL,
MONEY AND LABOR WITH**

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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**WARNING
TURRET WILL NOT OPERATE
UNLESS SAFETY SWITCHES ARE ON**

500,000,000 to ONE

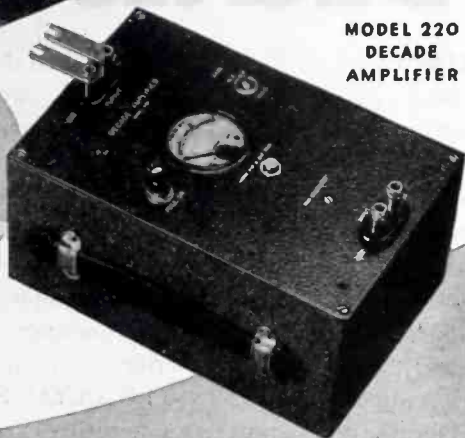
0.00002 TO 10,000 VOLTS



MODEL 300
ELECTRONIC
VOLTMETER



MODEL 402
MULTIPLIER



MODEL 220
DECADE
AMPLIFIER

This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. May also be used as a highly stable amplifier, 70 DB gain, flat to 150,000 cycles.



BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

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.

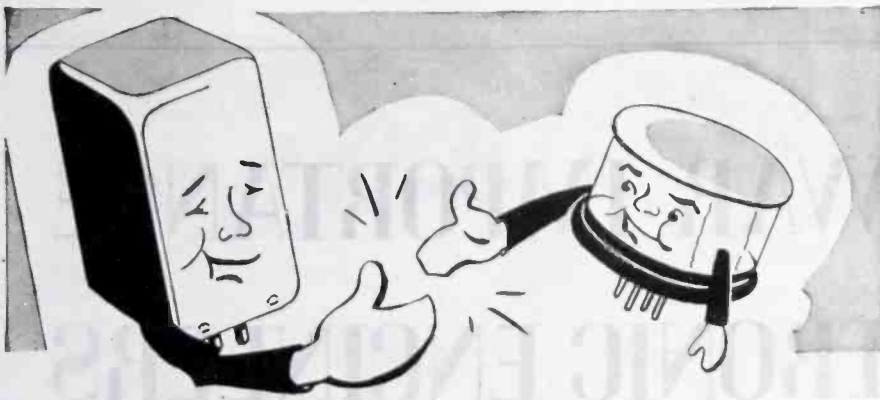
The exact knowledge of the chemical and physical properties of rubber—both natural and synthetic—as well as the techniques for engineering it—gained by "U. S." specialists, is of timely significance for electronic engineers.

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.

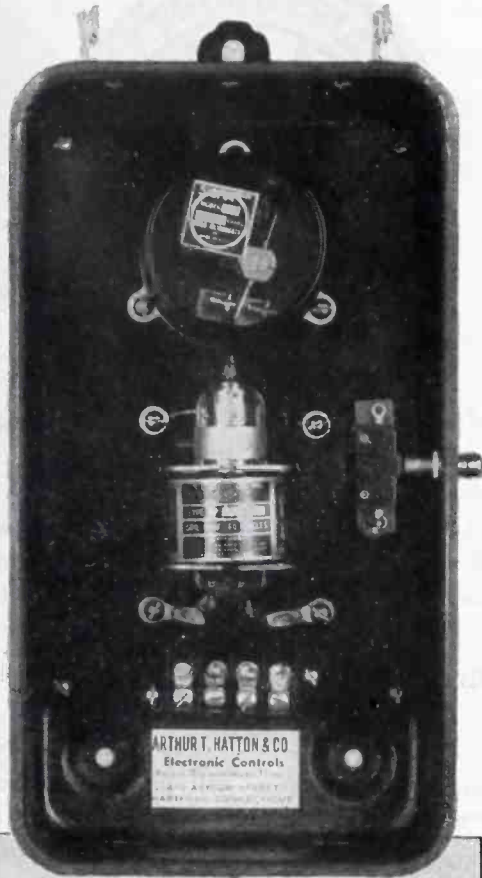


SIGMA RELAYS

ARE GOOD MIXERS

Designed for great sensitivity and high speed, Sigma Relays are capable of more precise adjustment than most commercial relays.

When the job at hand requires large current capacity and precise pick-up adjustment it's a good idea to combine the Sigma Relay with another type to obtain these characteristics.



This circuit breaker designed by *Hatton of Hartford* provides instantaneous cut-off when current exceeds a pre-set value.

Our engineering staff will gladly advise you of the best combination to meet your requirements.

SIGMA
Sigma Instruments, Inc.
Sensitive **RELAYS**
 62 CEYLON ST., BOSTON 21, MASS.

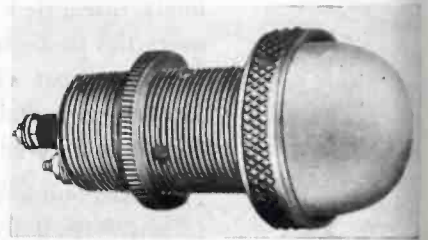
Lacing Cord

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.

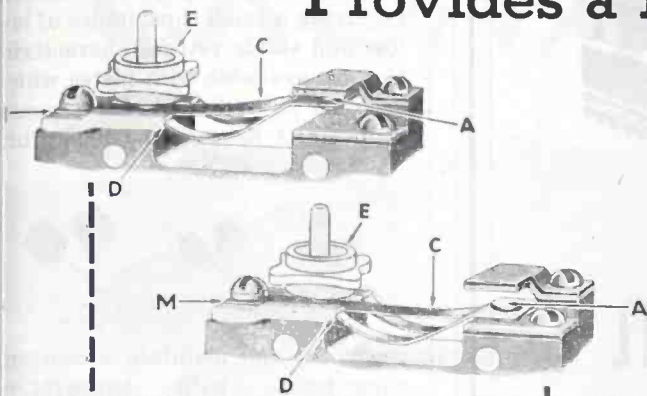
Coaxial Connectors

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 beryllium-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.

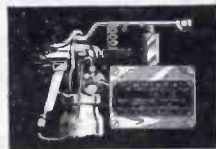
This performance is made possible by use of the unique, field tested, and proven operating principles of the Micro Switch. The snap motion of the Micro Switch contact is in the same direction as that of the operating plunger. There are no reverse bends in the Micro Switch spring, and there is no life-limiting "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*.

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.

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



MICRO TRADE MARK **MS** **SWITCH**

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



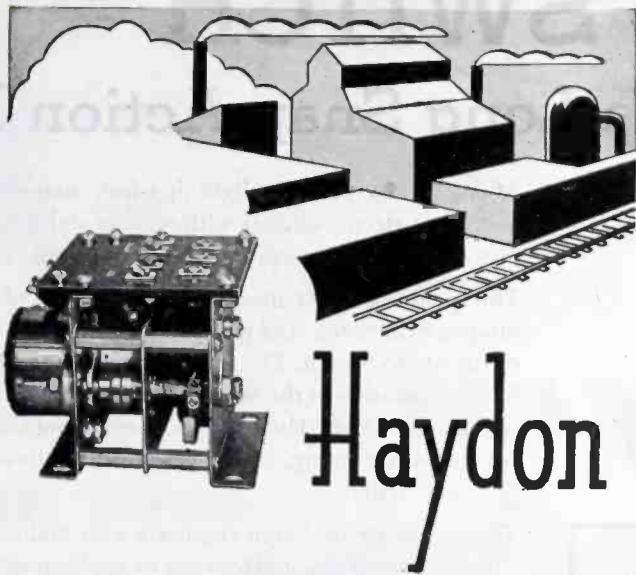
UNLIMITED

"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 Bands



"Electroneered" timing
**WILL BE THE HEART-BEAT
 OF TOMORROW'S INDUSTRY**

New electronic-engineered timing devices by Haydon, now measuring and motivating thousands of mechanical functions in war-time industry, will find wider scope in uncounted duties after the war.



AC MOTORS
 Available 450 RPM to one Revolution per month; manufactured to your specific voltage, frequency and speed requirements. Special lubricants for -60°C. to $+100^{\circ}\text{C.}$

DC MOTORS
 Reversible—Compact—light in weight—with seven segment commutator—low reactance rotor winding—alnico magnet field—totally enclosed. Virtually any speed or voltage.

They are engineered into new applications for homes, factories, laboratories; in transportation and communication—in short, Haydon timing devices will regulate and govern the energy of tomorrow, for greater economy and efficiency.

Write today for your copy of this catalogue.

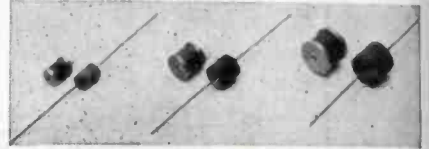


Haydon
MANUFACTURING COMPANY
 * INCORPORATED *
Forestville, Connecticut

©1944

**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 $-0.00075 \mu\text{mf}/\mu\text{mf}/\text{deg C.}$

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
GRILLS

OPERATING MECHANISMS

CROWE NAME PLATE & MANUFACTURING CO.

3701 RAVENSWOOD AVENUE

CHICAGO 13, ILLINOIS

OVER 40 YEARS EXPERIENCE IN FINE METALCRAFT

ERCO TRANSMITTERS AND RECEIVERS

ENGINEERED FOR EXACTING PERFORMANCE



Base to plane, ship to ship, and wherever radio communication is vital in the war effort . . . "ERCO-Built" Transmitters and Receivers are proving efficient and dependable. Because in research, design, and manufacture, the painstaking

skill and expert talent behind ERCO engineering assure the technical perfection that only long years' knowledge and experience can provide. Although largely occupied in wartime production, we are in a position to meet your present requirements for specialized radio equipment, priorities of course, or to help plan your postwar needs. Your inquiry invited.

ERCO RADIO LABORATORIES INC
HEMPSTEAD, NEW YORK
Manufacturers of CUSTOM BUILT RADIO APPARATUS

test specimens through a bleeder resistor when the remote switch is released.

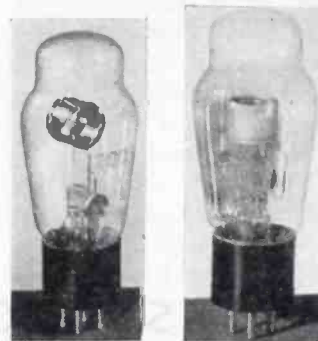


The test set delivers up to 4000-v dc, continuously adjustable by means of a primary Variac. An output meter is used to indicate the voltage being applied to the specimen.

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-Imregnated 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



* Also available in some case size and style are new microphone input transformer, and modulation transformer.

Only 1-inch in diameter by $1\frac{5}{8}$ 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.

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

BAUMAN & BLUZAT

2753 WEST NORTH AVE.

CHICAGO 47, ILL.

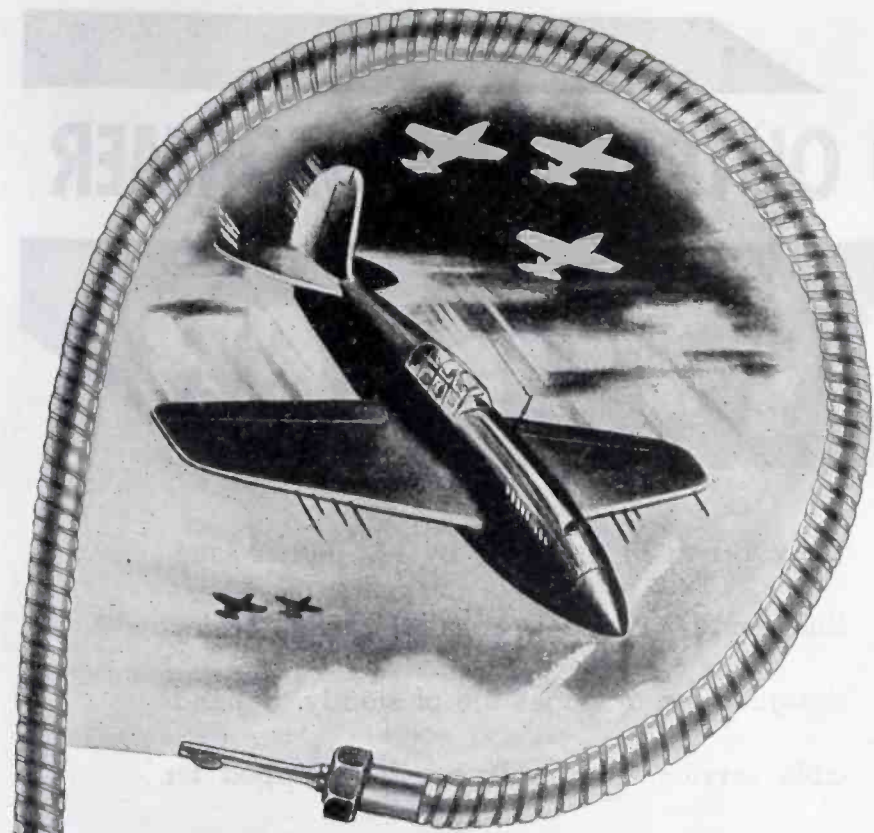
TELEPHONE: HUMBOLT 6809-10-11-12

SPECIALISTS IN BUILDING TRANSFORMERS SINCE 1938

A. P. FOSTER COMPANY

TRANSFORMER ENGINEERS & MANUFACTURERS

719 WYOMING AVENUE, LOCKLAND 15, OHIO (SUBURB OF CINCINNATI)



**WHEN THE "LONGEST WAY 'ROUND
IS THE SHORTEST WAY HOME"...
Specify Walker-Turner Flexible Shafting**

In transmitting light power loads between two points, it is often possible to design a simpler, lighter, more compact product with Flexible Shafting than with gears.

You'll find, too, that it pays to specify Walker-Turner Flexible Shafting on jobs like these — for smoother power flow, more sensitive control, trouble-free operation. Into this product, we've packed all the "know-how" picked up in years of manufacturing our own flexible shaft machines . . . in years of working with other manufacturers on problems of power transmission and remote control. Let us know if we can put that experience to work for you!

WALKER - TURNER COMPANY, INC. Plainfield, New Jersey



FLEXIBLE SHAFTING

FOR REMOTE CONTROL AND POWER TRANSMISSION

6-12

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 impregnation 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.



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!

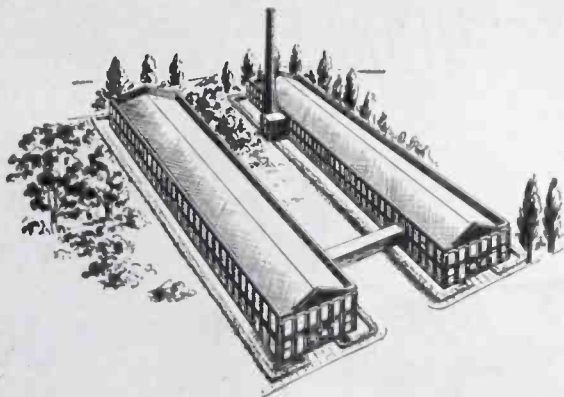
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Within a few weeks our entire Electronics Division will move into new quarters—affording not only greater facilities to meet ever-expanding wartime production, but also greater scope to anticipate the great electronics developments of peacetime. From this vast, new plant—containing 100,000 square feet of space—will come rich contribution to the vast commercial requirements at war's end.



Electronics Division

TEMPLETONE RADIO MFG. CORP.

New London, Conn.

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



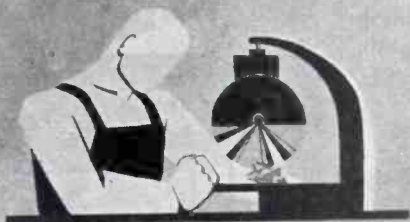
PREWAR

Crystal units average cost about \$25 each



TODAY

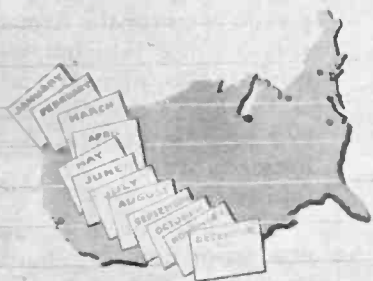
Due to improvements in design and manufacturing by Western Electric and Bell Laboratories \$25 buys 10 times as many crystal units



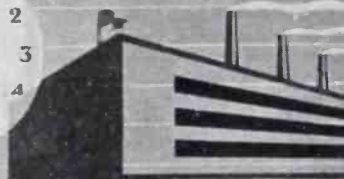
PREWAR Skilled Craftsmen were required for cutting and mounting



TODAY Semi-skilled workers on assembly lines have increased output 7500%



PREWAR Annual production of crystals by all U.S. manufacturers →



TODAY Single day's production from one of Western Electric's Crysta Shops →

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!



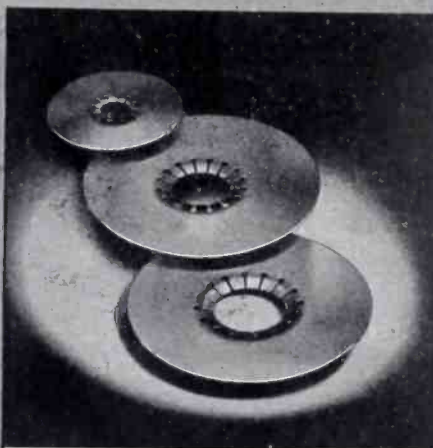
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Western Electric
 ARSENAL OF COMMUNICATIONS EQUIPMENT



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Application



No. 33446 — Cavity Socket Contact Discs

Now that the Secret classification has been lifted from the General Electric type GL496 or "Lighthouse" ultra high frequency tube, we can list the cavity contact discs we have been furnishing to authorized customers during the past few years. This set consists of three different size unhardened beryllium copper multifinger contact discs. Heat treating instructions forwarded with each kit for hardening after spinning or forming to frequency requirements.

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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.

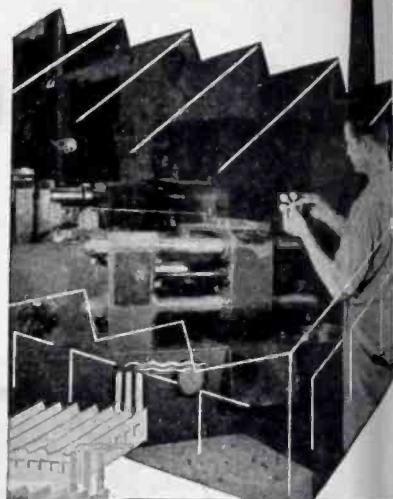
D-C Solenoids. A 32-page bulletin which contains photographs of this manufacturer's full line of d-c solenoids, together with tabular data, dimensional drawings, wiring diagrams, and response characteristic charts is available from Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Cal.

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-

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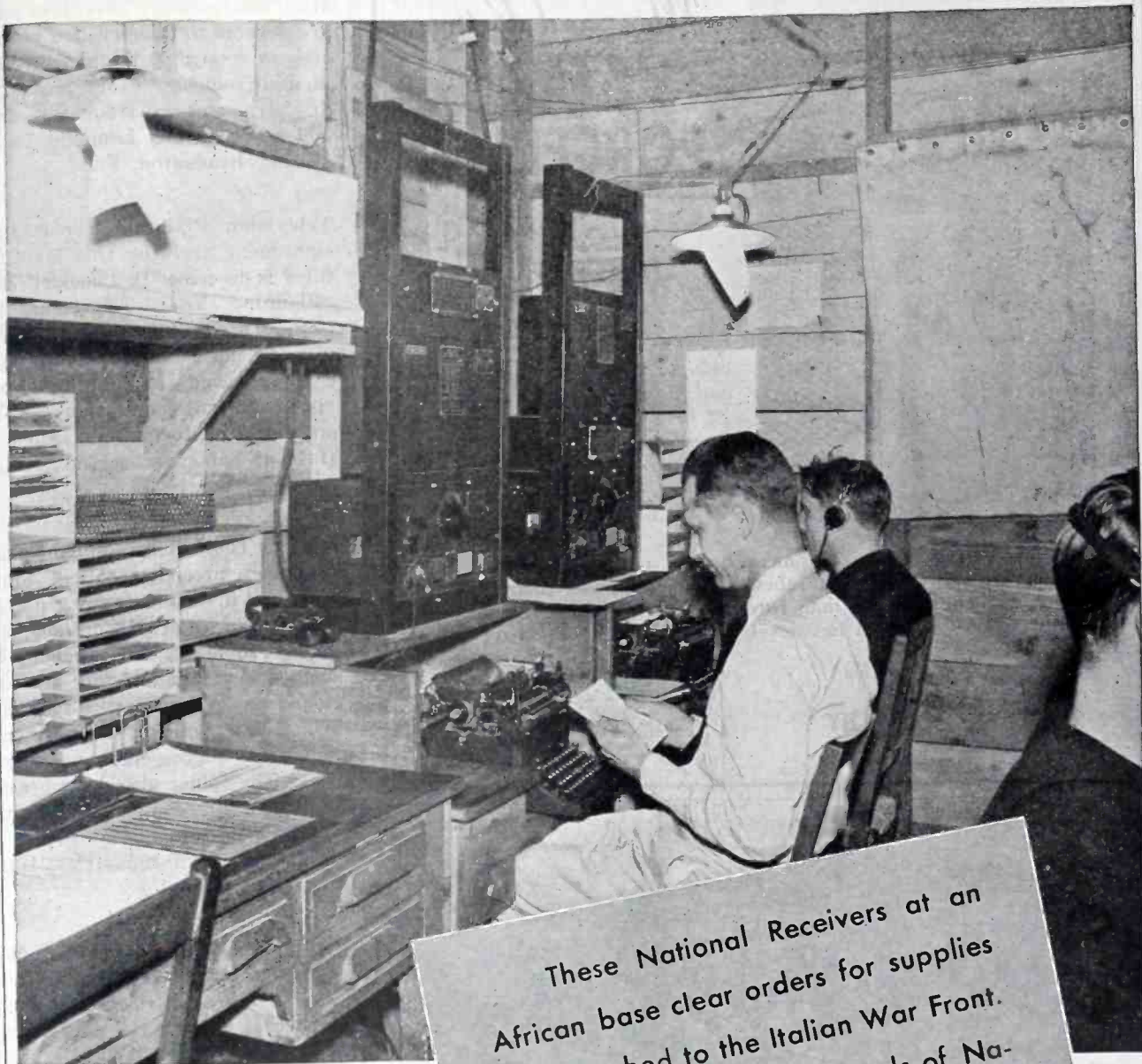
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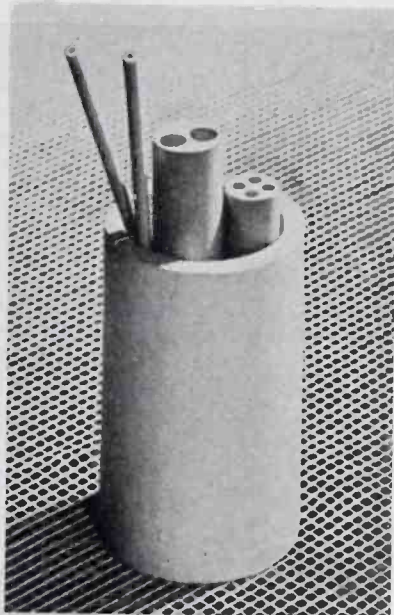
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circuit diagrams, parts lists, and operating instructions. Seventeen pages are devoted to tables which make it easy to determine the meter fundamental-frequency for measuring any transmitter frequency from 100 kc to 56 Mc. Lampkin Laboratories, Bradenton, 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.



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Versatile is the word for Atlas Sound's latest creation, the DR-12 Little Giant (Bell diameter 7 in. Overall length 7 1/2 in.) Its construction gives equally gratifying service when used for marine application, factory, police and other communications . . . a design that has proven itself more than equal to War's rigorous demands.



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Catalog 4340 contains complete description and full information with prices. Write for a copy.

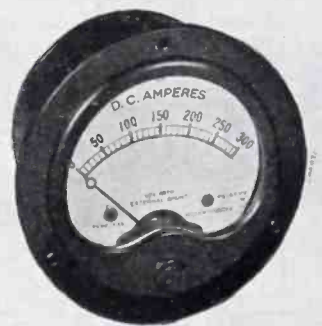


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NEW BOOKS

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, construction, 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.

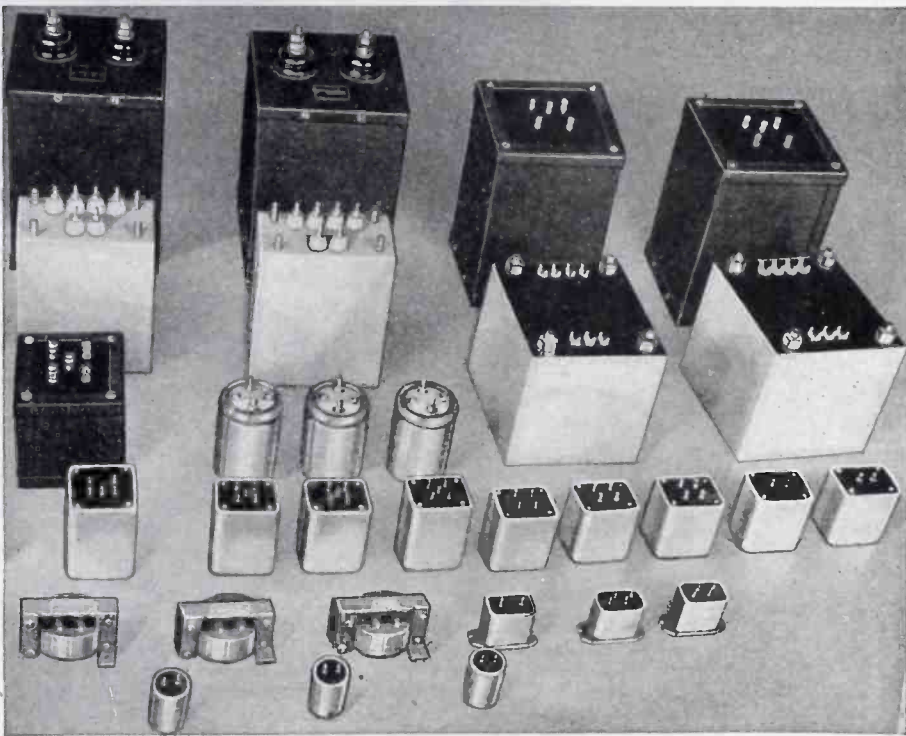
While primarily a textbook, the information presented should attract both technical and nontechnical readers, who have a desire to understand the purpose, fundamental principles of design and operation of the many instruments now in use in modern aircraft.—J.K.

• • •

Alternating Current Bridge Methods

By **B. HAGUE**, Issac 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-



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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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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.

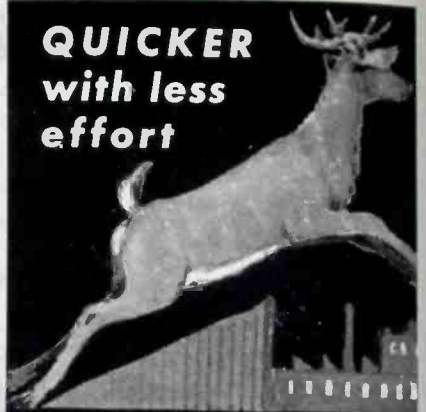
The final chapter contains much practical and theoretical information which will assist the laboratory worker to select that bridge arrangement which will provide the desired results and the required precision with the minimum amount of expenditure of time, energy, and equipment. A valuable portion of 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

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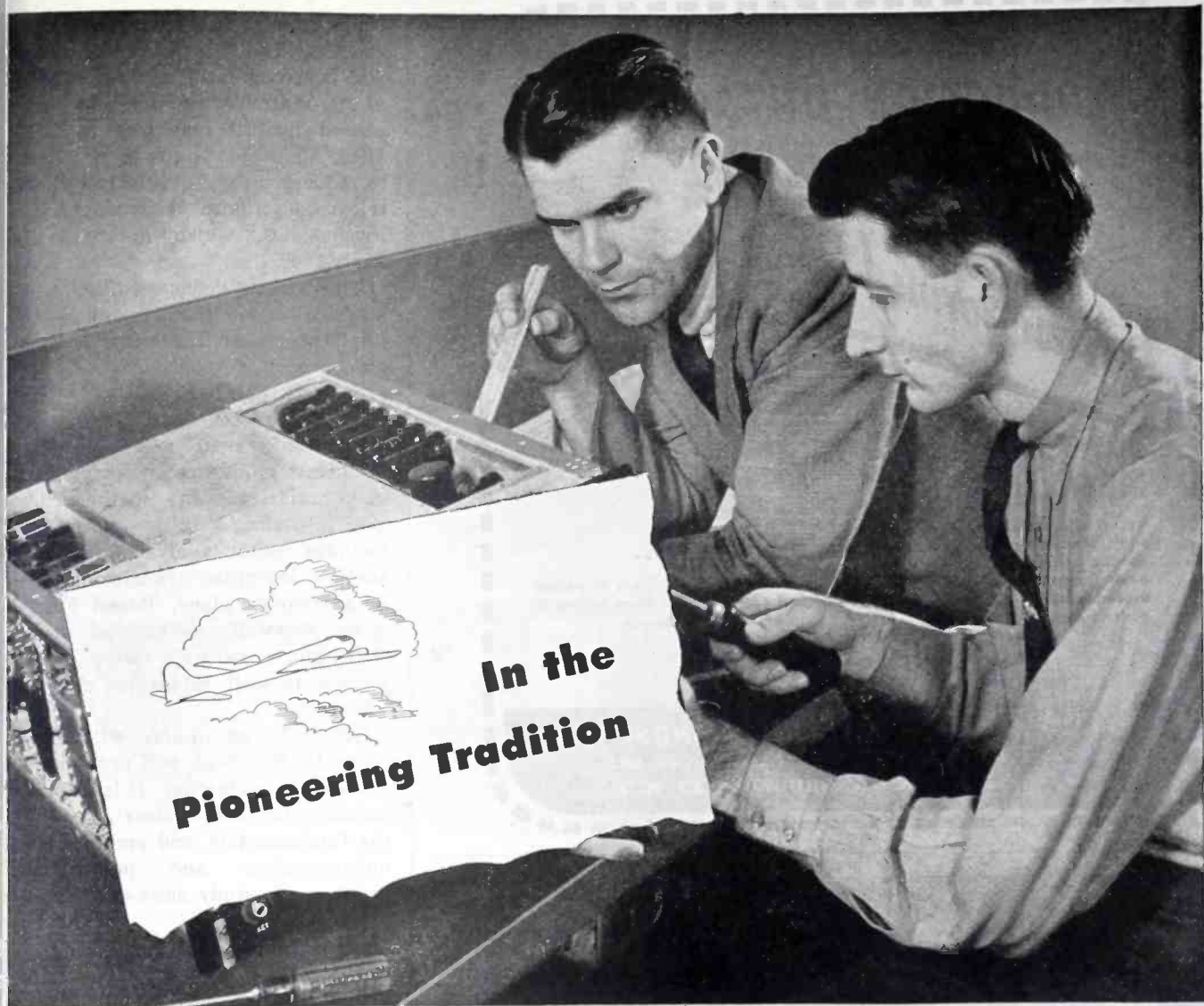
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*The Collins Autotune is a repositioning mechanism which quick-shifts all transmitter or receiver controls simultaneously and with extreme precision to any one of a number of pre-determined frequencies. U. S. Patents issued and pending.



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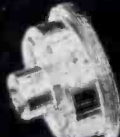
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usual engineering courses through calculus. The chapter on skin effect will be recognized as an extension of Mr. Whinnery's article which appeared in this magazine in Feb. 1942. Mr. Ramo is already familiar to readers through his paper, *Electrical 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.

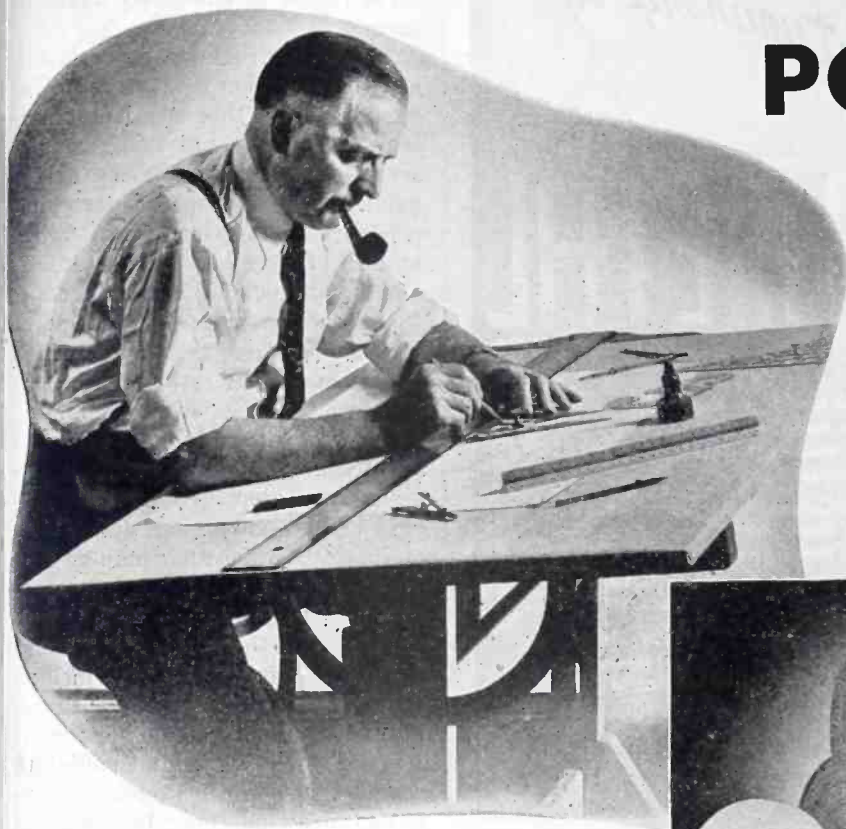
Aircraft Production Illustration

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.

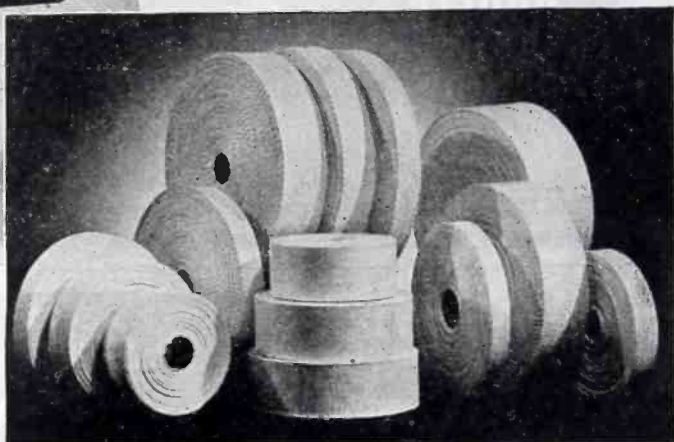
Production illustrations, as outlined by the author, are simple but accurately drawn to scale, three-dimensional picturizations of parts, subassemblies or any mechanical operation of assembling parts. They provide production line workers with picture instructions of proper mechanical procedure and also afford engineers a quick method of explaining operations to produc-

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*T. M. Reg. U. S. Pat. Off.

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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.

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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.

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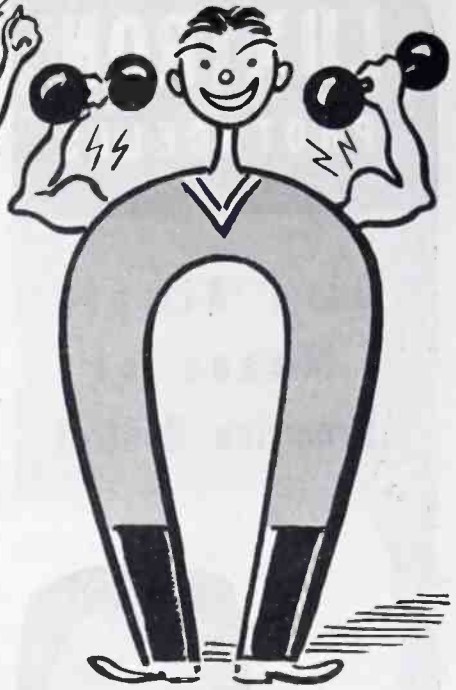
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tinuous mechanical systems, are solved to illustrate the use of theorems dealing with the functions of a complex variable and the inversion integral.

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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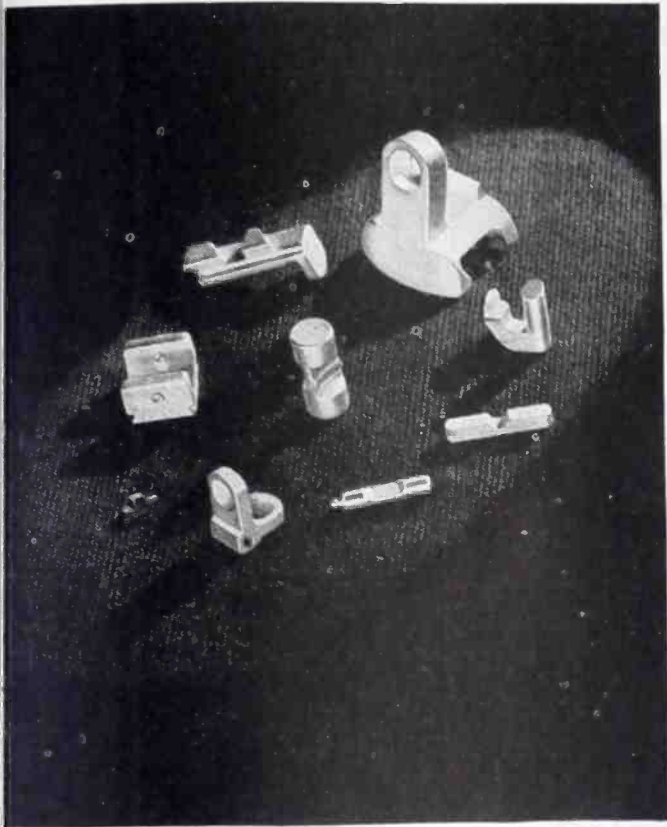
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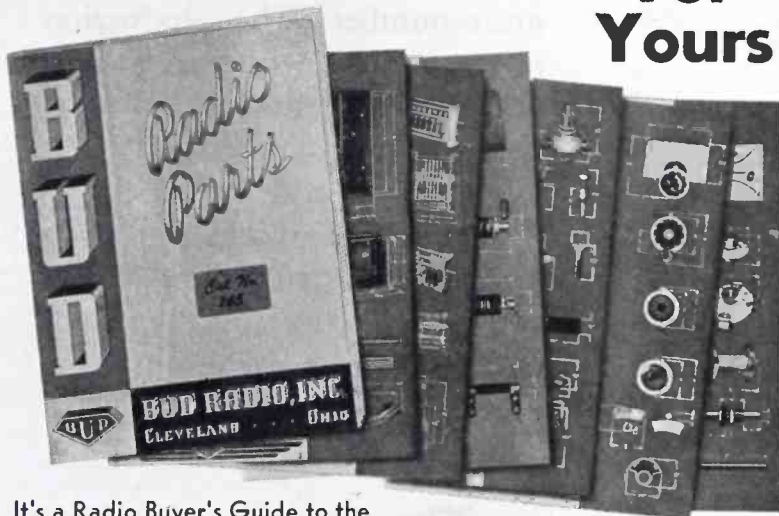
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Chapter headings are: (1) Analysis of Engineering Problems, (2) Some Basic Physical Principles, (3) Transient and Steady-State Conditions, (4) Setting Up Equations, (5) Graphical and Numerical Solutions of Differential Equations, (6) Ordinary Differential 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.

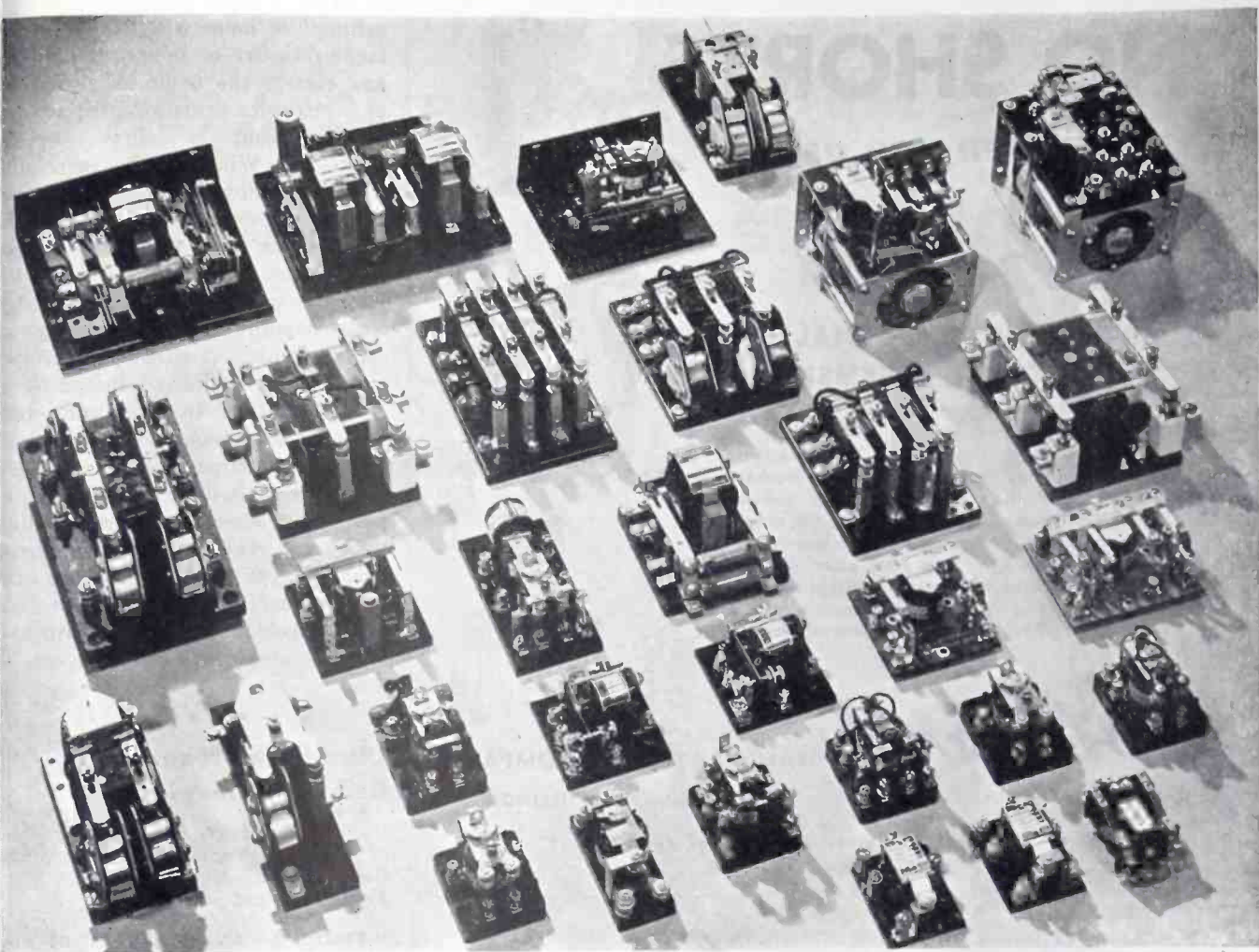
Operational procedures are employed in treating ordinary differential equations. In most cases electric circuit theory is employed to illustrate the solution of the differential equations. An introduction to Bessel's equation and Bessel functions is included. The treatment of vector representations of sinusoids employs the rotating vector $e^{j\omega t}$ 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.

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.

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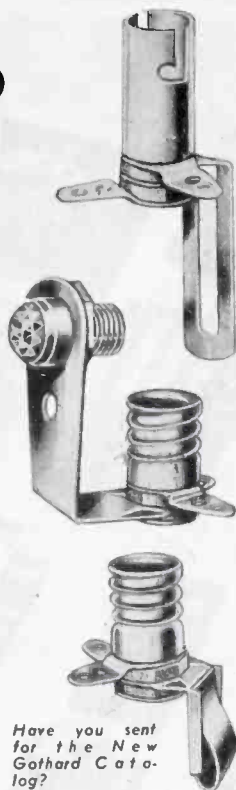
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selling" is done will depend in a large measure on how convincingly and clearly the technical problems of electronics are presented to the public. That is where "Speak Well—and Win" can be especially useful to those who must do the explaining.

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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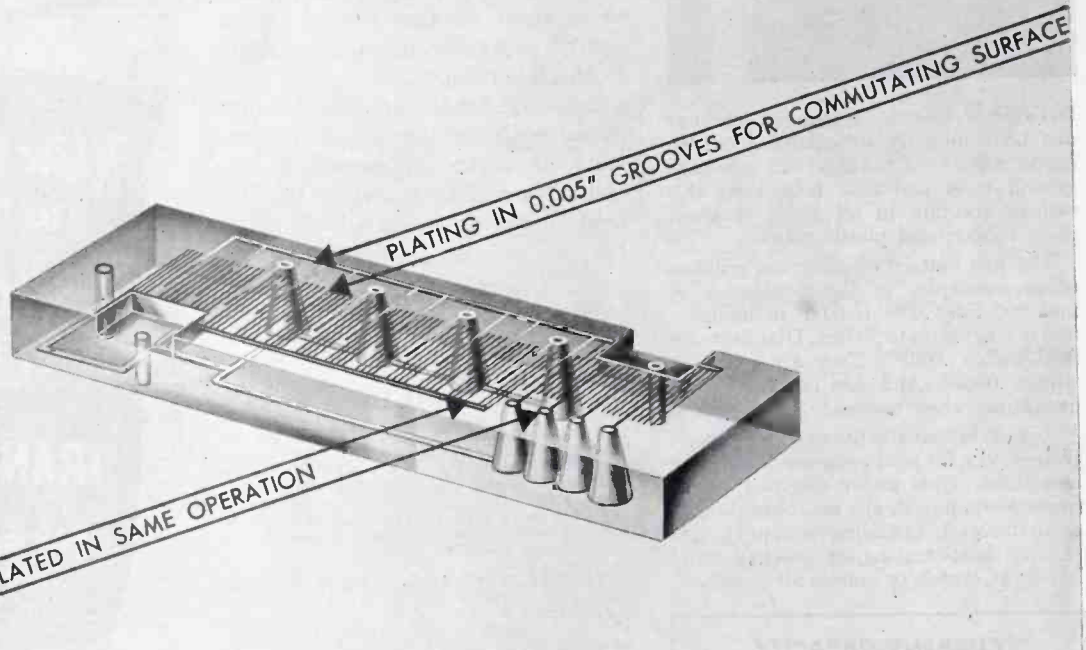


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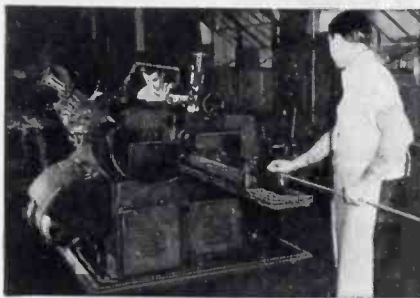
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Although this book serves only as an introduction to a wide variety of topics, references at the end of each chapter enable the student to extend basic knowledge.—
F.R.

• • •

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., 9 W. 37th 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.

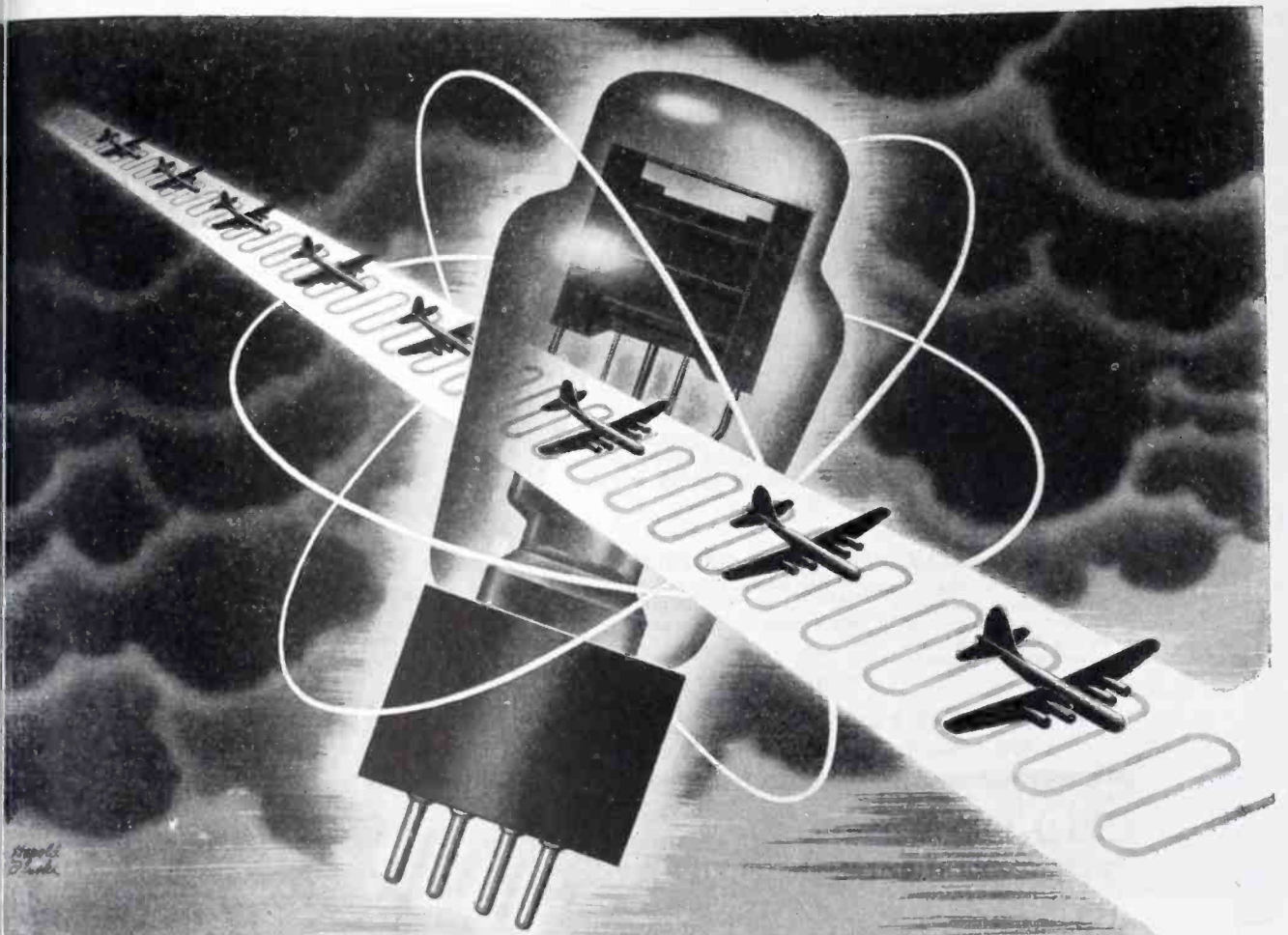


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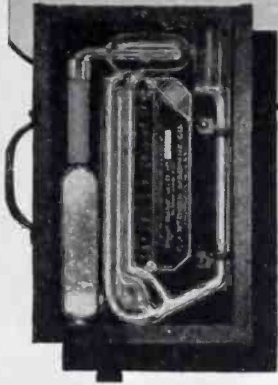
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Backtalk

This department is operated as an open forum where our readers may discuss problems of the 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 microscope 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 Prize 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.

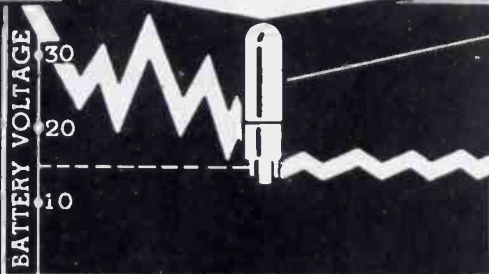
On Electronic Music

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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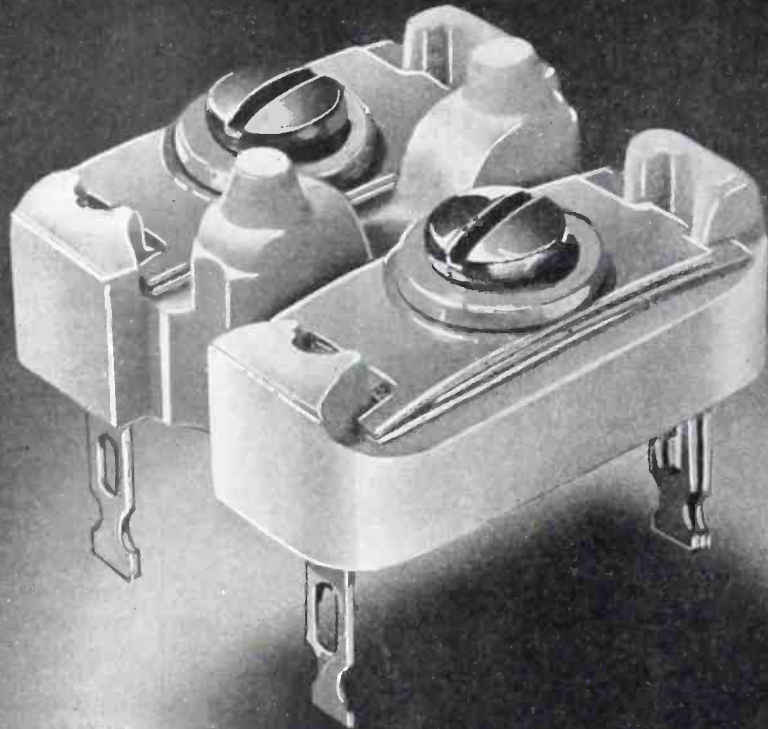
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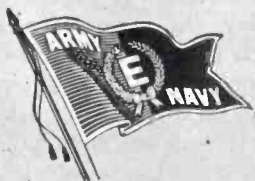
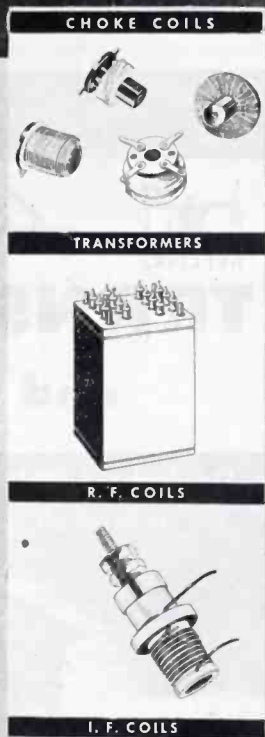
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tuned minor triad (10:12:15). For use in this chord, the frequency of D must be 10/9 instead of 9/8, which could only be obtained by momentarily shifting the organ to the key of F whenever this chord occurs. The same difficulty of frequent shifts is 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 re-tuning 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.

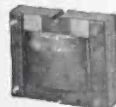
An electronic orchestra could easily play the true frequencies, since each player would have command of only one note at a time and would find no difficulty in using an instrument with continuously variable frequency. But in order to put all the harmonic and melodic components of a piece of music into the hands of a single performer, as with the piano and organ, it may well be necessary to sacrifice some



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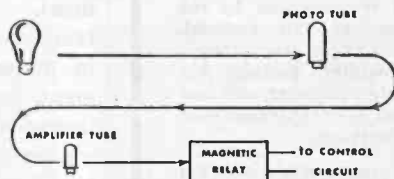
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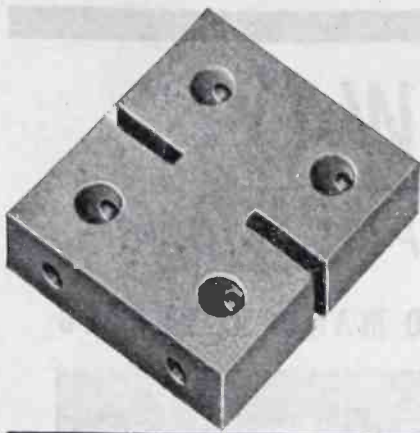


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of the fine structure and introduce simplifications such as the tempered scale.

C. ROLAND EDDY
Philadelphia, Pa.

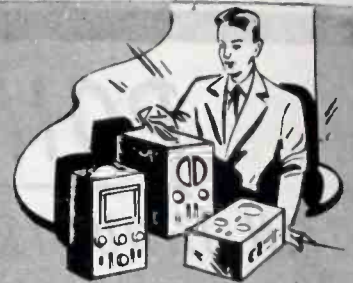
Dear Mr. Eddy:

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 those 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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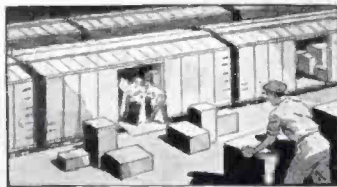
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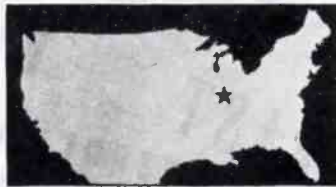
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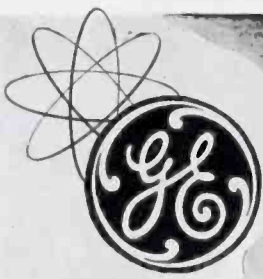
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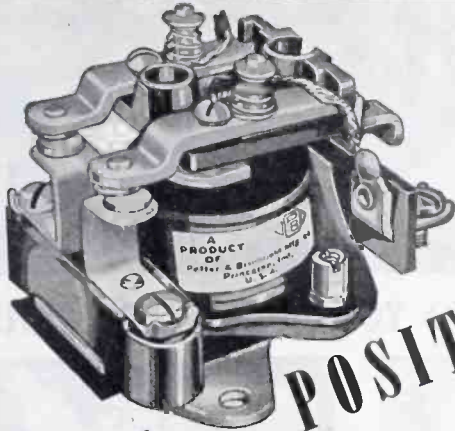


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problem would certainly lead to the desired result. The same comments apply equally to the pedal clavier of the organ.

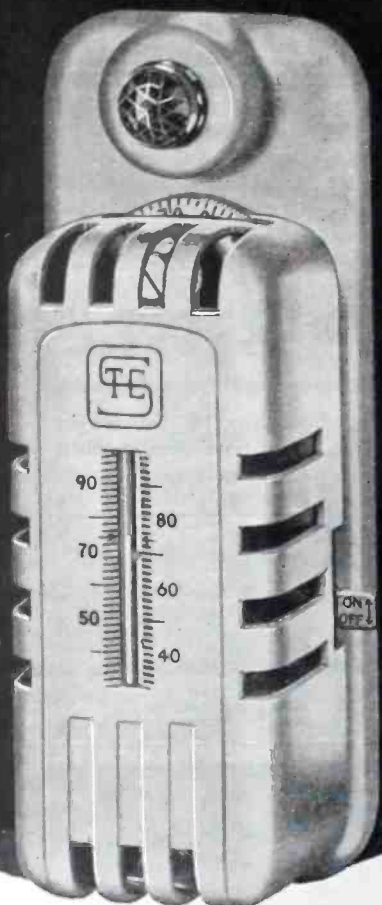
I have perhaps not given proper consideration to the question of the key-changing switch. Rather than operate it with the left foot, it might be better to add an octave of switches in front of the manual keyboard, to be operated by one finger of the right hand. Other and possibly better schemes will 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
<i>Triads of C Major</i>				
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.
<i>Triads of A Minor</i>				
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



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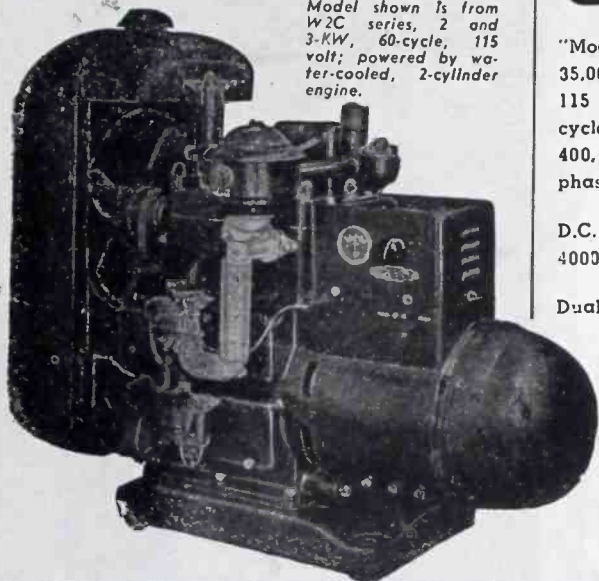
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major scale, two of the chords ascribed to each key do not, in fact, belong to it, and are not properly used when writing in that key. They are, of course, replaced by two chords at present ascribed to two other keys. In the minor scale it is seen 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

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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 $\frac{1}{2}$ 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

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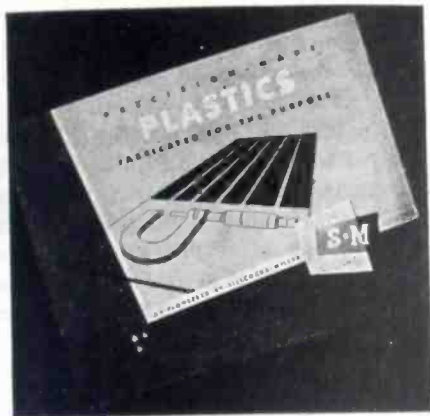
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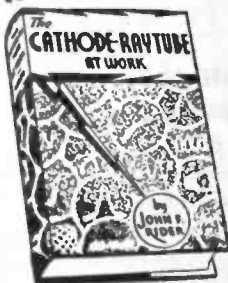


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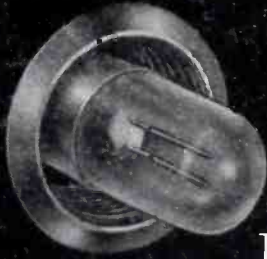
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of sunrise the linear speed of the earth in its orbit around the sun and the rotation of the earth on its axis combine to cause the sunrise portion of the earth to cut more meteor paths per unit of time.)

(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.

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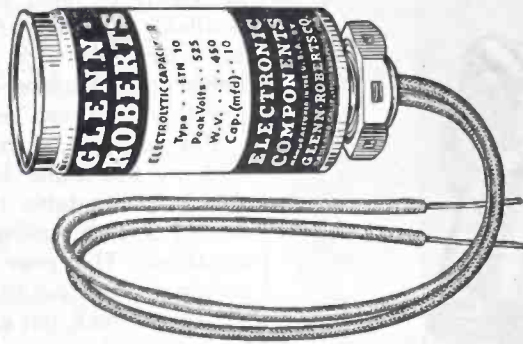
WALTER ORR ROBERTS
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Fremont Pass Station
Olmaz, Colo.

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 . . .

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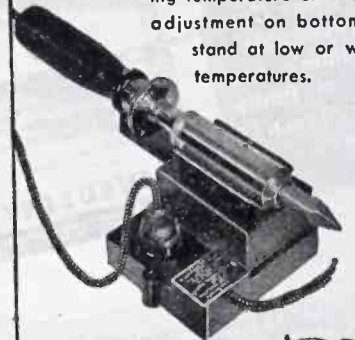
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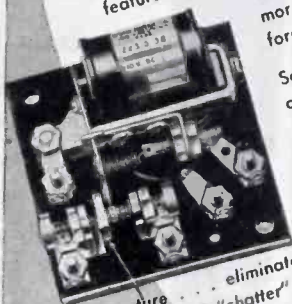
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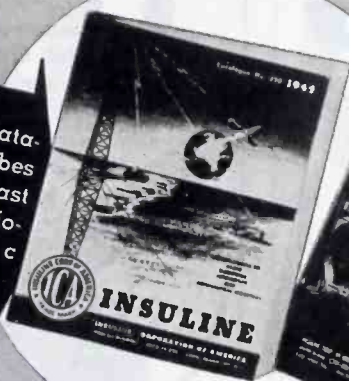
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Colorful Electronics

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.

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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?

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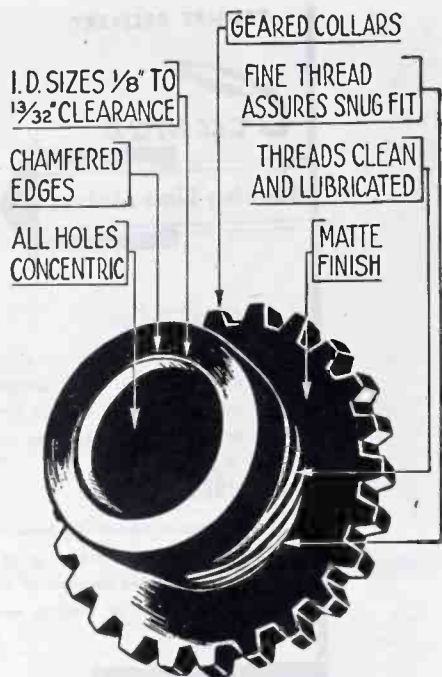


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interest, I believe, because, to get an economy going after the war, new designs to tempt customers will be good business. And a large part of design is color. In very few cases that I know about has the manufacturer been able actually to duplicate 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.

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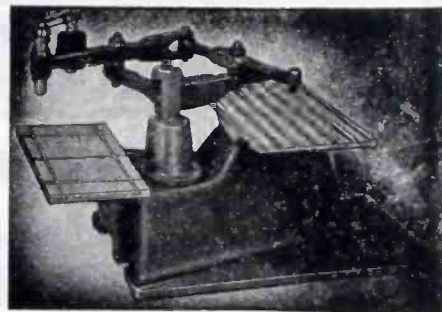
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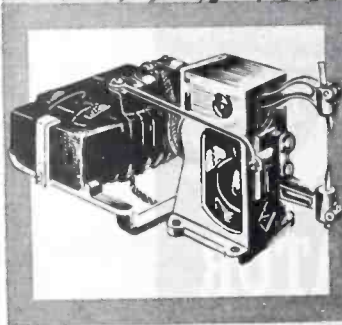
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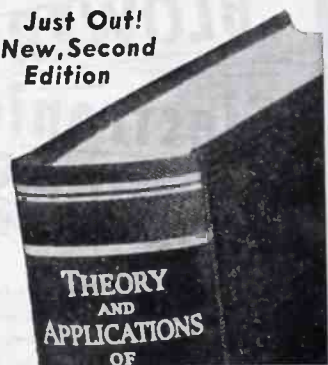
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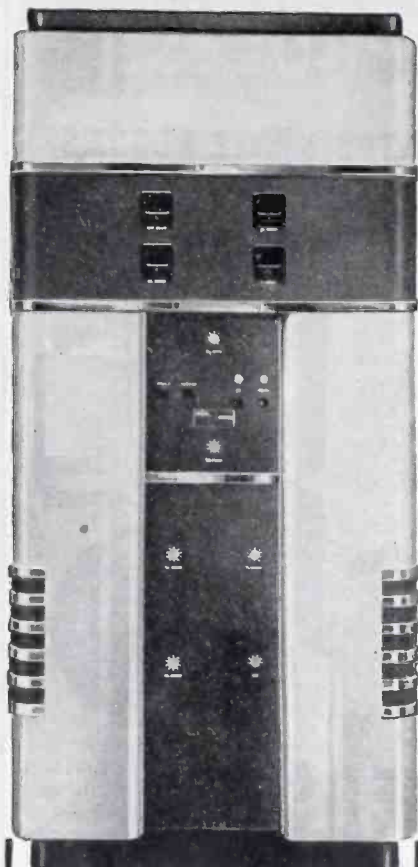
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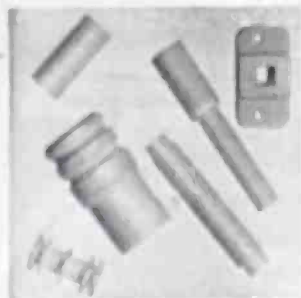
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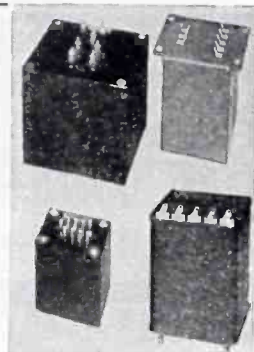
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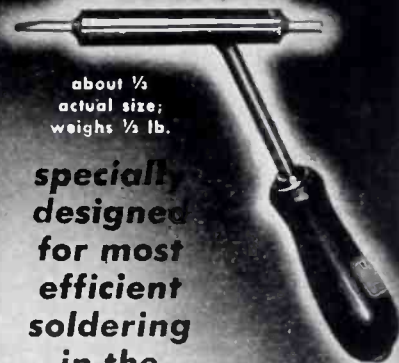


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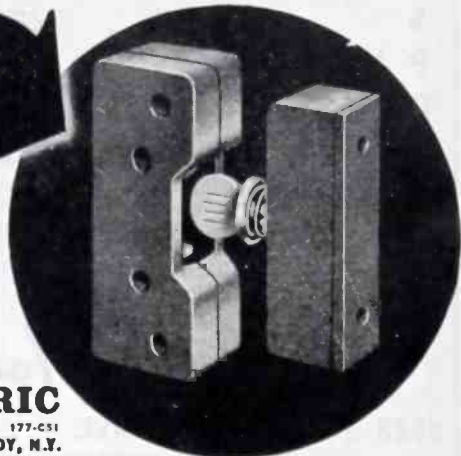
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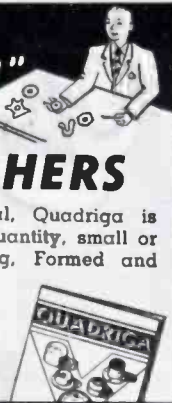
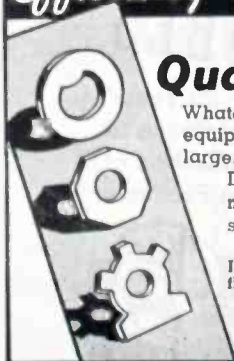
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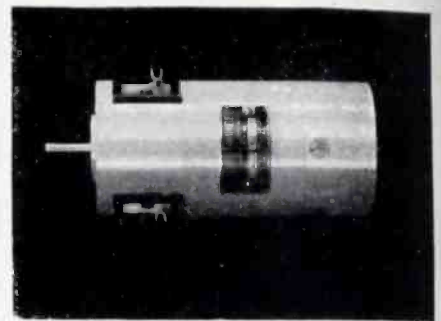
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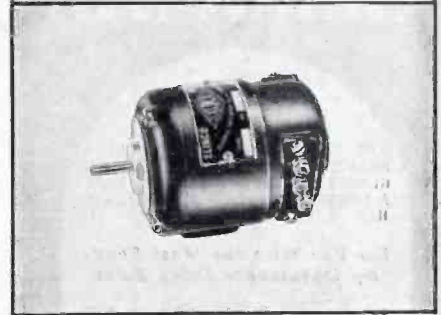
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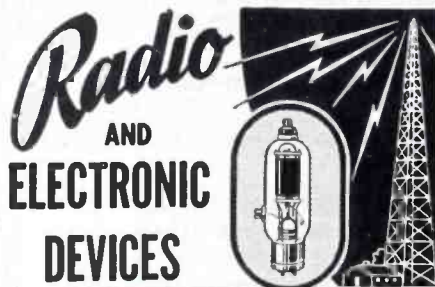
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P-743, Electronics

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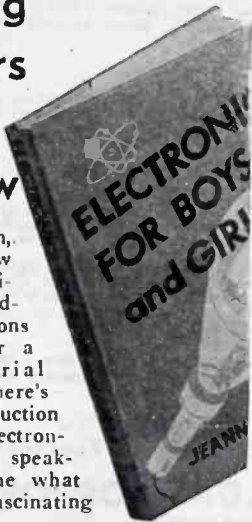
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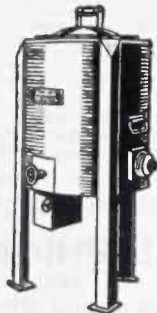
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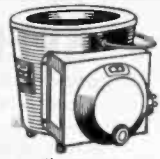
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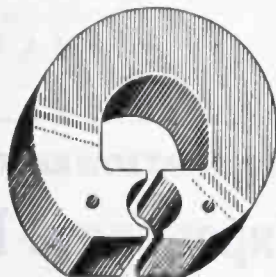


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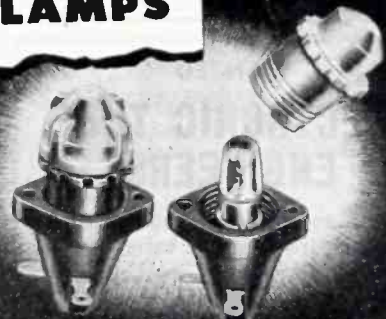
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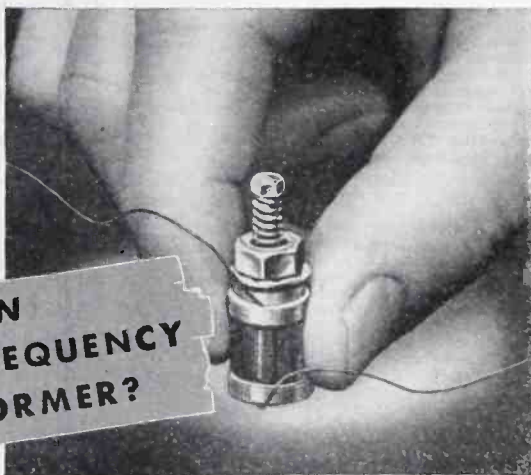
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- to measure insertion loss of a network
- to measure noise pick-up level
- to test band width, selectivity, fidelity, sensitivity

OP-193-A—OP-193-B
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 Impedance:
 OP-193-A—18 values, 400 to 20,000 Ω
 OP-193-B—40 values, 2.5 to 20,000 Ω
 Accuracy: $\pm 5\%$.
 Special Feature: Provision for use of
 headphone and/or meter.

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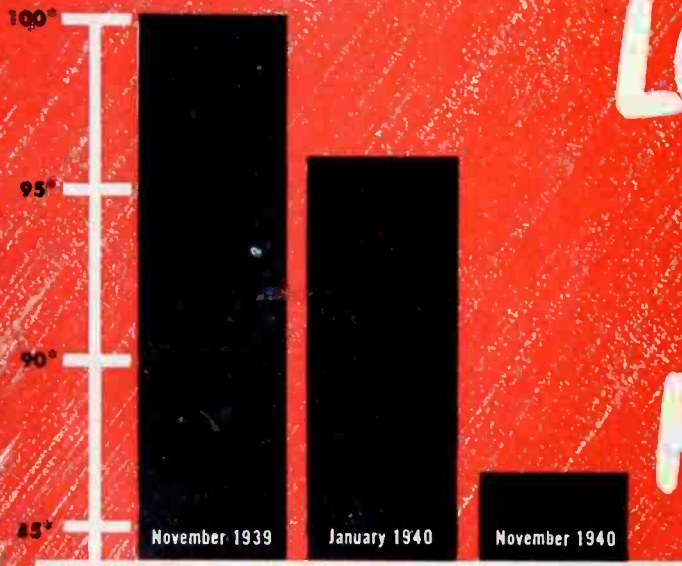
OP-961
 Power Range: 0.1 to 50 watts.
 Impedance: 40 values,
 2.5 to 20,000 Ω
 Accuracy: $\pm 2\%$.



OP-182

Power Range: 0.1mw to 5 watts.
 Impedance: 40 values,
 2.5 to 20,000 Ω
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